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(72) Inventor: **Hirota, Hisatoshi**
Hachioji-shi
Tokyo 193-0942 (JP)

(74) Representative: **Grünecker, Kinkeldey, Stockmair & Schwanhäusser**
Anwaltssozietät
Maximilianstrasse 58
80538 München (DE)

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(71) Applicant: **TGK COMPANY, LTD.**
Tokyo 193-0942 (JP)

(54) **Expansion valve**

(57) A body 4 of an expansion valve accommodating a valve section 2 is formed, using forming dies, such as die-casting dies, integrally with an inlet port 5, an outlet port 6, and an external thread 16, to connect a power element 3. The forming process forms the external thread

16, the inlet port 5, the outlet port 6, a valve hole 7, a hole 8 for receiving a valve element 9 and set value-adjusting members (10, 11), and a hole 12 for receiving a shaft 13 extending between the power element 3 and the valve element.

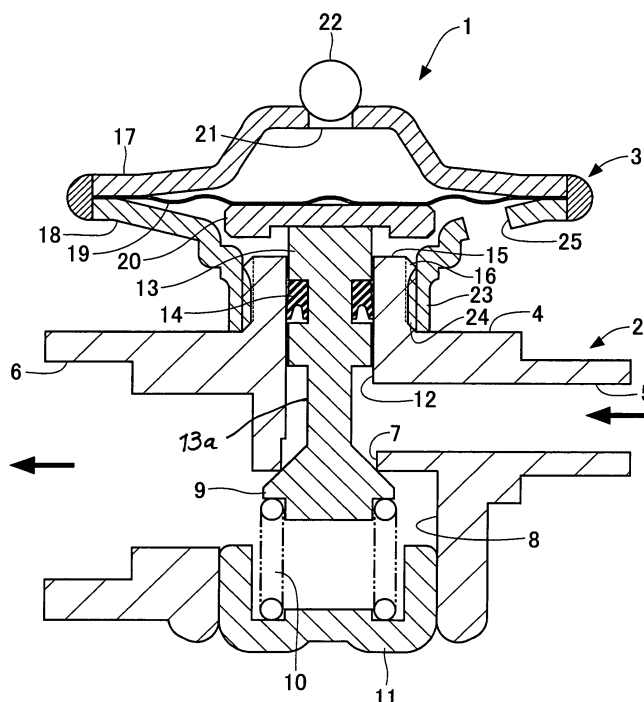


FIG. 1

Description

[0001] The invention relates to a mounting structure according to the preamble of claim 1, more particularly for mounting an expansion valve in a refrigeration cycle of an automotive air conditioner.

[0002] In general, a refrigeration cycle of an automotive air conditioner comprises a compressor that compresses refrigerant, a condenser that condenses the compressed refrigerant, a receiver that temporarily stores refrigerant and separates the condensed refrigerant into a gas and a liquid, an expansion valve that throttles and expands the liquid refrigerant obtained by gas/liquid separation, and an evaporator that evaporates the refrigerant expanded by the expansion valve. The expansion valve is implemented e.g. by a thermostatic expansion valve.

[0003] A known thermostatic expansion valve (JP-A-2002-2002-115938) configured to sense the temperature and pressure of refrigerant at the outlet of an evaporator and to control the refrigerant flow rate to the evaporator includes a body with a first passage between a receiver and the evaporator, and a second return passage between the evaporator and a compressor. A valve section in the first passage controls the flow rate. A power element in the body at a location on the second passage side senses the temperature and pressure in the second passage, and controls the valve lift. The body is made by cutting an extrusion-moulded blank of an aluminium alloy into a prism-like block to prepare a half-finished solid part. The first and second passages, and a power element connection portion are formed, by cutting. The cutting process takes much time, degrades the yield from the material, and increases the manufacturing costs.

[0004] JP-A-10-267470 proposes a blow extrusion moulded body. When the second passage is simple and straight, the second passage simultaneously is formed by extrusion moulding. This omits a hole-forming process by cutting the second passage, saves material of the aluminium alloy, and is an improvement of the manufacturing efficiency of the body to some extent. However it is required to extrude the aluminium alloy in a fixed extruding direction and hence it can be applied only to a straight shape without a varying cross-section. This technique cannot be applied to the formation of a first passage in the intermediate portion of which the valve section is integrally formed. At ends of the first and second passages, sealing surfaces for sealing members are to be formed for pipes leading to the compressor, the receiver, and the evaporator. The sealing surfaces are formed as increased-diameter portions and cannot be formed by extrusion moulding. There is no other way than to perform cutting when forming these portions. For these reasons the saving of material and the improvement of the manufacturing efficiency as achieved are not sufficient. When cutting is performed on an end of the blow extension moulded second passage it is not easy to align the axis of the passage formed by the extrusion moulding and the

rotational axis during the cutting process. Therefore, when a sealing portion is formed by a tool, such as a drill, the axis of the tool can become offset from the axis of the passage, so that off-centred load can be applied to the tool and the body during the cutting process, which can cause a trouble in cutting. A juncture between the body and the power element has a screwing structure, which needs to thread a portion of the body. This also degrades the manufacturing efficiency and increases manufacturing costs.

[0005] It is an object of the present invention is to improve the manufacturing efficiency of a body of and to reduce the manufacturing cost of an expansion valve.

[0006] This object is achieved by the features of claim 1.

[0007] The expansion valve passes introduced refrigerant through a valve section in the body to throttle and expand the refrigerant. The body accommodating the valve section is formed integrally with a thread part for connecting a power element by using forming dies. In the thus formed body an inlet port, an outlet port, a hole for receiving therein a valve element and a set value-adjusting member, a valve hole, a hole for receiving therein a member that transmits an actuating force dependent on temperature sensed by the power element to the valve element, and the thread part for having the power element connected thereto are formed integrally with the body. This is advantageous in that it is no longer necessary to subject the body to further fabrication steps, and hence it is possible to improve the manufacturing efficiency of the body, provide a higher yield from material, and reduce the manufacturing cost of the expansion valve.

[0008] Further, in the power element as well, by forming a housing that is connected to the thread part formed on the body, in a one-turn thread configuration such that an inner peripheral edge of a central opening thereof is continuously displaced in an axial direction over an angle range of smaller than 360 degrees, the housing can be simply formed by pressing. This makes it unnecessary to carry out thread cutting steps, and hence it is possible to further reduce the manufacturing cost of the expansion valve.

Brief description of the drawings:

[0009]

- Fig. 1 is a cross-section of an expansion valve (first embodiment),
- Fig. 2 is a schematic explanatory view illustrating an essential part of the method of making a body of the expansion valve,
- Fig. 3A is a plan view of the body,
- Fig. 3B is a front view of the body,
- Fig. 4 is a cross-section of an example of mounting the expansion valve,
- Fig. 5 is a section on line A-A of Fig. 4.

- Fig. 6 is a cross-section of a mounted state of a second embodiment,
 Fig. 7 is a section on line B-B of Fig. 6.
 Fig. 8 is a cross-section of a mounted state of a third embodiment,
 Fig. 9 is a view of the third embodiment from an inlet port side.
 Fig. 10 is a cross-section of a mounted state of a fourth embodiment,
 Fig. 11 is a section on line C-C of Fig. 10.

[0010] An expansion valve 1 in Fig. 1 (first embodiment) comprises a valve section 2 and a power element 3. The valve section 2 includes a body 4. The body 4 has sides integrally formed with a high-pressure, high-temperature refrigerant inlet port 5 connected to a receiver of the refrigeration cycle, and a low-temperature, low-pressure refrigerant outlet port 6 connected to an evaporator. In a central body portion there is formed a valve hole 7 between the inlet and outlet ports 5, 6. The valve hole 7 extends in a direction orthogonal to the axes of the inlet and outlet ports 5, 6. The body 4 has a hole 8, larger in diameter than the valve hole 7 that extends downward from the valve hole 7 through the body 4 in the direction of the axis of the valve hole 7. The hole 8 contains a valve element 9, triangular in cross-section. The valve element 9 is urged by a spring 10 in valve closing direction. The spring 10 is received by a spring-receiving member 11 press-fitted in the opening of the hole 8. The load of the spring 10 is adjusted by the press-fitting depth of the spring-receiving member 11 in the opening of the hole 8, to adjust a set value of the expansion valve 1. The body 4 is also formed with a hole 12, slightly smaller in diameter than the valve hole 7. The hole 12 extends upward from the valve hole 7 through the body 4 in the direction of the axis of the valve hole 7. The hole 12 contains a shaft 13 integrally formed with the valve element 9. The shaft 13 has a reduced-diameter portion 13a facing a the inlet port 5, defining a refrigerant passage from the inlet port 5 into the valve hole 7. A circumferential groove in the periphery of a of the shaft 13 within the valve hole 12 contains a V-packing 14 for preventing that high-pressure refrigerant leaks via a clearance between the shaft 13 and the body 4 from the inlet port 5 to the power element 3. A protruding hollow cylindrical guide 15 is formed on a central part of an upper portion of the body 4 for guiding the shaft 13. An external thread 16 is formed on the outer periphery of the guide 15.

[0011] The power element 3 comprises an upper housing 17, a lower housing 18 (thick metal discs), a diaphragm 19 made of a flexible metal sheet partitioning a space enclosed by the housings 17 and 18, and a disc 20 on the side of the diaphragm 19 facing the valve section 2. The power element 3 is formed by welding the peripheral edges of the upper housing 17, the lower housing 18, and the diaphragm 19 to each other e.g. by TIG welding. This defines a temperature-sensing chamber enclosed by the upper housing 17 and the diaphragm

19. The temperature-sensing chamber is filled with saturated vapour gas via a gas introducing hole 21 formed in the upper housing 17. The gas introducing hole 21 is closed by a metal ball 22 e.g. by resistance-welding. The temperature-sensing chamber has to sense the temperature of refrigerant coming from the evaporator.

[0012] The lower housing 18 has gas-passing holes 25 and an open central portion integrally formed with a hollow cylindrical hub 23. The hub 23 has an internal thread fitting on the external thread 15. The gas-passing holes 25 lead refrigerant from the evaporator into a space below the diaphragm 19. The amount of introduced refrigerant is adjusted by either changing the size of each gas-passing hole or by varying the number of gas-passing holes.

[0013] An end face of the shaft 13 protruding from the body 4 abuts via the disc 20 against the lower surface of the diaphragm 19 to transmit displacements of the diaphragm 19 to the valve element 9.

[0014] The body 4 is formed by die-casting a metal, to dispense with mechanical machining such as cutting.

[0015] The body 4 in Fig. 4 can be made by die-casting of an aluminium alloy, a zinc alloy, or another metal. In the present embodiment, there e.g. is used an aluminium alloy die-casting apparatus including a first die 30, a second die 40, and a third die 50. The first die 30 and the second die 40 are actuated by an actuator, not shown, in horizontal directions in Fig. 2. The third die 50 is actuated by an actuator, not shown, in vertical directions.

[0016] The first die 30 on a side opposed to the second die 40 has a cavity 31 forming the portion of the body 4 with the inlet port 5. Within the cavity 31, a port and passage-forming portion 32 protrudes toward the second die 40, for forming the inlet port 5, and further, a thread-forming portion 33 forms half of the external thread 16. The second die 40 on a side opposed to the first die 30 has a cavity 41 for forming the portion of the body 4 with the outlet port 6. Within the cavity 41, an outlet port passage-forming portion 42 protrudes toward the first die 30, and a thread-forming portion 43 forms the other half of the external thread 16. The third die 50 has a cavity 51 forming the portion of the body 4 where the spring-receiving member 11 will be press-fitted. Within the cavity 51, a hole-forming portion 52, a valve hole-forming portion 53, and a hole-forming portion 54 are protruding upward for forming the hole 8, the valve hole 7, and the hole 12. The first to third dies 30, 40, 50 are formed in opposed surfaces with injection passage-forming grooves, not shown, for pouring in molten aluminium alloy, and exhaust passage-forming grooves, not shown, for evacuating the cavities 31, 41, and 51, and with insertion holes for inserting tools for releasing the casting from the dies.

[0017] In making the body 4, molten aluminium alloy is poured via the injection holes into the tightly fastened die set of the first to third dies 30, 40, 50. The aluminium alloy may be an Al-Si-Cu alloy having excellent castability. After the molten alloy has solidified, the third die 50 is pulled downward and then the first and second dies

30, 40, 40 are separated from each other. The first and second dies 30, 40 are moved in horizontal directions while causing inserted releasing tools to be pushed against the casting. Configuring the dies as a three-way separable structure, the body 4 can be formed integrally with the inlet port 5, the outlet port 6, the valve hole 7, the holes 8 and 12, and the external thread 16. Due to the three-way separable structure of the dies the respective axes of the inlet and outlet ports 5, 6 can be identical or parallel with each other. The hole 8, the valve hole 7, and the hole 12 are disposed on the same axis in a direction orthogonal to the direction of the axes of the ports 5, 6, and, such that they have respective inner diameters sequentially reduced in the mentioned order.

[0018] The dies, the die apparatus may comprise a plurality of sets of first to third dies 30, 40, 50 in parallel with each other, which all are simultaneously operated in the three directions. This allows to easily construct a die-casting apparatus which permits a plurality of castings to be obtained at any given time.

[0019] The die-cast body 4 in Figs 3A, 3B has a hollow cylindrical part 5a defining the inlet port 5 and extending in the direction of separating the first die 30, a hollow cylindrical part 6a defining the outlet port 6 and extending in the direction of separating the second die 40, and a hollow cylindrical part 8a defining the hole 8 and a guide 15 defining the hole 12, extending in the direction of separating the third die 50. The external thread 16 on the outer periphery of the guide 15 is a partial thread in which portions of an outer peripheral surface of the guide 15 facing in directions at right angles to the respective directions of separating the first and second dies 30, 40 are not threaded, and comprise a thread portion 16a formed on an outer peripheral portion facing in the direction of separating the first die 30 and a thread portion 16b formed on an outer peripheral portion in the direction of separating the second die 40. In the present embodiment, the body 4 is shown with an extending part 4a extended in a direction at right angles to the respective directions of separating the first and second dies 30, 40, serving to position the expansion valve 1 when incorporated in the refrigeration cycle later.

[0020] The expansion valve 1 in Figs 4 and 5 is mounted in a return low-pressure pipe between the evaporator 60 and the compressor, such that the expansion valve 1 is accommodated in the pipe in its entirety. The connection of the inlet port 5 to a high-pressure pipe 61 through which condensed liquid refrigerant is supplied and the connection of the outlet port 6 via which the expanded refrigerant is delivered to an inlet pipe 62 of the evaporator 60 are also established within the return low-pressure pipe.

[0021] The evaporator 60 in Fig. 4 is integrally formed with a casing 64 e.g. by furnace brazing, such the casing 64 surrounds the inlet pipe 62 and a refrigerant outlet port 63. An end of the low-pressure pipe 65 is welded to a joint 66 (via a portion indicated by a black triangle), and the joint 65 is hermetically connected to the casing 64 by

a pipe clamp 67. The low-pressure pipe 65 and the high-pressure pipe 61 commonly form a double pipe with the high-pressure pipe 61 coaxially arranged within the low-pressure pipe 65. A juncture between the inlet port 5 and the high-pressure pipe 61, a juncture between the outlet port 6 and the inlet pipe 62, and a juncture between the casing 64 and the joint 66 are sealed by respective O-rings. The expansion valve 1 carries a heat insulation cover 68 made of resin or rubber attached to cover the power element 3.

[0022] The expansion valve 1 is positioned in Fig. 5 in the centre of the casing 64. The extended part 4a of the body 4 and the heat insulation cover 68 have respective outer contours fitting into the inner shape of the casing 64.

[0023] The expansion valve 1 is mounted as follows: As the evaporator 60 and the casing 64 are integrally welded such that the inlet pipe 62 of the evaporator 60 protrudes into the casing 64, first, an O-ring is fitted on the inlet pipe 62, and then the expansion valve 1 is pushed into the casing 64 until the inlet pipe 62 is fitted in the outlet port 6. An O-ring is fitted on the inlet port 5 of the expansion valve 1 in advance, or at this time. The inlet port 5 then is positioned such that it can be fitted in the high-pressure pipe 61, and the joint part 66 having O-rings fitted beforehand in respective grooves formed by bending the end portion of the joint part 66 is pushed into the casing 64. Finally, a connecting portion of the casing 64 and that of the joint part 66 are connected by the pipe clamp 67.

[0024] The inlet port 5 is connected to the high-pressure pipe 61, and the outlet port 6 is connected to the inlet pipe 62 of the evaporator 60. Because the expansion valve 1 is accommodated in the low-pressure return pipe from the evaporator 60, together with the juncture to the high-pressure pipe 61 the entire arrangement is leakagesafe. Even if a minute amount of high-pressure refrigerant leaks out via the O-ring at the juncture, the leaked out refrigerant will remain in the low-pressure return pipe but cannot leak out into the atmosphere.

[0025] When an automotive air conditioner is in stoppage, saturated vapour gas filling the temperature-sensing chamber of the power element 3 is condensed. The pressure of the gas is low, the diaphragm 19 is displaced inward, and the expansion valve 1 is in the fully closed state.

[0026] When the automotive air conditioner is started now refrigerant is sucked-in by the compressor, and hence pressure within the low-pressure pipe 65 drops. The power element 3 senses this. The diaphragm 19 is displaced outward to lift the valve element 9. Refrigerant compressed by the compressor is condensed by a condenser, and liquid refrigerant obtained by gas/liquid separation in the receiver is supplied through the high-pressure pipe 61 to the inlet port 5 of the expansion valve 1. Arrows in the figures indicate respective flow directions. The high-temperature, high-pressure liquid refrigerant is expanded while passing through the expansion valve 1 and flows out from the outlet port 6 as low-temperature,

low-pressure gas-liquid mixture refrigerant. The refrigerant is supplied through the inlet pipe 62 to the evaporator 60, and is evaporated in the evaporator 60 to flow out from the refrigerant outlet 63. The refrigerant delivered from the evaporator 60 is returned to the compressor via the casing 64 and the low-pressure pipe 65.

[0027] The space enclosed by the diaphragm 19 of the power element 3 and the lower housing 18 communicates via the gas-passing holes 25 with the inside of the casing 64, so that while refrigerant from the evaporator 60 is passing through the casing 64, some of the refrigerant is introduced into the space within the power element 3, and the temperature of the introduced refrigerant is detected by the power element 3. In the early stage after the start of the automotive air conditioner, the temperature of the refrigerant returning from the evaporator 60 is high due to heat exchange with high-temperature air in a vehicle compartment. The pressure within the temperature-sensing chamber becomes high. The diaphragm 19 actuates the valve element 9 in valve opening direction. The expansion valve 1 is fully opened.

[0028] As the temperature of refrigerant from the evaporator 60 becomes lower, the pressure within the temperature-sensing chamber also becomes lower. Accordingly, the diaphragm 19 controls the expansion valve 1 in valve closing direction to control the flow rate. At this time, the expansion valve 1 detects the temperature at the outlet of the evaporator 60, and controls the flow rate to the evaporator 60 such that the refrigerant maintains a predetermined degree of superheat.

[0029] Since the power element 3 is disposed in the low-pressure return pipe from the evaporator 60 the temperature could immediately be detected by the entire power element 3. For this reason, the power element 3 would have a very short temperature-sensing time constant, and the response to a change in the temperature of refrigerant would be so sensitive as to perform an excessive feedback correction on the operation of the valve section 2, which can result in a periodic pressure variation (hunting). To eliminate this inconvenience, the provided heat insulation cover 68 somewhat blocks the heat transfer to the upper housing 17 to increase the temperature-sensing time constant.

[0030] The expansion valve 1 a in Figs 6, 7 (second embodiment) differs from the first embodiment, in that in the body 4 the respective axes of the inlet port 5 and the outlet port 6 are orthogonal to each other. This body 4 is also formed by a die-casting apparatus having a three-way separable die structure. The first die 30 forms the extended part 4a and the thread portion 16a of the external thread 16. The valve element 9, the spring 10 urging the valve element 9 in the valve closing direction, and the spring-receiving member 11 for receiving the spring 10 are disposed within the outlet port 6 of the body 4.

[0031] The expansion valve 1 a is advantageous in a case where it is arranged such that the longitudinal direction of the double pipe formed by the high-pressure pipe 61 and the low-pressure pipe 65 extending from an

engine room where the compressor is disposed to the vehicle compartment where the evaporator 60 is disposed is substantially at right angles to directions in which the inlet pipe 62 of the evaporator 60 and the refrigerant outlet port 63 open.

[0032] Therefore, the return low-pressure pipe containing the expansion valve 1 a is bent at a right angle. More specifically, the evaporator 60 is integrally formed with the inlet pipe 62 and a connecting part 64a by furnace brazing. The casing 64 is connected to the connecting part 64a by the pipe clamp 67, and the joint part 66 is welded to an upper portion of the casing 64. The joint part 66 is connected to the low-pressure pipe 65 by the pipe clamp 67.

[0033] The body 4 has an outer shape in which extended parts 4a are extended in respective three directions up to the vicinity of the inner surface of the casing 64 (Fig. 7). This facilitates positioning the expansion valve 1 a, when inserting it into the casing 64 and connecting the outlet port 6 to the inlet pipe 62.

[0034] The expansion valve 1 b in Figs 8, 9 (third embodiment) has a different construction of the juncture between the power element 3 and the body 4. The power element 3 of the expansion valves 1 and 1 a has the internal thread 24 in the inner periphery of the hub 23 extended outward from the central opening of the lower housing 18. The internal thread 24 is formed by tapping or pressing the hub 23 after the lower housing 18 is formed by pressing. Therefore, the configuration of the power element 3 of the expansion valves 1 and 1 a requires fabrication for forming the internal thread 34. In contrast, the power element 3 of the expansion valve 1 b in Figs 8, 9 is configured such that the internal thread 24 is simultaneously formed when the lower housing 18 is formed by pressing.

[0035] The inner periphery of the central opening of the lower housing 18 is formed with a thread such that the thread has a cut-out in an angle range of about 60 degrees within the whole circumference, and is continuously displaced in axial direction over a remaining angle of about 300 degrees. The axial displacement between the ends of the thread assumed to be formed over an angle range of 360 degree is substantially equal to the thread pitch of the external thread 16 on the guide 15. This means that the central opening of the lower housing 18 has a one-turn thread structure. This allows to form the lower housing 18 by pressing in its entirety, including the internal thread 24, and by combining it with the body 4 formed by die-casting without requiring other fabrication steps. Thus the cost of the expansion valve 1 can be further reduced.

[0036] In the expansion valve 1 b, the power element 3 does not have protruding portions. For this reason, the heat insulation cover 68 is simplified in shape. The upper housing 17 has a generally outwardly inflating shape. A central portion including the gas introducing hole 21 defines a recess, such that the metal ball 22 does not protrude beyond the outermost surface of the upper housing

17.

[0037] The expansion valve 1 b is mounted within the casing 64 integrally formed with the evaporator 60. The inlet pipe 62 of the evaporator 60 connected to the outlet port 6 is formed by recessing a plate forming a header part of the evaporator 60 such that the hollow cylindrical part 6a of the outlet port 6 is fitted therein. The low-pressure pipe 65 is directly connected to the casing 64 at an expanded end and by using a pipe clamp 67. The connection is performed by fixing the casing 64 and a backup ring 69 by the pipe clamp 67, in a state where the backup ring 69 holds the casing 64, the low-pressure pipe 65, and the O-ring, on the atmosphere side.

[0038] In the expansion valves 1, 1 a, and 1b (first to third embodiments) the valve element 9 acts in valve opening direction when the inlet port 5 receives high-pressure refrigerant. In the expansion valve 1 c in Figs 10, 11 (fourth embodiment) the valve element 9 is acting in valve closing direction when high-pressure refrigerant is received at the inlet port 5. Inside the body 4 the inlet port 5 and the hole 8 receiving the valve element 9 communicate with each other, and the hole 12 receiving the shaft 13 and the outlet port 6 communicate with each other. In short, the fourth embodiment is configured such that the relation between the inlet port 5 and the outlet port 6 is inverted compared to the first embodiment.

[0039] In the expansion valve 1 c, the configuration of the juncture between the power element 3 and the body 4 is also changed. At the power element 3 of the expansion valves 1 and 1 a the hub 23 formed with the internal thread 24 protrudes outward from the central opening of the lower housing 18. However, in the expansion valve 1 c the hub 23 is formed by bending inward the inner periphery of the central opening of the lower housing 18, and the inner peripheral surface of the bent portion of the hub 23 is formed with the interior thread. This reduces the overall height of the expansion valve 1 c to reduce the total size. Further, the internal thread 24 can be preferably formed by rolling. The rolled internal thread is easier to form than a pressed thread. This reduces the cost of fabrication.

[0040] The heat insulation cover 68 on the power element 3 is integrally formed with fixing legs 68a by resin-moulding. Although not shown, each fixing leg 68a has a hook at an end. The hook engages at a stepped portion of the body 4 to fix the heat insulation cover 68.

[0041] The manner of mounting the expansion valve 1 c is modified compared with the cases of the first to third embodiments. In the first and third embodiments, not only the high-pressure pipe 61 and the low-pressure pipe 65 but also the inlet pipe 65 and the casing 64 are formed by a double pipe, respectively. The expansion valve 1, 1 a, and 1b is mounted in an intermediate portion of the double pipe. In contrast, in the expansion valve 1 c the pipe upstream of and the low-pressure pipe 65 downstream of the evaporator are separate pipes, and the expansion valve 1 c is mounted in the intermediate portions of the pipes.

[0042] The inlet pipe 62 extending from the evaporator and the low-pressure pipe 65a have their ends integrally joined to the casing 64 e.g. by welding, and the end of the high-pressure pipe 61 opposed to that of the inlet pipe 62 and the end of the low-pressure pipe 65b opposed to that of the low-pressure pipe 65a are rigidly joined to a disc-shaped joint part 66 by welding. The casing 64 and the joint part 66 are connected by the pipe clamp 67. The pipe extending from the evaporator to the compressor passes refrigerant lower in density than refrigerant flowing through the pipe extending to the evaporator, and hence has a larger diameter than the pipe extending to the evaporator. Therefore, in the junctures where the pipes are connected, the respective sizes of the casing 64, the joint 66, and the pipe clamp 67 are increased according to the diameters of the associated pipes. The low-pressure pipe 65b connected to the joint 66 has a foremost joint portion with a flatted shape (Fig. 11) to prevent the size of the joint 66 from becoming larger. The foremost end of the low-pressure pipe 65a connected to the casing 64 also has a flatted shape.

[0043] Although in the first to fourth embodiments, the body 4 is described to be formed by die-casting of an aluminium alloy, it may instead be formed by injection moulding of a resin or the like by using the three-way separable dies structure. The material of the resin body may be a polyphenylene sulfide (PPS) which has excellent heat resistance, good mechanical properties, etc. The resin has a material mixed therein which makes noise generated inside the body difficult to be transmitted to the outside.

[0044] In the expansion valve, noise is generated when refrigerant flows through the narrow gap between the valve seat and the valve element. The flow noise is externally emitted as an unusual sound, but if the material of the body is an aluminium alloy, the sound insulation and sound absorption effects thereof are high enough to prevent the externally emitted noise from being considered troublesome. However, when the material of the body is a resin, the sound insulation and sound absorption effects thereof are not so high compared with the aluminium alloy. In view of this, a material, higher in density than the resin, such as a metal powder or metal fibres of iron, brass, or copper, is mixed in the resin. As a consequence, energy of flow noise produced from the valve section is damped by the metal powder or metal fibres within the body, which makes it possible to reduce sound pressure level of flow noise emitted from the body.

Claims

1. An expansion valve (1, 1 a, 1b, 1 c) that passes introduced refrigerant through a valve section (2) in a body (4) to throttle and expand the refrigerant, **characterised in that** the body (4) accommodating the valve section (2) is formed in forming dies (30, 40, 50) integrally with a thread part (16) for connect-

ing a power element (3).

2. The expansion valve according to claim 1, **characterised in that** in the body (4) an axis of an inlet port (5) and an axis of an outlet port (6) either are identical or are parallel to each other, that a first hole (8) for receiving a valve element (9) and a set value-adjusting member (11), a valve hole (7), and a second hole (12) for receiving a member (13) that transmits an actuating force dependent on temperature sensed by the power element (3) to the valve element (9), are arranged on a common axis which is orthogonal to the axis of the inlet port (5) or to the axis of the outlet port (6), that the respective diameters of the holes (8, 12) are reduced step-wise in the mentioned order, and that the thread part (16) is formed on an outer periphery of a hollow cylindrical part (15) defining the second hole (12). 5 10
3. The expansion valve according to claim 2, **characterised in that** the thread part (16) is formed as a partial thread in which portions of an outer peripheral surface of the hollow cylindrical part (15) facing in directions perpendicular to an identical surface or parallel surfaces including the axis of the inlet port (5), the axis of the outlet port (6), and an axis of the valve hole (7), are not threaded. 15 20 25
4. The expansion valve according to claim 1, **characterised in that** in the body (4) an axis of an inlet port (5) and an axis of an outlet port (6) are orthogonal to each other and have a common plane including the axes or as viewed from a direction perpendicular to parallel planes respectively including the axes, that the inlet port (5) or the outlet port (6), a valve hole, and a hole for receiving a member transmitting an actuating force dependent on temperature sensed by the power element (3) to the valve element have a common axis, that the respective diameters of the holes are reduced step-wise in a mentioned order, and that the thread part (16) is formed on an outer periphery of a hollow cylindrical part defining one of the holes. 30 35 40
5. The expansion valve according to claim 4, **characterised in that** the thread part (16) is formed as a partial thread in which portions of an outer peripheral surface of the hollow cylindrical part facing in directions perpendicular to an identical surface or parallel surfaces including the axis of the inlet port (5), the axis of the outlet port (6), and an axis of the valve hole, are not threaded. 45 50
6. The expansion valve according to claim 1, **characterised in that** the power element (3) has a one-turn thread (24) formed along an inner peripheral edge of a central opening of a housing (18) on a side where said thread part (16) is connected, and that the one turn thread (24) is continuously displaced in axial direction over an angle range of less than 360 degrees. 55
7. The expansion valve according to claim 1, **characterised in that** the power element (3) has a hub (23) formed by bending inward an inner periphery of a central opening of a housing (18) on a side where the thread part (16) is connected, and that an inner peripheral surface of the hub (23) is threaded.
8. The expansion valve according to claim 1, **characterised in that** the body (4) is formed by die-casting a metal, using dies (30, 40, 50) having a three-way separable structure as the forming dies.
9. The expansion valve according to claim 1, **characterised in that** the body is formed by resin casting, using dies having a three-way separable structure as the forming dies.
10. The expansion valve according to claim 9, **characterised in that** the resin is mixed with a metal powder or metal fibres, larger in density than the resin.
11. The expansion valve according to claim 1, **characterised in that** the expansion valve (1, 1a, 1b, 1c) is a thermostatic expansion valve in which the body (4) and the power element (3) are disposed within a low-pressure pipe (65) extending from an evaporator (60) to a compressor, that a connection of an inlet port (5) to a high-pressure pipe (61) through which high-pressure refrigerant is supplied, and a connection of an outlet port (6) to an evaporator inlet pipe (62) through which expanded refrigerant is delivered to the evaporator (60), are established within the low-pressure pipe (65).
12. The expansion valve according to claim 11, **characterised in that** an outer housing (17) of the power element (3) is at least partly covered by a heat insulation cover (68).

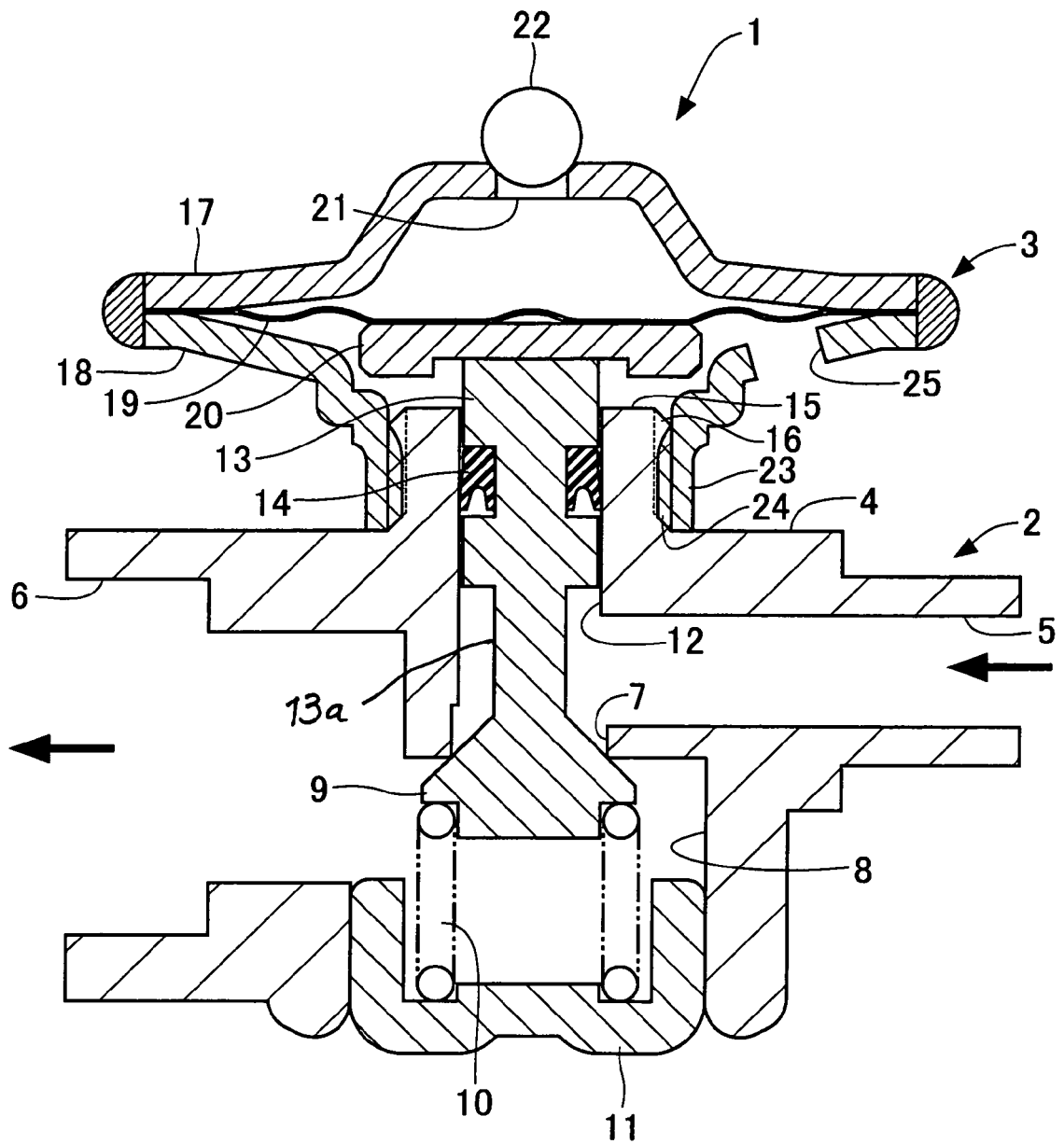


FIG. 1

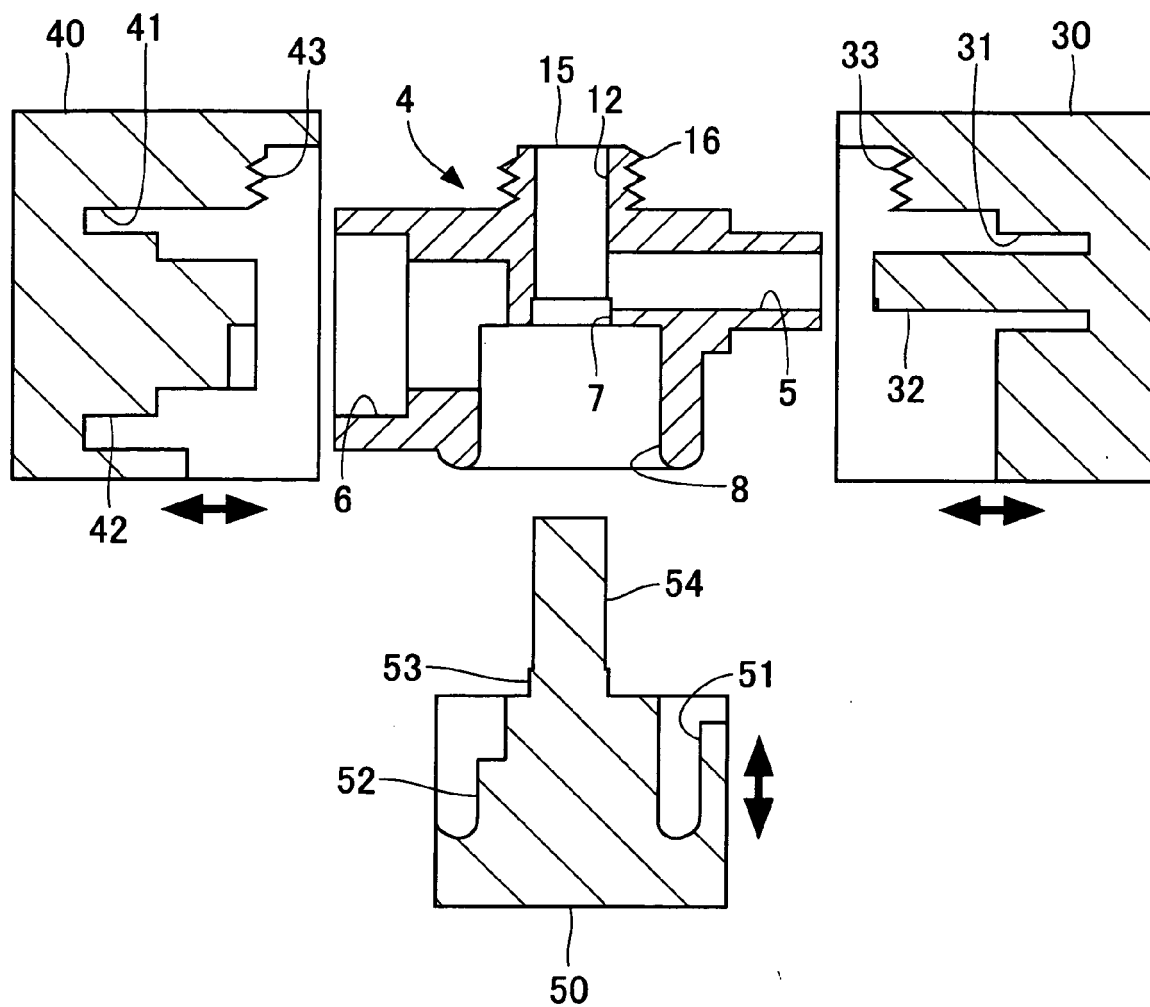


FIG. 2

FIG. 3A

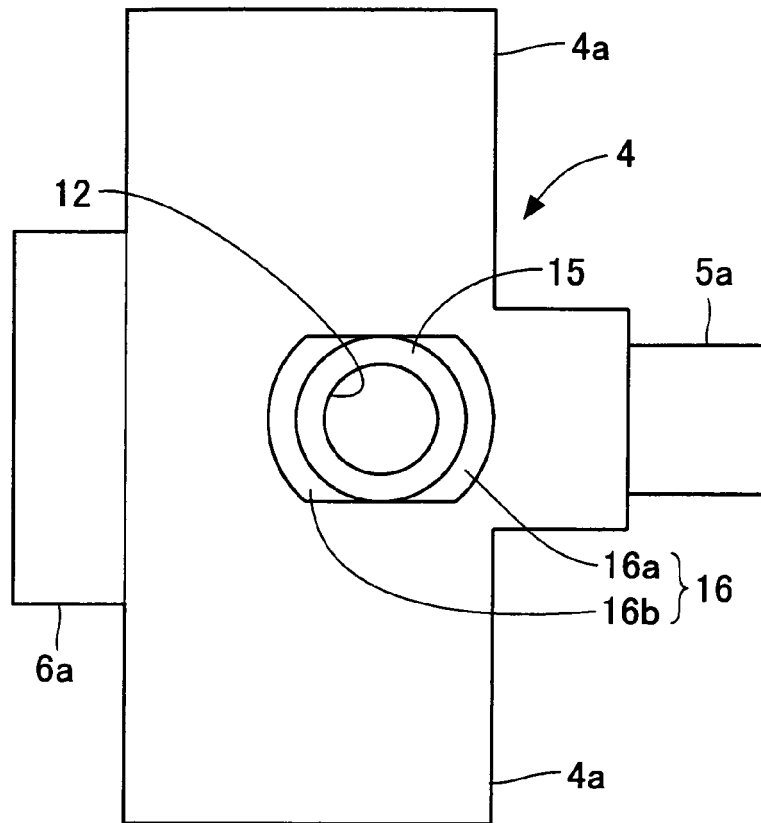
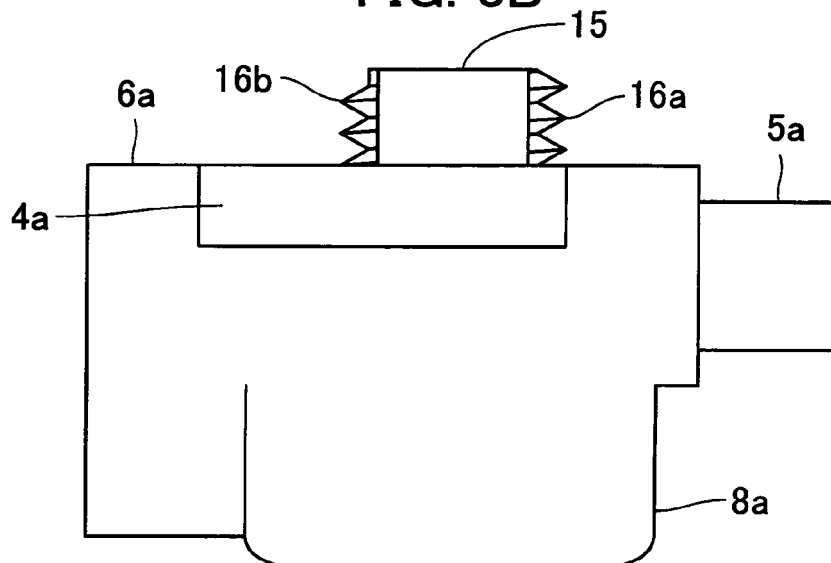


FIG. 3B



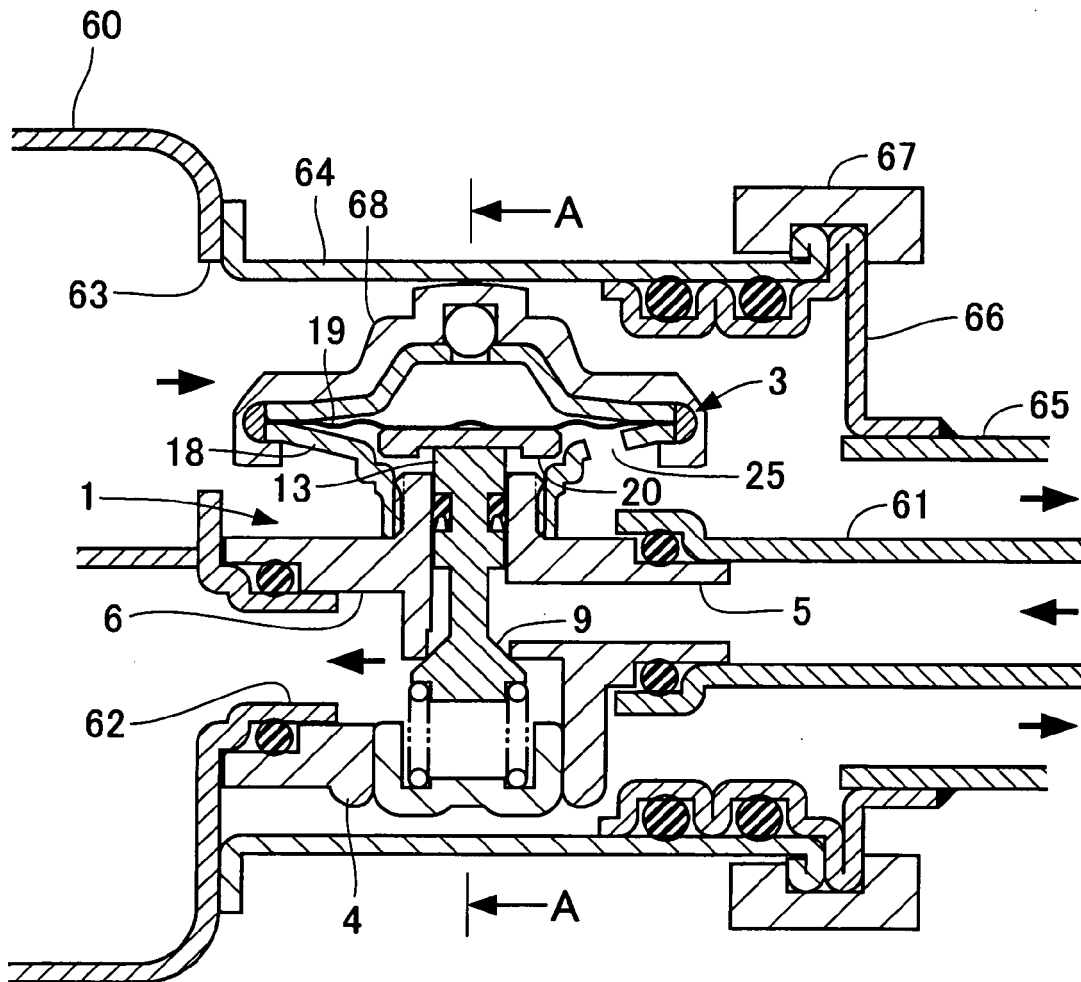


FIG. 4

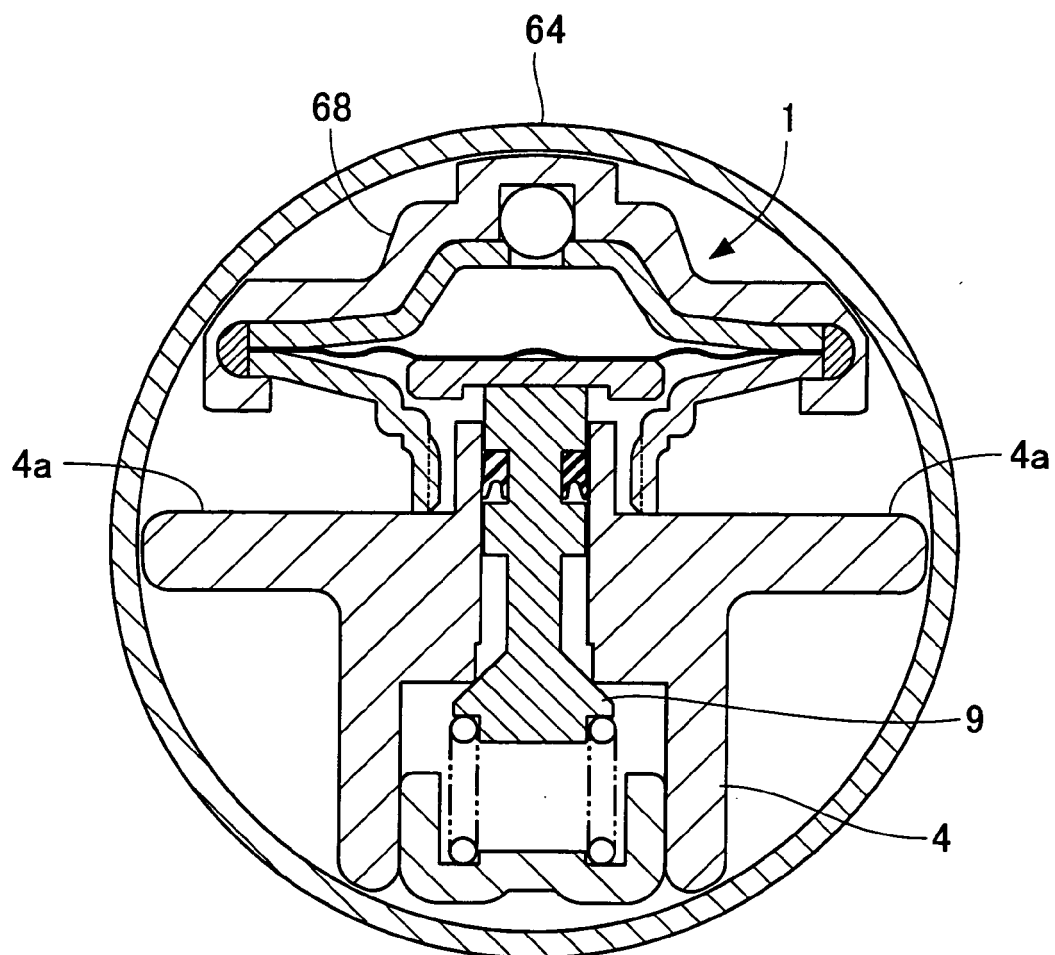


FIG. 5

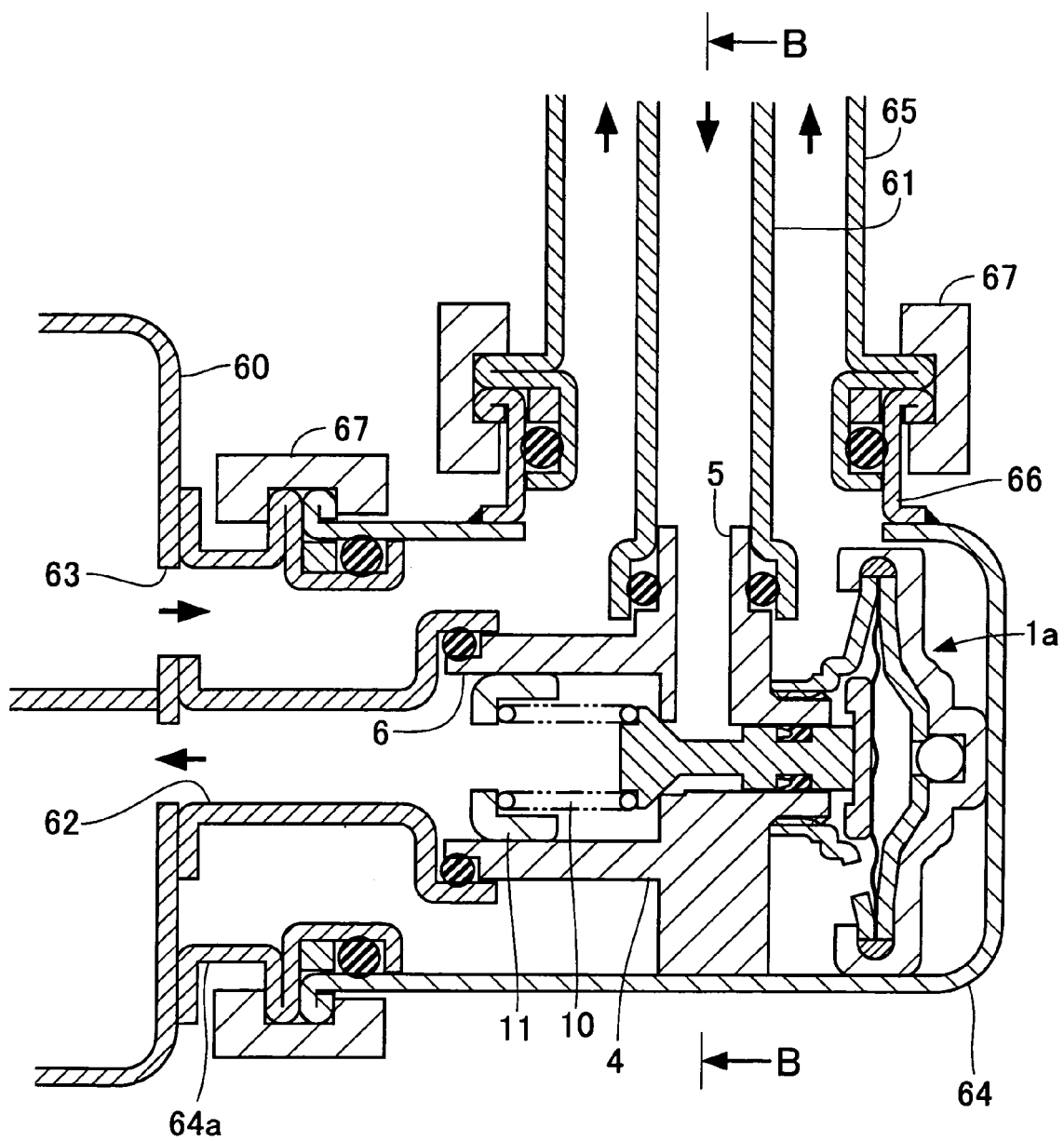


FIG. 6

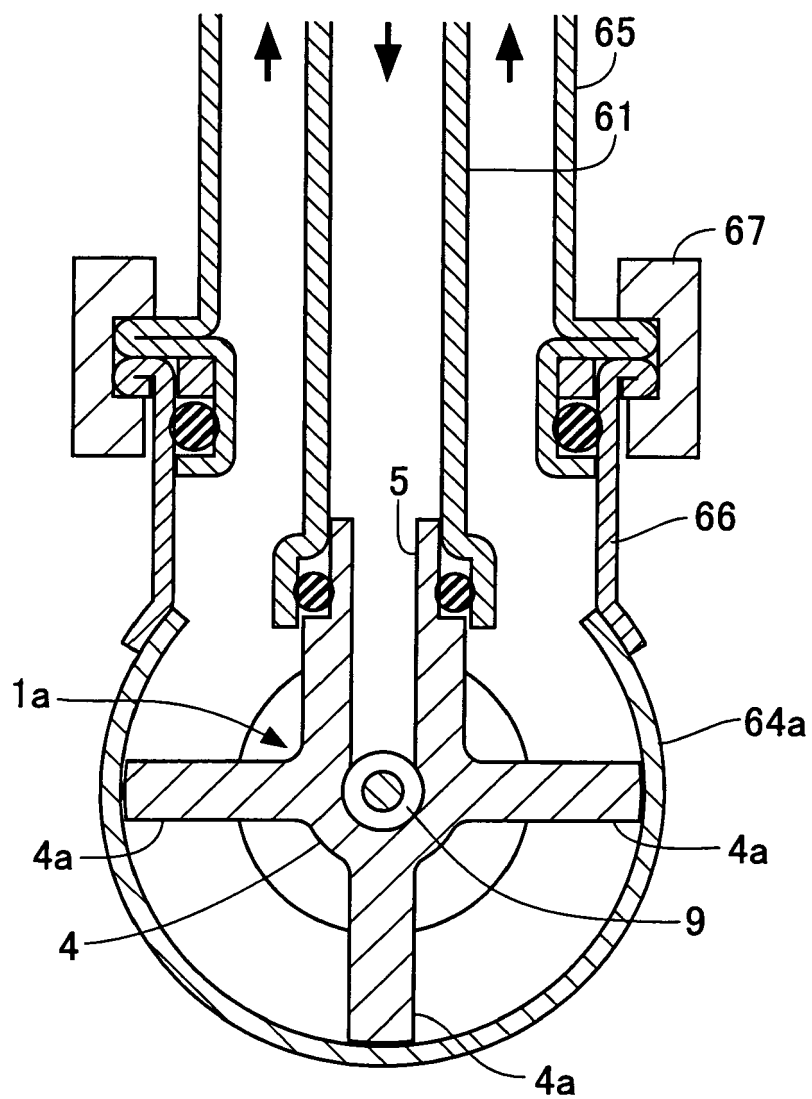


FIG. 7

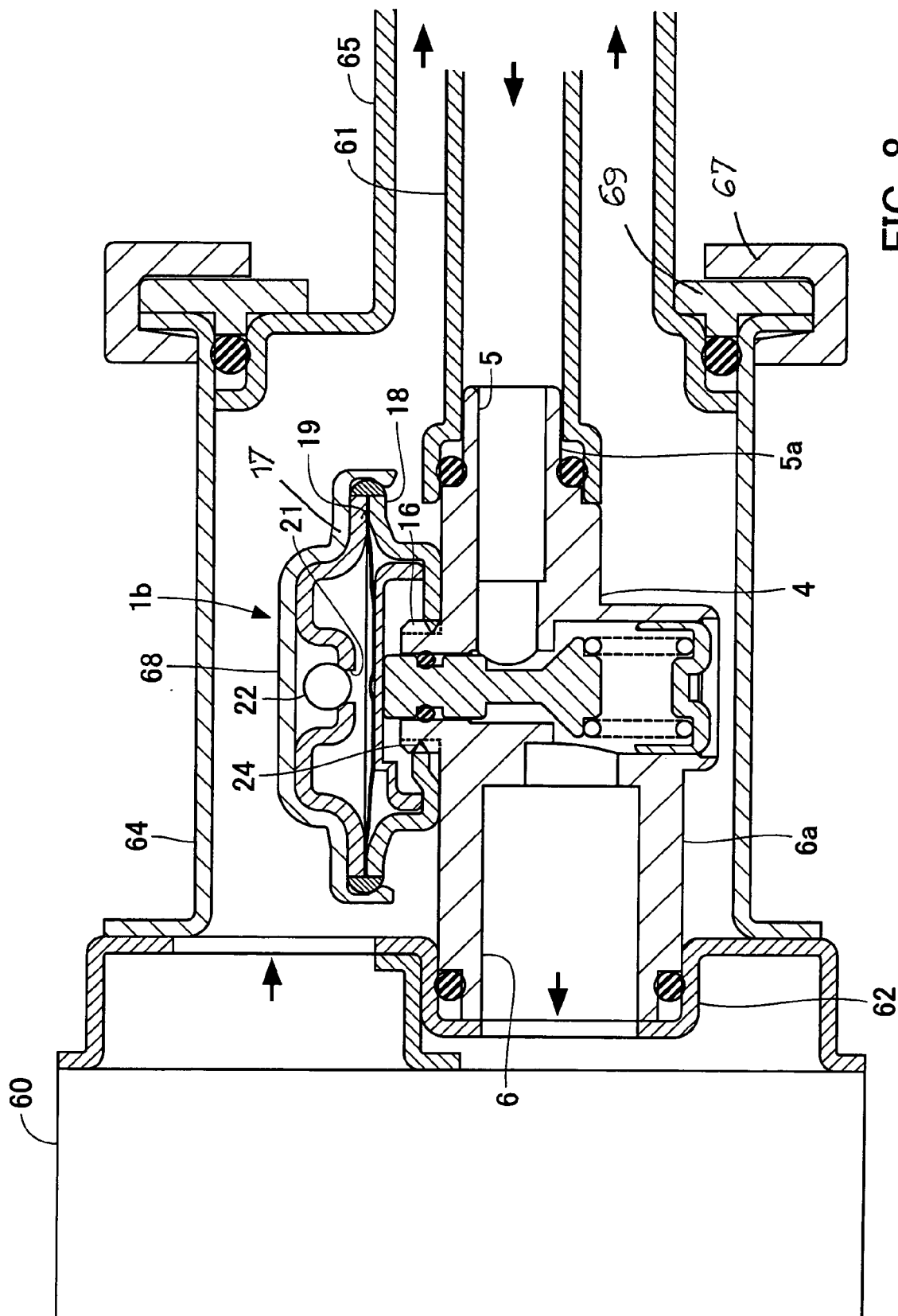


FIG. 8

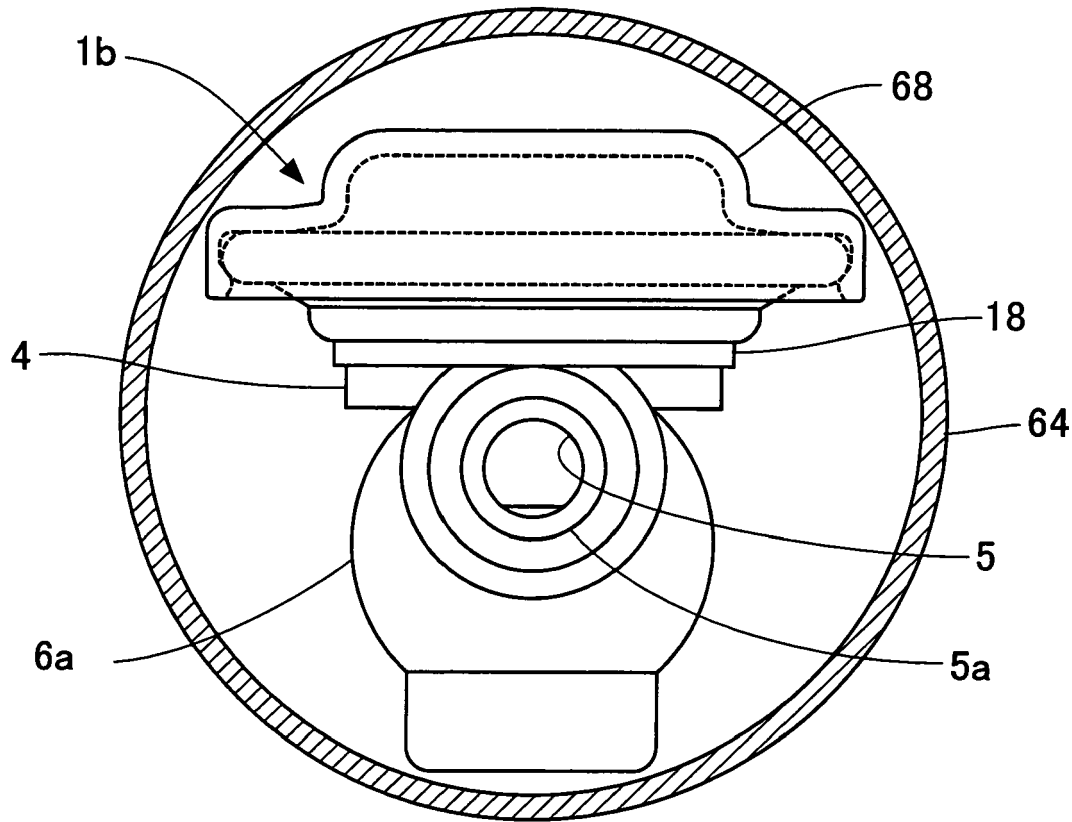


FIG. 9

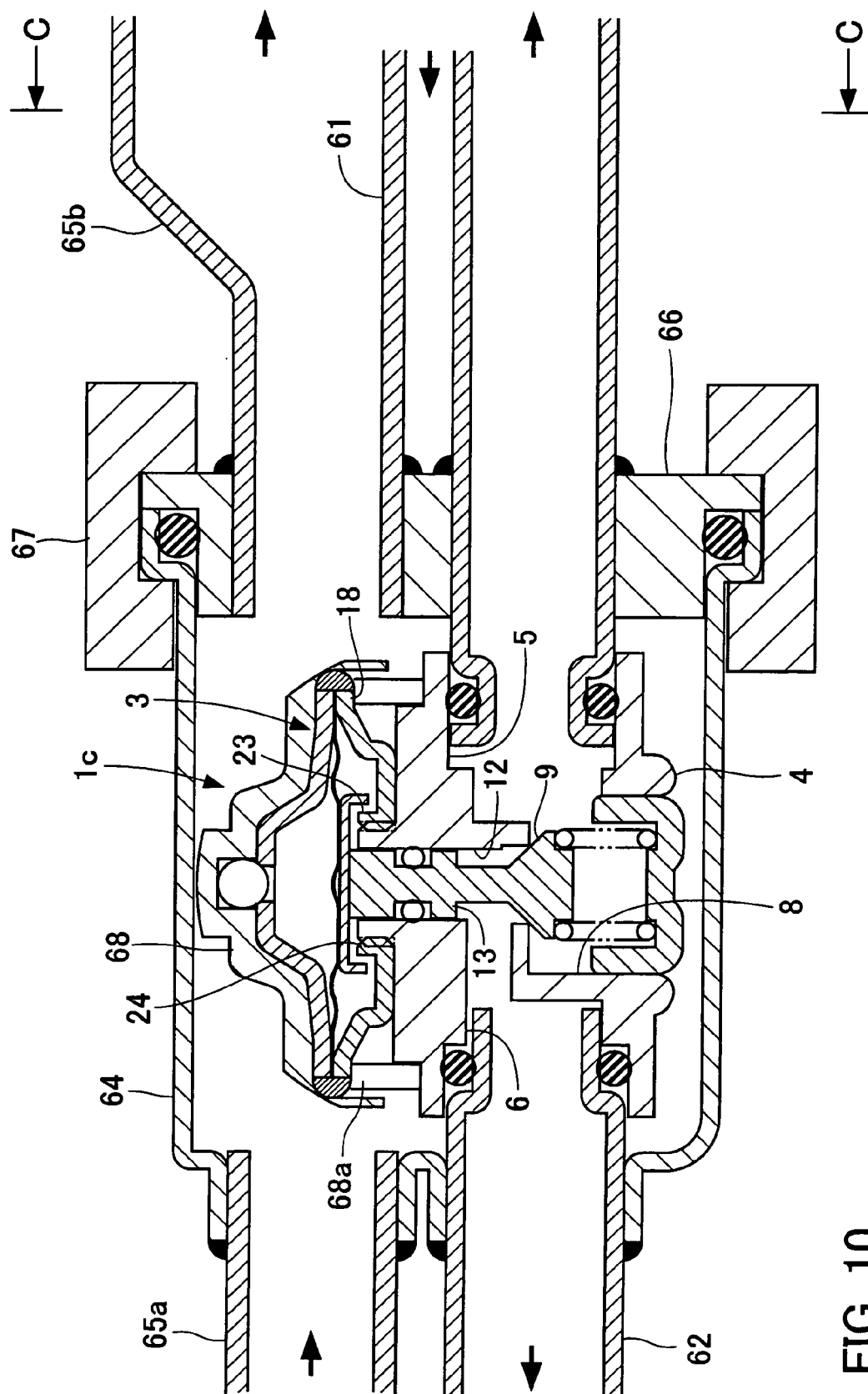


FIG. 10

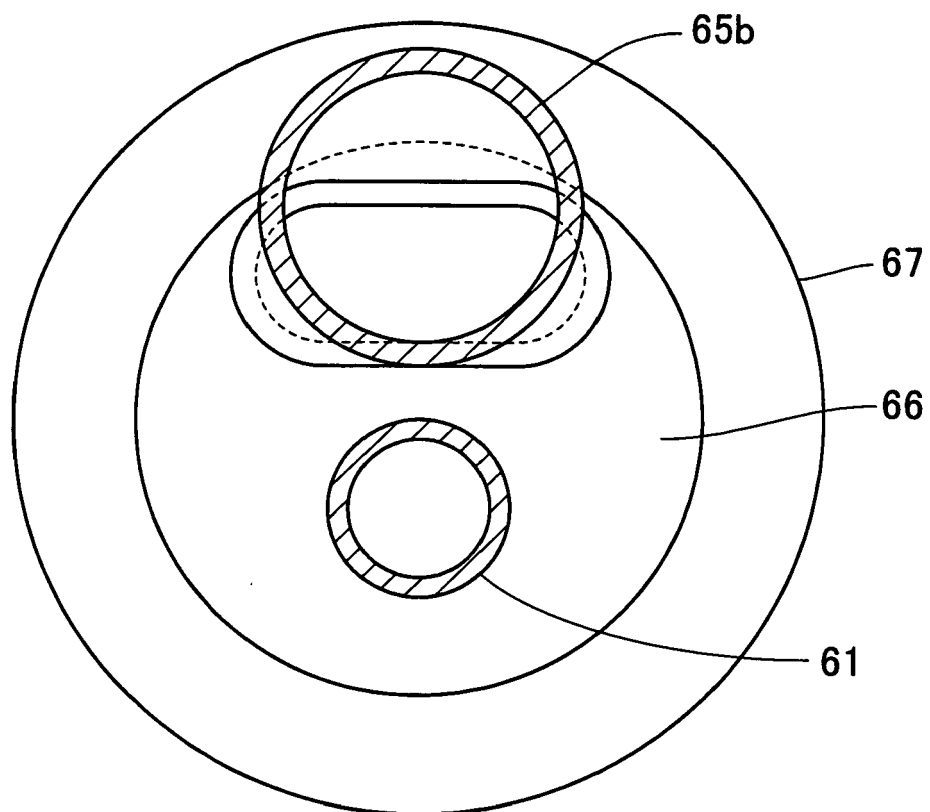


FIG. 11

REFERENCES CITED IN THE DESCRIPTION

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