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(54) **PUMP APPARATUS**

(57) A pump apparatus which is expected to realize satisfactory work efficiency of an assembly operation, reduction of noise and suppression of rust comprises: two pump units (22 and 23); a valve unit (24) provided between the pump units (22 and 23); and a fastening means (36) for fastening the pump units (22 and 23) to each other such that the valve unit (24) is able to be held by the pump units (22 and 23) therebetween.

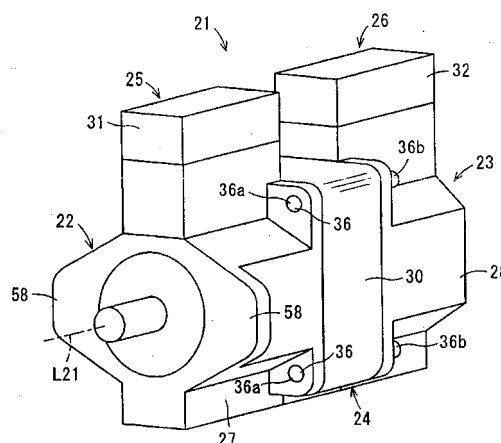


Fig. 1

Description

Technical Field

[0001] The present invention relates to a pump apparatus.

Background Art

[0002] Fig. 14 is a perspective view showing a pump apparatus 1 of a prior art. Fig. 15 is a front view showing the pump apparatus 1. Fig. 16 is a side view showing the pump apparatus 1. The pump apparatus 1 of Figs. 14 to 16 is shown in, for example, "Hydraulics and Pneumatics October Extra Issue" (Japan Industrial Publishing Co., Ltd, published on October 5, 2000), Vol. 39, 12th. The pump apparatus 1 is a combined pump apparatus called, for example, a tandem pump in which two swash plate type piston pumps are arranged axially. The pump apparatus 1 includes two pump units 2 and 3 and a valve unit 4. The pump units 2 and 3 include pump casings 5 and 6, respectively. In each of the pump casings 5 and 6, a cylinder block, a piston, a swash plate, etc. are accommodated. The valve unit 4 includes a valve casing 7. In the valve casing 7, two valve plates are accommodated, which are slidable relative to the cylinder blocks of the pump units 2 and 3, respectively.

[0003] The pump unit 2 and the valve unit 4 are fastened to each other by a plurality of, for example, four, fastening bolts 10. Similarly, the pump unit 3 and the valve unit 4 are fastened to each other by four fastening bolts 10. Each fastening bolt 10 is threadedly engaged with the valve unit 4 in a state in which a head portion of the fastening bolt 10 engages with a flange portion of an end portion on one side of each of the pump units 2 and 3, the side being opposite a side facing the valve unit 4. An intermediate portion of each fastening bolt 10 is exposed outside the pump casing 5 or 6.

Disclosure of the Invention

Problems to be Solved by the Invention

[0004] In the pump apparatus 1 of the prior art, the axially intermediate portion of the fastening bolt 10 is exposed outside the pump casing 5 or 6, so that noise is emitted when the fastening bolt 10 resonates and oscillates at a radio frequency with respect to an n-th frequency component of a fundamental frequency of each of the pump units 2 or 3. Further, since the pump casing 5 or 6 is externally partially covered by the fastening bolt 10, such covered portion may be painted insufficiently and therefore rust.

[0005] Since the pump units 2 and 3 are separately fastened to the valve unit 4 by the separate fastening bolts 10, the number of the fastening bolts 10 to be used becomes large, specifically, eight. Therefore, the number of processed portions of the pump units 2 and 3 and the

valve unit 4, such as screw holes used for fastening by the fastening bolts 10, becomes large, and the productivity of components deteriorates. In addition, the number of steps of fastening the pump units 2 and 3 and the valve unit 4 by the fastening bolts 10 becomes large, so that the work efficiency of an assembly operation is reduced.

[0006] An object of the present invention is to provide a pump apparatus which realizes satisfactory productivity of components and satisfactory work efficiency of the assembly operation.

[0007] Another object of the present invention is to provide a pump apparatus which can reduce the noise and prevent the generation of the rust.

Means for Solving the Problems

[0008] The present invention provides a pump apparatus comprising: two pump units; a valve unit provided between the pump units; and a fastening means for fastening the pump units to each other such that the valve unit is able to be held by the pump units therebetween.

[0009] In accordance with the present invention, by causing the pump units to be fastened to each other by the fastening means, the valve unit provided between the pump units is held by the pump units therebetween. Thus, the number of the fastening means can be reduced compared to the construction in which the pump units are separately fastened to the valve unit. Therefore, it is possible to reduce the number of processed portions of the pump units and the valve unit, the processed portions being used to fasten the pump units and the valve unit by the fastening means, and the productivity of components of the pump apparatus can be made satisfactory. In addition, the number of steps of fastening the pump units and the valve unit can be reduced, so that the work efficiency of the assembly operation of the pump apparatus can be made high.

[0010] Moreover, the fastening means may be provided so as to be inserted through the valve unit. In accordance with this construction, the fastening means is externally covered by the valve unit, so that the fastening means is not exposed outside. Therefore, even if the fastening means resonates and oscillates at a radio frequency with respect to the n-th frequency component of the fundamental frequency of the pump unit, the emitting of the noise generated due to the oscillation is prevented. On this account, the noise of the pump apparatus can be reduced. Moreover, since the fastening means does not cover the pump units or the valve unit, a painting operation of the pump apparatus is easy, and the occurrence of a painting failure can be prevented. Therefore, the generation of the rust caused by the painting failure can be prevented.

[0011] Moreover, the pump apparatus may further comprise a positioning means for positioning the pump units and the valve unit.

[0012] In accordance with this construction, even in a case where the valve unit is held by the pump units ther-

between, the pump units and the valve unit are positioned by the positioning means. With this, the pump apparatus can be assembled easily without causing problems including malfunctions. The positioning means may be comprised of: a positioning projection which projects from a first end surface of the pump unit and a first end surface of the valve unit; and an opening which is formed on a second end surface and in which the positioning projection fits.

Effects of the Invention

[0013] In accordance with the present invention, the number of the fastening means for fastening the pump units and the valve unit can be reduced. Therefore, since the number of processed portions of the pump units and the valve unit and the number of steps of the assembly operation can be reduced, the productivity of components of the pump apparatus and the work efficiency of the assembly operation can be made high.

[0014] Moreover, in accordance with the present invention, the fastening means is not exposed outside. Therefore, even if the fastening means oscillates at a radio frequency, the noise generated due to the oscillation is not emitted. Thus, the noise of the pump apparatus can be reduced. In addition, since the fastening means does not disturb the painting operation of the pump apparatus, the painting failure is prevented. Therefore, the generation of the rust of the pump apparatus is prevented.

[0015] Further, in accordance with the present invention, the pump units and the valve unit are positioned, so that the pump apparatus can be easily assembled without causing problems including malfunctions.

Brief Description of the Drawings

[0016]

[Fig. 1] Fig. 1 is a perspective view showing a pump apparatus of one embodiment of the present invention.

[Fig. 2] Fig. 2 is a perspective view showing the pump apparatus when viewed from a direction different from that of Fig. 1.

[Fig. 3] Fig. 3 is a front view schematically showing the pump apparatus.

[Fig. 4] Fig. 4 is a side view schematically showing the pump apparatus.

[Fig. 5] Fig. 5 is a cross-sectional view showing a first pump casing.

[Fig. 6] Fig. 6 is a side view showing the first pump casing when viewed from a right side of Fig. 5.

[Fig. 7] Fig. 7 is a plane view showing the first pump casing when viewed from an upper side of Fig. 5.

[Fig. 8] Fig. 8 is a cross-sectional view showing a second pump casing.

[Fig. 9] Fig. 9 is a side view showing the second

pump casing when viewed from a right side of Fig. 8. [Fig. 10] Fig. 10 is a plane view showing the second pump casing when viewed from an upper side of Fig. 8.

[Fig. 11] Fig. 11 is a front view showing a valve unit. [Fig. 12] Fig. 12 is a side view showing the valve unit when viewed from a left side of Fig. 11.

[Fig. 13] Fig. 13 is a side view showing the valve unit when viewed from a right side of Fig. 11.

[Fig. 14] Fig. 14 is a perspective view showing a pump apparatus of a prior art.

[Fig. 15] Fig. 15 is a front view showing the pump apparatus.

[Fig. 16] Fig. 16 is a side view showing the pump apparatus.

Best Mode for Carrying Out the Invention

[0017] Fig. 1 is a perspective view showing a pump apparatus 21 of one embodiment of the present invention. Fig. 2 is a perspective view showing the pump apparatus 21 when viewed from a direction different from that of Fig. 1. Fig. 3 is a front view schematically showing the pump apparatus 21. Fig. 4 is a side view schematically showing the pump apparatus 21. The pump apparatus 21 is a pump apparatus mounted on, for example, industrial machineries and construction machineries that are mounting targets, and is a combined pump apparatus, called a tandem pump, in which two pump portions are combined. The type of two pumps to be combined is not especially limited, but may be a gear pump. In the present embodiment, the pump is, for example, a swash plate type piston pump. The swash plate type piston pump may be a fixed displacement pump, but is a variable displacement pump in the present embodiment.

[0018] The pump apparatus 21 includes first and second pump units 22 and 23 and a valve unit 24, and further includes first and second regulators 25 and 26. The pump units 22 and 23 and the valve unit 24 are provided coaxially, and axes of the pump units 22 and 23 and the valve unit 24 constitute an axis L21 of the pump apparatus 21. The pump units 22 and 23 and the valve unit 24 are arranged along the axis L21 of the pump apparatus 21 so as to be connected to each other such that the valve unit 24 is sandwiched by the pump units 22 and 23. The regulators 25 and 26 are respectively provided on top of the pump unit 22 and on top of the pump unit 23 so as to be respectively connected to the pump units 22 and 23.

[0019] The pump units 22 and 23 include first and second pump casings 27 and 28, respectively. In each of the pump casings 27 and 28, components, such as a cylinder block, a piston, a swash plate, etc., are accommodated. The valve unit 24 includes a valve casing 30. In the valve casing 30, two valve plates are accommodated, which are slidable relative to the cylinder blocks of the pump units 22 and 23, respectively. The valve casing 30 and the valve plates may be formed as a unitary component or as separate components. The regulators

25 and 26 include regulator casings 31 and 32, respectively. In each of the regulator casings 31 and 32, a structure for causing the swash plate to tilt is accommodated.

[0020] The pump apparatus 21 includes a plurality of fastening bolts 36 that are fastening means. In the present embodiment, four fastening bolts 36 are used. The pump units 22 and 23 and the valve unit 24 are fastened to each other by the fastening bolts 36. The pump units 22 and 24 are provided so as to be fastened to each other by the fastening bolts 36 such that the accommodated cylinder blocks, pistons, swash plates, etc. are substantially symmetrical to each other. Each fastening bolt 36 is provided to extend substantially in parallel with the axis L21 of the pump apparatus 21. Since the valve unit 24 is provided between the pump units 22 and 23, it is held by the pump units 22 and 23 therebetween. Thus, the pump units 22 and 23 and the valve unit 24 are connected to each other.

[0021] End portions of the fastening bolt 36 engage with the pump casings 27 and 28, respectively, so that the pump casings 27 and 28 are fastened to each other. A structure of how each end portion of the fastening bolt 36 engages with the pump casing 27 or 28 is realized by, for example, any one of constructions in which a head portion of the fastening bolt 36 engages with the pump casing 27 or 28, in which the fastening bolt 36 is threadedly engaged with the pump casing 27 or 28, and in which a nut member which is threadedly engaged with the fastening bolt 36 engages with the pump casing 27 or 28. The fastening bolt 36 is provided so as to be inserted through the valve unit 24, and an axially intermediate portion between both end portions of the fastening bolt 36 is not exposed outside.

[0022] The pump apparatus 21 includes a positioning means. The positioning means can position the pump units 22 and 23 and the valve unit 24 regarding a direction crossing the axis L21 of the pump apparatus 21 so as to prevent relative displacements of the pump units 22 and 23 and the valve unit 24. The positioning means is not an essential component, and for example, the relative displacements may be prevented by frictional forces acting between the pump units 22 and 23 and the valve casing 24. In the present embodiment, the positioning means is included. The specific construction of the positioning means is not limited, but may be any construction as long as the positioning means can position the pump units 22 and 23 and the valve unit 24 so as to prevent the displacements.

[0023] The pump unit 22 includes a rotational shaft. The rotational shaft is rotatably supported by the first pump casing 27 via a bearing. The cylinder block is splined to the rotational shaft or connected to the rotational shaft by a key, and the rotational shaft and the cylinder block are integrally rotatable. The cylinder block is provided with a plurality of piston chambers, and pistons fit in the piston chambers so as to be extendable and retractable. The piston contacts, at one end portion thereof projecting from the cylinder block, a supporting

surface of the swash plate via a shoe so as to be displaced along the supporting surface. The supporting surface of the swash plate is inclined relative to a virtual flat surface perpendicular to a rotational axis. The piston carries out a reciprocating displacement that is extending and retracting in accordance with the rotation of the cylinder block.

[0024] A first valve plate that is one of the valve plates provided in the valve unit 24 is provided with an inlet port which is connected to, for example, a tank that is an oil source storing hydraulic oil that is hydraulic fluid, and an outlet port which is connected to, for example, an actuator to which the hydraulic oil is supplied. The valve plate is constructed such that the piston chamber in which the piston in an extending stroke fits is connected to the inlet port and the piston chamber in which the piston in a retracting stroke fits is connected to the outlet port. Therefore, when power is transferred from a power unit to the rotational shaft to rotate the cylinder block, the hydraulic oil is suctioned from the tank by the reciprocating displacement of the piston so as to be supplied to the actuator.

[0025] The first regulator 25 can cause the swash plate to tilt to change a tilt angle of the supporting surface of the swash plate by controlling a servo mechanism provided in the first pump unit 22. With this, a pump capacity can be changed. Thus, the first pump unit 22, the first regulator 25 connected to the first pump unit 22, and some components including the first valve plate of the valve unit 24 constitute a first pump portion.

[0026] The second pump unit 23 has substantially the same construction as the first pump unit 22, and the second regulator 26 has substantially the same construction as the first regulator 25. The second pump unit 23, the second regulator 26 connected to the second pump unit 23 and some components including a second valve plate that is another valve plate of the valve unit 24 constitute a second pump portion. This second pump portion has substantially the same construction as the first pump portion constructed of the first pump unit 22, the regulator 25 connected to the first pump unit 22 and some components including the first valve plate of the valve unit 24.

[0027] These pump portions have the same construction as each other except that only the first pump casing 27 of the first pump unit 22 is provided with a fixing flange portion 58 to be attached to a body of the mounting target, and the constructions of respective rotational shafts are different from each other. The rotational shaft of the first pump portion including the first pump unit 22 projects from the first pump casing 27, and power is transferred from a power unit to this rotational shaft. The rotational shaft of the second pump portion including the second pump unit 23 is connected, in the valve unit, to the rotational shaft of the first pump portion including the first pump unit 22. Therefore, these two pump portions operate in association with each other.

[0028] Fig. 5 is a cross-sectional view showing the first pump casing 27. Fig. 6 is a side view showing the first

pump casing 27 when viewed from a right side of Fig. 5. Fig. 7 is a plane view showing the first pump casing 27 when viewed from an upper side of Fig. 5. The first pump casing 27 has an accommodating space 44. In the accommodating space 44, components including the rotational shaft, the cylinder block, the pistons and the swash plate are accommodated. The accommodating space 44 axially penetrates through the first pump casing 27. The accommodating space 44 opens by an opening 48 at a first side surface portion 45 that is a first axial end portion of the first pump casing 27, and opens by an opening 49 at a second side surface portion 46 that is a second axial end portion of the first pump casing 27. In addition, the accommodating space 44 opens by an opening 50 at a flat surface portion 47 that is an upper end portion of the first pump casing 27.

[0029] The first pump casing 27 includes on the second side surface portion 46 a plurality of connecting flange portions 55 which are arranged so as to be spaced apart from each other in a circumferential direction and project radially outwardly. In the present embodiment, the first pump casing 27 includes four connecting flange portions 55. Each connecting flange portion 55 has a fastening screw hole 56 in which an internal thread is formed. An axis L56 of each screw hole 56 is in parallel with an axis L27 of the first pump casing 27. The axis L27 of the first pump casing 27 is identical with the axis L21 of the pump apparatus 21.

[0030] Moreover, the first pump casing 27 includes on the first side surface portion 45 a plurality of, for example, two, mounting and fixing flange portions 58 which project radially outwardly. Each mounting and fixing flange portion 58 has a fixing insertion through hole 59.

[0031] Fig. 8 is a cross-sectional view showing the second pump casing 28. Fig. 9 is a side view showing the second pump casing 28 when viewed from a right side of Fig. 8. Fig. 10 is a plane view showing the second pump casing 28 when viewed from an upper side of Fig. 8. The second pump casing 28 has an accommodating space 64. In the accommodating space 64, components including the rotational shaft, the cylinder block, the pistons and the swash plate are accommodated. The accommodating space 64 axially penetrates through the second pump casing 28. The accommodating space 64 opens by an opening 68 at a first side surface portion 65 that is a first axial end portion of the second pump casing 28, and opens by an opening 69 at a second side surface portion 66 that is a second axial end portion of the second pump casing 28. In addition, the accommodating space 64 opens by an opening 70 at a flat surface portion 67 that is an upper end portion of the second pump casing 28.

[0032] The second pump casing 28 includes on the second side surface portion 66 a plurality of connecting flange portions 75 which are arranged so as to be spaced apart from each other in a circumferential direction and project radially outwardly. In the present embodiment, the second pump casing 28 includes four connecting

flange portions 75. Each connecting flange portion 75 has an engaging hole 76. Each engaging hole 76 is comprised of a main hole portion 76a which is formed on the second side surface portion 66 side in an axial direction of the second pump casing 28 so as to have a small diameter and a concave portion 76b which is formed on the first side surface portion 65 side in the axial direction of the second pump casing 28 so as to have a large diameter. There is a step between an inner peripheral surface of the main hole portion 76a and an inner peripheral surface of the concave portion 76b. An axis L76 of each engaging hole 76 is in parallel with an axis L28 of the second pump casing 28. The axis L28 of the second pump casing 28 is identical with the axis L21 of the pump apparatus 21.

[0033] Fig. 11 is a front view showing the valve unit 24. Fig. 12 is a side view showing the valve unit 24 when viewed from a left side of Fig. 11. Fig. 13 is a side view showing the valve unit 24 when viewed from a right side of Fig. 11. The valve casing 30 of the valve unit 24 accommodates a valve block 80. The valve casing 30 and the valve block 80 are formed integrally. Two valve plates 201 and 202 are fixed to the valve block 80 so as not to be rotatable. In the valve casing 30, an accommodating space 81 accommodating the valve block 80 opens at an axial end portion 84 by an opening 86 and at an axial end portion 85 by an opening 87.

[0034] The valve casing 30 of the valve unit 24 has a plurality of, in the present embodiment, four, insertion through holes 90. The insertion through holes 90 are formed in an outer peripheral portion of the valve unit 24 so as to be spaced apart from each other in a circumferential direction. The insertion through hole 90 is a cylindrical hole. An axis L90 of each insertion through hole 90 is in parallel with an axis L24 of the valve unit 24. The axis L24 of the valve unit 24 is identical with the axis L21 of the pump apparatus 21.

[0035] Referring to Figs. 1 to 13, the pump units 22 and 23 and the valve unit 24 are arranged such that the axes of the pump casings 27 and 28 and the axis L24 of the valve unit 24 coincide with each other, and the valve unit 24 is sandwiched by the pump units 22 and 23. Which surface of the valve unit 24 face which of the pump units 22 and 23 is not especially limited, but can be suitably selected depending on the construction of the mounting target and the rotational direction of the pump apparatus 21. Although it is just one example, in the example shown in Figs. 1 to 13, the first pump unit 22 is provided such that the second side surface portion 46 faces the first axial end portion 84 of the valve unit 24, and the second pump unit 23 is provided such that the second side surface portion 66 faces the second axial end portion 85 of the valve unit 24. Further, the pump units 22 and 23 and the valve unit 24 are arranged such that respective axes L56 of the screw holes 56, their corresponding axes L76 of the engaging holes 76 and their corresponding axes L90 of the insertion through holes 90 coincide with each other so as to be placed coaxially. Thus, four holes are

formed, each of which is formed by axially arranging and connecting the screw hole 56, the insertion through hole 90 and the engaging hole 76 in this order.

[0036] The fastening bolt 36 has at its first axial end portion, a screw portion 36a on which an external thread is formed and at second axial end portion, a head portion 36b which projects radially outwardly. The fastening bolts 36 are respectively inserted into four holes, each formed by the screw hole 56, the insertion through hole 90 and the engaging hole 76, from the engaging hole 76 through the insertion through hole 90 to the screw hole 56 such that the screw portion 36a is located on the first pump unit 22 side and the head portion 36b is located on the second pump unit 23 side. The fastening bolts 36 are provided such that: each head portion 36b fits in the concave portion 76b of the engaging hole 76 so as to contact a step surface of a boundary between the main hole portion 76a and the concave portion 76b in a state where the displacement of the fastening bolt 36 relative to the second pump casing 28 in a direction perpendicular to the axis of the fastening bolt 36 is prevented, thus engaging with the second pump casing 28; and each screw portion 36a is threaded into the screw hole 56 so as to be fastened to the first pump casing 27.

[0037] Thus, the end portions 36a and 36b of the fastening bolt 36 respectively engage with the pump casings 27 and 28, so that the pump casings 27 and 28 are fastened to each other. The valve unit 24 is provided between the pump units 22 and 23 so as to be sandwiched by the pump casings 27 and 28. Thus, the valve unit 24 is held by the pump units 22 and 23 therebetween. To be specific, the valve casing 30 is held by the pump casings 27 and 28 therebetween. Therefore, the pump units 22 and 23 and the valve unit 24 are connected to each other such that the valve unit 24 is sandwiched by the pump units 22 and 23, and the pump units 22 and 23 are fastened to each other.

[0038] In the present embodiment, as a positioning means for positioning the pump units 22 and 23 and the valve unit 24, projecting portions 33 and 34 and positioning pins 95 are provided.

[0039] The projecting portions 33 and 34, called pilot portions, are respectively formed on the axial end portions 84 and 85 of the valve casing 30 so as to project axially. Moreover, the projecting portions 33 are formed in an annular shape extending in a circumferential direction so as to respectively surround the openings 86 and 87 of the axial end portions 84 and 85 of the valve casing 30. Further, the projecting portions 33 and 34 are formed coaxially with the axis L24 of the valve unit 24. In a state where the pump units 22 and 23 and the valve unit 24 are arranged, the projecting portion 33 and 34 respectively fit in the opening 49 and 69 of the second side surface portions 46 and 66 of the pump casings 27 and 28 so as to be respectively supported from radially outwardly by inner peripheral surface portions 205 and 206 which respectively surround the openings 49 and 69. Each of the openings 49 and 69 of the second side sur-

face portions 46 and 66 of the pump casings 27 and 28 has a circular shape so as to be formed coaxially with the axes L27 and L28 of the pump casings 27 and 28. Therefore, by causing the projecting portions 33 and 34 to respectively fit in the openings 49 and 69 of the second side surface portions 46 and 66 of the pump casings 27 and 28, the pump casings 27 and 28 and the valve casing 24 are positioned so as to be coaxial with each other.

[0040] The second side surface portion 46 of the pump casing 27 and the second side surface portion 66 of the pump casing 28 have bottomed fitting holes 100 and 101, respectively. The valve casing 30 of the valve block 24 has a bottomed fitting hole 102 at the axial end portion 84 and a bottomed fitting hole 103 at the axial end portion 85. As described above, in a state where the pump units 22 and 23 and the valve unit 24 are placed coaxially, and the screw holes 56, their corresponding insertion through holes 90 and their corresponding engaging holes 76 are placed coaxially, the fitting hole 100 of the first pump casing and the fitting hole 102 of the first axial end portion of the valve casing 30 are placed coaxially, and the fitting hole 101 of the second pump casing and the fitting hole 103 of the second axial end portion of the valve casing 30 are placed coaxially.

[0041] One of the positioning pins 95 fits in the fitting hole 100 of the first pump casing and the fitting hole 102 of the first axial end portion of the valve casing 30, and another positioning pin 95 fits in the fitting hole 101 of the second pump casing and the fitting hole 103 of the second axial end portion of the valve casing 30. With this, the valve unit 24 can be positioned relative to the pump units 22 and 23 while preventing the displacement of the valve unit 24 in a circumferential direction around the axis L21 of the pump apparatus 21.

[0042] As in the present invention, in the construction in which the valve unit 24 is held by the pump units 22 and 23 therebetween fastened to each other, so as to be connected to the pump units 22 and 23, the pump units 22 and 23 are positioned regarding a direction crossing the axis L21 of the pump apparatus 21 by four fastening bolts 36 provided in a circumferential direction. The valve unit 24 is positioned relative to the pump units 22 and 23 by the positioning means. Thus, the positioning is accomplished easily and highly precisely by using the projecting portions 33 and 34 and the positioning pins 95.

[0043] The fitting holes 102 and 103 of the valve unit 24 are placed at positions shifted from each other in a direction perpendicular to the axis L24 of the valve unit 24. In other words, the fitting holes 102 and 103 of the valve unit 24 are formed non-coaxially each other. In the present embodiment, the fitting hole 102 of the first axial end portion 84 side is formed at a position close to a bottom surface portion and rear surface portion of the valve unit 24, and the fitting hole 103 of the second axial end portion 85 side is formed at a position close to the bottom surface portion and front surface portion of the valve unit 24. Therefore, the positioning pins 95 are provided so as to be shifted from each other in a direction

perpendicular to the axis L21 of the pump apparatus 21, that is, the positioning pins 95 are provided non-coaxially.

[0044] The pump apparatus 21 is fixed to the body of the mounting target by the mounting and fixing flange portion 58 of the first pump unit 22. In this state, the pump apparatus 21 is connected to the power unit provided in the mounting target, so as to be driven to supply the hydraulic oil to the actuator of the mounting target.

[0045] In accordance with the present embodiment, by causing the pump units 22 and 23 to be fastened to each other by the fastening bolts 36, the valve unit 24 provided between the pump units 22 and 23 is held by the pump units 22 and 23 therebetween. Thus, the number of the fastening bolts 36 can be reduced compared to the construction in which the pump units 22 and 23 are separately fastened to the valve unit 24. Therefore, it is possible to reduce the number of processed portions of the pump units 22 and 23 and the valve unit 24, the processed portions being used to fasten the pump units 22 and 23 and the valve unit 24 by the fastening bolts 36. Specifically, it is possible to reduce the number of portions where the screw hole 56, the engaging hole 76 and the insertion through hole 90 are formed. Therefore, the productivity of components of the pump apparatus 21 can be made satisfactory. In addition, the number of steps of fastening the pump units 22 and 23 and the valve unit 24 can be reduced, so that the work efficiency of the assembly operation of the pump apparatus 21 can be made high.

[0046] Moreover, by causing the fastening bolts 36 to be respectively inserted through the insertion through holes 90 of the valve unit 24, the fastening bolts 36 are externally covered by the valve unit 24, so that at least the axially intermediate portion of the fastening bolt 36 is not exposed outside. Therefore, even if the fastening bolt 36 resonates and oscillates at a radio frequency with respect to the n-th frequency component of the fundamental frequency of the pump units 22 and 23, the emitting of the noise generated due to the oscillation is prevented. On this account, the noise of the pump apparatus 21 can be reduced. Moreover, since the fastening bolt 36 does not externally cover the pump unit 22 or 23 or the valve unit 24, the painting operation of the pump apparatus 21 including the pump units 22 and 23 and the valve unit 24 is easy, and the occurrence of the painting failure can be prevented. Therefore, the generation of the rust caused by the painting failure can be prevented.

[0047] Moreover, even in a case where the valve unit 24 is held by the pump units 22 and 23 therebetween, the pump units 22 and 23 and the valve unit 24 are positioned by the positioning means. With this, the pump apparatus 21 can be assembled easily without causing problems including malfunctions in such a manner that the pump units 22 and 23 and the valve unit 24 are placed surely coaxially.

[0048] The above-described embodiment is just an illustration of the present invention, and the constructions may be modified.

Industrial Applicability

[0049] In accordance with the present invention, the number of the fastening means for fastening the pump units and the valve unit can be reduced, and the number of processed portions of the pump units and the valve unit and the number of steps of the assembly operation can be reduced. Therefore, the present invention is useful for so-called tandem pumps.

Claims

1. A pump apparatus comprising:

two pump units;
a valve unit provided between the pump units;
and
a fastening means for fastening the pump units to each other such that the valve unit is able to be held by the pump units therebetween.

2. The pump apparatus according to claim 1, wherein the fastening means is provided so as to be inserted through the valve unit.

3. The pump apparatus according to claim 1, further comprising a positioning means for positioning the pump units and the valve unit.

4. The pump apparatus according to claim 3, wherein the positioning means is comprised of: a positioning projection which projects from a first end surface of the pump unit and a first end surface of the valve unit; and an opening which is formed on a second end surface and in which the positioning projection fits.

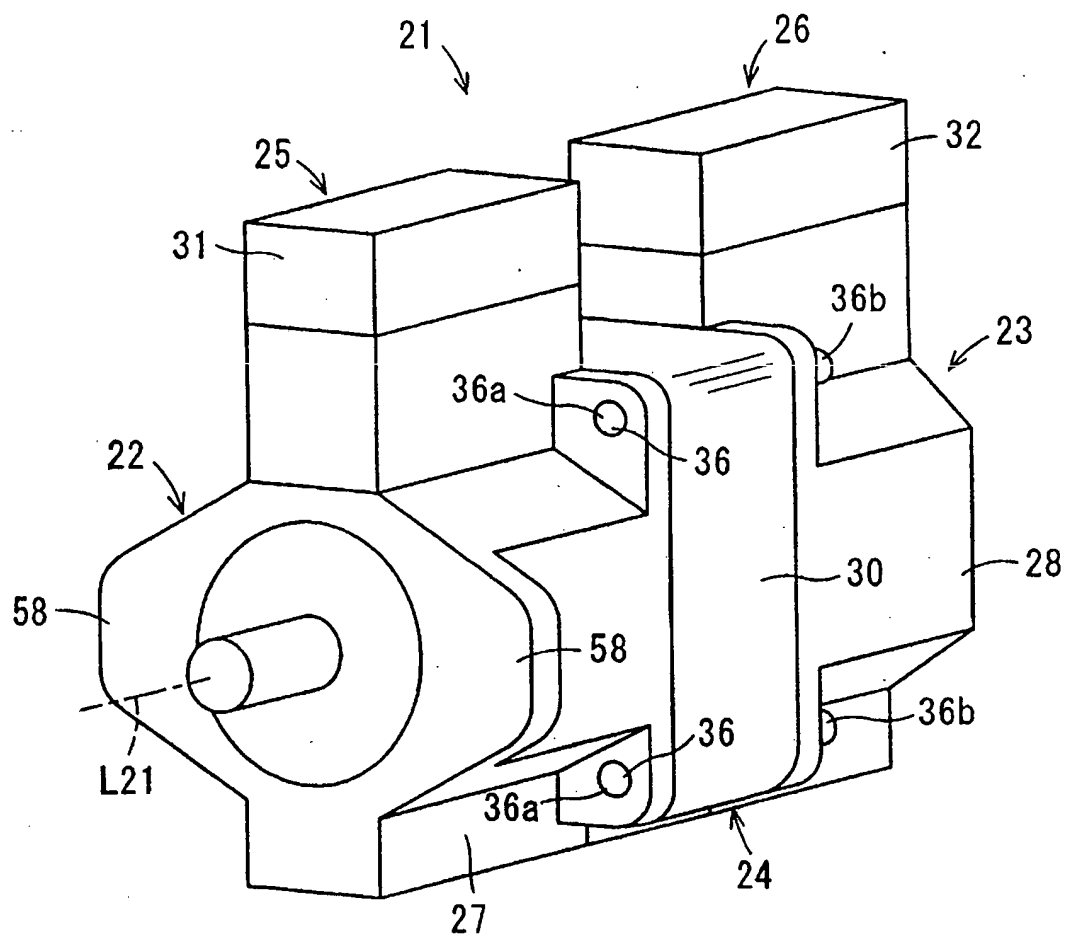


Fig. 1

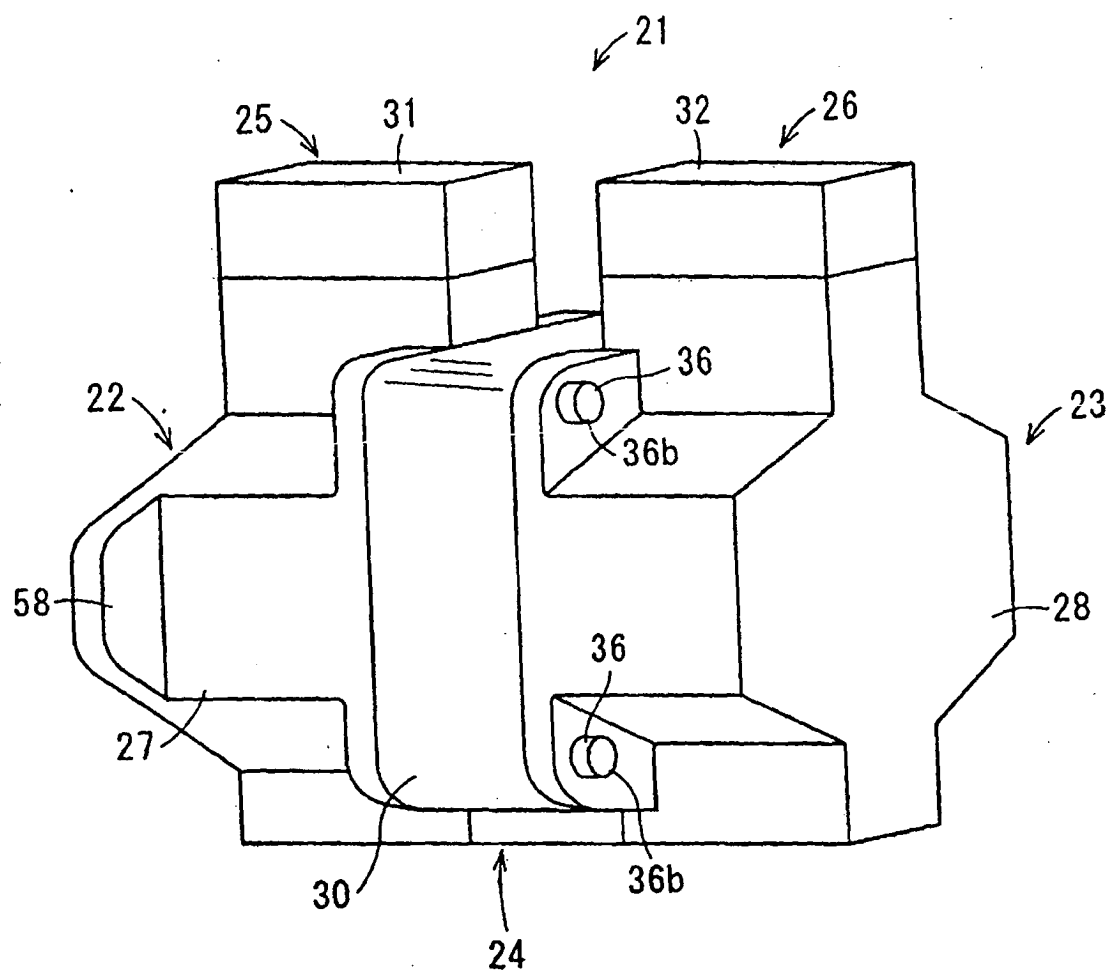
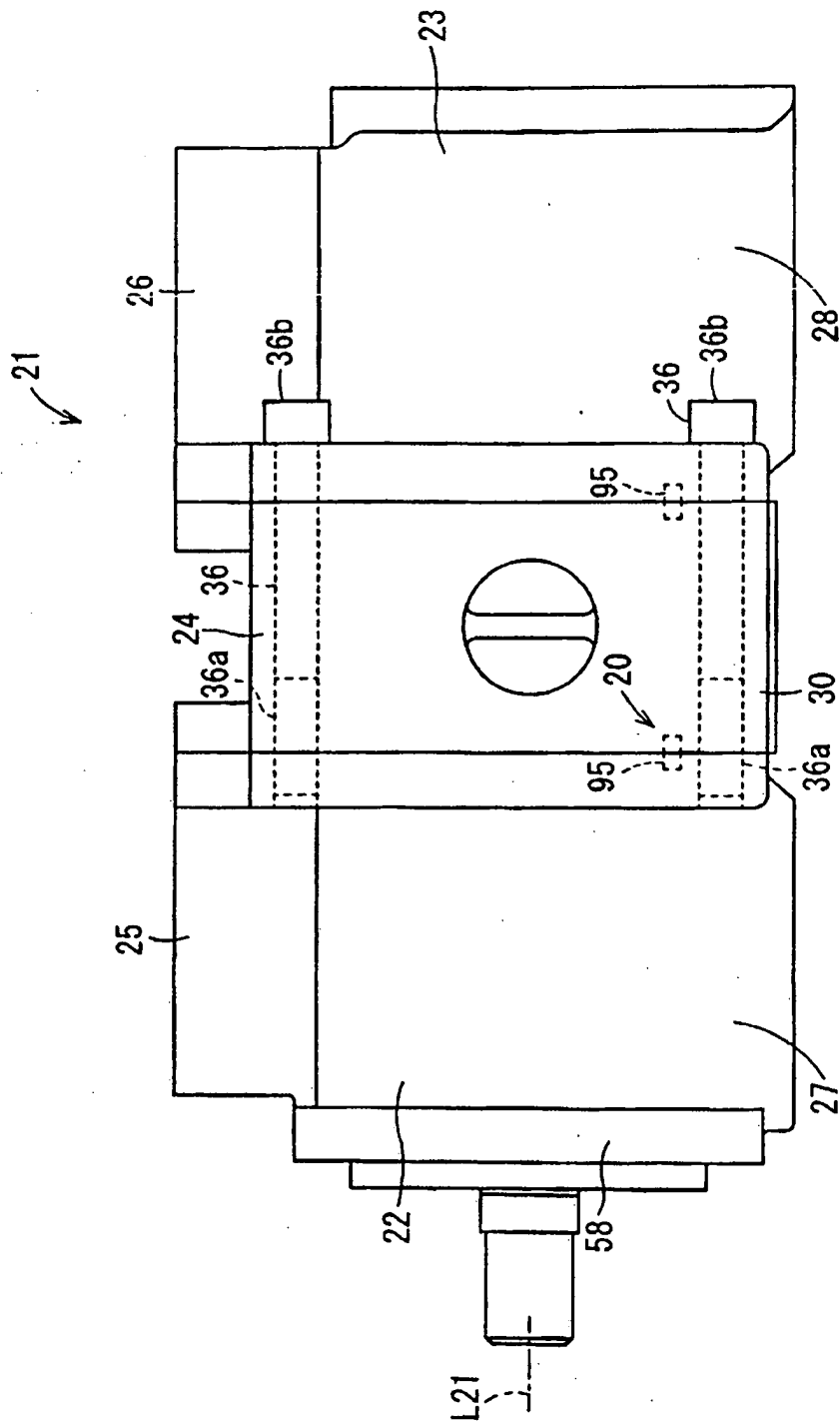


Fig. 2



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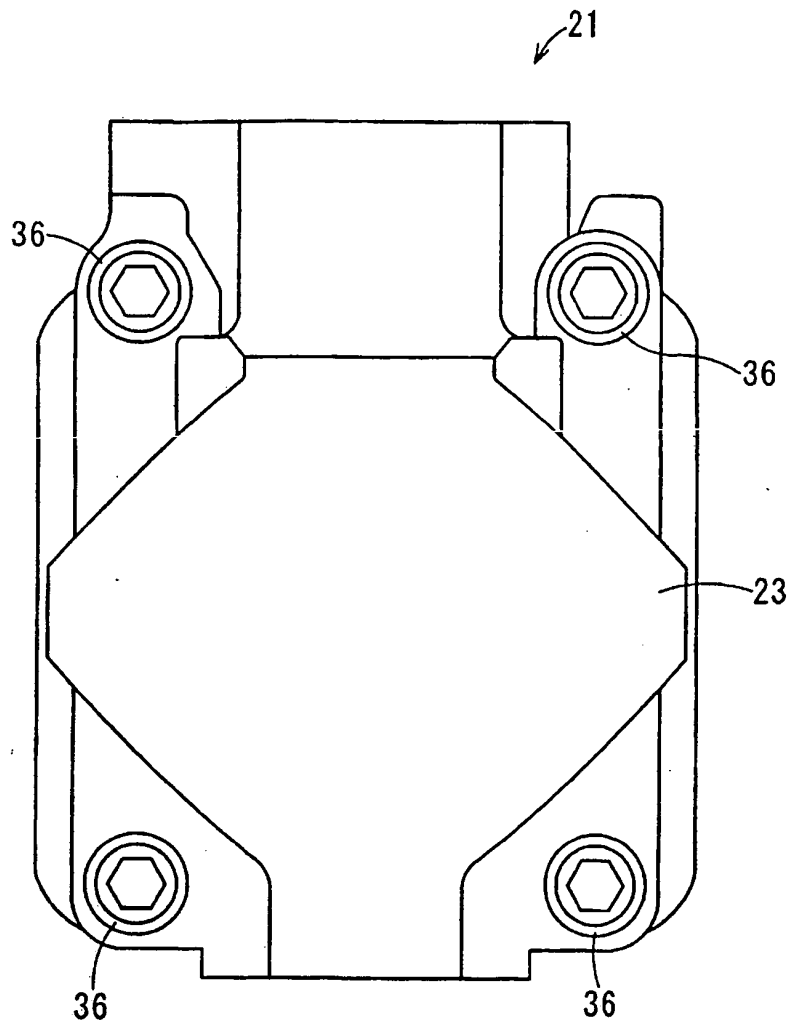


Fig. 4

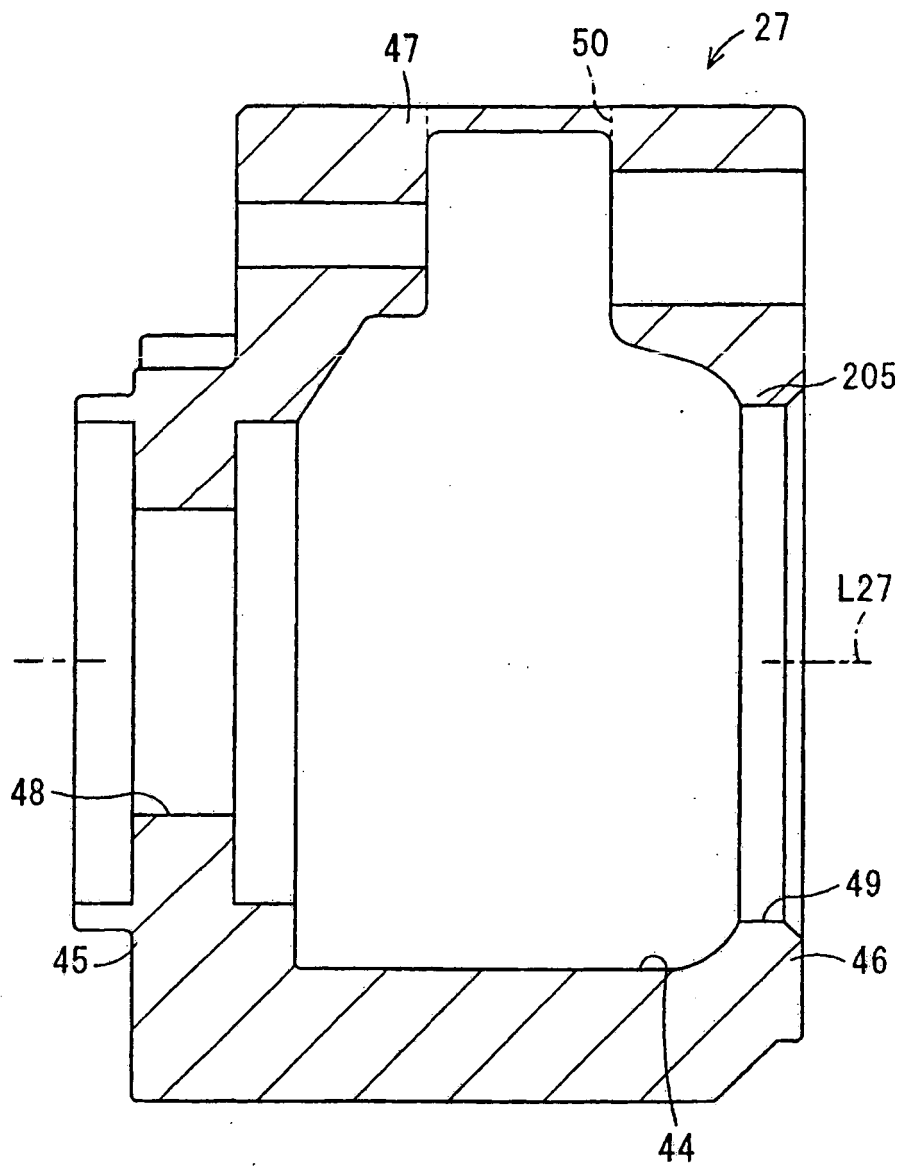


Fig. 5

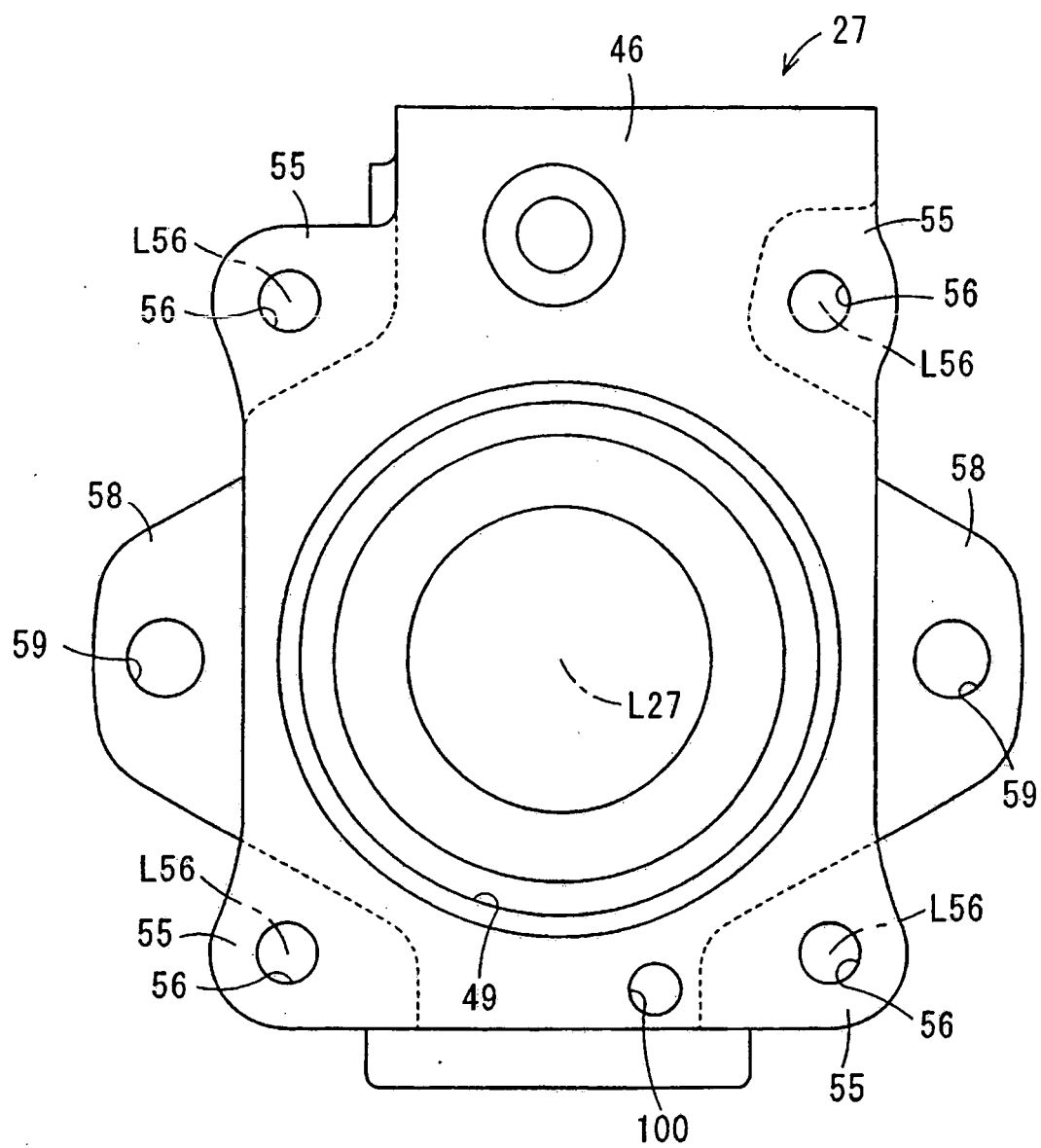


Fig. 6

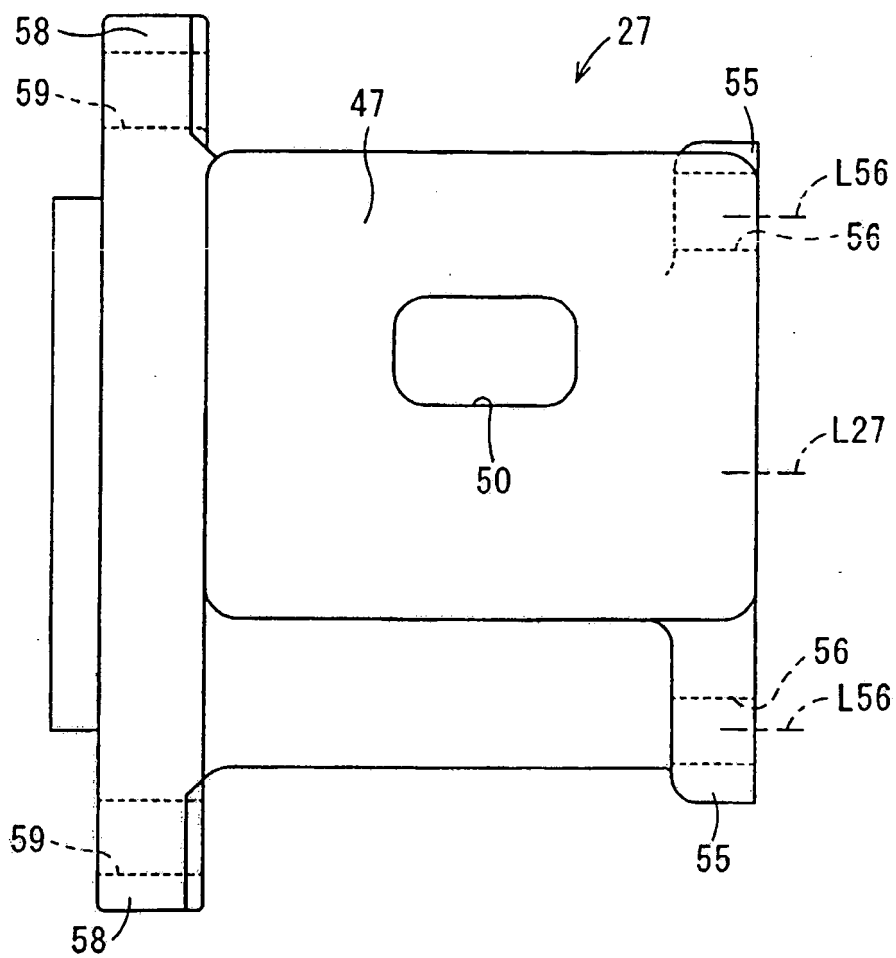


Fig. 7

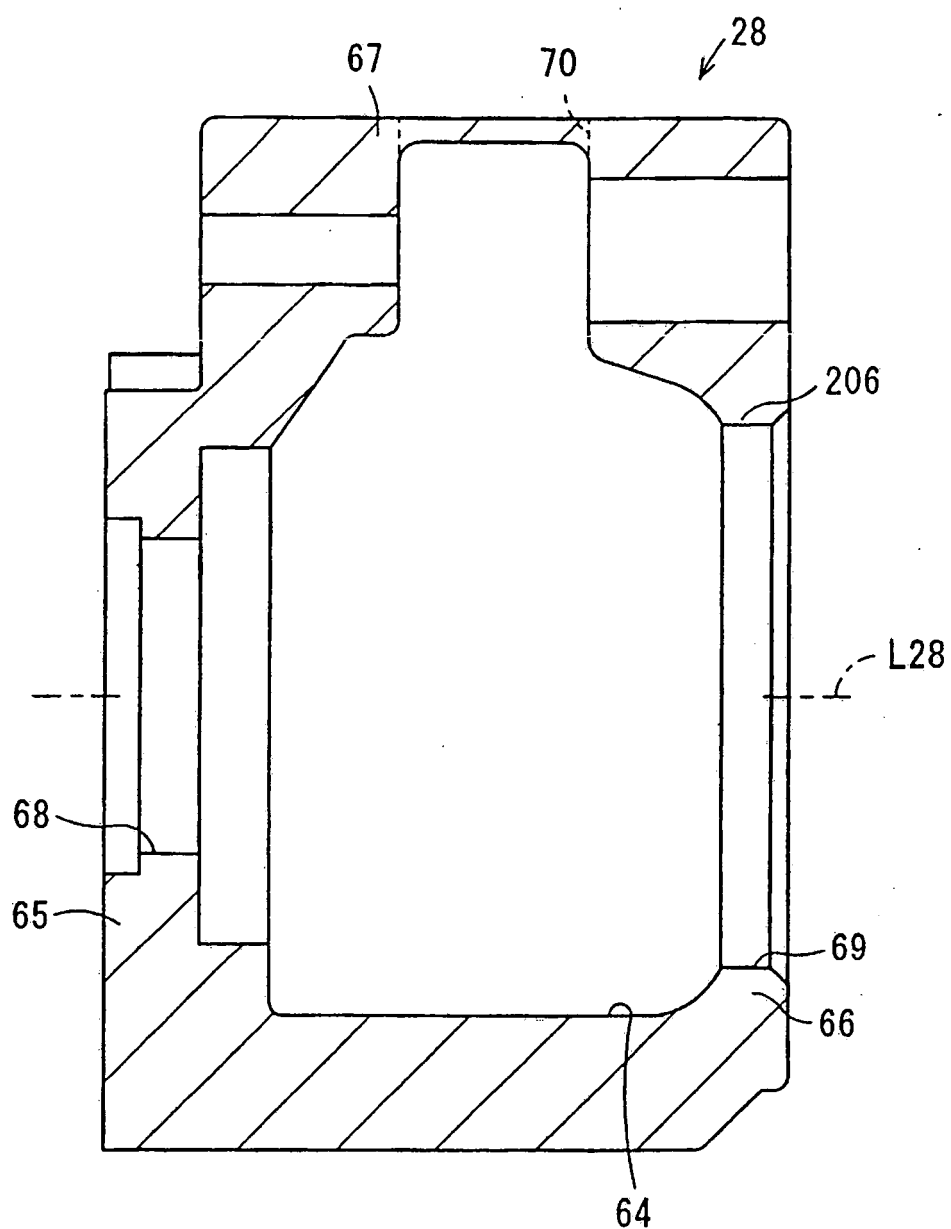


Fig. 8

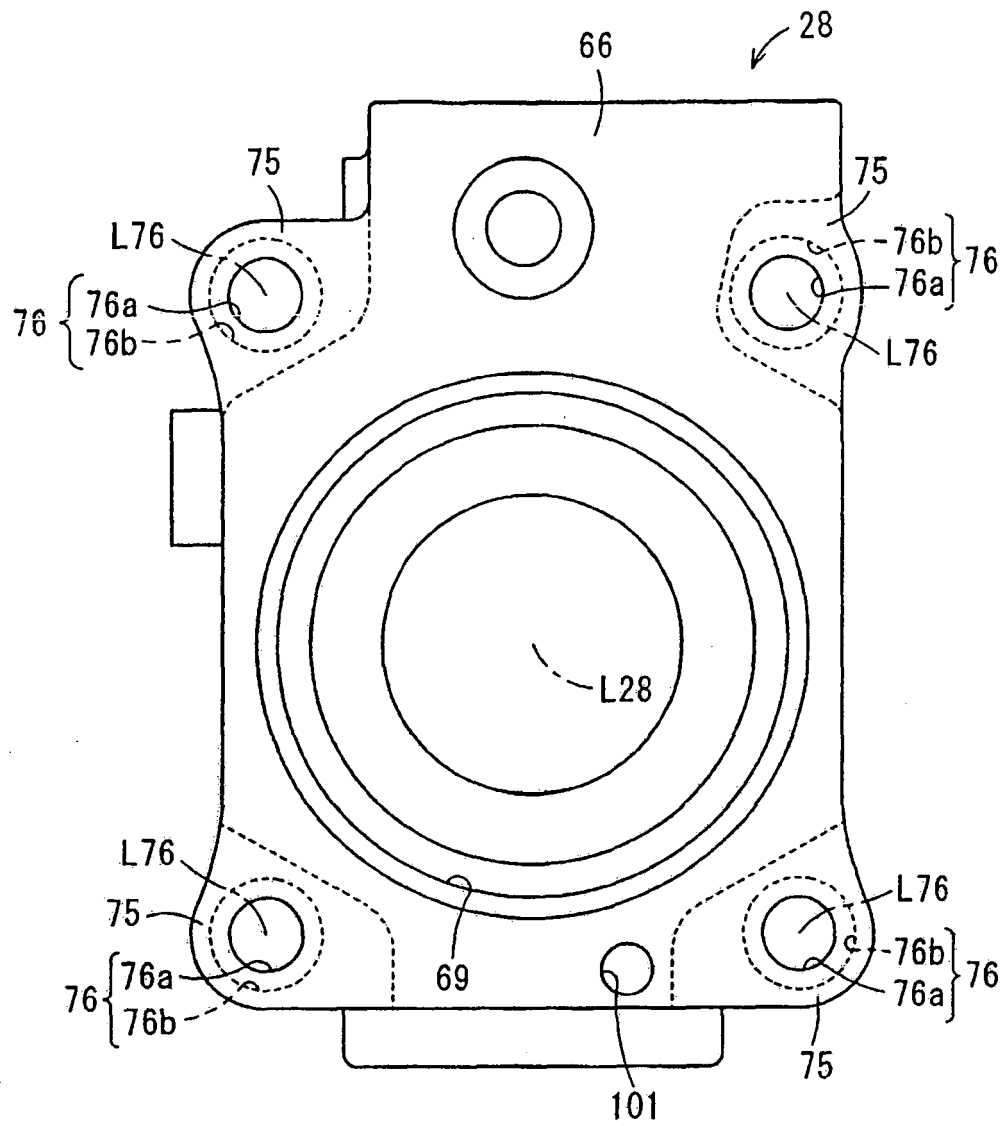


Fig. 9

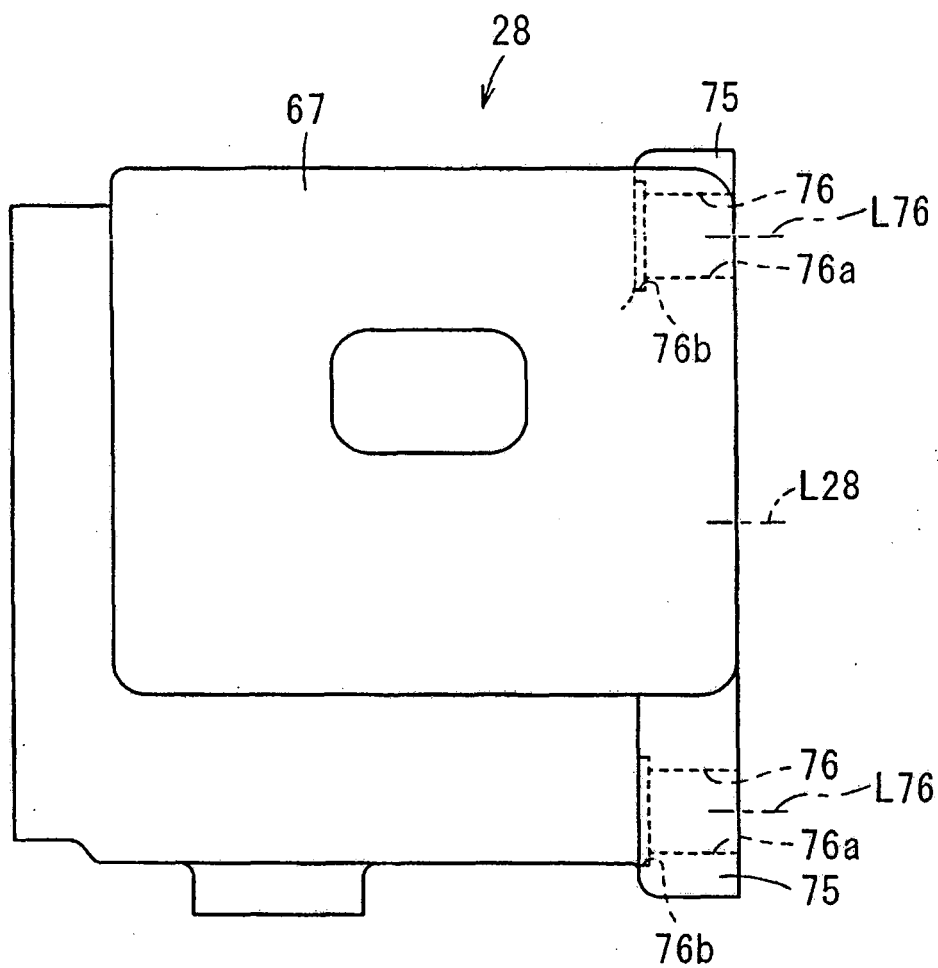


Fig. 10

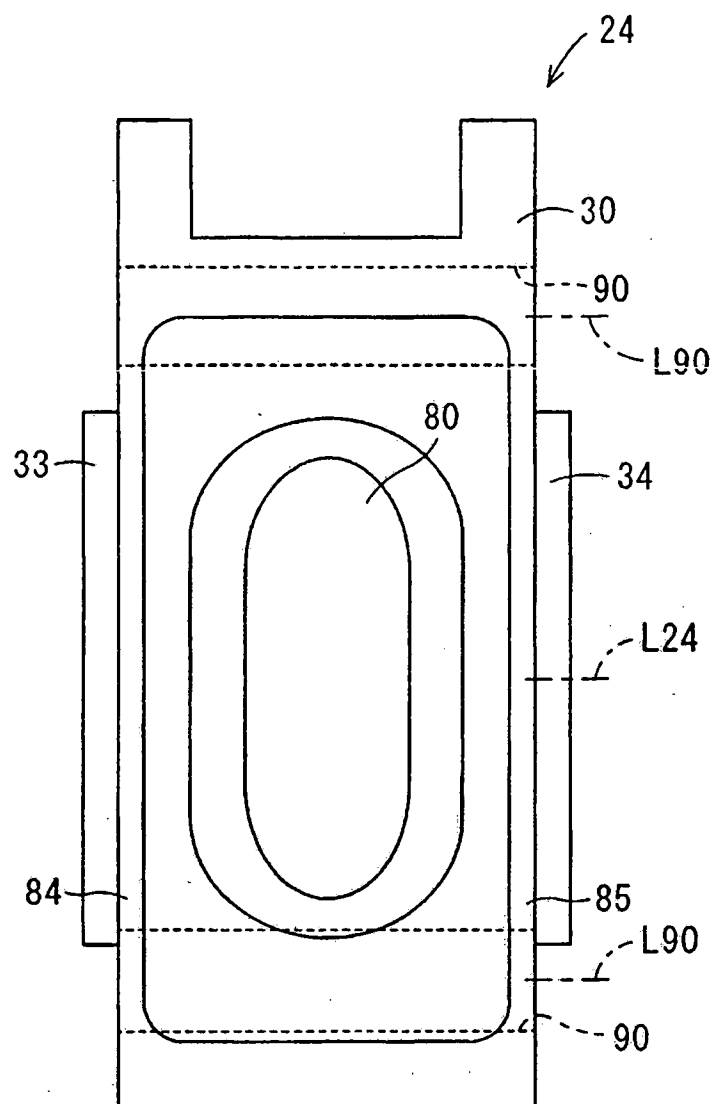


Fig. 11

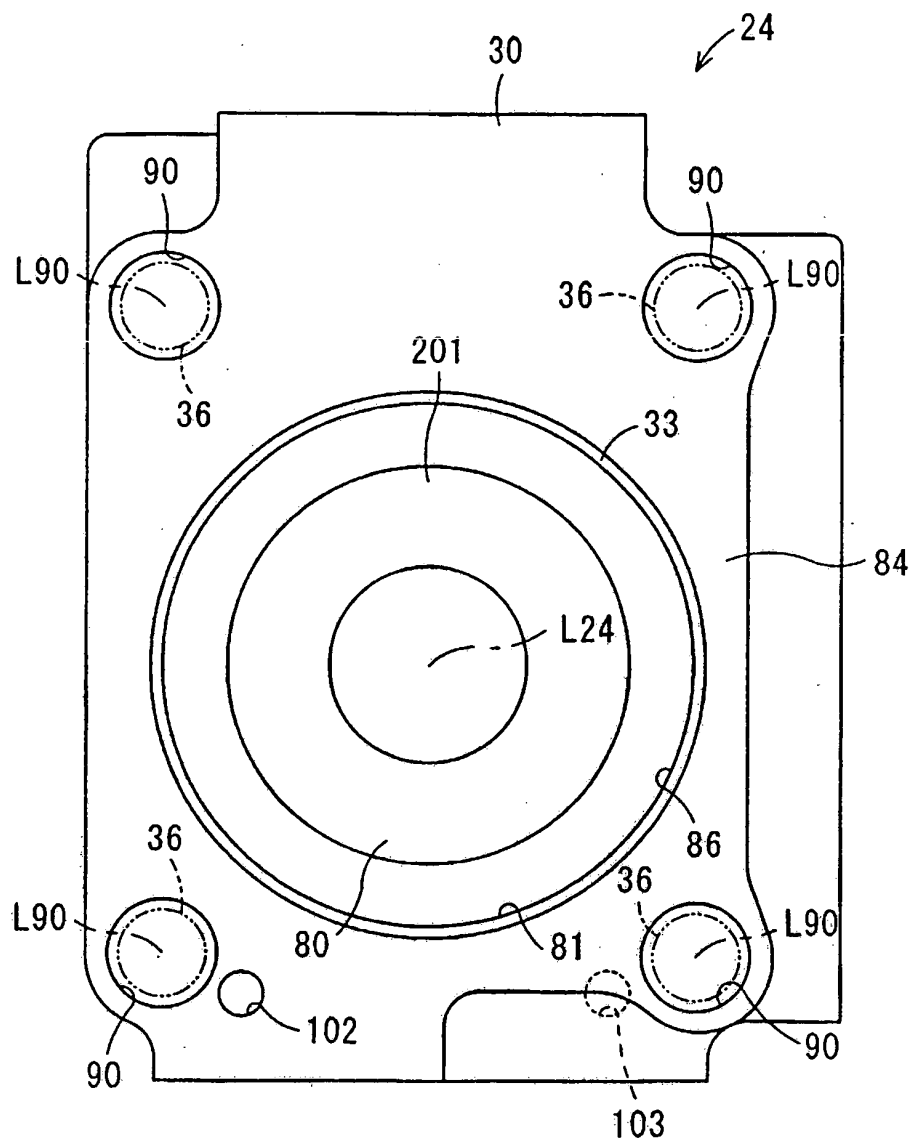


Fig. 12

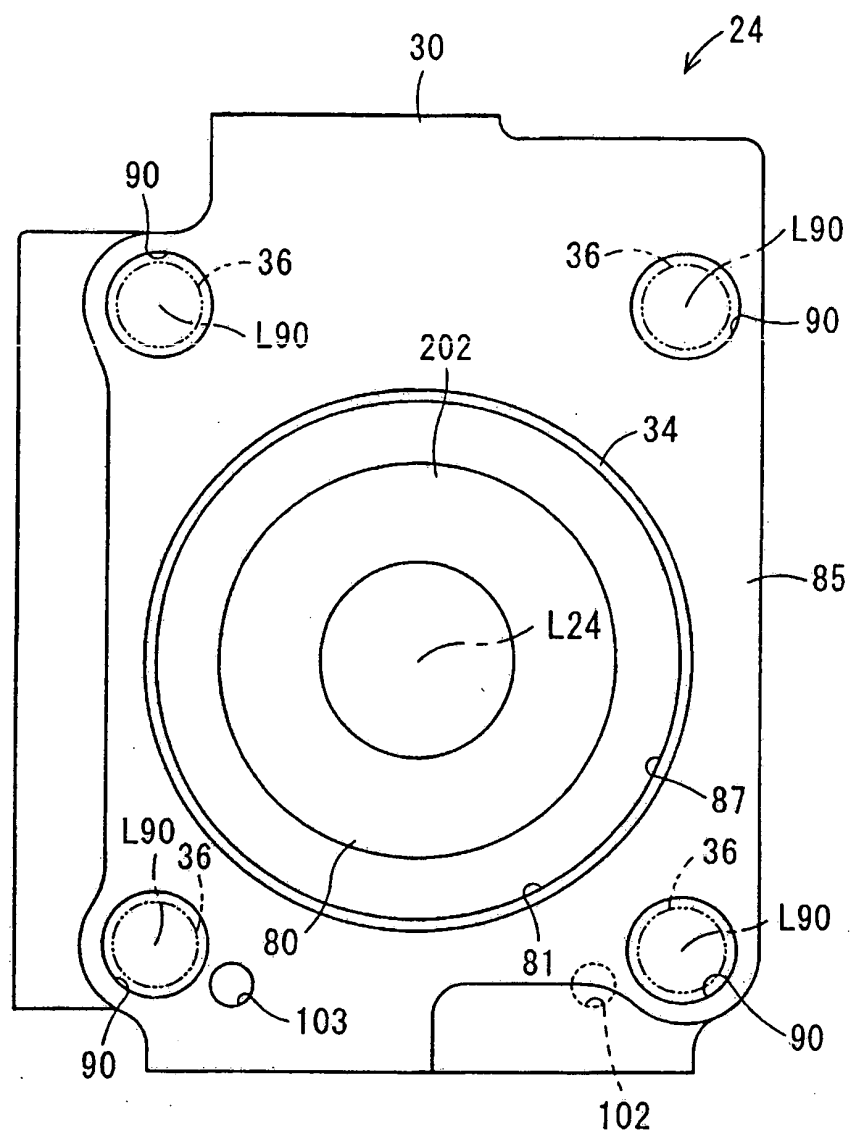


Fig. 13

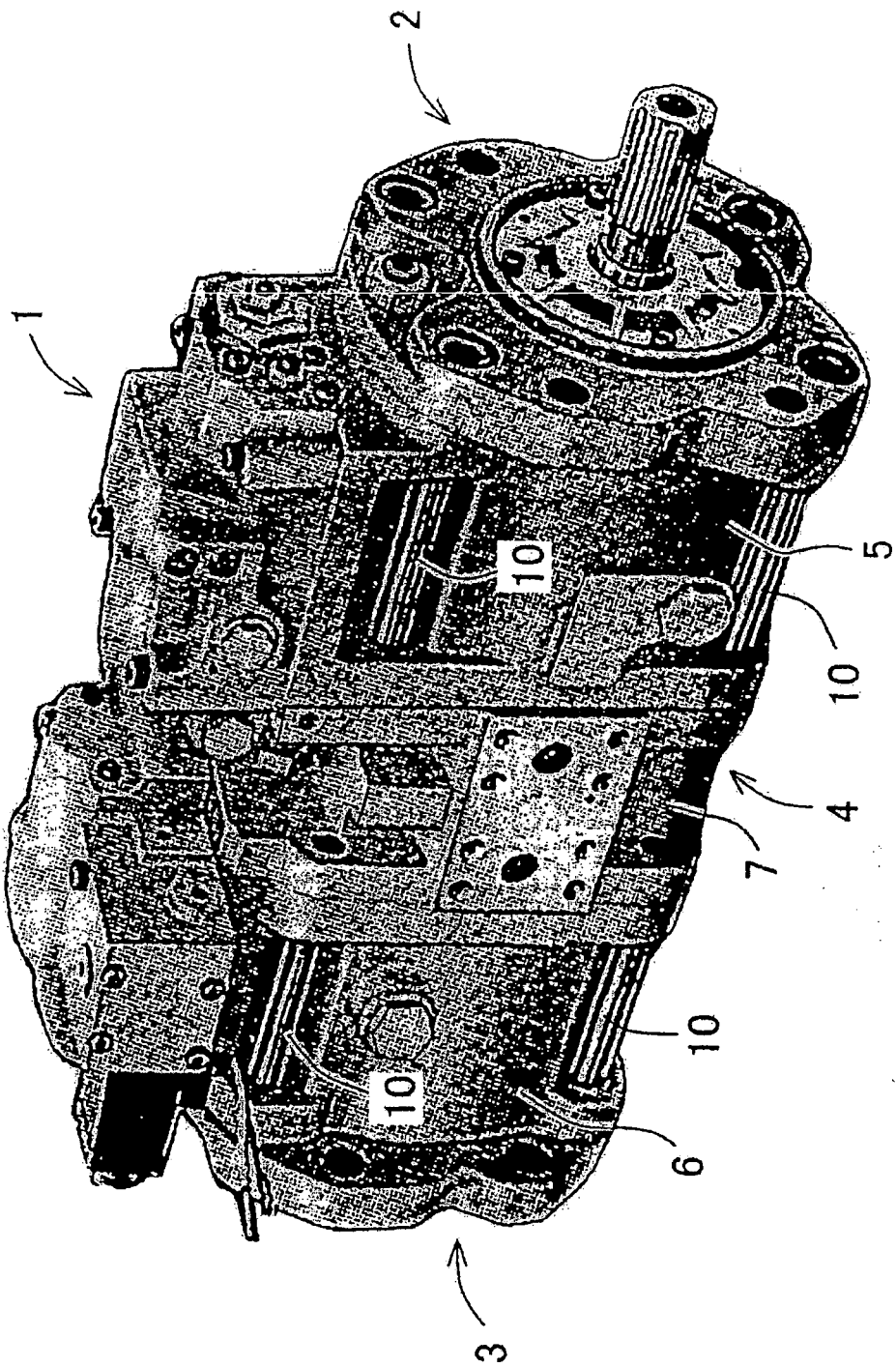


Fig. 14

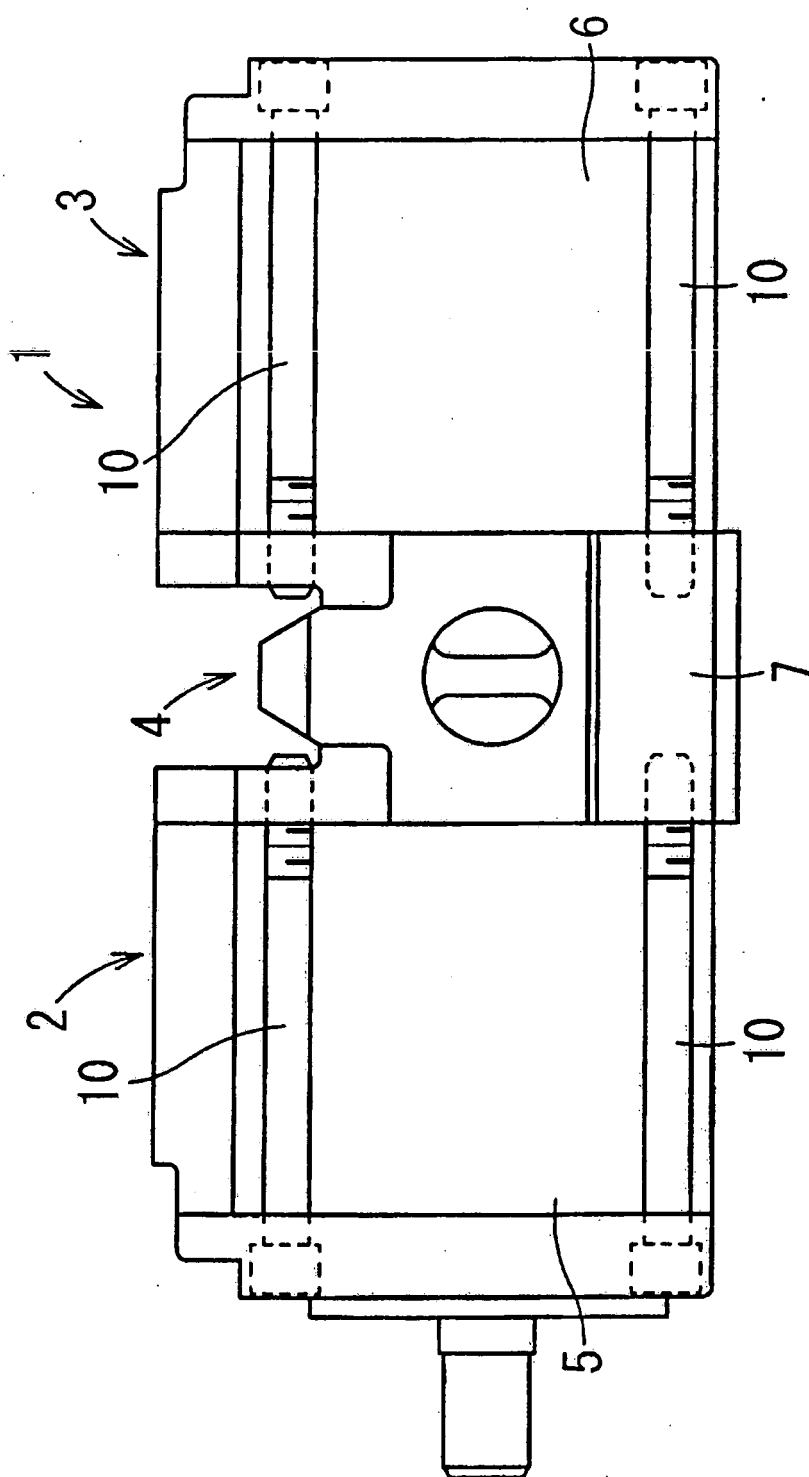


Fig. 15

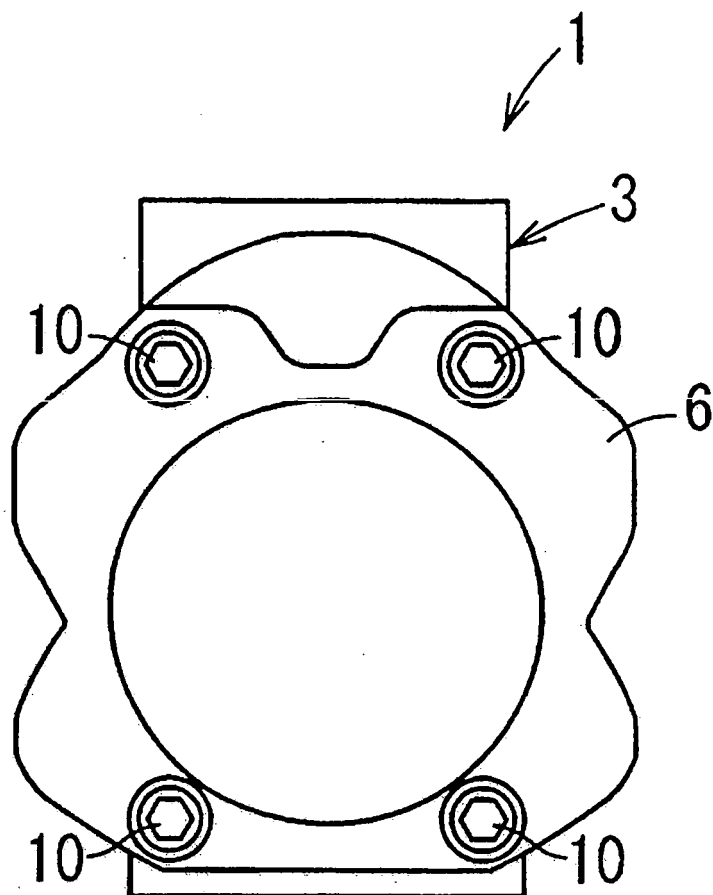


Fig. 16

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2006/315113

A. CLASSIFICATION OF SUBJECT MATTER

F04B23/04(2006.01) i, F04B53/00(2006.01) i

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)

F04B23/04, F04B53/00

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2006
Kokai Jitsuyo Shinan Koho	1971-2006	Toroku Jitsuyo Shinan Koho	1994-2006

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 83980/1987 (Laid-open No. 193780/1988) (Kawasaki Heavy Industries, Ltd.), 13 December, 1988 (13.12.88), Description, page 8; Fig. 2 (Family: none)	1-2
Y		3-4
Y	JP 3209860 B2 (Kawasaki Heavy Industries, Ltd.), 17 September, 2001 (17.09.01), Fig. 1 & KR 166433 B	3-4

☒ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search
16 October, 2006 (16.10.06)Date of mailing of the international search report
31 October, 2006 (31.10.06)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2006/315113

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 30910/1990 (Laid-open No. 122276/1991) (Toyoda Machine Works, Ltd.), 13 December, 1991 (13.12.91), (Family: none)	1-4

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REFERENCES CITED IN THE DESCRIPTION

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Non-patent literature cited in the description

- Hydraulics and Pneumatics October Extra Issue. Japan Industrial Publishing Co., Ltd, 05 October 2000, vol. 39 [0002]