(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
4 December 2008 (04.12.2008)

PCT

(10) International Publication Number
WO 2008/145818 A2

(51) International Patent Classification:
F02M 55/02 (2006.01)

(21) International Application Number:
PCT/FI2008/050307

(22) International Filing Date: 27 May 2008 (27.05.2008)

(25) Filing Language: Finnish

(26) Publication Language: English

(30) Priority Data:
20075394 31 May 2007 (31.05.2007) FI

(71) Applicant *(for all designated States except US)*: **WÄRTSILÄ FINLAND OY** [FI/FI]; Tarhaajantie 2, FI-65380 Vaasa (FI).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **EKLUND, Kjell** [FI/FI]; Pihlajatie 28, FI-65370 Vaasa (FI).

(74) Agent: **AWEK INDUSTRIAL PATENTS LTD OY**; P.O.Box 230, Lautatarhankatu 6, FI-00101 Helsinki (FI).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report*

(54) **Title:** FUEL STORAGE IN A FUEL FEED SYSTEM

(57) **Abstract:** A fuel storage (12) in a fuel feed system of a piston engine comprising a body (20) defining a fuel space (21) for pressurised fuel, and at least one channel (22) that opens into the fuel space (21). At the orifice (25) of the channel (22) there is a trough-shaped recess (24, 24'), which extends only over a portion of the length of the fuel space (21).

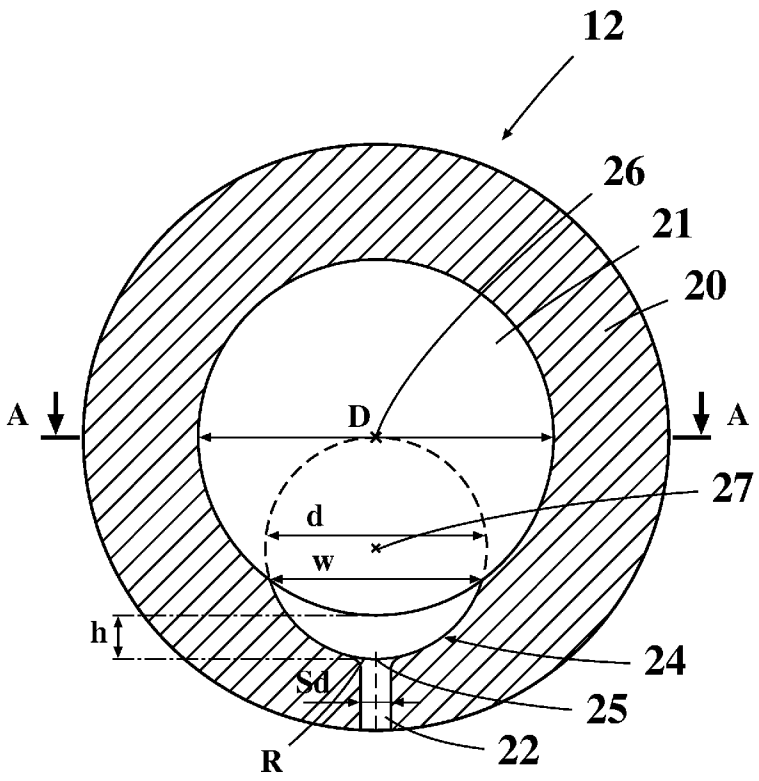

Fig.2

WO 2008/145818 A2

FUEL STORAGE IN A FUEL FEED SYSTEM

The present invention relates to a fuel storage for a fuel feed system of a piston engine.

In common rail fuel injection systems of diesel engines the fuel is fed by means of low-pressure and high-pressure pumps into a high-pressure fuel storage, such as a high-pressure accumulator or a so-called common rail. From the high-pressure fuel storage the fuel is fed further along separate pipes to the injection nozzle of each cylinder. From the injection nozzles the fuel is led to the respective combustion chambers of the cylinders at a desired moment according to the operation of the engine. There may be several high-pressure fuel starages, whereby fuel is fed from each fuel storage to two or more injection nozzles.

The fuel pressure in a high-pressure fuel storage is high, even 2000 bar, whereby the fuel accumulator is exposed to strong stresses resulting in cracks that may develop in its construction material, especially in the area of the openings in the fuel storage wall and sharp-edged cross-sectional changes thereof.

The document EP 1413744 discloses a fuel storage for a piston engine, where the fuel space consists of two elongated cylindrical bores, which are arranged so as to partially overlap in cross-section.

The object of the invention is to increase the pressure strength of the fuel storage of a fuel feed system.

The object according to the invention is achieved as disclosed in the appended claim 1. The fuel storage of a fuel feed system according to the invention comprises a channel which opens into the fuel space of the fuel storage. At the orifice of the channel in the fuel space there is a trough-shaped recess extending only over a portion of the length of the fuel space.

Considerable advantages are achieved by the present invention.

The recess at the orifice that opens into the fuel space reduces substantially the stresses exerted on the fuel storage in the area of the orifice. This, in turn, reduces the risk of crack formation in the construction material of the fuel space body thus increasing the durability of the component. Furthermore, it is easy to make a recess also in conjunction with existing fuel storages.

In the following, the invention is explained more in detail, by way of example, with reference to the appended drawings.

Figure 1 shows schematically a fuel feed system of a diesel engine;

Figure 2 is a cross-sectional view of one fuel accumulator according to the invention;

Figure 3 shows the fuel accumulator of Fig. 2 sectioned along the line A-A;

Figure 4 shows another fuel accumulator according to the invention;

Figure 5 shows the fuel accumulator of Fig. 4 sectioned along the line B-B.

Fig. 1 shows a fuel feed system 28 of a diesel engine comprising several cylinders, especially a large diesel engine. Large diesel engine refers here to such engines that can be used, e.g., as main or auxiliary engines in ships or in power plants for the production of electricity and/or heat. Fuel is fed from a fuel tank 1 by a low-pressure pump 2 along a low-pressure piping 3 to high-pressure pumps 4. The pressure in the low-pressure piping 3 is typically about 7 bar. The low-pressure piping 3 is provided with a relief valve 5, by which the low-pressure piping 3 can be reconnected to the fuel tank 1. A desired constant pressure is maintained in the low-pressure piping 3 by means of the relief valve 5. Instead of the relief valve 5, a simple throttle member may be used to maintain the constant pressure in the low-pressure piping 3.

From the low-pressure piping 3 fuel is pumped by the high-pressure pumps 4 along a high-pressure line 11 to pressure accumulators 12 which act as fuel storages. The high-pressure pumps 4 are provided with control valves 6 and piston members 7. The piston members 7 receive their guidance 10 from cam members 8 of a camshaft 9 of the engine. When necessary, each cam member 8 may include several cams, and thereby, when a high-pressure pump 4 provides a certain volume flow rate per time unit into a pressure accumulator unit, the outer dimensions of the pump may respectively be kept smaller and accordingly, the pressure shocks provided by it to the pressure accumulator are smaller.

In the embodiment according to Fig. 1 each high-pressure pump 4 is connected by means of a high-pressure line 11 to a high-pressure fuel storage of its own, such a pressure accumulator 12. The pressure accumulator 12 is, in turn, connected by separate pipes 14 to injection

nozzles 15 of the cylinders. Each pressure accumulator 12 is connected to two or more injection nozzles 15. The arrangement may also be realised so that there are fewer high-pressure pumps 4 than pressure accumulators 12, whereby each high-pressure pump 4 supplies fuel to several pressure accumulators. Then, the fuel feed system has for instance two or more pressure accumulators 12 per one high-pressure pump 4 or three or more pressure accumulators 12 per two high-pressure pumps 4. The high-pressure fuel storage may be a so-called common rail, to which fuel is fed by one or more high-pressure pumps and from which fuel is fed along separate pipes to two or more injection nozzles 15.

The pressure accumulators 12 are connected to one another by means of a pipe 13 in order to equalise the pressure differences between the accumulators. The fuel pressure in the pressure accumulator 12 is over 800 bar, typically 1000 - 2000 bar. The operation of high-pressure pumps 4 and the injection pressures to be used can be controlled in accordance with the engine load, operating speed or other parameters in a manner known as such.

Only one or several pressure accumulators 12 in the system is/are provided with an auxiliary valve 16, the operation of which is controlled by a pre-control valve 17 attached to the servo oil circuit of the engine. A servo oil pump 18 maintains a pressure of about 100 bar in the servo oil circuit. The servo oil circuit is utilised in a manner know per se also in the injection valves 15 to control the fuel injection together with a conventional solenoid valve (not shown). By means of the valve 16 the pressure accumulators 12 of the system may be connected through a line 19 to the fuel tank 1. Thus, when necessary, the pressure accumulators 12 may be de-pressurised by

means of the valve 16. In addition, the valve 16 makes it possible to circulate fuel, especially heavy fuel oil, in the system for instance for the purpose of heating it before starting the engine. When desired, by opening and closing the control valves 6 it may also be ensured by means of the valve 16 that the flow passes through every pressure accumulator 12. Further, the valve 16 may with advantage act as a pressure relief valve since, in any case, the high-pressure circuit of the system also requires a pressure relief valve.

The fuel feed system shown in Fig. 1 is described in more detail in the document EP 959245.

In the fuel feed system according to Fig. 1, the high-pressure fuel storage 12 according to Figs. 2 and 3 or 4 and 5 may be used as pressure accumulators. In both embodiments, the fuel storage 12 comprises a body 20 with an elongated fuel space 21 for pressurised fuel. The fuel space 21 is cylindrical. As shown in Figs. 2 and 4, the cross-section of the fuel space 21 is circular. Typically, the diameter D, D' of the fuel space 21 is 20 - 100 mm. In addition, the body 20 comprises a feed channel 22, which opens into the fuel space 21, through which channel pressurised fuel is led into the fuel space 21 from the high-pressure pump 4 along the high-pressure line 11. The edge of the orifice of the feed channel 22 facing the fuel space 21 is rounded. The cross-section of the feed channel 22 has a circular shape. The orifice 25 of the feed channel 22 in the body 20 is located in the middle of the fuel space 21 in its longitudinal direction, i.e. in the direction of the middle axis 26. In addition, the body 20 comprises discharge channels 23, which open into the fuel space 21, through which channels fuel is discharged from the fuel space 21 and led along the pipes 14 to the

injection nozzles 15. There is one discharge channel 23 per each injection nozzle, which is in flow connection with the high-pressure fuel storage 12. The orifices of the discharge channels 23 are located in the proximity of the end of the fuel space 21.

Due to the high fuel pressure prevailing in the fuel storage 12, cracks and wear-out failures may develop in the material of the body 20, especially in the area of the orifice 25 of the feed channel 22. In order to prevent damages the inner surface of the fuel space 21 in the body 20 is provided with a trough-shaped recess 24 or two trough-shaped recesses 24', which are located at the orifice 25 of the feed channel 22. The recess 24, 24' extends only over a portion of the length of the fuel space 21. The recess 24, 24' is elongated. Typically, the length of the recess 24, 24' is less than a half of the length of the fuel space 21. The recesses 24, 24' are cylindrical. The longitudinal axis 27 of the recess 24, 24' is parallel with the longitudinal axis 26 of the fuel space 21. A recess 24, 24' may be made on the inner wall of the fuel storage for instance by milling. After the machining of the recess, the edge of the orifice of the feed channel 22 facing the fuel space 21 is rounded for instance by means of abrasion liquid. The radius of curvature R is selected according to the dimensions of the fuel storage. The radius of curvature R is at least 0.5 mm.

In the embodiment according to Figs. 2 and 3 the cross-section of the recess 24 is curved, preferably having a shape of a circular arc. The shape of the cross-section is constant or essentially constant over the entire length of the recess 24. The recess 24 is made e.g. by milling. The midpoint of the orifice 25 of the feed channel 22 is both in the cross direction and in the longitudinal direction of the fuel space 21, i.e. in the direction of the

middle axis 26, located in the middle of the recess 24. An extension of the recess 24 with a shape of a circular arc is marked by a dashed line in Fig. 2. The diameter d of the recess 24 is selected so that the extension of the recess 24 passes via the middle axis 26 of the fuel space 21. The diameter of the recess 24 is d and the depth of the midpoint of the recess 24 is h, whereby the ratio h/d is between 0.05 and 0.2. The ratio of the breadth w of the recess 24 to the diameter Sd of the feed channel 22 is typically 2 - 5. The ratio of the length L of the recess 24 to the diameter Sd of the feed channel 22 is 2 - 5.

In the embodiment according to Figs. 4 and 5 the body 20 is, at the orifice 25 of the feed channel 22, provided with two trough-shaped recesses 24', which are arranged so that their cross-sections partially overlap. The recesses 24' are identical. The recesses 24' intersect one another in the middle of the orifice 25 in the cross direction of the fuel space 21. The recesses 24' are parallel. The cross-sections of the recesses 24' are curved, preferably having a shape of a circular arc. The cross-section of the recesses 24' is constant or essentially constant over their entire length. The midpoint of the orifice 25 of the feed channel 22 is located in the midpoint of the recesses 24' in the longitudinal direction of the fuel space 21. The recesses 24' are arranged symmetrically with respect to the midpoint of the orifice 25 of the feed channel 22. The diameter of the recess 24' with a shape of a circular arc is d' and the depth of the recess 24' is h', whereby the ratio h'/d' is between 0.05 and 0.2.

Extensions of two recesses 24' having a shape of a circular arc are marked by dashed lines in Fig. 4. The diameters d' of the recesses 24' are selected so that the extensions pass via the middle axis 26 of the fuel space 21'. The

breadth w' of the recess 24' is almost equal to the diameter D' of the fuel space. The breadth w' of the recess 24' may be for instance 80 - 95 % of the diameter D' of the fuel space. The ratio of the length L' of the recess 24' to the diameter Sd of the feed channel 22 is 2 - 5.

In both above-described embodiments the depth h, h' of the recess 24, 24' is 3 - 10 % of the diameter D, D' of the fuel space 21. Recesses 24, 24' may be arranged in a similar way also in the area of another orifice that opens into the fuel space 21, 21', for instance in the area of the discharge channel 23. There may be more than one feed channel that open into the fuel space 21, whereby a recess 24 or recesses 24' are preferably arranged at the orifice of each feed channel.

CLAIMS

1. A fuel storage (12) for a fuel feed system of a piston engine comprising a body (20) defining a fuel space (21) for pressurised fuel, and at least one channel (22) that opens into the fuel space (21), **characterised** in that at the orifice (25) of the channel (22) there is a trough-shaped recess (24, 24'), which extends only over a portion of the length of the fuel space (21).

2. A fuel storage (12) according to claim 1, **characterised** in that at the orifice (25) of the channel (22) there are two trough-shaped recesses (24'), the cross-sections of which partially overlap.

3. A fuel storage (12) according to claim 2, **characterised** in that the intersection point of the recesses (24') is located in the midpoint of the orifice (25) of the channel (22).

4. A fuel storage (12) according to claim 1, 2 or 3, **characterised** in that the cross-section of the recess (24, 24') has a shape of a circular arc.

5. A fuel storage (12) according anyone of the preceding claims, **characterised** in that the longitudinal axis (27) of the recess (24, 24') is parallel with the longitudinal axis (26) of the fuel space (21).

6. A fuel storage (12) according anyone of the preceding claims 1, 4 or 5, **characterised** in that the midpoint of the orifice (25) of the channel (22) is located in the middle of the recess (24).

7. A fuel storage (12) according anyone of the preceding claims, **characterised** in that the depth (h, h') of the recess (24, 24') is 3 - 10 % of the inner diameter (D) of the fuel space (21).

8. A fuel storage (12) according anyone of the preceding claims, **characterised** in that the length (L, L') of the recess (24, 24') is 2 - 5 times larger than the diameter of the channel (22).

9. A fuel storage (12) according anyone of the preceding claims, **characterised** in that the channel is a feed channel (22), through which fuel is led into the fuel space (21).

10. A fuel feed system (28) for a piston engine, **characterised** by a fuel storage (12) according to anyone of the preceding claims.

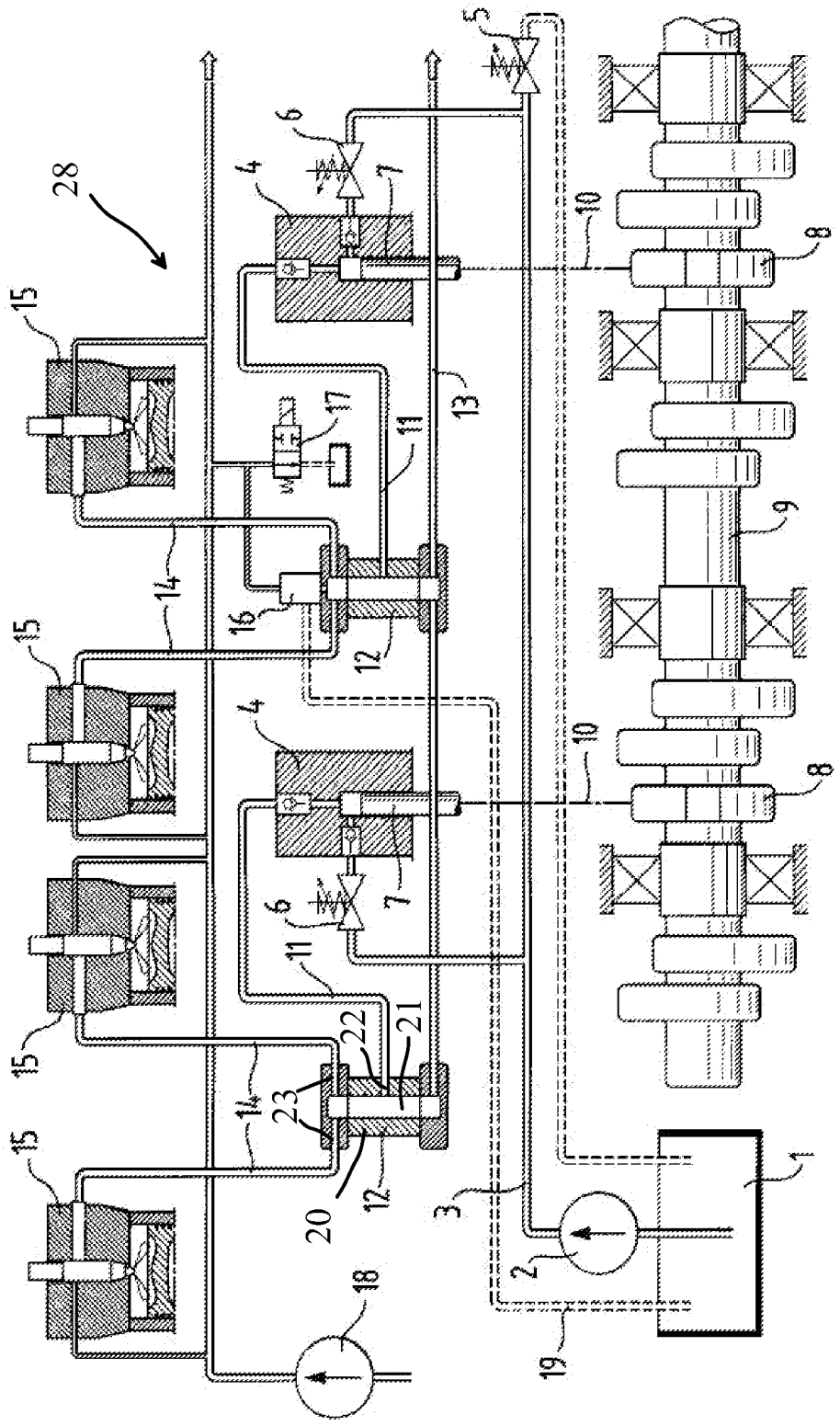

Fig. 1

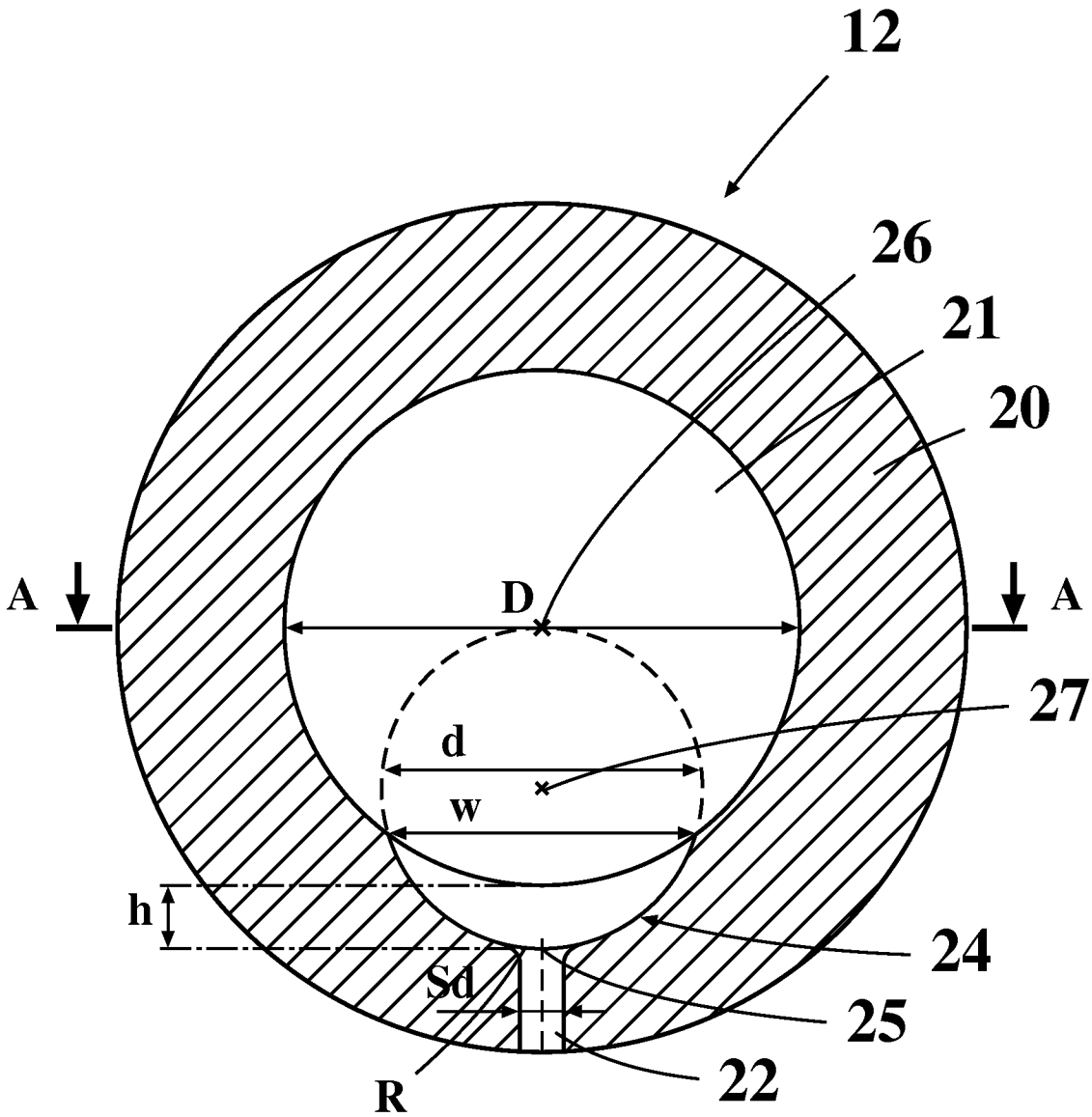

Fig.2

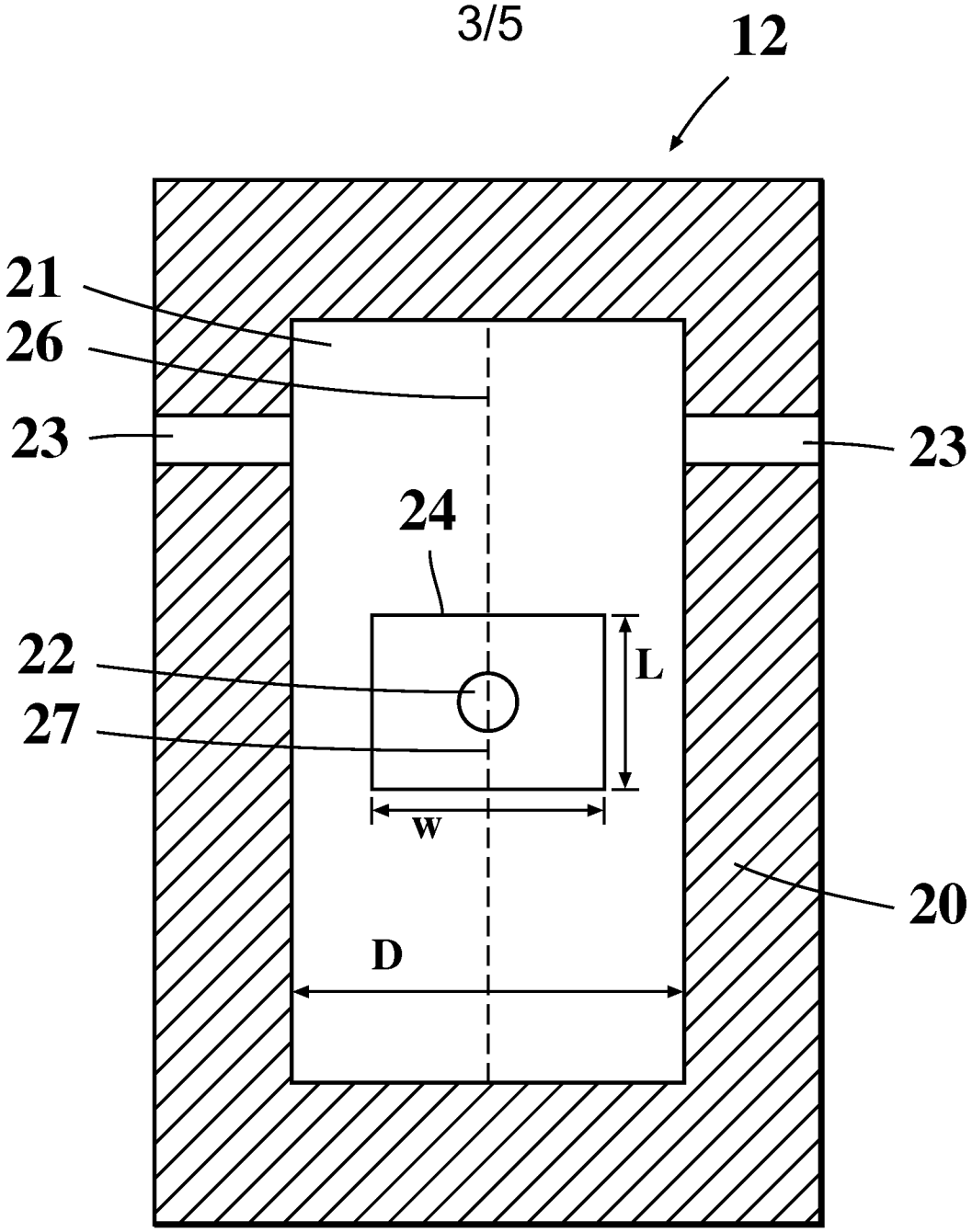

Fig.3

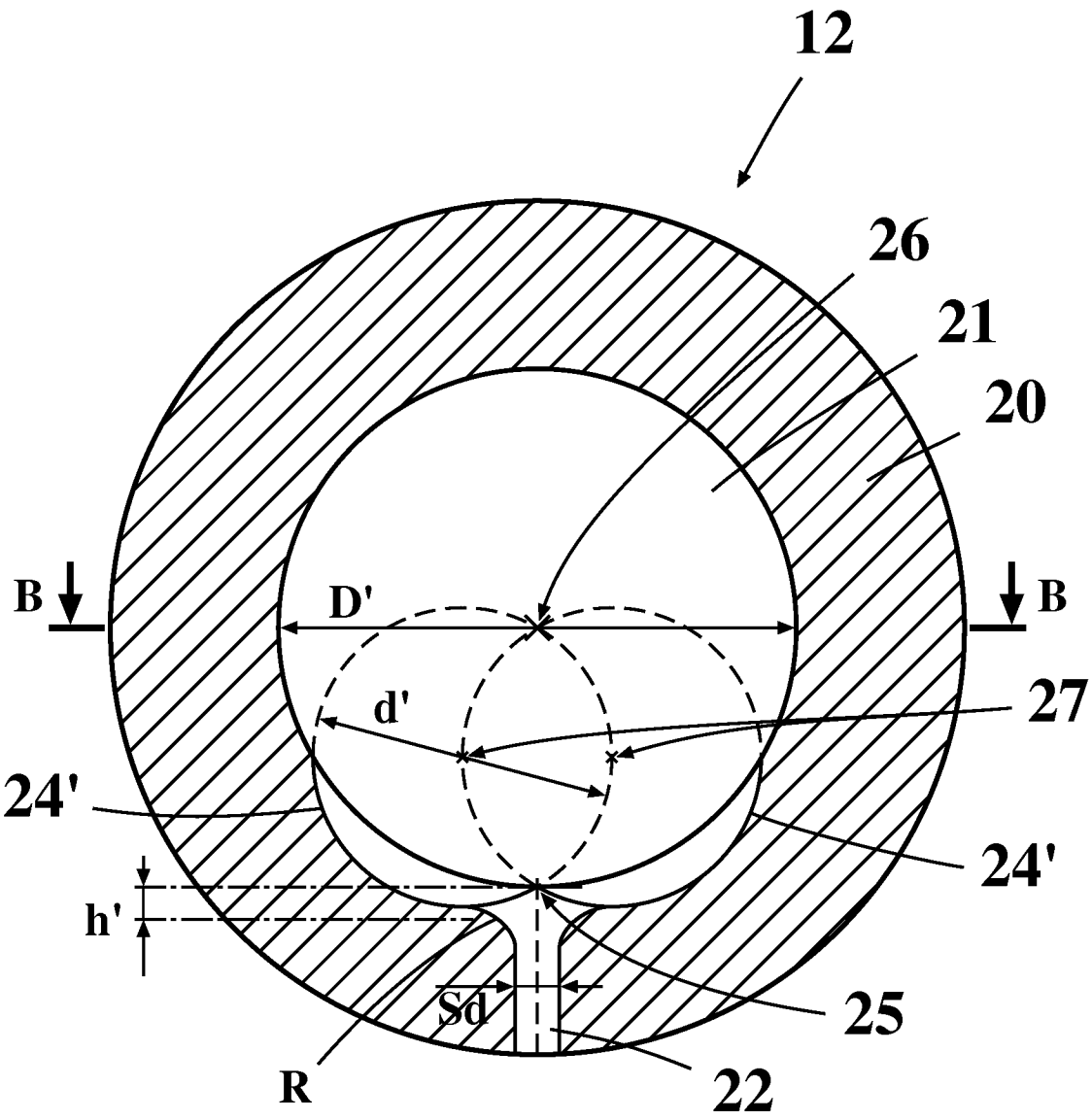

Fig.4

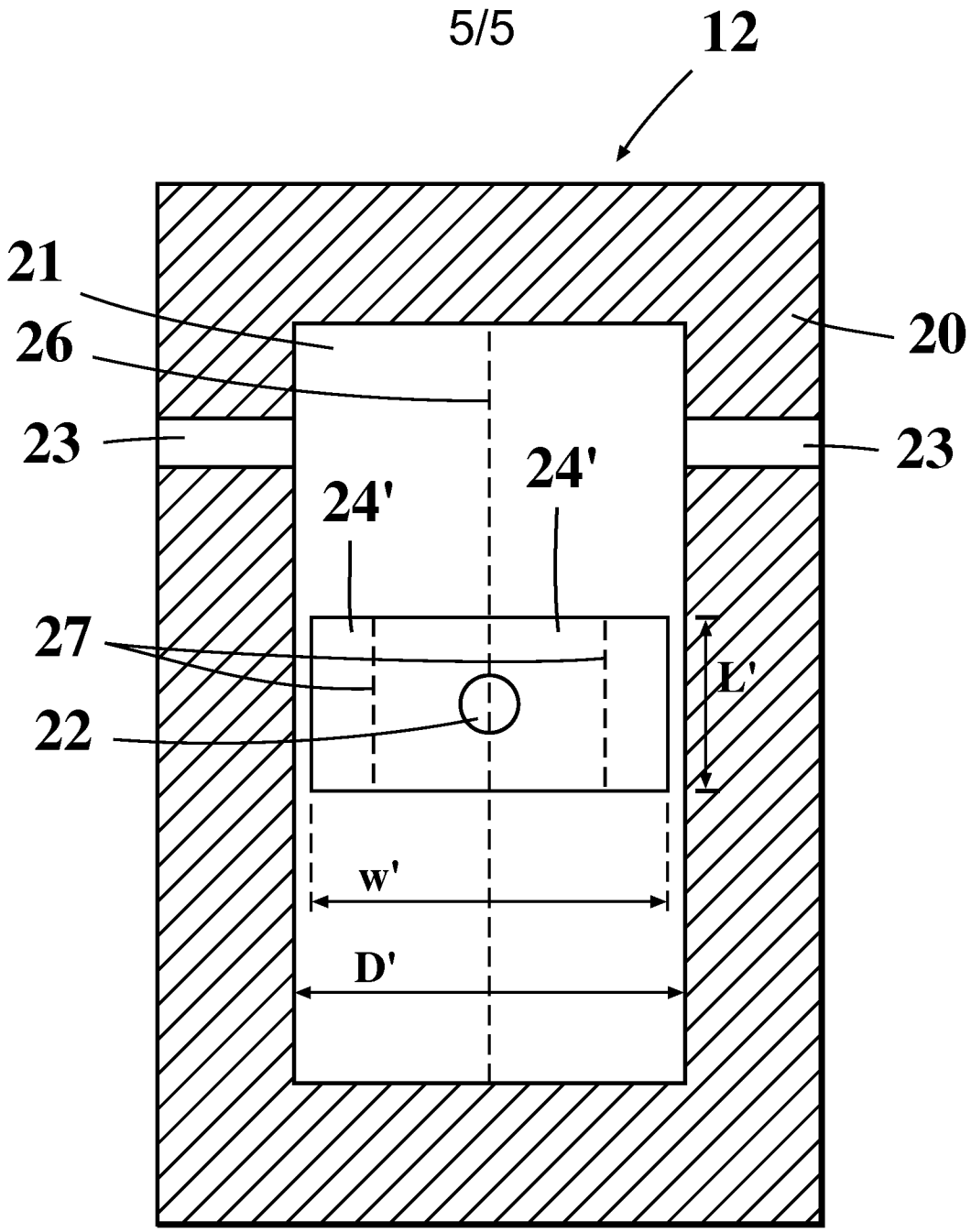

Fig.5