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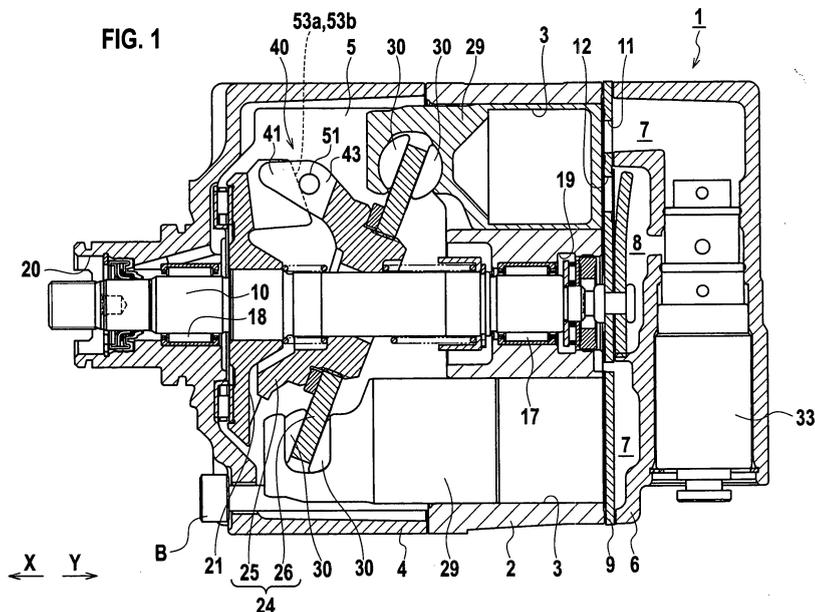
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(54) **VARIABLE DISPLACEMENT COMPRESSOR**

(57) A hinge mechanism (40) of a variable capacity compressor (1) includes an arm (41) protruded toward a tilting member (24) from a rotation member (21), an arm (43) protruded toward the rotation member (21) from the tilting member (24) to receive a rotational torque from the arm (41) of the rotation member, a pin (51) fixed to one of the arm (41) of the rotation member and the arm (43) of the tilting member, and an axial-load receiving surface (53a, 53b) formed on the other of the arm (41) of the

rotation member and the arm (43) of the tilting member and configured to be in contact with the pin (51) so as to receive an axial load produced between the rotation member (21) and the tilting member (24). A position where the pin (51) and the axial-load receiving surface (53a) contact with each other when the swash plate (24) has a maximum inclination angle is located within a range of 27 to 90 degrees anterior, in the rotational direction, to a position (TDC) corresponding to the top dead center.



Description

TECHNICAL FIELD

[0001] The present invention relates to a variable capacity compressor equipped with a hinge mechanism which is rotatable while transmitting a rotational torque.

BACKGROUND ART

[0002] A conventional variable capacity compressor is disclosed in Japanese Patent Application Laid-Open No. 2004-068756. The variable capacity compressor includes, as shown in Figs. 11 to 13, a drive shaft 105, a rotor 103 fixed to the drive shaft 105 to rotate with the drive shaft, a swash plate 101 (a cam plate) slidably attached to the drive shaft 105, and pistons (not shown) reciprocatably accommodated in cylinder bores (not shown) and engaged with the swash plate 101. The discharge capacity can be changed by changing the piston stroke while changing the inclination angle of the swash plate 101. A hinge mechanism is provided between the rotor 103 and the swash plate 101 to change the inclination angle of the swash plate while transmitting torque from the rotor 103 to the swash plate 101.

[0003] The hinge mechanism includes an arm 104 of the rotor projected towards the swash plate 101 from the rotor 103, and an arm 102 of the swash plate projected towards the rotor 103 from the swash plate 101. The arm 104 of the rotor and the arm 102 of the swash plate are overlapped with each other in the rotational direction, so that rotation of the rotor 103 which rotates with the drive shaft 105 is transmitted to the swash plate 101. An axial-load receiving surface 106 is provided in a base portion of the arm 104 of the rotor and receives a compressive reaction (axial load) which is applied from the pistons to the swash plate 101. The receiving surface 106 has a function to guide a change of the inclination angle of the swash plate 101 while being in slide contact with the arm 102 of the swash plate.

DISCLOSURE OF THE INVENTION

[0004] In the swash plate compressor, as shown in Figs. 12 and 13, a position where the compressive reaction F_p from the piston is maximum is located off a position TDC in the swash plate 101 corresponding to the top dead center and located anterior to the position TDC corresponding to the top dead center in the rotational direction. Therefore, the compressive reaction F_p is not symmetrically applied to the swash plate 101 with respect to a line C passing through the position TDC in the swash plate 101 corresponding to the top dead center and a position BDC of the swash plate 101 corresponding to a bottom dead center, so that a twisting force F_n is applied to the swash plate 101 as shown in Fig. 13. The swash plate 24 thus is inclined about the line C and twisted. When the swash plate 101 is twisted, a corner K1 of the

arm 102 of the swash plate 101 is digged into the arm 104 of the rotor 103 and also a corner K2 of the arm 104 of the rotor 103 is digged into the arm 102 of the swash plate 101. With this, the sliding resistance between the arms 102 and 104 when changing the inclination of the swash plate 101 becomes extremely high.

[0005] The present invention is developed in view of such a conventional art, and an object of the present invention is to provide a variable capacity compressor capable of reducing a sliding resistance between an arm of a swash plate and an arm of a rotor by preventing the swash plate from being twisted.

[0006] The present invention is a variable capacity compressor including: a drive shaft; a rotation member fixed to the drive shaft to rotate with the drive shaft; a tilting member attached to the drive shaft to be slidable along an axial direction of the drive shaft and inclinable with respect to the drive shaft; a hinge mechanism configured to transmit a rotational torque of the rotation member to the tilting member while allowing the inclination of the tilting member to change; and pistons each configured to reciprocate in respective cylinder bores in response to rotation of the tilting member, the hinge mechanism includes: an arm of the rotation member protruded towards the tilting member from the rotation member; an arm of the tilting member protruded towards the rotation member from the tilting member and configured to receive the rotational torque from the arm of the rotation member; a pin provided at one of the arm of the rotation member and the arm of the tilting member; and an axial-load receiving surface provided on the other of the arm of the rotation member and the arm of the tilting member and configured to contact with the pin so as to receive an axial load produced between the rotation member and the tilting member, Wherein a position where the pin and the axial-load receiving surface contacts with each other when the inclination angle of the tilting member is maximum is located within an angular range of 27 to 90 degrees anterior, in the rotation direction R, to a position in the tilting member corresponding to the top dead center.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007]

[Fig. 1] Fig. 1 is a sectional view of a variable capacity compressor which is in a maximum stroke position according to an embodiment of the present invention.

[Fig. 2] Fig. 2 is a sectional view of the variable capacity compressor which is in a minimum stroke position.

[Fig. 3] Fig. 3 is a side view of an assembly of the drive shaft, rotor, and swash plate which is in the maximum stroke position of the variable capacity compressor.

[Fig. 4] Fig. 4 is a side view of the assembly which is in the minimum stroke position.

[Fig. 5] Fig. 5 is a perspective view of the assembly.

[Fig. 6] Fig. 6 is a view of the assembly as seen from the direction VI in Fig. 3, in which a main body of the swash plate is removed.

[Fig. 7] Fig. 7 is a graph of theoretical pressure curves in a cylinder bore when discharge pressure Pd is the upper limit value of 3.16Mpa.

[Fig. 8] Fig. 8 is a graph of theoretical pressure curves in the cylinder bore when discharge pressure Pd is the lower limit value of 1.12Mpa.

[Fig. 9] Fig. 9 is a graph of measured results showing a relation between the pressure peak in the cylinder bore and a rotation speed.

[Fig. 10] Fig. 10 is a perspective view of a modification of the assembly of the variable capacity compressor.

[Fig. 11] Fig. 11 is a view of a conventional variable capacity compressor counterpart to Fig. 3.

[Fig. 12] Fig. 12 is a side view as seen along the arrow XII in Fig. 11.

[Fig. 13] Fig. 13 is a view of a state where a swash plate in Fig. 11 receives a large compressive reaction force and twisted.

BEST MODE OF CARRYING OUT THE INVENTION

[0008] Hereafter, an embodiment of a variable capacity compressor and a hinge mechanism thereof according to the present invention will be described with reference to the drawings.

[0009] First, outline of a variable capacity compressor will be described with reference to Figs. 1 and 2. Fig. 1 shows the maximum stroke position and Fig. 2 shows the minimum stroke position.

[0010] As shown in Figs. 1 and 2, the variable capacity compressor 1 includes a cylinder block 2 having a plurality (six in this embodiment) of cylinder bores 3 arranged in the circumferential direction at an interval, a front housing 4 joined to a front end of the cylinder block 2 and forming a crank chamber 5 therein, and a rear housing 6 joined to a rear end of the cylinder block 2 with a valve plate 9 therebetween and forming a suction chamber 7 and a discharge chamber 8 therein. The cylinder block 2, the front housing 4, and the rear housing 6 are fastened to each other by through bolts B.

[0011] The valve plate 9 is formed with suction holes 11 connecting and communicating the cylinder bore 3 and the suction chamber 7 and discharge holes 12 connecting and communicating the cylinder bores 3 and the discharge chamber 8.

[0012] A valve system (not shown) is provided on the cylinder block side of the valve plate 9 to open and close the suction holes 11. A valve system (not shown) is provided on the rear housing side of the valve plate 9 to open and close the discharge holes 12.

[0013] A drive shaft 10 is rotatably supported by bearings 17, 18 provided in bearing holes 19 and 20 at the center of the cylinder block 2 and the front housing 4, so

that the drive shaft 10 is rotatable in the crank chamber 5.

[0014] The crank chamber 5 accommodates therein a rotor 21 as a "rotation member" fixed to the drive shaft 10 and a swash plate 24 as a "tilting member" attached to the drive shaft 10. The swash plate 24 includes a hub 25 attached to the drive shaft 10 so as to be slidable along the axis of the drive shaft and tiltable with respect to the axis of the drive shaft, and a swash plate body 26 fixed to a boss portion of the hub 25.

[0015] Each piston 29 is slidably accommodated in each cylinder bore 3 and is connected with the swash plate body 26 of the swash plate 24 through a pair of hemispherical piston shoes 30.

[0016] A hinge mechanism 40 is provided between the rotor 21 as a rotation member and the hub 25 of the swash plate 24 as a tilting member such that rotation of the rotor 21 is transmitted to the swash plate 24, permitting the inclination of the swash plate 24 to change. When the drive shaft 10 rotates, the rotor 21 rotates with the drive shaft 10, and rotation of the rotor 21 is transmitted to the swash plate 24 via the hinge mechanism 40. The rotation of the swash plate 24 is converted into reciprocation of the pistons 29 via a pair of piston shoes 30 so that the pistons 29 reciprocate in the cylinder bores 3. When the pistons 29 reciprocate, refrigerant is suctioned from the suction chamber 7 into the cylinder bores 3 through the suction holes 11 of the valve plate 9, compressed in the cylinder bores, and then discharged into the discharge chamber 8 through the discharge holes 12 of the valve plate 9.

Control of variable capacity

[0017] The variable capacity compressor is provided with a pressure-control mechanism, to adjust a pressure difference (pressure balance) between a crank chamber pressure Pc in back of the pistons 29, and a suction chamber pressure Ps in front of the pistons 29 to change the inclination of the swash plate 24. The pressure-control mechanism includes a gas extraction passage (not shown) which connects and communicates the crank chamber 5 and the suction chamber 7, a gas supply passage (not shown) which connects and communicates the crank chamber 5 and the discharge chamber 8, and the control valve 33 which is disposed in the midstream of the gas supply passage to open and close the gas supply passage.

[0018] When the gas supply passage is opened by the control valve 33, refrigerant flows from the discharge chamber 8 into the crank chamber 5 through the gas supply passage, thereby the crank chamber pressure Pc increases, and the inclination angle of the swash plate 24 decreases according to the pressure balance between the crank chamber pressure Pc and the suction chamber pressure Ps. As a result, the piston stroke and the discharge amount decrease. Because refrigerant keeps flowing from the crank chamber 5 into the suction chamber 7 through the gas extraction passage, when the gas

supply passage is closed by the control valve 33, the crank chamber pressure P_c decreases and thereby the inclination angle of the swash plate 24 increases according to the pressure balance between the crank chamber pressure P_c and the suction chamber pressure P_s . As a result, the piston stroke and the discharge amount increase. When the hub 25 moves toward the cylinder block 2, the inclination angle of the swash plate 24 decrease, and when the hub 25 moves away from the cylinder block 2, the inclination angle of the swash plate 24 increases.

Hinge mechanism

[0019] Next, the hinge mechanism 40 will be explained with reference to Figs. 3 to 6.

[0020] Fig. 3 is a side view of the maximum stroke state of the assembly of the drive shaft, the swash plate and the rotor, Fig. 4 is a side view of the minimum stroke state of the assembly, Fig. 5 is a perspective view of the maximum stroke state of the assembly, and Fig. 6 is a view of the assembly without the swash plate body as seen along the arrow VI in Fig. 3.

[0021] As shown in Figs. 3 to 6, the hinge mechanism 40 includes an arm 41 which is protruded towards the hub 25 from the rotor 21, and an arm 43 which is protruded towards the rotor 21 from the hub 25. The arm 41 of the rotor and the arm 43 of the hub overlap with each other in the rotational torque transmitting direction F_t (a direction tangent to the rotational direction of the drive shaft 10), and thereby, the rotational torque of the rotor 21 is transmitted to the swash plate 24. In this embodiment, as shown in Figs. 3 and 4, the arm 41 of the rotor has a slit 41s extending in the axial direction XY (a direction perpendicular to the rotation torque transmitting direction F_t) and is formed a fork shape. The arm 43 of the swash plate is slidably fit in the slit 41s (that is, between a pair of arms 41 a and 41 b) in a sandwich manner. In this embodiment, the arm 43 of the swash plate is also formed in a fork shape.

[0022] When the swash plate 24 rotates and the pistons 29 reciprocate, a compressive reaction (axial load F_p) is applied to the swash plate 24 from the pistons 29. The compressive reaction F_p is received at a contact between a pin 51 which is press fit in a hole formed in the arm 43 of the swash plate 24 and the axial-load receiving surfaces 53a and 53b formed at the tips of the arms 41a, 41b of the rotor 21. The pin 51 extends in a direction tangent to the rotational direction of the rotor 21 and the swash plate 24. That is, the pin 51 extends towards the rotational torque transmitting direction F_t .

[0023] These axial-load receiving surfaces 53a and 53b has a function to guide a change of the inclination of the swash plate. Therefore, when the inclination of the swash plate 24 is changed, the axial load F_p (compressive reaction from a piston) is applied between the pin 51 and the axial-load receiving surfaces 53a and 53b.

[0024] Since large compressive reaction (axial load F_p) is applied to the contacts between the pin 51 and the

axial-load receiving surfaces 53a and 53b of the rotor 21, the axial-load receiving surfaces 53a and 53b of the rotor 21 and the pin 51 are hardened or quenched.

5 Positions of the axial-load receiving surfaces 53a and 53b

[0025] As a result of experiment conducted by the inventor, a position where the compressive reaction F_p is maximum with parameters of the suction pressure, the discharge pressure and the rotational speed was found to be located within the range α of 27 to 90 degrees anterior, in the rotational direction R, to a position TDC of the swash plate 24 corresponding to the top dead center (see Figs. 7, 8 and 9). When a compressive load is maximum (that is, when the pressure difference between the discharge pressure and the suction pressure is maximum), the compressive reaction F_p becomes more intense. The position where the compressive reaction F_p becomes more intense in the range of 27 to 90 degrees was found to be located within the range α of 27 to 37 degrees anterior, in the rotational direction R, to the position TDC of the swash plate corresponding to the top dead center, with a parameter of the rotation speed (see Figs. 7 and 9).

[0026] When a refrigerant 134a or the similar is used, the suction pressure is in a range of 0.26 to 0.51 Mpa, and the discharge pressure is in a range of 3.16 to 1.12 Mpa. In these ranges, theoretical pressure peak in the cylinder bore (pressure peak occurs when the discharge valve starts to open) is located at 323 degrees (that is, 37 degrees anterior to the top dead center in the rotational direction) which is the upper limit as shown in Fig. 7, and at 270 degrees (that is, 90 degrees anterior to the top dead center in the rotational direction) which is the lower limit as shown in Fig. 8. Fig. 7 is a graph of theoretical pressure curves in the cylinder bore when the discharge pressure P_d is the upper limit of 3.16Mpa. Fig. 8 is a graph of theoretical pressure curves in the cylinder bore when the discharge pressure P_d is the lower limit of 1.12Mpa.

[0027] Actual pressure peaks in the cylinder bore occur after the theoretical pressure peak, depending on the rotation speed of the drive shaft. As a result of the experiment, the pressure peaks in the cylinder bore turned out to occur after the theoretical pressure peak by a maximum of 10 degrees, as shown in Fig. 9. More specifically, it occurred after the theoretical pressure peak by 4 degrees when the rotation of the drive shaft is at low speed (when the vehicle idles), and it occurred after the theoretical pressure peak by 10 degrees when the rotation of the drive shaft is at high speed (when the vehicle runs faster than 100 km/h).

[0028] Therefore, when the discharge pressure, suction pressure and rotational speed are variable, the position where the compressive reaction F_p from the piston 29 is maximum was found to be located within the range of 27 to 90 degrees anterior, in the rotational direction,

to the position TDC of the swash plate 24 corresponding to the top dead center. When the pressure difference between the discharge pressure and the suction pressure is maximum (that is, when the discharge pressure is 3.16 Mpa and the suction pressure is 0.26 Mpa), the compressive reaction FP is most intense in the range of 27 to 90 degrees. The theoretical position where the compression reaction FP is most intense was found to be located at 37 degree anterior, in the rotational direction, to the position TDC corresponding to the top dead center, and the actual position where the compression reaction Fp is most intense was found to be located behind a maximum of 10 degrees from the theoretical position, depending on the rotation speed. With this, the actual position was found to be located within a range α of 27 to 37 degrees anterior, in the rotational direction R, to the position TDC corresponding to the top dead center (see Figs. 7 and 9).

[0029] Based upon the above analysis, in the present embodiment, a contact between the pin 51 and one 53a of the axial-load receiving surfaces 53a and 53b when the swash plate 24 is in the maximum inclination angle is preferably provided within the angle range of 27 to 90 degrees anterior, in the rotational direction, to the position TDC of the swash plate 24 corresponding to the top dead center. Further, the contact is more preferably provided within the angle range of 27 to 37 degrees anterior, in the rotational direction R, to the position TDC of the swash plate corresponding to the top dead center. When the difference between the discharge pressure and the suction pressure is maximum and the rotation speed is at low speed (the vehicle idles), the above problem is the most remarkable. Therefore, in this embodiment, the contact is provided at 33 degrees anterior, in the rotation direction R, to the position TDC of the swash plate 24 corresponding to the top dead center (that is, the contact is provided at the position 4 degrees behind the theoretical pressure peak of 37 degrees).

[0030] According to the embodiment, the axial-load receiving surface 53a receives the compressive reaction Fp via the pistons 29 right or nearly right in front of the axial-load receiving surface 53a. This makes torsion of the swash plate 24 smaller than the conventional art. Therefore, sliding resistance between the arm 43 of the swash plate and the arm 41 of the rotor become small so that the controllability of the compressor improves.

Effect

[0031] The present embodiment has the following effects according to the above configuration.

[0032] First, according to the variable capacity compressor of the embodiment, the hinge mechanism 40 includes: the arm 41 protruded from the rotor 21; the arm 43 protruded from the swash plate 24 and receiving the rotational torque from the arm 41 of the rotor; a pin 51 provided at one (the arm 43 of the swash plate in this embodiment) of the arm 41 of the rotor and the arm 43

of the swash plate; and, the axial-load receiving surfaces 53a and 53b provided at the other (the arm 41 of the rotor in this embodiment) of the arm 41 and the arm 43 and configured to be in contact with the pin 51 to receive the compressive reaction Fp (axial load) from the pistons 29. The position where the pin 51 and one (53a in this embodiment) of the axial-load receiving surfaces 53a, 53b contact with each other when the swash plate 24 is in the maximum inclination angle is located where the compressive reaction Fp from the piston 29 is maximum, that is, within the range of 27 to 90 degrees anterior, in the rotation direction, to the position TDC corresponding to the top dead center.

[0033] Therefore, the compressive reaction Fp from the piston 29 is received by the position almost right opposite thereto, and thereby, the swash plate 24 can be prevented from being twisted unlike the above conventional art. Therefore, the sliding resistance between the arm 43 of the swash plate and the arm 41 of the rotor becomes small, and the controllability of the compressor improves.

[0034] Second, according to the variable capacity compressor of the present embodiment, the position where the pin 51 and one (53a in this embodiment) of the axial-load receiving surfaces 53a and 53b when the swash plate 24 is in the maximum inclination angle is provided within the angle range α of 27 to 37 degrees anterior, in the rotational direction, to the position TDC corresponding to the top dead center. Therefore, sliding resistance between the arm 43 of the swash plate and the arm 41 of the rotor becomes smaller.

[0035] Third, in the variable capacity compressor, one (the arm 43 of the swash plate in this embodiment) of the arms 41, 43 has the slit 41s to be formed in a fork shape, and the other (the arm 41 of the rotor in this embodiment) of the arms 41, 43 is slidably fit in the slit 41s in a sandwich manner. Therefore, a backlash hardly occurs between the arms 41 and 43.

[0036] Fourth, according to the hinge mechanism 40 of the present embodiment, the pin 51 is formed of a separate member separated from and fixed to one of the arm 41 of the rotor and the arm 43 of the swash plate (the arm 43 of the swash plate in the present embodiment).

[0037] Since the pin 51 is formed of a member separated from the arm (the arm 43 of the swash plate in the present embodiment), the arm (the arm 43 of the swash plate this example) is not required to be hardened or quenched if only the pin 51 is hardened or quenched. Therefore, the manufacturing cost is reduced.

[0038] Moreover, since the arm (the arm 43 of the swash plate in the embodiment) is formed of a separate member, the peripheral surface of the pin 51 can be easily formed into a complicated shape. In such a structure, the manufacturing cost can be reduced compared with a structure in which the arm (the arm 43 of the swash plate) is formed in a complicated shape. In addition, replacing only the pin 51 is allowed.

[0039] The present invention should not be limited to the above embodiment.

[0040] For example, although the pin 51 is fixed to the arm 43 of the swash plate and the axial-load receiving surfaces 53a and 53b are formed at the arm 41 of the rotor in the above embodiment, the axial-load receiving surface may be formed at the arm 43 of the swash plate, and the pin 51 may be provided at the arm 41 of the rotor in the present invention.

[0041] Although the above embodiment has the pin 51 formed of a separate member separated from the arm, the pin 51 may be formed integrally with the arm 41 or the arm 43.

[0042] Although the axial-load receiving surfaces 53a and 53b are symmetrically provided about the position TDC corresponding to the top dead center in the above embodiment, the axial-load receiving surfaces 53a and 53b do not have to be symmetrically provided about the position TDC corresponding to the top dead center in the present invention.

[0043] Although the arm 41 of the rotor is formed with the slit 41s and the arm 43 of the swash plate is slidably fit in the slit 41s in a sandwich manner in the above-mentioned embodiment, the arm 43 of the swash plate may be formed with the slit 43s and the arm 41 of the rotor may be slidably fit in the slit 43s in a sandwich manner, as seen in the modification shown in Fig. 10, in the present invention.

[0044] Although the pin has a circular cross section in the above embodiment, it may have other sectional shapes in the present invention.

[0045] Although the swash plate 24 is assembled by combining separate members of the swash plate body 26 and the hub 25 in the above embodiment, the swash plate may be formed of a member in the present invention. Moreover, although the above embodiment has a non-sleeve structure in which the swash plate 24 is directly attached to the drive shaft 10 without a sleeve, the swash plate may be attached to the drive shaft via a sleeve in the present invention.

[0046] Although the swash plate is used in the above embodiment, a wobble plate may be used as a substitute in the present invention.

[0047] Moreover, various changes and modifications may be made to the present invention without departing the scope of the invention.

Claims

1. A variable capacity compressor comprising:

a drive shaft;
a rotation member fixed to the drive shaft to rotate with the drive shaft;
a tilting member attached to the drive shaft such that the tilting member is slidable along the axis of the drive shaft and inclinable with respect to

the drive shaft;

a hinge mechanism configured to transmit rotational torque of the rotation member to the tilting member while permitting the inclination of the tilting member to change; and

pistons configured to reciprocate in cylinder bores in accordance with rotation of the tilting member,

the hinge mechanism including:

an arm projected from the rotation member toward the tilting member;

an arm projected from the tilting member toward the rotation member and configured to receive the rotational torque from the arm of the rotation member;

a pin provided at one of the arm of the rotation member and the arm of the tilting member; and

an axial-load receiving surface formed on the other of the arm of the rotation member and the arm of the tilting member and configured to contact with the pin to receive an axial load applied to the rotation member from the tilting member,

wherein a position where the pin and the axial-load receiving surface contact with each other when the inclination angle of the tilting member is maximum is located within a range of 27 to 90 degrees anterior, in the rotational direction R, to a position corresponding to a top dead center.

2. The variable capacity compressor according to claim 1,

wherein the position where the pin and the axial-load receiving surface contact with each other when the inclination angle of the tilting member is maximum is located within a range of 27 to 37 degrees anterior, in the rotational direction R, to the position corresponding to the top dead center.

3. The variable capacity compressor according to claim 1, wherein

the arm of the rotation member is formed in a fork shape with a slit in which the arm of the tilting member is slidably fit in a sandwich manner.

4. The variable capacity compressor according to claim 1, wherein

the arm of the tilting member is formed in a fork shape with a slit in which the arm of the rotation member is slidably fit in a sandwich manner.

5. The variable capacity compressor according to claim 1, wherein

the pin is formed of a separated member separated from and fixed to one of the arm of the rotation mem-

ber and the arm of the tilting member.

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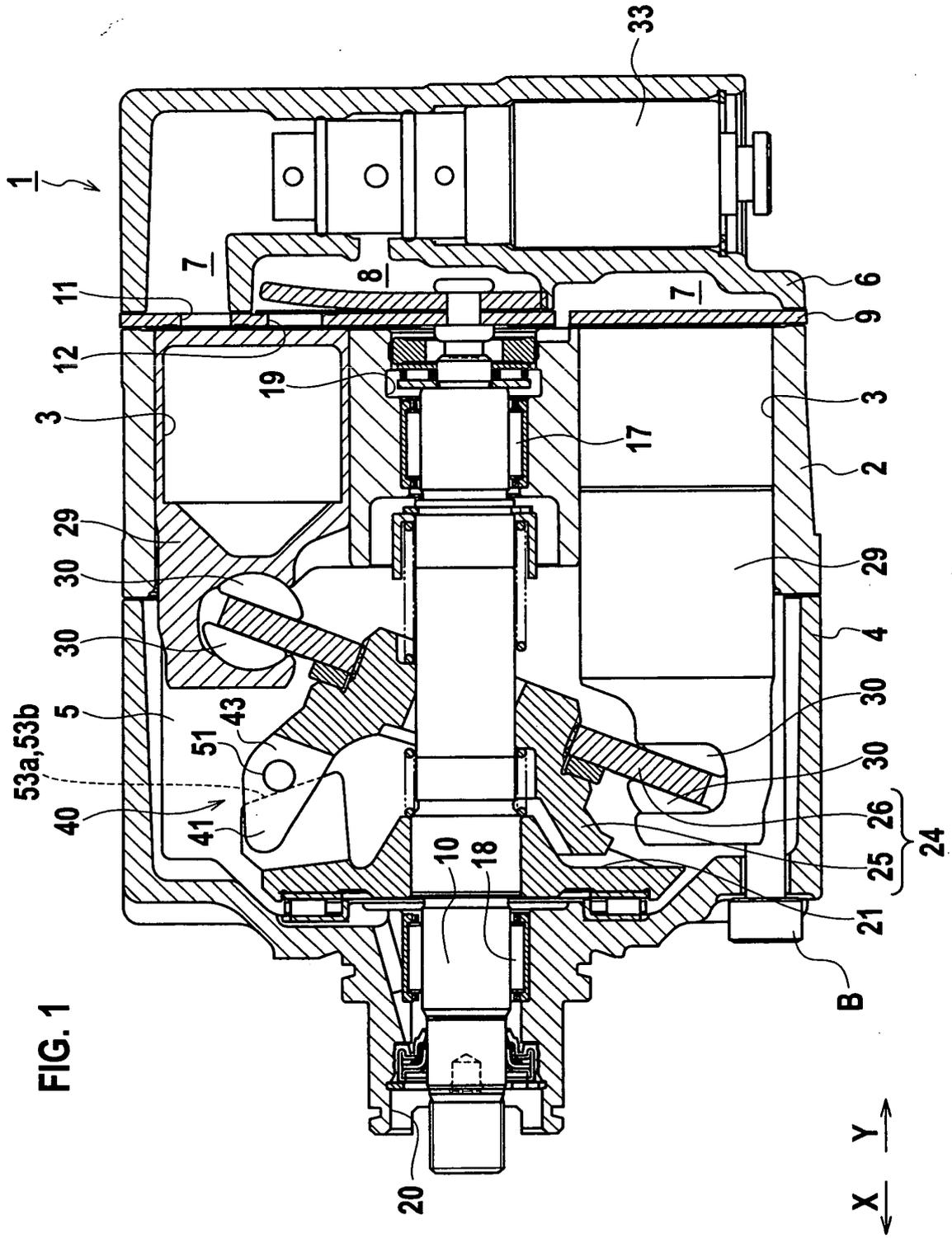
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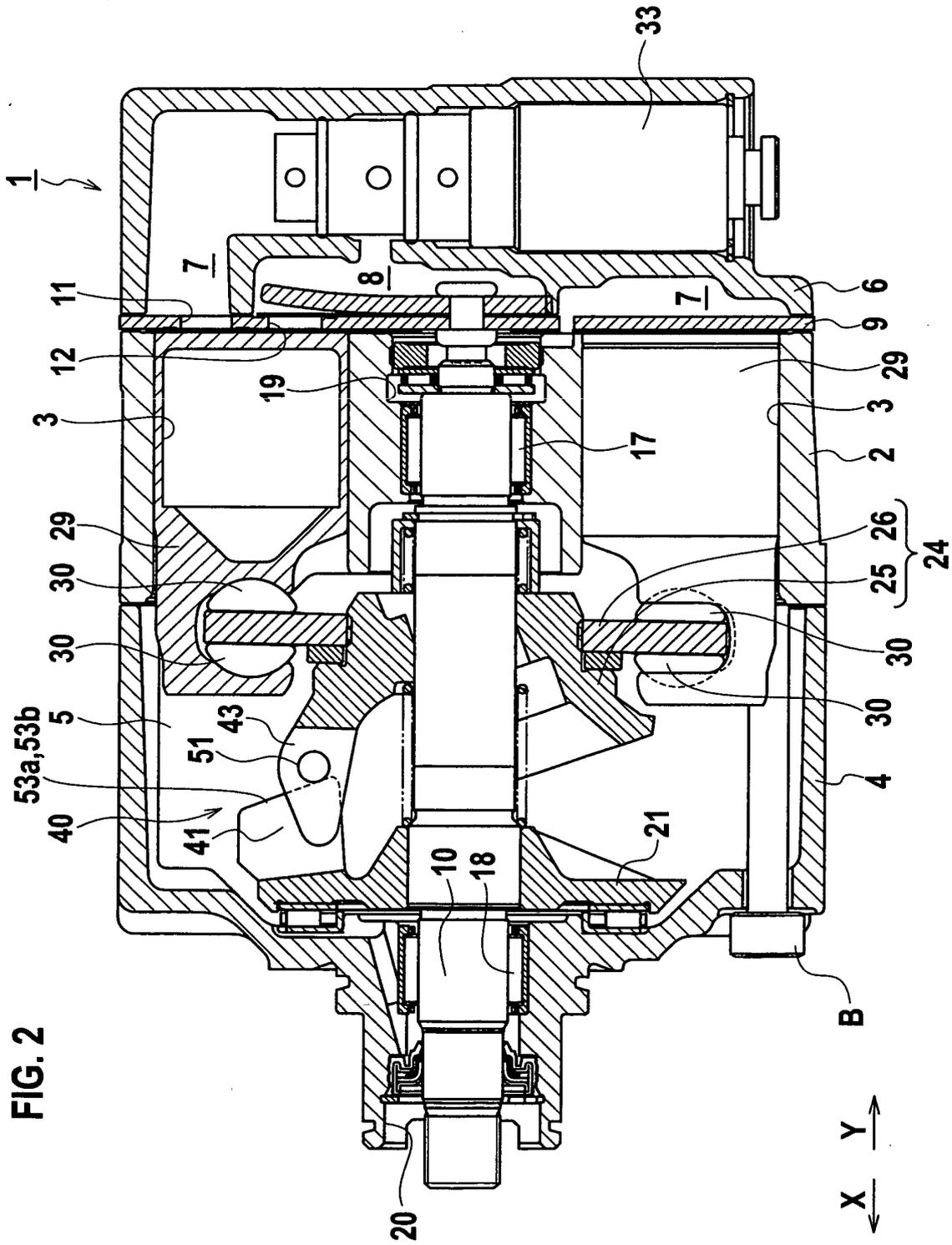


FIG. 2

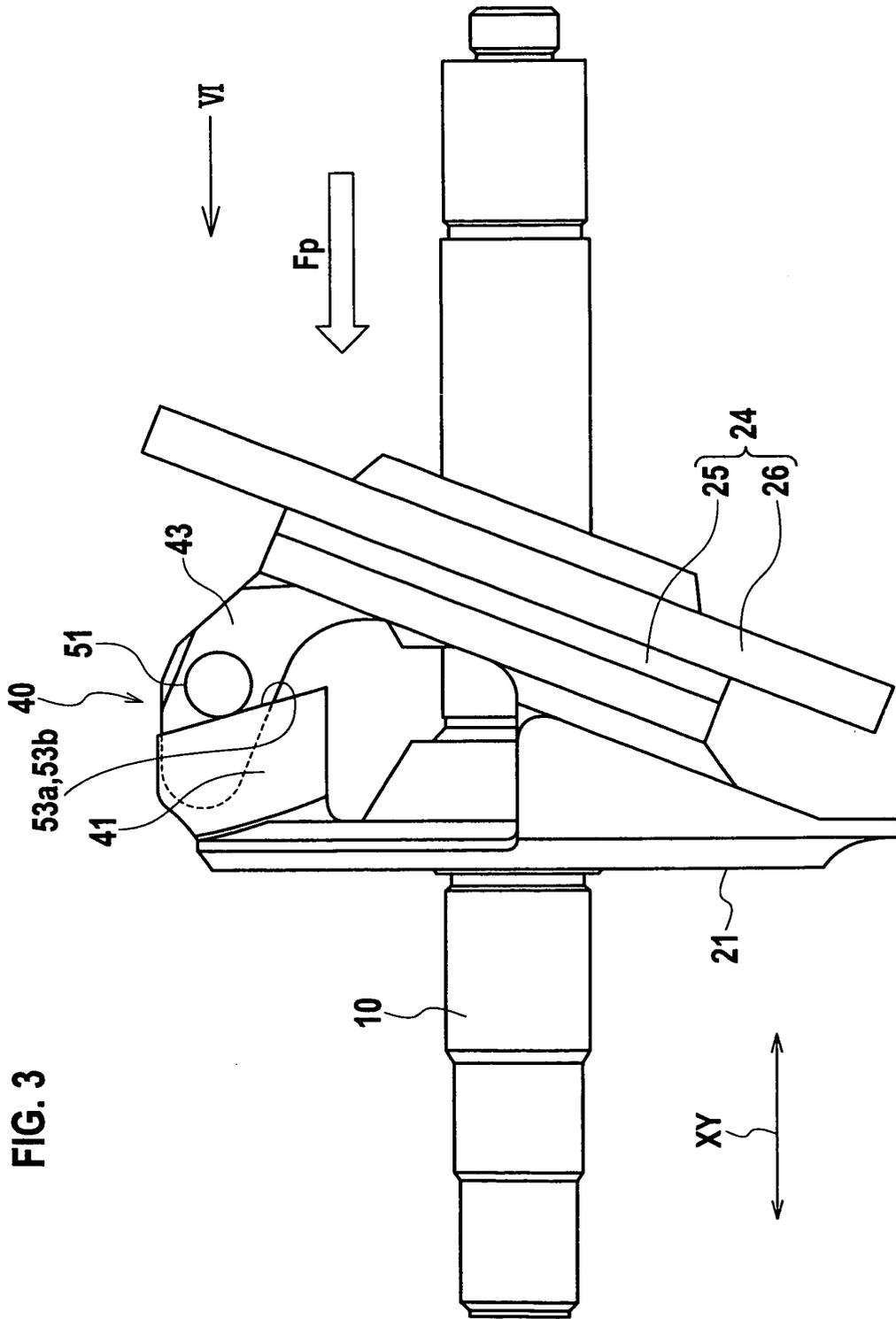


FIG. 3

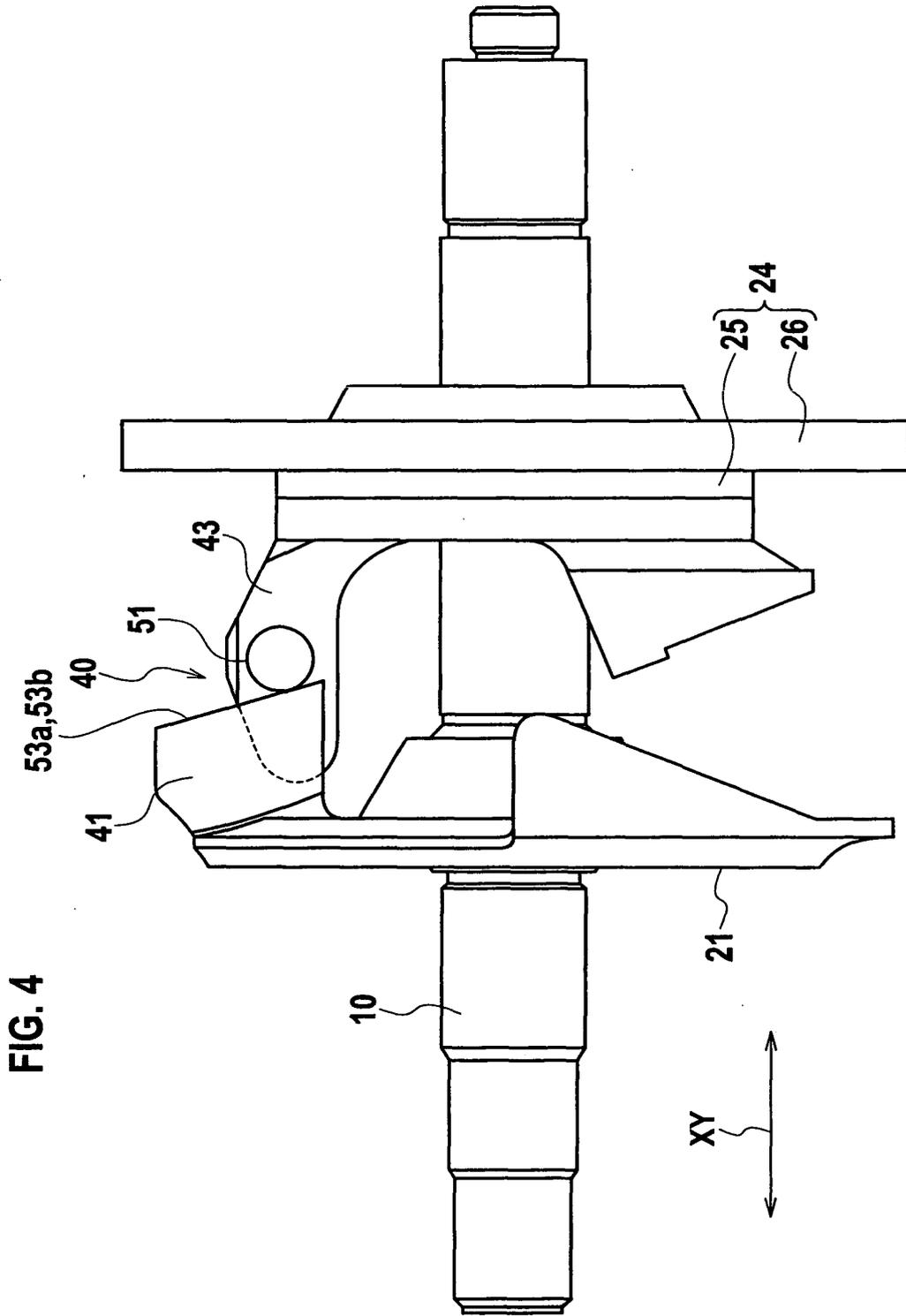


FIG. 5

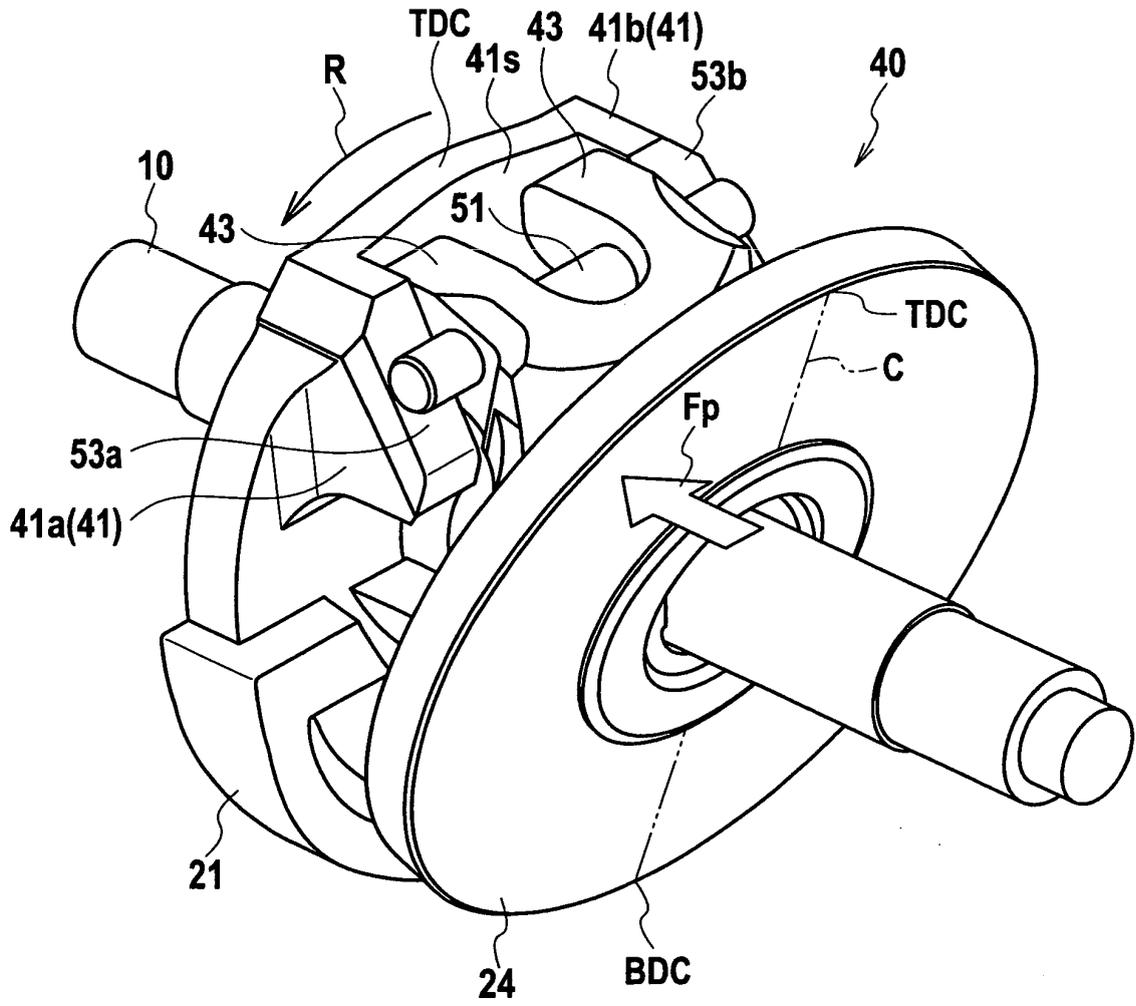


FIG. 6

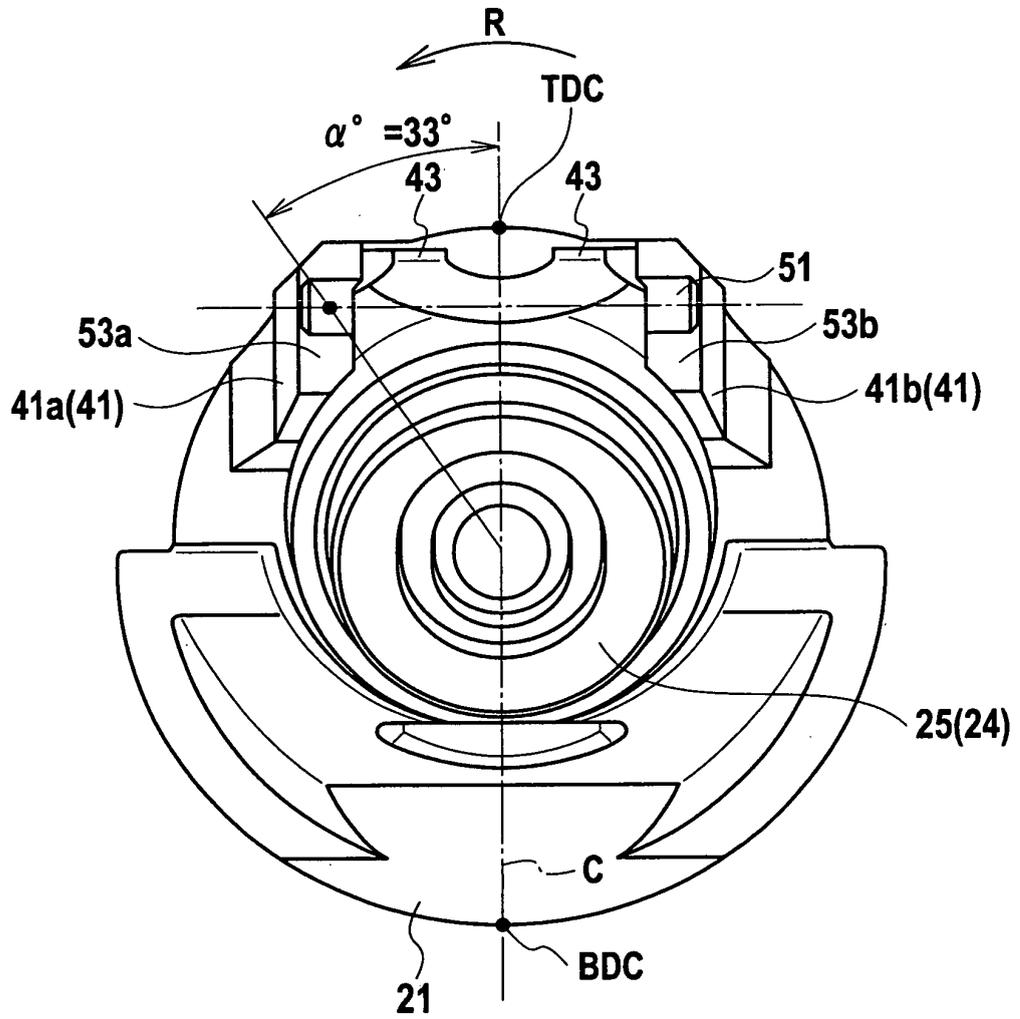


FIG. 7

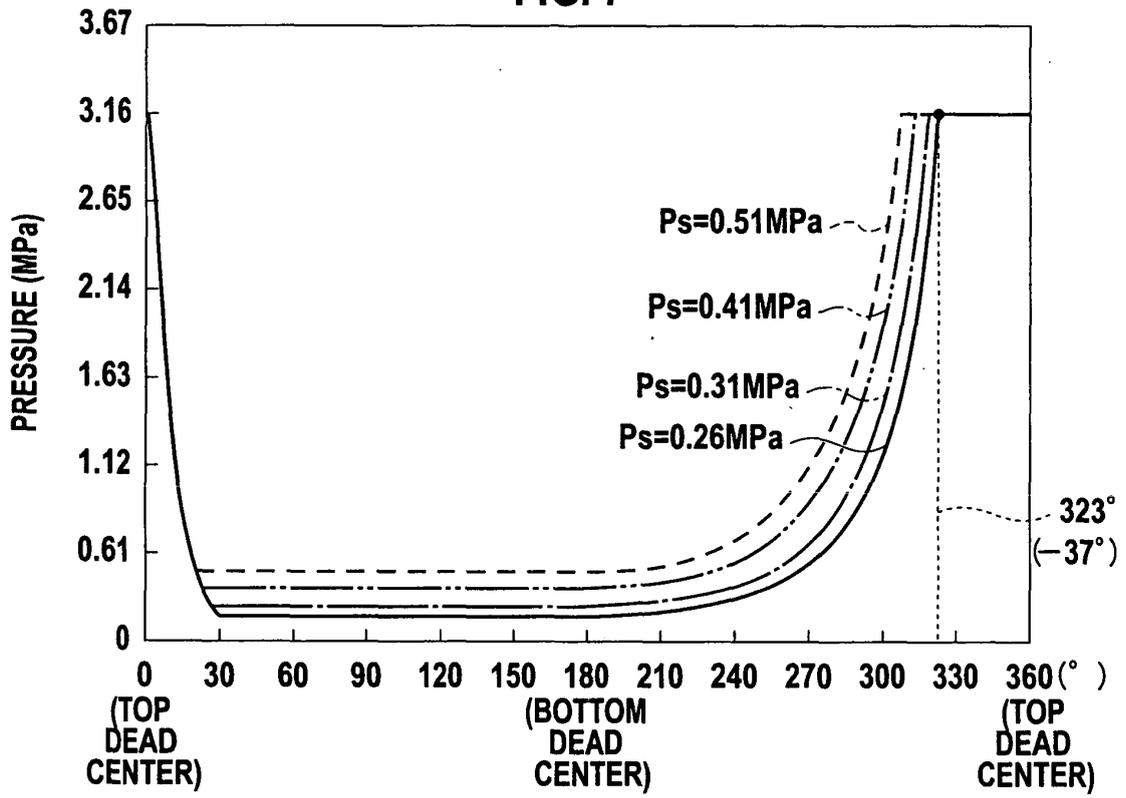


FIG. 8

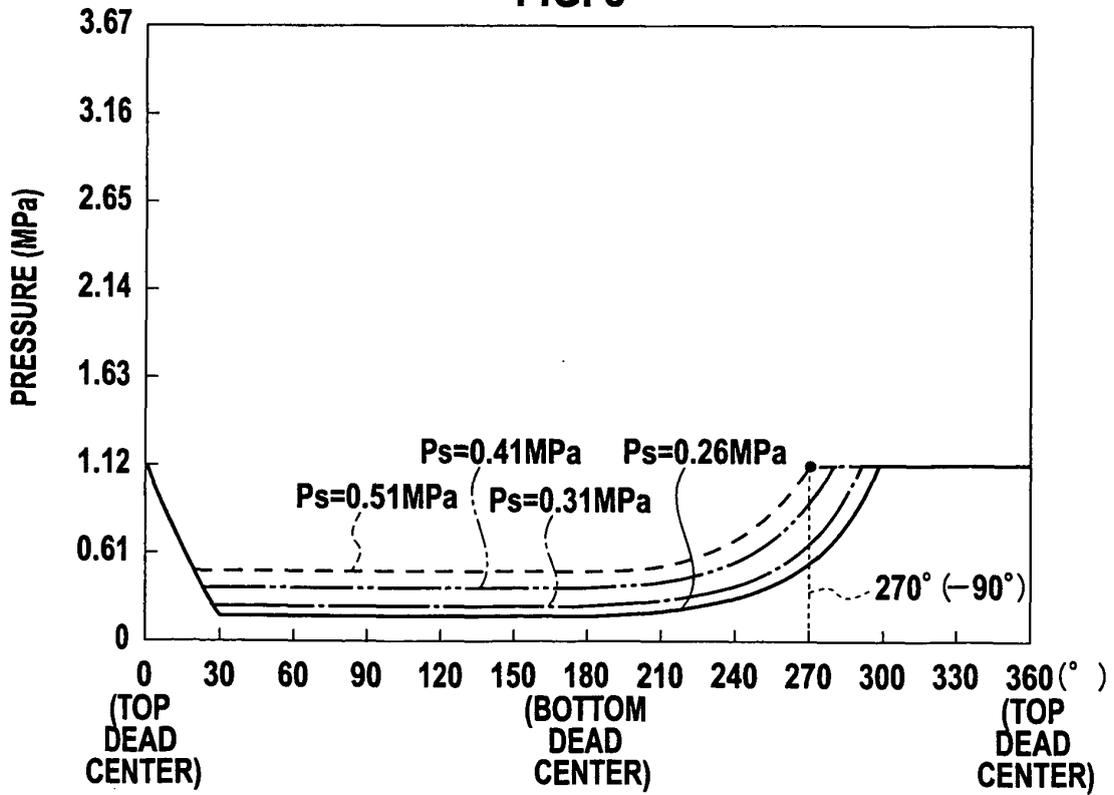


FIG. 9

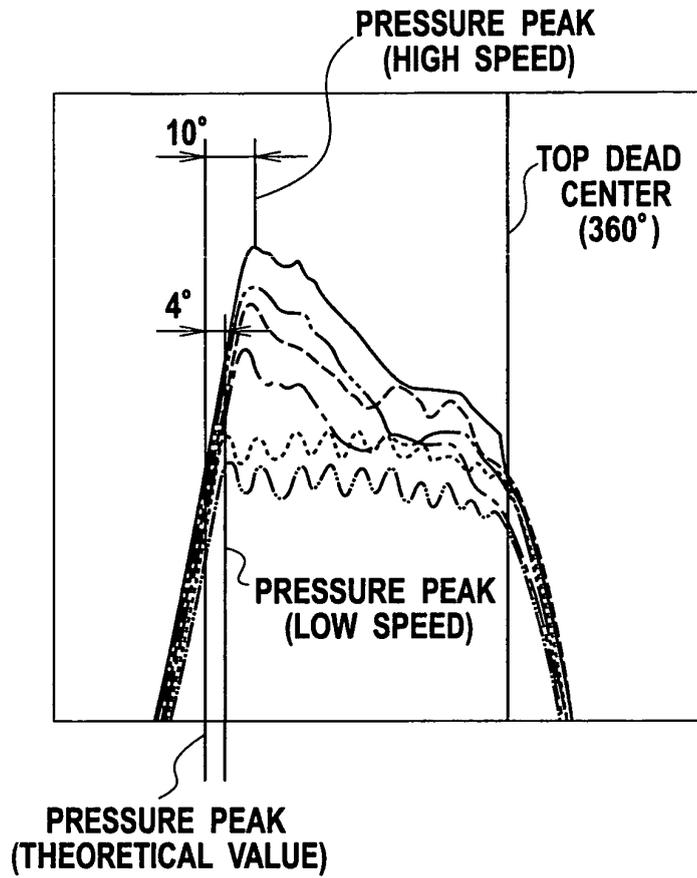


FIG. 10

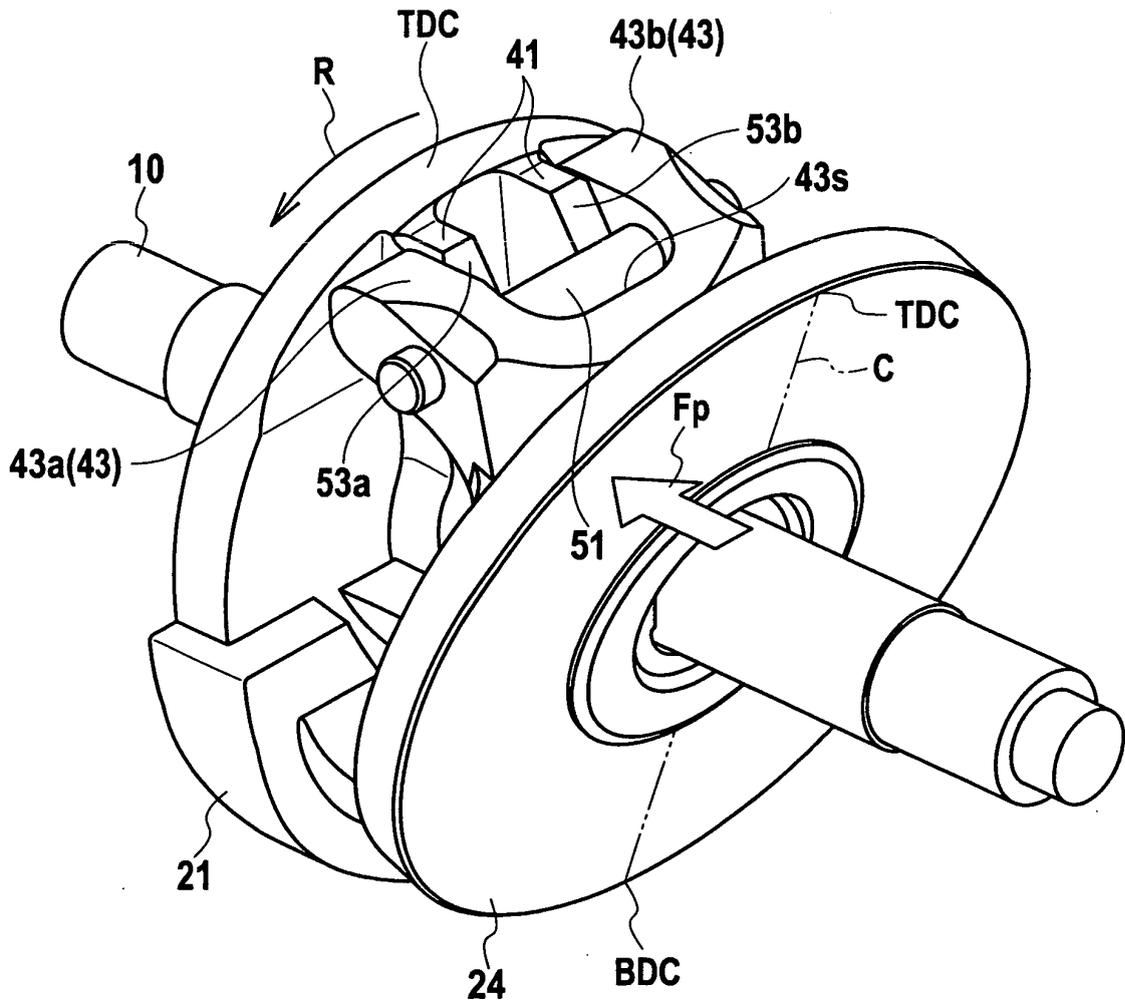


FIG. 11

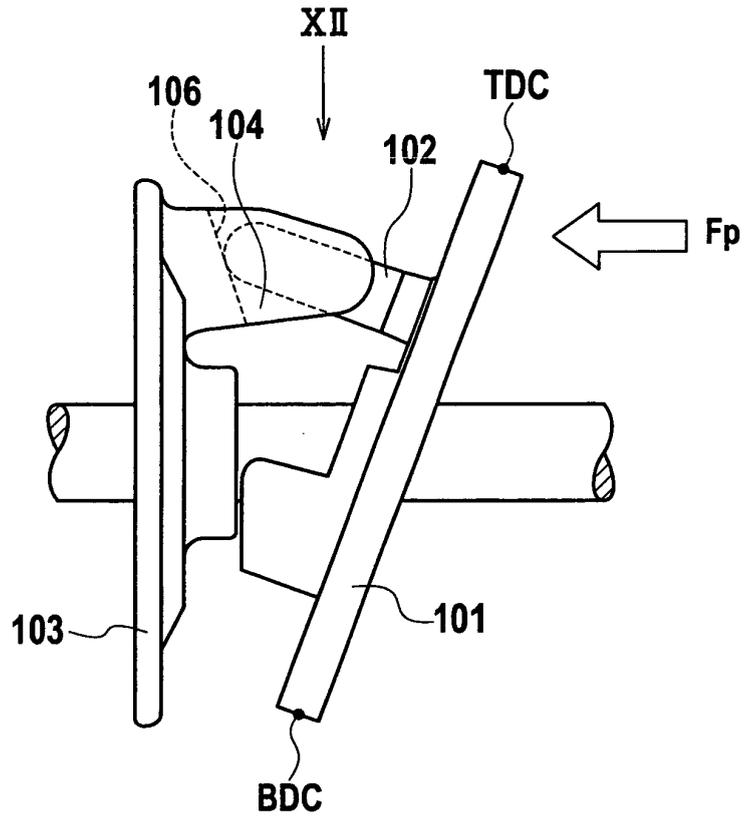


FIG. 12

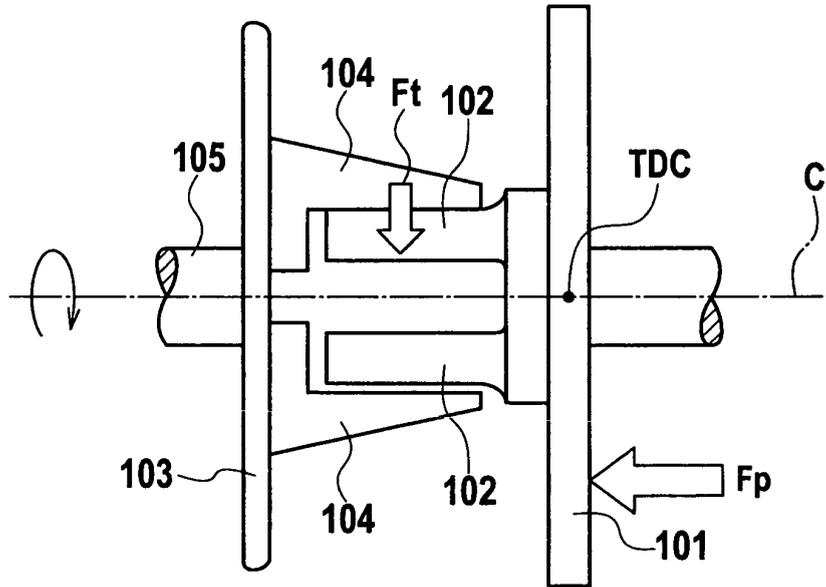
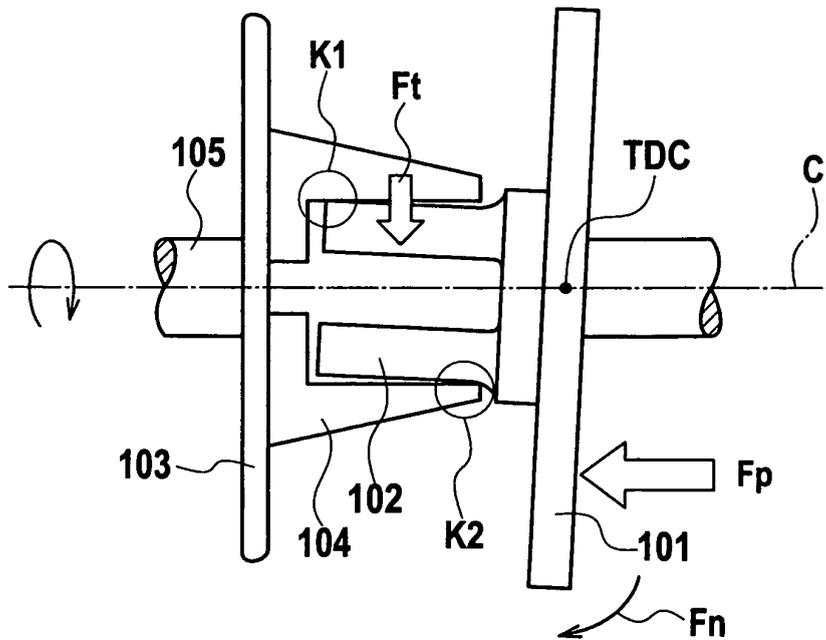


FIG. 13



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2007/067522

A. CLASSIFICATION OF SUBJECT MATTER F04B27/08 (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) F04B27/08		
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 1996-2007 Kokai Jitsuyo Shinan Koho 1971-2007 Toroku Jitsuyo Shinan Koho 1994-2007		
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.
Y	JP 11-336657 A (Nippon Soken, Inc.), 07 December, 1999 (07.12.99), Par. Nos. [0011] to [0013]; Figs. 1 to 3 (Family: none)	1-5
Y	JP 2001-207956 A (Kanda Kucho Kabushiki Kaisha), 03 August, 2001 (03.08.01), Par. Nos. [0039] to [0041], [0045] to [0048]; all drawings & US 6402481 B1 & EP 1111235 A2	1-5
Y	JP 2002-303261 A (Sanden Corp.), 18 October, 2002 (18.10.02), Par. No. [0007]; Figs. 2 to 3 & US 2002/0144591 A1 & DE 10214149 A1 & FR 2823261 A1	1-5
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
* Special categories of cited documents:		
"A"	document defining the general state of the art which is not considered to be of particular relevance	"T"
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		document member of the same patent family
Date of the actual completion of the international search 20 September, 2007 (20.09.07)		Date of mailing of the international search report 02 October, 2007 (02.10.07)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
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INTERNATIONAL SEARCH REPORT

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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.
A	JP 4-303184 A (Toyoda Automatic Loom Works, Ltd.), 27 October, 1992 (27.10.92), Par. Nos. [0016], [0021]; Figs. 4 to 5 & US 5336056 A & WO 1992/017705 A1 & DE 4290950 C2	1-5

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2004068756 A [0002]