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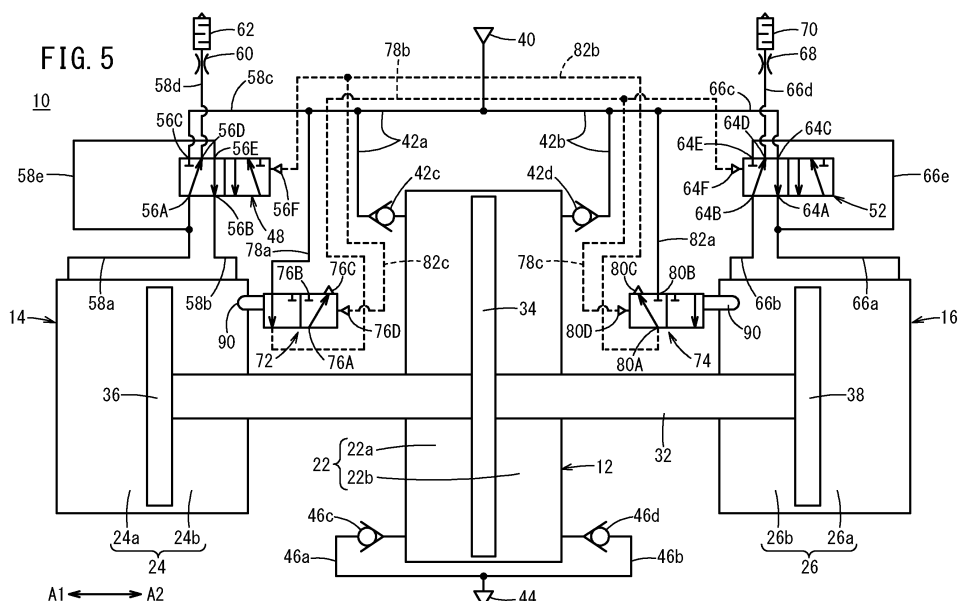
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(54) **PRESSURE BOOSTER**

(57) A pressure booster (10) in which drive cylinders (14, 16) are arranged at both sides of a boost cylinder (12), and which is equipped with: a pair of pilot valves (72, 74) equipped with knock pins (90) that come into contact with pistons (36, 38) of the drive cylinders at a moving end; and a pair of actuation valves (48, 52) for switching the supply state of a pressure fluid with respect

to pressure chambers (24a, 26a) of the drive cylinders. When a piston presses against a knock pin and one or the other pilot valve thus switches to a first position, the state in which the pressure fluid is supplied to the pair of actuation valves is switched and a prescribed fluid pressure acts on the knock pin so as to keep the pilot valve in the first position.



Description

Technical Field

[0001] The present invention relates to a pressure booster for increasing the pressure of a pressurized fluid and outputting the pressurized fluid.

Background Art

[0002] Conventionally, pressure booster devices have been known which consecutively increase the pressure of pressurized fluid by means of reciprocating motion of pistons and then output the pressurized fluid.

[0003] For example, Japanese Laid-Open Patent Publication No. 08-021404 discloses a pressure booster in which a pair of boosting cylinders having their respective pistons directly connected to a piston rod are arranged so as to face each other, and an energy collecting cylinder is provided between the pair of boosting cylinders. In this pressure booster, compressed air is supplied into the compressing chamber and operating chamber of one of the boosting cylinders and into the compressing chamber of the other boosting cylinder, and then the air supplied into the compressing chamber of that one boosting cylinder is boosted and outputted. Switching operation of air-supply between the boosting cylinders and of flow channels connected to the collecting cylinder is performed by reed switches detecting the positions of the pistons in the boosting cylinders to thereby turn on and off solenoids of a switching valve accordingly.

[0004] In the pressure booster of Japanese Laid-Open Patent Publication No. 08-021404, the pair of boosting cylinders each have the operating chamber for driving the piston and the compressing chamber for compressing the fluid. This may limit flexibility in design. In addition, since the reed switches and the solenoids are used to perform the switching operation, electrical means including electrical wiring is required.

[0005] Accordingly, the applicant of the present invention has filed a patent application of an invention relating to a pressure booster in which cylinders for driving the pistons and a cylinder for compressing pressurized fluid are separately arranged in an organized manner, and which is capable of performing switching operations without using electrical means (Japanese Patent Application No. 2017-164945).

[0006] The pressure booster of the above patent application includes driving cylinders provided respectively on both sides of a boosting cylinder, a pair of pilot valves each having a push rod with which the piston of the corresponding driving cylinder comes in contact at its travel end, and a pair of operating valves for switching the state of supply of the pressurized fluid from a pressurized fluid supply source to the pressurizing chambers of the individual driving cylinders.

Summary of Invention

[0007] With the pressure booster of the above patent application, force with which the piston of each driving cylinder pushes the push rod becomes weak, for example, when the output of the pressure booster has become close to saturation, and then the push rod may be disadvantageously returned by spring force without the pilot valve being sufficiently switched. The pressure booster was thus not completely satisfactory. The present invention has been devised considering such a situation, and an object of the present invention is to provide a pressure booster capable of reliably switching the pilot valves even when the pistons of the driving cylinders push the pilot valves with a weak force.

[0008] According to the present invention, a pressure booster in which driving cylinders are provided respectively on both sides of a boosting cylinder includes: a pair of pilot valves each including a knock pin with which a piston of a corresponding one of the driving cylinders comes in contact at a travel end of the piston, and a pair of operating valves each configured to switch the state of supply of a pressurized fluid from a pressurized fluid supply source into a pressurizing chamber of a corresponding one of the driving cylinders. When one or the other of the pilot valves switches to a first position by the knock pin of the pilot valve being pushed by the corresponding piston, then the state of supply of the pressurized fluid to the pair of operating valves is switched and a certain fluid pressure acts on the knock pin so as to hold the pilot valve in the first position.

[0009] According to the pressure booster above, a knock pin that has come in contact with the driving cylinder's piston can be pushed completely to the end by the certain fluid pressure, and the pilot valve can be kept in a fully switched position.

[0010] According to the pressure booster of the invention, the certain fluid pressure acts on the knock pins so as to keep the pilot valves in the fully switched positions. Accordingly, even if a driving cylinder's piston pushes the knock pin with a weak force, the knock pin can be pushed completely to the end and the pilot valve can be switched reliably.

Brief Description of Drawings

[0011]

FIG. 1 is a perspective view illustrating the appearance of a pressure booster according to an embodiment of the present invention;

FIG. 2 is a side view of the pressure booster of FIG. 1; FIG. 3 is a cross sectional view taken along III-III of FIG. 2;

FIG. 4 is a cross sectional view taken along IV-IV of FIG. 2;

FIG. 5 is a schematic overall diagram illustrating the pressure booster of FIG. 1 using a circuit diagram;

FIG. 6 is a cross sectional view of a first pilot valve of the pressure booster of FIG. 1;

FIG. 7 is a diagram corresponding to FIG. 6, where the knock pin of the first pilot valve has moved to a different position;

FIG. 8 is a diagram corresponding to FIG. 6, where the knock pin of the first pilot valve has moved further to a different position; and

FIG. 9 is a diagram corresponding to FIG. 5, where the pressure booster has changed from the state of FIG. 5 to another state.

Description of Embodiments

[0012] The pressure booster of the present invention will be described below in detail in connection with preferred embodiments while referring to the accompanying drawings. A pressure booster 10 according to an embodiment of the invention is installed between a pressurized fluid supply source (compressor; not shown) and an actuator (not shown) that operates with the pressurized fluid whose pressure has been boosted.

[0013] As shown in FIGS. 1 and 3, the pressure booster 10 has a triple cylinder structure including a boosting cylinder 12, a first driving cylinder 14 disposed at one end of the boosting cylinder 12 (an end on an A1 direction side), and a second driving cylinder 16 disposed at the other end of the boosting cylinder 12 (an end on an A2 direction side), which are connected in a row. That is, in the pressure booster 10, the first driving cylinder 14, the boosting cylinder 12, and the second driving cylinder 16 are arranged in this order from the A1 direction to the A2 direction.

[0014] A first cover member 18 in the form of a block is interposed between the first driving cylinder 14 and the boosting cylinder 12, and a second cover member 20 in the form of a block is interposed between the boosting cylinder 12 and the second driving cylinder 16.

[0015] The boosting cylinder 12 includes a boosting chamber 22 therein, and the first driving cylinder 14 and the second driving cylinder 16 include a first driving chamber 24 and a second driving chamber 26 therein, respectively. In this case, a third cover member 28 is fixed at an end of the first driving cylinder 14 on the A1 side, and the first cover member 18 is disposed at an end thereof on the A2 side, thus forming the first driving chamber 24. Also, the second cover member 20 is disposed at an end of the second driving cylinder 16 on the A1 side, and an end thereof on the A2 side is closed by a wall 30, thus forming the second driving chamber 26.

[0016] As shown in FIG. 3, a piston rod 32 is provided to pass through the first cover member 18, the boosting cylinder 12, and the second cover member 20. One end of the piston rod 32 extends into the first driving chamber 24, and the other end of the piston rod 32 extends into the second driving chamber 26.

[0017] In the boosting chamber 22, a boosting piston 34 is coupled to a middle portion of the piston rod 32.

The boosting chamber 22 is thus partitioned into a first boosting chamber 22a on the A1 side and a second boosting chamber 22b on the A2 side (see FIG. 5). In the first driving chamber 24, a first driving piston 36 is coupled at one end of the piston rod 32. The first driving chamber 24 is thus partitioned into a pressurizing chamber 24a on the A1 side and a back pressure chamber 24b on the A2 side (see FIG. 5). Further, in the second driving chamber 26, a second driving piston 38 is coupled to the other end of the piston rod 32. The second driving chamber 26 is thus partitioned into a pressurizing chamber 26a on the A2 side and a back pressure chamber 26b on the A1 side (see FIG. 5). The boosting piston 34, the first driving piston 36, and the second driving piston 38 are integrally connected through the piston rod 32.

[0018] As shown in FIG. 1, the boosting cylinder 12 includes, at an upper portion of the front surface, a supply port 40 to which a pressurized fluid is supplied from a pressurized fluid supply source (not shown). As shown in FIGS. 4 and 5, a fluid supply mechanism is provided in the interiors of the boosting cylinder 12, the first cover member 18, and the second cover member 20. The fluid supply mechanism communicates with the supply port 40 and supplies the supplied pressurized fluid into the first boosting chamber 22a and the second boosting chamber 22b. The fluid supply mechanism includes a first supply passage 42a that allows the supply port 40 and the first boosting chamber 22a to communicate with each other, and a second supply passage 42b that allows the supply port 40 and the second boosting chamber 22b to communicate with each other.

[0019] The first supply passage 42a is provided with a first supply check valve 42c that permits the flow of fluid from the supply port 40 to the first boosting chamber 22a and blocks the flow of fluid from the first boosting chamber 22a to the supply port 40. The second supply passage 42b is provided with a second supply check valve 42d that permits the flow of fluid from the supply port 40 to the second boosting chamber 22b and blocks the flow of fluid from the second boosting chamber 22b to the supply port 40.

[0020] As shown in FIG. 1, the boosting cylinder 12 includes an output port 44 formed in a lower portion of the front surface. Fluid whose pressure is boosted by boosting operation, which will be described later, is outputted from the output port 44 to the outside. As shown in FIGS. 4 and 5, a fluid output mechanism is provided in the interiors of the boosting cylinder 12, the first cover member 18, and the second cover member 20. The fluid output mechanism communicates with the output port 44, and outputs, from the output port 44, fluid whose pressure has been boosted in the first boosting chamber 22a or the second boosting chamber 22b. The fluid output mechanism includes a first output passage 46a that allows the first boosting chamber 22a and the output port 44 to communicate with each other, and a second output passage 46b that allows the second boosting chamber 22b and the output port 44 to communicate with each other.

other.

[0021] The first output passage 46a is provided with a first output check valve 46c that permits the flow of fluid from the first boosting chamber 22a to the output port 44 and blocks flow of fluid from the output port 44 to the first boosting chamber 22a. The second output passage 46b is provided with a second output check valve 46d that permits the flow of fluid from the second boosting chamber 22b to the output port 44 and blocks flow of fluid from the output port 44 to the second boosting chamber 22b.

[0022] Next, a configuration of the operating valves will be described. As shown in FIG. 1, the first driving cylinder 14 includes, on an upper part thereof, a first housing 50 having a first operating valve 48, and the second driving cylinder 16 includes, on an upper part thereof, a second housing 54 having a second operating valve 52.

[0023] As shown in FIG. 5, the first operating valve 48 has first to fifth ports 56A to 56E as points of connection and switching of passages. The first operating valve 48 is configured so as to be capable of switching between a first position for driving the first driving piston 36 and a second position for allowing the first driving piston 36 to follow movement of the second driving piston 38 being driven.

[0024] The first port 56A is connected to the pressurizing chamber 24a in the first driving cylinder 14 through a passage 58a. The second port 56B is connected to the back pressure chamber 24b in the first driving cylinder 14 through a passage 58b. The third port 56C is connected to the first supply passage 42a through a passage 58c. The fourth port 56D is connected through a passage 58d to a first silencer 62 having a discharge port. The fifth port 56E is connected to a midway point of the passage 58a through a passage 58e. The passage 58d has a first fixed orifice 60 interposed therein.

[0025] When the first operating valve 48 is in the first position, the first port 56A and the third port 56C communicate with each other, and the second port 56B and the fourth port 56D communicate with each other. Then, the pressurized fluid from the supply port 40 is supplied into the pressurizing chamber 24a through the passage 58c and passage 58a, and the fluid in the back pressure chamber 24b is discharged through the passage 58b and passage 58d and through the first fixed orifice 60 and the first silencer 62.

[0026] When the first operating valve 48 is in the second position, the first port 56A and the fourth port 56D communicate with each other, and the second port 56B and the fifth port 56E communicate with each other. Then, part of the fluid in the pressurizing chamber 24a is collected into the back pressure chamber 24b through the passage 58a, passage 58e, and passage 58b, and the remaining part is discharged through the passage 58d and through the first fixed orifice 60 and the first silencer 62.

[0027] The first operating valve 48 further includes a pilot port 56F for introducing a pilot pressure from a second pilot valve 74 which will be described later. The first

operating valve 48 is in the first position when pressurized fluid (pilot pressure) is being supplied to the pilot port 56F, and it is in the second position when the pressurized fluid (pilot pressure) is not being supplied to the pilot port 56F.

[0028] The second operating valve 52 has first to fifth ports 64A to 64E as points of connection and switching of passages. The second operating valve 52 is configured so as to be capable of switching between a first position for driving the second driving piston 38 and a second position for allowing the second driving piston 38 to follow movement of the first driving piston 36 being driven.

[0029] The first port 64A is connected to the pressurizing chamber 26a in the second driving cylinder 16 through a passage 66a. The second port 64B is connected to the back pressure chamber 26b in the second driving cylinder 16 through a passage 66b. The third port 64C is connected to the second supply passage 42b through a passage 66c. The fourth port 64D is connected through a passage 66d to a second silencer 70 having a discharge port. The fifth port 64E is connected to a midway point of the passage 66a through a passage 66e. The passage 66d has a second fixed orifice 68 interposed therein.

[0030] When the second operating valve 52 is in the first position, the first port 64A and the third port 64C communicate with each other, and the second port 64B and the fourth port 64D communicate with each other. Then, the pressurized fluid from the supply port 40 is supplied into the pressurizing chamber 26a through the passage 66c and passage 66a, and the fluid in the back pressure chamber 26b is discharged through the passage 66b and passage 66d and through the second fixed orifice 68 and the second silencer 70.

[0031] When the second operating valve 52 is in the second position, the first port 64A and the fourth port 64D communicate with each other, and the second port 64B and the fifth port 64E communicate with each other. Then, part of the fluid in the pressurizing chamber 26a is collected into the back pressure chamber 26b through the passage 66a, passage 66e, and passage 66b, and the remaining part is discharged through the passage 66d and through the second fixed orifice 68 and the second silencer 70.

[0032] The second operating valve 52 further includes a pilot port 64F for introducing a pilot pressure from a first pilot valve 72 which will be described later. The second operating valve 52 is in the first position when pressurized fluid (pilot pressure) is being supplied to the pilot port 64F, and it is in the second position when the pressurized fluid (pilot pressure) is not being supplied to the pilot port 64F.

[0033] Next, a configuration of the pilot valves will be described. The first pilot valve 72 is provided inside the first cover member 18, and the second pilot valve 74 is provided inside the second cover member 20.

[0034] The first pilot valve 72 has first to fourth ports

76A to 76D. The first pilot valve 72 is configured to be capable of switching between a first position for generating the pilot pressure for the second operating valve 52 and a second position for eliminating the pilot pressure.

[0035] The first port 76A is connected to the pilot port 64F of the second operating valve 52 through a first pilot passage 78b. The second port (supply port) 76B is connected to the first supply passage 42a through a passage 78a. The third port 76C constitutes a discharge port. The fourth port (cooperation port) 76D is connected to a first port 80A of the second pilot valve 74, which will be described later, through a branch passage 82c and a second pilot passage 82b described later. Further, a branch passage 78c connecting to a fourth port 80D of the second pilot valve 74, which will be described later, branches off from the first pilot passage 78b.

[0036] When the first pilot valve 72 is in the first position, the first port 76A and the second port 76B communicate with each other. Then, the pressurized fluid from the supply port 40 is supplied to the pilot port 64F of the second operating valve 52 through the passage 78a and the first pilot passage 78b, and the pressurized fluid is also supplied to the fourth port 80D of the second pilot valve 74 (described later) through the branch passage 78c branching off from the first pilot passage 78b.

[0037] When the first pilot valve 72 is in the second position, the first port 76A and the third port 76C communicate with each other. Then, the pressurized fluid that has been being supplied to the pilot port 64F of the second operating valve 52 is discharged through the first pilot passage 78b, and the pressurized fluid supplied to the fourth port 80D of the second pilot valve 74 is discharged through the branch passage 78c and first pilot passage 78b.

[0038] The second pilot valve 74 has first to fourth ports 80A to 80D. The second pilot valve 74 is configured to be capable of switching between a first position for generating the pilot pressure for the first operating valve 48 and a second position for eliminating the pilot pressure.

[0039] The first port 80A is connected to the pilot port 56F of the first operating valve 48 through the second pilot passage 82b. The second port (supply port) 80B is connected to the second supply passage 42b through a passage 82a. The third port 80C constitutes a discharge port. The fourth port 80D (cooperation port) is connected to the first port 76A of the first pilot valve 72 through the branch passage 78c and the first pilot passage 78b. Further, the branch passage 82c connecting to the fourth port 76D of the first pilot valve 72 branches off from the second pilot passage 82b.

[0040] When the second pilot valve 74 is in the first position, the first port 80A and the second port 80B communicate with each other. Then, the pressurized fluid from the supply port 40 is supplied to the pilot port 56F of the first operating valve 48 through the passage 82a and second pilot passage 82b, and the pressurized fluid is also supplied to the fourth port 76D of the first pilot

valve 72 through the branch passage 82c branching off from the second pilot passage 82b.

[0041] When the second pilot valve 74 is in the second position, the first port 80A and the third port 80C communicate with each other. Then, the pressurized fluid that has been being supplied to the pilot port 56F of the first operating valve 48 is discharged through the second pilot passage 82b, and the pressurized fluid supplied to the fourth port 76D of the first pilot valve 72 is discharged through the branch passage 82c and second pilot passage 82b.

[0042] Now, referring to FIGS. 6 to 8, a specific structure of the first pilot valve 72 will be described. The second pilot valve 74 has the same structure as the first pilot valve 72, and so it will not be described herein.

[0043] The first pilot valve 72 includes a valve seat 86 accommodated in a valve container hole 84 formed in the first cover member 18, a valve seat retainer 88, and a knock pin 90. The valve container hole 84 is closed on the side of the boosting cylinder 12 and opens on the side of the first driving cylinder 14. The valve container hole 84 includes, at the closed end, a large-diameter hole portion 84a, and the fourth port 76D communicates with this large-diameter hole portion 84a.

[0044] The valve container hole 84 further has a small-diameter hole portion 84b connecting to the large-diameter hole portion 84a, and a medium-diameter hole portion 84c disposed on the opening side of the valve container hole and connecting to the small-diameter hole portion 84b. The first port 76A, the second port 76B, and the third port 76C communicate with the small-diameter hole portion 84b of the valve container hole 84. Of these three ports, the second port 76B is located closest to the fourth port 76D, and the third port 76C is located farthest from the fourth port 76D.

[0045] The valve seat 86 having a thin-walled cylindrical shape, and the valve seat retainer 88 having a thick-walled cylindrical shape, are inserted and fitted into the small-diameter hole portion 84b of the valve container hole 84. The valve seat retainer 88 includes one end surface located at one end in the axial direction and another end surface located at the other end in the axial direction, the one end surface facing toward the back pressure chamber 24b of the first driving cylinder 14, the other end surface abutting against the valve seat 86. A snap ring 92 abutting on the valve seat retainer 88 is fixed to the medium-diameter hole portion 84c of the valve container hole 84. The valve seat 86 and the valve seat retainer 88 are thus positioned and fixed in the axial direction inside the valve container hole 84. The valve seat 86 is engaged and locked with a step formed at a middle position of the small-diameter hole portion 84b.

[0046] An annular groove 86a facing the first port 76A is formed in the outer periphery of a middle portion of the valve seat 86 in the axial direction, and an annular recess 86b facing the third port 76C is formed in the outer periphery of an end of the valve seat 86 in the axial direction on a side that abuts on the valve seat retainer 88. The

annular groove 86a of the valve seat 86 communicates with the inner peripheral side of the valve seat 86 through a first through hole 86c that penetrates through the valve seat 86 in the radial direction, and the annular recess 86b of the valve seat 86 communicates with the inner peripheral side of the valve seat 86 through a second through hole 86d that penetrates through the valve seat 86 in the radial direction.

[0047] A first seal member 94a and a second seal member 94b that abut against the small-diameter hole portion 84b of the valve container hole 84 are fitted into grooves formed in the outer peripheral surface of the valve seat 86. The first seal member 94a prevents the first port 76A and the second port 76B from communicating with each other through the gap between the valve seat 86 and the valve container hole 84, and the second seal member 94b prevents the first port 76A and the third port 76C from communicating with each other through the gap between the valve seat 86 and the valve container hole 84.

[0048] A third seal member 96a abutting against the small-diameter hole portion 84b of the valve container hole 84 is fitted into a groove formed in the outer peripheral surface of the valve seat retainer 88, and a fourth seal member 96b in sliding contact with the knock pin 90 is fitted into a groove formed in the inner peripheral surface of the valve seat retainer 88. The third seal member 96a and the fourth seal member 96b provide a seal between the third port 76C and the back pressure chamber 24b of the first driving cylinder 14.

[0049] The knock pin 90 has a large-diameter shaft portion 90a, a medium-diameter shaft portion 90b, and a small-diameter shaft portion 90c. The large-diameter shaft portion 90a is inserted and fitted into the small-diameter hole portion 84b of the valve container hole 84. The medium-diameter shaft portion 90b is inserted and fitted into the inside of the valve seat 86 in such a manner that part of the shaft portion 90b protrudes from the valve seat 86, and the part protruding from the valve seat 86 faces the small-diameter hole portion 84b of the valve container hole 84 at a certain interval in the radial direction. The small-diameter shaft portion 90c is inserted and fitted into the inside of the valve seat retainer 88.

[0050] A first packing 98a in sliding contact with the small-diameter hole portion 84b of the valve container hole 84 is fitted into a groove formed in the large-diameter shaft portion 90a of the knock pin 90. The first packing 98a provides a seal between the second port 76B and the fourth port 76D. A second packing 98b and a third packing 98c that can be in sliding contact with the inner peripheral surface of the valve seat 86 are fitted into grooves formed in the medium-diameter shaft portion 90b of the knock pin 90. The outer periphery of the medium-diameter shaft portion 90b of the knock pin 90 has, formed therein, an annular groove 90d between the portion where the second packing 98b is fitted and the portion where the third packing 98c is fitted.

[0051] The knock pin 90 can slide between a position

where its end on the large-diameter shaft portion 90a side contacts the bottom surface (closed end surface) of the valve container hole 84 and a position where a step surface 90e between the medium-diameter shaft portion 90b and the small-diameter shaft portion 90c contacts the end surface of the valve seat retainer 88. When the knock pin 90 contacts the end surface of the valve seat retainer 88, the length that the small-diameter shaft portion 90c of the knock pin 90 projects into the back pressure chamber 24b of the first driving cylinder 14 (hereinafter referred to as "projecting length of the knock pin") becomes the maximum. The first driving piston 36 comes in contact with the end of the knock pin 90 on its small-diameter shaft portion 90c side and presses the knock pin 90 in the direction toward the bottom surface of the valve container hole 84.

[0052] The annular groove 90d of the knock pin 90 communicates with the annular groove 86a through the first through hole 86c in the valve seat 86, irrespective of the projecting length of the knock pin 90. In other words, the annular groove 90d of the knock pin 90 always communicates with the first port 76A irrespective of the position of the knock pin 90. Further, the second port 76B always communicates with the gap formed between the medium-diameter shaft portion 90b of the knock pin 90 and the small-diameter hole portion 84b of the valve container hole 84.

[0053] When the projecting length of the knock pin 90 is large, the second packing 98b contacts the inner surface of the valve seat 86, and the third packing 98c separates away from the inner surface of the valve seat 86 (see FIG. 6). Accordingly, the first port 76A communicates with the third port 76C through the gap between the inner surface of the valve seat 86 and the knock pin 90 including the annular groove 90d of the knock pin 90, and through the second through hole 86d and the annular recess 86b of the valve seat 86.

[0054] When the first driving piston 36 comes in contact with the knock pin 90 and the projecting length of the knock pin 90 becomes somewhat shorter than in the state described above, then both the second packing 98b and the third packing 98c contact the inner surface of the valve seat 86 (see FIG. 7). Accordingly, the first port 76A does not communicate with either of the second port 76B and the third port 76C.

[0055] When the projecting length of the knock pin 90 is small, the second packing 98b separates away from the inner surface of the valve seat 86 and the third packing 98c contacts the inner surface of the valve seat 86 (see FIG. 8). Accordingly, the first port 76A communicates with the second port 76B through the gap between the inner surface of the valve seat 86 and the knock pin 90 including the annular groove 90d of the knock pin 90 and through the gap formed between the medium-diameter shaft portion 90b of the knock pin 90 and the small-diameter hole portion 84b of the valve container hole 84.

[0056] When the pressurized fluid is supplied into the fourth port 76D, then the knock pin 90 is pushed in such

a direction that its projecting length increases. This is because the area (pressure receiving area) on which the fluid pressure at the fourth port 76D acts in the direction to increase the projecting length of the knock pin 90 is larger than the area (pressure receiving area) on which the fluid pressure at the second port 76B acts in the direction to reduce the projecting length of the knock pin 90.

[0057] On the other hand, when the pressurized fluid is not supplied into the fourth port 76D, then the knock pin 90 is pressed in such a direction that its projecting length decreases. This is because the fluid pressure at the fourth port 76D acting in the direction to increase the projecting length of the knock pin 90 disappears, while the fluid pressure at the second port 76B acting in the direction to reduce the projecting length of the knock pin 90 is maintained.

[0058] The pressure booster 10 of the first embodiment of the present invention is configured basically as described above. Next, its operations, and functions and effects will be described. As shown in FIG. 5, it is assumed that, in the initial position, the first operating valve 48 has switched to the second position, the second operating valve 52 has switched to the first position, and the boosting piston 34 is positioned close to the center in the boosting chamber 22. In the description below, in order to distinguish the knock pin of the first pilot valve 72 and the knock pin of the second pilot valve 74, the former will be referred to as "knock pin 90-1" and the latter will be referred to as "knock pin 90-2". Further, in order to distinguish the valve container hole of the first pilot valve 72 and the valve container hole of the second pilot valve 74, the former will be referred to as "valve container hole 84-1" and the latter will be referred to as "valve container hole 84-2".

[0059] In this initial position, the pressurized fluid is supplied from the pressurized fluid supply source to the supply port 40, and then the pressurized fluid flows into the first supply passage 42a and the second supply passage 42b. Then, the pressurized fluid is introduced into the first boosting chamber 22a and the second boosting chamber 22b of the boosting cylinder 12 through the first supply check valve 42c and the second supply check valve 42d.

[0060] Part of the pressurized fluid supplied from the supply port 40 is supplied into the pressurizing chamber 26a in the second driving cylinder 16 through the passage 66c, the second operating valve 52 being in the first position, and the passage 66a. The pressurized fluid supplied into the pressurizing chamber 26a drives the second driving piston 38 in the A1 direction. Then, the boosting piston 34, which is integrally coupled to the second driving piston 38, slides to boost the pressure of the pressurized fluid in the first boosting chamber 22a of the boosting cylinder 12. The boosted pressurized fluid is guided through the first output passage 46a and the first output check valve 46c to the output port 44 and is outputted therefrom.

[0061] On the other hand, the first driving piston 36,

which is integrally coupled to the second driving piston 38, slides, and then the volume of the pressurizing chamber 24a in the first driving cylinder 14 becomes small. Since the first operating valve 48 is in the second position, part of the pressurized fluid in the pressurizing chamber 24a is collected into the back pressure chamber 24b through the passage 58a, passage 58e, and passage 58b, and the remaining part thereof is discharged through the passage 58d.

[0062] As explained earlier, in the process in which the boosting piston 34 moves from the initial position to a certain distance in the A1 direction, the first pilot valve 72 is in the first position and so the pressurized fluid from the supply port 40 is being supplied to the fourth port 80D of the second pilot valve 74 through the first pilot valve 72. On the other hand, the second pilot valve 74 is in the second position, and so the pressurized fluid is not supplied to the fourth port 76D of the first pilot valve 72. Accordingly, in the first pilot valve 72, the knock pin 90-1 is urged in the direction to reduce the projecting length of the knock pin 90-1, and therefore the first pilot valve 72 is stably kept in the first position. On the other hand, in the second pilot valve 74, the knock pin 90-2 is urged in the direction to increase the projecting length of the knock pin 90-2, and therefore the second pilot valve 74 is stably kept in the second position.

[0063] Then, as shown in FIG. 9, in the vicinity of the stroke end of the displacement of the boosting piston 34 in the A1 direction, the second driving piston 38 comes in contact with the knock pin 90-2 of the second pilot valve 74. The knock pin 90-2 is pushed and displaced by the second driving piston 38, causing the first port 80A and the second port 80B of the second pilot valve 74 to communicate with each other. Then, the pressurized fluid from the supply port 40 is supplied to the pilot port 56F of the first operating valve 48 through the second pilot passage 82b, and also supplied to the fourth port 76D of the first pilot valve 72 through the branch passage 82c. This causes the first operating valve 48 to switch to the first position and the first pilot valve 72 to switch to the second position.

[0064] When the first pilot valve 72 has switched to the second position, the pressurized fluid that was being supplied to the pilot port 64F of the second operating valve 52 flows through the first pilot passage 78b and is then discharged from the third port 76C of the first pilot valve 72. This causes the second operating valve 52 to switch to the second position.

[0065] Further, when the first pilot valve 72 has switched to the second position, the pressurized fluid that was being supplied to the fourth port 80D of the second pilot valve 74 is discharged from the third port 76C of the first pilot valve 72 through the branch passage 78c and the first pilot passage 78b. Accordingly, in the second pilot valve 74, the fluid pressure acts in the direction to reduce the projecting length of the knock pin 90-2. Then, the knock pin 90-2, which has been pushed by the second driving piston 38 and displaced to a position at which the

first port 80A and the second port 80B of the second pilot valve 74 communicate with each other, is further subjected to the fluid pressure, and is kept in the position in which the knock pin 90-2 abuts against the bottom surface of the valve container hole 84-2. That is, the second pilot valve 74 is stably kept in the first position. The state in which the second pilot valve 74 is kept in the first position is maintained until the first driving piston 36 is driven in the A2 direction and displaces the knock pin 90-1, as will be described later.

[0066] This time, part of the pressurized fluid supplied from the supply port 40 is supplied into the pressurizing chamber 24a in the first driving cylinder 14 through the passage 58c, the first operating valve 48 being in the first position, and the passage 58a. The pressurized fluid supplied into the pressurizing chamber 24a drives the first driving piston 36 in the A2 direction. This causes the boosting piston 34, which is integrally coupled to the first driving piston 36, to slide to boost the pressure of the pressurized fluid in the second boosting chamber 22b of the boosting cylinder 12. The boosted pressurized fluid is guided through the second output passage 46b and the second output check valve 46d to the output port 44 and is outputted therefrom.

[0067] On the other hand, the second driving piston 38, which is integrally coupled to the first driving piston 36, slides, and then the volume of the pressurizing chamber 26a in the second driving cylinder 16 becomes small. Since the second operating valve 52 is in the second position, part of the pressurized fluid in the pressurizing chamber 26a is collected into the back pressure chamber 26b through the passage 66a, passage 66e, and passage 66b, and the remaining part thereof is discharged through the passage 66d.

[0068] Then, in the vicinity of the stroke end of the displacement of the boosting piston 34 in the A2 direction, the first driving piston 36 comes in contact with the knock pin 90-1 of the first pilot valve 72. The knock pin 90-1 is pressed and displaced by the first driving piston 36, causing the first port 76A and the second port 76B of the first pilot valve 72 to communicate with each other. Then, the pressurized fluid from the supply port 40 is supplied to the pilot port 64F of the second operating valve 52 through the first pilot passage 78b, and also supplied to the fourth port 80D of the second pilot valve 74 through the branch passage 78c. This causes the second operating valve 52 to switch to the first position and the second pilot valve 74 to switch to the second position.

[0069] When the second pilot valve 74 has switched to the second position, the pressurized fluid that was being supplied to the pilot port 56F of the first operating valve 48 is discharged from the third port 80C of the second pilot valve 74 through the second pilot passage 82b. This causes the first operating valve 48 to switch to the second position.

[0070] Further, when the second pilot valve 74 has switched to the second position, the pressurized fluid that was being supplied to the fourth port 76D of the first pilot

valve 72 is discharged from the third port 80C of the second pilot valve 74 through the branch passage 82c and the second pilot passage 82b. Accordingly, in the first pilot valve 72, the fluid pressure acts in the direction to reduce the projecting length of the knock pin 90-1. Then, the knock pin 90-1, which was pushed by the first driving piston 36 and displaced to a position at which the first port 76A and the second port 76B of the first pilot valve 72 communicate with each other, is further subjected to the fluid pressure, and is kept in the position in which the knock pin 90-1 abuts on the bottom surface of the valve container hole 84-1. That is, the first pilot valve 72 is stably kept in the first position. The state in which the first pilot valve 72 is kept in the first position is maintained until the second driving piston 38 is driven again in the A1 direction and displaces the knock pin 90-2. After this, in the same way, the boosting piston 34 repeats the reciprocating movement and the boosted pressurized fluid is continuously outputted from the output port 44.

[0071] According to the pressure booster 10 of the embodiment, the knock pin 90-1 is pushed by the first driving piston 36 and displaced to such a position as to cause the first port 76A and the second port 76B of the first pilot valve 72 to communicate with each other, then the knock pin 90-1 is further pushed by a certain fluid pressure to a position where the knock pin 90-1 abuts on the bottom surface of the valve container hole 84-1, and as a result, the knock pin 90-1 can be kept in this position. In the same way, after the knock pin 90-2 is pushed by the second driving piston 38 and displaced to such a position as to cause the first port 80A and the second port 80B of the second pilot valve 74 to communicate with each other, the knock pin 90-2 is further pushed by a certain fluid pressure to a position where the knock pin 90-2 abuts on the bottom surface of the valve container hole 84-2, and as a result, the knock pin 90-2 can be kept in this position.

[0072] Further, the first operating valve 48 switches to the first position when the pilot pressure is supplied from the second pilot valve 74 configured to switch its position in cooperation with the first pilot valve 72, and the first operating valve 48 switches to the second position when the supply of the pilot pressure from the second pilot valve 74 disappears. In the same way, the second operating valve 52 switches to the first position when the pilot pressure is supplied from the first pilot valve 72 configured to switch its position in cooperation with the second pilot valve 74, and the second operating valve 52 switches to the second position when the supply of the pilot pressure from the first pilot valve 72 disappears. Thus, the first operating valve 48 and the second operating valve 52 operate stably and switch at the same time.

[0073] Further, part of the fluid that was supplied into the pressurizing chamber 24a in order to drive the first driving piston 36 is collected into the back pressure chamber 24b when the first driving piston 36 is driven in conjunction with movement of the second driving piston 38, and thus it is possible to reduce the consumption of the

pressurized fluid. In the same way, part of the fluid that was supplied into the pressurizing chamber 26a in order to drive the second driving piston 38 is collected into the back pressure chamber 26b when the second driving piston 38 is driven in conjunction with movement of the first driving piston 36, and thus it is possible to reduce the consumption of the pressurized fluid.

[0074] The pressure booster according to the present invention is not limited to the embodiments described above, but can of course adopt various configurations without departing from the essence and gist of the present invention.

Claims

1. A pressure booster in which driving cylinders (14, 16) are provided respectively on both sides of a boosting cylinder (12), the pressure booster comprising:

a pair of pilot valves (72, 74) each including a knock pin (90) with which a piston (36, 38) of a corresponding one of the driving cylinders comes in contact at a travel end of the piston; and a pair of operating valves (48, 52) each configured to switch a state of supply of a pressurized fluid from a pressurized fluid supply source into a pressurizing chamber (24a, 26a) of a corresponding one of the driving cylinders, wherein, when one or another of the pilot valves switches to a first position by the knock pin of the pilot valve being pushed by the corresponding piston, then a state of supply of the pressurized fluid to the pair of operating valves is switched and a certain fluid pressure acts on the knock pin so as to hold the pilot valve in the first position.

2. The pressure booster according to claim 1, wherein a position of another of the operating valves is switched depending on presence or absence of a pilot pressure supplied from the one of the pilot valves, and a position of one of the operating valves is switched depending on presence or absence of a pilot pressure supplied from the other of the pilot valves.

3. The pressure booster according to claim 1, wherein the one of the pilot valves has a supply port to which the pressurized fluid is always supplied and a cooperation port to which the pressurized fluid is supplied through the other of the pilot valves, and the other of the pilot valves has a supply port to which the pressurized fluid is always supplied and a cooperation port to which the pressurized fluid is supplied through the one of the pilot valves, and wherein, when the pressurized fluid is supplied to the coop-

eration port of the one or the other of the pilot valves, then the knock pin of the pilot valve is urged in a direction in which the pilot valve moves toward a second position, and when the pressurized fluid is not supplied to the cooperation port, then the certain fluid pressure acts on the knock pin.

4. The pressure booster according to claim 3, wherein, when the one of the pilot valves is in the first position, a pilot pressure is supplied to another of the operating valves and the pressurized fluid is supplied to the cooperation port of the other of the pilot valves, and when the other of the pilot valves is in the first position, the pilot pressure is supplied to one of the operating valves and the pressurized fluid is supplied to the cooperation port of the one of the pilot valves.

5. The pressure booster according to claim 1, wherein each of the operating valves switches between a state that the pressurized fluid is supplied into the pressurizing chamber of the corresponding one of the driving cylinders and a pressurized fluid in a back pressure chamber (24b, 26b) of the driving cylinder is discharged, and a state that part of the pressurized fluid in the pressurizing chamber of the driving cylinder is collected into the back pressure chamber of the driving cylinder.

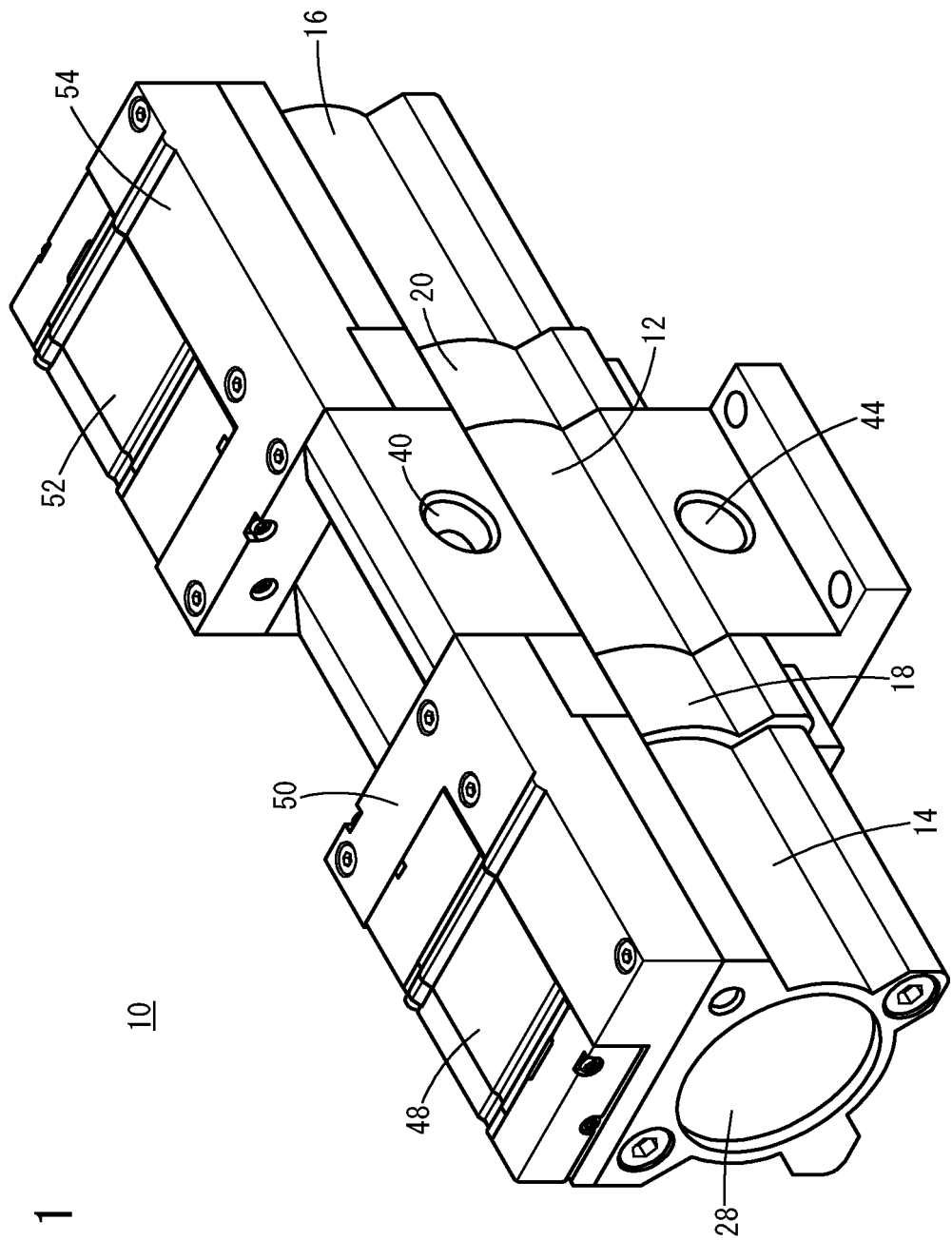


FIG. 1

FIG. 2

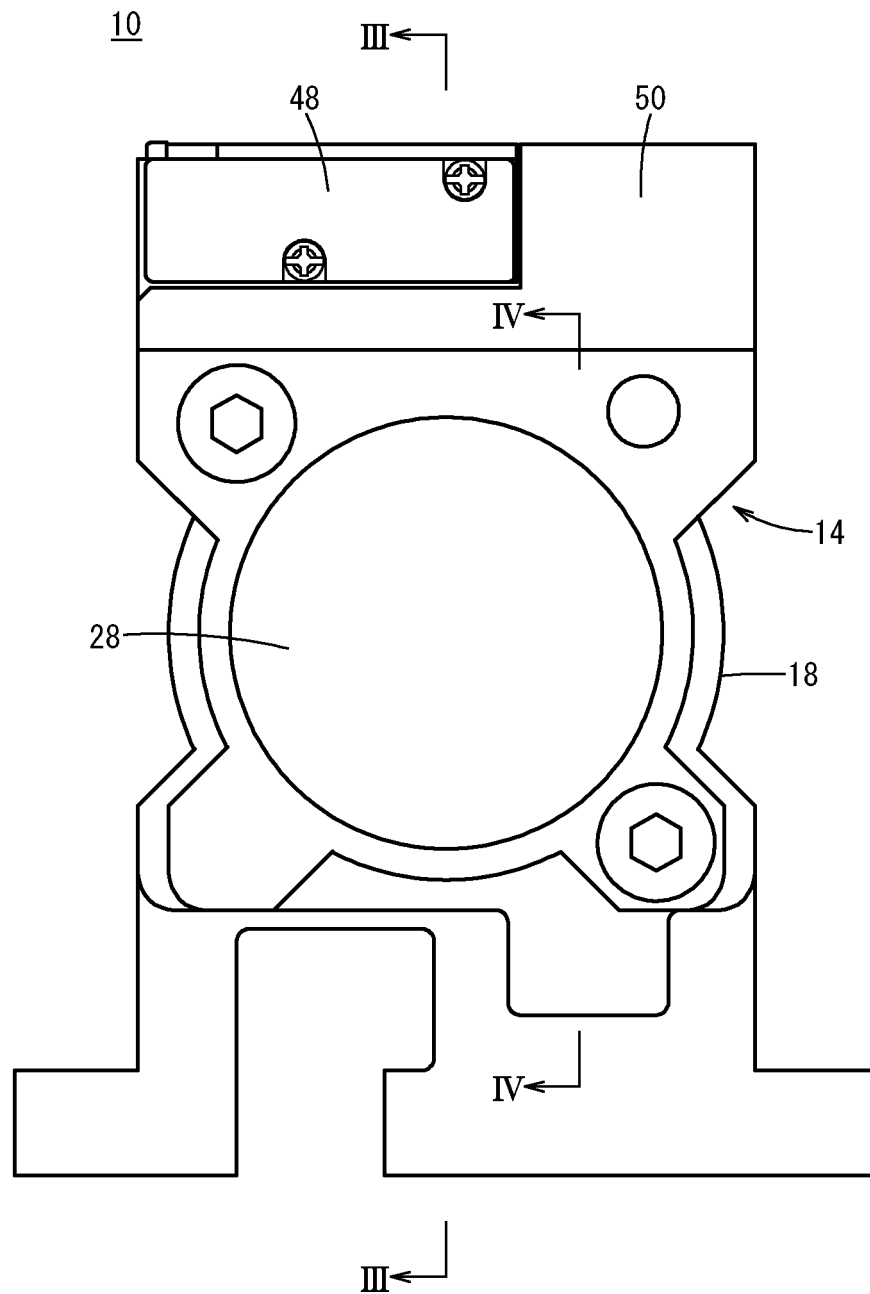
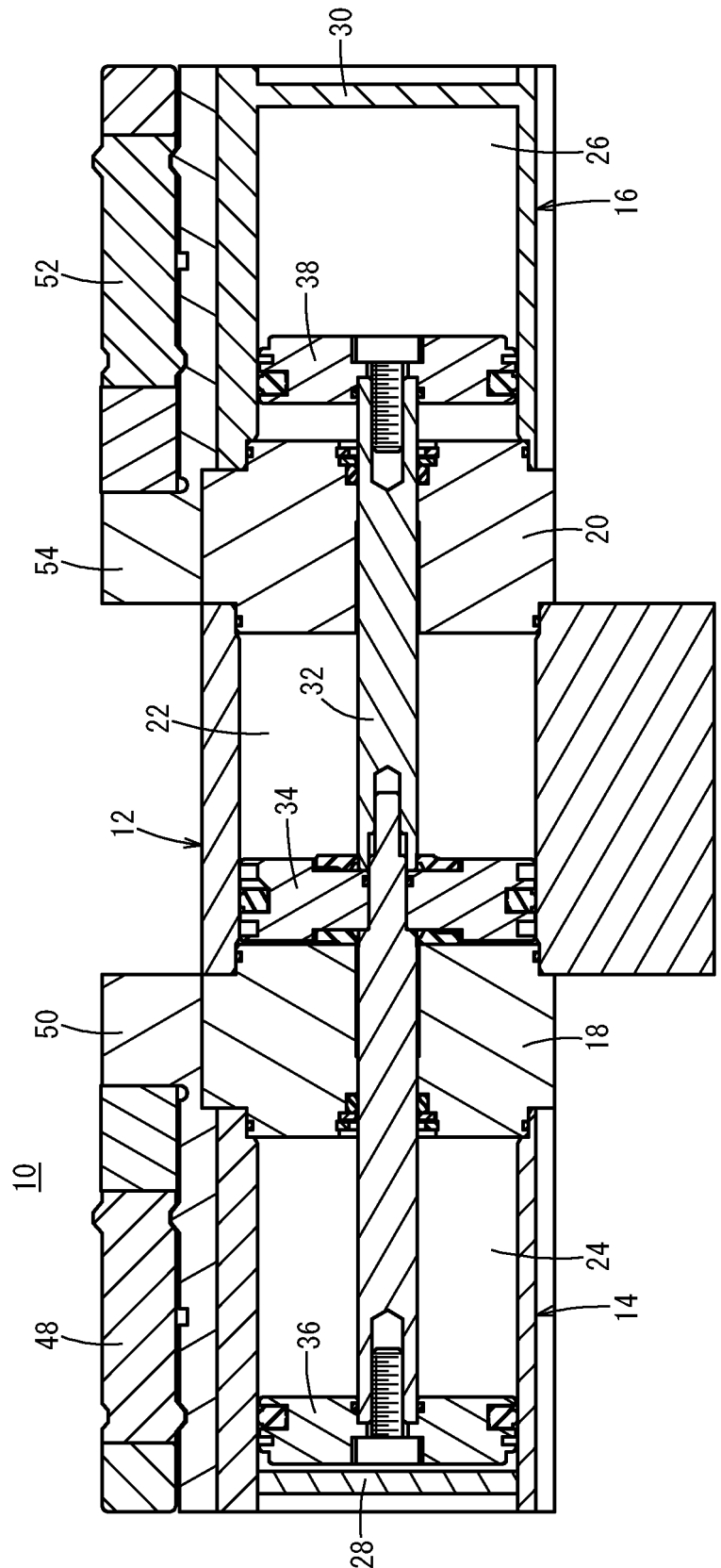
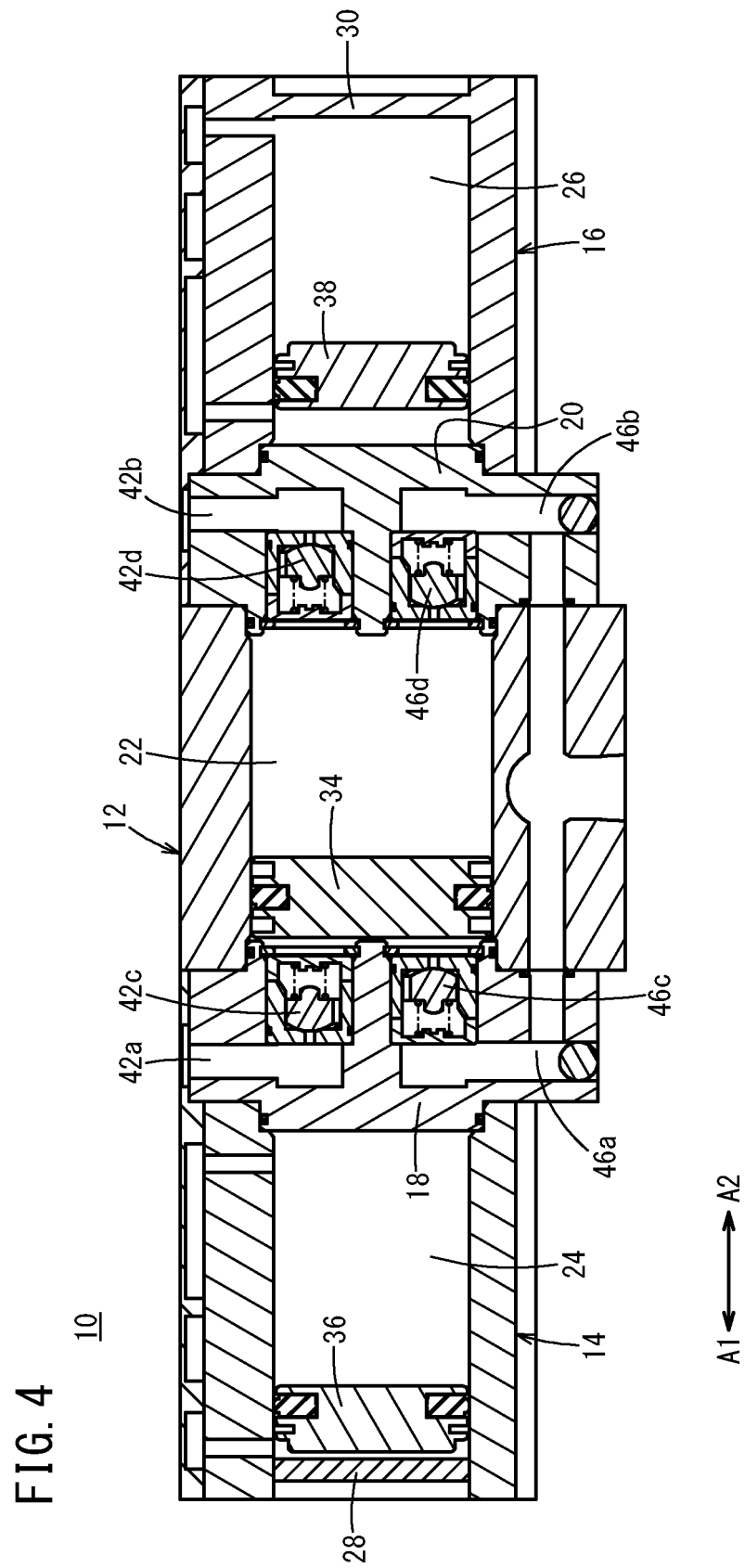


FIG. 3



A1 ← → A2



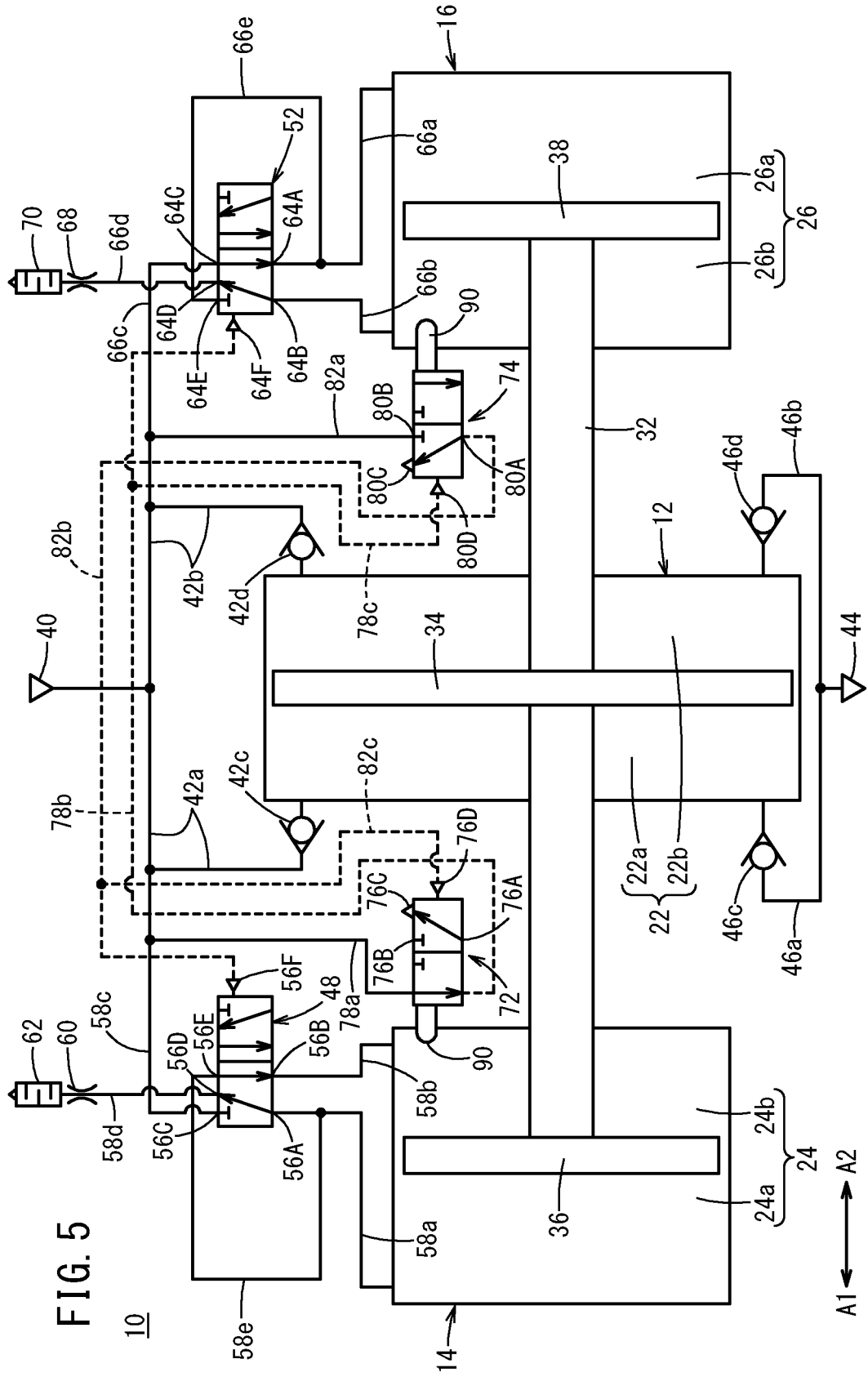


FIG. 6

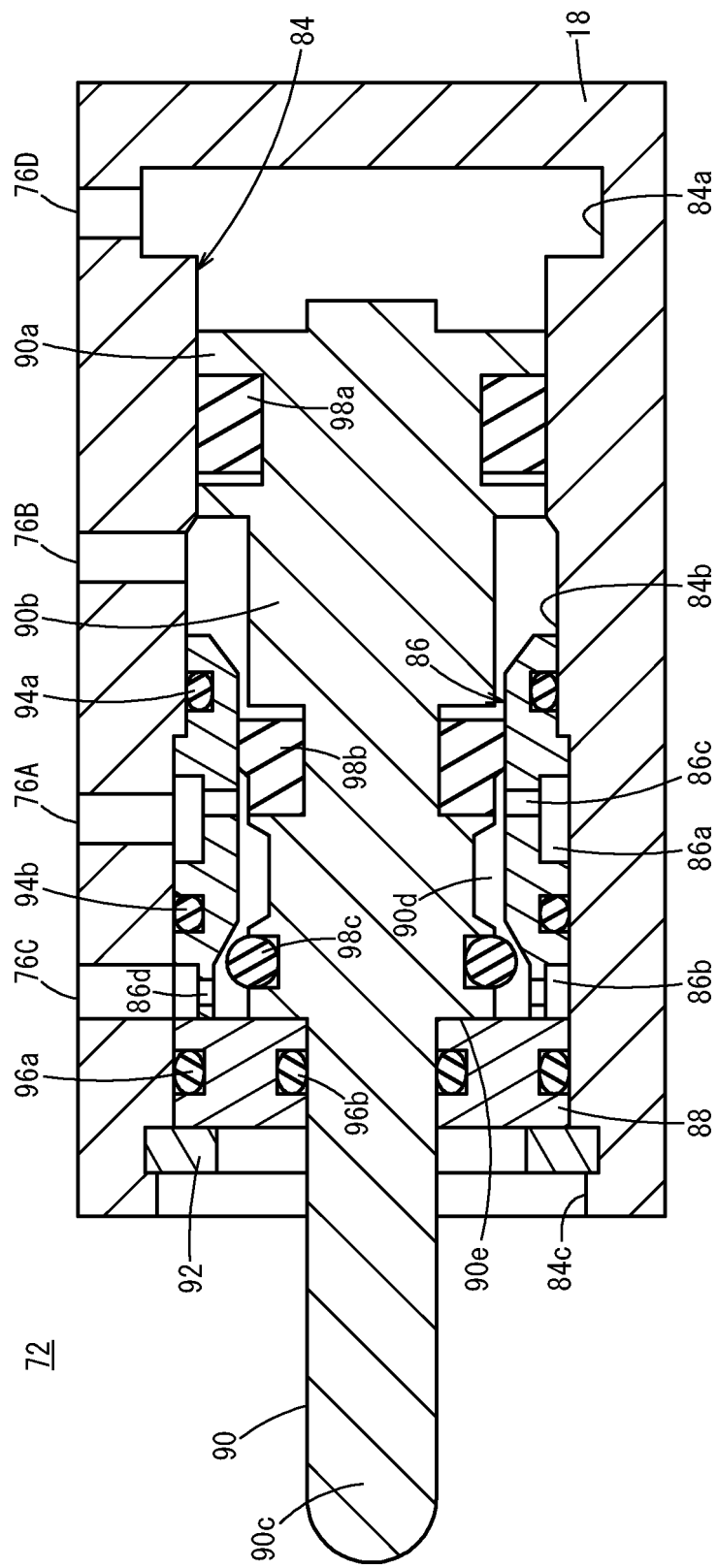
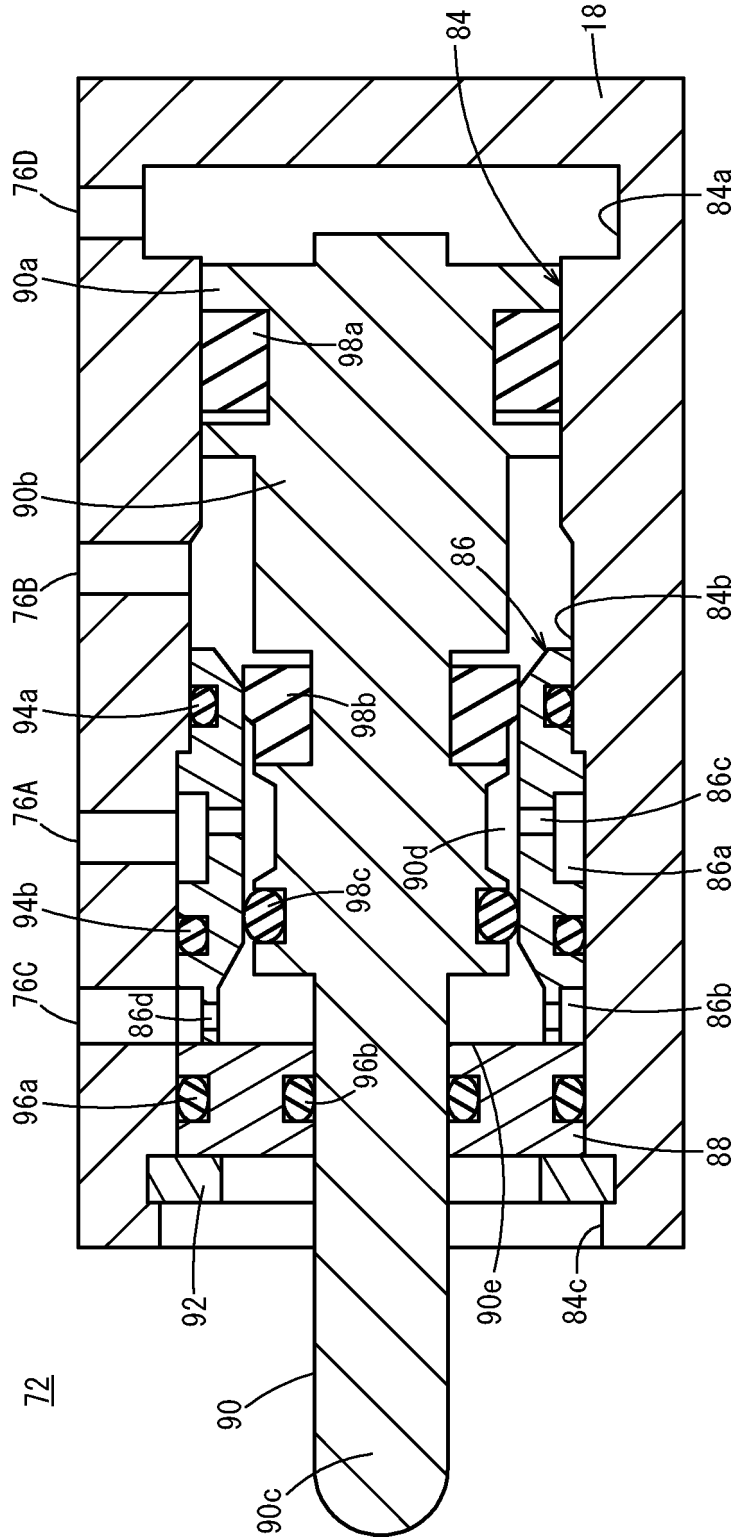


FIG. 7



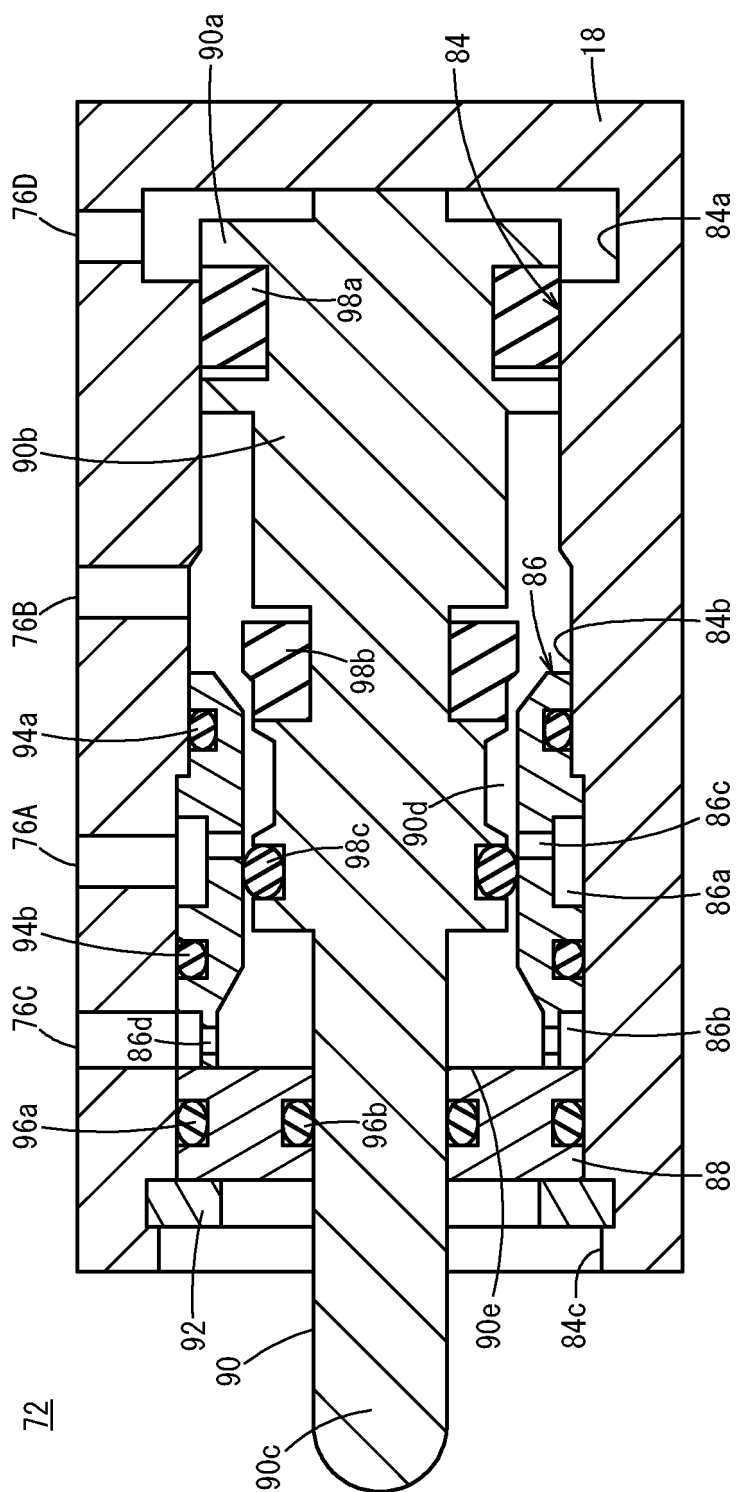
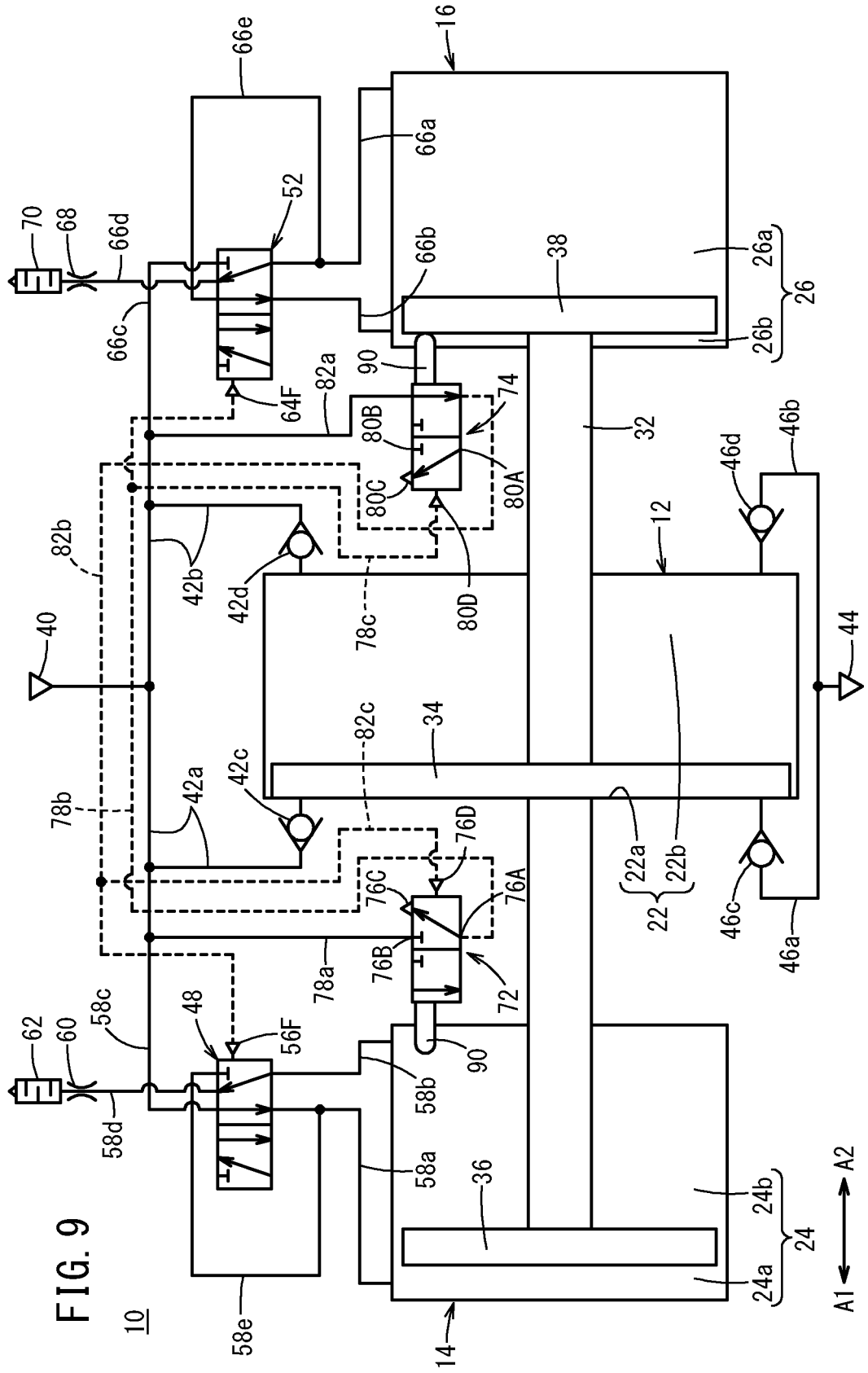


FIG. 8



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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2019/028933

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A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. F15B3/00 (2006.01) i, F04B9/115 (2006.01) i, F04B9/135 (2006.01) i

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

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B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. F15B3/00, F04B9/00-15/08

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2019

Registered utility model specifications of Japan 1996-2019

Published registered utility model applications of Japan 1994-2019

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

25

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2018-84270 A (SMC CORPORATION) 31 May 2018, paragraphs [0079]-[0080], [0149]-[0165]; fig. 15-16 & WO 2018/096739 A1	1-5
Y	US 2296647 A (RACINE TOOL & MACHINE COMPANY) 22 September 1942, page 2, left column, line 1 to page 2, right column, line 28, fig. 1 (Family: none)	1-5

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☒ 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
12 September 2019 (12.09.2019)Date of mailing of the international search report
24 September 2019 (24.09.2019)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/028933

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 40-33392 Y1 (ITANO SEISAKUSHO KK) 22 November 1965, page 2, left column, line 22 to page 3, left column, line 10; drawings (Family: none)	1-5
A	US 2942553 A (GENERAL MOTORS CORPORATION) 28 June 1960 (Family: none)	1-4
A	CN 201347907 Y (DALIAN MARITIME UNIVERSITY) 18 November 2009 (Family: none)	1-4

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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- JP 8021404 A [0003] [0004]
- JP 2017164945 A [0005]