(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 857 675 A1

(12) # EUROPEAN PATENT APPLICATION
published in accordance with Art. 158(3) EPC

(43) Date of publication:
21.11.2007 Bulletin 2007/47

(21) Application number: **06714184.6**

(22) Date of filing: **21.02.2006**

(51) Int Cl.:
F04B 27/10 *(2006.01)*

(86) International application number:
PCT/JP2006/303044

(87) International publication number:
WO 2006/095565 (14.09.2006 Gazette 2006/37)

(84) Designated Contracting States:
DE FR GB

(30) Priority: **09.03.2005 JP 2005066123**

(71) Applicant: **Calsonic Kansei Corp.**
Tokyo 164-0014 (JP)

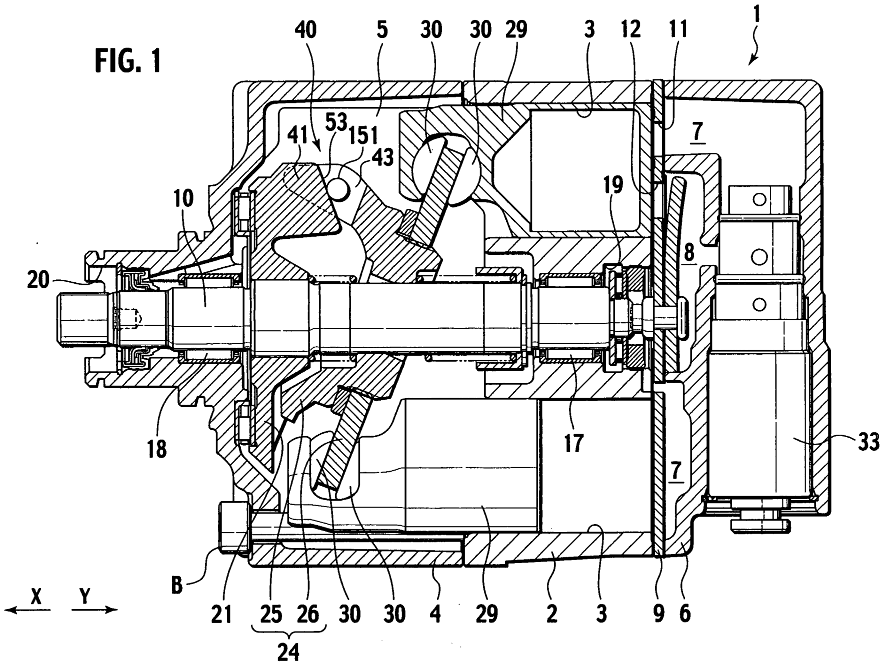
(72) Inventors:
- **MAKISHIMA, Hiroyuki**
c/o Calsonic Kansei Corp.
Tokyo 164-8602 (JP)
- **KOBAYASHI, Nobuyuki**
c/o Calsoni Kansei Corp.
Tokyo 164-8602 (JP)

(74) Representative: **Grünecker, Kinkeldey,**
Stockmair & Schwanhäusser
Anwaltssozietät
Maximilianstrasse 58
80538 München (DE)

(54) **VARIABLE DISPLACEMENT COMPRESSOR**

(57) A linkage mechanism (40) of a variable displacement compressor includes an arm (41) extending from a rotating member (21) toward a tilting member (24), an arm (43) extending from the tilting member (24) toward the rotating member (21) and receiving rotary torque from the arm (41) of the rotating member, a pin (51) fixed to one of the arm (41) of the rotating member and the arm (43) of the tilting member, and an axial direction load receiving face (53) formed on the other of the arm (41) of the rotating member and the arm (43) of the tilting member and configured to contact with the pin (51) to receive axial a direction load applied between the rotating member (21) and the tilting member (24).

FIG. 1



EP 1 857 675 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a variable displacement compressor having a linkage mechanism.

BACKGROUND ART

[0002] A variable displacement compressor includes a drive shaft, a rotor that is fixed to the drive shaft and rotates integrally with the drive shaft, a swash plate (cam plate) that is attached to the drive shaft and changeable its tilt with respect to the axis of the drive shaft, a linkage mechanism that links the rotor and the swash plate, and pistons that are engaged to the swash plate. When the drive shaft rotates, the swash plate rotates with the rotor and the piston reciprocates corresponding to the inclination angle of the swash plate. The linkage mechanism links the rotor and the swash plate so that the inclination angle of the swash plate can be changed as transferring the rotation of the rotor to the swash plate. With this, the piston strokes are changed by changing the inclination angle of the swash plate so as to change the discharging amount (see Japanese Patent Laid-Open No. 2004-068756, for example).

[0003] The conventional linkage mechanism includes a projection extending from the rotor toward the swash plate and a projection extending from the swash plate toward the rotor. The projection of the rotor and the projection of the swash plate overlap each other in the rotating direction and, with this structure, rotary torque from the rotor is transferred to the swash plate. The projection of the swash plate slidably contacts with a base of the projection of the rotor. The base of the projection of the rotor functions an axial direction load receiving face for receiving an axial direction load applied to the swash plate. The inclination angle of the swash plate changes with the slide of the projection of the swash plate on the pressure receiving face.

DISCLOSURE OF THE INVENTION

[0004] With such a conventional structure, the inclination angle of the swash plate is changed while a large compression reaction force (the axial direction load) from the pistons is applied to the contact between the axial direction load receiving face and the projection of the swash plate so that the contact are easily worn. Accordingly, the contact are required to be quenched or the like in order to enhance their hardness and to prevent such damages. If the contact are worn down compared to the initial condition, the upper dead center of the each piston is lowered so that the compressive performance of the compressor may be decrease.

[0005] The contact between the axial direction load receiving face and the projection of the swash plate are formed in a complicated shape so that the inclination angle of the swash plate varies as the projection of the swash plate slides on the axial direction load receiving face. Since the contacting face is formed on the projection of the rotor or the swash plate, difficult processing is required and manufacturing cost increases.

[0006] The present invention is made based on such a conventional technique. An object of the present invention is to provide a variable displacement compressor capable of preventing an abrasion of a portion where a large axial direction load is applied and reducing manufacturing cost of the variable displacement compressor.

[0007] An aspect of the present invention is a variable displacement compressor, including: a drive shaft; a rotating member fixed to the drive shaft and rotating integrally with the drive shaft; a tilting member attached to the drive shaft and being changeable a tilt thereof with respect to an axis of the drive shaft; a linkage mechanism configured to rotate the rotating member and the tilting member integrally as allowing the tilt of the tilting member; and a piston configured to reciprocate in a cylinder bore corresponding to rotary movement of the tilting member. The linkage mechanism includes an arm extending from the rotating member; an arm extending from the tilting member and overlapping with the arm of the rotating member in a rotating direction; a pin fixed to one of the arm of the rotating member and the arm of the tilting member; and an axial direction load receiving face formed on the other of the arm of the rotating member and the arm of the tilting member and configured to contact with the pin to receive an axial direction load applied between the rotating member and the tilting member.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

Fig. 1 is a cross-sectional view showing a variable displacement compressor in a full stroke condition according to an embodiment of the present invention;

Fig. 2 is a cross-sectional view showing the variable displacement compressor in a no-stroke condition;

Fig. 3 is a perspective view showing an assembly of a drive shaft, a rotor, and a swash plate of the variable displacement compressor in a full stroke condition;

Fig. 4 is a perspective view showing the assembly of the drive shaft, the rotor, and the swash plate of the variable displacement compressor in a no-stroke condition;

Fig. 5 is a side view showing the assembly taken along the arrow V-V in Fig. 3;

Fig. 6 is a side view showing the assembly taken along the arrow VI-VI in Fig. 4;

Fig. 7 is a cross-sectional view showing a pin of a linkage mechanism in the variable displacement compressor;

Fig. 8 is a perspective view showing the first modification of the first embodiment corresponding to Fig.

3;

Fig. 9 is a perspective view showing the second modification of the first embodiment corresponding to Fig. 3; and

Fig. 10 is a perspective view showing the third modification of the first embodiment corresponding to Fig. 3.

DETAILED DESCRIPTION OF THE INVENTION

[0009] A variable displacement compressor according to an embodiment of the present invention and a linkage mechanism used therein will be explained with reference to the drawings.

[0010] Firstly, an over all structure of the variable displacement compressor will be explained with reference to Figs. 1 and 2. Fig. 1 shows a full stroke condition and Fig. 2 shows a destroke condition.

[0011] As shown in Figs. 1 and 2, a variable displacement compressor 1 includes a cylinder block 2, a front head 4 attached to a front end of the cylinder block 2, a rear head 6 attached to a rear end of the cylinder block 2 via a valve plate 9. The cylinder block 2, the front head 4, and the rear head 6 are fixed to each other by a plurality of penetrating bolts B and compose a housing of the compressor.

[0012] The cylinder block 2 is formed in a substantially cylindrical shape and has a plurality of cylinder bores 3 placed evenly spaced apart in a circumferential direction. The front head 2 is attached to the front end of the cylinder block 2 and has a crank chamber 5 therein. The rear head 6 is attached to the rear end of the cylinder block 2 via the valve plate 9 and has a suction chamber 7 and a discharge chamber 8 therein.

[0013] The valve plate 9 is formed with suction ports 11 that communicates the cylinder bores 3 with the suction chamber 7 and is formed with discharge ports 12 that communicates the cylinder bores 3 with the discharge chamber 8.

[0014] A valve system (not shown) adapted to open and close the suction ports 11 is provided on the valve plate 9 at the cylinder block side. On the other hand, a valve system (not shown) adapted to open and close the discharge ports 12 is provided on the valve plate 9 at the rear head side. A gasket is interposed between the valve plate 9 and the rear head 6 for providing an airtight sealing property between the suction chamber 7 and the discharge chamber 8.

[0015] A drive shaft 10 is supported by bearings 17, 18 in support holes 19, 20 that are formed at centers of the cylinder block 2 and the front head 4so that the drive shaft 10 is rotatable in the crank chamber 5.

[0016] the crank chamber 5 accommodates a rotor 21 as a "rotating member" fixed to the drive shaft 10, a swash plate 24 as a "tilting member" attached to the drive shaft slidably in the axial direction and tiltably with respect to the axis of the drive shaft, and a linkage mechanism 40 for linking the rotor 21 and the swash plate 24. The linkage mechanism 40 links the rotor 21 and the swash plate 24 so that the rotor 21 and the swash plate 24 rotate integrally as allowing changes of the inclination angle of the swash plate 24. The swash plate 24 includes a hub 25 attached to the drive shaft 10 and a swash plate body 26 fixed to a boss segment 25a of the hub 25. To the swash plate body 26 of the swash plate 24, a piston 29 is linked via a pair of hemispherical-shaped shoes 30, 30. The pistons 29 are slidably fit in each cylinder bore 3.

[0017] When the drive shaft 10 rotates, the rotor 21 rotates integrally with the drive shaft 10, and the swash plate 24 rotates corresponding to the rotor 21 via the linkage mechanism 40. The rotation of the swash plate 24 is converted into a reciprocating movement of the pistons 29 by the pairs of piston shoes 30, 30 so that the pistons 29 reciprocate in the cylinder bores 3. By the reciprocation of the pistons 29, refrigerant in the suction chamber 7 is sucked into the cylinder bores 3 through the suction ports 11 of the valve plate 9 to be compressed, and then discharged to the discharge chamber 8 through the discharge ports 12 of the valve plate 9.

Control of Variable Capacity

[0018] In the variable displacement compressor, a pressure control mechanism is provided. The pressure control mechanism is configured to adjust a difference in pressure (pressure balance) between the crank chamber pressure Pc in back of the pistons 29 and the suction chamber pressure Ps in front of the pistons 29 is provided in order to change the inclination angle of the swash plate 24. The pressure control mechanism includes a gas extraction passage (not shown) that allows the crank chamber 5 to communicate with the suction chamber 7, an gas supply passage (not shown) that allows the crank chamber 5 to communicate with the discharge chamber 8, and a control valve 33 that is provided in the midstream of the gas supply passage to open and close the gas supply passage.

[0019] When the control valve 33 opens the gas supply passage, the refrigerant flows from the discharge chamber 8 into the crank chamber 5 through the gas supply passage, so that the crank chamber pressure Pc increases. With this, the pressure balance between the crank chamber pressure Pc and the suction chamber pressure Ps decreases the inclination angle of the swash plate 24. As a result, piston strokes become smaller so as to decrease the discharging amount. On the other hand, when the control valve 33 closes the gas supply passage, the refrigerant is gradually extracted from the crank chamber 5 to the suction chamber 7 through the gas extraction passage, so that the crank chamber pressure Pc reduces. With this, the pressure balance between the crank chamber pressure Pc and the suction chamber pressure Ps increases the inclination angle of the swash plate 24. As a result, the piston strokes become longer so as to increase the discharging mount. In other words, the inclination angle of the swash plate 24 reduces when the hub 25 moves toward the cylinder block 2 and the inclination angle of the swash plate 24 increases when the hub 25 moves away from the cylinder block 2.

Linkage Mechanism

[0020] A linkage mechanism 40 will be explained with reference to Figs. 3 to 7.

[0021] As shown in Figs. 3 to 6, the linkage mechanism 40 includes an arm 41 extending from the rotor 21 toward the hub 25 and an arm 43 extending from the hub 25 toward the rotor 21. The arm 41 of the rotor and the arm 43 of the hub are overlapped in the rotary torque transfer direction Ft (that is, the rotating direction of the drive shaft 10). With this structure, the rotary torque of the rotor 21 is transferred to the swash plate 24. In this example, as shown in Figs. 3 and 4, the arm 43 is formed in a bifurcated shape having a slit S extending in the axial direction XY (orthogonally to the rotary torque transfer direction Ft) and the arm 41 is slidably fit in the slit S in a sandwiched manner.

[0022] When the swash plate 24 rotates, the pistons 29 reciprocate so that compression reaction force (axial direction load Fp) from the pistons is applied to the swash plate 24. The arm 43 of the swash plate 24 is formed with press-insertion holes 43s (see Fig. 7) that a pin 151 is pressed into and fixed in. An axial direction load receiving face 53 is formed on an end of the arm 41 of the rotor 21. The compression reaction force Fp is received at a contact between the pin 151 and the an axial direction load receiving face 53.

[0023] The pin 151 extends in a tangential direction of rotary orbits of the rotating member 21 and the swash plate 24, in other words, extends toward the rotary torque transfer direction Ft. Since a large compression reaction force (axial direction load Fp) is applied to the contact between the pin 151 and the axial direction pressure receiving face 53 of the rotor 21, the hardness of the pin 151 and the axial direction pressure receiving face 53 of the rotor 21 is enhanced by a quenching process or the like.

Effects

[0024] With the above described structure, the present embodiment brings about the following effects.

[0025] Firstly, according to the present embodiment, the linkage mechanism 40 includes an arm 41 extending from a rotor 21, an arm 43 extending from a swash plate 24 and receiving rotary torque from the arm 41 of the rotor, a pin 151 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 this embodiment), and an axial direction load receiving face 53 formed on the other of the arm 41 of the rotor and the arm 43 of the swash plate (the arm 41 of the rotor, in this embodiment) and configured to contact with the pin 151 to receive compression reaction force Fp (axial direction load) from the pistons 29.

[0026] Accordingly, the inclination angle of the swash plate 24 is changed in the condition that great axial direction load Fp (compression reaction force from the pistons) is applied between the pin 151 and the axial direction load receiving face 53. However, since the pin 151 is a member formed separately from the arm (the arm 43 of the swash plate, in this embodiment), only the pin 151 can be quenched, etc. in a hardness enhancement process so that the arm (the arm 43 of the swash plate, in this embodiment) is not needed to be quenched. As a result, manufacturing cost can be reduced.

[0027] Further, since the pin 151 is separated form the arm (the arm 43 of the swash plate, in this embodiment), it is relatively easy to form the outer surface of the pin 151 to be complicated. With such a case, the manufacturing cost can be reduced comparing to the case forming the arm (the arm 43 of the swash plate, in this embodiment) to be a complicated shape.

[0028] Further, only the pin 151 can be exchanged.

[0029] Secondly, the linkage mechanism has a structure in which one of the arms 41, 43 (the arm 43 of the swash plate, in this embodiment) is formed in a bifurcated shape having a slit S and the other of the arms (the arm 41 of the rotor, in this embodiment) is slidably fit in the slit S in a sandwiched manner. This structure is preferable since backlash is hardly provided between the both arms 41, 43.

[0030] As described above, according to the present invention, the linkage mechanism includes the arm extending form the rotating member, the arm extending from the tilting member and overlapped with the arm of the rotating member, the pin fixed to one of the arm of the rotating member and the arm of the tilting member, the axial direction load receiving face formed on the other of the arm of the rotating member and the arm of the tilting member arm and configured to contact with the pin to receive axial direction load between the rotating member and the tilting member. In this structure, the inclination angle of the tilting member is changed in a state that great axial direction load (compression reaction force from the pistons) is applied between the pin and the axial direction load receiving face. However, since the pin and the arm are individual members, only the pin can be quenched, etc. in a hardness enhancement process and the arm is not required to be quenched. As a result, the manufacturing cost can be reduced.

[0031] It is noted that the present invention should not be limited to the above described embodiment.

[0032] For example, according to the above embodiment, the pin 51 is fixed to the arm 43 of the swash plate and the axial direction load receiving face 53 is formed on the arm 41 of the rotor. However, in the present invention, as shown in the first modification in Fig. 8 and the second modification in Fig. 9, the axial direction load receiving face 53 may be formed on the arm 43 of the swash plate and the pin 151 may be fixed to the arm 41 of the rotor.

[0033] According to the above embodiment, a slit S is provided to the arm 43 of the swash plate and the arm 41 of the rotor is slidably held in the slit S. However, in the present invention, as shown in the second modification in Fig. 9 and the third modification in Fig. 10, the slit S may be provided to the arm 41 of the rotor and the arm 43 of the swash plate may be slidably fit in the slit S.

[0034] According to the above embodiment, the cross-section of the pin is a circular shape; however, in the present invention, it may be formed in other shapes.

[0035] Further, according to the above embodiment, the swash plate 24 is made in combination of the swash plate body 26 and the hub 25 which are separately formed; however, in the present invention, the swash plate body and the hub may be formed integrally in advance to constitute the swash plate. Further, the above embodiment employs a sleeveless structure in which the swash plate 24 is directly attached to the drive shaft 10 without any sleeve; however, in the present invention, the swash plate may be attached to the drive shaft via a sleeve.

INDUSTRIAL APPLICABILITY

[0036] The present invention may be applied to not only a swash plate type variable displacement compressor but also a wobble plate type variable displacement compressor and the present invention may be implemented with various modifications.

Claims

1. A variable displacement compressor, comprising:

a drive shaft;
a rotating member fixed to the drive shaft and rotating integrally with the drive shaft;
a tilting member attached to the drive shaft and being changeable a tilt thereof with respect to an axis of the drive shaft;
a linkage mechanism configured to rotate the rotating member and the tilting member integrally with allowing the tilt of the tilting member to change; and
a piston reciprocating in a cylinder bore corresponding to rotary movement of the tilting member; wherein
the linkage mechanism includes:

an arm extending from the rotating member;
an arm extending from the tilting member and overlapping with the arm of the rotating member in a rotating direction;
a pin fixed to one of the arm of the rotating member and the arm of the tilting member; and
an axial direction load receiving face formed on the other of the arm of the rotating member and the arm of the tilting member and configured to contact with the pin to receive an axial direction load applied between the rotating member and the tilting member.

2. The variable displacement compressor according to claim 1, wherein the arm of the rotating member is formed in a bifurcated shape divided by a slit to slidably hold the arm of the tilting member in a sandwiching manner.

3. The variable displacement compressor according to claim 1, wherein the arm of the tilting member is formed in a bifurcated shape divided by a slit to slidably hold the arm of the rotating member in a sandwiching manner.

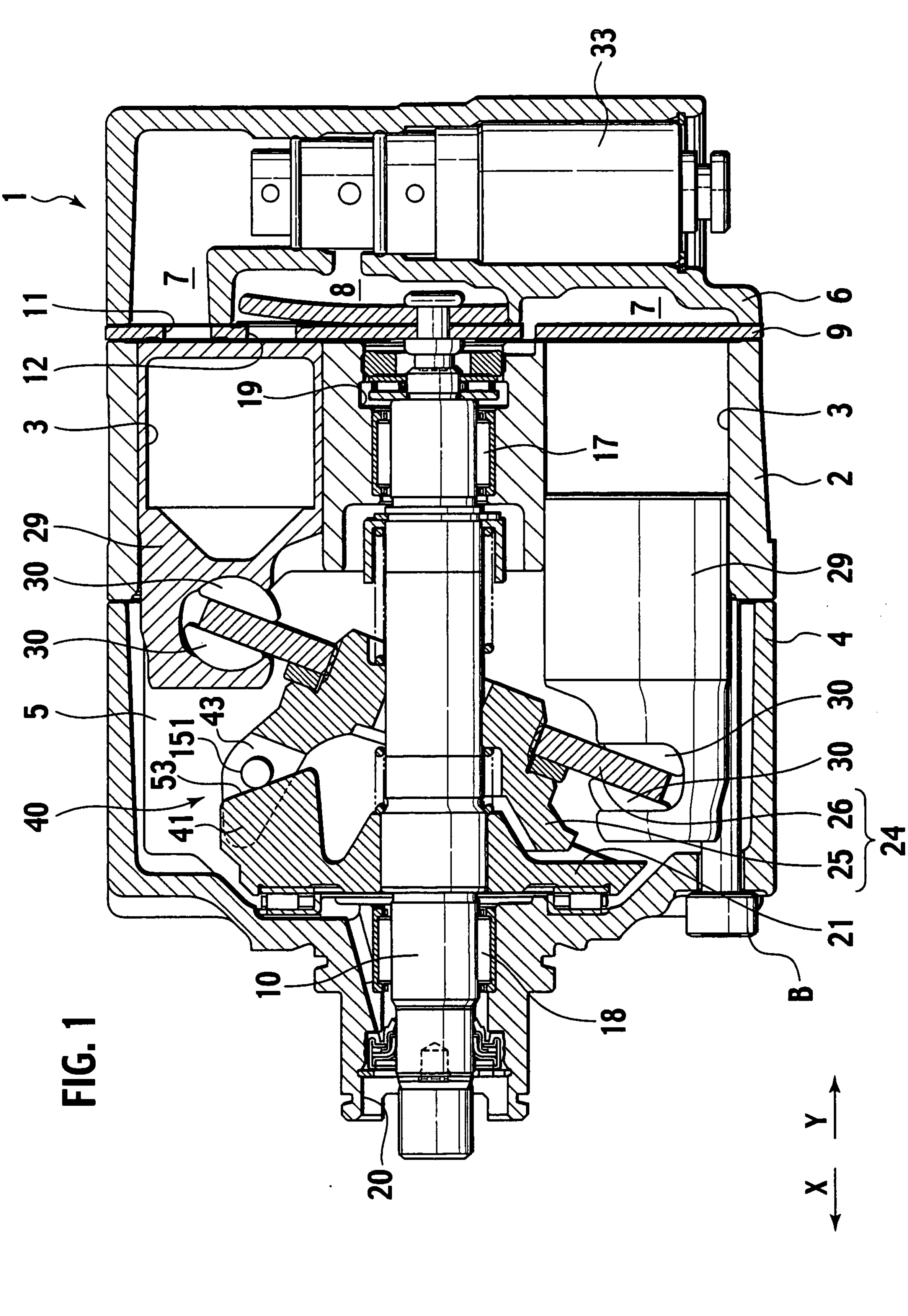
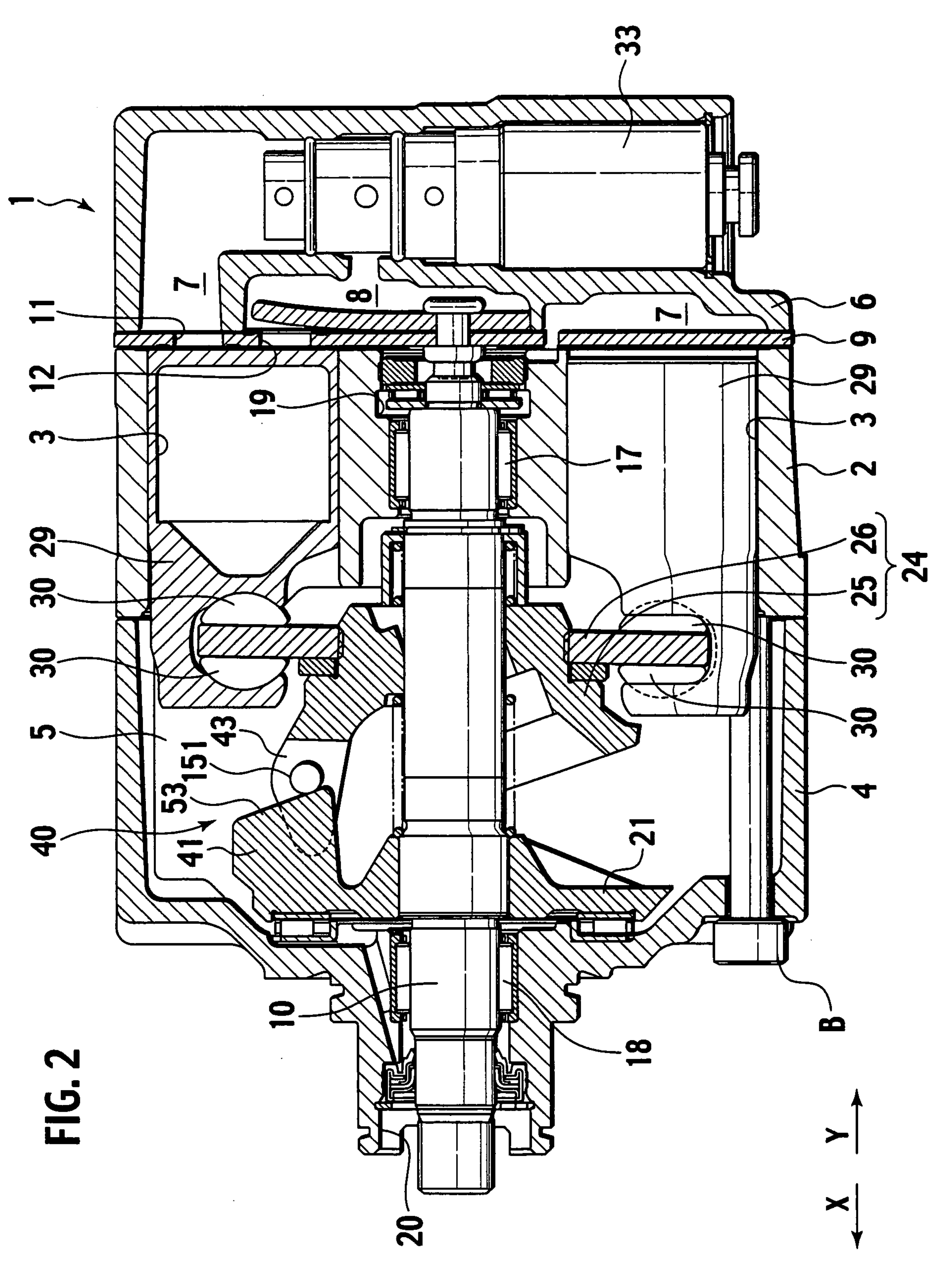

1
33
7
8
11
12
3
19
29
30
5
43
151
53
40
41
10
20
6
9
17
2
4
26
25
24
21
B
18
X
Y

FIG. 1

FIG. 2


1
33
7
8
11
12
19
3
29
30
5
43
151
53
40
41
21
4
6
9
17
2
26
25
24
B
10
18
20
X
Y

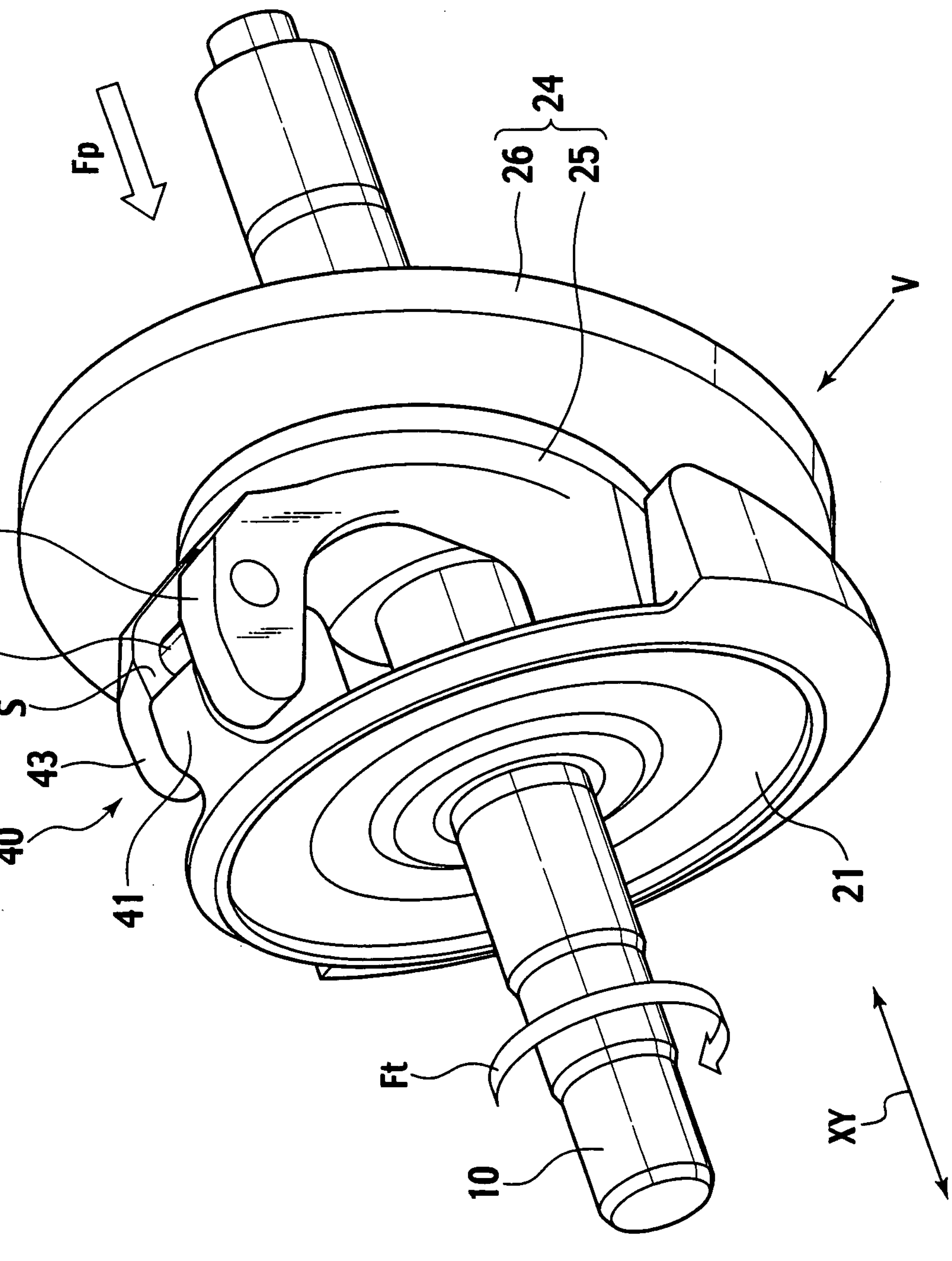
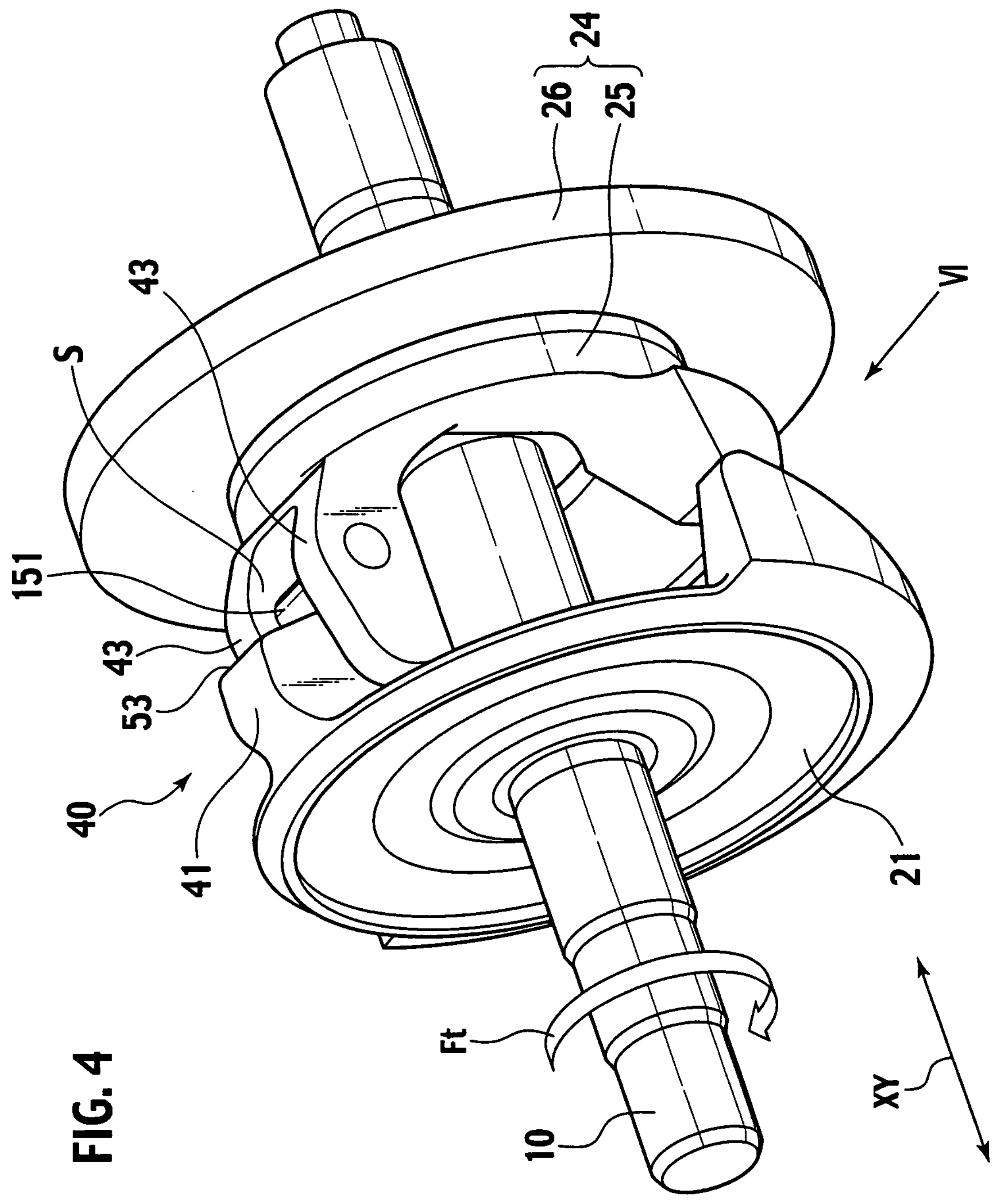


FIG. 3

FIG. 4



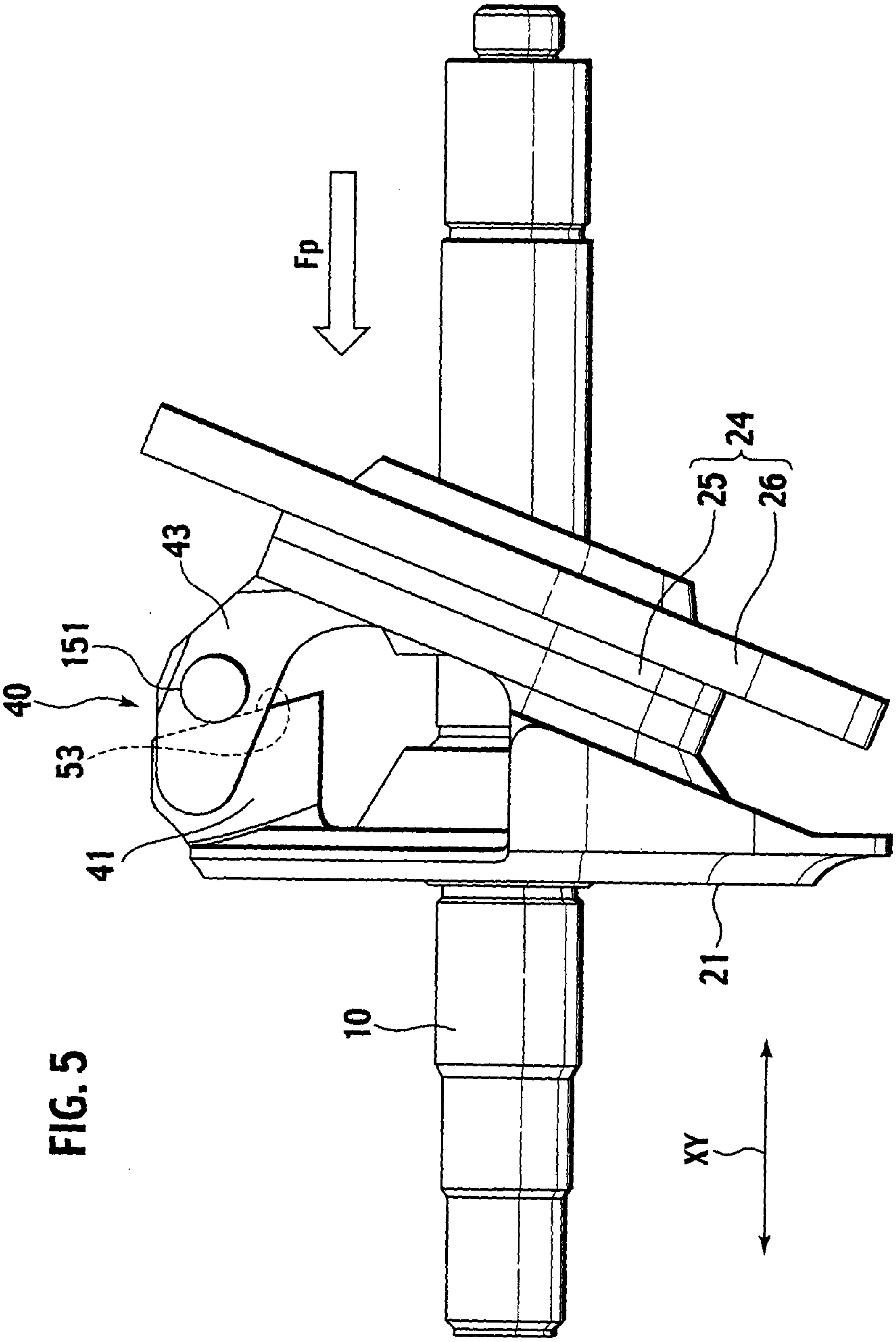


FIG. 5

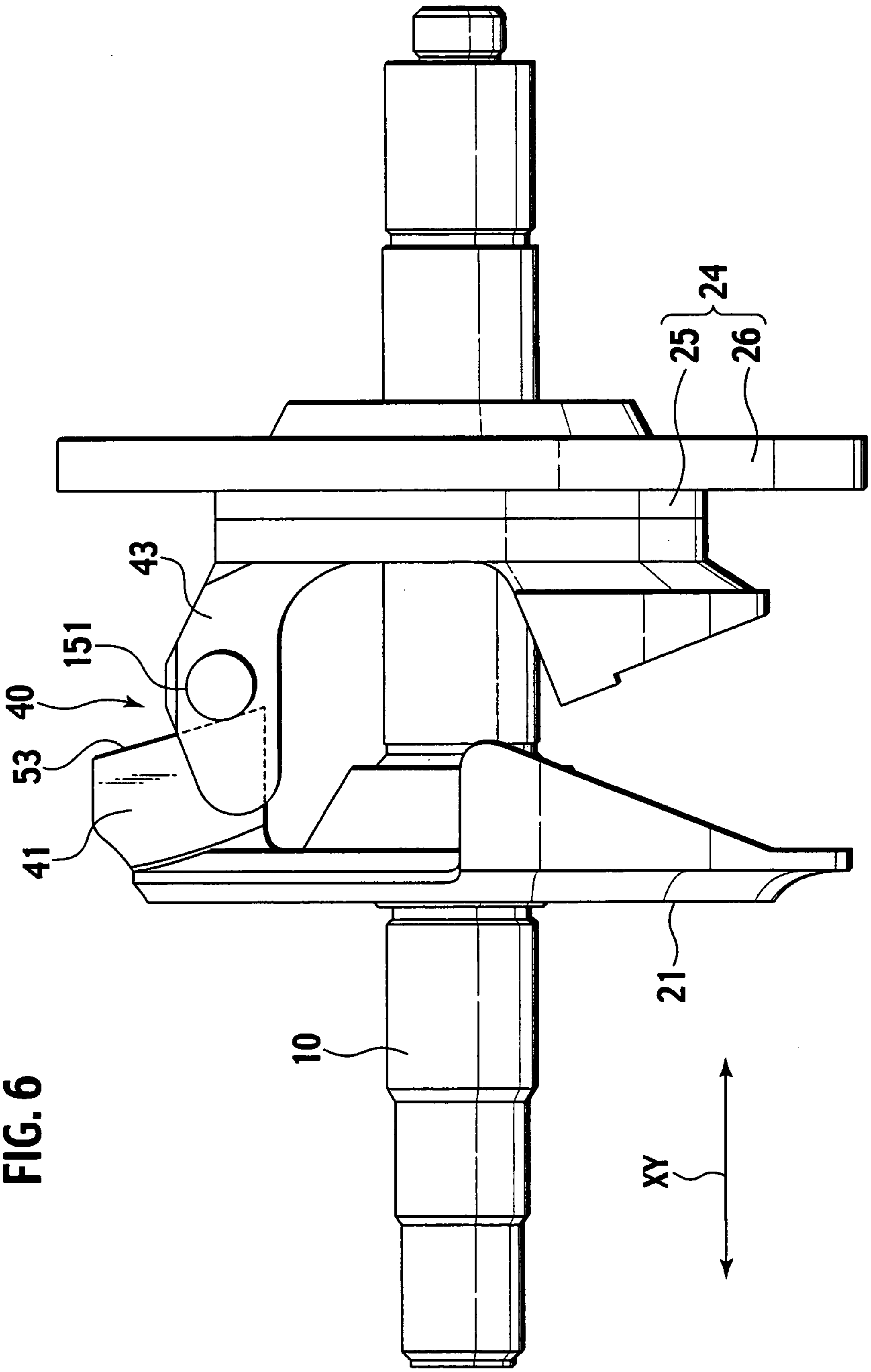
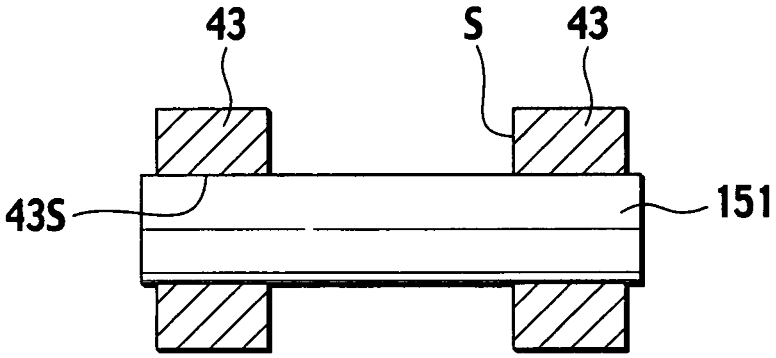


FIG. 6

FIG. 7



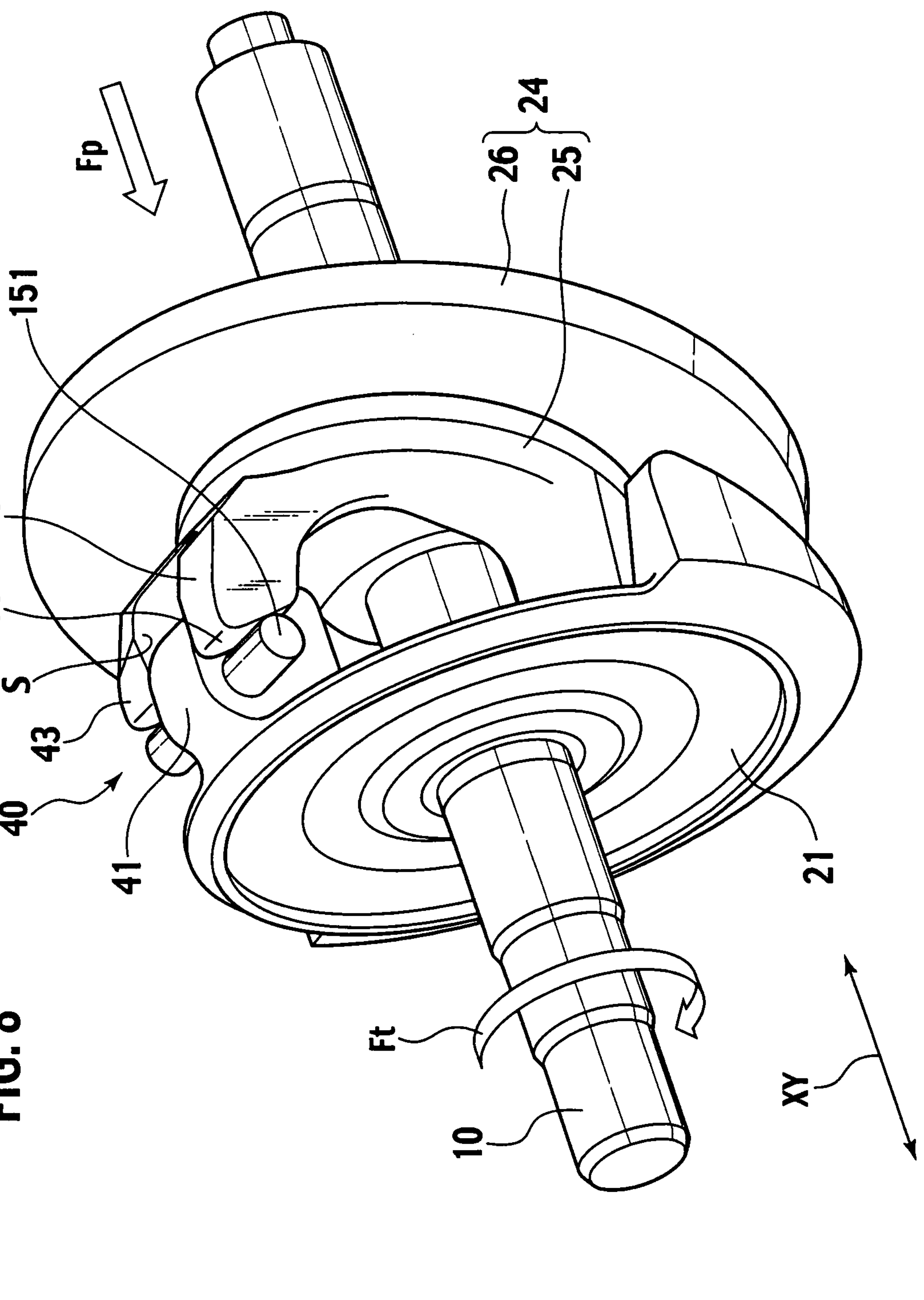


FIG. 8

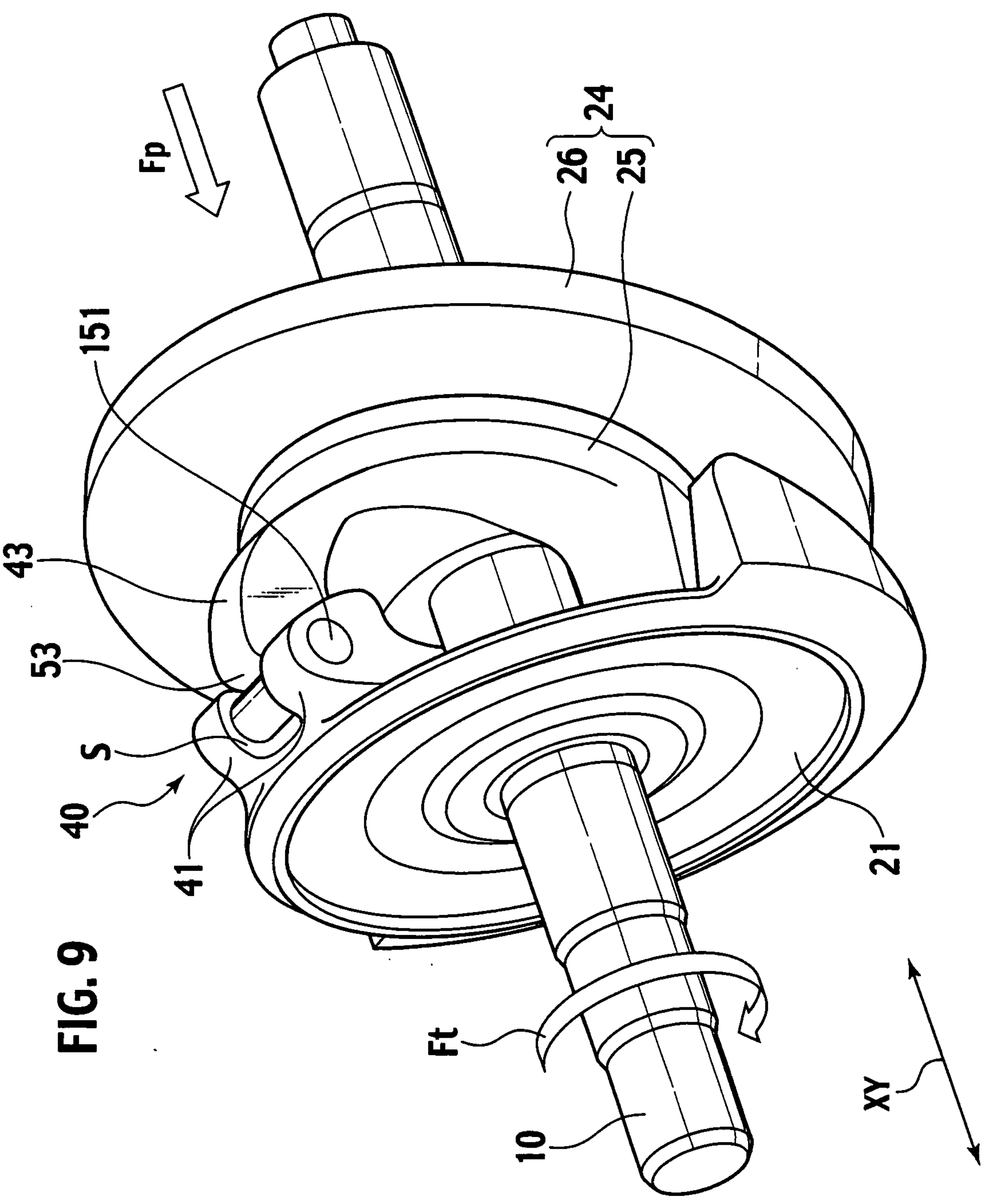


FIG. 9

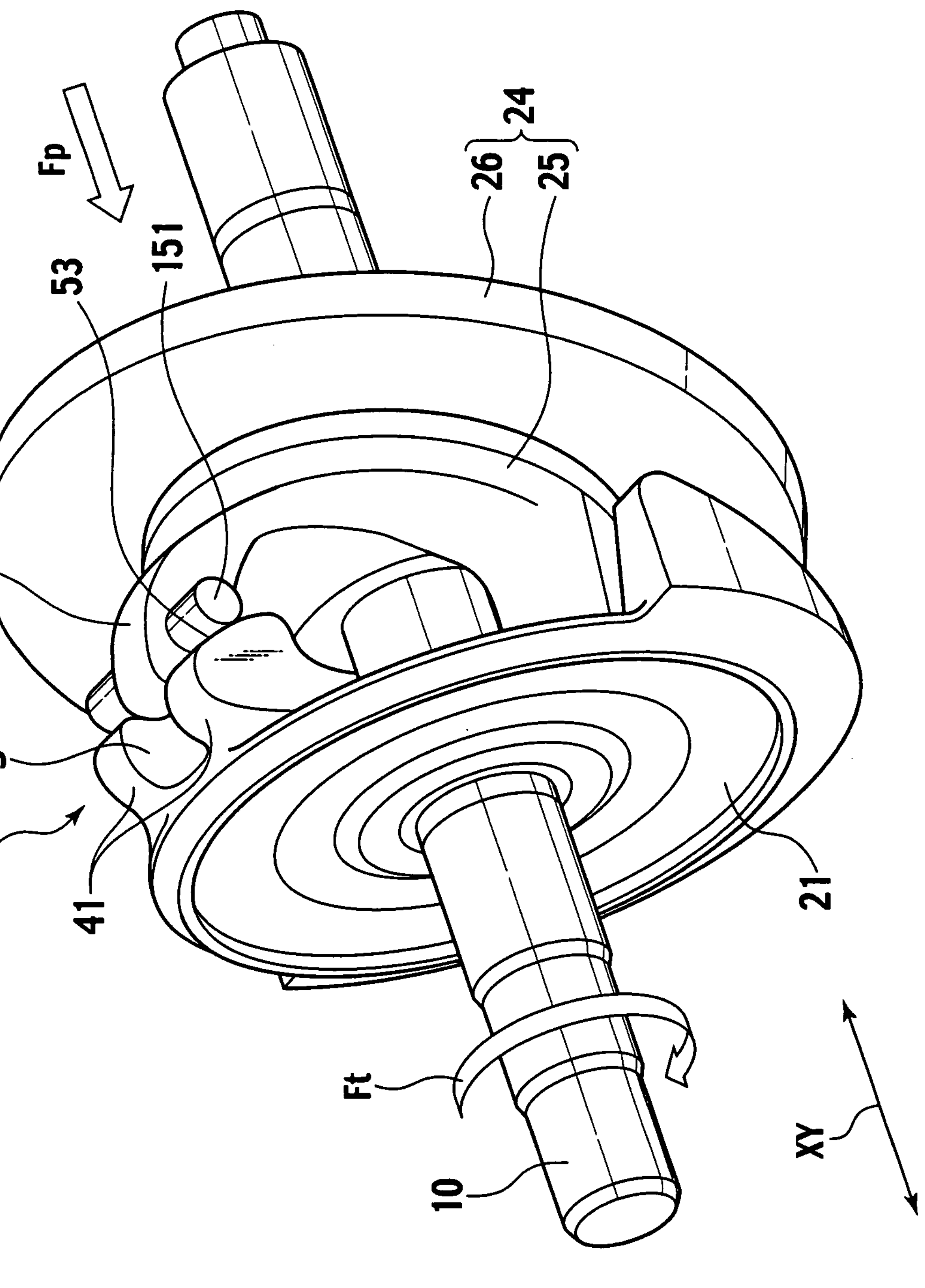


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/303044

A. CLASSIFICATION OF SUBJECT MATTER
F04B27/10(2006.01)

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)
F04B27/10

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 Y	JP 11-336657 A (Kabushiki Kaisha Nihon Jidosha Buhin Sogo Kenshusho), 07 December, 1999 (07.12.99), Par. Nos. [0010] to [0018]; Figs. 1 to 3, 6 to 7 (Family: none)	1,3 2
Y	JP 9-203377 A (Toyota Industries Corp.), 05 August, 1997 (05.08.97), Par. Nos. [0017] to [0027]; Figs. 1 to 4 & CN 1161413 A & CN 1177060 A & EP 775824 A1 & EP 775824 B1 & JP 3422186 B2 & KR 202791 B1 & US 5785503 A	2

☒ Further documents are listed in the continuation of Box C. ☐ 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
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 May, 2006 (08.05.06)	16 May, 2006 (16.05.06)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/303044

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2002-180952 A (Sanden Corp.), 26 June, 2002 (26.06.02), Par. Nos. [0010] to [0014]; Figs. 1 to 4 (Family: none)	1,3
X	JP 2001-304103 A (Kabushiki Kaisha Zekuseru Vareokuraimeto Kontororu), 31 October, 2001 (31.10.01), Par. Nos. [0014] to [0046]; Figs. 1 to 6 (Family: none)	1,3

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2004068756 A **[0002]**