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(54) **FUEL INJECTION SYSTEM**

KRAFTSTOFFEINSPRITZSYSTEM

SYSTÈME D'INJECTION DE CARBURANT

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(56) References cited:

EP-A1- 2 110 543

EP-A2- 0 964 153

DE-A1-102007 010 502

DE-A1-102007 016 134

DE-A1-102010 031 356

FR-A3- 2 933 147

US-A- 5 429 094

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Description

[0001] The invention relates to a fuel injection system of a reciprocating engine. The invention also relates to a safety valve arrangement for releasing pressure from a pressurized system, such as a fuel injection system of a reciprocating engine.

[0002] For improving the operation of reciprocating 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, which comprises a pressure accumulator, from which fuel is led through separate pipes into the injector of each cylinder.

[0003] The fuel pressure in the common rail system after the high pressure pump is relatively high, even above 2000 bar. In order to prevent leakages and other damages in case of a system malfunction, the pressure accumulator is provided with a safety valve, which maintains the fuel pressure in the system below a predetermined level. The safety valve releases the pressure from the pressure accumulator to a low pressure system if the pressure exceeds this level. The outlet side of the safety valve is provided with an expansion volume, which reduces the fuel pressure to a suitable level before entering the low pressure system.

[0004] A safety valve for a common rail system is shown in EP 2 110 543 A. Typically the pressure drop in the expansion volume is quite high, which may cause stresses to the safety valve and other components of the fuel injection system. For this reason stronger and thus more expensive components must be used.

[0005] An object of the present invention is to provide a fuel injection system with an improved pressure release arrangement.

[0006] The object can be achieved by a fuel injection system according to claim 1. The fuel injection system according to the invention comprises fuel injectors for injecting fuel into cylinders of the engine, a pump for feeding fuel to at least one fuel injector, a feed system for conducting fuel from the pump to at least one fuel injector, and a safety valve arrangement for releasing fuel pressure from the feed system, which safety valve arrangement comprises a safety valve, which is arranged to open when the fuel pressure in the feed system reaches a predetermined value. The safety valve arrangement further comprises at least two expansion volumes connected in series, and one of the expansion volumes is connected to an outlet of the safety valve.

[0007] In the fuel injection system according to the invention the pressure after the safety valve is dropped in steps. Instead of having one large expansion volume with high pressure drop, at least two successive expansion volumes are provided and the pressure is reduced in smaller steps. As a result, the stress directed to the safety valve and other system components can be reduced. Since the expansion volumes can be made smaller than

in the case of a single volume, the stress affecting the expansion volumes is reduced.

[0008] The safety valve arrangement according to the invention comprises at least two expansion volumes connected in series, and one of the expansion volumes is connected to an outlet of the safety valve.

[0009] In the following the invention will be described by way of an example with reference to the accompanying drawing, which shows schematically a fuel injection system according to an embodiment of the invention.

[0010] The drawing shows a common rail fuel injection system 1 of a diesel engine. The engine is a large diesel engine, which can be used as a main and/or an auxiliary engine in ships and/or in power plants for generation of electricity and/or heat. The engine is a medium speed, four-stroke engine. However, the use of the invention is not limited to four-stroke engines. The maximum rotational speed of the engine is 300-1200 rpm. Cylinders 13 of the engine can be arranged in a single bank or in two banks in a V-configuration. Typically, the engine has 8-20 cylinders 13. The cylinder bore is typically 10-80 cm. However, the invention can also be applied to engines with smaller and larger cylinder bores. The engine can be operated by heavy fuel oil.

[0011] The fuel injection system 1 comprises fuel injectors 12 for injecting fuel into the cylinders 13 of the engine. The fuel injection system 1 further comprises a fuel source, for example a fuel tank 2, from which fuel is fed by means of a low pressure 3 pump along a fuel line 4 into a high pressure pump 5. The high pressure pump 5 elevates the fuel pressure to a level enabling that a sufficient injection pressure may be obtained in the injectors 12. If the cylinders 13 are arranged in V-configuration, the fuel injection system 1 can comprise a common high pressure pump for both cylinder banks or each cylinder bank can be provided with a separate high pressure pump.

[0012] The fuel injection system 1 comprises a feed system 6, which connects the high pressure pump 5 to the fuel injectors 12. During the engine operation, fuel pressure in the feed system 6 is typically over 2000 bar. The feed system 6 is provided with at least one pressure accumulator 7, 8 for storing fuel. The fuel injection system 1 shown in the drawing 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 conducted through the connecting pipe 9 into a second pressure accumulator 8. The feed system 6 comprises supply lines 14, by means of which the fuel injectors 13 are connected to the pressure accumulators 7, 8. Also each fuel injector 12 is provided with a separate pressure accumulator 20 for storing fuel before the injection.

[0013] 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 it before the start-up of the engine. The fuel injection system 1 com-

prises a safety valve arrangement 18 for releasing the pressure from the feed system 6. The safety valve arrangement comprises a safety valve 11, which is mounted to the second pressure accumulator 8. The safety valve 11 is arranged to open when the fuel pressure in the feed system 6 reaches a predetermined value. The safety valve 11 also maintains the pressure in the accumulators 7, 8 below said predetermined value.

[0014] The safety valve arrangement 18 further comprises at least two, typically 2-5 expansion volumes 15, which are fluidly connected in series. Each expansion volume 15 is connected to the preceding and/or to the subsequent expansion volume 15 via one or more ducts and/or ports. The cross-sectional areas of the ducts or ports in the flow direction are smaller than the cross-sectional areas of the expansion volumes 15. The flow from an expansion volume 15 to the subsequent expansion volume 15 is thus restricted for allowing different pressure levels in the expansion volumes 15. The embodiment shown in the drawing comprises three expansion volumes 15. One of the expansion volumes 15, i.e. the first expansion volume in the fuel flow direction, is connected to the outlet of the safety valve 11. A throttle 16 is arranged between each two successive expansion volumes 15. The downstream side of the last expansion volume 15 is also provided with a throttle 16. The last expansion volume 15 is connected to the return line 17, which leads to the fuel source, i.e. the fuel tank 2. The fuel pressure in the return line 17 is lower than that in the feed system 6. The expansion volume 15 can be e.g. a container. The volumes of the expansion volumes 15 can be equal. Alternatively, the volumes of the expansion volumes 15 can be unequal. For example, the first expansion volume 15 in fuel flow direction can have the largest volume and the last expansion volume 15 the smallest volume.

[0015] When the pressure in the feed system 6, for example in pressure accumulator 7,8 reaches a predetermined value, the safety valve 11 opens. Excess pressure in the feed system 6 is released through the safety valve 11 and the expansion volumes 15 to the return line 17. The expansion volumes 15 and the throttles 16 reduce the pressure in steps to a suitable level before entering the return line 17. Typically, the fuel pressure after the last expansion volume 16 is below 15 bar. Also fuel flows from the feed system 6 through the safety valve 11 and the expansion volumes 15 into the return line 17.

[0016] The invention may have embodiments different from that described above. The pressure accumulators 7, 8 can be replaced by fuel line, which connects the high pressure pump 5 to the supply lines 14. In this embodiment each fuel injector 12 is provided with separate pressure accumulator 20, in which fuel is stored before injection. The safety valve 11 of the safety valve arrangement 18 can be connected to the fuel line.

Claims

1. A fuel injection system (1) of a reciprocating engine, comprising:
 - fuel injectors (12) for injecting fuel into cylinders (13) of the engine,
 - a pump (5) for feeding fuel to at least one fuel injector (12),
 - a feed system (6) for conducting fuel from the pump (5) to at least one fuel injector (12),
 - at least one pressure accumulator (7, 8, 20) for storing fuel, and
- a safety valve arrangement (18) for releasing fuel pressure from the feed system (6), which safety valve arrangement (18) comprises a safety valve (11), which is arranged to open when the fuel pressure in the feed system (6) reaches a predetermined value, the safety valve arrangement (18) further comprising at least two expansion volumes (15) connected in series for reducing pressure in steps, one of the expansion volumes (15) being connected to an outlet (19) of the safety valve (11), **characterized in that** the first expansion volume (15) in fuel flow direction has the largest volume or the volumes of the expansion volumes (15) are equal.
2. The fuel injection system (1) according to claim 1, **characterized in that** the safety valve arrangement (18) comprises 2-5 expansion volumes (15) connected in series.
3. The fuel injection system (1) according to claim 1 or 2, **characterized in that** a throttle (16) is arranged between each two successive expansion volumes (15).
4. The fuel injection system (1) according to claim 3, **characterized in that** a downstream side of a last expansion volume (15) is provided with a throttle (16).
5. The fuel injection system (1) according to any of the preceding claims, **characterized in that** the last expansion volume (15) in fuel flow direction has the smallest volume.
6. The fuel injection system (1) according to claim 1, **characterized in that** the feed system (6) comprises at least one pressure accumulator (7, 8) to which the fuel injectors (12) are connected by separate supply lines (14), and that the pressure accumulator (7, 8) is provided with the safety valve arrangement (18).

Patentansprüche

1. Einspritzsystem (1) eines Hubkolbenmotors, umfassend:

- Einspritzventile (12) zum Einspritzen von Kraftstoff in Zylinder (13) des Motors,
- eine Pumpe (5) zum Zuführen von Kraftstoff zu mindestens einem Einspritzventil (12),
- ein Zufuhrsystem (6) zum Leiten von Kraftstoff von der Pumpe (5) zu mindestens einem Einspritzventil (12),
- mindestens einen Druckspeicher (7, 8, 20) zum Speichern von Kraftstoff und

eine Sicherheitsventilanordnung (18) zum Freigeben von Kraftstoffdruck vom Zufuhrsystem (6), wobei die Sicherheitsventilanordnung (18) ein Sicherheitsventil (11) umfasst, das ausgeführt ist, sich zu öffnen, wenn der Kraftstoffdruck im Zufuhrsystem (6) einen voreingestellten Wert erreicht, **dadurch gekennzeichnet, dass** die Sicherheitsventilanordnung (18) weiter mindestens zwei Expansionsvolumina (15) umfasst, die in Reihe verbunden sind, um Druck in Schritten zu reduzieren, wobei eines der Expansionsvolumina (15) mit einem Auslass (19) des Sicherheitsventils (11) verbunden ist, **dadurch gekennzeichnet, dass** das erste Expansionsvolumen (15) in der Kraftstoffflussrichtung das größte Volumen aufweist oder die Volumina der Expansionsvolumina (15) gleich sind.

2. Einspritzsystem (1) nach Anspruch 1, **dadurch gekennzeichnet, dass** die Sicherheitsventilanordnung (18) 2 - 5 Expansionsvolumina (15) umfasst, die in Reihe verbunden sind.
3. Einspritzsystem (1) nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** eine Drossel (16) zwischen jeweils zwei aufeinanderfolgenden Expansionsvolumina (15) angeordnet ist.
4. Einspritzsystem (1) nach Anspruch 3, **dadurch gekennzeichnet, dass** eine Abströmseite eines letzten Expansionsvolumens (15) mit einer Drossel (16) versehen ist.
5. Einspritzsystem (1) nach einem der vorstehenden Ansprüche, **dadurch gekennzeichnet, dass** das letzte Expansionsvolumen (15) in Kraftstoffflussrichtung das kleinste Volumen aufweist.
6. Einspritzsystem (1) nach Anspruch 1, **dadurch gekennzeichnet, dass** das Zufuhrsystem (6) mindestens einen Druckspeicher (7, 8) umfasst, mit dem die Einspritzventile (12) durch separate Versorgungsleitungen (14) verbunden sind, und dass der Druckspeicher (7, 8) mit der Sicherheitsventilanord-

nung (18) versehen ist.

Revendications

1. Système d'injection de carburant (1) d'un moteur alternatif, comprenant :

- des injecteurs de carburant (12) pour injecter du carburant dans des cylindres (13) du moteur,
- une pompe (5) pour alimenter en carburant au moins un injecteur de carburant (12),
- un système d'alimentation (6) pour conduire du carburant depuis la pompe (5) jusqu'à au moins un injecteur de carburant (12),
- au moins un accumulateur à pression (7, 8, 20) pour stocker du carburant et

un dispositif de vanne de sécurité (18) pour relâcher la pression du carburant provenant du système d'alimentation (6), lequel dispositif de vanne (18) comprend une vanne de sécurité (11) qui est conçue pour s'ouvrir lorsque la pression de carburant dans le système d'alimentation (6) atteint une valeur prédéterminée, le dispositif de vanne de sécurité (18) comprenant en outre au moins deux volumes d'expansion (15) connectés en série pour réduire la pression par étapes, un des volumes d'expansion (15) étant connecté à une sortie (19) de la vanne de sécurité (11), **caractérisé en ce que** le premier volume d'expansion (15) a, dans le sens d'écoulement du carburant, le volume le plus important ou que les volumes des volumes d'expansion (15) sont égaux.

2. Système d'injection de carburant (1) selon la revendication 1, **caractérisé en ce que** le dispositif de vanne de sécurité (18) comprend 2 - 5 volumes d'expansion (15) connectés en série.
3. Système d'injection de carburant (1) selon la revendication 1 ou 2, **caractérisé en ce qu'un** étrangleur (16) est disposé entre deux volumes d'expansion successifs (15).
4. Système d'injection de carburant (1) selon la revendication 3, **caractérisé en ce qu'une** face aval d'un dernier volume d'expansion (15) est pourvue d'un étrangleur (16).
5. Système d'injection de carburant (1) selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le dernier volume d'expansion (15) dans le sens d'écoulement du carburant a le volume le plus petit.
6. Système d'injection de carburant (1) selon la revendication 1, **caractérisé en ce que** le système d'alimentation (6) comprend au moins un accumulateur

à pression (7, 8) auquel les injecteurs de carburant (12) sont connectés par des lignes d'alimentation séparées (14) et que l'accumulateur à pression (7, 8) est équipé du dispositif de vanne de sécurité (18).

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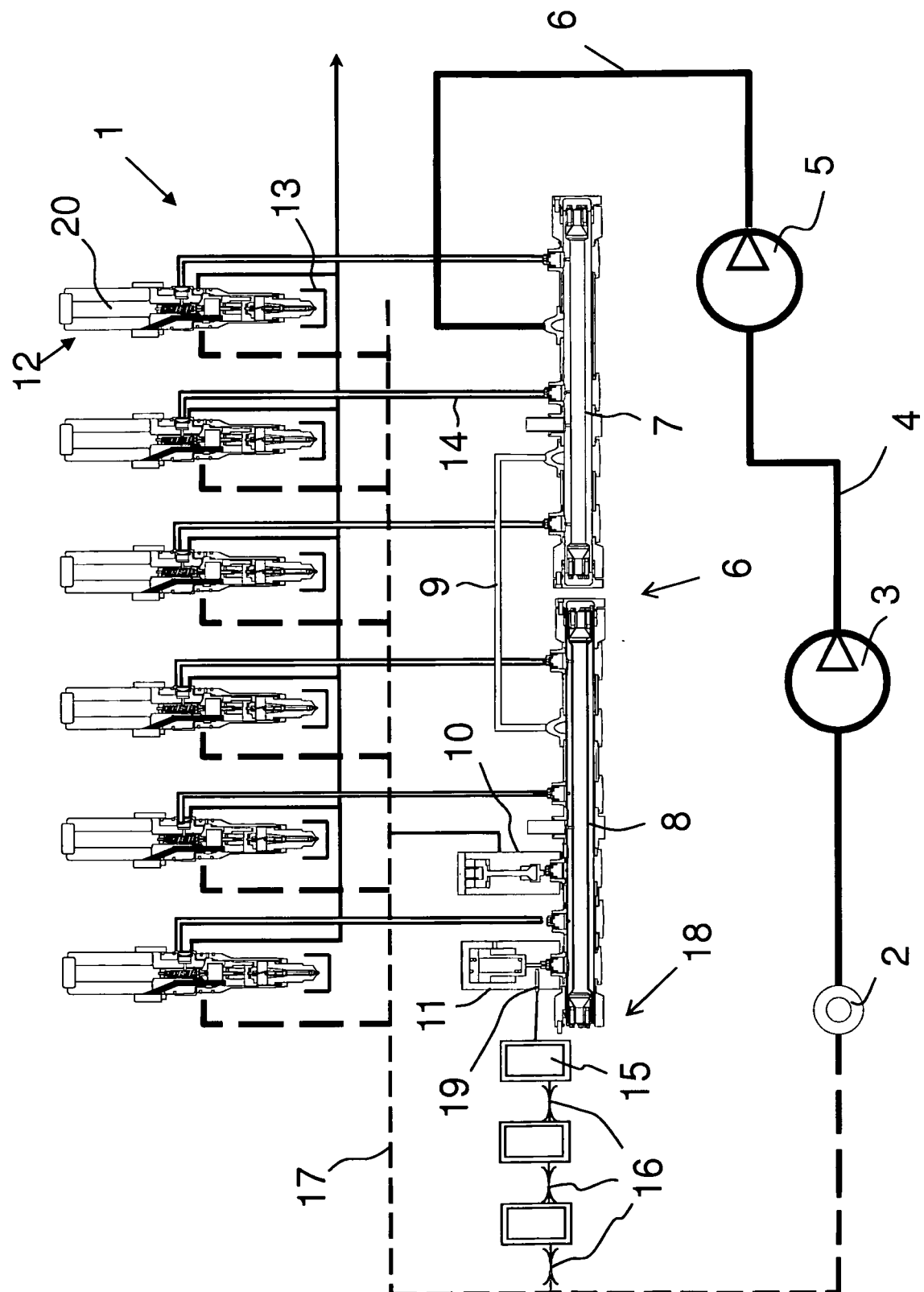
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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 2110543 A [0004]