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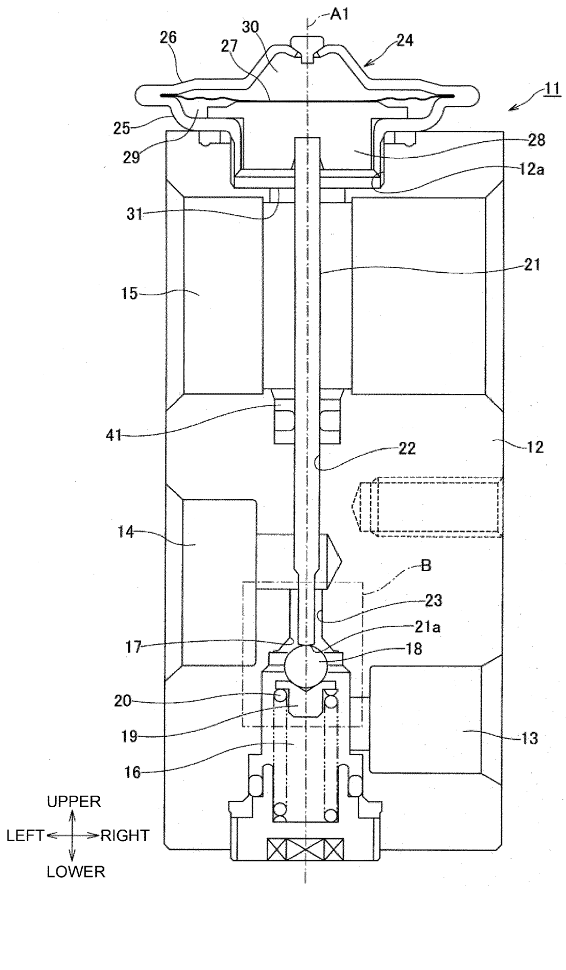
(54) **EXPANSION VALVE**

(57) To suppress generation of a valve vibration sound without any another member such as an anti-vibration spring. In an expansion valve including a valve main body (12) having a valve chamber (16) which is communicated with a refrigerant inflow channel (13) and a refrigerant outflow channel (14), a valve body (18) which is arranged within the valve chamber, and changes a flow rate of the refrigerant by moving forward and backward with respect to a valve seat (17), a biasing member (20) which biases the valve body toward the valve seat, an actuating bar (21) which comes into contact with the valve body and moves the valve body in a valve opening direction against a biasing force generated by the biasing member, and a drive unit (24) which drives the actuating bar, the valve body is adapted to include a convex curved surface (for example, a spherical body), a leading end surface (21a) of the actuating bar is formed into a convex curved surface (for example, a spherical surface), and the leading end surface is brought into contact with the convex curved surface of the valve body.

FIG. 1



EP 4 080 139 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to an expansion valve, and more particularly to a technique for suppressing a valve vibration of an expansion valve which is provided in a refrigeration cycle equipment such as an air conditioner.

BACKGROUND ART

[0002] In the refrigeration cycle equipment such as a car air-conditioner, an expansion valve is provided for sufficiently bringing out a performance of an evaporator. The expansion valve is configured to narrow down a refrigerant supplied to the evaporator in response to a refrigerant temperature in an outlet side piping of the evaporator, and control to an optimum flow rate.

[0003] In the meantime, in the expansion valve mentioned above, a valve vibration may be generated by the refrigerant flowing within the valve, and an abnormal noise may be generated. Thus, a technique for suppressing the valve vibration has been conventionally proposed (refer, for example, to the following patent literature 1).

CITATION LIST

PATENT LITERATURE

[0004] Patent Literature 1: Japanese Unexamined Patent Publication No. 2014-149128

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0005] In the meantime, in the conventional expansion valve, a ball valve (a spherical valve body) tends to become unstable particularly when the valve has a very small opening degree, and the valve vibration sound accordingly tends to be generated. As a result of detail consideration of a cause and a mechanism thereof, the following facts have been found.

[0006] First of all, in a case where the valve body is eccentric when the valve has a very small opening degree, a bias is generated between a fluid pressure and a flow rate within a flow channel opening between the valve body and the valve seat, so that the valve body comes to an unstable state, and the valve body is vibrated.

[0007] Next, there is a problem in a vibration of an actuating bar. The actuating bar transmitting a driving force of a drive unit to the valve body extends through a valve main body from an upper surface portion of the valve main body in which the drive unit is arranged, to a valve chamber in a lower portion of the valve main body in which the valve body is provided, and a leading end thereof is in contact with the valve body. Further, in a portion (an actuating bar insertion hole) passing through the valve main body, a fixed clearance (a gap) S is provided with respect to the valve main body 12 as shown in Fig. 9 in order to allow a sliding motion of the actuating bar. Therefore, the actuating bar 21 vibrates together with the valve body within the clearance S between the actuating bar and the valve main body 12 when the valve vibration is generated, and the vibration may cause the generation of an abnormal noise.

[0008] On the one hand, in order to suppress the vibration of the actuating bar as mentioned above, in the invention described in the patent literature 1 mentioned above, an anti-vibration spring is provided in an intermediate portion of the actuating bar, and the actuating bar is pressed against an inner wall of the valve main body (an inner wall surface of the actuating bar insertion hole), thereby achieving a vibration suppression of the actuating bar.

[0009] However, in the invention mentioned above, there is a problem that manhours of assembling the expansion valve is increased as well as the number of parts is increased since the new member (the anti-vibration spring) is necessarily provided for the anti-vibration.

[0010] On the other hand, there has been conventionally proposed to be provided with the anti-vibration spring within the valve chamber and suppress the vibration of the valve body via the valve body support member.

[0011] However, the method as mentioned above is necessarily provided with the anti-vibration spring as another member in the same manner as that of the invention described in the above-mentioned patent literature. In addition, a structure within the valve chamber is complicated for installing the anti-vibration spring. Thus, there is a problem that an assembling work of the expansion valve is complicated. Further, the anti-vibration spring provided in the valve chamber comes to a flow resistance for the refrigerant, and the anti-vibration spring itself may vibrate depending on a shape and an arranged position of the vibration proofing spring, thereby causing the generation of the abnormal noise. Therefore, it is desirable to have as few extra member as possible in the valve chamber which comes to the flow channel of the refrigerant.

[0012] Therefore, an object of the present invention is to obtain a new valve structure which can suppress generation of a valve vibration sound without any another member such as an anti-vibration spring.

SOLUTION TO PROBLEM

[0013] In order to solve the problem and achieve the object, the present inventions relate to an expansion valve. Among them, a first invention is characterized by a contact structure between an actuating bar and a valve body (a leading end structure of the actuating bar), and a second invention is characterized by an engagement structure between an actuating bar and a drive unit (a base end portion of the actuating bar and an actuating bar receiving member of the drive unit). A description will be given below of each of the inventions.

[First Invention]

[0014] An expansion valve according to a first aspect of the present invention is an expansion valve including a valve main body having a valve chamber which is communicated with an inflow channel introducing a refrigerant and an outflow channel discharging the refrigerant, a valve body which is arranged in an inner portion of the valve chamber, and changes a flow rate of the refrigerant by moving forward and backward with respect to a valve seat between a valve-closed state in which the valve body seats on the valve seat and a valve-opened state in which the valve body separates from the valve seat, a biasing member which biases the valve body toward the valve seat, an actuating bar which comes into contact with the valve body and moves the valve body in a valve opening direction against a biasing force generated by the biasing member, and a drive unit which drives the actuating bar, wherein the valve body includes a convex curved surface, a leading end surface of the actuating bar is formed into a convex curved surface (a curved surface protruding toward the valve body), and the leading end surface of the actuating bar is brought into contact with the convex curved surface of the valve body.

[0015] A lateral displacement (a displacement toward a direction intersecting with a valve opening and closing direction) of the valve body can be listed up as mentioned above as one of causes by which the valve vibration is generated. Accordingly, in the first aspect of the present invention, the leading end surface of the actuating bar is formed into the convex curved surface and is brought into contact with the convex curved surface of the valve body. That is to say, the actuating bar and the valve body should be in contact with each other on the curved surfaces.

[0016] According to the contact structure as mentioned above, a force (a load) toward the lateral direction (the direction intersecting with the valve opening and closing direction) is applied to the actuating bar (refer to reference sign F1 in Fig. 3 mentioned later) when the valve body displaces laterally. Therefore, the actuating bar is pressed against the valve main body (for example, an inner surface of an actuating bar insertion hole which is formed between a drive unit installation part of the valve main body having the drive unit fixed thereto and the valve chamber, and allows the actuating bar to be inserted). Thus, it is possible to suppress the vibration of the actuating bar without provision of the anti-vibration spring.

[0017] The term "convex curved surface" with regard to the actuating bar and the valve body typically corresponds to a spherical surface, however, is not limited to the spherical surface. For example, the object of the present invention can be achieved by the other convex curved surface than the spherical surface, for example, a paraboloid surface, and the term "convex curved surface" is accordingly a concept widely including the convex curved surface. Further, the valve body typically corresponds to a spherical body (a body having a spherical shape) such as an embodiment mentioned later, however, is not limited to the spherical body. A whole shape of the valve body (a shape of the other portions than the contact portion with the actuating bar) is not particularly limited. As long as the convex curved surface is at least partly included, that is, the portion coming into contact with the actuating bar is formed into the convex curved surface, the object of the present invention can be achieved.

[0018] As a mode which can obtain the same operations and effects, an expansion valve according to a first mode of the first aspect mentioned above is adapted to form the leading end surface of the actuating bar as a conical surface.

[0019] In particular, an expansion valve according to the first mode is an expansion valve including a valve main body having a valve chamber which is communicated with an inflow channel introducing a refrigerant and an outflow channel discharging the refrigerant, a valve body which is arranged in an inner portion of the valve chamber, and changes a flow rate of the refrigerant by moving forward and backward with respect to a valve seat between a valve-closed state in which the valve body seats on the valve seat and a valve-opened state in which the valve body separates from the valve seat, a biasing member which biases the valve body toward the valve seat, an actuating bar which comes into contact with the valve body and moves the valve body in a valve opening direction against a biasing force generated by the biasing member, and a drive unit which drives the actuating bar, wherein the valve body includes a convex curved surface, a leading end surface of the actuating bar is formed into a conical surface (a conical surface protruding toward the valve body), and the leading end surface is brought into contact with the convex curved surface of the valve body.

[0020] Here, the term "conical shape" mentioned above does not mean only an exact cone having a sharp apex. For example, a curved surface having a dome-shaped round curved top (apex) can achieve the same object. Therefore, the term "conical shape" mentioned above is a concept including such a shape (a conical shape having a rounded leading end).

[Second Invention]

[0021] A second aspect of the present invention is an engagement structure between a base end portion of an actuating bar and a drive unit (an actuating bar receiving member), which is adapted to generate a lateral load in the actuating bar by bringing the curved surfaces into contact with each other in the same manner as the first aspect mentioned above. However, the load (refer to reference symbol F2 in Fig. 5 mentioned later) can be generated regardless of presence of the lateral displacement of the valve body.

[0022] In particular, an expansion valve according to a second aspect of the present invention is an expansion valve including a valve main body having a valve chamber which is communicated with an inflow channel introducing a refrigerant and an outflow channel discharging the refrigerant, a valve body which is arranged in an inner portion of the valve chamber, and changes a flow rate of the refrigerant by moving forward and backward with respect to a valve seat between a valve-closed state in which the valve body seats on the valve seat and a valve-opened state in which the valve body separates from the valve seat, a biasing member which biases the valve body toward the valve seat, an actuating bar which comes into contact with the valve body and moves the valve body in a valve opening direction against a biasing force generated by the biasing member, and a drive unit which has an actuating bar receiving member engaging with the actuating bar and transmits a driving force to the actuating bar via the actuating bar receiving member, wherein a base end surface of the actuating bar engaging with the actuating bar receiving member is formed into a convex curved surface, the actuating bar receiving member is provided with a projection portion which is formed into a convex curved surface in a leading end surface thereof, and the base end surface of the actuating bar and the leading end surface of the projection portion are brought into contact with each other in such a manner as to confront with each other while making the actuating bar and the projection portion eccentric, the base end surface of the actuating bar being formed into the convex curved surface (a curved surface protruding toward the projection portion), and the leading end surface of the projection portion being formed into the convex curved surface (a curved surface protruding toward the actuating bar).

[0023] In the second aspect, the transmission of the driving force from the drive unit to the actuating bar is performed via the actuating bar receiving member, however, the actuating bar receiving member is provided with the projection portion which is formed into the convex curved surface in the leading end surface thereof, and the base end surface (an end surface opposite to the leading end surface which comes into contact with the valve body) of the actuating bar is formed into the convex curved surface. Further, the contact between the curved surfaces is formed by bringing both the convex curved surfaces (the projection portion and the actuating bar base end surface) into contact with each other in such a manner as to confront with each other in a state in which both (the actuating bar and the projection portion) are made eccentric.

[0024] The term "eccentric" mentioned above means a state in which an apex of the convex curved surface of the projection portion leading end portion is misaligned with an apex of the convex curved surface of the actuating bar base end portion in a horizontal direction (a direction which is orthogonal to an axis of the projection portion and an axis of the actuating bar). For example, the projection portion (the actuating bar receiving member) and the actuating bar may be arranged in such a manner that a center axis (the axis) of the projection portion and a center axis (the axis) of the actuating bar are parallel without coming into line. Further, the meaning of the term "convex curved surface" is the same as that of the first aspect mentioned above (same applies to each of modes of the second aspect mentioned later).

[0025] According to the structure mentioned above, the lateral load is always applied to the actuating bar regardless of presence of the lateral displacement of the valve body, and it is possible to achieve the vibration suppression.

[0026] Further, in the second aspect, the spherical surface may be provided by forming the base end portion of the actuating bar and the projection portion of the actuating bar receiving member into the conical surface in place of the convex curved surface or fixing the spherical member in the same manner as the first aspect. The following modes correspond to these modes. The meaning of the term "eccentric" in each of the modes is as described in the second aspect, and the meaning of the term "conical surface" is as described in the first aspect mentioned above.

[0027] An expansion valve according to a second mode of the second aspect is an expansion valve including a valve main body having a valve chamber which is communicated with an inflow channel introducing a refrigerant and an outflow channel discharging the refrigerant, a valve body which is arranged in an inner portion of the valve chamber, and changes a flow rate of the refrigerant by moving forward and backward with respect to a valve seat between a valve-closed state in which the valve body seats on the valve seat and a valve-opened state in which the valve body separates from the valve seat, a biasing member which biases the valve body toward the valve seat, an actuating bar which comes into contact with the valve body and moves the valve body in a valve opening direction against a biasing force generated by the biasing member, and a drive unit which has an actuating bar receiving member engaging with the actuating bar and transmits a driving force to the actuating bar via the actuating bar receiving member, wherein a base end surface of the actuating bar engaging with the actuating bar receiving member is formed into a conical surface, the actuating bar receiving member is provided with a projection portion which is formed into a convex curved surface in a leading end surface thereof, and the base end surface of the actuating bar and the leading end surface of the projection portion are brought into contact with each other in such a manner as to confront with each other while making the actuating bar and the projection portion eccentric, the base end surface of the actuating bar being formed into the conical surface, and the leading end surface of the projection portion being formed into the convex curved surface.

[0028] An expansion valve according to a third mode of the second aspect is an expansion valve including a valve main body having a valve chamber which is communicated with an inflow channel introducing a refrigerant and an outflow channel discharging the refrigerant, a valve body which is arranged in an inner portion of the valve chamber, and changes a flow rate of the refrigerant by moving forward and backward with respect to a valve seat between a valve-closed state in which the valve body seats on the valve seat and a valve-opened state in which the valve body separates from the valve seat, a biasing member which biases the valve body toward the valve seat, an actuating bar which comes into contact with the valve body and moves the valve body in a valve opening direction against a biasing force generated by the biasing member, and a drive unit which has an actuating bar receiving member engaging with the actuating bar and transmits a driving force to the actuating bar via the actuating bar receiving member, wherein a base end surface of the actuating bar engaging with the actuating bar receiving member is formed into a convex curved surface, the actuating bar receiving member is provided with a projection portion which is formed into a conical surface in a leading end surface thereof, and the base end surface of the actuating bar and the leading end surface of the projection portion are brought into contact with each other in such a manner as to confront with each other while making the actuating bar and the projection portion eccentric, the base end surface of the actuating bar being formed into the convex curved surface, and the leading end surface of the projection portion being formed into the conical surface.

[0029] An expansion valve according to a fourth mode of the second aspect is an expansion valve including a valve main body having a valve chamber which is communicated with an inflow channel introducing a refrigerant and an outflow channel discharging the refrigerant, a valve body which is arranged in an inner portion of the valve chamber, and changes a flow rate of the refrigerant by moving forward and backward with respect to a valve seat between a valve-closed state in which the valve body seats on the valve seat and a valve-opened state in which the valve body separates from the valve seat, a biasing member which biases the valve body toward the valve seat, an actuating bar which comes into contact with the valve body and moves the valve body in a valve opening direction against a biasing force generated by the biasing member, and a drive unit which has an actuating bar receiving member engaging with the actuating bar and transmits a driving force to the actuating bar via the actuating bar receiving member, wherein a base end surface of the actuating bar engaging with the actuating bar receiving member is formed into a conical surface, the actuating bar receiving member is provided with a projection portion which is formed into a conical surface in a leading end surface thereof, and the base end surface of the actuating bar and the leading end surface of the projection portion are brought into contact with each other in such a manner as to confront with each other while making the actuating bar and the projection portion eccentric, the base end surface of the actuating bar being formed into the conical surface, and the leading end surface of the projection portion being formed into the conical surface.

[0030] The first invention and the second invention mentioned above can be summarized as follows. The expansion valve according to the present invention includes a valve main body having a valve chamber which is communicated with an inflow channel introducing a refrigerant and an outflow channel discharging the refrigerant, a valve body which is arranged in an inner portion of the valve chamber, and changes a flow rate of the refrigerant by moving forward and backward with respect to a valve seat between a valve-closed state in which the valve body seats on the valve seat and a valve-opened state in which the valve body separates from the valve seat, a biasing member which biases the valve body toward the valve seat, an actuating bar which comes into contact with the valve body and moves the valve body in a valve opening direction against a biasing force generated by the biasing member, and a drive unit which has an actuating bar receiving member engaging with the actuating bar and transmits a driving force against the biasing force to the actuating bar via the actuating bar receiving member, wherein at least one of a portion between the actuating bar receiving member and the actuating bar, and a portion between the actuating bar and the valve body comes into contact or engages with each other between convex surfaces which are pressed by the biasing force. Further, as the expansion valve according to the present invention, the expansion valve to which both the first aspect and the second aspect are applied can be listed up, in addition to the expansion valves to which only one of the first aspect and the second aspect is applied.

EFFECT OF INVENTION

[0031] According to the present invention, it is possible to suppress the generation of the valve vibration sound without depending on another member such as the vibration proofing spring.

[0032] The other objects, features and advantages of the present invention can be apparent from the following description of embodiments according to the present invention which will be given on the basis of the accompanying drawings. Further, in the drawings, same reference numerals denote same or corresponding portions.

BRIEF DESCRIPTION OF DRAWINGS

[0033]

Fig. 1 is a vertical cross sectional view showing an expansion valve (in a valve-opened state) according to a first embodiment of the present invention.

Fig. 2 is a view showing a valve body arranged portion (a portion of reference sign B in Fig. 1) of the expansion valve (in a valve-closed state) according to the first embodiment in an enlarged manner.

Fig. 3 is a view showing a state in which the valve body is laterally displaced in the expansion valve (in the valve-opened state according to the first embodiment.

Fig. 4 is a view showing a valve body arranged portion of an expansion valve (in a valve-closed state) according to a second embodiment of the present invention in the same manner as Fig. 2.

Fig. 5 is a vertical cross sectional view showing an upper portion (an engagement portion between a drive unit and an actuating bar) of an expansion valve according to a third embodiment of the present invention in an enlarged manner.

Fig. 6 is a view showing an upper portion (an engagement portion between a drive unit and an actuating bar) of an expansion valve according to a fourth embodiment of the present invention in the same manner as Fig. 5.

Fig. 7 is a view showing an upper portion (an engagement portion between a drive unit and an actuating bar) of an expansion valve according to a fifth embodiment of the present invention in the same manner as Fig. 5.

Fig. 8 is a view showing an upper portion (an engagement portion between a drive unit and an actuating bar) of an expansion valve according to a sixth embodiment of the present invention in the same manner as Fig. 5.

Fig. 9 is a vertical cross sectional view showing a relationship (an actuating bar insertion hole portion) between an actuating bar and a valve main body in an expansion valve.

DESCRIPTION OF EMBODIMENTS

[First Embodiment]

[0034] A description will be given of an expansion valve according to a first embodiment of the present invention with reference to Figs. 1 to 3. Fig. 1 shows a two-dimensional coordinate indicating longitudinal and lateral directions which are orthogonal to each other, and the following description will be given on the basis of these directions.

[0035] As shown in Figs. 1 and 2, an expansion valve 11 according to the first embodiment of the present invention is provided with a valve main body 12 having a valve chamber 16 which is communicated with an inflow channel 13 introducing a refrigerant and an outflow channel 14 discharging the refrigerant, a spherical valve body 18 (forming a spherical body) which changes a flow rate of the refrigerant by moving forward and backward (moving up and down) with respect to a valve seat 17 between a valve-closed state in which the valve body seats on the valve seat 17 provided within the valve chamber 16 and a valve-opened state in which the valve body separates from the valve seat 17, a biasing member (a compression coil spring) 20 which biases the valve body 18 toward the valve seat 17 via a valve body support member 19 and presses the valve body 18 against a lower end surface 21a of an actuating bar 21, the actuating bar 21 which moves the valve body 18 toward a valve opening direction (downward) against a biasing force generated by the biasing member 20, a diaphragm device 24 which is fixed to a drive unit installation part 12a in an upper surface portion of the valve main body and drives the valve body 18 via the actuating bar 21, and a return flow channel 15 which passes through an upper portion of the valve main body 12 and allows passage of the refrigerant.

[0036] The actuating bar 21 is arranged in an inner portion of the valve main body 12 in such a manner as to extend in a perpendicular direction (a vertical direction), and connects an upper end portion (a base end portion) thereof to a diaphragm 27 within the diaphragm device 24 via an actuating bar receiving member 28. In the meantime, a lower end surface (a leading end surface) 21a of the actuating bar 21 is formed into a spherical surface (a curved surface formed into a spherical surface protruding toward the valve body 18), and the spherical lower end surface 21a is brought into contact with the valve body 18. A contact relationship and a function of the actuating bar 21 and the valve body 18 will be described in detail later.

[0037] Further, an intermediate portion of the actuating bar 21 passes through an actuating bar insertion hole 22 formed in the valve main body 12, and a fixed clearance S (not illustrated in Fig. 1 and refer to Fig. 9) is formed between the intermediate portion of the actuating bar 21 and the valve main body 12 (an inner wall surface of the actuating bar insertion hole 22) so as to allow the actuating bar 21 to move up and down. Further, in the present embodiment, an anti-vibration spring 41 (disclosed in the patent literature 1 mentioned above) coming into contact with the intermediate portion of the actuating bar 21 is provided in order to further enhance an anti-vibration function. However, the anti-vibration spring 41 is not essential for the present invention.

[0038] The return flow channel 15 passes through the upper portion of the valve main body 12 horizontally (in a left-right direction), and a refrigerant fed from an evaporator (not shown) to a compressor (not shown) passes through the return flow channel 15. Further, the refrigerant fed from a condenser (not shown) flows into the inflow channel 13, and the refrigerant is fed out of the outflow channel 14 to the evaporator (not shown) through the valve chamber 16 and a throat portion 23.

[0039] The diaphragm device 24 has a dish-shaped lower casing 25 corresponding to a casing of the diaphragm device 24, and a lid-shaped upper housing 26 covering an upper surface of the lower housing 25, and the diaphragm 27 is held between the lower housing 25 and the upper housing 26. Further, an internal space in an upper side of the diaphragm 27 (between the diaphragm 27 and the upper housing 26) is set to a working fluid encapsulating chamber 30 which encapsulates a working fluid (for example, a working gas). Further, an internal space in a lower side of the diaphragm 27 (between the diaphragm 27 and the lower housing 25) is set to a refrigerant introducing chamber 29 which introduces the refrigerant.

[0040] Further, a bottom surface center portion of the lower housing 25 is provided with an opening 31 which communicates the refrigerant introducing chamber 29 with the return flow channel 15. Therefore, the refrigerant flowing in the return flow channel 15 flows into the refrigerant introducing chamber 29 through the opening 31, and a pressure and a volume of the working fluid within the working fluid encapsulating chamber 30 changes depending on a temperature and a pressure of the refrigerant (the refrigerant flowing out of the evaporator).

[0041] Further, when the pressure of the working fluid within the working fluid encapsulating chamber 30 reduces, the diaphragm 27 is pulled upward in response to a difference from the pressure of the refrigerant introducing chamber 29, and the actuating bar 21 moves upward according to the movement of the diaphragm 27, so that the valve body 18 moves forward toward the valve seat 17 and the refrigerant flow rate is throttled. On the contrary, when the pressure of the working fluid rises up, the diaphragm 27 is pushed downward in response to the difference from the pressure of the refrigerant introducing chamber 29, and the actuating bar 21 moves downward according to the movement of the diaphragm 27, so that the valve body 18 moves backward from the valve seat 17 and the refrigerant flow rate is increased. As mentioned above, in the expansion valve 11, an amount of the refrigerant supplied from the expansion valve 11 to the evaporator is regulated in correspondence to the temperature and the pressure of the refrigerant returning from the evaporator to the expansion valve 11.

[0042] Here, the valve body 18 laterally displaces, thereby generating the valve vibration particularly when the opening degree of the valve is small, and the actuating bar 21 vibrates together with the valve body 18 as already mentioned. Then, in the present embodiment, the actuating bar 21 and the valve body 18 are adapted to come into contact with each other on the spherical surfaces. More specifically, the lower end surface 21a of the actuating bar 21 is formed into the spherical surface and the lower end surface 21a is adapted to come into contact with the spherical valve body 18.

[0043] Therefore, according to the present embodiment, when a center axis A3 of the valve body 18 displaces in a lateral direction (leftward in Fig. 3) with respect to a center axis A1 (an apex of the low-end surface 21a) of the actuating bar 21 (the spherical surface shaped lower end surface 21a) according to the lateral displacement of the valve body 18 as shown in Fig. 3 (refer also to Fig. 2 for comparison), a pressing force of the biasing member 20 is converted into a force in a horizontal direction since the valve body 18 is always pressed to the lower end surface 21a of the actuating bar 21 by the biasing member 20, so that a lateral load as shown by reference sign F1 in Fig. 3 is applied to the actuating bar 21. Thus, an intermediate portion of the actuating bar 21 is pressed to an inner wall surface of the actuating bar insertion hole 22 (refer to Fig. 1), so that the vibration of the actuating bar 21 is suppressed. Further, the vibration of the valve body 18 pressed to the lower end surface 21a of the actuating bar 21 is suppressed by the suppression of the vibration in the actuating bar 21.

[0044] In the conventional expansion valve, the lower end surface of the actuating bar 21 is formed into a flat surface. Therefore, the lateral load F1 as mentioned above is not generated even when the valve body 18 displaces laterally. On the contrary, according to the expansion valve 11 of the present embodiment which is provided with the contact structure on the spherical surfaces of the actuating bar 21 and the valve body 18, the lateral load F1 can be generated, and the valve vibration can be suppressed without the anti-vibration spring.

[0045] Further, the vibration suppression function as mentioned above can be achieved by the following second embodiment.

[Second Embodiment]

[0046] Fig. 4 shows a contact structure between a valve body 18 and an actuating bar 21 in an expansion valve according to a second embodiment of the present invention. As shown in Fig. 4, in this embodiment, a lower end surface 21b of the actuating bar 21 is formed into a conical surface (a conical surface protruding toward the valve body 18), and the lower end surface 21b is brought into contact with the spherical valve body 18.

[0047] According to the contact structure mentioned above, when the valve body 18 displaces laterally, the lower end surface 21b comes into contact with a surface of the valve body 18 forming the spherical surface. Therefore, the lateral load F1 can be generated in the same manner as the first embodiment mentioned above, and the vibration can be suppressed by pressing the actuating bar 21 to the valve main body 12 (an inner wall surface of an actuating bar insertion hole 22).

[0048] The first and second embodiments mentioned above are obtained by specifying the first aspect of the present invention. However, the lateral load can be generated in the actuating bar 21 and the vibration suppression can be achieved in the same manner by the third to sixth embodiments which are obtained by specifying the second aspect of the present invention and are mentioned below. The following third to sixth embodiments relate to an engagement structure between an actuating bar 21 and a diaphragm device 24.

[Third Embodiment]

[0049] Fig. 5 shows an engagement portion between an actuating bar 21 and a diaphragm device 24 in an expansion valve according to a third embodiment of the present invention. As shown in Fig. 6, in this embodiment, an upper end surface (a base end surface) 21d of the actuating bar 21 is processed into a spherical surface (a spherical curved surface protruding toward an actuating bar receiving member 28, and a lower surface of the actuating bar receiving member 28 of the diaphragm device 24 is provided with a projection portion 28a which protrudes downward and has a spherical surface (a spherical curved surface protruding toward the actuating bar 21) in a lower end thereof. The projection portion 28a is formed into the spherical surface in the lower end thereof, and a center axis A2 thereof is displaced in a horizontal direction (leftward in this example) from a center axis A1 of the actuating bar 21. In other words, the projection portion 28a is made eccentric with respect to the actuating bar 21 by making the center axis A2 of the projection portion 28a and the center axis A1 of the actuating bar 21 parallel to each other without being aligned.

[0050] Further, a driving force applied downward to the diaphragm device 24 via the actuating bar receiving member 28 can be transmitted to the actuating bar 21 from the projection portion 28a by bringing the eccentric projection portion 28a into contact with the upper end surface 21d of the actuating bar 21 so as to confront with each other.

[0051] Therefore, according to the present embodiment, the actuating bar 21 receiving an upward biasing force of the biasing member 20 (refer to Fig. 1) via the valve body 18 is always pressed an upper end thereof to the projection portion 28a of the actuating bar receiving member 28 as well as having the contact structure between the upper end surface 21d and the projection portion 28a serving as the spherical surfaces as mentioned above. Accordingly, the pressing force is converted into a force in a horizontal direction, and a lateral load F2 is applied to the actuating bar 21. Thus, an intermediate portion of the actuating bar 21 is pressed to an inner wall surface of the actuating bar insertion hole 22 (refer to Fig. 1), and the vibration of the actuating bar 21 is suppressed. Further, the vibration of the valve body 18 pressed to the lower end of the actuating bar 21 is suppressed since the vibration of the actuating bar 21 is suppressed.

[0052] Further, the vibration suppression function obtained by generating the lateral load F2 mentioned above in the actuating bar 21 can be achieved by the following fourth to sixth embodiments.

[Fourth Embodiment]

[0053] Fig. 6 shows an engagement structure between an actuating bar receiving member 28 and an actuating bar 21 in an expansion valve according to a fourth embodiment of the present invention. In the third embodiment mentioned above, the upper end surface 21d of the actuating bar 21 is formed into the spherical surface. However, in place of this, a conical surface 21e (a conical surface protruding toward the actuating bar receiving member 28) is formed in the present embodiment. In the same manner as the fourth embodiment, the projection portion 28a is provided in such a manner as to be eccentric with respect to the actuating bar 21 in the present embodiment.

[0054] In the present embodiment, the inclined conical surface 21e comes into contact with the projection portion 28a of the actuating bar receiving member 28. Therefore, an upward pressing force generated by the biasing member 20 is converted into a force in a horizontal direction, and the same lateral load F2 can be generated in the actuating bar 21.

[Fifth Embodiment]

[0055] Fig. 7 shows an engagement structure between an actuating bar receiving member 28 and an actuating bar 21 in an expansion valve according to a fifth embodiment of the present invention. In the third embodiment mentioned above, the actuating bar receiving member 28 is provided with the projection portion 28a in which the lower end surface thereof is formed into the spherical surface. In place of this, in the present embodiment, a projection portion 28c in which a lower end surface thereof is formed into a conical surface (a conical surface protruding to the actuating bar 21) is provided. In the same manner as the fourth embodiment, in the present embodiment, the projection portion 28c is provided in such a manner as to be eccentric with respect to the actuating bar 21.

[0056] In the present embodiment, the actuating bar 21 comes into contact with the inclined conical surface of the projection portion 28c. Therefore, an upward pressing force generated by a biasing member 20 is converted into a force in a horizontal direction, and a lateral load F2 can be generated in the actuating bar 21.

[Sixth Embodiment]

[0057] Fig. 8 shows an engagement structure between an actuating bar receiving member 28 and an actuating bar 21 in an expansion valve according to a sixth embodiment of the present invention. As shown in Fig. 14, in the present embodiment, a conical surface is formed in both the actuating bar 21 side (an upper end surface 21e of the actuating bar 21) and the actuating bar receiving member 28 side (a lower end surface of the projection portion 28c) (in which the conical surface protruding toward the actuating bar receiving member 28 is formed in the actuating bar 21 side, and the conical surface protruding toward the actuating bar 21 is formed in the actuating bar receiving member 28 side), and the upper end surface 21e of the actuating bar and the lower end surface of the projection portion 28c which form the conical surfaces are brought into contact with each other while being made eccentric. In other words, the projection portion 28c and the actuating bar 21 are brought into contact with each other in such a manner that an apex of the projection portion 28c and an apex of the upper end surface 21e of the actuating bar are displaced in the horizontal direction without coming into contact with each other.

[0058] The present embodiment is a structure in which the conical surfaces are brought into contact with each other. However, the lateral force F2 can be generated in the lateral direction by bringing the inclined surfaces into contact with each other even in this contact structure mentioned above. Therefore, in the same manner as the third to fifth embodiments mentioned above, the vibration suppression can be achieved by pressing the actuating bar 21 to the inner wall surface of the actuating bar insertion hole 22.

[0059] The embodiments according to the present invention are described above. However, it is apparent for a person skilled in the art that the present invention is not limited to these embodiments, but can be variously changed within the scope of the invention described in claims.

[0060] For example, in the first embodiment mentioned above, the anti-vibration spring 41 provided in the intermediate portion of the actuating bar 21 is not essential for the present invention as already mentioned. In the present invention, for example, in order to further enhance the anti-vibration function, it is possible to use the anti-vibration spring 41 (described in the patent literature 1) provided in the first embodiment and the other anti-vibration spring, or the anti-vibration spring provided in the inner portion of the valve chamber 16 in addition to the vibration suppression structure according to the present invention. The present invention does not inhibit combination use of the anti-vibration spring mentioned above.

[0061] Further, the expansion valve according to the present invention can be preferably applied to the car air-conditioner and can contribute to improvement of quietness in a vehicle room. However, an intended use and an applied subject are not limited to the car air-conditioner, and the present invention can be applied to an expansion valve which is used in the other various refrigeration cycle equipment such as a room air-conditioner, a refrigerator and a freezer.

REFERENCE SIGNS LIST

[0062]

A1	center axis of actuating bar
A2	center axis of actuating bar receiving member side (projection portion or spherical member fixed to actuating bar receiving member)
A3	center axis of laterally displaced valve body
F1, F2	lateral load
R1, R2	flow of refrigerant
S	clearance between actuating bar and valve main body (inner wall surface of actuating bar insertion hole)
11	expansion valve
12	valve main body
12a	drive unit installation part
13	inflow channel
14	outflow channel
15	return flow channel
16	valve chamber
17	valve seat
18	valve body
19	valve body support member
20	biasing member (compression coil spring)
21	actuating bar
21a	lower end surface of actuating bar (spherical surface)
21b	lower end surface of actuating bar (conical surface)
21c, 21f, 28b	concave portion
21d	upper end surface of actuating bar (spherical surface)
21e	upper end surface of actuating bar (conical surface)
22	actuating bar insertion hole
23	throat portion
24	diaphragm device
25	lower housing
26	upper housing
27	diaphragm
28	actuating bar receiving member
28a	projection portion having spherical surface shaped lower end surface
28c	projection portion having conical surface shaped lower end surface
29	refrigerant introducing chamber
30	working fluid encapsulating chamber
31	opening
41	anti-vibration spring

Claims

1. An expansion valve comprising:

a valve main body having a valve chamber which is communicated with an inflow channel introducing a refrigerant and an outflow channel discharging the refrigerant;

a valve body which is arranged in an inner portion of the valve chamber, and changes a flow rate of the refrigerant by moving forward and backward with respect to a valve seat between

a valve-closed state in which the valve body seats on the valve seat and a valve-opened state in which the valve body separates from the valve seat;
a biasing member which biases the valve body toward the valve seat;
an actuating bar which comes into contact with the valve body and moves the valve body in a valve opening direction against a biasing force generated by the biasing member; and
a drive unit which has an actuating bar receiving member engaging with the actuating bar and transmits a driving force against the biasing force to the actuating bar via the actuating bar receiving member,
wherein at least one of a portion between the actuating bar receiving member and the actuating bar, and a portion between the actuating bar and the valve body comes into contact or engages with each other between convex surfaces which are pressed by the biasing force

2. The expansion valve according to claim 1, wherein the valve body includes a convex curved surface,

wherein a leading end surface of the actuating bar is formed into a convex curved surface, and
wherein the leading end surface of the actuating bar is brought into contact with the convex curved surface of the valve body.

3. The expansion valve according to claim 2, wherein the convex curved surface of the actuating bar is a spherical surface.

4. The expansion valve according to claim 1,

wherein the valve body includes a convex curved surface,
wherein a leading end surface of the actuating bar is formed into a conical surface, and
wherein the leading end surface is brought into contact with the convex curved surface of the valve body.

5. The expansion valve according to claim 1,

wherein a base end surface of the actuating bar engaging with the actuating bar receiving member is formed into a convex curved surface,
wherein the actuating bar receiving member is provided with a projection portion which is formed into a convex curved surface in a leading end surface thereof, and
wherein the base end surface of the actuating bar and the leading end surface of the projection portion are brought into contact with each other in such a manner as to confront with each other while making the actuating bar and the projection portion eccentric, the base end surface of the actuating bar being formed into the convex curved surface, and the leading end surface of the projection portion being formed into the convex curved surface.

6. The expansion valve according to claim 5, wherein any one or both of the base end surface of the actuating bar and the leading end surface of the projection portion is a spherical surface.

7. The expansion valve according to claim 1,

wherein a base end surface of the actuating bar engaging with the actuating bar receiving member is formed into a conical surface,
wherein the actuating bar receiving member is provided with a projection portion which is formed into a convex curved surface in a leading end surface thereof, and
wherein the base end surface of the actuating bar and the leading end surface of the projection portion are brought into contact with each other in such a manner as to confront with each other while making the actuating bar and the projection portion eccentric, the base end surface of the actuating bar being formed into the conical surface, and the leading end surface of the projection portion being formed into the convex curved surface.

8. The expansion valve according to claim 1,

wherein a base end surface of the actuating bar engaging with the actuating bar receiving member is formed into a convex curved surface,
wherein the actuating bar receiving member is provided with a projection portion which is formed into a conical surface in a leading end surface thereof, and
wherein the base end surface of the actuating bar and the leading end surface of the projection portion are brought into contact with each other in such a manner as to confront with each other while making the actuating bar and the projection portion eccentric, the base end surface of the actuating bar being formed into the convex curved surface, and the leading end surface of the projection portion being formed into the conical surface.

9. The expansion valve according to claim 1,

wherein a base end surface of the actuating bar engaging with the actuating bar receiving member is formed into a conical surface,
wherein the actuating bar receiving member is

provided with a projection portion which is formed into a conical surface in a leading end surface thereof, and

wherein the base end surface of the actuating bar and the leading end surface of the projection portion are brought into contact with each other in such a manner as to confront with each other while making the actuating bar and the projection portion eccentric, the base end surface of the actuating bar being formed into the conical surface, and the leading end surface of the projection portion being formed into the conical surface.

10. The expansion valve according to any one of claims 7 and 8, wherein the convex curved surface is a spherical surface.

FIG. 1

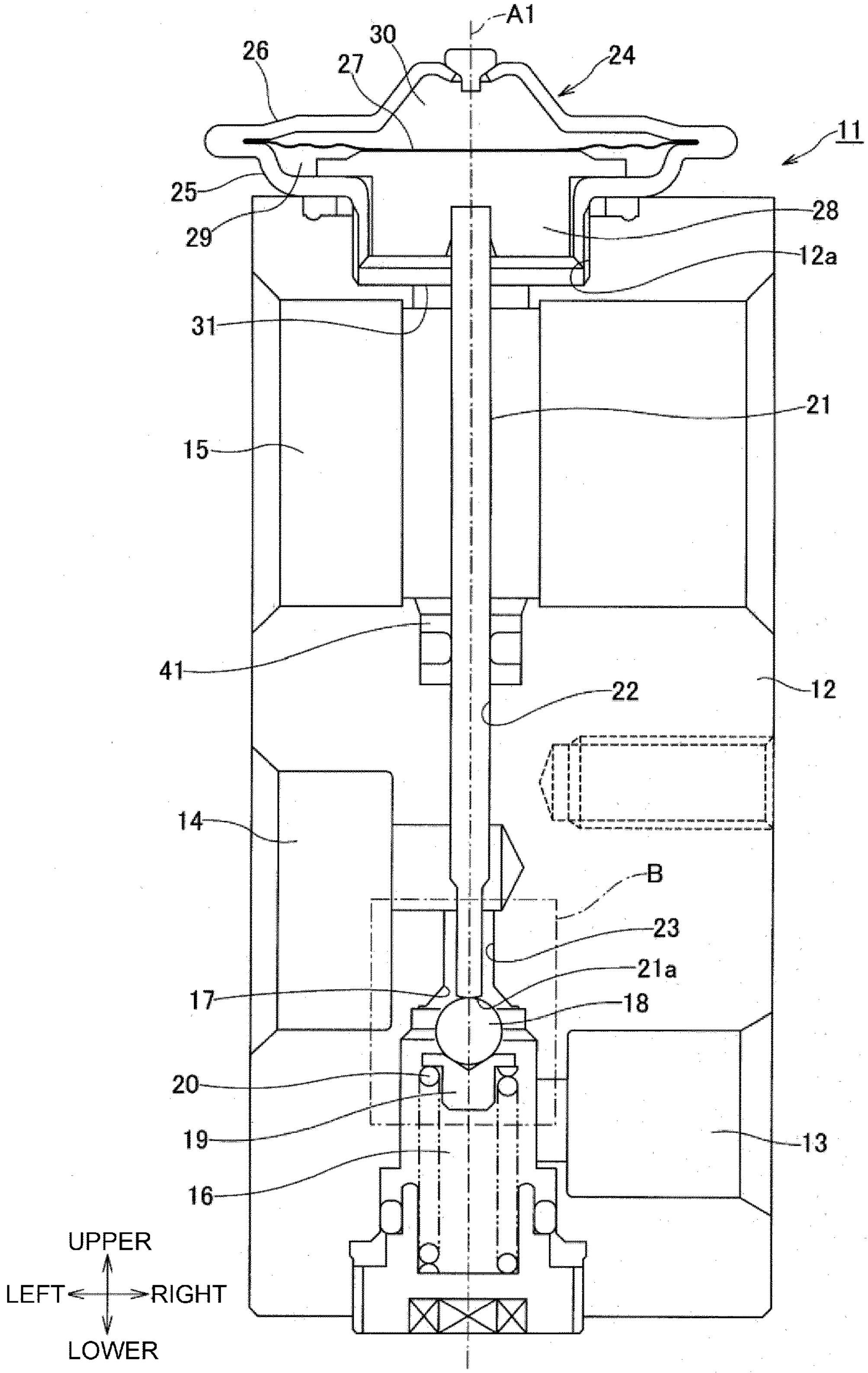
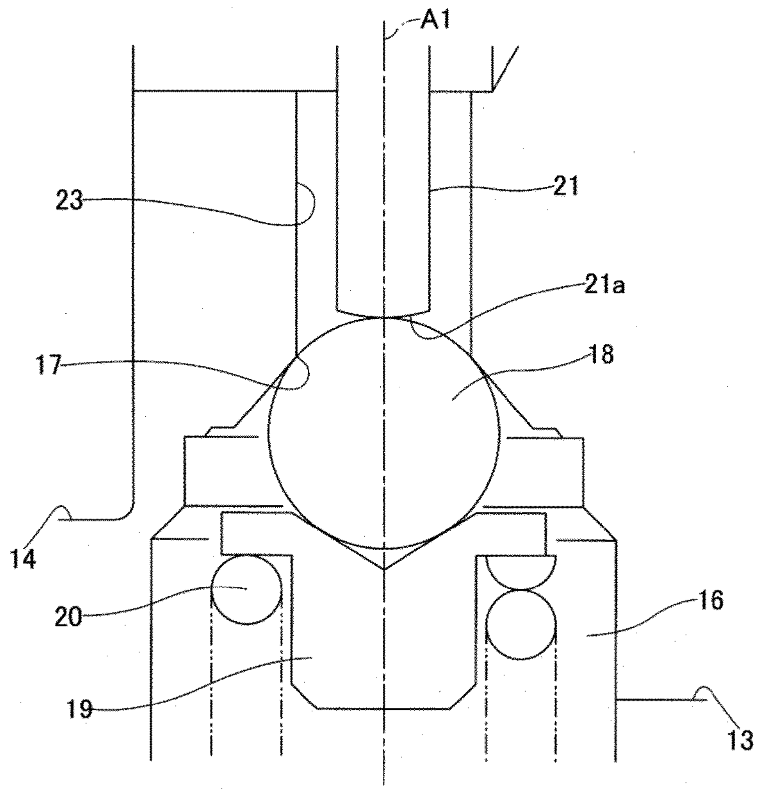

A1
30
26
27
24
11
25
28
29
12a
31
21
15
41
22
12
14
B
23
21a
17
18
20
19
13
16
UPPER
LEFT
RIGHT
LOWER

FIG. 2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21a
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13

FIG. 3

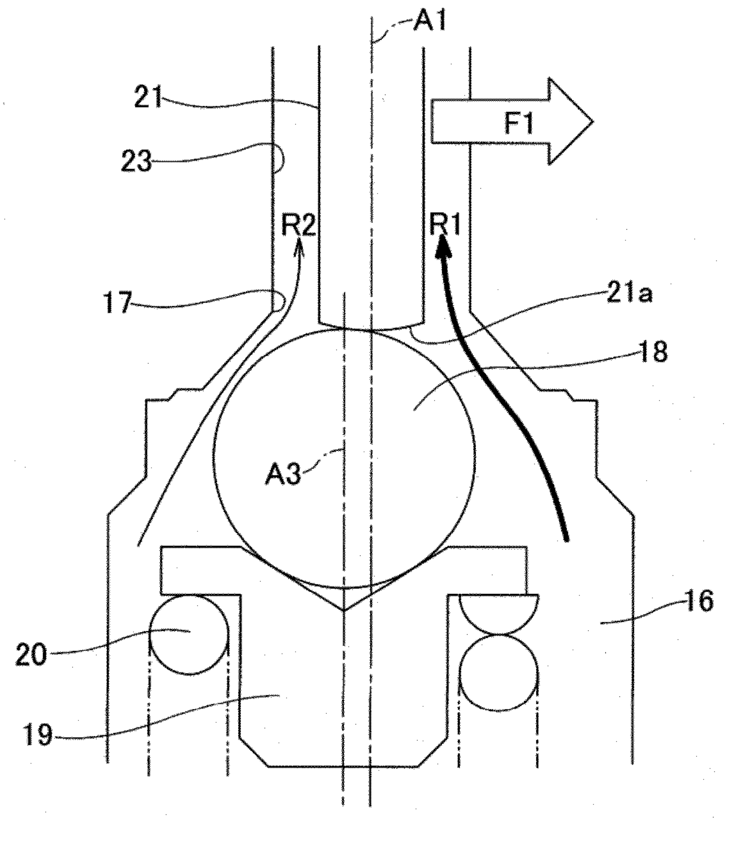
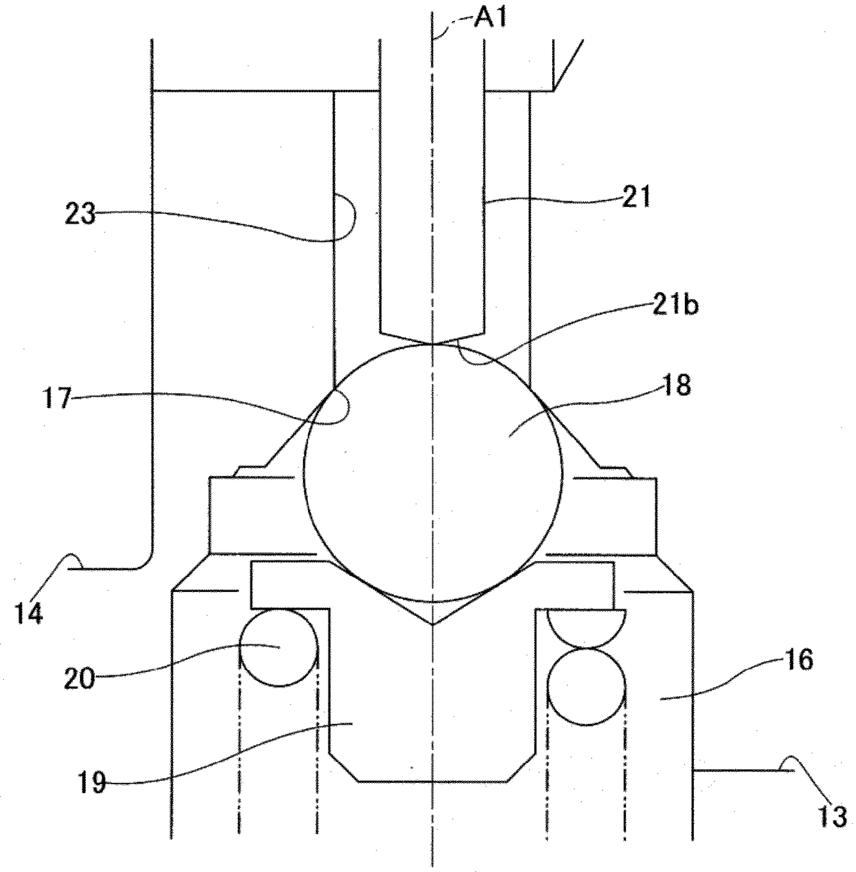

A1
21
F1
23
R2
R1
17
21a
18
A3
16
20
19

FIG. 4


A1
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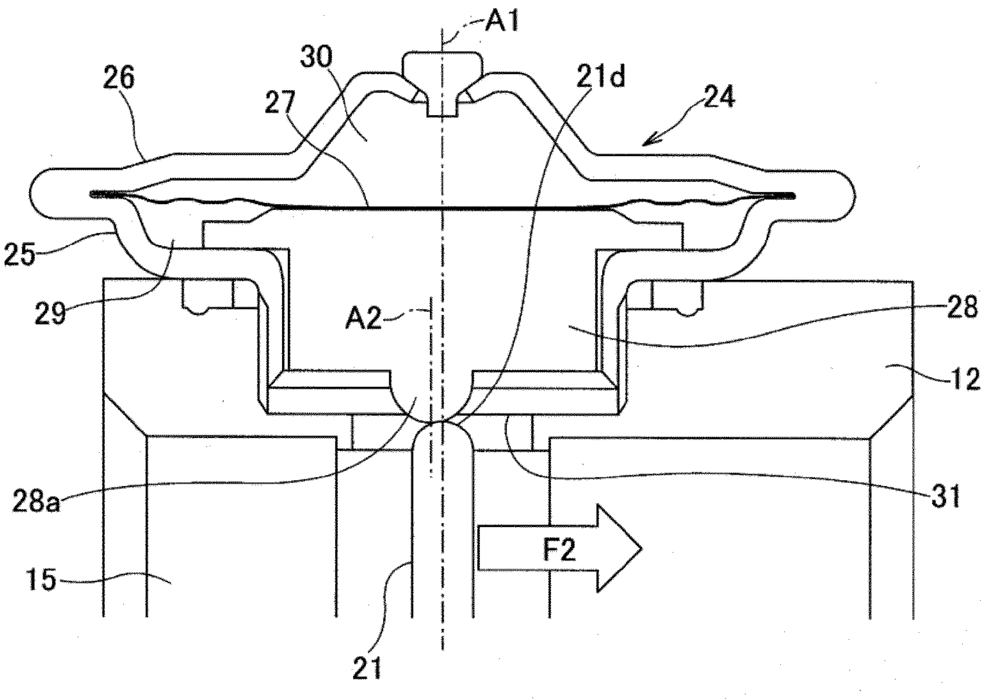
23
21b
17
18
14
20
16
19
13

FIG. 5


A1
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21d
24
27
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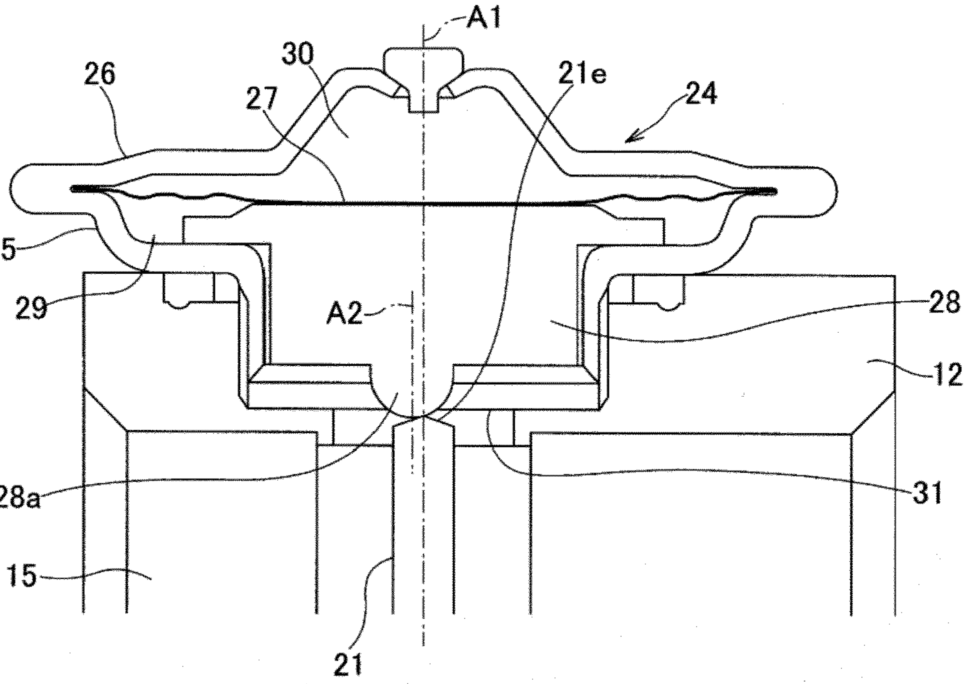
29
A2
28
12
28a
31
F2
15
21

FIG. 6


A1
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21e
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A2
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28a
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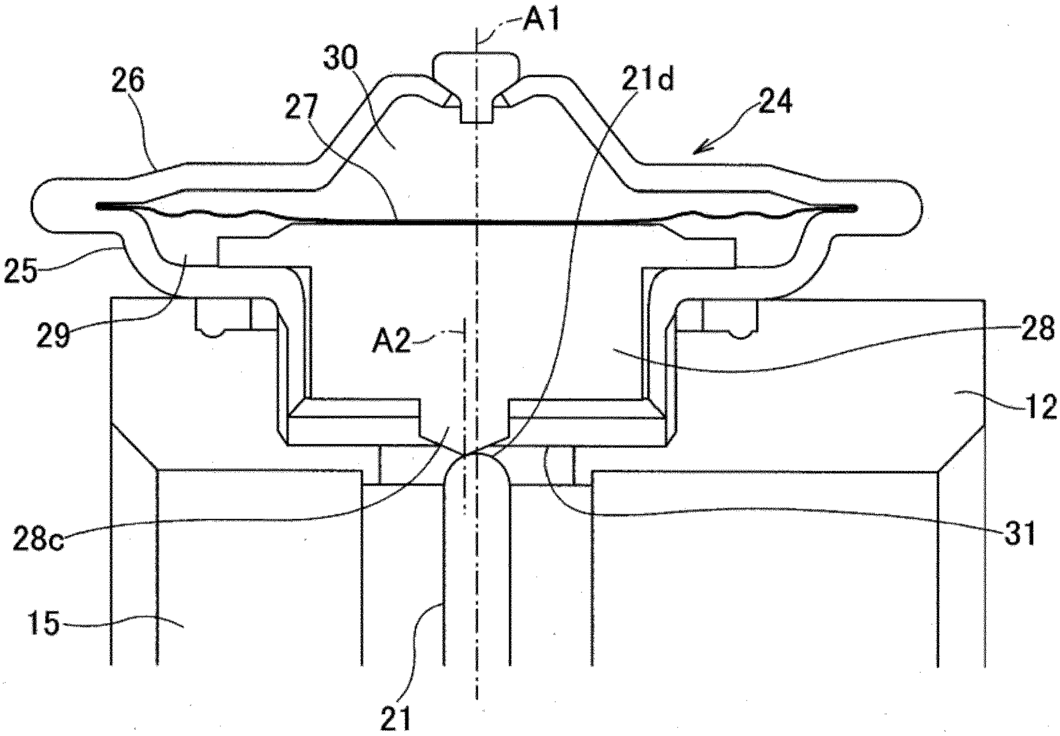
21

FIG. 7


A1
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21d
24
25
29
28
A2
12
28c
31
15
21

FIG. 8

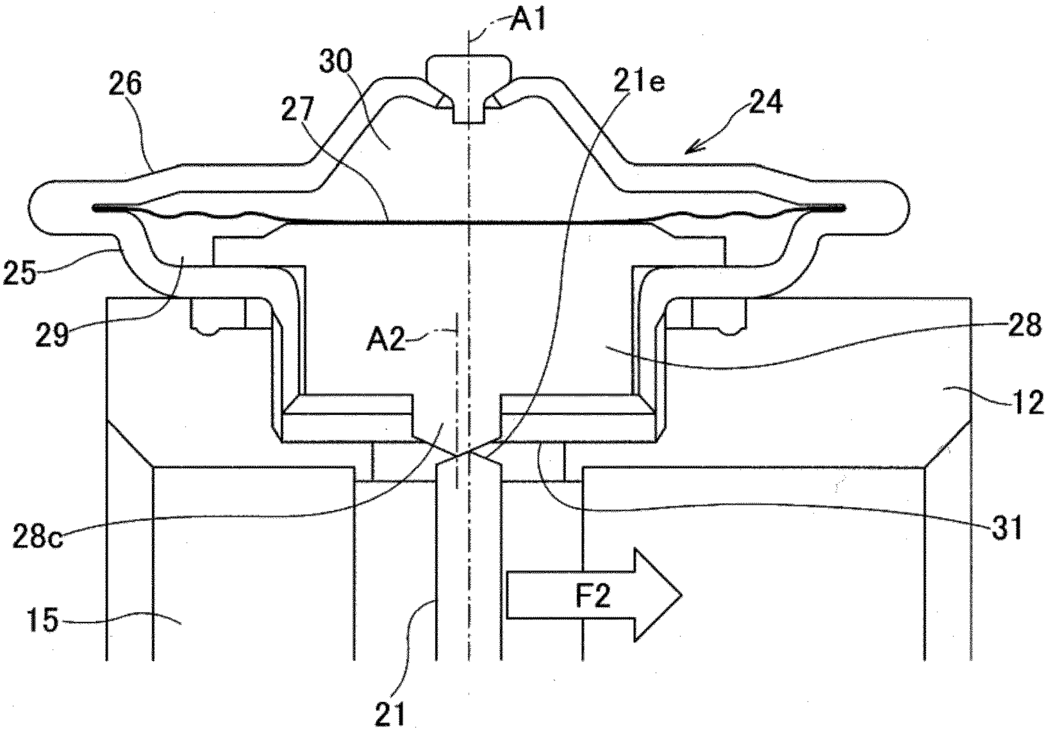
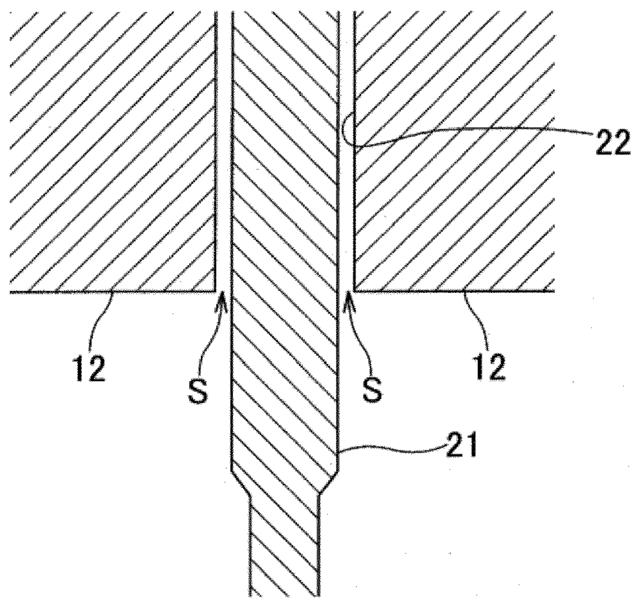


FIG. 9



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EUROPEAN SEARCH REPORT

Application Number
EP 22 16 5463

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP 2001 141335 A (TGK CO LTD) 25 May 2001 (2001-05-25)	1,5-10	INV. F25B41/335
Y	* paragraphs [0031] - [0053]; figures 4,5,8,9,10 *	1-4	
X	US 2020/208888 A1 (MOGI TAKASHI [JP] ET AL) 2 July 2020 (2020-07-02)	1	
Y	* paragraphs [0034] - [0038]; figures 2A,2B *	1-4	
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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 August 2022	Weisser, Meinrad

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16-08-2022

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			JP 6754121	B2	09-09-2020
			JP 2019039579	A	14-03-2019
			US 2020208888	A1	02-07-2020
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