(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 351 874 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
25.07.2018 Bulletin 2018/30

(51) Int Cl.:
F25B 41/06 *(2006.01)*

(21) Application number: **18151983.6**

(22) Date of filing: **16.01.2018**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD TN

(30) Priority: **18.01.2017 JP 2017006436**

(71) Applicant: **TGK CO., Ltd.**
Tokyo 193-0942 (JP)

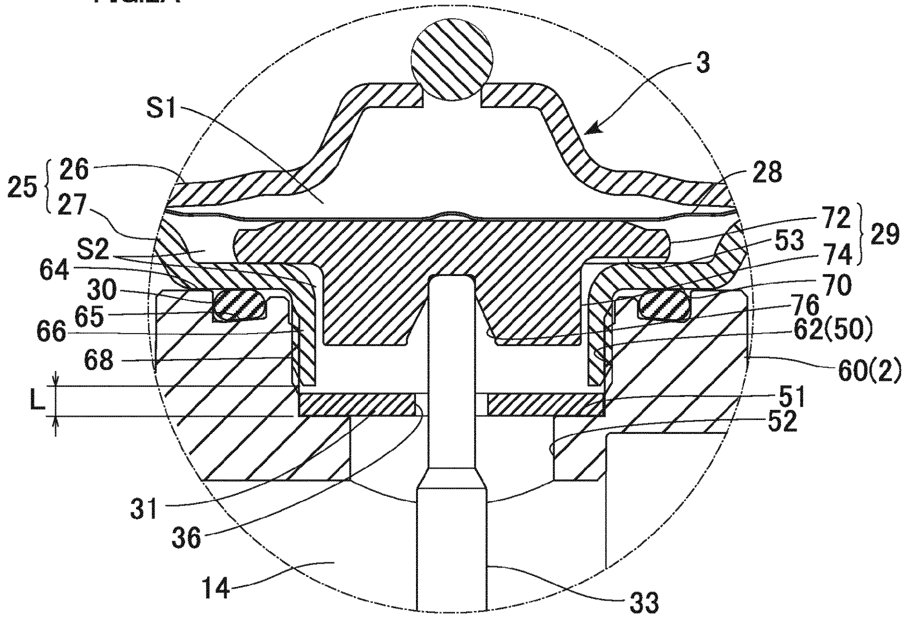
(72) Inventors:
- **SATAKE, Ryosuke**
  Tokyo, 193-0942 (JP)
- **KANEKO, Takeshi**
  Tokyo, 193-0942 (JP)

(74) Representative: **Schröer, Gernot H.**
Meissner Bolte Patentanwälte
Rechtsanwälte Partnerschaft mbB
Bankgasse 3
90402 Nürnberg (DE)

(54) **EXPANSION VALVE**

(57) An expansion valve includes: a body (2) having a second passage (14) through which a refrigerant returning from an evaporator passes, and a mounting hole (50) communicating with the second passage (14); a power element (3) mounted on the body (2) in such a manner as to close the mounting hole (50); a shaft (33) that transmits a drive force from the power element (3) to a valve element (18); and a plate (31) that separates an open space (S2) from the second passage (14), has an insertion hole (36), through which the shaft (33) extends, coaxially along a central axis of the plate (31), and limits a flow of the refrigerant from the second passage (14) into the open space (S2) to a flow through a clearance between the shaft (33) and the insertion hole (36). The insertion hole (36) is formed such that an opening area of the clearance between the shaft (33) and the insertion hole (36) is 7.0 mm^2 or smaller.

FIG.2A



EP 3 351 874 A1

Printed by Jouve, 75001 PARIS (FR)

Description

[0001] The present invention relates to an expansion valve, and more particularly to a thermostatic expansion valve suitable for use in a refrigeration cycle.

[0002] A refrigeration cycle in an automotive air conditioner typically includes a compressor for compressing a circulating refrigerant, a condenser for condensing the compressed refrigerant, an expansion valve for throttling and expanding the condensed refrigerant, and an evaporator for cooling the air in a vehicle interior using evaporative latent heat of the refrigerant. The expansion valve is, for example, a thermostatic expansion valve that senses the temperature and the pressure of the refrigerant on the outlet side of the evaporator and adjusts the valve opening degree so that the refrigerant delivered from the evaporator has a predetermined degree of superheat, to control the flow rate of the refrigerant to be delivered to the evaporator (refer, for example, to Japanese Patent Application Publication No. 2013-242129).

[0003] Such an expansion valve has a body in which a first passage, through which the refrigerant flowing from the condenser toward the evaporator passes, and a second passage, through which the refrigerant having returned from the evaporator passes, are formed. The first passage includes a valve hole, and a valve element disposed facing the valve hole. The valve element moves toward and away from the valve hole to regulate the flow rate of the refrigerant flowing toward the evaporator. The body has a mounting hole formed at one end thereof, which communicates with the second passage via a communication hole. A power element is mounted on the mounting hole. The power element senses the temperature and the pressure of the refrigerant flowing through the second passage and operates in response to the sensed temperature and pressure. The drive force of the power element is transmitted to the valve element via a shaft. The shaft extends through a partition between the first passage and the second passage. One end of the shaft is connected to the power element, and the other end thereof is connected to the valve element.

[0004] The power element has a housing mounted on the body, a diaphragm that partitions the housing into a closed space and an open space, and a disc disposed in the open space. A gas for sensing temperature is sealed in the closed space. The open space communicates with the second passage. Part of the refrigerant flowing through the second passage flows into and out from the open space. Expansion or contraction of the closed space depending on the temperature and the pressure of the refrigerant displaces the diaphragm, and the drive force caused by the displacement is transmitted to the shaft via the disc. When the refrigerant temperature at the outlet of the evaporator becomes lower, the closed space contracts, and the valve section thus operates in the closing direction. Conversely, when the refrigerant temperature becomes higher, the closed space expands, and the valve section thus operates in the opening direction. Such autonomous operation of the power element adjusts the opening degree of the valve section and thus properly controls the degree of superheat of the refrigerant at the evaporator outlet. A material having a high thermal conductivity is typically used for the disc so that the temperature of the refrigerant introduced into the open space is efficiently transmitted to the diaphragm.

[0005] Note that, during low-load operation of the refrigeration cycle, the proportion of liquid-phase components in the refrigerant delivered from the evaporator outlet may increase, and the liquid refrigerant (droplets) may be directed into the open space of the power element and adhere to the disc. Since liquid refrigerant (liquid phase) has a smaller heat transfer time constant (hereinafter also simply referred to as "time constant") than gas refrigerant (gas phase), the liquid refrigerant adhering to the disc having a high thermal conductivity may cause hunting, which is frequent opening and closing of the valve section.

[0006] Thus, in order to prevent or minimize the hunting, a technique of regulating the flow of the liquid refrigerant into the open space by providing a closing plate in a communication passage through which the open space of the power element and the second passage communicate with each other and permitting flow of the refrigerant only through a pressure equalizing hole formed in the closing plate is also proposed (refer, for example, to Japanese Patent Application Publication No. 2013-245921). In this structure, the closing plate has a stepped disc-like shape, and has an insertion hole for the shaft at the center and the pressure equalizing hole having a small diameter at a position offset from the insertion hole. The pressure equalizing hole is positioned in the closing plate to open at the downstream of the shaft in the second passage. In addition, a small-diameter part of the closing plate is fitted into the communication passage, which results in no step at the position of the communication passage in the second passage, so as to reduce the noise caused by the refrigerant passing therethrough.

Related Art List

[0007]

(1) Japanese Patent Application Publication No. 2013-242129
(2) Japanese Patent Application Publication No. 2013-245921

[0008] With the structure disclosed in Japanese Patent Application Publication No. 2013-245921, however, the pressure equalizing hole needs to be formed in addition to the insertion hole in the closing plate. In addition, coaxial alignment of the outer shape of the closing plate and the insertion hole needs to be ensured so that the operation of the shaft will not be inhibited, which requires high processing accuracy of the closing plate. Furthermore, since the pressure equalizing hole being offset from the center makes the closing plate directional, the pressure equalizing hole needs to be precisely positioned in mounting of the closing plate. This leads to an increase in the numbers of processes and manhours, and constitutes a factor in rising manufacturing cost. As a result of verification conducted by the inventors, however, no advantage is found in forming the pressure equalizing hole at a position downstream of the shaft in terms of reducing the liquid refrigerant entering the power element.

[0009] In view of the above and other circumstances, one purpose of an embodiment of the present invention is to provide an expansion valve that favorably functions at low cost while preventing control hunting.

[0010] An expansion valve according to an embodiment of the present invention throttles and expands a refrigerant flowing from an upstream side, supplies the expanded refrigerant to an evaporator, and senses a pressure and a temperature of the refrigerant returning from the evaporator to control an opening degree of a valve section. The expansion valve includes: a body having a first passage through which the refrigerant flowing from the upstream side toward the evaporator passes, a second passage through which the refrigerant returning from the evaporator passes, a valve hole formed in the first passage, and a mounting hole communicating with the second passage; a valve element that moves toward and away from the valve hole to adjust an opening degree of the valve section; a power element having a housing mounted on the body in such a manner as to close the mounting hole, a diaphragm partitioning an inside of the housing into a closed space in which a temperature sensing medium is sealed and an open space communicating with the second passage, and a disc located in the open space in contact with the diaphragm; a shaft extending through a partition between the first passage and the second passage, having a first end connected to the diaphragm through the disc and a second end connected to the valve element, and being configured to transmit a drive force in an axial direction to the valve element, the drive force being generated by displacement of the diaphragm; and an inflow regulating part that separates the open space from the second passage, has an insertion hole, through which the shaft extends, coaxially along a central axis of the inflow regulating part, and limits a flow of the refrigerant from the second passage into the open space to a flow through a clearance between the shaft and the insertion hole.

[0011] The insertion hole is formed such that an opening area of the clearance between the shaft and the insertion hole is 7.0 mm^2 or smaller.

[0012] According to the embodiment, the inflow regulating part permits the flow of the refrigerant from the second passage into the open space but limits the flow to a proper amount. In particular, since the opening area of the insertion hole is set as above, occurrence of control hunting is prevented or minimized as will be explained in the embodiment described below. In addition, the insertion hole has both of the function of allowing the shaft to pass and the function of properly limiting the inflow of the refrigerant. Furthermore, since the clearance is formed between the insertion hole and the shaft, the need for strict control of the dimensional accuracy of the inflow regulating part is reduced. Thus, the number of processes required for the inflow regulating part is reduced, and the expansion valve can be provided at low cost.

FIG. 1	is a cross-sectional view of an expansion valve according to an embodiment;
FIGS. 2A and 2B	illustrate a power element and a structure around the power element;
FIGS. 3A and 3B	illustrate temperature sensing operation of the expansion valve;
FIGS. 4A and 4B	show a result of a hunting verification test;
FIGS. 5A and 5B	show a result of the hunting verification test;
FIG. 6	is a graph showing the relation between the opening degree of an insertion hole and the amount of hunting; and
FIGS. 7A and 7B	each illustrate a structure of a main part of an expansion valve according to a modification.

[0013] Certain embodiments of the invention will now be described. The description does not intend to limit the scope of the present invention, but to exemplify the invention.

[0014] An embodiment of the present invention will now be described in detail with reference to the drawings. In the description below, for convenience of description, the positional relationship in each structure may be expressed with reference to how the structure is depicted in the drawings. In the following embodiment and its modifications, components that are substantially the same will be designated by the same reference numerals and redundant description thereof may be omitted as appropriate.

[0015] The embodiment embodies an expansion valve of the present invention in a form of a thermostatic expansion valve applicable to a refrigeration cycle in an automotive air conditioner. The refrigeration cycle includes a compressor for compressing a circulating refrigerant, a condenser (external heat exchanger) for condensing the compressed refrigerant, a receiver for separating the condensed refrigerant into gas and liquid, an expansion valve for throttling and expanding the separated refrigerant and delivering the expanded refrigerant, and an evaporator (internal heat exchanger) for evaporating the misty refrigerant to cool the air in a vehicle interior by evaporative latent heat. For convenience of description, detailed description of components other than the expansion valve will be omitted herein.

[0016] FIG. 1 is a cross-sectional view of the expansion valve according to the embodiment.

[0017] The expansion valve 1 has a body 2 formed by extrusion molding of a material made of an aluminum alloy and performing predetermined cutting on the member obtained by the extrusion molding. The body 2 has a prism shape, and a valve section for throttling and expanding the refrigerant is provided inside the body 2. A power element 3 is disposed at an end in the longitudinal direction of the body 2.

[0018] The body 2 has, on lateral sides thereof, an inlet port 6 through which a high-temperature and high-pressure refrigerant is introduced from the receiver side (condenser side), an outlet port 7 through which the low-temperature and low-pressure refrigerant resulting from the throttling expansion through the expansion valve 1 is delivered toward the evaporator, an inlet port 8 through which the refrigerant evaporated by the evaporator is introduced, and an outlet port 9 through which the refrigerant having passed through the expansion valve 1 is delivered to the compressor side. In the embodiment, the inlet port 6 and the outlet port 9 are open in a first side face of the body 2. The outlet port 7 and the inlet port 8 are open in a second side face opposite to the first side face. In a modification, the first side face and the second side face may be adjacent to each other at the right angle. A screw hole 10 for mounting a pipe, which is not illustrated, is formed between the inlet port 6 and the outlet port 9. Each of the ports is connected with a pipe joint.

[0019] In the expansion valve 1, the inlet port 6, the outlet port 7, and a refrigerant passage connecting these ports constitute a first passage 13. A valve section is formed in an intermediate portion of the first passage 13. The refrigerant introduced through the inlet port 6 is throttled and expanded into a spray through the valve section, and delivered toward the evaporator through the outlet port 7. In addition, the inlet port 8, the outlet port 9, and a refrigerant passage connecting these ports constitute a second passage 14. The second passage 14 extends straight and an intermediate portion thereof communicates with the inside of the power element 3. Part of the refrigerant introduced through the inlet port 8 is supplied to the power element 3, which senses the temperature of the refrigerant. The refrigerant having passed through the second passage 14 is delivered toward the compressor through the outlet port 9.

[0020] A valve hole 16 is formed at the intermediate portion of the first passage 13. An open end edge of the valve hole 16 on the side of the inlet port 6 is a valve seat 17. A valve element 18 is disposed facing the valve seat 17 from the side of the inlet port 6. The valve element 18 has a spherical ball valve element 41 for opening and closing the valve section by leaving and touching the valve seat 17, and a valve element support 43 for supporting the ball valve element 41 from below, which are joined together.

[0021] A communication hole 19 connecting the inside and the outside of the body 2 is formed in the lower part of the body 2. The upper half of the communication hole 19 forms a valve chamber 40, in which the valve element 18 is accommodated. The valve chamber 40 communicates with the valve hole 16, and is formed coaxially with the valve hole 16. The valve chamber 40 also communicates with the inlet port 6 at a lateral side thereof via an upstream-side passage 37. The upstream-side passage 37 includes a small hole 42 that is open toward the valve chamber 40. The small hole 42 is a portion of the first passage 13 where the cross-section of the first passage 13 is locally made small.

[0022] The valve hole 16 communicates with the outlet port 7 via a downstream-side passage 39. Thus, the upstream-side passage 37, the valve chamber 40, the valve hole 16, and the downstream-side passage 39 constitute the first passage 13. The upstream-side passage 37 and the downstream-side passage 39 are parallel to each other and each extend in a direction perpendicular to the axis of the valve hole 16. In a modification, the inlet port 6 or the outlet port 7 may be positioned so that projections of the upstream-side passage 37 and the downstream-side passage 39 are perpendicular to each other (so that the upstream-side passage 37 and the downstream-side passage 39 are skew with respect to each other).

[0023] An adjusting screw 20 is screwed into a lower half of the communication hole 19 in such a manner as to seal the communication hole 19 from outside. A spring 23 for biasing the valve element 18 in a valve closing direction is disposed between the valve element 18 (more specifically, the valve element support 43) and the adjusting screw 20. The load of the spring 23 can be adjusted by adjustment of the insertion amount of the adjusting screw 20 into the body 2. An O-ring 24 for preventing leakage of the refrigerant is disposed between the adjusting screw 20 and the body 2.

[0024] A support portion 60, which is raised in an embossed manner, is formed on the middle of an upper face of the body 2, and a mounting hole 50 having a recessed shape (a bottomed, circular hole shape) is formed in the middle of the support portion 60. A communication hole 52 is formed through a partition 51 between the mounting hole 50 and the second passage 14. The communication hole 52 is coaxial with the center of a bottom portion of the mounting hole 50. The power element 3 has a lower part screwed into the mounting hole 50 and is mounted on the body 2 in such a manner as to seal an upper end opening of the body 2. An O-ring 30 for preventing leakage of refrigerant is disposed between the power element 3 and the body 2.

[0025] The power element 3 has a housing 25 mounted on the body 2 in such a manner as to close the mounting hole 50, and a diaphragm 28 disposed in such a manner as to partition the inside of the housing 25 in the axial direction. The housing 25 includes an upper housing 26 and a lower housing 27 attached to each other in the axial direction. The upper housing 26 functions as a "first housing" and the lower housing 27 functions as a "second housing."

[0026] Specifically, the power element 3 includes the diaphragm 28 between the upper housing 26 and the lower housing 27, and a disc 29 disposed on the lower housing 27 side of the diaphragm 28. The upper housing 26 is formed by press-forming a stainless steel material into a lidded shape. The lower housing 27 is formed by press-forming a stainless steel material into a stepped cylindrical shape. The disc 29 is made of aluminum or an aluminum alloy, for example, and has a higher thermal conductivity than the upper and lower housings.

[0027] The power element 3 is formed in a shape of a container by making the upper housing 26 and the lower housing 27 in contact with each other at the openings thereof, mounting the diaphragm 28 so that an outer edge of the diaphragm 28 is placed between outer edges of the upper housing 26 and the lower housing 27, and welding along a circumferential joint of the upper and lower housings. The inside of the power element 3 is partitioned into a closed space S1 and an open space S2 by the diaphragm 28. A gas for sensing temperature (which functions as a "temperature sensing medium") is sealed in the closed space S1. The disc 29 is located in the open space S2.

[0028] A disc-like plate 31 is provided at the bottom portion of the mounting hole 50. The plate 31 separates the open space of the power element 3 from the second passage 14, and has an insertion hole 36 through which the shaft 33 extends in the middle. The plate 31 functions as an "inflow regulating part" that limits the flow of the refrigerant from the second passage 14 into the open space S2 to a flow through a clearance between the shaft 33 and the insertion hole 36. Part of the refrigerant passing through the second passage 14 is directed to the open space S2 via the communication hole 52 and the insertion hole 36. The power element 3 senses the pressure and the temperature of the refrigerant and generates a drive force in the opening or closing direction of the valve section. A temperature sensing structure of the power element 3 will be described later in detail.

[0029] An insertion hole 34 is formed through a partition 35 that separates the first passage 13 from the second passage 14 at a middle part of the body 2. The insertion hole 34 is a stepped hole having a small-diameter part 44 and a large-diameter part 46, which are coaxial with each other. A lower end of the small-diameter part 44 is open toward the first passage 13, while an upper end of the large-diameter part 46 is open toward the second passage 14. An elongated shaft 33 extends through the small-diameter part 44 slidably in the axial direction. The large-diameter part 46 constitutes a mounting hole in which a vibration-proof spring 48, which will be described below, is contained in a coaxial manner.

[0030] The shaft 33 is a rod made of metal such as stainless steel, and disposed between the disc 29 and the valve element 18. This enables the drive force generated by displacement of the diaphragm 28 to be transmitted to the valve element 18 via the disc 29 and the shaft 33 to open or close the valve section. One end side of the shaft 33 extends across the second passage 14 and through the plate 31, and is connected with the disc 29. The other end side of the shaft 33 extends across the downstream-side passage 39 of the first passage 13 and through the valve hole 16, and is connected with the valve element 18.

[0031] The large-diameter part 46 contains the vibration-proof spring 48 for applying biasing force in a direction perpendicular to the axial direction of the shaft 33, that is, a lateral load (sliding load) onto the shaft 33. The shaft 33 is subjected to the lateral load of the vibration-proof spring 48, which suppresses vibration of the shaft 33 and the valve element 18 due to refrigerant pressure fluctuation.

[0032] The vibration-proof spring 48 is fixed coaxially with the small-diameter part 44, and supports the shaft 33 with the shaft 33 coaxially extending through the vibration-proof spring 48. The vibration-proof spring 48 biases the shaft 33 radially inward to apply sliding resistance (friction) to the shaft 33. Note that a structure disclosed in Japanese Patent Application Publication No. 2013-242129 can be used for the vibration-proof spring 48. Detailed description of a specific structure of the vibration-proof spring 48 will thus be omitted.

[0033] In the present embodiment, a clearance between the insertion hole 34 and the shaft 33 is sufficiently small to achieve clearance seal to prevent or minimize leakage of refrigerant from the first passage 13 into the second passage 14. In a modification, a seal ring such as an O-ring may be disposed between the insertion hole 34 and the shaft 33 to prevent leakage of refrigerant from the first passage 13 into the second passage 14.

[0034] In the expansion valve 1 having the structure as described above, the power element 3 senses the pressure and the temperature of refrigerant having returned from the evaporator via the inlet port 8, and the diaphragm 28 displaces. This displacement of the diaphragm 28 results in the drive force, which is transmitted to the valve element 18 via the disc 29 and the shaft 33 so as to open and close the valve section. In the meantime, a liquid refrigerant supplied from a receiver is introduced through the inlet port 6, throttled and expanded while passing through the valve section to be turned into a low-temperature and low-pressure spray of refrigerant. The refrigerant is then delivered through the outlet port 7 toward the evaporator.

[0035] Next, a temperature sensing structure of the power element will be described in detail.

[0036] FIGS. 2A and 2B illustrate the power element and the structure around the power element. FIG. 2A is an enlarged view of part A in FIG. 1, and FIG. 2B is a plan view of the plate 31.

[0037] As illustrated in FIG. 2A, an internal thread portion 62 is formed on an inner surface of the mounting hole 50. The communication hole 52 mentioned above is formed in the middle of the bottom portion (partition 51) of the mounting hole 50. A stopper surface 64 is formed on the upper face of the body 2, and an O-ring

30 is fitted into a fitting groove 65 formed in the stopper surface 64.

[0038] The lower housing 27 has a stepped cylindrical shape with the diameter gradually decreasing downward in a stepwise manner. A lower half part of the lower housing 27 constitutes a connection part 66. An external thread portion 68 (which functions as a "screw portion") to be screwed into the thread portion 62 is formed on an outer surface of the connection part 66. The lower housing 27 is mounted on the body 2 in such a manner that the connection part 66 is screwed into the mounting hole 50. A base end (which functions as a "stopper") of the connection part 66 of the lower housing 27 has a stopper surface 70 perpendicular to the axis, and is to come in contact with the stopper surface 64 of the body 2.

[0039] The disc 29 has a disc-shaped body 72, and a heat transfer promoting part 74 extending downward from a middle of a lower face of the disc body 72. As illustrated, the heat transfer promoting part 74 has a large side face, which allows efficient transfer of the temperature of the refrigerant introduced into the open space S2. The heat transfer promoting part 74 has an outer diameter slightly smaller than the inner diameter of the connection part 66. A recess 76 having a diameter increasing downward in a tapered manner is formed in the middle of a lower face of the heat transfer promoting part 74. A groove 53 is formed in a lower face of the disc body 72. Refrigerant having flowed into the open space S2 is directed to a lower face of the diaphragm 28 via the groove 53.

[0040] As also illustrated in FIG. 2B, the plate 31 has a disc-like shape having flat upper and lower faces. The insertion hole 36 is formed in the plate 31 coaxially with the central axis of the plate 31. The plate 31 is coaxially supported at the bottom portion of the mounting hole 50, and the shaft 33 extends coaxially through the plate 31. Note that "coaxially" used herein includes cases where the axes are substantially in alignment as well as cases where the axes are exactly in alignment. The plate 31 has an outer diameter approximately equal to but slightly smaller than the inner diameter of the mounting hole 50. This facilitates mounting of the plate 31. The plate 31 has a thickness slightly smaller than a distance L between the bottom portion of the mounting hole 50 and a lower end of the lower housing 27. The lower end of the lower housing 27 faces an upper face around a circumferential edge of the plate 31. The gap between the lower housing 27 and the plate 31 is smaller than the thickness of the plate 31.

[0041] As a result of allowing for play (looseness) between the plate 31 and the lower housing 27 in this manner, the lower housing 27 is securely fastened to the body 2 and the sealing function of the O-ring 30 is ensured. In addition, as a result of making the gap between the lower end of the lower housing 27 and the plate 31 small, flapping of the plate 31, if any, is suppressed.

[0042] An upper part of the shaft 33 extends through the insertion hole 36 into the open space S2, and a leading end thereof is inserted in the recess 76 and in contact with a lower face of the disc 29.

[0043] The plate 31 is made of resin (or plastic) having a lower hardness and a lower thermal conductivity than the housing 25. The clearance between the insertion hole 36 and the shaft 33 has a cross-sectional area (referred to as "an opening area of the insertion hole 36"; see the dotted region) limits the flow of refrigerant from the second passage 14 into the open space S2. The opening area is set to such a size that passage of gas refrigerant (gas-phase components) is promoted while passage of liquid refrigerant (liquid-phase components) is reduced (such a size that inflow of droplets is reduced or prevented). In the present embodiment, the opening area is about 5 mm^2.

[0044] For mounting the power element 3 onto the body 2, the plate 31 is inserted in the mounting hole 50, the O-ring 30 is then fitted into the fitting groove 65, and in this state, the lower housing 27 is screwed into the mounting hole 50. In this manner, the O-ring 30 is pressed in close contact with both of the power element 3 and the body 2, which achieves good sealing performance. As the lower housing 27 is screwed in this manner, the stopper surface 70 of the lower housing 27 is stopped by the stopper surface 64 of the body 2, and the mounting of the power element 3 is thus completed.

[0045] Next, operations and advantageous effects of the present embodiment will be explained in detail.

[0046] FIGS. 3A and 3B illustrate temperature sensing operation of the expansion valve. FIG. 3A illustrates the temperature sensing operation of the expansion valve 1 according to the present embodiment, and FIG. 3B illustrates the temperature sensing operation of an expansion valve 101 according to a comparative example. The difference between the expansion valve 1 and the expansion valve 101 is that the expansion valve 1 includes the plate 31 while the expansion valve 101 has no plate 31. In FIGS. 3A and 3B, two-dot chain arrows indicate the flow of refrigerant. In FIGS. 3A and 3B, components similar to each other are designated by the same reference numerals.

[0047] As illustrated in FIG. 3A, the inlet port 8 is connected with an end portion (joint) of a pipe 80 connecting an outlet of the evaporator with the expansion valve 1. An O-ring 82 for sealing is fitted around an outer surface of the end portion of the pipe 80, so as to prevent leakage of refrigerant to the outside. In addition, a flange portion 84 protruding radially outward is formed in the vicinity of the end portion of the pipe 80. The flange portion 84 is stopped by a side face of the body 2, so that the length to which the pipe 80 is inserted into the second passage 14 is restricted.

[0048] The outlet port 9 is connected with an end portion (joint) of a pipe 90 connecting an inlet of the compressor with the expansion valve 1. An O-ring 92 for sealing is fitted around an outer surface of the end portion of the pipe 90, so as to prevent leakage of refrigerant to the outside. In addition, a flange portion 94 protruding radially outward is formed in the vicinity of the end portion of the pipe 90. The flange portion 94 is stopped by the side face of the body 2, so that the length to which the pipe 90 is inserted into the second passage 14 is restricted. Although these pipes 80 and 90 are fixed to the body 2 with respective pipe fixing plates, which are not illustrated, the description thereof is omitted herein.

[0049] In the present embodiment, most of the refrigerant delivered from the evaporator flows straight from an outlet of the pipe 80 through the second passage 14, enters an inlet of the pipe 90, and is directed to the compressor. In contrast, part of the refrigerant flows in such a manner as to spread from the outlet of the pipe 80, reaches an end face 96 of the pipe 90 or an inner side face on a downstream side of the communication hole 52, changes its flowing direction, and flows toward the power element 3. Most of the refrigerant that has changed its direction, however, reaches the plate 31, is returned to the second passage 14, and is directed to the inlet of the pipe 90. Part of the refrigerant having changed its direction is directed to the open space S2 through the insertion hole 36.

[0050] The refrigerant in the open space S2 is delivered to the second passage 14 via the insertion hole 36 and the communication hole 52, and directed to the inlet of the pipe 90. In this manner, a proper amount of refrigerant enters and exits the open space S2. This allows the power element 3 to sense the temperature and the pressure at the outlet of the evaporator stably and in real time. Liquid refrigerant delivered into the communication hole 52, if any, is actively received by the plate 31, which minimizes liquid refrigerant being introduced into the open space S2. As a result, the control hunting is prevented or minimized.

[0051] In contrast, in the comparative example illustrated in FIG. 3B, liquid refrigerant delivered into the communication hole 52 is then delivered into the open space S2. This is likely to cause the control hunting. In other words, according to the present embodiment, the control hunting is effectively prevented or minimized only by providing the plate 31 of a simple structure in the mounting hole 50.

[0052] FIGS. 4A, 4B, 5A, and 5B show results of a hunting verification test. In this test, a test product in which the body and the housing are made of transparent resin is used to visualize the flow of refrigerant during operation of the refrigeration cycle. FIGS. 4A and 4B show a result of experiments according to the present embodiment, and FIGS. 5A and 5B show a result of experiments according to a comparative example. In the comparative example, the plate 31 of the present embodiment is not provided. FIGS. 4A and 5A each show the flow of refrigerant in the vicinity of a temperature sensing part when the degree of superheat is zero, and FIGS. 4B and 5B each show a result of measurement of hunting when the refrigeration cycle is switched from operation with a minimum capacity to normal operation. In FIGS. 4B and 5B, the horizontal axis represents time (seconds) elapsed from the switching of operation of the refrigeration cycle, and the vertical axis represents the degree of superheat (°C) of refrigerant at the evaporator outlet. FIG. 6 is a graph showing the relation between the opening degree of the insertion hole 36 and the amount of hunting. In FIG. 6, the horizontal axis represents the opening area (mm^2) of the insertion hole 36, and the vertical axis represents the amount (°C) of fluctuation in the degree of superheat.

[0053] FIG. 4B shows that, according to the present embodiment, the degree of superheat becomes substantially constant and thus stable after about 200 seconds have elapsed from the operation switching. In addition, FIG. 4A shows that, when the degree of superheat zero, that is, when the refrigerant is in a gas-liquid two-phases state, the gas-phase components of the refrigerant are stably introduced into the open space S2. In contrast, FIG. 5B shows that, according to the comparative example, the degree of superheat fluctuates significantly independently of the elapsed time. In addition, FIG. 5A shows that, when the degree of superheat is zero, refrigerant in a gas-liquid two-phase state flows rapidly into the open space S2 (see the bubbling state). Note that about 200 second from the operation switching is the time taken for the refrigeration cycle to be stabilized after transition to steady operation. Thus, comparison in the steady operation state of the refrigeration cycle shows that control hunting notably appears in the comparative example while control hunting is reduced in the present embodiment.

[0054] In addition, FIG. 6 shows that the effect of reducing hunting according to the present embodiment is increased by setting the opening area of the insertion hole 36 to 7.0 mm^2 or smaller while permitting flow of refrigerant through the insertion hole 36.

[0055] As described above, according to the present embodiment, the plate 31 separating the open space S2 of the power element 3 from the second passage 14 and the opening area of the insertion hole 36 in the plate 31 is set to 7.0 mm^2 or smaller, which effectively reduces occurrence of control hunting. In addition, the plate 31 has such a simple shape in which the insertion hole 36 is formed at the center of a flat disc, which can be achieved at low cost in such a manner that the plate 31 is easily obtained by punching a sheet material into this shape, for example. Since the shape of the plate 31 is centrally symmetric and nondirectional, the plate 31 is easily mounted on the body 2. Since the clearance of such a suitable size that promotes passage of gas refrigerant is formed between the insertion hole 36 and the shaft 33, error in the dimensional accuracy of the plate 31, if any, does not interfere with the shaft 33. In other words, the need for strict control of the dimensional accuracy of the plate 31 is reduced. Thus, the number of manhours required for fabrication and mounting of the plate 31 is reduced, which achieves the expansion valve 1 at low cost.

[Modifications]

[0056] FIGS. 7A and 7B each illustrate a structure of a main part of an expansion valve according to a modification. FIG. 7A illustrates a first modification, and FIG. 7B illustrates a second modification.

[0057] As illustrated in FIG. 7A, the "inflow regulating part" is integrated with a "power element 203" in the first modification. Specifically, a plate 231 is fixed to an open end of the lower housing 27. The method for fixing the plate 231 may be press-fitting, welding, swaging, fastening (screwing), or other fixing means. The plate 231 has an insertion hole 36 in the middle, and limits the flow of refrigerant from the second passage 14 to the open space S2. With such a structure, control hunting is prevented or minimized similarly to the embodiment described above. Note that the plate 231 may be made of resin or may be made of metal. In the latter case, the plate 231 may be made of metal having a higher thermal conductivity than the housing 25, such as aluminum or an aluminum alloy.

[0058] As illustrated in FIG. 7B, the "inflow regulating part" is constituted by a plate 331 of a stepped disc-like shape in the second modification. The plate 331 has a plate body 310 supported by the bottom portion of the mounting hole 50, and a fitted portion 312 to be partially inserted in the communication hole 52. An insertion hole 36 is formed through the middle of the plate 331 in the axial direction. With such a structure, control hunting is prevented or minimized similarly to the embodiment described above. In addition, the state in which the plate 331 is mounted on the body 2 is stable without press-fitting of the plate 331 into the body 2.

[0059] The description of the present invention given above is based upon a certain embodiment. The embodiment is intended to be illustrative only and it will be obvious to those skilled in the art that various modifications could be further developed within the technical idea underlying the present invention.

[0060] In the embodiment described above, the plate 31 has an outer diameter slightly smaller than the inner diameter of the mounting hole 50, which achieves easier mounting of the plate 31. In addition, even if this structure results in misalignment of the axes of the plate 31 and the shaft 33, the size (opening area) of the insertion hole 36 is set such that the plate 31 does not interfere with the shaft 33. Specifically, the size (opening area) of the insertion hole 36 is set so that the clearance between the insertion hole 36 and the shaft 33 is larger than the clearance between the plate 31 and the mounting hole 50. In a modification, the plate 31 may have a press-fit allowance for being press-fitting into the mounting hole 50.

[0061] In the embodiment described above, the plate 31 has a thickness slightly smaller than the distance L between the bottom portion of the mounting hole 50 and the lower end of the lower housing 27, and play (looseness) is provided between the plate 31 and the lower housing 27. In a modification, the plate 31 may be held between the body 2 and the lower housing 27 without such play. This allows the plate 31 to be stably supported. In this case, the plate 31 is preferably made of a material having lower hardness than the lower housing 27, such as a resin material.

[0062] In the embodiment described above, an example in which the power element 3 (the housing 25) is mounted on the body 2 by screwing of the screw portion has been presented. In a modification, the power element (housing) and the body may be assembled by press-fitting or swaging.

[0063] While the expansion valve of the embodiment described above is suitably applicable to a refrigeration cycle using an alternative for chlorofluorocarbon (HFC-134a) or the like as the refrigerant, the expansion valve of the present invention can also be applied to a refrigeration cycle using a refrigerant such as carbon dioxide with high working pressure. In this case, an external heat exchanger such as a gas cooler is provided instead of the condenser in the refrigeration cycle.

[0064] In the embodiment described above, an example in which the expansion valve is a valve for throttling and expanding a refrigerant having flowed therein via an external heat exchanger and supplying the resulting refrigerant to an evaporator (internal evaporator) has been presented. In a modification, the expansion valve may be applied to a heat pump automotive air conditioner and disposed downstream of an internal condenser (internal heat exchanger). Specifically, the expansion valve may be a valve for throttling and expanding a refrigerant having flowed therein via an internal condenser and supplying the resulting refrigerant to an external heat exchanger (external evaporator).

[0065] The present invention is not limited to the above-described embodiment and modifications only, and the components may be further modified to arrive at various other embodiments without departing from the scope of the invention. Various other embodiments may be further formed by combining, as appropriate, a plurality of structural components disclosed in the above-described embodiment and modifications. Furthermore, one or some of all of the components exemplified in the above-described embodiment and modifications may be left unused or removed.

Claims

1. An expansion valve (1) for throttling and expanding a refrigerant flowing from an upstream side and supplying the expanded refrigerant to an evaporator and for sensing a pressure and a temperature of the refrigerant returning from the evaporator to control an opening degree of a valve section, the expansion valve (1) comprising:

   a body (2) having a first passage (13) through which the refrigerant flowing from the upstream

side toward the evaporator passes, a second passage (14) through which the refrigerant returning from the evaporator passes, a valve hole (16) formed in the first passage (13), and a mounting hole (50) communicating with the second passage (14);
a valve element (18) that moves toward and away from the valve hole (16) to adjust an opening degree of the valve section;
a power element (3, 203) having a housing (25) mounted on the body (2) in such a manner as to close the mounting hole (50), a diaphragm (28) partitioning an inside of the housing (25) into a closed space (S1) in which a temperature sensing medium is sealed and an open space (S2) communicating with the second passage (14), and a disc (29) located in the open space (S2) in contact with the diaphragm (28);
a shaft (33) extending through a partition (35) between the first passage (13) and the second passage (14), having a first end connected to the diaphragm (28) through the disc (29) and a second end connected to the valve element (18), and being configured to transmit a drive force in an axial direction to the valve element (18), the drive force being generated by displacement of the diaphragm (28); and
an inflow regulating part (31, 231, 331) that separates the open space (S2) from the second passage (14), has an insertion hole (36), through which the shaft (33) extends, coaxially along a central axis of the inflow regulating part (31, 231, 331), and limits a flow of the refrigerant from the second passage (14) into the open space (S2) to a flow through a clearance between the shaft (33) and the insertion hole (36),
wherein the insertion hole (36) is formed such that an opening area of the clearance between the shaft (33) and the insertion hole (36) is 7.0 mm^2 or smaller.

2. The expansion valve (1) according to claim 1, wherein the inflow regulating part (31, 231, 331) is constituted by a shield member (31, 231, 331) located between the body (2) and the housing (25) and prevented from dropping off from the mounting hole (50).

3. The expansion valve (1) according to claim 2, wherein the shield member (31, 231, 331) is a flat, circular plate (31, 231, 331) and has the insertion hole (36) at the center.

4. The expansion valve (1) according to claim 2 or claim 3,
wherein the body (2) has a communication hole (52) through which the mounting hole (50) and the second passage (14) communicate with each other, and
the shield member (31, 231, 331) is supported by a stepped portion formed at a boundary of the mounting hole (50) and the communication hole (52).

5. The expansion valve (1) according to claim 4, wherein the shield member (31, 231, 331) has an outer diameter smaller than an inner diameter of the mounting hole (50), and the shield member (31, 231, 331) is not fixed to the mounting hole (50) in a radial direction.

6. The expansion valve (1) according to any one of claims 2 to 5, wherein the shield member (31, 231, 331) is held between the housing (25) and the body (2).

7. The expansion valve (1) according to any one of claims 1 to 6, wherein the inflow regulating part (31, 231, 331) is made of a resin material having a smaller hardness than the housing (25).

8. The expansion valve (1) according to any one of claims 1 to 7, wherein the insertion hole (36) has a cross section of a perfect circular shape.

FIG.1

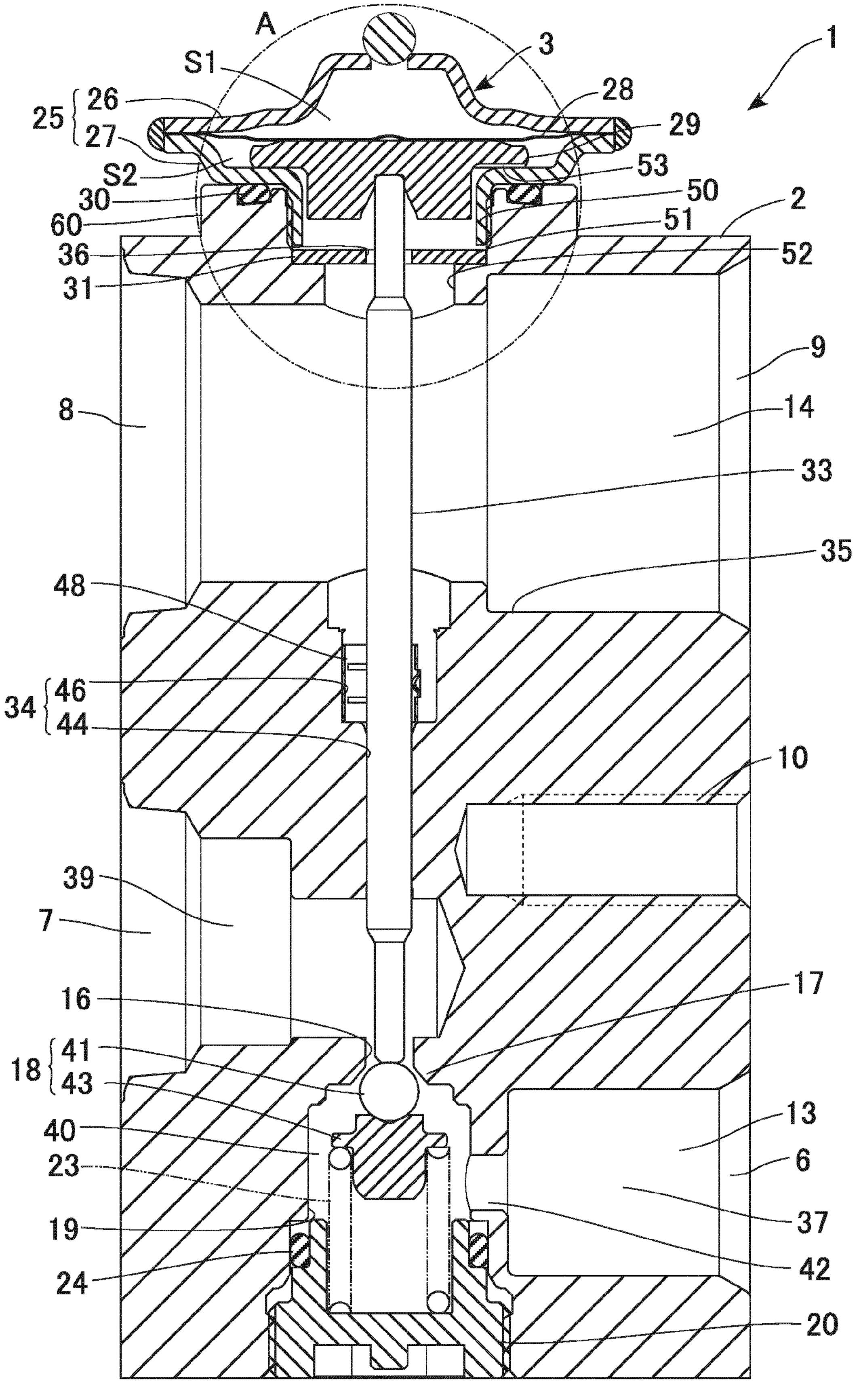

A
S1
3
1
25
26
27
28
29
S2
53
30
50
60
51
2
36
52
31
9
8
14
33
35
48
34
46
44
10
39
7
16
17
18
41
43
13
40
6
23
37
19
42
24
20

FIG.2A

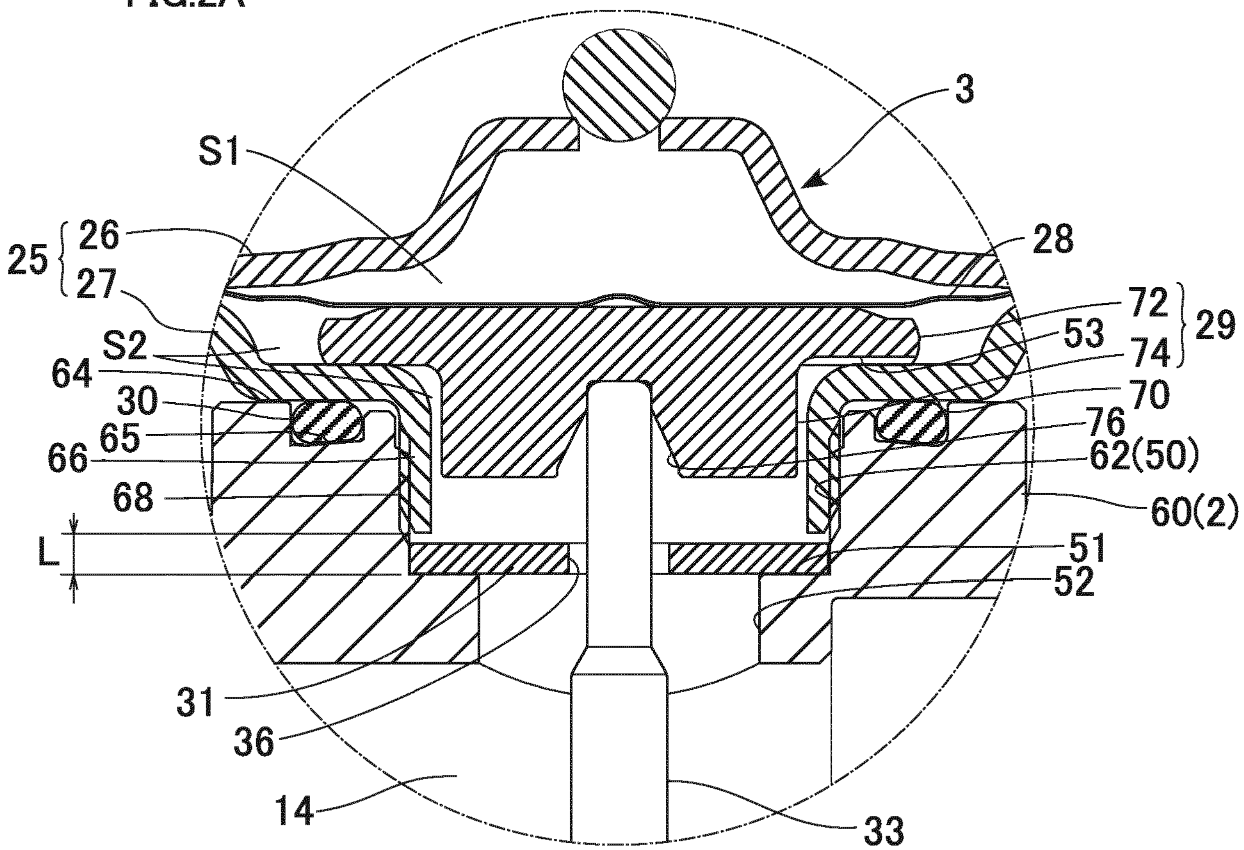

3
S1
26
25
27
28
72
29
53
S2
74
64
70
30
76
65
62(50)
66
68
60(2)
L
51
52
31
36
14
33

FIG.2B

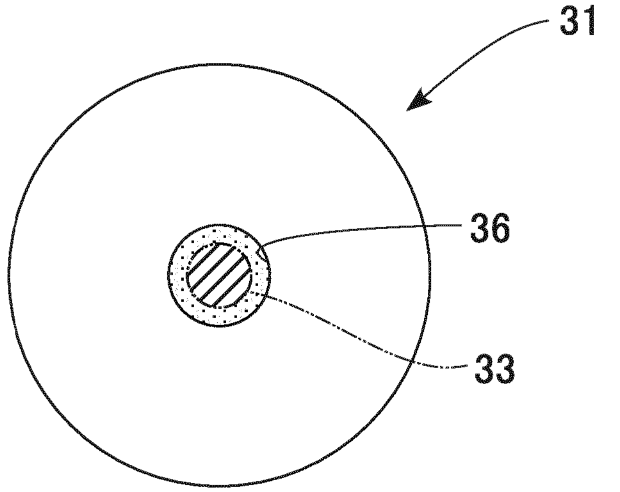

31
36
33

FIG.3A

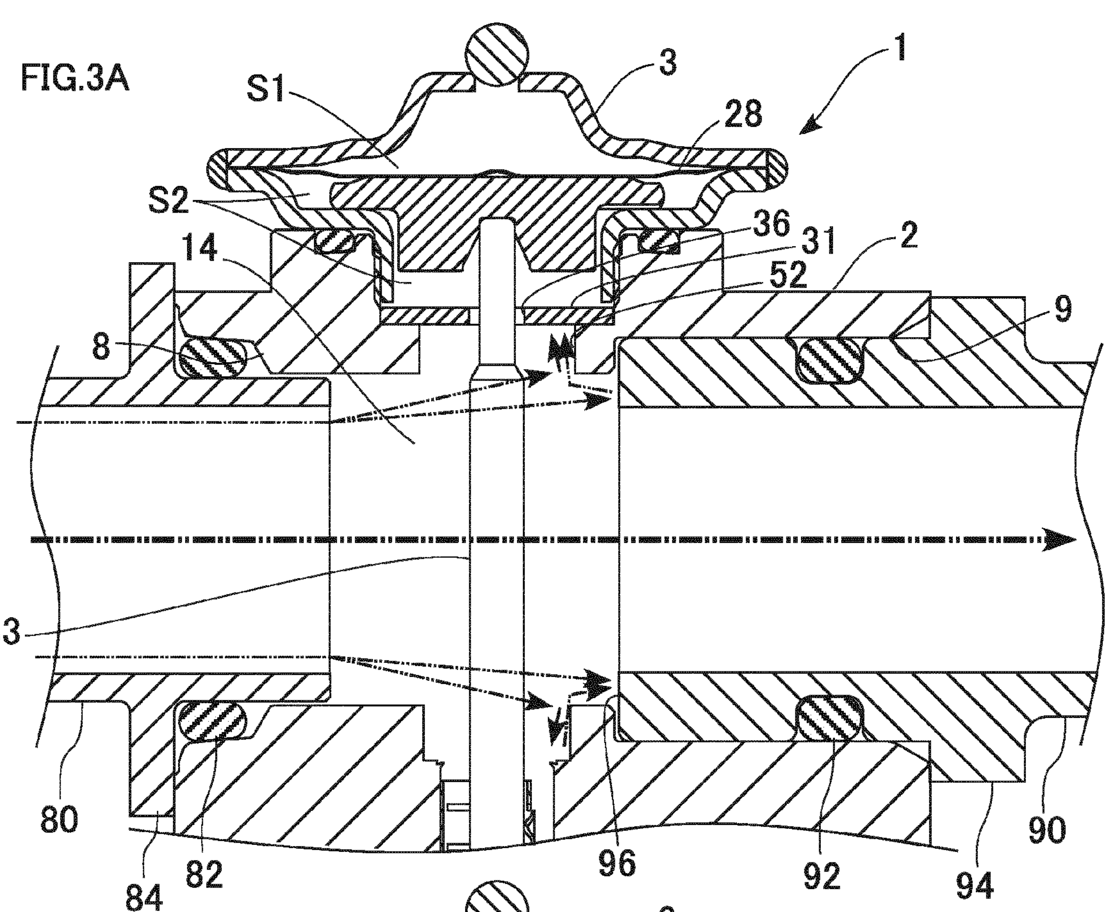

1
3
S1
28
S2
36
31
14
2
52
9
8
33
80
84
82
96
92
94
90

FIG.3B

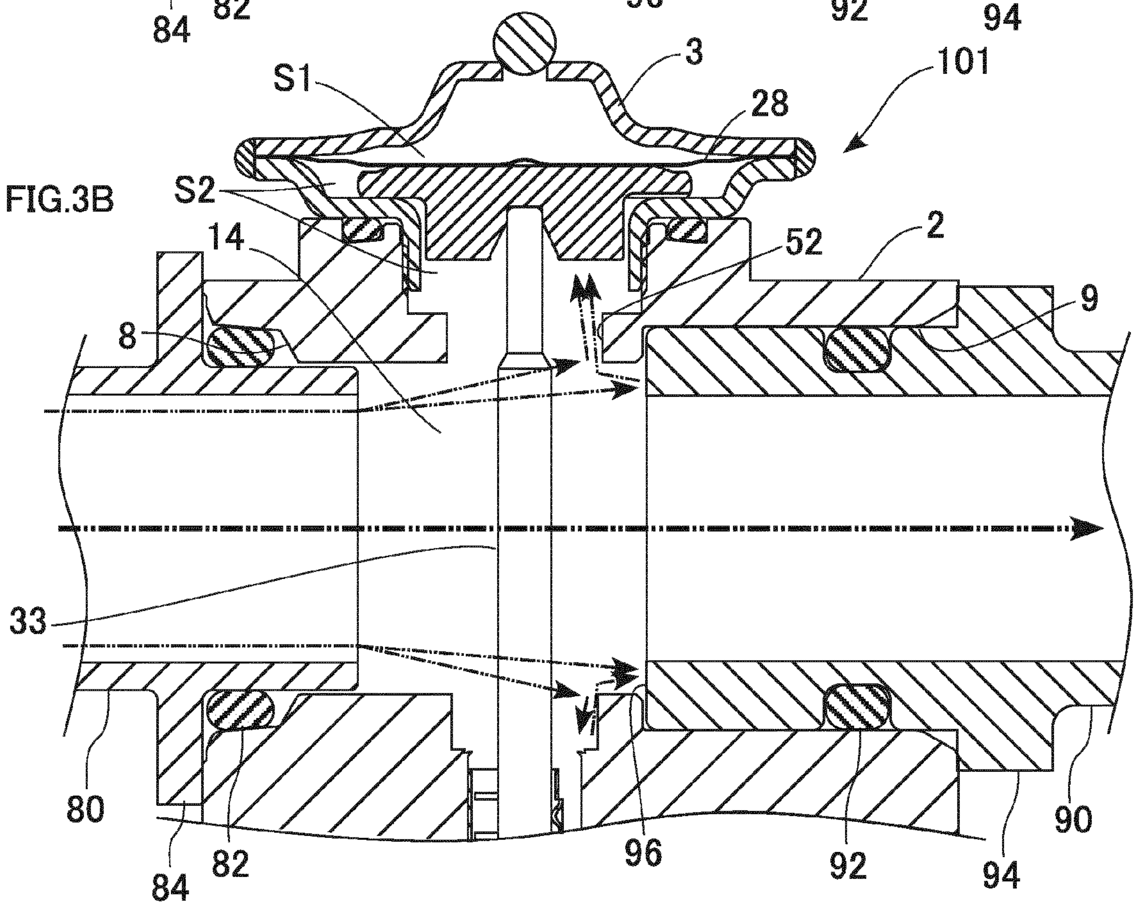

101
3
S1
28
S2
14
52
2
9
8
33
80
84
82
96
92
94
90

FIG.4A

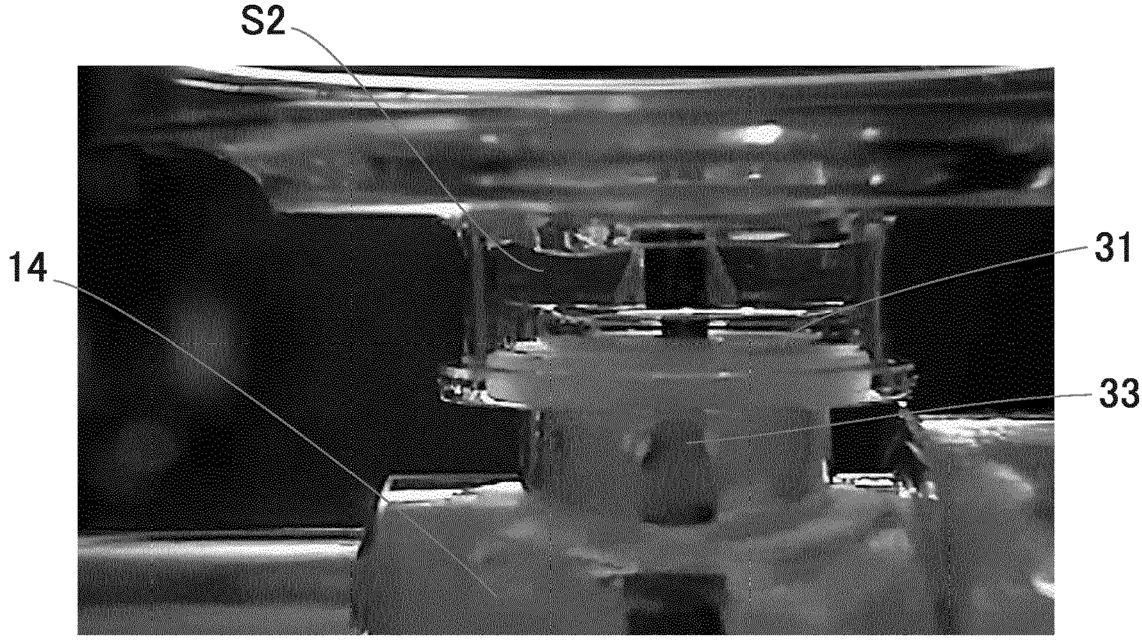


FIG.4B

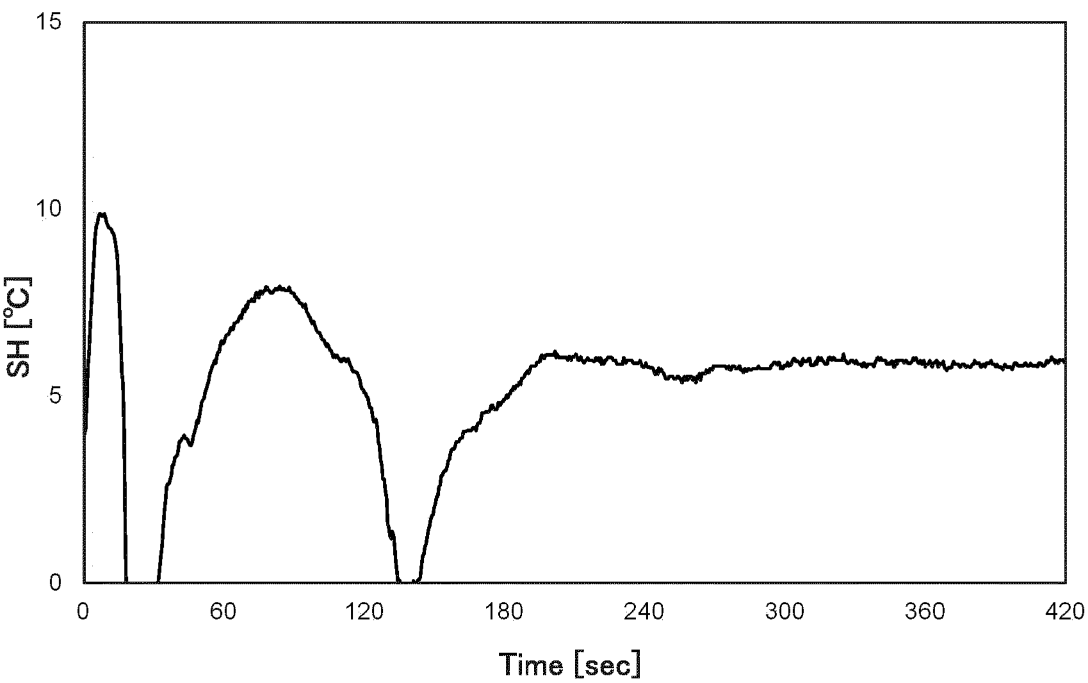


FIG.5A

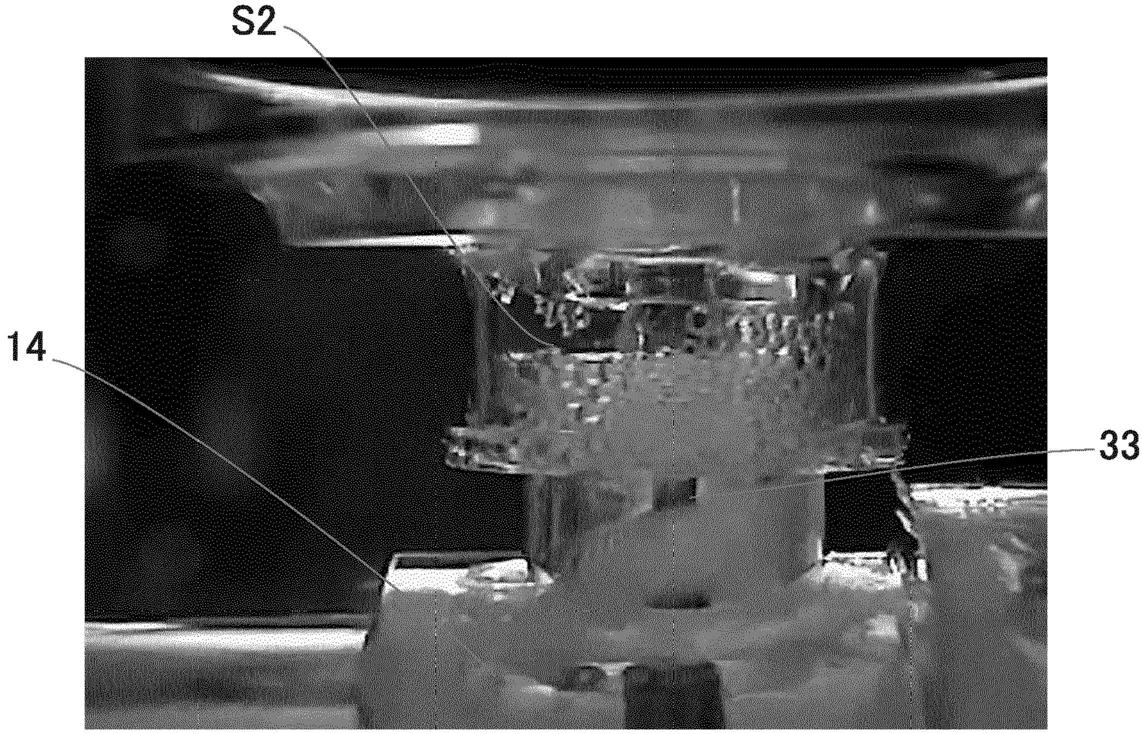


FIG.5B

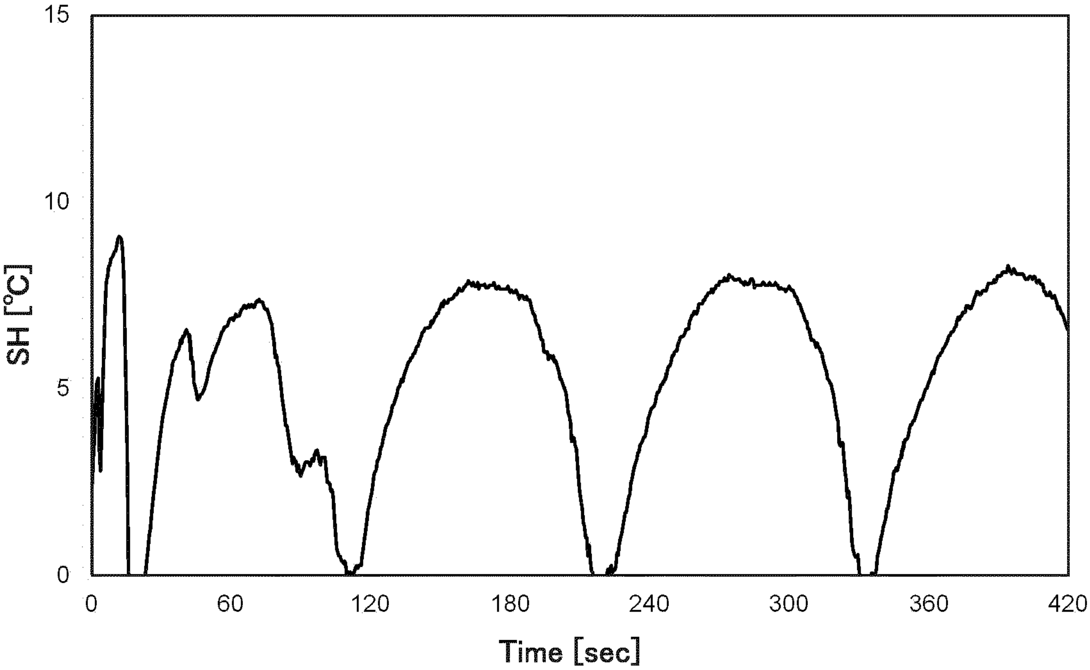


FIG.6

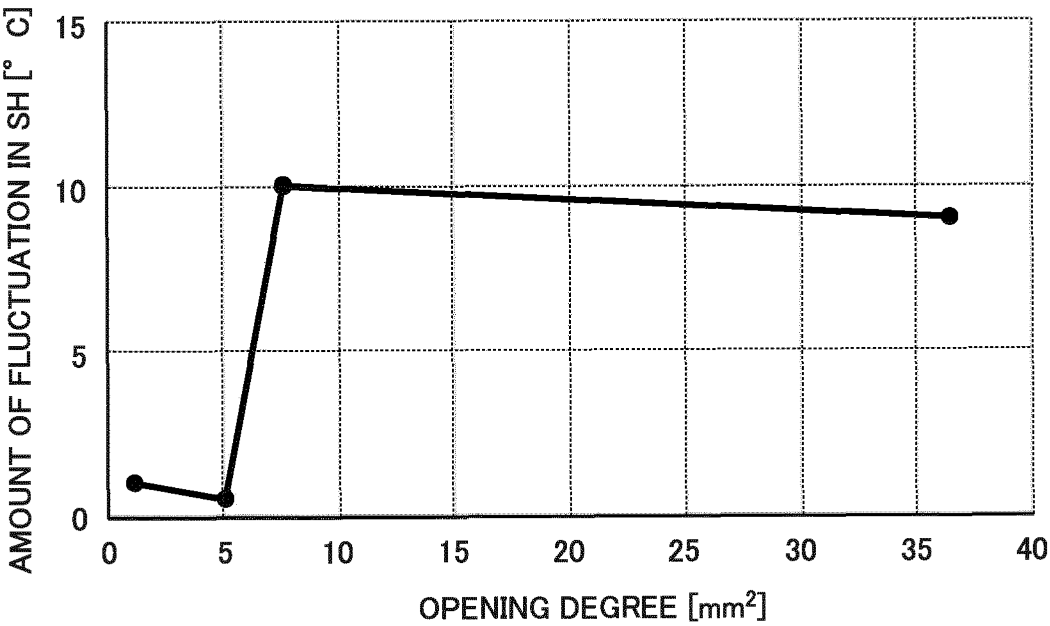

AMOUNT OF FLUCTUATION IN SH [° C]
15
10
5
0
0
5
10
15
20
25
30
35
40
OPENING DEGREE [mm2]

FIG.7A

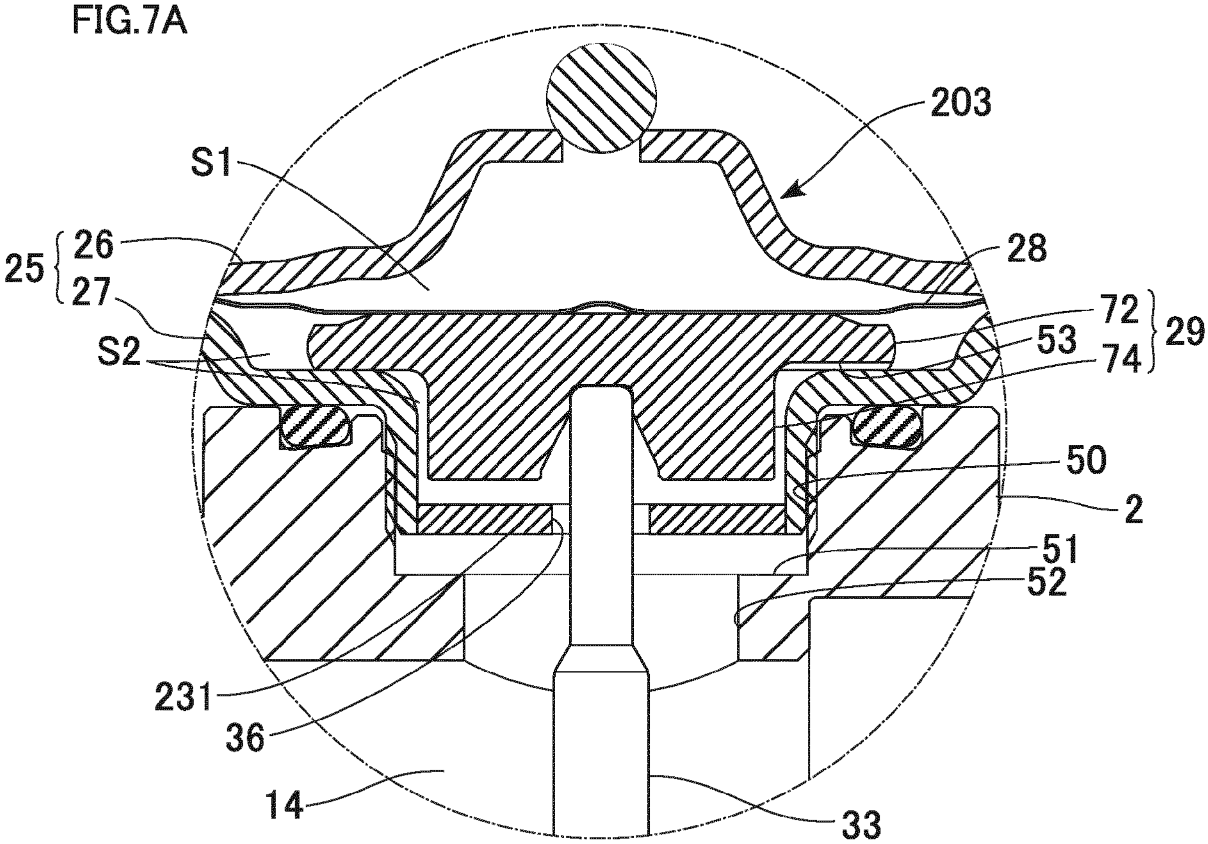
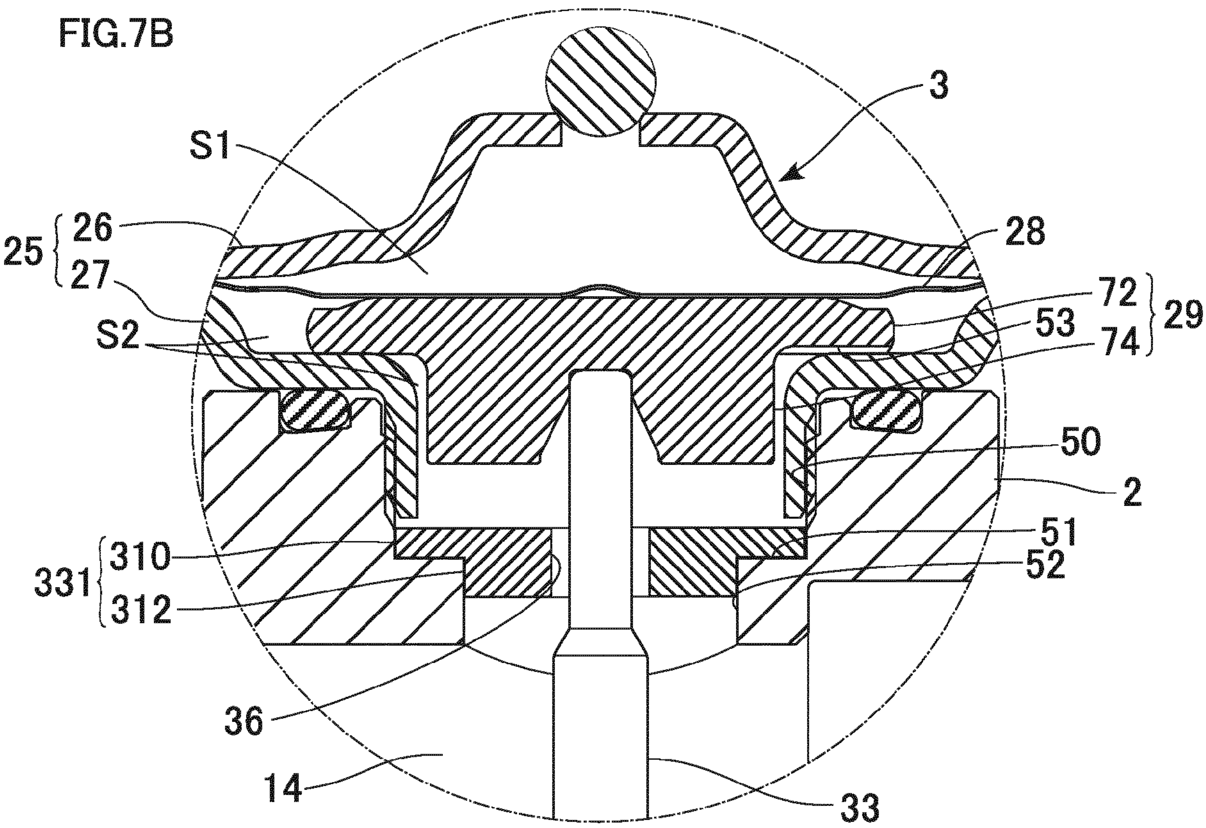

203
S1
25
26
27
28
72
29
S2
53
74
50
2
51
52
231
36
14
33

FIG.7B


3
S1
25
26
27
28
72
29
S2
53
74
50
2
331
310
51
312
52
36
14
33

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 18 15 1983

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 2009/045264 A1 (LOU ZHENG [US] ET AL) 19 February 2009 (2009-02-19) * paragraph [0040]; figure 8 * -----	1,8 2-7	INV. F25B41/06
X A	JP 2016 090067 A (TGK CO LTD) 23 May 2016 (2016-05-23) * abstract; figures 4a,4b * -----	1,8 2-7	
A	JP H10 122706 A (FUJI KOKI KK) 15 May 1998 (1998-05-15) * abstract; figures * -----	1-8	
A	JP 2000 304382 A (FUJI KOKI KK) 2 November 2000 (2000-11-02) * abstract; figures * -----	1-8	

TECHNICAL FIELDS SEARCHED (IPC)
F25B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	16 May 2018	Ritter, Christoph

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 18 15 1983

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

16-05-2018

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009045264 A1	19-02-2009	NONE	
JP 2016090067 A	23-05-2016	NONE	
JP H10122706 A	15-05-1998	NONE	
JP 2000304382 A	02-11-2000	JP 4294155 B2	08-07-2009
		JP 2000304382 A	02-11-2000

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

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2013242129 A **[0002] [0007] [0032]**
- JP 2013245921 A **[0006] [0007] [0008]**