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(54) Title: RELIEF VALVE

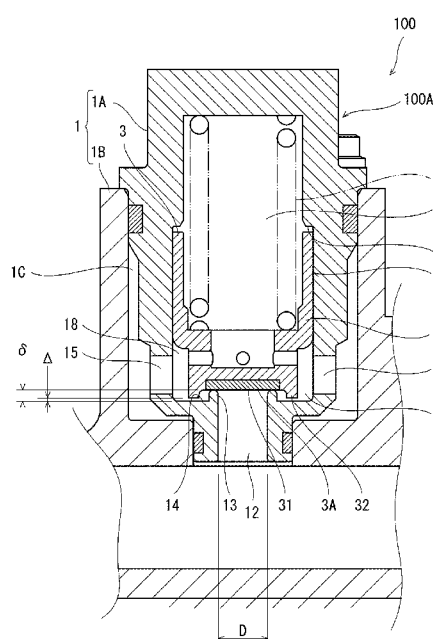


Fig. 1

(57) Abstract: A relief valve (100) is provided, which includes a housing member (1) having a valve chest (11), a pressure port (12) communicating with the valve chest, a seat part (13) provided to an opening edge of the pressure port, and a bottom surface (14) formed around the seat part, a valve body (3), inserted into the valve chest so as to be linearly movable, located at a closed position where the pressure port is closed when the pressure of the pressure port is below a set pressure, and configured to move to an opening side in moving directions thereof from the closed position when the pressure of the pressure port exceeds the set pressure, to open the pressure port, and a spring (5) configured to bias the valve body to a closing side in the moving directions. The valve body has a contact-separate part (31) configured to contact to or separate from the seat part, and an annular protrusion (32) protruding around the contact-separate part to the closing side in the moving directions. The valve body forms a choke part between the annular protrusion and the bottom surface when the valve body separates from the seat part.



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Description

Title of Invention: RELIEF VALVE

Technical Field

[0001] The present disclosure relates to a relief valve.

Background Art

[0002] Some relief valves have a valve body which is inserted into a valve chest so as to be linearly movable, and is constructed to open and close a pressure port which opens to the valve chest (e.g., see PTL 1). The valve body is biased by a spring so that it seats at a seat part provided to an opening edge of the pressure port. When the pressure port is closed, pressure of the pressure port acts on the valve body. The pressure-receiving area corresponds to the opening area of the pressure port. If the pressure of the pressure port exceeds a set pressure, the valve body moves to resist a biasing force of the spring so that the valve body separates from the seat part, resulting in the pressure port being opened.

Citation List

Patent Literature

[0003] PTL 1: JP2014-43866A

Summary of Invention

Technical Problem

[0004] When the valve body moves a given amount from a closed position, the pressure port is fully opened. As the moving amount of the valve body from the closed position increases, the contraction of the spring becomes greater to increase the biasing force. Therefore, there is a problem that the pressure required for fully opening the pressure port is large (the pressure required for fully opening the pressure port becomes larger than the pressure required for initiating the opening of the pressure port).

[0005] Thus, one purpose of the present disclosure is to provide a relief valve, which is capable of reducing pressure required for fully opening a pressure port.

Solution to Problem

[0006] A relief valve according to one aspect of the present disclosure includes a housing member having a valve chest, a pressure port communicating with the valve chest, a seat part provided to an opening edge of the pressure port, and a bottom surface formed around the seat part, a valve body, inserted into the valve chest so as to be linearly movable, located at a closed position where the pressure port is closed when the pressure of the pressure port is below a set pressure, and configured to move to an opening side in moving directions thereof from the closed position when the pressure of the pressure port exceeds the set pressure, to open the pressure port, and a spring

configured to bias the valve body to a closing side in the moving directions. The valve body has a contact-separate part configured to contact to or separate from the seat part, and an annular protrusion protruding around the contact-separate part to the closing side in the moving directions. The valve body forms a choke part between the annular protrusion and the bottom surface when the valve body separates from the seat part.

[0007] According to this structure, the contact-separate part of the valve body is surrounded by the annular protrusion. When the pressure port begins opening, the lateral propagation of the pressure (in directions perpendicular to the moving directions of the valve body) is impeded by the inner circumferential surface of the annular protrusion so that the annular protrusion forms the choke part. Thus, the valve body can receive the pressure to the opening side in the moving directions thereof at the area inward of the annular protrusion. Therefore, when the pressure port begins opening, the pressure-receiving area increases from the area of the opening of the pressure port to the area of the inner circle of the annular protrusion. For this reason, the pressure required for fully opening the pressure port can be reduced. Note that it is possible to decrease a difference between a "set pressure" required for opening the pressure port and the pressure required for fully opening the pressure port. Thereby, a degree of freedom in selecting the spring increases.

[0008] A ratio Δ/D of a clearance Δ between the annular protrusion and the bottom surface in a valve closed state where the valve body is located at the closed position, with respect to an inner diameter D of the pressure port may be 0.011 to 0.24.

[0009] According to this structure, when the pressure port begins opening, the lateral propagation of the pressure (in the directions perpendicular to the moving directions of the valve body) is impeded more certainly by the inner circumferential surface of the annular protrusion.

[0010] The seat part may be formed in an annular shape protruding from the bottom surface to the opening side in the moving directions, and a ratio δ/D of a protruding amount δ of the seat part from the bottom surface with respect to the inner diameter D may be 0.1 to 0.6.

[0011] According to this structure, the surface pressure on the protruding part increases because the part which receives the valve body is protruded, thereby increasing the sealing property.

[0012] An inner circumferential surface of the annular protrusion and a tip-end surface of the annular protrusion may make a substantially right angle.

[0013] According to this structure, it is easier to impede the lateral pressure propagation, and to obtain the effect of increasing the pressure-receiving area when the pressure port begins opening.

[0014] A part of an outer circumferential surface of the valve body may form a slidably

contacting part configured to slidably contact an inner circumferential surface of the valve chest, and grease may be applied to the slidably contacting part.

[0015] According to this structure, chattering can be prevented by the viscosity of the grease.

Advantageous Effects of Invention

[0016] According to the present disclosure, a relief valve, which is capable of reducing the pressure required for fully opening the pressure port, can be provided.

Brief Description of Drawings

[0017] [fig.1]Fig. 1 is a cross-sectional view of a relief valve according to one embodiment.

[fig.2]Figs. 2A to 2C are views illustrating operation of the relief valve, where Fig. 2A illustrates a state of a valve body located at a closed position, Fig. 2B illustrates a state of the valve body immediately after separated from the closed position, and Fig. 2C illustrates a state of the valve body located at a fully-open position.

[fig.3]Fig. 3 is a view illustrating operation of the relief valve and illustrates a state where the valve body is pushed into a closing side.

[fig.4]Fig. 4 is a view illustrating operation of the relief valve according to a first modification.

[fig.5]Fig. 5 is a view illustrating operation of the relief valve according to a second modification.

[fig.6]Figs. 6A and 6B are views each illustrating operation of the relief valve according to a third modification, where Fig. 6A illustrates a state of the valve body pushed into the closing side, and Fig. 6B illustrates a state of the valve body located at the closed position or immediately before beginning opening.

Description of Embodiments

[0018] Hereinafter, one embodiment is described with reference to the drawings. Note that the same reference characters are given to the same or corresponding elements throughout the drawings to omit redundant description.

[0019] Fig. 1 is a cross-sectional view of a relief valve 100 according to one embodiment. As illustrated in Fig. 1, the relief valve 100 includes a housing member 1, a valve body 3, and a spring 5. The relief valve 100 according to this embodiment is of a cartridge type. A part of the housing member 1, the valve body 3, and the spring 5 are combined to constitute a cartridge 100A. The housing member 1 has an inner bushing part 1A and a socket part 1B. The inner bushing part 1A accommodates therein the valve body 3 and the spring 5. The inner bushing part 1A (cartridge 100A) is attachably and detachably mounted to a mounting bore 1C formed in the socket part 1B to constitute the housing member 1 (relief valve 100).

[0020] The housing member 1 (inner bushing part 1A) has a valve chest 11 which ac-

commodates the valve body 3, a pressure port 12 which communicates with the valve chest 11, a seat part 13 provided to an opening edge of the pressure port 12, and a bottom surface 14 around the seat part 13. Further, the housing member 1 has an outlet port 15 which communicates with the valve chest 11, and a spring chamber 16 where the spring 5 is accommodated.

[0021] The bottom surface 14 is an inner bottom surface of the valve chest 11. The valve chest 11 is formed into a cylindrical shape as one example, and the bottom surface 14 has a circular shape. The pressure port 12 opens in a central part of the bottom surface 14, and is coaxial with the valve chest 11. The pressure port 12 has a circular cross-section with an inner diameter D. The bottom surface 14 spreads around the seat part 13, and intersects perpendicularly with the axis of the valve chest 11 and the pressure port 12.

[0022] The valve body 3 is inserted in the valve chest 11 so as to be linearly movable. The valve body 3 is located at a closed position where the pressure port 12 is closed when the pressure of the pressure port 12 is below a set pressure. When the pressure of the pressure port 12 becomes above the set pressure, the valve body 3 moves from the closed position to an "opening side" in its moving directions to open the pressure port 12. Note that the moving directions of the valve body 3 correspond to the vertical directions in Fig. 1. The "opening side" corresponds to the upper side, and a "closing side" which is opposite therefrom corresponds to the lower side. Below, among two end parts of the valve body 3, an end part on the closing side is referred to as a "tip-end part."

[0023] In this embodiment, the valve chest 11 is stepped, and the housing member 1 has a stepped surface 17 which opposes to the bottom surface 14 and is separated therefrom. The valve body 3 is accommodated between the bottom surface 14 and the stepped surface 17, and when it moves from the closed position to the opening side, the valve body 3 abuts against the stepped surface 17 so that its movement is regulated. Below, the upper-limit position of the valve body 3 on the opening side is referred to as a "fully-open position." In this embodiment, the valve body 3 is movable between the closed position and the fully-open position.

[0024] The spring chamber 16 is formed on the opposite side from the pressure port 12 with respect to the valve body 3 or the valve chest 11. The spring 5 is accommodated in the spring chamber 16, and biases the valve body 3 to the closing side. The spring 5 is a compression coil spring as one example.

[0025] The valve body 3 is formed into a stepped cylindrical shape. A part of an outer circumferential surface of the valve body 3 forms a slidably contacting part 39 which slidably contacts an inner circumferential surface of the valve chest 11, and the linear movement of the valve body 3 is guided by the inner circumferential surface of the

valve chest 11. Note that grease is applied to the slidably contacting part 39. The grease is lubricant having comparatively large viscoelasticity.

[0026] The tip-end part of the valve body 3 is formed in a cylindrical shape with a smaller diameter than the slidably contacting part 39. Thus, a gap 18 having an annular cross-section is formed between the outer circumferential surface of the tip-end part of the valve body 3 and the inner circumferential surface of the valve chest 11. The outlet port 15 opens to the inner circumferential surface of the valve chest 11, and communicates with the gap 18.

[0027] The valve body 3 has a contact-separate part 31 which contacts or separates its tip-end part to/from the seat part 13, and an annular protrusion 32 which protrudes around the contact-separate part 31 to the closing side. The valve body 3 is comprised of a contact-separate member 3A which constitutes the contact-separate part 31, and a main-body member 3B which constitutes other parts. The contact-separate member 3A is fitted in a recessed part formed in a tip-end surface of the main-body member 3B. The annular protrusion 32 is provided radially outward of a circumferential edge part and the recessed part of the tip-end surface of the main-body member 3B. Thus, the tip-end surface of the main-body member 3B remains in an annular shape between the contact-separate member 3A or the recessed part and the inner circumferential surface of the annular protrusion 32. The inner circumferential surface of the annular protrusion 32 and the tip-end surface of the annular protrusion 32 make substantially 90 degrees. Note that the material of the contact-separate member 3A may be rubber, synthetic resin, or elastic material which is not limited thereto. Moreover, the material of the main-body member 3B may be metal or synthetic resin.

[0028] In this embodiment, the seat part 13 is formed in an annular shape which protrudes from the bottom surface 14 to the opening side. The shape of the seat part 13 is not limited in particular. It may be formed in a convex shape (a D-shape in the cross-section) like the illustrated example, or may be formed in a cylindrical shape (a rectangular shape in the cross-section). If forming in the convex shape, the protruded tip end may be rounded at both of the inner and outer circumferential sides, in order to protect the contact-separate part 31 (contact-separate member 3A).

[0029] The annular tip-end surface of the main-body member 3B and the end face of the contact-separate member 3A form substantially the same surface. The tip-end surface of the annular protrusion 32 is positioned on the closing side of the tip-end surface of the main-body member 3B and the end face of the contact-separate member 3A. Note that the tip-end surface of the annular protrusion 32 is substantially parallel to the bottom surface 14.

[0030] As illustrated in Fig. 2A where the valve body 3 is located at the closed position, since the diameter of the contact-separate part 31 is larger than the inner diameter D of

the pressure port, the contact-separate part 31 contacts the seat part 13. The seat part 13 protrudes from the bottom surface 14, and is accommodated in a space inside the annular protrusion 32. The tip-end surface of the annular protrusion 32 is separated from the bottom surface 14 by a clearance Δ . The clearance Δ is set very small. As one example, a ratio Δ/D of the clearance Δ with respect to the inner diameter D is 0.011 to 0.24, preferably 0.04 to 0.07.

- [0031] In the valve closed state, the spring 5 is contracted from its free length so that it biases the valve body 3 to the closing side by an initial biasing force S_0 according to the contracted amount and the spring constant to maintain the valve closed state. Meanwhile, the pressure of the pressure port 12 acts to the opening side on the contact-separate part 31 of the valve body 3. In the valve closed state, a pressure receiving area A_{close} of the valve body 3 corresponds to an area of a circle which is defined by the tip end of the seat part 13, and a pushing-up force F_{close} , which is obtained by multiplying the pressure of the pressure port 12 by the pressure receiving area A_{close} , acts on the valve body 3.
- [0032] When the pressure equals to the set pressure described above, the pushing-up force F_{close} balances with the initial biasing force S_0 . When the pushing-up force F_{close} exceeds the initial biasing force S_0 (when the pressure exceeds the set pressure), the valve body 3 moves to the opening side while resisting the biasing force of the spring 3 so that it separates from the seat part 13 and the pressure port 12 begins opening.
- [0033] As illustrated in Fig. 2B, when the valve body 3 separates from the seat part 13, the pressure port 12 communicates with the outlet port 15 through the space inside of the annular protrusion 32, the clearance between the annular protrusion 32 and the bottom surface 14, and the gap 18. However, since the clearance Δ in the valve closed state is set very small as being defined by the ratio Δ/D , the clearance is small also at the beginning of valve opening. That is, a path to communicate the pressure port 12 with the outlet port 15 is choked by the clearance. Thus, a choke part 38 is formed between the annular protrusion 32 and the bottom surface 14. When the pressure of the pressure port 12 propagates to the valve chest 11, a propagation in lateral directions (a direction perpendicular to the moving directions of the valve body 3) is interrupted by the annular protrusion 32. The pressure is confined in the space inside the annular protrusion 32, and acts to the opening side on the valve body 3 inside this space.
- [0034] In particular, in this embodiment, the inner circumferential surface of the annular protrusion 32 and the tip-end surface of the annular protrusion 32 make the right angle. Thus, it becomes easier to impede that the pressure propagates to the gap 18 than a case where the corner part formed by the inner circumferential surface and the tip-end surface is round chamfered.
- [0035] Moreover, in this embodiment, in the valve closed state, the tip-end surface of the

annular protrusion 32 is located at the closing side with respect to a tip end of the seat part 13. Thus, immediately after the beginning of valve opening, the path to communicate the pressure port 12 with the gap 18 becomes a labyrinth shape. Therefore, the choke effect at the choke part 38 (the impeding effect of the pressure propagation) increases.

[0036] As the result, when the pressure port 12 begins to open, the pressure receiving area A_{open} of the valve body 3 is equivalent to the area of the inner circumferential circle of the annular protrusion 32, and the pushing-up force F_{open} , which is obtained by multiplying the pressure of the pressure port 12 by the pressure receiving area A_{open} , acts on the valve body 3. The pressure receiving area A_{open} is larger than the pressure receiving area A_{close} . Thus, even if there is no difference in the pressure which acts on the valve body 3 before and after the opening, the pushing-up force which acts on the valve body 3 increases. Therefore, although the biasing force of the spring 5 increases with the movement of the valve body 3, the valve body 3 can easily be moved to the fully-open position while resisting the biasing force of the spring 5.

[0037] The clearance between the annular protrusion 32 and the bottom surface 14 expands during the process of moving to the fully-open position, and, thereby, the pressure of the pressure port 12 can be released to the outlet port 15. On the other hand, when the pressure of the pressure port 12 falls under the setting value, the valve body 3 is held at the closed valve position by the biasing force of the spring 5.

[0038] As described above, by the relief valve 100 according to this embodiment, since the pressure receiving area increases when the pressure port 12 begins to open, the pressure required for moving the valve body 3 to the fully-open position can be reduced. In other words, a difference between the set pressure required for opening the valve body 3 and the pressure required for positioning the valve body 3 at the fully-open position becomes smaller. Therefore, a selection range of the spring 5 can be extended, compared with the conventional art. In particular, even if the spring 5 with a larger spring constant than the conventional art is selected, it becomes easier to move the valve body 3 to the fully-open position.

[0039] As illustrated in Fig. 3, since the clearance between the annular protrusion 32 and the bottom surface 14 in the valve closed state is set very small, the annular protrusion 32 can immediately be abutted against the bottom surface 14 when an excessive pushing force acts to the closing side on the valve body 3. Therefore, the excessive pushing force can be received by the housing member 1 so that an excessive pressure-contact of the contact-separate part 31 to the seat part 13 is prevented, thereby protecting the contact-separate part 31.

[0040] A ratio δ/D of a protruding amount δ of the seat part 13 from the bottom surface 14 with respect to the inner diameter D is 0.1 to 0.6, and preferably 0.21 to 0.23. This

protrusion of the seat part 13 begins to open the pressure port, the lateral propagation of the pressure (in directions perpendicular to the moving directions of the valve body) is impeded more certainly by the inner circumferential surface of the annular protrusion.

- [0041] Although the embodiment has been described so far, a change, addition, and/or deletion to the above structure may suitably be possible within the scope of the present disclosure.
- [0042] As illustrated in Fig. 4, the seat part 13 does not need to be protruded to the opening side from the bottom surface. The tip-end surface of the annular protrusion 32 may be positioned to the opening side of the end face of the contact-separate part 31. Also in this case, the ratio of the clearance between the tip-end surface of the annular protrusion 32 and the bottom surface 14 of the housing member 1 in the valve closed state with respect to the inner diameter D of the pressure port 12 is set similar to the above embodiment. Therefore, a similar operation and effect to the above embodiment are acquired.
- [0043] As illustrated in Fig. 5, the inner bushing part 1A and the socket part 1B of the housing member 1 may be integrated. That is, the relief valve 100 may not be the cartridge type.
- [0044] As shown in Figs. 6A and 6B, a central part 14b of the bottom surface 14 of the housing member 1 may be recessed. An outer edge part 14a of the bottom surface 14 is separated from the central part 14b of the bottom surface 14 in the moving direction of the valve body 3, and is positioned to the opening side with respect to the central part 14b. The housing member 1 has a stepped surface 14c which connects the outer edge part 14a and the central part 14b of the bottom surface 14 in the moving direction of the valve body 3. As one example, the outer edge part 14a of the bottom surface 14 is formed in an annular shape, and the central part 14b of the bottom surface 14 is formed in a circular shape. The central part 14b is concentric or coaxial with the valve body 3, and the central part 14b has a diameter slightly greater than that of the tip-end part (in particular, the annular protrusion 32) of the valve body 3.
- [0045] Since the bottom surface 14 is formed in this manner, when the valve body 3 is pushed into the closing side (see Fig. 6A), the outer circumferential surface of the annular protrusion 32 opposes to the stepped surface, such that the outer circumferential surface slidably contacts the stepped surface or a very slight clearance is formed between the outer circumferential surface and the stepped surface. In this state, the tip-end surface of the annular protrusion 32 is abutted against the central part 14b of the bottom surface 14. When the valve body 3 is located at the closed position (see Fig. 6B), the tip-end surface of the annular protrusion 32 is separated from the central part 14b of the bottom surface 14 by a very slight clearance. In this state, a part of the

outer circumferential surface of the annular protrusion 32 opposes to the stepped surface 14c, such that the part of the outer circumferential surface slidably contacts the stepped surface 14c, or is in close proximity to the stepped surface 14c in a non-contacting manner.

[0046] Accordingly, when the valve body 3 in the closed position has begun to move to the opening side, the choke effect is exerted to a great degree. In other words, the propagation of the internal pressure of the pressure port to the outlet port can be easily impeded by the annular protrusion and the bottom surface.

Reference Signs List

[0047] 100 Relief Valve
1 Housing Member
11 Valve Chest
12 Pressure Port
13 Seat Part
14 Bottom Surface
3 Valve Body
31 Contact-Separate Part
32 Annular Protrusion
38 Choke Part
39 Slidably Contacting Part
5 Spring
D Inner Diameter of Pressure Port
 Δ Clearance between Annular Protrusion and Bottom Surface
 δ Protruding Amount of Seat Part

Claims

- [Claim 1] A relief valve, comprising:
a housing member having a valve chest, a pressure port communicating with the valve chest, a seat part provided to an opening edge of the pressure port, and a bottom surface formed around the seat part;
a valve body, inserted into the valve chest so as to be linearly movable, located at a closed position where the pressure port is closed when the pressure of the pressure port is below a set pressure, and configured to move to an opening side in moving directions thereof from the closed position when the pressure of the pressure port exceeds the set pressure, to open the pressure port; and
a spring configured to bias the valve body to a closing side in the moving directions,
wherein the valve body has a contact-separate part configured to contact to or separate from the seat part, and an annular protrusion protruding around the contact-separate part to the closing side in the moving directions, and
wherein the valve body forms a choke part between the annular protrusion and the bottom surface when the valve body separates from the seat part.
- [Claim 2] The relief valve of claim 1, wherein a ratio Δ/D of a clearance Δ between the annular protrusion and the bottom surface in a valve closed state where the valve body is located at the closed position, with respect to an inner diameter D of the pressure port is 0.011 to 0.24.
- [Claim 3] The relief valve of claim 2, wherein the seat part is formed in an annular shape protruding from the bottom surface to the opening side in the moving directions, and
wherein a ratio δ/D of a protruding amount δ of the seat part from the bottom surface with respect to the inner diameter D is 0.1 to 0.6.
- [Claim 4] The relief valve of any one of claims 1 to 3, wherein an inner circumferential surface of the annular protrusion and a tip-end surface of the annular protrusion make a substantially right angle.
- [Claim 5] The relief valve of any one of claims 1 to 4, wherein a part of an outer circumferential surface of the valve body forms a slidably contacting part configured to slidably contact an inner circumferential surface of the valve chest, and grease is applied to the slidably contacting part.

[Fig. 2]

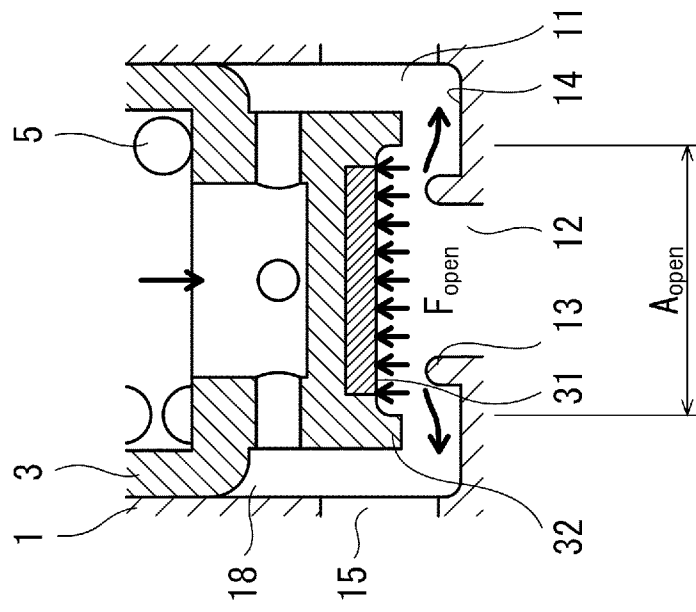


Fig. 2A

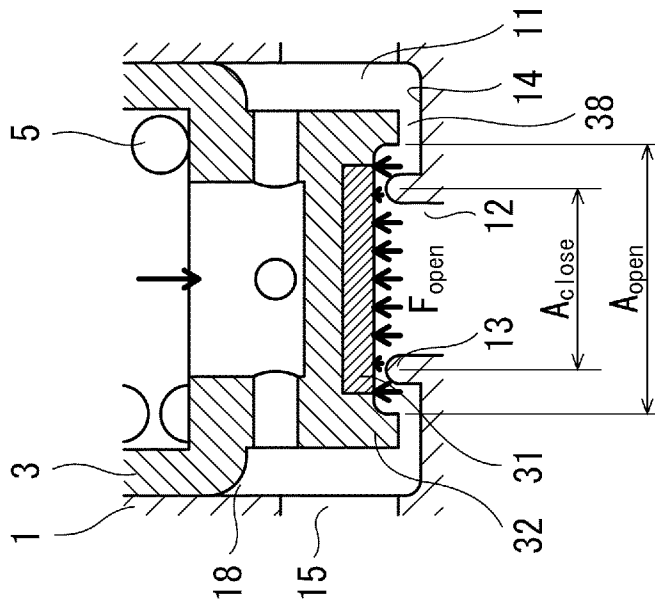


Fig. 2B

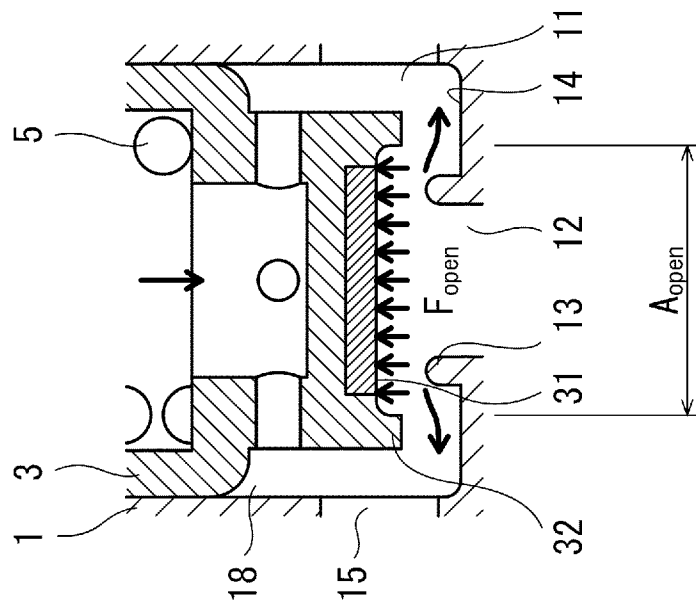


Fig. 2C

[Fig. 3]

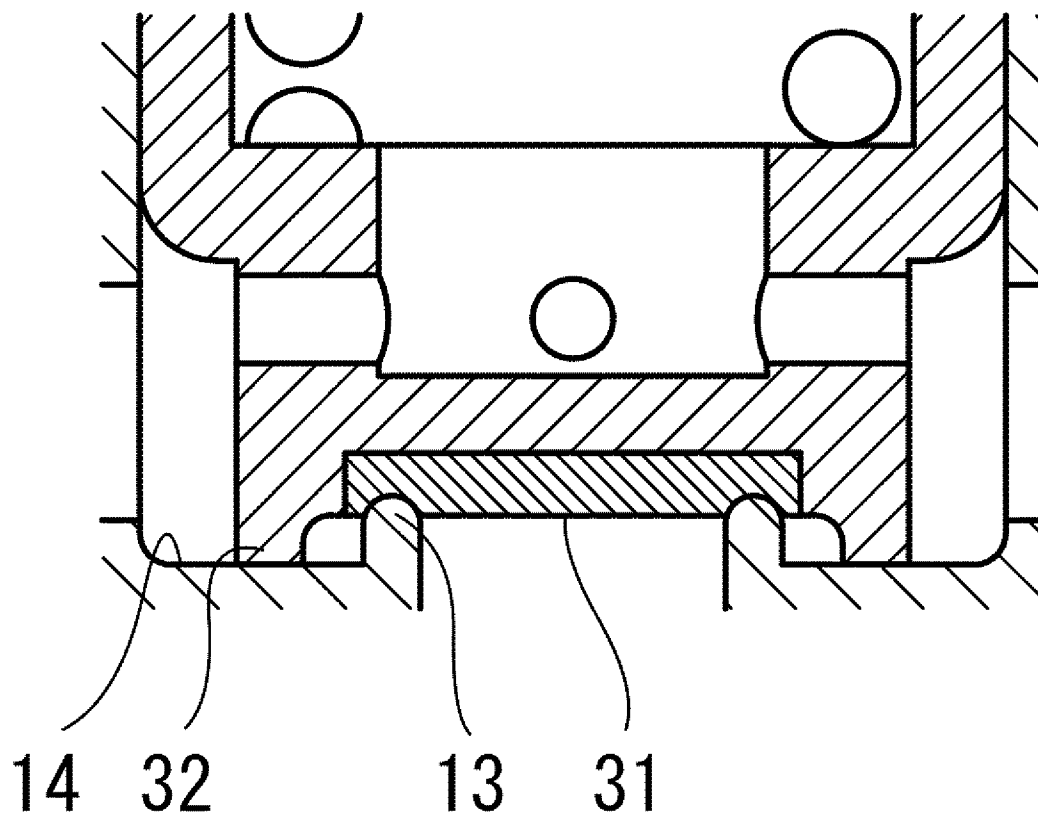


Fig. 3

[Fig. 5]

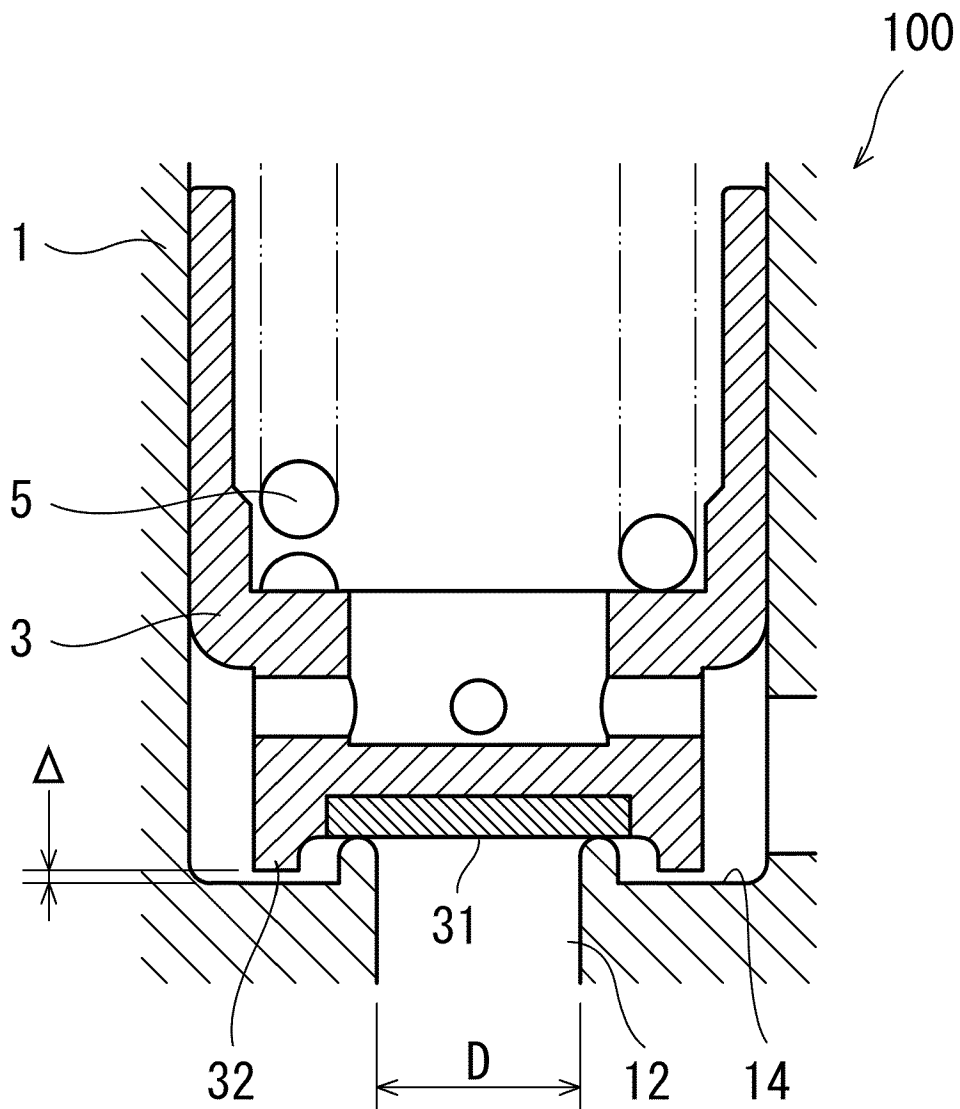


Fig. 5

[Fig. 6]

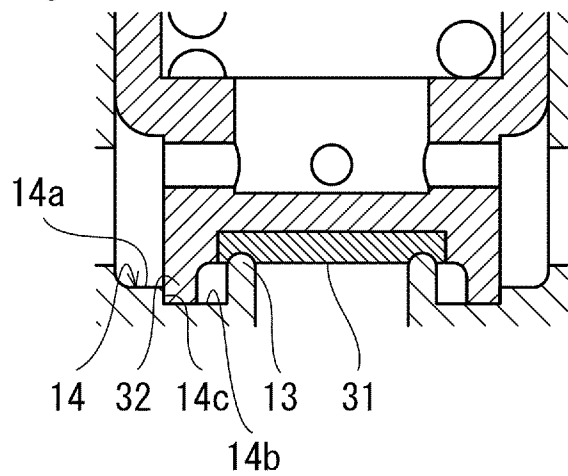


Fig. 6A

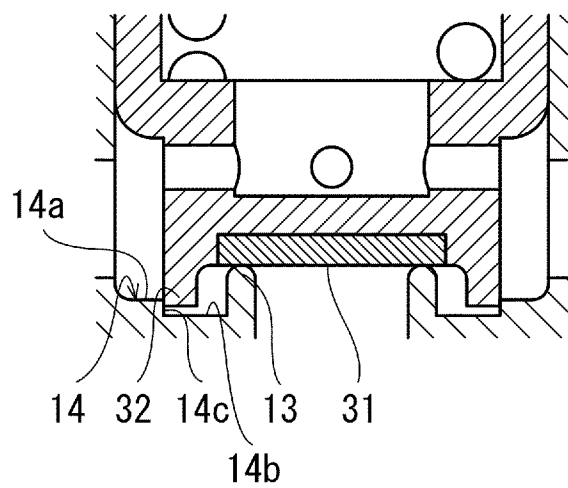


Fig. 6B

INTERNATIONAL SEARCH REPORT

International application No
PCT/JP2018/024601

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16K17/04
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F16K F16F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP S59 147964 U (-) 3 October 1984 (1984-10-03) figures -----	1-4
X	JP S51 128030 U (-) 16 October 1976 (1976-10-16) figures -----	1,4
Y		5
Y	JP 2008 257440 A (YAZAKI CORP) 23 October 2008 (2008-10-23) abstract; figures -----	5
X	US 3 422 840 A (BRYANT AUSTIN U ET AL) 21 January 1969 (1969-01-21) column 6, line 4 - line 45; figures ----- -/--	1-4



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

International application No
PCT/JP2018/024601

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	the whole document -----	5

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/JP2018/024601

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