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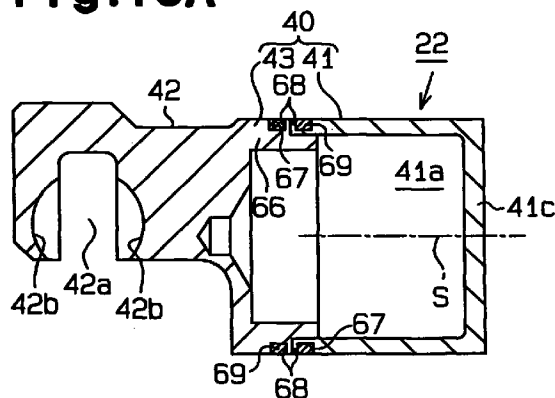
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(54) **Piston for compressors**

(57) Improved pistons (22), which are reciprocated by a swash plate (20) of a compressor, have two separate parts joined together. Each piston (22) has a head (40) and a skirt (42). The head (40) has a cylinder (41) with an opening at one end. The opening is closed by a lid (43). The lid (43) is mechanically fixed to the cylinder (41), for example, by crimping. Also, adhesive is used to fix the lid (43) to the cylinder (41). Accordingly, the cylinder (41) and the lid (43) are firmly secured to each other.

Fig.13A



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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to pistons of compressors

[0002] that are used in vehicle air conditioners. A typical compressor includes a cylinder block, which constitutes a part of the compressor housing. Cylinder bores are formed in the cylinder block. Each cylinder bore reciprocally houses a piston. Each piston has a head accommodated in the associated cylinder bore and a skirt coupled to a driving body (for example, a swash plate in a swash plate type compressor). The head includes a hollow cylinder with a closed end and a lid to close the opening of the cylinder. The lid is integrally formed with the skirt.

[0003] Such pistons are known as hollow pistons. In comparison to solid pistons, which have solid heads, hollow pistons are light. Using hollow pistons therefore reduces weight. The head and the skirt of a solid piston are integrally formed, for example, by casting. However, the cylinder and the skirt of a hollow piston must be separately formed and welded together.

[0004] Hollow pistons have the following drawbacks.

(1) Welding the skirt to the cylinder can produce bubbles in the metal forming the cylinder and the skirt. This lowers the strength of the joint between the cylinder and the skirt, deteriorates the appearance of the piston, and may prevent the piston from smoothly reciprocating in a cylinder bore. Also, the high temperature during welding deteriorates the material forming the piston.

(2) If trapped in the interior of the cylinder by the lid, air in the cylinder will expand during welding and apply excessive stress on the joint between the cylinder and the skirt. This may weaken the joint between the cylinder and the skirt. To avoid this problem, welding of pistons has been performed in a vacuum, for example, by using electron-beam welding. Thus, welding of pistons requires not only welding apparatus but also apparatus for creating vacuum, which increases the manufacturing cost.

SUMMARY OF THE INVENTION

[0005] Accordingly, it is an objective of the present invention to provide a compressor piston in which the cylinder and the lid are securely fixed to each other.

[0006] To achieve foregoing and other objectives and in accordance with the purpose of the present invention, a piston for cooperating with a driving body in a machine is provided. The piston includes a skirt, which serves to connect the piston to the driving body, and a head. The head includes a cylinder having at least at one open end and a lid for closing the open end. The lid is mechanically fixed to the cylinder.

[0007] Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The features of the present invention that are believed to be novel are set forth with particularity in the appended claims. The invention, together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

Fig. 1 is a cross-sectional view illustrating a variable displacement compressor having pistons according to a first embodiment of the present invention;

Fig. 2 is an enlarged partial cross-sectional view illustrating a piston of the compressor shown in Fig. 1;

Fig. 3 is an exploded perspective view illustrating the piston of Fig. 2;

Fig. 4 is cross-sectional view illustrating a piston according to a second embodiment;

Fig. 5 is cross-sectional view illustrating a piston according to a second embodiment;

Fig. 6A is a cross-sectional view illustrating a piston according to a fourth embodiment;

Fig. 6B is a cross-sectional view taken along line 6B-6B of Fig. 6A;

Fig. 7 is a cross-sectional view illustrating a piston according to a fifth embodiment;

Fig. 8 is a cross-sectional view illustrating a piston according to a sixth embodiment;

Fig. 9 is a cross-sectional view illustrating a piston according to a seventh embodiment;

Fig. 10A is a cross-sectional view illustrating a piston according to an eighth embodiment;

Fig. 10B is an exploded perspective view illustrating the piston of Fig. 10A;

Fig. 11A is a cross-sectional view illustrating a piston according to a ninth embodiment;

Fig. 11B is a cross-sectional view taken along line

11B-11B Fig. 11A;

Fig. 12 is a cross-sectional view illustrating a piston according to a tenth embodiment;

Fig. 13A is a cross-sectional view illustrating a piston according to an eleventh embodiment; and

Fig. 13B is an enlarged partial view illustrating the piston of Fig. 13A.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0009] Pistons according to a first embodiment will now be described with reference to Figs. 1-3. The pistons are used in a variable displacement compressor used in a vehicle air conditioner.

[0010] As shown in Fig. 1, a front housing 11 and a rear housing 13 are secured to a cylinder block 12. A valve plate 14 is located between the cylinder block 12 and the rear housing 13. A drive shaft 16 extends through and is rotatably supported by the front housing 11 and the cylinder block 12.

[0011] The drive shaft 16 is coupled to an external drive source (not shown), or a vehicle engine, by a clutch mechanism such as an electromagnetic clutch. When the engine is running, the clutch operably connects the shaft 16 with the engine thereby rotating the shaft 16.

[0012] A rotor 19 is fixed to the rotary shaft 16 in the crank chamber 15. The crank chamber 15 also accommodates a swash plate 20. The swash plate 20 is supported on the drive shaft 16 to slide along the drive shaft 16 and incline with respect to the axis L of the drive shaft 16. A hinge mechanism 21 is located between the rotor 19 and the swash plate 20 to rotate the swash plate 20 integrally with the drive shaft 16. The hinge mechanism 21 guides the movement of the swash plate 20 in the axial direction of the drive shaft 16 and the inclination of the swash plate 20 with respect to the drive shaft 16. The inclination of the swash plate 20 decreases as the swash plate 20 moves toward the cylinder block 12 and increases as the swash plate 20 moves to the rotor 19.

[0013] Cylinder bores 12a are formed in the cylinder block 12. Each cylinder bore 12a houses a single-headed piston 22. Each piston 22 is coupled to the swash plate 20 by way of a pair of shoes 23. The shoes 23 convert rotation of the swash plate 20 into reciprocation of each piston 22 in the associated cylinder bore 12a.

[0014] A suction chamber 24 and a discharge chamber 25 are defined in the rear housing 13. The valve plate 14 has suction ports 26, suction valve flaps 27, discharge ports 28 and discharge valve flaps 29. Each set of ports 26, 28 and valve flaps 27, 29 corresponds to one of the cylinder bores 12a. As each piston 22 moves

from the top dead center to the bottom dead center, refrigerant gas is drawn into the corresponding suction port 26 from the suction chamber 24 thereby opening the suction flap 27 to enter the associated cylinder bore 12a. As each piston 22 moves from the bottom dead center to the top dead center in the associated cylinder bore 12a, the gas in the cylinder bores 12a is compressed to a predetermined pressure. The gas is then discharged to the discharge chamber 28 through the associated discharge port 28 while causing the associated valve flap 27 to flex to an open position.

[0015] A bleeding passage 30 includes a passage 30a formed in the drive shaft 16 along its axis and a passage 30b formed in the cylinder block 12 and the valve plate 14. The bleeding passage 30 connects the crank chamber 15 with the suction chamber 24.

[0016] A supply passage 31 connects the discharge chamber 25 with the crank chamber 15. A displacement control valve 32 is accommodated in the rear housing 13 to regulate the supply passage 31.

[0017] The displacement control valve 32 includes a solenoid 32a and a valve body 32b. Excitation and de-excitation of the solenoid 32a causes the valve body 32b to open and close the supply passage 31. The control valve 32 is connected to a computer (not shown). The computer excites and de-excites the solenoid 32a in accordance with the cooling load thereby moving the valve body 32b. Accordingly, the control valve 32 regulates flow of refrigerant gas from the discharge chamber 25 to the crank chamber 15 thereby controlling the difference between the pressure of the crank chamber 15 and the pressure of the cylinder bores 12a. The inclination of the swash plate 20 is altered in accordance with changes in the pressure difference. This, in turn, alters the stroke of the pistons 22 and varies the displacement of the compressor.

[0018] When the solenoid 32a is de-excited, the valve body 32b opens the supply passage 31 thereby communicating the discharge chamber 25 with the crank chamber 15. The refrigerant gas in the discharge chamber 25 therefore flows into the crank chamber 15 through the supply passage 31, which raises the pressure P_c in the crank chamber 15. As a result, the inclination of the swash plate 20 decreases, and the stroke of the pistons 22 decreases, accordingly. This decreases the displacement of the compressor.

[0019] When the solenoid 32a is excited, the valve body 32b closes the supply passage 31. This decreases the amount of pressurized refrigerant gas supplied from the discharge chamber 25 to the crank chamber 15. As a result, the inclination of the swash plate 21 is increased and the stroke of the pistons 22 increases, accordingly. This increases the displacement of the compressor.

[0020] In this manner, the inclination of the swash plate 20 is changed in accordance with the changes in the pressure of the crank chamber 15, or with the changes in the cooling load. The pistons 22 must follow

the movement of the swash plate 20. Hollow pistons are relatively light and therefore have a small inertial force when reciprocated. The swash plate 20 is therefore moved to a desired inclination position without being significantly affected by the inertial force of the pistons 22. Also, deformation of the pistons 22 during manufacturing steps would adversely affects the reciprocation of the pistons 22. Therefore, preventing the deformation of the pistons 22 allows the swash plate 20 to positively control its inclination position.

[0021] The structure of each piston 22 will now be described with reference to Figs. 1 to 3.

[0022] As shown in Fig. 1, each piston 22 has a head 40 housed in the associated cylinder bore 12a and a skirt 42 coupled to the swash plate 20 by the shoes 23. The head 40 and the skirt 42 are joined to each other to form the piston 22. The head 40 includes a cylinder 41 and a lid 43. The cylinder 41 includes an end plate 41c for closing the end that faces the valve plate 14. A slot 42a, which faces the swash plate 20, is provided in the skirt 42. The slot 42a has a pair of opposing walls. A socket 42b is defined in each wall to receive a shoe 23. A pair of shoes 23 are supported by the sockets 42b. The shoes sandwich a peripheral portion of the swash plate 20 as shown in Fig 1.

[0023] The disk-shaped lid 43 is formed integrally with the skirt 42. The outer diameter of the lid 43 is substantially the same as the outer diameter of the cylinder 41. A boss 43a extends from the lid 43. The outer diameter of the boss 43a is substantially the same as the inner diameter of the cylinder 41. An annular groove 43b is formed in the outer surface of the boss 43a. The cylinder 41 and the skirt 42 are made by casting or forging metal such as aluminum or aluminum alloy.

[0024] The cylinder 41 and the lid 43 are fixed to each other by crimping and adhesive. Fig. 3 shows the piston 22 before assembling. In this state, adhesive (not shown) is applied to the outer surface of the boss 43a, which includes the annular groove 43b. The adhesive is also applied on the part of the lid 43 that faces the adjacent end surface 41b of the cylinder 41. The adhesive is, for example, resin adhesive such as epoxy, polyamide and vinyl acetate or low melting point alloy such as lead-tin alloy and zinc-tin alloy.

[0025] Then, the skirt 42 is attached to the cylinder 41 such that the lid 43 closes the inner space 41a of the cylinder 41. At this time, the outer surface of the boss 43a contacts a part of the inner wall of the cylinder 41, and the lid 43 contacts the end surface 41b of the cylinder 41.

[0026] Then, a crimping tool (not shown) is pressed against the cylinder 41 at a part corresponding to the annular groove 43b with a predetermined pressure. In this state, the tool is rotated about the axis S, which slides the tool along the groove 43b. The force of the tool uniformly deforms the cylinder 41 so that a section of the cylinder 41 is pressed into the groove 43b as shown in Fig 2. Further, when set, the adhesive rein-

forces the joint between the cylinder and the skirt 42.

[0027] The assembly of the cylinder 41 and the skirt 42 is performed in a vacuum. Therefore, the inner space 41a of the cylinder 41 is depressurized when the vacuum is removed.

[0028] The illustrated embodiment has the following advantages.

(1) The cylinder 41 is mechanically fixed to the skirt 42 by deformation, or crimping. In addition, adhesive reinforces the joint. Thus, heating the cylinder 41 and the skirt 42 (the lid 43) is not required. Therefore, compared to a welded joint, the strength of the joint between the cylinder 41 and the skirt 42 is not deteriorated by bubbles. Therefore, the piston 22 is stronger.

(2) The cylinder 41 and the skirt 42 are fixed to each other by two devices, namely crimping and adhesive. Thus, the cylinder 41 and the skirt 42 are firmly secured to each other.

(3) One of the devices for coupling the cylinder 41 with the skirt 42 is crimping. Therefore, there is no need for separate fasteners to couple the cylinder 41 to the skirt 42. This reduces the number of parts in each piston 22 and simplifies its structure.

(4) The annular groove 43b is formed on the boss 43a of the lid 43. The cylinder 41 is crimped to conform to the annular groove 43b. That is, the cylinder 41 is engaged with the skirt 42 about the entire circumference. Thus, the cylinder 41 has a uniform circumference at any given axial position. This structure reinforces the joint between the cylinder 41 and the skirt 42.

(5) The outer diameter of the boss 43a is substantially equal to the inner diameter of the cylinder 41. This increases the contact area between the cylinder 41 and the skirt 42. In other words, adhesive is applied to a relatively large area. As a result, the cylinder 41 and the skirt 42 are firmly joined to each other.

(6) The inner space 41a of the cylinder 41 is sealed by the lid 43 in a vacuum. Therefore, even if the temperature of piston 22 is increased due to the ambient heat during operation of the compressor, strong inner pressure is not applied to the piston 22 from the inner space 41a since there is little air in the space 41a. Thus, the joint of the piston 22 is not deformed and the durability of the piston 22 is improved.

[0029] Other embodiments of the present invention will now be described. The differences from the embodiment of Figs. 1-3 will mainly be discussed below. In the

following embodiments, adhesive is applied to the joint between the skirt 42 and the cylinder 41.

[0030] Fig. 4 illustrates a piston 22 according to a second embodiment. In this embodiment, the skirt 42 is mechanically fixed to the cylinder by press fitting. That is, the boss 43a of the lid 43 has no annular groove 43b. The outer diameter of the inner diameter 43a is slightly greater than the inner diameter of the cylinder 41. The boss 43a is press fitted into the cylinder 41 with a predetermined force. Accordingly, the cylinder 41 and the skirt 42 are fixed to each other by a predetermined force.

[0031] Since the boss 43a has no annular groove 43b, the structure of the piston 22 of Fig. 4 is relatively simple.

[0032] Fig. 5 illustrates a piston according to a third embodiment. In this embodiment, the skirt 42 is mechanically fixed to the cylinder 41 by screwing. That is, the boss 43a of the lid 43 has no annular groove 43b. Instead, an internal thread 44 is formed in the inner surface of the cylinder 41 in the vicinity of the open end, and an external thread 45 is formed on the outer surface of the boss 43a. The cylinder 41 and the skirt 42 are assembled by engaging the threads 44, 45.

[0033] Figs. 6A and 6B illustrate a piston 22 according to a fourth embodiment. In this embodiment, the skirt 42 is mechanically fixed to the cylinder 41 by radial fasteners. That is, the boss 43a of the lid 43 has no annular groove 43b. Instead, pinholes 46, the number of which is four in the piston of Figs. 6A and 6B, extend through the joint section of the cylinder 41 and the boss 43a of the lid 43. The pinholes 46 are spaced apart by equal angular intervals. The cylinder 41 and the skirt 42 are assembled by press fitting a rivet 47, into each pinhole 46.

[0034] To maintain vacuum in the inner space 41a of the cylinder 41, sealing material (not shown) fills the space between each pinhole 46 and the associated rivet 47. The adhesive between the cylinder 41 and the lid 43 also seals the inner space 41a.

[0035] Fig. 7 illustrates a piston 22 according to a fifth embodiment. In this embodiment, the skirt 42 is mechanically fixed to the cylinder 41 by an axial fastener. That is, the boss 43a of the lid 43 has no annular groove 43b. Instead, a rim 48 extends from the lid 43. A boss 49 is formed at the open end of the cylinder 41. The outer diameter of the boss 49 is smaller than the rest of the cylinder 41. Adhesive is applied on the outer surface of the boss 49. A recess 41d is formed in the end plate 41c of the cylinder 41. A hole 50 is formed at the center of the recess 41d. A fastener rod 51 extends axially from the lid 43 toward the recess 41d.

[0036] The rim 48 is fitted about the boss 49 to join the skirt 42 to the cylinder 41. At this time, the fastener rod 51 extends through the inner space 41a and protrudes from the hole 50. The distal end of the rod 51, which protrudes from the hole 50, is located in the recess 41d. In other words, the distal end of the rod 51 does not axially protrude from the end plate 41c. A coupling mem-

ber, or snap ring 52, is fitted on a groove formed in the distal end of the rod 51. The snap ring 52 prevents the skirt 42 from disengaging from the cylinder 41. As a result, the cylinder 41 and the skirt 42 are joined.

[0037] To maintain vacuum in the inner space 41a of the cylinder 41, sealing material (not shown) fills the space between the hole 50 and the coupling rod 51. The adhesive between the boss 49 and the rim 48 also seals the inner space 41a.

[0038] Fig. 8 illustrates a piston 22 according to a sixth embodiment. In this embodiment, the skirt 42 is mechanically fixed to the cylinder 41 with an axial bolt. That is, the boss 43a of the lid 43 has no annular groove 43b. A threaded hole 53 is formed in the lid 43 along the axis S of the piston. A recess 41d is formed in the end plate 41c of the cylinder 41. A hole 54 is formed at the center of the recess 41d. A bolt 55 is inserted through the inner space 41a of the cylinder 41 via the hole 54 and is screwed into the threaded hole 53. In this manner, the cylinder 41 and the skirt 42 are joined by the bolt 55. A head 55a of the bolt 55 is accommodated in the recess 41d. That is, the head 55a does not axially protrude from the end plate 41c.

[0039] To maintain vacuum in the inner space 41a of the cylinder 41, sealing material (not shown) fills the space between the hole 54 and the bolt 55. The adhesive between the cylinder 41 and the boss 43a of the lid 43 also seals the inner space 41a.

[0040] Fig. 9 illustrates a piston according to a seventh embodiment. In this embodiment, the skirt 42 is mechanically fixed to the cylinder 41 by an axial extension of the cylinder 41. That is, the boss 43a of the lid 43 has no annular groove 43b. Instead, a threaded rod 56 extends from the end plate 41c of the cylinder 41. Threads 56a are formed at the distal end of the coupling rod 56. A threaded hole 57 is formed in the lid 43. The cylinder 41 and the skirt 42 are assembled by threading the rod 56 into the threaded hole 57.

[0041] Figs. 10A and 10B illustrate a piston 22 according to an eighth embodiment. In this embodiment, the skirt 42 is mechanically fixed to the cylinder 41 by a fastener ring 60. That is, the boss 43a of the lid 43 has no annular groove 43b. A rim 58 is integrally formed with the lid 43. The outer diameter of the rim 58 is equal to the outer diameter of the cylinder 41. A semi-cylinder 70a is formed at the distal end of the rim 58. A semi-cylinder 70b is also formed at the open end of the cylinder 41.

[0042] The cylinder 41 and the rim 58 are assembled such that the semi-cylinders 70a and 70b are engaged to form a complete ring. Grooves 59 are formed in the outer surface of the semi-cylinders 70a and 70b. When the semi-cylinders 70a and 70b are engaged, the grooves 59 form a single annular groove. Adhesive is applied on at least one of the contact surfaces of the cylinder 41 and the rim 58.

[0043] The fastener ring 60, includes two semi-circular pieces 60a. The semi-circular pieces 60a are engaged

at the corresponding ends to form the ring 60. The inner diameter of the ring 60 is slightly smaller than the diameter of the grooves 59. The cylinder 41 and the skirt 42 are first engaged with each other. Then, the semi-circular pieces 60a are coupled to each other in the grooves 59, which fastens the cylinder 41 and the skirt 42 to one another.

[0044] Figs. 11A and 11B illustrate a piston 22 according to a ninth embodiment. In this embodiment, the skirt 42 is mechanically fixed to the cylinder 41 by a pin 63. That is, the boss 43a of the lid 43 has no annular groove 43b. Instead, two pinholes 61 extend through the joint portion of the cylinder 41 and the boss 43a of the lid 43. The pinholes 61 are spaced apart by 180 degrees. An annular groove 62 is formed in the outer surface of the cylinder 41. The pinholes 61 are formed in the groove 62.

[0045] The pin 63, is inserted into the cylinder 41 through one of the pinholes 61. A pair of arms 63a of the pin 63 protrude from the other pinhole 61. The arms 63a separate and conform to the circumference of the cylinder 41. The arms 63a are accommodated in the groove 62. In this manner, the cylinder 41 and the skirt 42 are held together by the pin 63.

[0046] To maintain vacuum in the inner space 41a of the cylinder 41, sealing material (not shown) fills the space between each hole 61 and the pin 63. Adhesive between the cylinder 41 and the lid 43 also seals the inner space 41a.

[0047] Fig. 12 illustrates a piston 22 according to a tenth embodiment. In this embodiment, the skirt 42 is mechanically fixed to the cylinder 41 by an internal fastening ring 65. That is, the boss 43a of the lid 43 has no annular groove 43b. Instead, annular grooves 64 are formed on the inner surface of the boss 43a and on the inner surface of the cylinder 41. A fastener ring 65, which is made of iron-based metal, has an arcuate cross-section, a groove facing radially outward and a pair of annular rims 65a. One of the rims 65a of the fastener ring 65 is engaged with the groove 64 of the boss 43a and the other edge 65a is engaged with the groove 64 of the cylinder 64. In this manner, the cylinder 41 and the skirt 42 are held together.

[0048] Figs. 13A and 13B illustrate a piston 22 according to an eleventh embodiment. In this embodiment, the skirt 42 is mechanically fixed to the cylinder 41 by retainers 67. That is, the boss 43a of the lid 43 has no annular groove 43b. Instead, a rim 66 extends from the lid 43. The outer diameter of the rim 66 is substantially the same as the outer diameter of the cylinder 41. A small diameter portion is formed at the distal end of the rim 66. The outer diameter of the small diameter portion is substantially the same as the inner diameter of the cylinder 41. Adhesive is applied on the outer surface of the small diameter portion. The cylinder 41 is fitted about the small diameter portion of the rim 66.

[0049] As shown in Fig. 13B, square grooves 67 are formed in the outer surface of the cylinder 41 and the

rim 66. Each groove 67 extends from the cylinder 41 to the rim 66. Projections 68 are formed on the cylinder 41 and the rim 66. Specifically, a projection 68 of the cylinder 41 and a corresponding projection of the rim 66 are located in each groove 67. Fasteners, or retainers 67, are fitted in the groove 67. Each retainer 67 is press fitted into one of the grooves 67, which retains the projection 68 of the cylinder 41 in contact with the associated projection 68 of the rim 66. In this manner, the cylinder 41 and the skirt 42 are held together by the retainers 67.

[0050] It should be apparent to those skilled in the art that the present invention may be embodied in many other specific forms without departing from the spirit or scope of the invention. Particularly, it should be understood that the invention may be embodied in the following forms.

[0051] In the embodiments of Fig. 1 to Fig. 13B, the cylinder 41 and the skirt 42 may be assembled without using adhesive. That is, the cylinder 41 and the skirt 42 may be joined only by mechanical means. Alternatively, the cylinder 41 and the skirt 42 may be joined only by adhesive.

[0052] The end plate 41c may be formed separately from the cylinder 41 and may be assembled with the cylinder 41 by a method described in the embodiments of Figs. 1 to 13B. In this case, the cylinder 41 may be separately formed from the skirt 42 as in the embodiments of Figs. 1 to 13B. Alternatively, the cylinder 41 may be integrally formed with the skirt 42.

[0053] The inner space 41a of the cylinder 41, which is closed by the lid 43, does not need be depressurized. In this case, assembly of the cylinder and the skirt 42 does not need be performed in a vacuum. This reduces the manufacturing costs of the pistons 22.

[0054] The present invention may be embodied in pistons other than the pistons 22 of Figs. 1 to 13B, which are used in swash plate compressors. For example, the present invention may be embodied in pistons of wave cam plate type compressors, pistons of double-headed piston type variable displacement compressor, pistons in air compressors and pistons in reciprocation internal combustion engines.

[0055] Therefore, the present examples and embodiments are to be considered as illustrative and not restrictive and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalence of the appended claims.

[0056] Improved pistons (22), which are reciprocated by a swash plate (20) of a compressor, have two separate parts joined together. Each piston (22) has a head (40) and a skirt (42). The head (40) has a cylinder (41) with an opening at one end. The opening is closed by a lid (43). The lid (43) is mechanically fixed to the cylinder (41), for example, by crimping. Also, adhesive is used to fix the lid (43) to the cylinder (41). Accordingly, the cylinder (41) and the lid (43) are firmly secured to each other.

Claims

1. A piston (22) for cooperating with a driving body (20) in a machine, the piston (22) comprising:

a skirt (42), wherein the skirt (42) serves to connect the piston (22) to the driving body (20); and
a head (40) including:

a cylinder (41) having at least at one open end; and

a lid (43) for closing the open end, **characterized in that** the lid (43) is mechanically fixed to the cylinder (41).

2. The piston (22) according to claim 1, **characterized in that** adhesive is applied to a joint between the lid (43) and the cylinder (41).

3. The piston (22) according to claim 2, **characterized in that** the adhesive forms a hermetic seal between the lid (43) and the cylinder (41).

4. The piston (22) according any one of claims 1 to 3, **characterized in that** the piston (22) is made of aluminum or aluminum alloy.

5. The piston (22) according any one of claims 1 to 4, **characterized in that** the interior of the cylinder (41) is depressurized.

6. The piston (22) according any one of claims 1 to 5, **characterized in that** the lid (43) and the cylinder (41) are threaded to each other.

7. The piston (22) according any one of claims 1 to 5, **characterized in that** the lid (43) and the cylinder (41) are fixed to each other by metal deformation.

8. The piston (22) according to claim 7, **characterized in that** the lid (43) includes a cylindrical boss (43a) that is fitted into the opening of the cylinder (41), the boss has an annular groove (43b) formed in its outer surface, and **characterized in that** the cylinder (41) is deformed to fit into the annular groove (43b).

9. The piston (22) according any one of claims 1 to 5, **characterized in that** the lid (43) is press fitted to the cylinder (41).

10. The piston (22) according any one of claims 1 to 5, **characterized in that** the lid (43) and the cylinder (41) are fixed with each other by a fastener (47, 52, 55, 60, 61, 65, 69).

11. The piston (22) according any one of claims 1 to 10,

characterized in that the lid (43) is integrally formed with the skirt (42).

12. A piston (22) for cooperating with a driving body (20) in a machine, the piston (22) comprising:

a skirt (42), wherein the skirt (42) serves to connect the piston (22) to the driving body (20); and
a head (40) including:

a cylinder (41) having an opening at least at one end; and

a lid (43) for closing the open end, **characterized in that** the lid (43) is joined to the cylinder (41) by adhesive.

13. A compressor including a piston (22) according any one of claims 1 to 12.

Fig.1

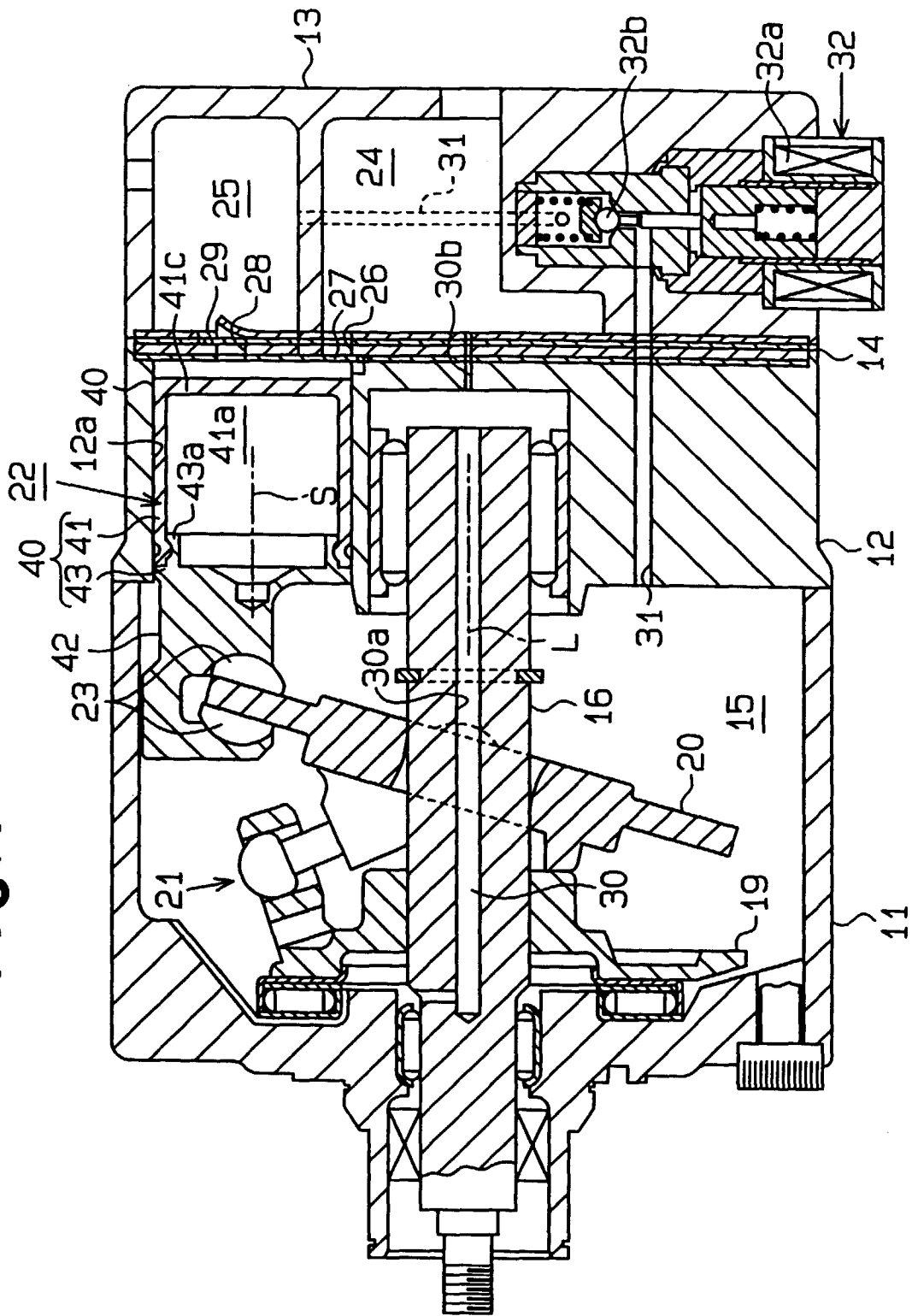


Fig. 2

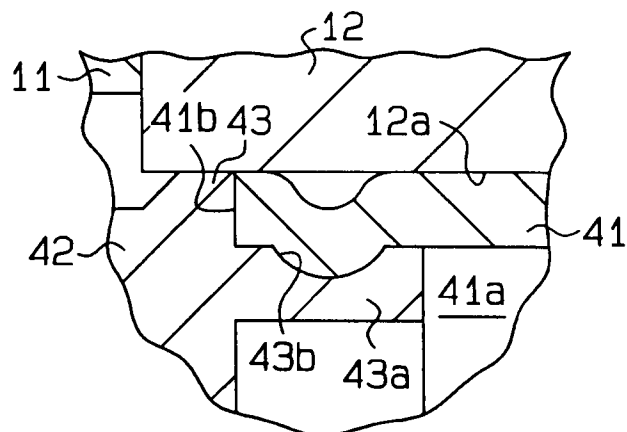


Fig. 3

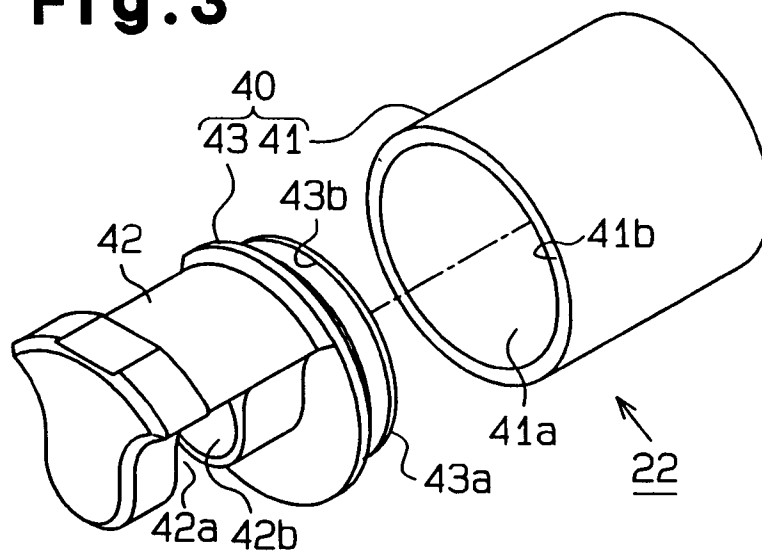


Fig. 4

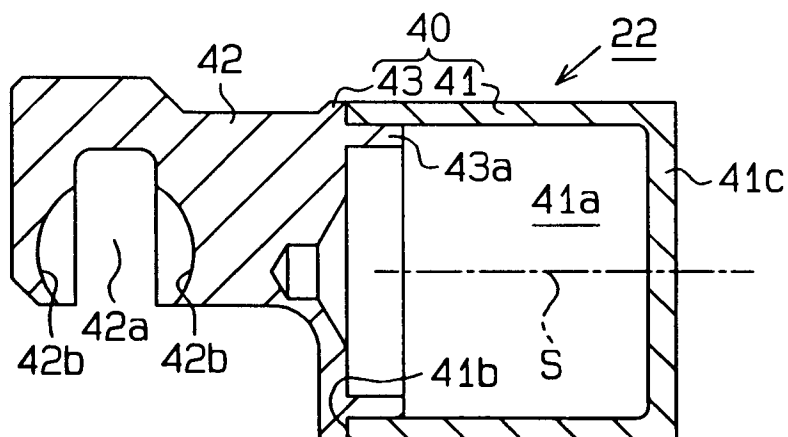


Fig. 5

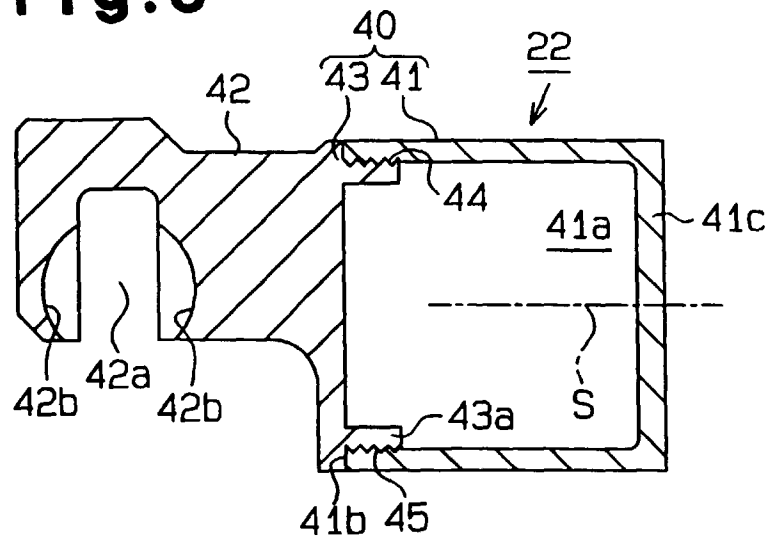


Fig. 6A

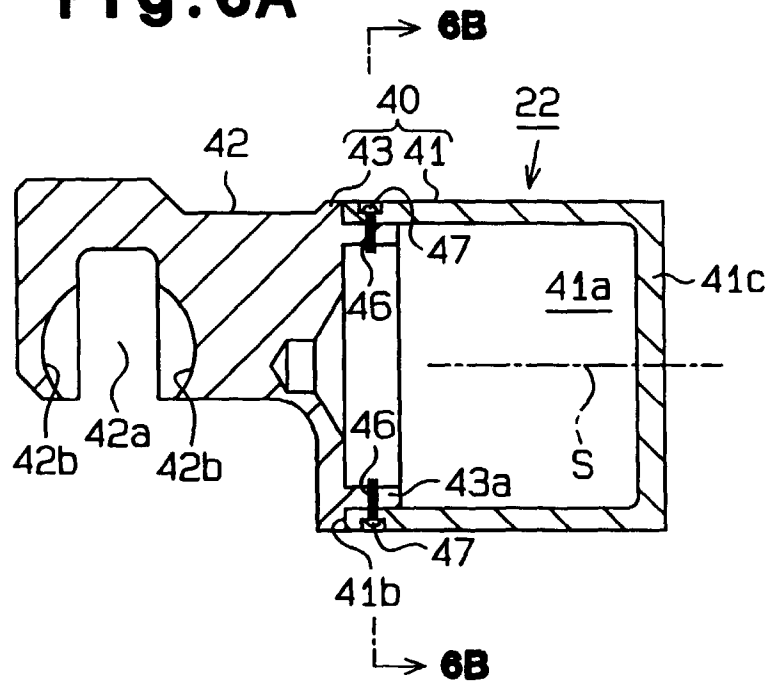


Fig. 6B

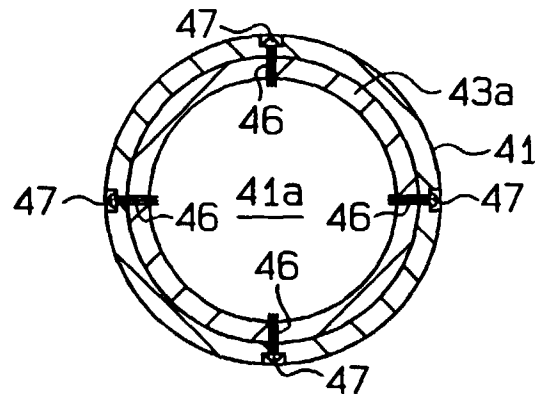


Fig.7

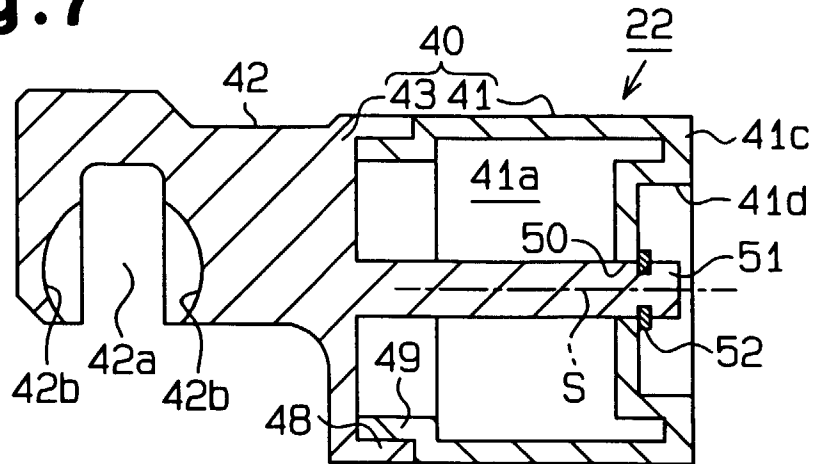


Fig.8

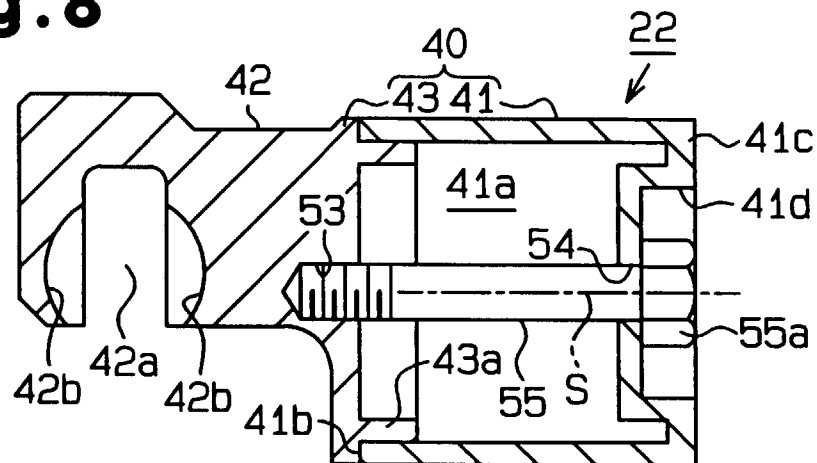


Fig.9

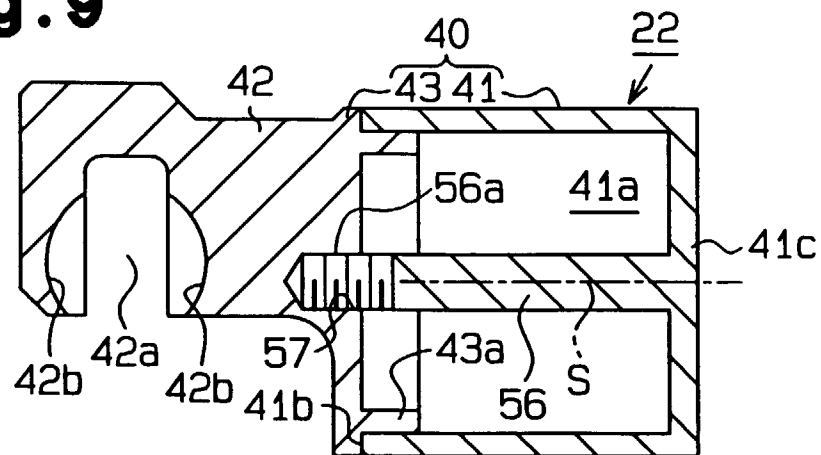


Fig.10A

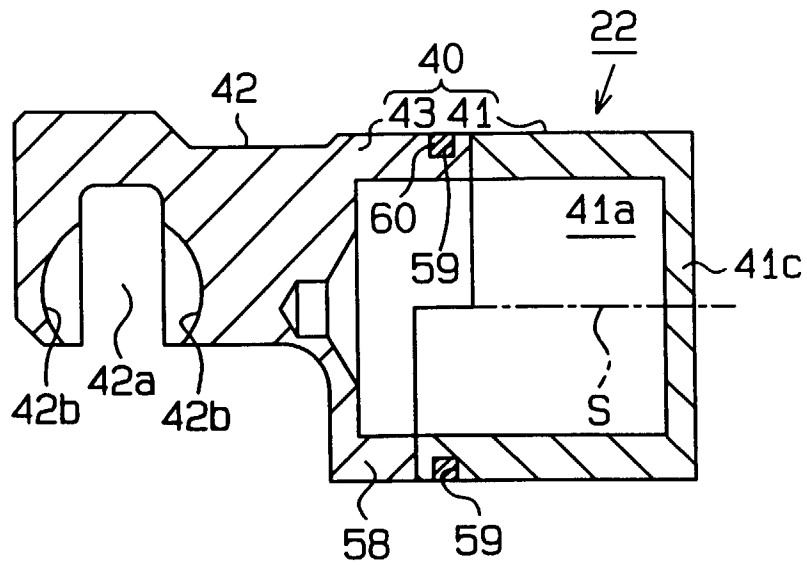


Fig.10B

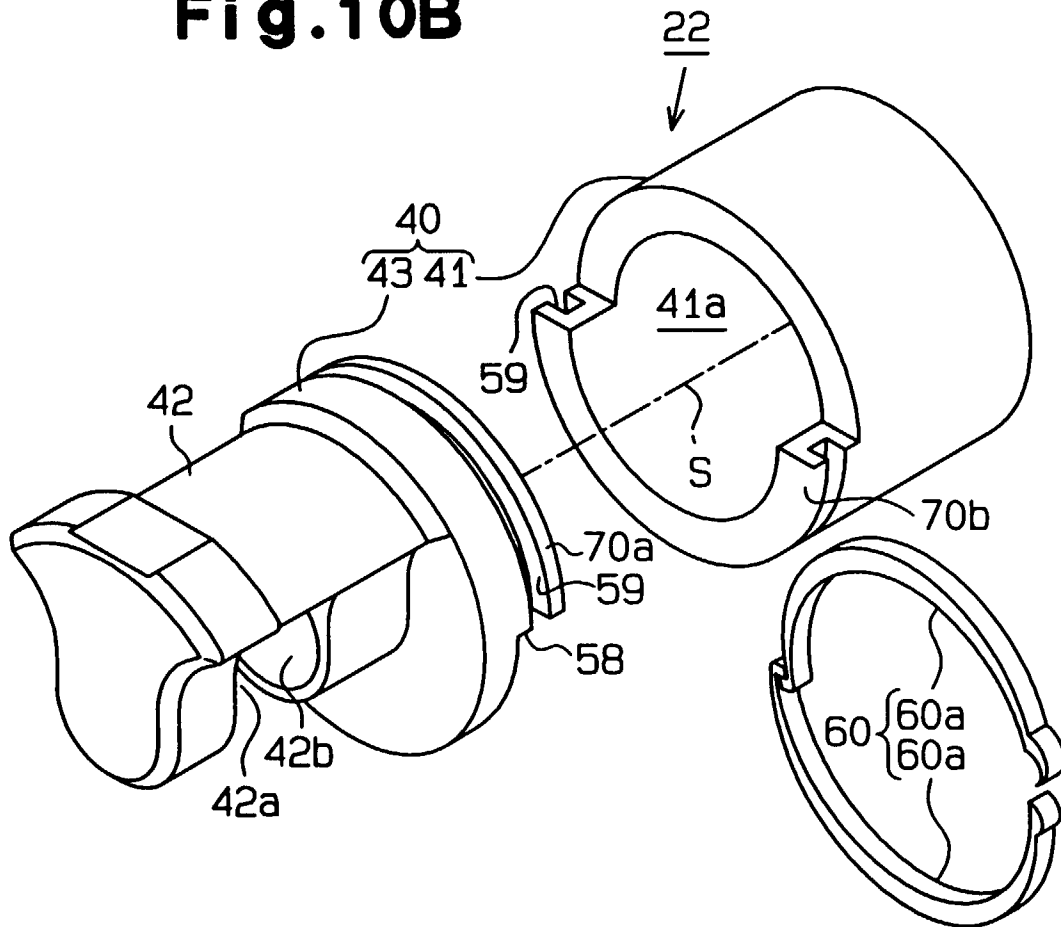


Fig.11A

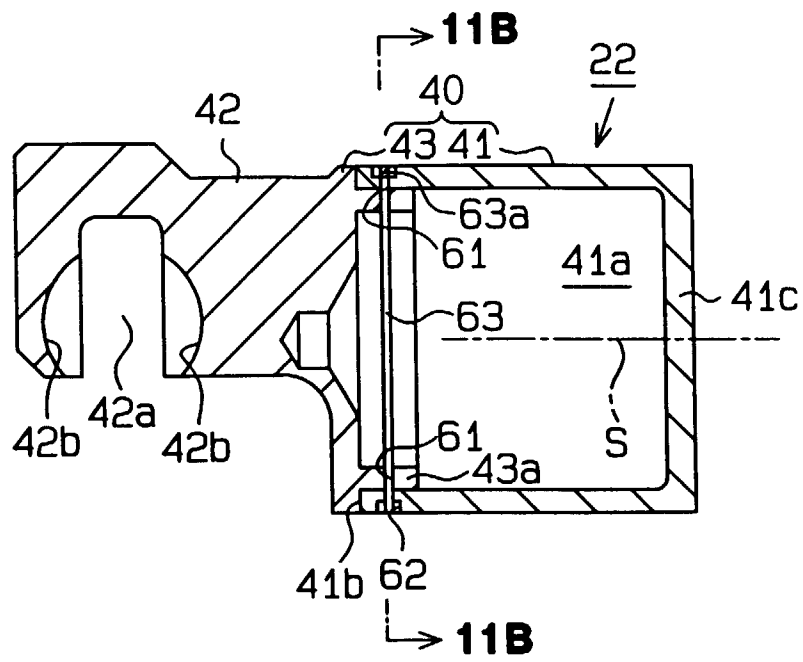


Fig.11B

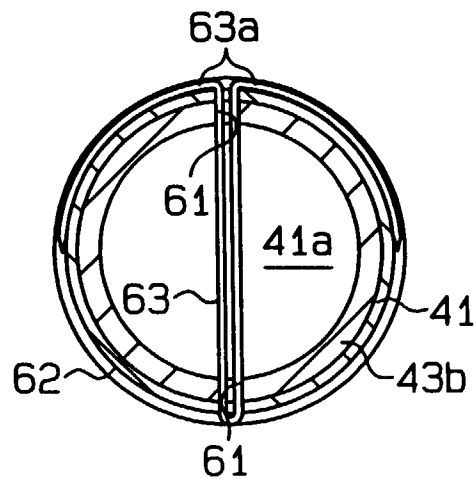


Fig.12

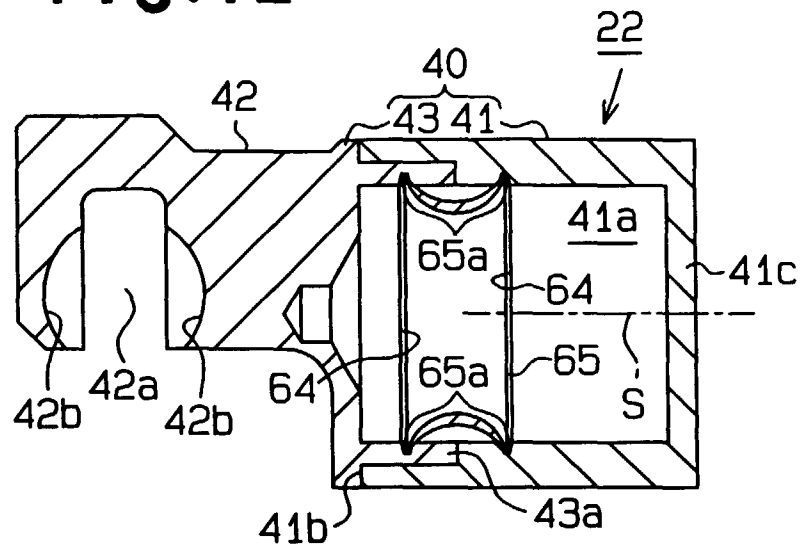


Fig.13A

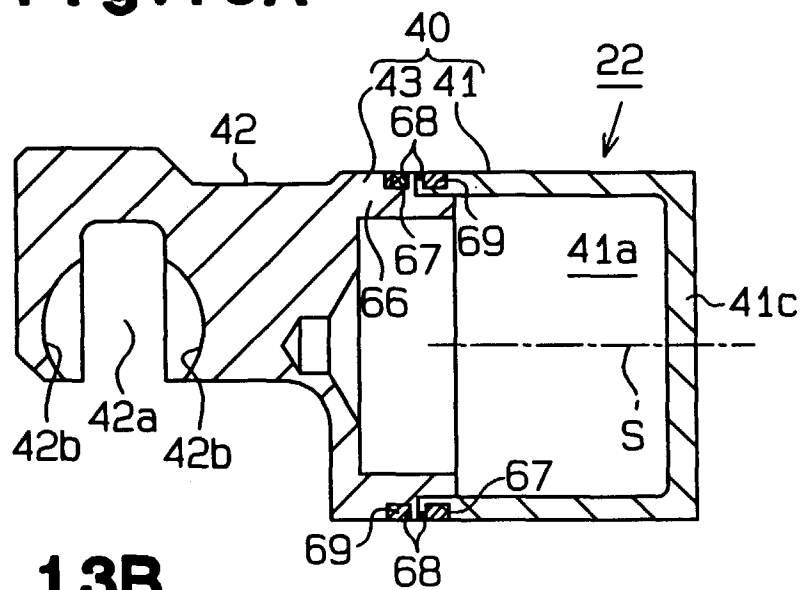


Fig.13B

