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(54) A FUEL VALVE FOR A LARGE TURBOCHARGED TWO-STROKE UNIFLOW CROSSHEAD INTERNAL COMBUSTION ENGINE

(57) Described is a fuel valve (1) for a large turbocharged two-stoke uniflow crosshead internal combustion engine, said fuel valve (1) comprising an elongated fuel valve housing (2) with a rear end (3) and a front end (4), a nozzle (5) with at least one bore (7) opening into at least one nozzle hole (9) having a nozzle hole area, said nozzle (5) being arranged at the front end (4) of said housing (2), a fuel channel (11) extending from the rear end (3) towards the front end (4) and being connected to a source of pressurized fuel, an axially displaceable valve needle (12) having a closed position, in which said axially displaceable valve needle (12) is resting on a valve seat (8) preventing fuel from flowing to the nozzle (5), and an open position in which said axially displaceable needle (12) is lifted from said valve seat (8) thereby exposing a valve needle flow area (13) between said needle (12) and said valve seat (8) allowing fuel to flow through the fuel valve (1) to the nozzle hole (9) via a flow path defined by at least the fuel channel (11), the valve needle flow area (13) and the at least one bore (9) in the nozzle (5). The fuel valve (1) is peculiar in that it comprises a flow restriction (20) in said flow path of the fuel.

Hence, by introducing a flow restriction (20) in the flow path at a different location than the nozzle hole(s) (9) itself the injection flow rate is determined by the injection pressure and the effective open flow area of the flow restriction (20), thereby avoiding high exit velocities into the cylinder at the nozzle hole(s) (9). In this way the fuel may be injected into the combustion chamber (10) of a cylinder of an internal combustion engine at a lower injection velocity and thus facilitating a lower risk of extinction of the flame, while still maintaining a high fuel supply pressure in the fuel injection system. The fuel, such as ammonia may thus be injected with a well-controlled mass rate into the cylinder, that eliminates or at least lowers the risk of extinction of the flame.

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Description

TECHNICAL FIELD

[0001] The present invention relates to a fuel valve for a large turbocharged two-stoke uniflow crosshead internal combustion engine..

BACKGROUND OF THE INVENTION

[0002] Large turbocharged two-stroke uniflow crosshead internal combustion engines are typically used as prime movers in large ocean going ships, such as container ships or in power plants. Very often, these engines are operated with heavy fuel oil or with fuel oil.

[0003] Recently, there has been a demand for large two-stroke diesel engines to be able to handle alternative types of fuel, such as gaseous fuel, for example, methanol, LPG, LNG, ethane, ammonia and/or other similar fuels.

[0004] Such fuels are relatively clean fuels that result in significantly lower levels of sulfurous components, NOx and CO2 in the exhaust gas when used as fuel for a large low-speed uniflow turbocharged two-stroke internal combustion engine when compared with e.g. using Heavy Fuel Oil as fuel.

[0005] However, there are problems associated with using such fuels in a large turbocharged two-stroke uniflow crosshead internal combustion engine. One of those problems is the willingness and predictability of the fuel to self-ignite and both are essential to have under control in such an engine. Therefore, existing large turbocharged two-stroke uniflow crosshead internal combustion engines typically use pilot injection of oil simultaneously with the injection of the gaseous fuel to ensure reliable and properly timed ignition of the gaseous fuel.

[0006] Further, these engines are typically provided with two or three fuel valves arranged in each cylinder cover. The fuel valve may be provided with a spring biased axially movable valve needle that acts as a movable valve member. When the pressure of the fuel exceeds a preset pressure (typically about 350 Bar) the axially movable valve needle is lifted from its valve seat and the fuel is allowed to flow into the combustion chamber via a nozzle at the front of the fuel valve. The fuel valve needle may also be actuated and controlled by external hydraulic or electrical power.

[0007] Currently, ammonia enjoys very high interest as fuel for internal combustion engines mainly because it may be produced in an environmental friendly way by use of electricity from renewable energy sources, such as sun, wind and wave energy and because the combustion of ammonia per se takes place without formation of carbon containing greenhouse gases, such as carbon dioxide.

[0008] When ammonia is used as fuel for an internal combustion engine, the engine may be operated according to the Otto principle where ammonia fuel is introduced at relatively low pressure during the compression stroke of the piston, or the engine may be operated after the Diesel principle, where the ammonia fuel is injected at high pressure into the combustion chamber when piston is close to top dead center (TDC). During the ammonia fuel injection and combustion phase of the piston cycle the cylinder pressure is undergoing dramatic changes in level both due to compression/expansion of the chamber and due to the combustion taking place.

[0009] Current fuel injection systems for internal combustion engines being operated according to the Diesel principle all require the fuel injection pressures to be considerably higher than the maximum pressure inside the combustion chamber of the cylinder in order to ensure a steady and well controlled fuel mass rate into the cylinder during injection. The main pressure drop is always located at the nozzle hole, where fuel is injected into the combustion chamber with high velocity. Hence, the injection pressure level together with the effective nozzle area is defining the fuel injection mass rate.

[0010] While this is desirable with most fuels, when injecting ammonia into a combustion chamber of a cylinder of an internal combustion engine the injection pressure and velocity may need to be much lower in order to not disturb the combustion and make stabilization of the flame close to a fuel valve or injector possible. Ammonia has a laminar flame velocity that is almost 10 times lower than that of most hydrocarbons, hence quenching/extinction of the flame may happen at even low turbulence levels. Furthermore, too high velocities in the fuel jet may just sweep/convert a flame downstream with no chance to stabilize itself at a limited lift off length from the nozzle hole exit. It may be seen as blowing out a candle.

[0011] The currently existing fuel injection systems are not able to inject fuel at a steady injection rate with low pressures, because the downstream pressure is varying dramatically during the injection duration. Transient control of the injection pressure (for instance by controlling the hydraulic driving pressure of the booster or the fuel pressure of a common rail system within milliseconds) is not possible.

[0012] WO 2015/091180 A1 (equivalent to JP 2017/507269) and US 2009/0032622 disclose fuel valves for a large turbocharged two-stoke uniflow crosshead internal combustion engine. In these known fuel valves the flow restriction is arranged in the flow path upstream of the valve seat. Thus, in these known fuel valves the forces from the fuel medium acting on the valve needle, that need to be counteracted by springs, actuators (electric, hydraulic, etc.) will be affected by the flow restriction or changes of the flow restriction. Hence the demands for actuation forces on and the control of the actuation of the valve needle are dependent of the flow restriction. Further, in these prior art fuel valves opening of the valve needle will immediately result in a steep decrease of pressure acting on the needle, which in turn will require a very large actuation force in order to keep the needle open.

[0013] The invention also relates to a large turbocharged two-stoke uniflow crosshead internal combustion engine comprising a fuel valve as described above and claimed in the attached claims.

SUMMARY OF THE INVENTION

[0014] It is an object of the present invention to provide a fuel valve of the kind mentioned in the introduction, where the above mentioned challenges relating to extinction of the flame and the forces from the fuel medium acting on the valve needle are at least significantly reduced.

[0015] The foregoing and other objects are achieved by the features of the independent claims. Further implementation forms are apparent from the dependent claims, the description, and the figures.

[0016] According to a first aspect, there is provided a fuel valve for a large turbocharged two-stoke uniflow crosshead internal combustion engine, said fuel valve comprising an elongated fuel valve housing with a rear end and a front end, a nozzle with at least one bore opening into at least one nozzle hole having a nozzle hole area, said nozzle being arranged at the front end of said housing, a fuel channel extending from the rear end towards the front end and being connected to a source of pressurized fuel, an axially displaceable valve needle having a closed position, in which said axially displaceable valve needle is resting on a valve seat preventing fuel from flowing to the nozzle, and an open position in which said axially displaceable needle is lifted from said valve seat thereby exposing a valve needle flow area between said needle and said valve seat allowing fuel to flow through the fuel valve to the nozzle hole via a flow path defined by at least the fuel channel, the valve needle flow area and the at least one bore in the nozzle, where said fuel valve comprises a flow restriction in said flow path of the fuel, and being characterized in that the flow restriction is provided in the flow path between the valve seat and the nozzle hole(s).

[0017] Hence, by introducing a flow restriction in the flow path between the valve seat and the nozzle hole(s), at a different location than the nozzle hole itself (or nozzle holes themselves) the injection flow rate is determined by the injection pressure and the effective open flow area of the flow restriction, thereby avoiding high exit velocities into the cylinder at the nozzle hole(s). In this way, the fuel may be injected into the combustion chamber of a cylinder of an internal combustion engine at a lower injection velocity and thus facilitating a lower risk of extinction of the flame, while still maintaining a high fuel supply pressure in the fuel injection system. The fuel, such as ammonia may thus be injected with a well-controlled mass rate into the cylinder, which eliminates or at least lowers the risk of extinction of the flame. In addition, the forces from the fuel medium acting on the valve needle are not affected by the flow restriction.

[0018] The injection system may maintain a high supply pressure by controlling the pressure in a common-rail system or by keeping constant high hydraulic pressure driving booster valves.

[0019] The flow restriction should provide a flow area that ensures the correct fuel flow rate given the chosen pressure level. Thus, it is preferred that the flow area of the flow restriction is significantly smaller than the nozzle hole area. In a preferred embodiment of the invention the flow area of the flow restriction is less than 3/4, preferably less than 1/2 and most preferably less than 1/3 of the nozzle hole area. Hence, in this way, the fuel may be injected through the nozzle hole at a constant mass rate and velocity independent of the cylinder pressure.

[0020] The nozzle may comprise more than one bore opening into at least one nozzle hole. In such embodiment the nozzle holes preferably have equal nozzle hole area. However, a nozzle with more nozzle holes of different areas is conceivable. In another embodiment the nozzle may comprise one bore supplying fuel to all nozzle holes. In embodiments with a nozzle having more nozzle holes it is the total nozzle hole area of all nozzle holes, which has to be compared and sized relative to the flow area of the flow restriction.

[0021] In one embodiment of the invention, where the flow restriction is provided in the flow path between the valve seat and the nozzle hole, a reduction of the cross sectional area of at least a part of the bore may be provided. In practice such restriction could be provided by introducing a flow restriction insert into the bore extending from valve seat to the nozzle hole. If fuel is delivered to each nozzle hole via an individual bore for each nozzle hole, flow restriction inserts have to be provided in all of the bores, where the flow restriction area of the inserts being smaller than the nozzle hole area of each individual nozzle hole that is supplied with fuel from that bore.

[0022] In another embodiment of the invention, where the flow restriction also is provided in the flow path between the valve seat and the nozzle hole(s), the nozzle of the fuel valve only comprises one bore, which one bore supplies fuel to a number of nozzle holes, only one such flow restriction insert will be needed, with a flow restriction area that is smaller than the sum of all nozzle hole flow areas.

[0023] In yet another embodiment of the invention, the fuel valve may be a kind of a slide valve, where the nozzle comprises only one bore delivering fuel to a number of nozzle holes and where the valve needle is formed as a cut-off shaft, which extends into the bore and cuts off the nozzle holes, when the valve needle is in its closed position. In such kind of valve, the fuel passes the cut-off shaft via at least one orifice, when the valve needle is in its open position and accordingly, the flow restriction in such valve may be provided in said at least on orifice.

[0024] The nozzle holes in the nozzle may be distributed radially and preferably also axially over the nozzle. The nozzle holes may axially be positioned near a tip of the nozzle, which tip preferably is closed. The nozzle holes may preferably be positioned over a relatively narrow range of the perimeter of the nozzle, such as between approximately 50° to 120°. The radial orientation of the nozzle holes may further be directed away from a wall of the combustion chamber defined by a cylinder liner. Further, the nozzle holes may be directed such that they are roughly in the same direction as a direction of a swirl of scavenge air in the combustion chamber caused by the configuration of scavenge ports.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] The invention will be explained in more details with reference to the example embodiments shown in the drawings, in which:

Fig. 1 shows an embodiment of the fuel valve according to the invention, where the flow restriction is provided in the bore of the nozzle, so the flow area of at least a part of the bore is smaller than the nozzle hole area,

Fig. 2 shows an embodiment of the fuel valve according to the invention, where the nozzle comprises only one bore and the flow restriction is provided in said bore, so the flow area of at least a part of the bore is smaller than the nozzle hole area, and

Fig. 3 shows an embodiment of the fuel valve according to the invention, where the fuel valve is a slide valve, where the nozzle has only one bore and the valve needle is formed as a cut-off shaft, where the flow restriction is provided in an orifice of said cut-off shaft.

DETAILED DESCRIPTION

[0026] In the following detailed description, the fuel valve according to the invention will be described for use in a large two-stroke uniflow scavenged internal combustion engine with crossheads, but it is understood that the internal combustion engine could be of another type.

[0027] In Fig. 1 is shown an example embodiment of a fuel valve 1 according to the invention. The example embodiment and the embodiments shown in Fig. 2 and 3 are shown in different cross sections, and therefore are all the same structural elements not shown in all figures, however same reference numbers are used for corresponding elements in the three figures.

[0028] The fuel valve 1 shown in Fig. 1 comprises an elongated fuel valve housing 2 with a rear end 3 and a front end 4. At the front end of the housing 2 is a nozzle 5 mounted by means of a retaining element 6. The nozzle 5 comprises, as seen in Fig. 1, five bores 7, which all extend from a valve seat 8 and opening into a nozzle hole 9 for injecting fuel into a combustion chamber 10. The bore 7 has a diameter X defining its flow area and a nozzle hole area is defined by a diameter Y of the nozzle hole 9. The fuel valve 1 further comprises a fuel channel, not seen in Fig. 1, which fuel channel extend from the rear end 3 towards the front end 4 of the fuel valve 1. The fuel channel are connected to a source of pressurized fuel, not shown. Further, the fuel valve comprises a fuel return channel, not shown. In order to control the flow of fuel through the fuel valve 1, it comprises an axially displaceable valve needle 12, which has a closed position, in which the axially displaceable valve needle 12 is resting on the valve seat 8 preventing fuel from flowing to the nozzle 5, and an open position in which the axially displaceable needle 12 is lifted from the valve seat 8 thereby exposing a valve needle flow area 13 allowing fuel to flow through the fuel valve 1 to the nozzle holes 9. Thus, the fuel valve 1 has a flow path, that is defined by the fuel channel, the valve needle flow area 13 and the bores 7 in the nozzle 5.

[0029] The axially displaceable valve needle 12 is slidably received with a narrow clearance in a longitudinal bore in 14 in the elongated valve housing 2. The shown valve needle 12 is provided with a conical section that is shaped to match the valve seat 8. In the closed position the conical section of the valve needle 12 is resting on the valve seat 8. The conical section has lift from the valve seat 8 in the open position and the valve needle 12 is resiliently biased towards the closed position by a pre-tensioned helical spring 15. The pre-tensioned helical spring 15 acts on the valve needle 12 and biases the valve needle 12 towards its closed position where the conical section is resting on the valve seat 8. The helical spring 15 is a helical wire spring that is received in a spring chamber 16 in the elongated fuel valve housing 2.

[0030] The fuel valves 1 shown in Fig. 2 and 3 comprise basically the same elements as the fuel valve shown in Fig. 1, however with some differences as explained in the following. In Fig. 2 and 3 the nozzle 5 of the fuel valves comprises only one single bore 7, which supplies fuel to all the nozzle holes 9. In addition, the nozzle 5 is shown to be positioned relative to the housing 2 by means of a position pin 22, this applies also for the valve in Fig. 1. Also in these fuel valves, the nozzle 5 is mounted to the housing 2 by means of a retaining element 6, only shown in Fig. 1.

[0031] The fuel valve shown in Fig 3 is a slide valve, which is characterized by a special design of the valve needle 12. The valve needle 12 of a slide valve comprises an elongated member, which protrudes into the one single bore 7 and comprises a solid first part 23 and a hollow second part 24 farthest away from the valve seat 8, which hollow part comprises at least one orifice 26 and is open at its free end 25. During operation, when the valve needle is lifted to its open position away from the valve seat 8, the free end 25 of the elongated member is also lifted free of the nozzle holes 9, allowing the fuel to flow in the bore 7 between the elongated member and a wall of the bore 7 down to the orifice(s) 26 and into the hollow part 24 from where it continues to flow out of the open free end 25 and into the nozzle holes 9.

[0032] The elongated valve housing 2 and the other components of the fuel valve 1, as well as the nozzle 5 are in preferred embodiments made of steel, such as e.g. tool steel and stainless steel.

[0033] The nozzle 5 is, as mentioned, provided with nozzle holes 9, which are distributed radially and preferably also axially over the nozzle 5. The nozzle holes 9 are axially positioned near a tip 17 of the nozzle 5, which tip 17 in the shown embodiments is closed. The nozzle holes 9 are in the presented embodiments distributed over a relatively narrow range of the perimeter of the nozzle 5, such as between approximately 50° to 120° . The radial orientation of the nozzle holes 9 may in such an embodiment be directed away from a wall of the combustion chamber defined by a cylinder liner. Further, the nozzle holes 9 may be directed such that they are roughly in the same direction as a direction of a swirl of scavenge air in the combustion chamber caused by the configuration of scavenge ports (this swirl is a well-known feature of large two-stroke turbocharged internal combustion engines of the uniflow type).

[0034] According to the invention, the fuel valve comprises a flow restriction 20 provided in the flow path between the valve seat (8) and the nozzle hole(s) (9). Hereby, the fuel may be injected into the combustion chamber of a cylinder of an internal combustion engine at a lower injection velocity and thus facilitating a lower risk of extinction of the flame, while still maintaining a high fuel supply pressure in the fuel injection system. The fuel, such as ammonia may thus be injected with a well-controlled mass rate into the cylinder, which eliminates or at least lowers the risk of extinction of the flame.

[0035] In the embodiment shown in Fig. 1 the flow restriction 20 is provided in the flow path between the valve seat 8 and the nozzle holes 9. In practice, a reduction of the cross sectional area of at least a part of the bores 7 is provided, however in order to facilitate the manufacture of the nozzle 5, it is preferred, as shown, that the bores 7 over their whole length has the same diameter and that the flow restriction 20 in form of an insert is mounted in each bore 7, where the flow restriction 20 has a flow area that is smaller than the nozzle hole area.

[0036] In the embodiment shown in Fig. 2 the flow restriction 20 is also provided in the flow path between the valve seat 8 and the nozzle holes 9. In practice, a reduction of the cross sectional area of a part of the bore 7 is provided by mounting an insert in the bore 7, where the flow restriction 20 in form of the insert has a flow area that is smaller than the total area of the nozzle holes 9.

[0037] In the embodiment shown in Fig. 3 the flow restriction 20 is also provided in the flow path between the valve seat 8 and the nozzle holes 9. In this embodiment, the flow restriction 20 is provided in the orifice(s) 26, either by mounting an insert in the orifice(s) 26 or by making the orifice(s) 26 with a smaller diameter ensuring that total flow area of the orifice(s) 26 is smaller than the total area of the nozzle holes 9.

Claims

1. A fuel valve (1) for a large turbocharged two-stoke uniflow crosshead internal combustion engine, said fuel valve (1) comprising an elongated fuel valve housing (2) with a rear end (3) and a front end (4), a nozzle (5) with at least one bore (7) opening into at least one nozzle hole (9) having a nozzle hole area, said nozzle (5) being arranged at the front end (4) of said housing (2), a fuel channel (11) extending from the rear end (3) towards the front end (4) and being connected to a source of pressurized fuel, an axially displaceable valve needle (12) having a closed position, in which said axially displaceable valve needle (12) is resting on a valve seat (8) preventing fuel from flowing to the nozzle (5), and an open position in which said axially displaceable needle (12) is lifted from said valve seat (8) thereby exposing a valve needle flow area (13) between said needle (12) and said valve seat (8) allowing fuel to flow through the fuel valve (1) to the nozzle hole (9) via a flow path defined by at least the fuel channel (11), the valve needle flow area (13) and the at least one bore (9) in the nozzle (5), where said fuel valve (1) comprises a flow restriction (20) in said flow path of the fuel, **characterized in that** the flow restriction (20) is provided in the flow path between the valve seat (8) and the nozzle hole(s) (9).

2. The fuel valve (1) according to claim 1, **characterized in that** the flow area of the flow restriction (20) is smaller than the nozzle hole area.

3. The fuel valve (1) according to claim 1 or 2, **characterized in that** the flow area of the flow restriction (20) is less than 3/4, preferably less than 1/2 and most preferably less than 1/3 of the nozzle hole area.

4. The fuel valve (1) according to claim 1, 2 or 3, **characterized in that** the nozzle (5) comprises more than one bore (7) opening into at least one nozzle hole (9).

5. The fuel valve (1) according to claim 1, 2 or 3, **characterized in that** the nozzle (5) comprises only one bore (7) opening into at least one nozzle hole (9).

6. The fuel valve (1) according to claim 5, **characterized in that** it is a slide valve comprising a valve needle (12) with an elongated member, which protrudes into the one single bore 7.

7. The fuel valve (1) according to claim 6, **characterized in that** the elongated member comprises a solid first part (23) and a hollow second part (24) farthest away from the valve seat (8), which hollow part comprises at least one orifice (26) and is open at its free end (25).

8. The fuel valve (1) according to any one of the preceding claims, **characterized in that** the flow restriction (20) is provided in the flow path between the valve seat (8) and the nozzle hole(s) (9) as an insert mounted in the at least one bore (7) or in the at least one orifice (26) of the hollow second part (24) of the valve needle (12) with an elongated member.

9. The fuel valve (1) according to any one of claims 4 to 8, **characterized in that** the nozzle holes (9) in the nozzle (5) are distributed radially and preferably also axially over the nozzle (5), where the nozzle holes (9) axially are positioned near a tip (17) of the nozzle (5), which tip (17) preferably is closed.

10. A large turbocharged two-stoke uniflow crosshead internal combustion engine comprising a fuel valve (1) as defined in any one of the proceeding claims.

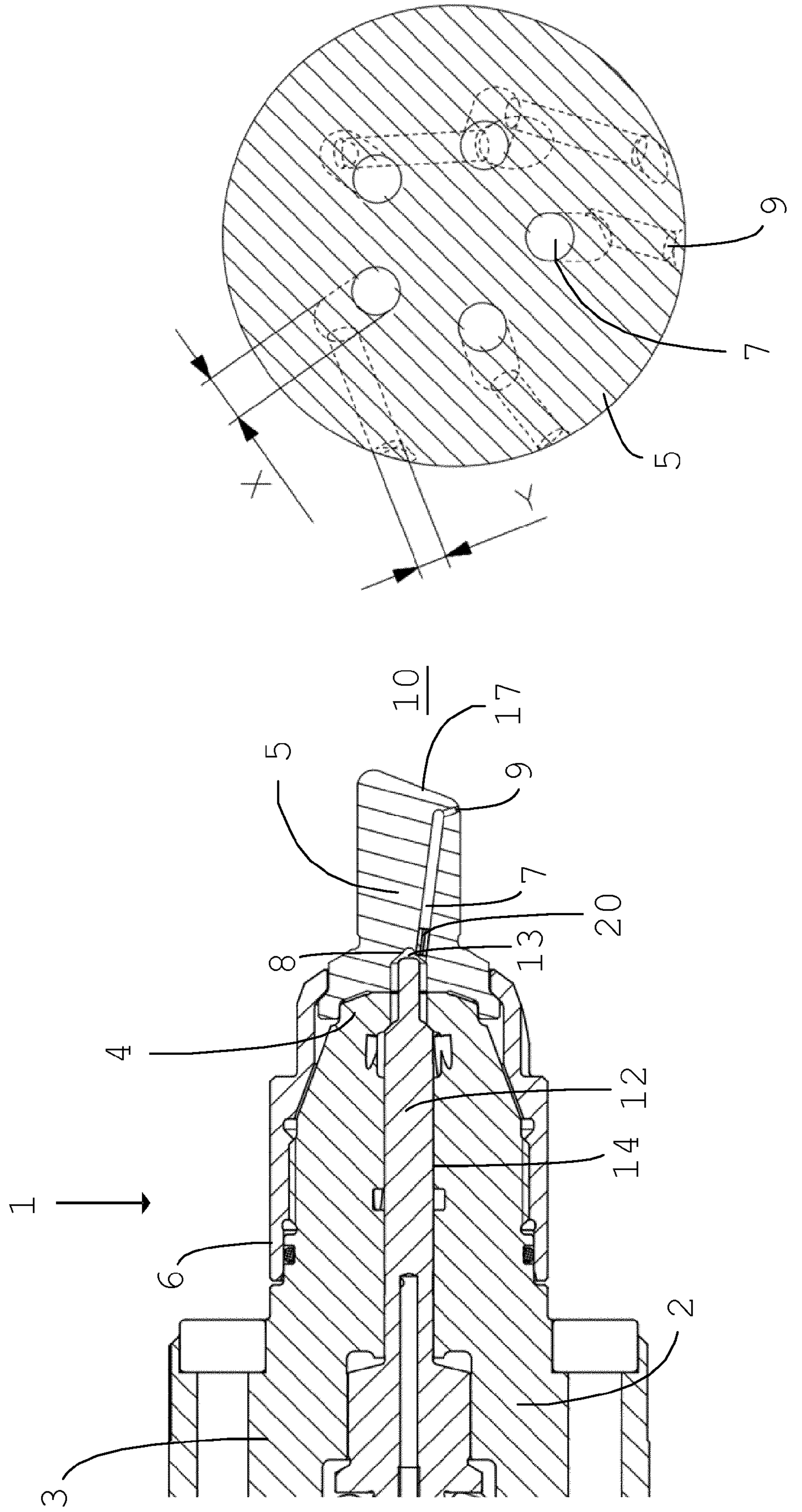

FIG. 1

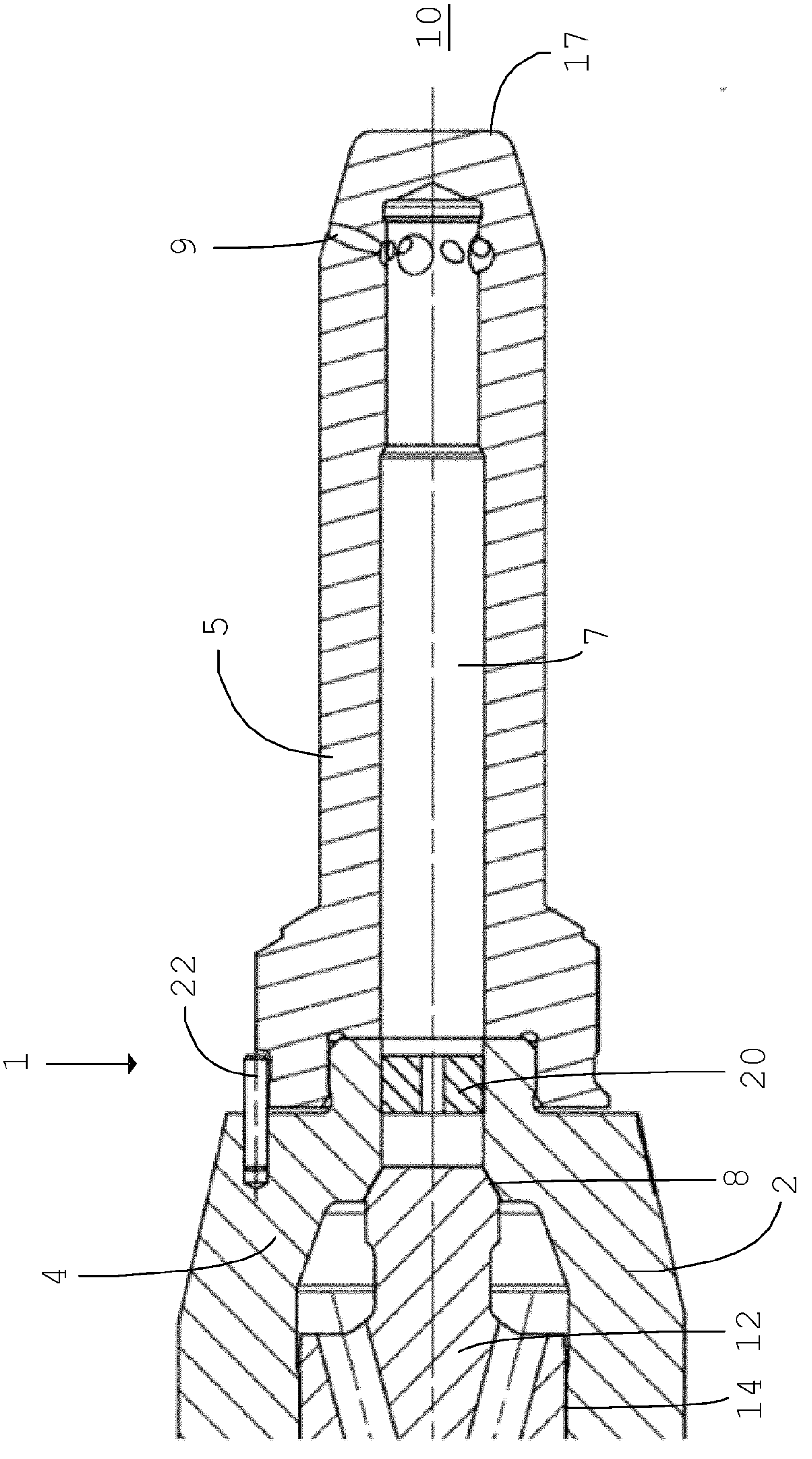

FIG. 2

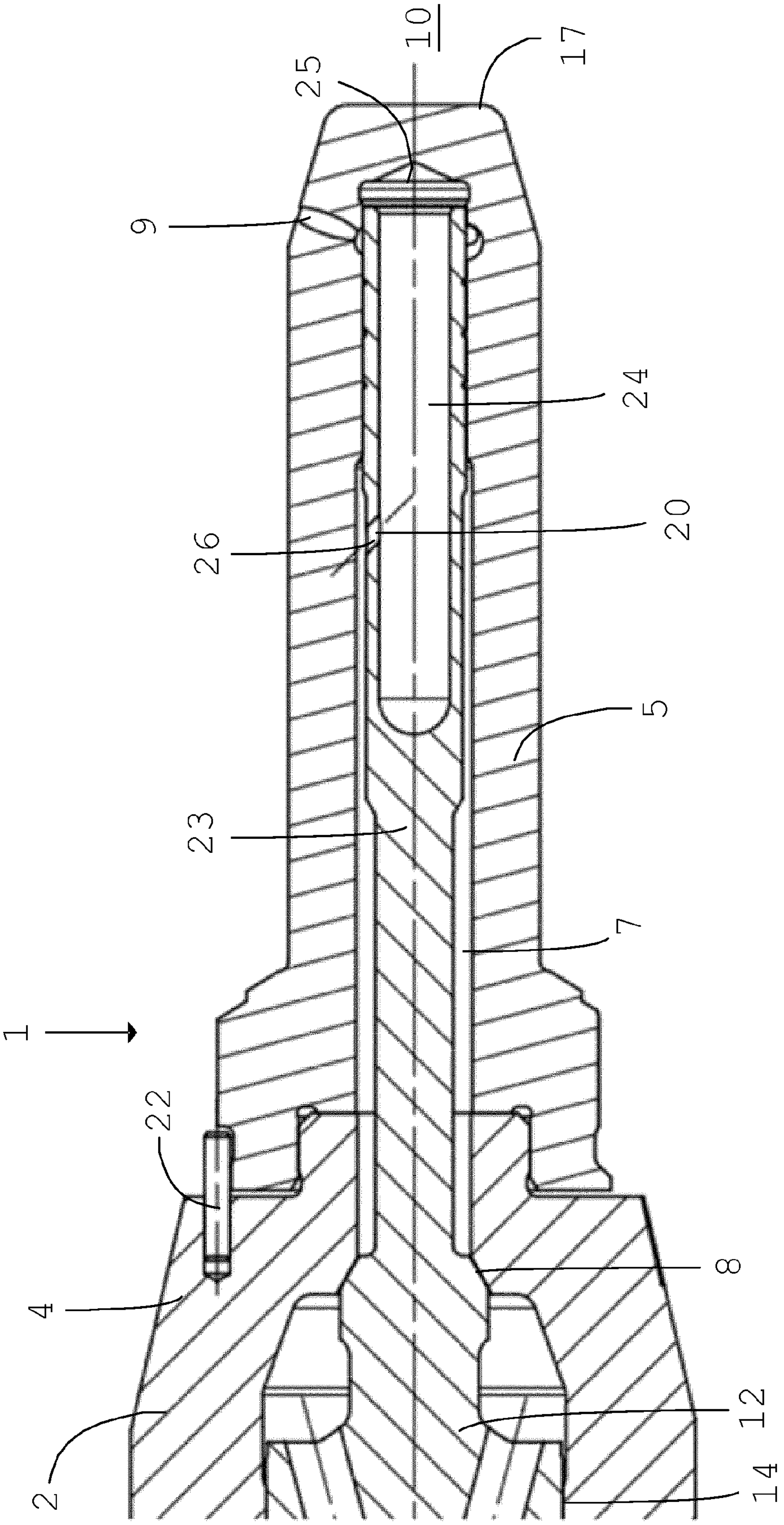

FIG. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 23 15 5526

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	US 2015/247478 A1 (SERIZAWA KAZUFUMI [JP] ET AL) 3 September 2015 (2015-09-03) * paragraph [0018] - paragraph [0031]; figures 1-4 * * abstract * -----	1-5,9,10 6-8	INV. F02M51/06 F02M21/02 F02M61/18 F02B75/02
A	EP 3 399 177 B1 (DELPHI TECH IP LTD [BB]) 8 January 2020 (2020-01-08) * paragraph [0025] - paragraph [0035]; figures 1,2 * * abstract * -----	1-10	
A	EP 3 336 342 A1 (MAN DIESEL & TURBO FILIAL AF MAN DIESEL & TURBO SE TYSKLAND [DK]) 20 June 2018 (2018-06-20) * paragraph [0001] - paragraph [0051]; figures 1-10 * * abstract * -----	1-10	
			TECHNICAL FIELDS SEARCHED (IPC)
			F02M F02B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	9 June 2023	Hermens, Sjoerd

CATEGORY OF CITED DOCUMENTS

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09-06-2023

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2015247478 A1	03-09-2015	CN 104879256 A	02-09-2015
		DE 102015101850 A1	03-09-2015
		JP 6080087 B2	15-02-2017
		JP 2015161271 A	07-09-2015
		US 2015247478 A1	03-09-2015
EP 3399177 B1	08-01-2020	EP 3219974 A1	20-09-2017
		EP 3399177 A1	07-11-2018
		GB 2548375 A	20-09-2017
EP 3336342 A1	20-06-2018	CN 108224476 A	29-06-2018
		DK 201670986 A1	03-04-2018
		EP 3336342 A1	20-06-2018
		JP 6493999 B2	03-04-2019
		JP 2018096378 A	21-06-2018
		KR 20180068284 A	21-06-2018
		RU 2677436 C1	16-01-2019

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2015091180 A1 **[0012]**
- JP 2017507269 A **[0012]**
- US 20090032622 A **[0012]**