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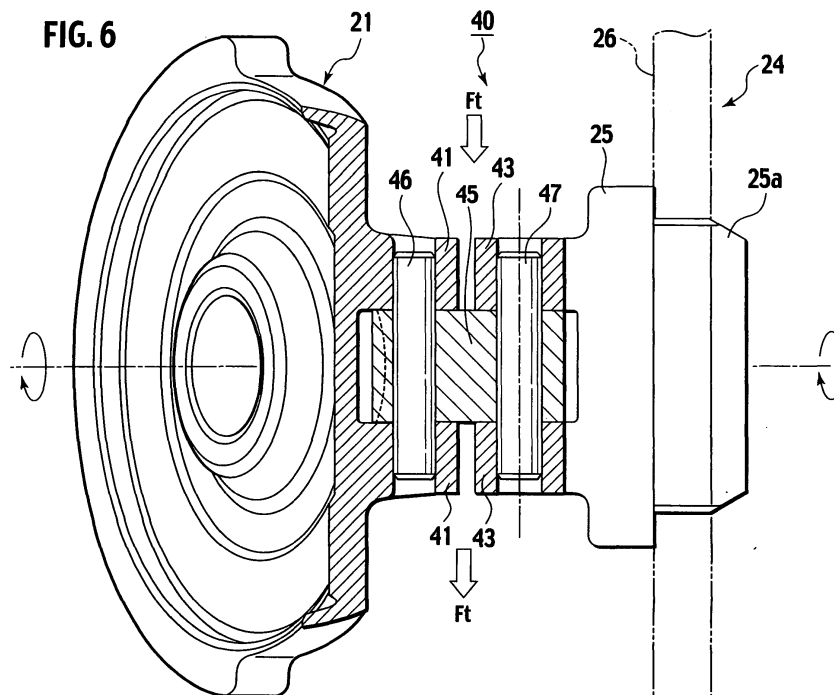
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(54) **LINK MECHANISM AND VARIABLE DISPLACEMENT COMPRESSOR**

(57) A linkage mechanism (40, 40B, 40C) includes a pair of arms (41, 41) extending from a rotating member (21) toward a tilting member (24), a pair of arms (43, 43) extending from the tilting member (25) toward the rotating member (21), and a link (45) inserted between the pair of arms (41, 41) of the rotating member and between the pair of arms (43, 43) of the tilting member.

extending from the tilting member (25) toward the rotating member (21), and a link (45) inserted between the pair of arms (41, 41) of the rotating member and between the pair of arms (43, 43) of the tilting member.



Description

TECHNICAL FIELD

[0001] The present invention relates to a linkage mechanism capable of relative rotating as transferring rotary torque and a variable displacement compressor using the linkage mechanism.

BACKGROUND ART

[0002] A variable displacement compressor includes a drive shaft, a rotor which is fixed to the drive shaft and rotates integrally with the drive shaft, and a swash plate which is attached to the drive shaft via a slidable hinge ball and is tiltable with respect to the drive shaft. Piston stroke is changed by changing the inclination angle of the swash plate so as to change the discharging amount. In order to change the inclination angle of the swash plate as transferring torque from the rotor to the swash plate, a linkage mechanism is provided between the rotor and the swash plate (see, for example, Japanese Patent Application Laid-Open Publications No. 2003-172417 and No. 10-176658).

[0003] A linkage mechanism described in the Publication No. 2003-172417 includes a pair of rotor arms which extend from a rotor toward a swash plate and face to each other, a single swash plate arm which extends from the swash plate toward the rotor, and a link whose first end is linked to the rotor arms by a first linking pin and second end is linked to the swash plate arm by a second linking pin.

[0004] The first end of the link is inserted between the pair of rotor arms of the rotor and linked to the rotor arms by the first linking pin. The second end of the link includes a pair of link arms facing each other, the swash plate arm is inserted between the link arms. In such a condition, the second end of the link is linked to the swash plate arm by a second linking pin. In other words, the swash plate arm is sandwiched by the pair of link arms provide at the second end of the link and the first end of the link is sandwiched by the pair of rotor arms. These five arms are stacked in the torque transfer direction.

[0005] According to a linkage mechanism described in Publication No. 10-176658, two separated link arms are used, substitute for the pair of link arms that are formed integrally.

DISCLOSURE OF THE INVENTION

[0006] An object of the present invention is to provide a linkage mechanism with improved durability and a variable displacement compressor using the linkage mechanism.

[0007] The first aspect of the present invention is a linkage mechanism including: a rotating member fixed to a drive shaft and rotating integrally with the drive shaft; a tilting member slidably attached to the drive shaft and

being tiltable with respect to the drive shaft; a pair of arms extending from the rotating member toward the tilting member and facing each other in a rotary torque transfer direction; a pair of arms extending from the tilting member toward the rotating member and facing each other in the rotary torque transfer direction; and a linkage member inserted between the pair of arms of the rotating member that face each other and between the pair of arms of the tilting member that face each other.

[0008] According to the structure, comparing to a conventional technique including five arms in the torque transfer direction, the first aspect of the present invention includes three arms (in the side of the rotating member, there are three arms including the pair of arms of the rotating member and the linkage member inserted therebetween) (in the side of the tilting member, there are three arms including the pair arms of the tilting member and the linkage member inserted therebetween). Accordingly, the torque durability of the linkage mechanism can be improved since each member is made thicker in the torque transfer direction without increasing the size of the linkage mechanism as a whole, comparing to conventional structures (see, for example, Japanese Patent Application Laid-Open Publications No. 2003-172417 and No. 10-176658).

[0009] If it is required to reduce the size of the linkage mechanism in the torque transfer direction according to layout restrictions due to a request for downsizing devices, the linkage mechanism can be significantly downsized as maintaining sufficient thickness of each member in torque transfer direction, comparing to conventional techniques.

[0010] As a preferable embodiment of the first aspect of the present invention, one end of the linkage member may be rotatably linked to the pair of arms of the rotating member by the first linking pin and the other end of the linkage member may be rotatably linked to the pair of arms of the tilting member by the second linking pin.

[0011] A distance between the pair of arms of the rotating member and a distance between the pair of arms of the tilting member may be formed in the same size.

[0012] According to this structure, the linkage member can be formed in a simple rectangular shape so that one end is inserted between the pair of arms of the rotating member and the other end is inserted between the pair of arms of tilting member. As a result, since complicated cutting works are not required in a manufacturing process of the linkage member, the manufacturing cost of the linkage member can be significantly reduced. For example, when the linkage member is made of aluminum, it can be made by extruding.

[0013] The first linking pin and the second linking pin may have the same diameter and length.

[0014] According to this structure, a pin can be used as the first linking pin and the second linking pin. Thus, the manufacturing cost of the linkage mechanism can be reduced. For example, since a manufacturing die can be used for both of the first linking pin and the second linking

pin, the number of necessary dies can be reduced. Further, there is an advantage such that load of workers can be reduced since they do not need to distinguish the storing locations of the first linking pin and the second linking pin in an assembling process of the linkage mechanism.

[0015] The second aspect of the present invention is a linkage mechanism including: a rotating member fixed to a drive shaft and rotating integrally with the drive shaft; a tilting member slidably attached to the drive shaft and being tiltable with respect to the drive shaft; an arm extending from the rotating member toward the tilting member; an arm extending from the tilting member toward the rotating member; and a linkage member provided between the arm of the rotating member and the arm of the tilting member. A slit is provided to one of the arm of the rotating member and one end of the linkage member, the other of the arm of the rotating member and the one end of the linkage member is inserted into the slit, the arm of the rotating member and the one end of the linkage member are rotatably connected each other by a first linking pin in a condition that the other is inserted into the one. A maximum inclination angle of the linkage member relative to the arm of the rotating member corresponds to a maximum inclination angle of the first linking pin in a bearing clearance between the first linking pin and a bearing hole for the first linking pin.

[0016] According this structure, when the linkage member tilts maximally relative to the arms of rotating member, the portion inserted in the slit contacts with only one of the opposite surfaces of the slit. Accordingly, unlike conventional structures, the portion inserted in the slit does not lockingly dig into the opposite surfaces of the slit at two points.

[0017] As a preferable embodiment of the first aspect of the present invention, the first linking pin may be fixed to a fixing hole provided to one of the arms of the rotating member and the linkage member and rotatably supported by the bearing hole provided to the other of the arms of the rotating member and the linkage member.

[0018] According to this structure, the design of the linkage mechanism becomes easy comparing to such a structure in which the first linking pin is rotatably supported by bearing holes provided to the arms of the rotating member and the linkage member respectively.

[0019] The third aspect of the present invention is a linkage mechanism including a rotating member fixed to a drive shaft and rotating integrally with the drive shaft; a tilting member slidably attached to the drive shaft and being tiltable with respect to the drive shaft; an arm extending from the rotating member toward the tilting member; an arm extending from the tilting member toward the rotating member; and a linkage member provided between the arm of the rotating member and the arm of the tilting member. A slit is provided to one of the arm of the tilting member and the other end of the linkage member, the other of the arm of the tilting member and the other end of the linkage member inserted into the slit, the arm of the tilting member and the other end of the linkage

member are rotatably connected each other by a second linking pin. A maximum inclination angle of the linkage member relative to the arm of the tilting member corresponds to a maximum inclination angle of the second linking pin in a bearing clearance between the second linking pin and a bearing hole for the second linking pin.

[0020] According this structure, when the linkage member tilts maximally relative to the arms of tilting member, the portion inserted in the slit contacts with only one of the opposite surfaces of the slit. Accordingly, unlike conventional structures, the portion inserted in the slit does not lockingly dig into the opposite surfaces of the slit at two points.

[0021] As a preferable embodiment of the present invention, the second linking pin may be fixed to a fixing hole provided one of the arms of the tilting member and the linkage member and supported by the bearing hole provided to the other of the arms of the tilting member and the linkage member.

[0022] According to this structure, the design of the linkage mechanism becomes easy comparing to such a structure in which the second linking pin is rotatably supported by bearing holes provided to the arms of the tilting member and the linkage member respectively.

[0023] As a preferable embodiment according to the second and third aspects of the present invention, the linking pin may include a reduced-diameter portion, at axial ends, where the diameter is reduced at a certain curvature, at a curvature that gradually increases, or a curvature that increases in stages.

[0024] According to this structure, a similar effect to crowned linking pins can be obtained. Namely, when the linking pins tilts maximally within bearing clearances in the bearing holes, the reduced-diameter portion provided at an axial end of the linking pin prevents point-contacts between the linking pins and the bearing holes.

[0025] Further, the bearing hole may include an expanded-diameter portion, at axial ends, where the diameter is enlarged at a certain curvature, at a curvature that gradually increases, or at a curvature that increases in stages.

[0026] According to this structure, a similar effect to crowned linking pins can be obtained. Namely, when the linking pins tilts maximally within bearing clearances in the bearing holes, the expanded-diameter portion provided at an axial end of the bearing hole prevents point-contacts between the linking pins and the bearing holes.

[0027] Further, the slit may be provided to the arm of the rotating member and an end of the linkage member is inserted into the slit, and the slit may be provided to the arm of the tilting member and the other end of the linkage member inserted into the slit.

[0028] In other words, the aspects of the present invention may have a pair of arms that extend from the rotating member toward the tilting member and face each other across the slit, a pair of arms that extend from the tilting member toward the rotating member and face each other across the slit, and a linkage member that is insert-

ed between the pair of arms of the rotating member and between the pair of arms of the tilting member.

[0029] Unlike a conventional technique including five arms in the torque transfer direction, the present invention includes three arms (in the side of the rotating member, there are three arms including the arms of the rotating member and the linkage member inserted therebetween) (in the side of the tilting member, there are three arms including the arms of the tilting member and the linkage member inserted therebetween). Accordingly, the torque durability of the linkage mechanism can be improved since the each member is made thicker in the torque transfer direction without increasing the size of the linkage mechanism as a whole, comparing to conventional structures. If it is required to reduce the size of the linkage mechanism in the torque transfer direction according to layout restrictions due to a request for downsizing devices, the linkage mechanism can be significantly downsized as maintaining sufficient thickness of each member in torque transfer direction, comparing to conventional techniques.

[0030] Further, a width of the slit (between the pair of arms) of the rotating member and a width of the slit (between the pair of arms) of the tilting member may be formed in same width.

[0031] According to this structure, since the width of the slit in the rotating member and the width of the slit in the tilting member are formed the same, the linkage member whose one end is inserted into the slit of the rotating member and whose other end is inserted into the slit of the tilting member can be formed in a simple rectangular shape. As a result, since complicated cutting works are not required in a manufacturing process of the linkage member, the manufacturing cost of the linkage member can be significantly reduced. For example, when the linkage member is made of aluminum, it can be made by extruding.

[0032] Further, the first linking pin and the second linking pin may have the same diameter and length.

[0033] According to this structure, since the first linking pin and the second linking pin have the same diameter and length, a pin can be used as the first linking pin and the second linking pin. Accordingly, the manufacturing cost of the linkage mechanism can be reduced. For example, since a die can be used for both of the first linking pin and the second linking pin, the number of necessary dies can be reduced. Further, there is an advantage such that load of workers can be reduced since they do not need to distinguish the storing locations of the first linking pin and the second linking pin in an assembling process of the linkage mechanism.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034]

Fig. 1 is a cross-sectional view showing a variable displacement compressor of a first embodiment;

Fig. 2 is an explanatory view of a full stroke condition of the variable displacement compressor;
 Fig. 3 is an explanatory view of a middle stroke condition of the variable displacement compressor;
 Fig. 4 is an explanatory view of a no-stroke condition of the variable displacement compressor;
 Fig. 5 is a perspective view showing a linkage mechanism of the variable displacement compressor;
 Fig. 6 is a side view showing the linkage mechanism of the variable displacement compressor having a cross-section taken along line VI-VI in Fig. 2;
 Fig. 7 is an enlarged sectional view showing the linkage mechanism;
 Fig. 8 is a side view showing a rotor;
 Fig. 9 is a vertical sectional view showing the rotor;
 Fig. 10(a) is a side view showing a linkage member and Fig. 10(b) is a cross-sectional view taken along line 10b-10b in Fig. 10(a);
 Fig. 11 is a side view showing a hub of a swash plate;
 Fig. 12 is a vertical sectional view showing the hub of the swash plate;
 Fig. 13 is an enlarged sectional view showing a modification of the linkage mechanism;
 Fig. 14 is an enlarged sectional view showing another modification of the linkage mechanism;
 Fig. 15 is a side view showing a linkage mechanism of a second embodiment;
 Fig. 16 is an enlarged sectional view showing the linkage mechanism;
 Fig. 17 is a cross-sectional view showing a first modification of the linkage mechanism according to the second embodiment;
 Fig. 18 is a side view showing a linking pin used in the linkage mechanism of Fig. 17;
 Fig. 19 is an enlarged view of the part X shown in Fig. 18;
 Fig. 20 is a cross-sectional view showing a second modification of the linkage mechanism according to the second embodiment;
 Fig. 21 is an enlarged sectional view showing the linkage mechanism of Fig. 20;
 Fig. 22 is a sectional view showing a linkage mechanism of the third embodiment;
 Fig. 23 is a sectional view showing a modification of the linkage mechanism according to the third embodiment;
 Fig. 24 is a sectional view of the linkage member shown in Fig. 23;
 Fig. 25 is a view showing a modification of the linkage mechanism according to the second embodiment and the third embodiment;
 Fig. 26 is a view showing a modification of the linkage mechanism of the second embodiment and the third embodiment;
 Fig. 27 is a view showing a modification of the linkage mechanism according to the second and third embodiments;
 Fig. 28 is a view showing a modification of the linkage

mechanism according to the second and third embodiments; and

Fig. 29 is a view showing an example of a conventional linkage mechanism.

DETAILED DESCRIPTION OF THE INVENTION

[0035] A variable displacement compressor and a linkage mechanism used in the variable displacement compressor of embodiments of the present invention will be described with reference to the accompanying drawings.

(First Embodiment)

General Structure of Variable Displacement Compressor

[0036] As shown in Fig. 1, a compressor 1 of the first embodiment is a swash plate type variable displacement compressor. The variable displacement compressor 1 includes a cylinder block 2 having a plurality of cylinder bores 3 placed evenly spaced apart in a circumferential direction, a front housing 4 attached to a front end of the cylinder block 2 and defining a crank chamber 5 with the cylinder block 2, and a rear housing 6 attached to a rear end of the cylinder block 2 via a valve plate 9 and having a suction chamber 7 and a discharge chamber 8 therein. The cylinder block 2, the front housing 4, and the rear housing 6 are fixedly connected to one another by a plurality of bolts B.

[0037] The valve plate 9 is formed with a suction port (not shown) that communicates with the cylinder bore 3 and the suction chamber 7, and a discharge port 12 that communicates with the cylinder bore 3 and the discharge chamber 8.

[0038] A valve system (not shown) adapted to open or close the suction port 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 or close the discharge port 12 is provided on the valve plate 9 at the rear housing side. A gasket is interposed between the valve plate 9 and the rear housing 6 for providing an airtight seal between the suction chamber 7 and the discharge chamber 8.

[0039] A drive shaft S is supported by bearings 17, 18 in support holes 19, 20 formed at the center portions of the cylinder block 2 and the front housing 4 so that the drive shaft S is rotatable in the crank chamber 5.

[0040] The crank chamber 5 accommodates, a rotor 21 as a "rotating member" fixed to the drive shaft S, a hinge ball 22 slidably attached to the drive shaft S, and a swash plate 24 as a "tilting member" tiltably attached to the hinge ball 22. The swash plate 24 includes a hub 25 tiltably and rotatably attached to the hinge ball 22 and a swash plate body 26 fixed to a boss segment 25a of the hub 25.

[0041] A piston 29 is slidably contained in each cylinder bore 3, and engaged with the swash plate body 26 of the swash plate 24 via a pair of hemispherical-shaped shoes

30, 30.

[0042] A linkage mechanism 40 is provided between the rotor 21 as a rotating member and the hub 25 of the swash plate 24 as a tilting member. The linkage mechanism 40 transfers rotary torque from the rotor 21 to the swash plate 24 as allowing the inclination angle of the swash plate 24 to change. The linkage mechanism 40 will hereinafter be described in detail.

[0043] The inclination angle of the swash plate 24 reduces when the hinge ball 22 moves toward the cylinder block 2. On the other hand, the inclination angle of the swash plate 24 increases when the hinge ball 22 moves away from the cylinder block 2.

[0044] When the drive shaft S rotates, the rotor 21 rotates integrally with the drive shaft S. The rotation of the rotor 21 is transferred to the swash plate 24 via the linkage mechanism 40. The rotation of the swash plate 24 is converted into a reciprocating movement of the pistons 29 via the pairs of piston shoes 30, 30 so that the pistons 29 reciprocate in the cylinder bores 3. By the reciprocating movements of the pistons 29, cooling medium is sucked in from the suction chamber 7 into the cylinder bores 3 through the suction ports 11 of the valve plate 9, and compressed in the cylinder bores 3, and discharged to the discharge chamber 8 through the discharge ports 12 of the valve plate 9.

Control of Variable Capacity

[0045] Changing the inclination angle of the swash plate 24 changes the piston stroke so as to change the amount of the discharge capacity. More particularly, changing pressure difference (pressure balancing) between the crank chamber pressure P_c in back of the piston 29 and the suction chamber pressure P_s in front of the piston 29 changes the inclination angle of the swash plate 24 to change the piston stroke. Thus, the variable displacement compressor includes a pressure control mechanism having 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. Here, Fig. 2 shows the inclination angle of the swash plate 24 in a full stroke mode, Fig. 3 shows the inclination angle of the swash plate 24 in a middle stroke mode, and Fig. 4 shows the inclination angle of the swash plate 24 in a destroke mode.

Linkage Mechanism

[0046] The linkage mechanism 40 will be described in detail. Fig. 5 is a perspective view showing a linkage mechanism 40, Fig. 6 is a side view showing the linkage mechanism 40 with a cross-section taken along line VI-VI in Fig. 2, and Fig. 7 is an enlarged sectional view show-

ing the linkage mechanism 40. Fig. 8 is a side view showing the rotor 21, Fig. 9 is a vertical sectional view showing the rotor 21, Figs. 10(a) and 10(b) are views showing the linkage member, Fig. 11 is a side view showing the hub 25 of the swash plate 24, and Fig. 12 is a vertical sectional view showing the hub 25 of the swash plate 24.

[0047] As shown in Figs. 5 and 6, the linkage mechanism 40 includes a pair of arms 41, 41 that extend from the rotor 21 toward the hub 25 and face each other in the rotary torque transfer direction, a pair of arms 43, 43 that extend from the hub 25 toward the rotor 21 and face each other in the rotary torque transfer direction, and a linkage member 45 that is inserted between the pair of opposite arms 41, 41 of the rotor 21 and between the pair of opposite arms 43, 43 of the hub 25.

[0048] A first end 45a of the linkage member 45 is pivoted to the pair of arms 41, 41 of the rotor 21 by a first linking pin 46 extending in the rotary torque direction. The second end 45b of the linkage member 45 is pivoted to the pair of arms 43, 43 of the hub 25 by a second linking pin 47 extending in the rotary torque direction.

[0049] As shown in Fig. 7, each of the arms 41, 41 of the rotor 21 is formed with a through hole 41a to which the first linking pin 46 is rotatably inserted. The first end 45a of the linkage member 45 is formed with a through hole 45c, coaxially with the through hole 41a, to which the first linking pin 46 is inserted with force. Each of the arms 43, 43 of the hub 25 is formed with a through hole 43a to which the second linking pin 47 is rotatably inserted. The second end 45b of the linkage member 45 is formed with a through hole 45d, coaxially with the through hole 43a, to which the first linking pin 46 is inserted with force. The first linking pin 46 and the second linking pin 47 have the same diameter and length.

[0050] The distance d1 between the pair of arms 41, 41 of the rotor 21 (that is, distance d1 between inner surfaces 41d, 41d of the arms 41, 41) and the distance d2 between the pair of arms 43, 43 of the hub 25 (that is, distance d2 between inner surfaces 43d, 43d of the arms 43, 43) are formed the same. The width d0 of the linkage member 45 (that is, distance d0 between outer surfaces 45e, 45e of the linkage member) is formed the same as the distance d1 between the arms 41, 41 of the rotor 21 and the distance d2 between the arms 43, 43 of the hub 25. Both of the outer faces 45e, 45e of the linkage member 45 are formed flat without any unevenness.

[0051] With the above described structure, the present embodiment brings about the following effects.

[0052] Firstly, the structure of the present embodiment includes a pair of arms 41, 41 that extend from a rotor 21 as a "rotating member" toward a hub 25 of a swash plate 24 as a "tilting member" and face each other in the rotary torque transfer direction, a pair of arms 43, 43 that extend from the hub 25 toward the rotor 21 and face each other in the rotary torque transfer direction, and a linkage member 45 that is inserted between the pair of facing arms 41, 41 of the rotor 21 and between the pair of facing arms 43, 43 of the hub 25. Comparing to conventional

structures (see, for example, Japanese Patent Application Laid-Open Publications No. 2003-172417 and No. 10-176658) including five arms in the torque transfer direction, the present embodiment includes three arms (in the side of the rotor 21, there are three arms including the pair of arms 41, 41 of the rotor 21 and the linkage member 45 inserted therebetween) (in the side of hub 25, there are three arms including the pair of arms 43, 43 of the hub 25 and the linkage member 45 inserted therebetween).

[0053] With this structure, the torque durability of the linkage mechanism 40 can be improved since each of the members 41, 43, 45 is made thicker in the torque transfer direction than the conventional structures without increasing the size of the linkage mechanism 40 as a whole. When layout restrictions corresponding to a downsizing request require to reduce the size of the linkage mechanism 40 in the torque transfer direction, the linkage mechanism 40 can be significantly downsized as maintaining sufficient thickness of each member 41, 43, 45 in torque transfer direction, comparing to the conventional structures.

[0054] Secondly, since the width d1 between the pair of arms 41, 41 of the rotor 21 and the width d2 between the pair of arms 43, 43 of the hub 25 are formed the same, the linkage member 45 whose first end 45a is inserted between the pair of arms 41, 41 of the rotor 21 and second end 45b is inserted between the pair of arms 43, 43 of the hub 25 can be formed in a simple rectangular shape. As a result, complicated cutting works are not required when manufacturing the linkage member 45. The manufacturing cost of the linkage member 45 can be significantly reduced. For example, when the linkage member is made of aluminum, it can be made by extruding.

[0055] Thirdly, the first linking pin 46 and the second linking pin 47 have the same diameter and length, so that a pin can be used as the first linking pin 46 and the second linking pin 47. Accordingly, the manufacturing cost of the linkage mechanism 40 can be reduced. For example, a manufacturing die can be used for both of the first linking pin 46 and the second linking pin 47, so that the number of necessary dies can be reduced. Further, workers do not need to distinguish the first linking pin 46 and the second linking pin 47 to store on a working bench in an assembling process of the linkage mechanism 40, so that work load can be reduced.

[0056] According to the first embodiment, the width d1 between the arms 41, 41 of the rotor 21 and the width d2 between the arms 43, 43 of the hub 25 are formed to be the same width and the linkage member 45 is formed in a rectangular shape; however, in the present invention, the width d1 between the arms of the rotor 21 and the width d2 between the arms of the hub may be formed different and the linkage member 45B, 45C may be formed with steps, as shown in Figs. 13 and 14. Hereinafter other linkage mechanisms 40B, 40C shown in Figs. 13 and 14 will be explained, elements which are same as or similar to those of the first embodiment are repre-

sented by same reference numbers and the explanations of those elements are omitted here.

[0057] According to the linkage mechanism 40B shown in Fig. 13, the width d2 between a pair of arms 43B, 43B of a hub 25 is formed larger than the width d1 between a pair of arms 41B, 41B of a rotor 21. Further, the width ($\cong$ d1) of a portion 45a which is to be inserted between the arms 41B, 41B of the rotor 21 is smaller than the width ($\cong$ d2) of a portion 45b which is to be inserted between the arms 43B, 43B of the hub 25. Accordingly, the linkage member 45B is formed with steps. Further, the length of the second linking pin 47B is made longer than the length of the first linking pin 46B.

[0058] Similar to the linkage mechanism 40 of the first embodiment, the linkage mechanism 40B shown in Fig. 13 includes a pair of arms 41B, 41B that extend from a rotor 21 as a "rotating member" toward a hub 25 of a swash plate 24 as a "tilting member" and face each other in the rotary torque transfer direction, a pair of arms 43B, 43B that extend from the hub 25 toward the rotor 21 and face each other in the rotary torque transfer direction, and a linkage member 45B that is inserted between the facing arms 41B, 41B of the rotor 21 and between the facing arms 43B, 43B of the hub 25. Unlike the conventional techniques (see, for example, Japanese Patent Application Laid-Open Publications No. 2003-172417 and No. 10-176658) including five arms in the torque transfer direction, the linkage mechanism 40B includes three arms (in the side of the rotor 21, there are three arms including the arms 41B, 41B of the rotor 21 and the linkage member 45B inserted therebetween) (in the side of hub 25, there are three arms including the arms 43B, 43B of the hub 25 and the linkage member 45B inserted therebetween).

[0059] With this structure, each of the members (41B, 43B, 45B) can be made thicker in the torque transfer direction than the conventional structures so that the torque durability of the linkage mechanism 40B can be improved without increasing the size of the linkage mechanism 40B.

[0060] If it is required to reduce the size of the linkage mechanism 40B in the torque transfer direction according to layout restrictions due to a downsizing request, the linkage mechanism 40B can be significantly downsized as maintaining sufficient thickness of each member (41B, 43B, 45B) in torque transfer direction, comparing to conventional structures.

[0061] According to the linkage mechanism 40C shown in Fig. 14, the width d2 between a pair of arms 43C, 43C of a hub 25 is made smaller than the width d1 between a pair of arms 41C, 41C of a rotor 21. Further, the width ($\cong$ d1) of a portion 45a which is to be inserted between the arms 41C, 41C of the rotor 21 is made larger than the width ($\cong$ d2) of a portion 45b which is to be inserted between the arms 43C, 43C of the hub 25. Accordingly, the linkage member 45C is formed with steps. The second linking pin 47B is made shorter in length than the first linking pin 46B.

[0062] Similar to the linkage mechanism 40 of the first embodiment, the linkage mechanism 40C shown in Fig. 14 also includes a pair of arms 41C, 41C that extend from a rotor 21 as a "rotating member" toward a hub 25 of a swash plate 24 as a "tilting member" and face each other in the rotary torque transfer direction, a pair of arms 43C, 43C that extend from the hub 25 toward the rotor 21 and face each other in the rotary torque transfer direction, and a linkage member 45C that is inserted between the facing arms 41C, 41C of the rotor 21 and between the facing arms 43C, 43C of the hub 25. Unlike the conventional structures (see, for example, Japanese Patent Application Laid-Open Publications No. 2003-172417 and No. 10-176658) including five arms in the torque transfer direction, the linkage mechanism 40C includes three arms (in the side of the rotor 21, there are three arms including the arms 41C, 41C of the rotor 21 and the linkage member 45C inserted therebetween) (in the side of hub 25, there are three arms including the arms 43C, 43C of the hub 25 and the linkage member 45C inserted therebetween).

[0063] With this structure, if the linkage mechanism 40C is made in the same size as the conventional linkage mechanism, each of the members (41C, 43C, 45C) is made thicker in the torque transfer direction than the conventional structures so that the torque durability of the linkage mechanism 40C is improved. When it is required to reduce the size of the linkage mechanism 40C in the torque transfer direction according to layout restrictions due to a downsizing request, the linkage mechanism 40C can be significantly downsized as maintaining sufficient thickness of each member (41C, 43C, 45C) in torque transfer direction, comparing to conventional structures.

[0064] As described above, according to the first embodiment, a linkage mechanism includes a pair of arms that extend from a rotating member toward a tilting member and face each other in the rotary torque transfer direction, a pair of arms that extend from the tilting member toward the rotating member and face each other in the rotary torque transfer direction, and a linkage member that is inserted between the facing arms of the rotating member and between the facing arms of the tilting member. Unlike the conventional techniques (see, for example, Japanese Patent Application Laid-Open Publications No. 2003-172417 and No. 10-176658) including five arms in the torque transfer direction, the first embodiment includes three arms (in the side of the rotating member, there are three arms including the arms of the rotating member and the linkage member inserted therebetween) (in the side of the tilting member, there are three arms including the arms of the tilting member and the linkage member inserted therebetween). With this structure, the torque durability of the linkage mechanism can be improved because each member can be made thicker in the torque transfer direction without increasing the size of the linkage mechanism as a whole, than the conventional structures (see, for example, Japanese Patent Application Laid-Open Publications No. 2003-172417 and

No. 10-176658).

(Second Embodiment)

[0065] A linkage mechanism 40F of the second embodiment will be described in detail. Fig. 15 is a side view showing the linkage mechanism 40F of the second embodiment and Fig. 16 is an enlarged sectional view showing the linkage mechanism 40F.

[0066] As shown in Fig. 15, the linkage mechanism 40F includes a pair of arms 41, 41 that extend from a rotor 21 toward a swash plate 24 and face each other in the rotary torque transfer direction across a slit 41s, a pair of arms 43, 43 that extend from the swash plate 24 toward the rotor 21 and face each other in the rotary torque transfer direction across a slit 43s, and a linkage member 45 that is inserted into the slit 41s of the rotor 21 (that is, between the arms 41, 41) and into the slit 43s of the swash plate 24 (that is, between the arms 43, 43).

[0067] A first end 45a of the linkage member 45 is pivotally connected to the arms 41, 41 of the rotor 21 by a first linking pin 46 which extends in the rotary torque direction, and a second end 45b of the linkage member 45 is pivotally connected to the arms 43, 43 of the swash plate 24 by a second linking pin 47 which extends in the rotary torque direction.

[0068] As shown in Figs. 15 and 16, the pair of arms 41, 41 of the rotor 21 have bearing holes 41a for rotatably supporting the first linking pin 46 and the first end 45a of the linkage member 45 has a fixing hole 45c to which the first linking pin 46 is inserted with force. The pair of arms 43, 43 of the swash plate 24 have bearing holes 43a for rotatably supporting the second linking pin 47 and the second end 45b of the linkage member 45 has a fixing hole 45d to which the second linking pin 47 is inserted with force. The first linking pin 46 and the second linking pin 47 have same diameter and length.

[0069] The width d1 of the slit 41s of the rotor 21 (that is, the width between inner surfaces 41d, 41d of the arms 41, 41 of the rotor 21) and the width d2 of the slit 43s of the swash plate 24 (that is, the width between inner surfaces 43d, 43d of the arms 43, 43 of the swash plate 24) are formed in the same width. The linkage member 45 is formed in a rectangular shape and its outer surfaces 45e, 45e are formed flat without any unevenness. The width d0 of the linkage member 45 (that is, the width between the outer surfaces 45e, 45e of the linkage member 45) is set smaller than the width d1 of the slit 41s of the rotor 21 and the width d2 of the slit 43 of the swash plate 24.

[0070] According to the second embodiment, as shown in Fig. 16, a clearance $\Delta d (=d1-d0)$ between the slit 41s of the rotor 21 and the linkage member 45 is set larger than a predetermined value. With this structure, a maximum inclination angle of the linkage member 45 relative to the arms 41, 41 of the rotor equals to a maximum inclination angle of the first linking pin permissible in the bearing clearance $\Delta d1 (=d21-d11)$ between the first link-

ing pin 46 and the bearing holes 41a, 41a. In other words, as shown in Fig. 16, when the linkage member 45 tilts maximally relative to the arms 41, 41 of the rotor 21 within a permissible range in the clearance $\Delta d1 (=d21-d11)$ between the first linking pin 46 and the bearing holes 41a, 41a, the linkage member 45 does not contact with both of the facing surfaces 41d, 41d of the slit 41s but contacts at only a point C1 shown in Fig. 16.

[0071] According to the second embodiment, the clearance $\Delta d (=d2-d0)$ between the slit 43s of the swash plate 24 and the linkage member 45 is set larger than a predetermined value. Accordingly, the maximum inclination angle of the linkage member 45 relative to the arms 43 of the swash plate equals to a maximum inclination angle of the second linking pin 47 permissible in a bearing clearance $\Delta d2 (=d22-d12)$ between the second linking pin 47 and the bearing holes 43a, 43a. In other words, as shown in Fig. 16, even when the linkage member 45 tilts maximally toward the arms 43, 43 of the swash plate within a permissible range in the clearance $\Delta d2 (=d22-d12)$ between the second linking pin 47 and the bearing holes 43a, 43a, the linkage member 45 does not contact with both of the facing surfaces 43d, 43d of the slit 43s but contacts at only a point (that is, the point C2 shown in Fig. 16).

[0072] With the above described structure, the second embodiment brings about the following effects.

[0073] (1) According to the second embodiment, a slit 41s for receiving one of arms 41 of a rotating member 21 and a first end 45a of a linkage member 45 (arms 41 of a rotating member, in this embodiment) is provided to the other of the arms 41 of the rotating member 21 and the first end 45a of the linkage member 45 (the first end 45a of the linkage member 45, in this embodiment) and they are pivotally connected each other by a first linking pin 46 in a state that the other of them is inserted into the one of them. A maximum inclination angle of the linkage member 45 relative to the arms 41 of the rotating member equals to a maximum inclination angle of the first linking pin 46 permissible in a bearing clearance $\Delta d1 (=d21-d11)$ between the first linking pin 46 and its bearing holes 41a, 41a. In other words, when the linkage member 45 tilts maximally relative to the arms 41 of rotating member within a permissible range in the clearance $\Delta d1 (=d21-d11)$ between the first linking pin 46 and the bearing holes 41a, 41a, the portion of the linkage member 45 inserted in the slit 41s (the first end 45a of the linkage member 45, in this embodiment) does not contact with both of the opposite surfaces 41d, 41d of the slit 41s simultaneously but contacts with only one 41d of the opposite surfaces 41d, 41d. Namely, unlike the conventional structures, the linkage member 45 does not lockingly dig into at two points.

[0074] (2) According to the second embodiment, a slit 43s for receiving one of arms 43 of a tilting member 25 and a second end 45b of the linkage member 45 (arms 43 of a tilting member, in this embodiment) is provided to the other of the arms 43 of the tilting member 25 and

the second end 45b of the linkage member 45 (the second end 45b of the linkage member 45, in this embodiment) and they are pivotably connected each other by a second linking pin 47 in a state that the other 45 of them is inserted into the one 43 of them. A maximum inclination angle of the linkage member 45 relative to the arms 43 of the tilting member equals to a maximum inclination angle of the second linking pin 47 permissible in a bearing clearance $\Delta d2 (=d22-d12)$ between the second linking pin 47 and the bearing holes 43a, 43a. In other words, when the linkage member 45 tilts maximally relative to the arms 43 of tilting member within a permissible range in the clearance $\Delta d2 (=d22-d12)$ between the second linking pin 47 and the bearing holes 43a, 43a, the portion of the linkage member 45 inserted in the slit 43s (the second end 45b of the linkage member 45, in this embodiment) does not contact with both of the opposite surfaces 43d, 43d of the slit 43s simultaneously but contacts with only one 43d of the opposite surfaces 43d, 43d. Namely, unlike the conventional structures, the linkage member 45 does not lockingly dig into at two points.

[0075] (3)According to the second embodiment, the first linking pin 46 is fixed to a fixing hole 45c formed in one of the arms 41 of the rotating member and the linkage member 45 (linkage member 45, in this embodiment) and supported by a bearing holes 41a, 41a formed in the other of the arms 41 of the rotating member and the linkage member 45 (the arms 41 of the rotating member, in this embodiment). Thus, unlike cases that the bearing holes are provided to the arms of the rotating member and the linkage member, one of the holes is made as a fixing hole 45c so that the design of the linkage mechanism becomes easier.

[0076] (4)According to the second embodiment, the second linking pin 47 is fixed to a fixing hole 45d formed in one of the arms 43 of the tilting member and the linkage member 45 (linkage member 45, in this embodiment) and rotatably supported by bearing holes 43a, 43a formed in the other of the arms 43 of the tilting member and the linkage member 45 (the arms 43 of the tilting member, in this embodiment). Thus, unlike cases that bearing holes are provided to the arms of the tilting member and the linkage member, one of the holes is made as a fixing hole 45d so that the design of the linkage mechanism becomes easier.

[0077] (5)According to the second embodiment, the first end 45a of the linkage member 45 is inserted into the slit 41s which is provided to the arms 41 of the rotating member, and the second end 45b of the linkage member 45 is inserted into the slit 43s which is provided to the arms 43 of the tilting member. In other words, the second embodiment has the pair of arms 43, 43 that extend from the rotating member 21 toward the tilting member 25 and face each other across the slit 41s, the pair of arms 43, 43 that extend from the tilting member 25 toward the rotating member 21 and face each other across the slit 43s, and a linkage member 45 that is inserted between the arms 41, 41 of the rotating member and between the

arms 43, 43 of the tilting member.

[0078] Therefore, unlike the conventional structures (see, for example, Japanese Patent Application Laid-Open Publications No. 2003-172417 and No. 10-176658) including five arms in the torque transfer direction, the present embodiment includes three arms (in the side of the rotating member, there are three arms including the arms 41, 41 of the rotating member and the linkage member 45 inserted therebetween) (in the side of the tilting member, there are three arms including the arms 43, 43 of the tilting member and the linkage member 45 inserted therebetween).

[0079] With this structure, even when each of the members (41, 43, 45) is made thicker in the torque transfer direction in order to improve the torque durability of the linkage mechanism 40F, the size of the linkage mechanism 40F as a whole is not enlarged. If it is required to reduce the size of the linkage mechanism 40F in the torque transfer direction according to layout restrictions, the linkage mechanism 40F can be significantly downsized as maintaining sufficient thickness of each member (41, 43, 45) in torque transfer direction, comparing to conventional structures.

[0080] (6)According to the second embodiment, the width d1 of the slit 41s of the arms 41, 41 of the rotating member and the width d2 of the slit 43s of the arms 43, 43 of the tilting member are formed in same width. Accordingly, the width d1 of the slit 41s of the arms 41, 41 of the rotating member and the width d2 of the slit 43s of the arms 43, 43 of the tilting member are formed in same width. Accordingly, the linkage member 45 can be made in a simple rectangular shape. As a result, complicated cutting works are not required when manufacturing the linkage member 45, so that the manufacturing cost of the linkage member 45 can be significantly reduced. For example, when the linkage member is made of aluminum, it can be made by extruding and the like.

[0081] (7)According to the second embodiment, the first linking pin 46 and the second linking pin 47 have the same diameter and length. Accordingly, a pin can be used as the first linking pin 46 and the second linking pin 47 and the manufacturing cost of the linkage mechanism 40F can be reduced. For example, since a manufacturing die can be used for both of the first linking pin 46 and the second linking pin 47, the number of necessary dies can be reduced. Further, workers do not need to distinguish the first linking pin 46 and the second linking pin 47 to sort on a working bench in an assembling process of the linkage mechanism 40F, so that work load can be reduced.

[0082] Next, modifications of the second embodiment will be explained.

First Modification of the Second Embodiment

[0083] Figs. 17 to 19 are views showing the first modification of the linkage mechanism according to the second embodiment.

[0084] A linkage mechanism 40G of the first modification includes reduced-diameter portions 60, at axial ends thereof, where the diameter is reduced at a certain curvature, at a curvature that gradually increases, or at a curvature that increases in stages. In other words, the linking pins 46, 47 are crowned. Here, reference "61" in Fig. 19 represents a linear portion located closer to the end than the curved reduced-diameter portion 60. According to this modification, when the linkage member 45 tilts such that the linking pins 46, 47 tilt maximally within the bearing clearance of bearing holes 41a, 41a, the contact area of the linking pins 46, 47 and the bearing holes 41a, 41a is increased at the edge portion so that they do not dig into each other. Here, the curvature radius is set according to the quality of material of the linking pins and arms or the pressure between the surfaces of the linking pins and the bearing holes. In this case, however, it is preferable that the curvature radius is larger than the axial length of the linking pins 46, 47.

Second Modification of the Second Embodiment

[0085] Figs. 20 and 21 are views showing the second modification of the linkage mechanism according to the second embodiment.

[0086] A linkage mechanism 40H of the second modification includes expanded-diameter portions 70, at the axial ends of the bearing holes 41a, 41a, and 43a, 43a. The diameters of the expanded-diameter portions 70 are expanded at certain curvature, at a curvature that gradually increases, or at a curvature that increases in stages. Accordingly, a similar effect to the crowned linking pins 46, 47 can be obtained. According to the second modification, when the linking pins 46, 47 tilt maximally within the bearing clearance of the bearing holes 41a, 41a, the contact area of the linking pins 46, 47 and the bearing holes 41a, 41a is increased at the edges so that they do no dig into each other.

(Third Embodiment)

[0087] The third embodiment of the present invention will be explained with reference to Fig. 22.

[0088] According to a linkage mechanism 40J of the third embodiment, holes 41a, 41a provided to arms 41, 41 of a rotating member are fixing holes to which a first linking pin 46 is inserted with force to be fixed thereto, and a hole 45c provided to a linkage member 45 is a bearing hole to which the first linking pin 46 is rotatably supported, in contrast to the second embodiment. And, holes 43a, 43a provided to arms 43, 43 of a tilting member is fixing holes to which a second linking pin 47 is inserted with force to be fixed thereto, and another hole 45c provided the linkage member 45 is a bearing hole to which the second linking pin 47 is rotatably supported, in contrast to the second embodiment. Therefore, the third embodiment can obtain similar effects to those of the second embodiment.

Modification of the Third Embodiment

[0089] Figs. 23 and 24 are views showing a modification of the third embodiment.

[0090] A linkage mechanism 40K of this modification includes an expanded-diameter portion 80 at axial ends of the bearing holes 45c, 45d. The diameter is expanded at certain curvature, at a curvature that gradually increases, or at a curvature that increases in stages. Accordingly, a similar effect to the crowned linking pins 46, 47 can be obtained. According to this modification, when the linking pins 46, 47 tilt maximally within a permissible range in a clearance in the bearing holes 45c, 45d, the increased contact area between the linking pins 46, 47 and the bearing holes 45c, 45d at the edges prevents themselves from lockingly digging into each other.

[0091] In the above described linkage mechanism 40F, 40G, 40H, 40J, and 40K, the width d1 of the slit 41S (between the arms 41, 41) of the rotor 21 and the width d2 of the slit 43S (between the arms 43, 43) of the swash plate 24 are formed to be the same width and the linkage member 45 is formed in a rectangular shape. However, for example, as shown in a linkage mechanism 40L in Fig. 25 and a linkage mechanism 40M in Fig. 26, the width d1 of the slit 41S (that is, between the arms) of the rotor 21 and the width d2 of the slit 43S (that is, between the arms) of the swash plate may be different and linkage member 45B, 45C may be formed with steps.

[0092] In the above described linkage mechanism 40F, 40G, 40H, 40J, and 40K, the rectangular-shaped linkage member 45 is inserted to the slit 41s (between the arms 41, 41) of the rotor 21 and the slit 43s (between the arms 43, 43) of the swash plate. However, for example, as shown in the linkage mechanism 40N of Fig. 27, a single arm 41 extending from the rotor 21 and a single arm 43 extending from the swash plate 24 may be inserted into slits 45s, 45s of an H-shaped linkage member 45D. Further, for example, as shown in a linkage mechanism 40P of Fig. 28, a single arm 43 extending from a swash plate 24 may be inserted in a slit 45s of a second end 45b of a Y-shaped linkage member 45 E and a first end 45a of the linkage member 45 may be inserted in to a slit 41s (between arms 41, 41) of a rotor 21.

[0093] According to the above described second and third embodiments, if the portion inserted into the slit contacts with only one of the facing surfaces in the slit when a linkage member tilts maximally within a permissible range in a clearance between bearing holes and linking pins, the first linking pin may be rotatably supported by each arms of the rotating member and the linkage member and the second linking pin may be supported by each arms of the rotating member and the linkage member. In addition, each bearing hole may be a bottomed hole.

[0094] Further, according to the second and third embodiments, the linking pins are inserted with force and fixed to the fixing holes; however, the linking pins may be fixed to the fixing holes by screws and the like.

[0095] Further, according to the second and third em-

bodiments, the first linking pin may be formed integrally with one of the arms of the rotating member or the linkage member, and the second linking pin may be formed integrally with one of the arm of the tilting member and the linkage member.

[0096] Fig. 29 shows a linkage mechanism as a comparative example.

[0097] A linkage mechanism shown in Fig. 29 includes a pair of rotor arms 145, 146 extending from a rotor 140 toward a swash plate 141, a single swash plate arm 147 extending from the swash plate 141 toward the rotor 140, and a pair of link arms 142A, 142B sandwiched therebetween. These five arms 145, 142A, 147, 142B, 146 are stacked in the torque transfer direction, so that the rotation of the rotor 140 is transferred to the swash plate. First ends of the pair of link arms 142A, 142B are rotatably connected to the pair of rotor arms 145, 146 by the first linking pin 143 and the second ends of the pair of link arms 142A, 142B are rotatably connected to the swash plate arms 147 by the second linking pin 144. With this, the link arms 142A, 142B rotate about the linking pin 143 with respect to the rotor arms 145, 146 and the swash plate arms 147 rotate about the linking pin 144 with respect to the link arms 142A, 142B. As a result, an inclination angle of the swash plate 141 is made to be varied with respect to a drive shaft (not shown).

When the compressor is operative, a contact face between the rotor arm 145 and the link arm 142A and a contact face between the link arm 142A and the swash plate arms 147 function as torque transferring faces, and also, as rotating-sliding faces. In other words, the rotor arm 145 and the link arm 142A slides and rotates with respect to one another under a large pressure of the rotary torque. The link arm 142A and the swash plate arm 147 also slide and rotate with respect to one another under a large pressure of the rotary torque. Accordingly, when changing the inclination angle of the swash plate 141, the slide friction resistance at the contact between the rotor arm 145 and the link arm 142A becomes extremely high and the slide friction resistance at the contact between the link arm 142A and the swash plate arm 147 also becomes extremely high.

[0098] Further, when the compressor is operative (when the drive shaft rotates), the swash plate 141 receives compression reaction force F_p from a piston (not shown) connected to the swash plate 141. As shown in Fig. 29, since the compression reaction force F_p is applied to a position anterior to the linkage mechanism in the rotating direction, torsion load is given to the swash plate arms 147 in the Y direction in the figure. Accordingly, the link 142 gets "stack" in the swash plate 141 at two points (C, C) and this causes a further increased slide friction resistance.

[0099] Unlike the linkage mechanism shown in Fig. 29, in the linkage mechanisms 40F, 40G, 40H, 40J, 40K, 40L, 40M, 40N, and 40P according to the second and third embodiments, the maximum inclination angle of the linkage member 45 relative to the arms 41 of the rotating

member equals to the maximum inclination angle of the first linking pin 46 in the bearing clearance $\Delta d1 (=d21-d11)$ between the first linking pin 46 and the bearing holes 41a, 41a. In other words, even when the linkage member 45 maximally tilts with respect to the arms 41 of the rotating member within a permissible range in the bearing clearance $\Delta d1 (=d21-d11)$ between the first linking pin 46 and the bearing holes 41a, 41a, a portion inserted in to the slit 41s (here, the first end 45a of the linkage member 45) contacts with only one of the facing surfaces 41d and do not contact with the both of the facing surfaces 41d, 41d on the slit 41 at the same time. That is, unlike the linkage mechanism shown in Fig. 29, they will not lockingly dig into each other at two points. Therefore, the durability of the linkage mechanisms 40F, 40G, 40H, 40J, 40K, 40L, 40M, 40N, and 40P is improved.

[0100] In the first to third embodiments, the swash plate 24 is composed of a swash plate body 26 and a hub 25 which are made of different materials; however, a swash plate 24 may be integrally formed in the present invention.

[0101] In the, first to third embodiments, the swash plate 24 is attached to the drive shaft S via a sleeve 22; however, for example, a sleeveless structure in which the swash plate 24 is directly attached to the drive shaft S without a sleeve may be employed in the present invention.

[0102] In the first to third embodiments, a swash-type swash plate is used; however, a wobble-type swash plate may be employed in the present invention.

[0103] Further, it will be appreciated that the present invention can be implemented with various modifications within the technical scope of the present invention.

INDUSTRIAL APPLICABILITY

[0104] The linkage mechanism according to the present invention can be applied not only to compressors but also as a linkage mechanism in other devices. Further, the compressor according to the present invention can be applied to various fields, for example, as a compressor for a refrigeration cycle to compress refrigerant, or as a compressor for compressing gas such as air.

Claims

1. A linkage mechanism comprising:

- a rotating member fixed to a drive shaft and rotating integrally with the drive shaft;
- a tilting member slidably attached to the drive shaft and being tiltable with respect to the drive shaft;
- a pair of arms extending from the rotating member toward the tilting member and facing each other in a rotary torque transfer direction;
- a pair of arms extending from the tilting member

- toward the rotating member and facing each other in the rotary torque transfer direction; and a linkage member inserted between the pair of arms of the rotating member and between the pair of arms of the tilting member.
2. The linkage mechanism according to claim 1, wherein one end of the linkage member is rotatably connected to the pair of arms of the rotating member by the first linking pin and the other end of the linkage member is rotatably connected to the pair of arms of the tilting member by the second linking pin.
 3. The linkage mechanism according to claim 1, wherein a distance between the pair of arms of the rotating member and a distance between the pair of arms of the tilting member are formed in a same size.
 4. The linkage mechanism according to claim 3, wherein the first linking pin and the second linking pin have the same diameter and length.
 5. 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 slidably attached to the drive shaft and being tiltable with respect to the drive shaft;
 - a linkage mechanism linking the rotating member and the tilting member and transferring rotary torque of the rotating member to the tilting member as allowing a tilt of the tilting member to change; and
 - a piston configured to reciprocate in a cylinder bores corresponding to rotary movement of the tilting member; wherein the linkage mechanism includes:
 - a pair of arms extending from the rotating member toward the tilting member and facing each other in a rotary torque transfer direction;
 - a pair of arms extending from the tilting member toward the rotating member and facing each other in the rotary torque transfer direction; and
 - a linkage member inserted between the pair of arms of the rotating member and between the pair of arms of the tilting member.
 6. The variable displacement compressor according to claim 5, wherein one end of the linkage member is rotatably connected to the pair of arms of the rotating member by the first linking pin and the other end of the linkage member is rotatably connected to the pair of arms of the tilting member by the second linking pin.
 7. The variable displacement compressor according to claim 5, wherein a distance between the pair of arms of the rotating member and a distance between the pair of arms of the tilting member are formed in the same size.
 8. The variable displacement compressor according to claim 7, wherein the first linking pin and the second linking pin have the same diameter and length.
 9. A linkage mechanism comprising:
 - a rotating member fixed to a drive shaft and rotating integrally with the drive shaft;
 - a tilting member slidably attached to the drive shaft and being tiltable with respect to the drive shaft;
 - an arm extending from the rotating member toward the tilting member;
 - an arm extending from the tilting member toward the rotating member; and
 - a linkage member provided between the arm of the rotating member and the arm of the tilting member; wherein a slit is provided to one of the arm of the rotating member and one end of the linkage member, the other of the arm of the rotating member and the end of the linkage member is inserted into the one, the arm of the rotating member and the one end of the linkage member are rotatably connected each other by a first linking pin; and a maximum inclination angle of the linkage member relative to the arm of the rotating member corresponds to a maximum inclination angle of the first linking pin in a bearing clearance between the first linking pin and a bearing hole for the first linking pin.
 10. The linkage mechanism according to claim 9, wherein the first linking pin is fixed to a fixing hole provided in one of the arms of the rotating member and the linkage member and rotatably supported in the bearing hole provided in the other of the arms of the rotating member and the linkage member.
 11. The linkage mechanism according to claim 9, wherein the linking pin includes a reduced-diameter portion, at axial ends, where the diameter is reduced at a certain curvature, at a curvature that gradually increases, or at a curvature that increases in stages.
 12. The linkage mechanism according to claim 9, wherein the bearing hole includes an expanded-diameter portion, at axial ends, where the diameter is enlarged at a certain curvature, at a curvature that gradually increases, or at a curvature that increases in stages.
 13. The linkage mechanism according to claim 9, wherein

the slit is provided to the arm of the rotating member and the one end of the linkage member is inserted into the slit; and
the slit is provided to the arm of the tilting member and the other end of the linkage member inserted into the slit.

14. The linkage mechanism according to claim 13, wherein a width of the slit in the rotating member and a width of the slit in the tilting member are formed in the same width.

15. The linkage mechanism according to claim 9, wherein the first linking pin and the second linking pin have the same diameter and length.

16. A linkage mechanism comprising:

a rotating member fixed to a drive shaft and rotating integrally with the drive shaft;
a tilting member slidably attached to the drive shaft and being tiltable with respect to the drive shaft;
an arm extending from the rotating member toward the tilting member;
an arm extending from the tilting member toward the rotating member; and
a linkage member provided between the arm of the rotating member and the arm of the tilting member; wherein
a slit is provided to one of the arm of the tilting member and the other end of the linkage member, the other of the arm of the tilting member and the other end of the linkage member inserted into the one, the arm of the tilting member and the other end of the linkage member are rotatably connected each other by a second linking pin; and
a maximum inclination angle of the linkage member relative to the arm of the tilting member corresponds to a maximum inclination angle of the second linking pin in a bearing clearance between the second linking pin and a bearing hole for the second linking pin.

17. The linkage mechanism according to claim 16, wherein the second linking pin is fixed to a fixing hole provided to one of the arms of the tilting member and the linkage member and rotatably supported in the bearing hole provided to the other of the arms of the tilting member and the linkage member.

18. The linkage mechanism according to claim 16, wherein the linking pin includes a reduced-diameter portion, at axial ends, where the diameter is reduced at a certain curvature, at a curvature that gradually increases, or at a curvature that increases in stages.

19. The linkage mechanism according to claim 16, wherein the bearing hole includes an expanded-diameter portion, at axial ends, where the diameter is enlarged at a certain curvature, at a curvature that gradually increases, or at a curvature that increases in stages.

20. The linkage mechanism according to claim 16, wherein
the slit is provided to the arm of the rotating member and one end of the linkage member is inserted into the slit; and
the slit is provided to the arm of the tilting member and the other end of the linkage member inserted into the slit.

21. The linkage mechanism according to claim 20, wherein a width of the slit in the rotating member and a width of the slit in the tilting member are formed in the same width.

22. The linkage mechanism according to claim 16, wherein the first linking pin and the second linking pin have the same diameter and length.

23. 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 slidably attached to the drive shaft and being tiltable with respect to the drive shaft;
a linkage mechanism linking the rotating member and the tilting member and transferring rotary torque of the rotating member to the tilting member as allowing a tilt of the tilting member to change; and
a piston configured to reciprocate in a cylinder bores corresponding to rotary movement of the tilting member; wherein
the linkage mechanism includes:
an arm extending from the rotating member toward the tilting member;
an arm extending from the tilting member toward the rotating member; and
a linkage member provided between the arm of the rotating member and the arm of the tilting member; and wherein
a slit is provided to one of the arm of the rotating member and one end of the linkage member, the other of the arm of the rotating member and the one end of the linkage member into the one, the arm of the rotating member and the one end of the linkage member are rotatably connected each other by a first linking pin; and
a maximum inclination angle of the linkage member relative to the arm of the rotating mem-

ber corresponds to a maximum inclination angle of the first linking pin in a bearing clearance between the first linking pin and a bearing hole for the first linking pin.

24. The variable displacement compressor according to claim 23, wherein the first linking pin is fixed to a fixing hole provided in one of the arms of the rotating member and the linkage member and rotatably supported in the bearing hole provided to the other of the arms of the rotating member and the linkage member.

25. The variable displacement compressor according to claim 23, wherein the linking pin includes a reduced-diameter portion, at axial ends, where the diameter is reduced at a certain curvature, at a curvature that gradually increases, or at a curvature that increases in stages.

26. The variable displacement compressor according to claim 23, wherein the bearing hole includes an expanded-diameter portion, at axial ends, where the diameter is enlarged at a certain curvature, at a curvature that gradually increases, or in stages.

27. The variable displacement compressor according to claim 23, wherein
the slit is provided to the arm of the rotating member and the one end of the linkage member is inserted into the slit; and
the slit is provided to the arm of the tilting member and the other end of the linkage member inserted into the slit.

28. The variable displacement compressor according to claim 27, wherein a width of the slit in the rotating member and a width of the slit in the tilting member are formed in the same width.

29. The variable displacement compressor according to claim 23, wherein the first linking pin and the second linking pin have the same diameter and length.

30. 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 slidably attached to the drive shaft and being tiltable with respect to the drive shaft;
a linkage mechanism linking the rotating member and the tilting member and transferring rotary torque of the rotating member to the tilting member as allowing a tilt of the tilting member to change; and
a piston configured to reciprocate in a cylinder

bores corresponding to rotary movement of the tilting member; wherein
the linkage mechanism includes:

an arm extending from the rotating member toward the tilting member;

an arm extending from the tilting member toward the rotating member; and

a linkage member provided between the arm of the rotating member and the arm of the tilting member; and wherein

a slit is provided to one of the arm of the tilting member and the other end of the linkage member, the other of the arm of the tilting member and the other end of the linkage member inserted into the one, the arm of the tilting member and the other end of the linkage member are rotatably connected each other by a second linking pin; and

a maximum inclination angle of the linkage member relative to the arm of the tilting member equals to a maximum inclination angle of the second linking pin in a bearing clearance between the second linking pin and a bearing hole for the second linking pin.

31. The variable displacement compressor according to claim 30, wherein the second linking pin is fixed to a fixing hole provided to one of the arms of the tilting member and the linkage member and rotatably supported in the bearing hole provided to the other of the arms of the tilting member and the linkage member.

32. The variable displacement compressor according to claim 30, wherein the linking pin includes a reduced-diameter portion, at axial ends, where the diameter is reduced at a certain curvature, at a curvature that gradually increases, or at a curvature that increases in stages.

33. The variable displacement compressor according to claim 30, wherein the bearing hole includes an expanded-diameter portion, at axial ends, where the diameter is enlarged at a certain curvature, at a curvature that gradually increases, or in stages.

34. The variable displacement compressor according to claim 30, wherein
the slit is provided to the arm of the rotating member and one end of the linkage member is inserted into the slit; and
the slit is provided to the arm of the tilting member and the other end of the linkage member inserted into the slit.

35. The variable displacement compressor according to claim 34, wherein a width of the slit in the rotating member and a width of the slit in the tilting member

are formed in same width.

- 36.** The variable displacement compressor according to claim 30, wherein the first linking pin and the second linking pin have the same diameter and length.

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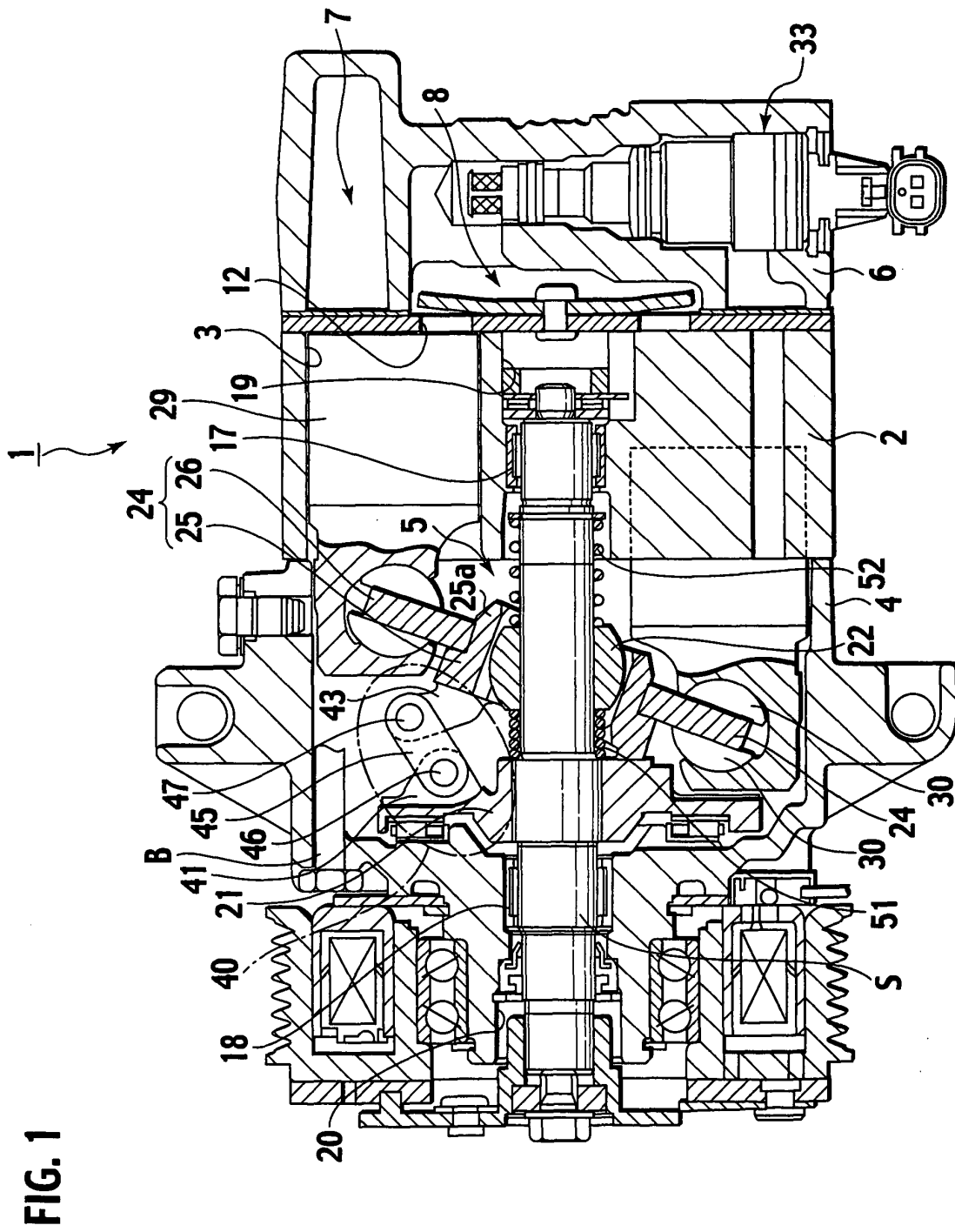
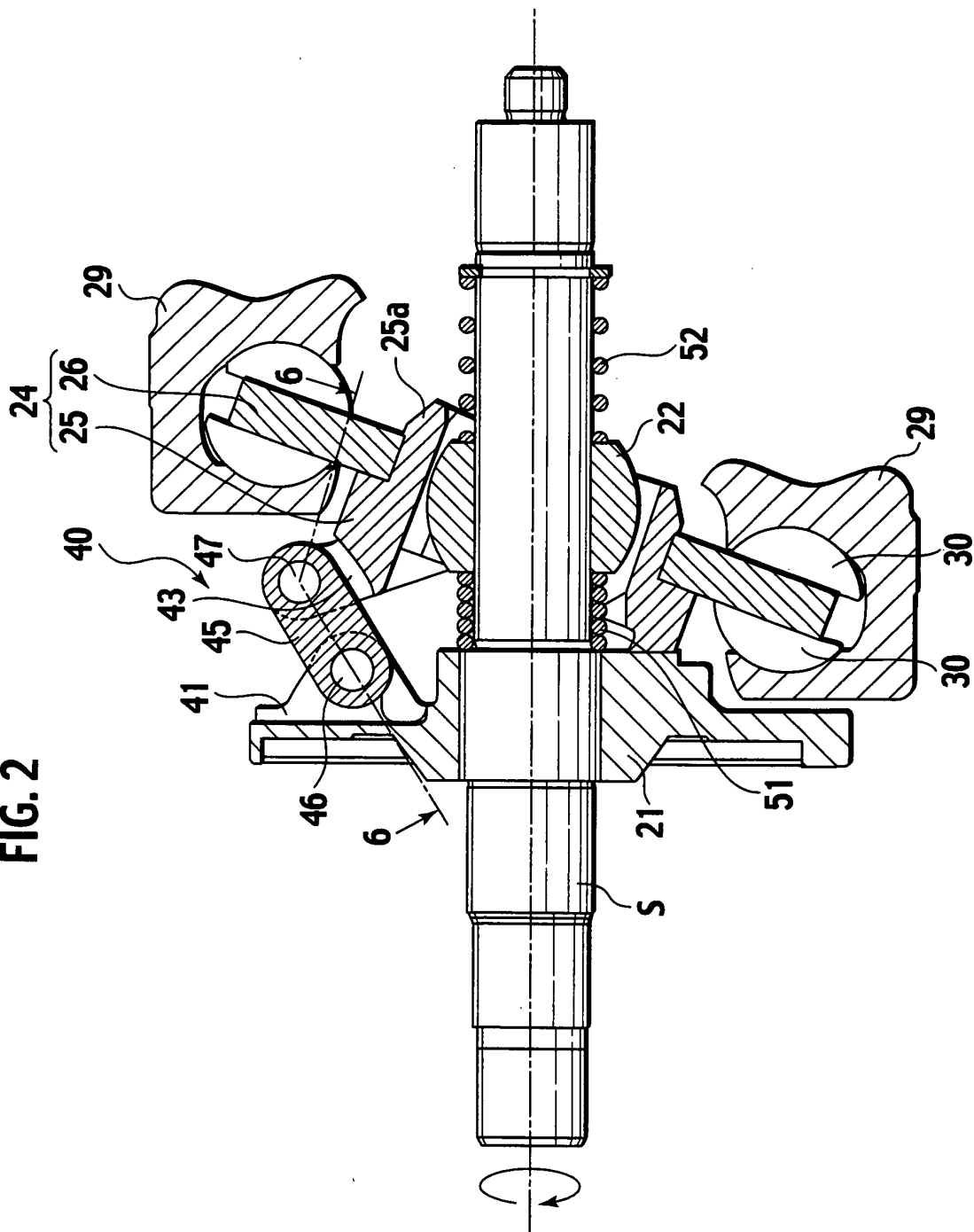


FIG. 2



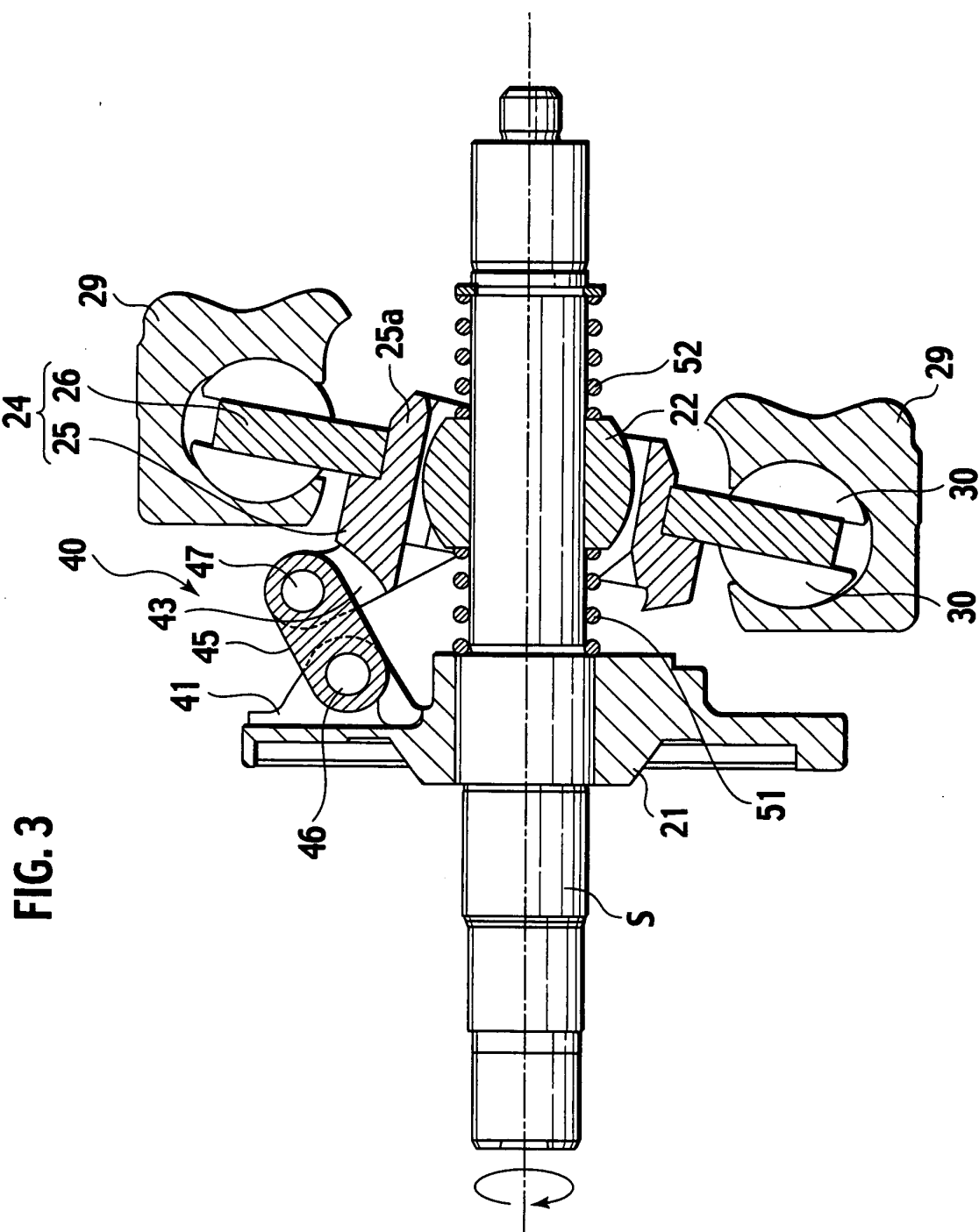


FIG. 4

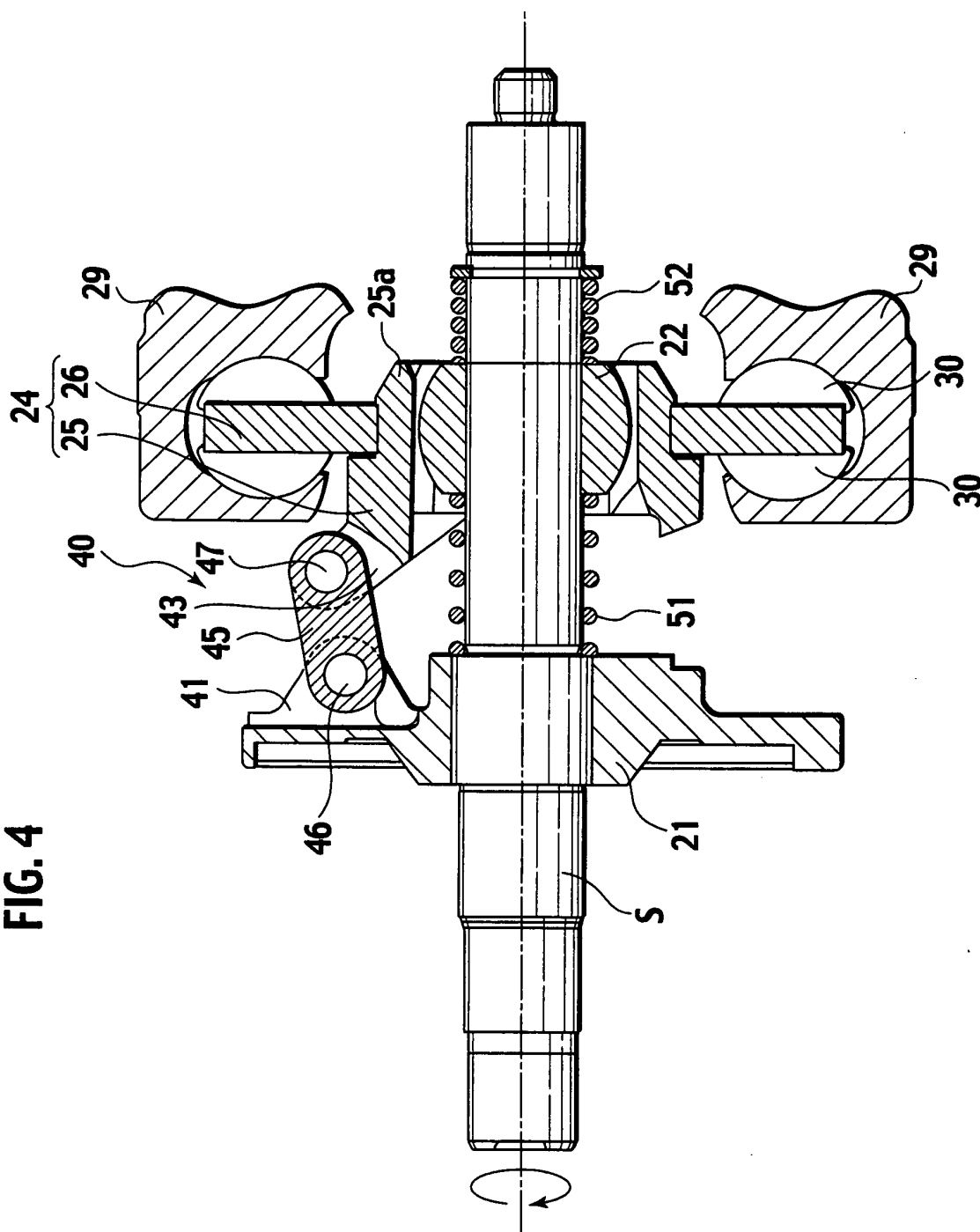
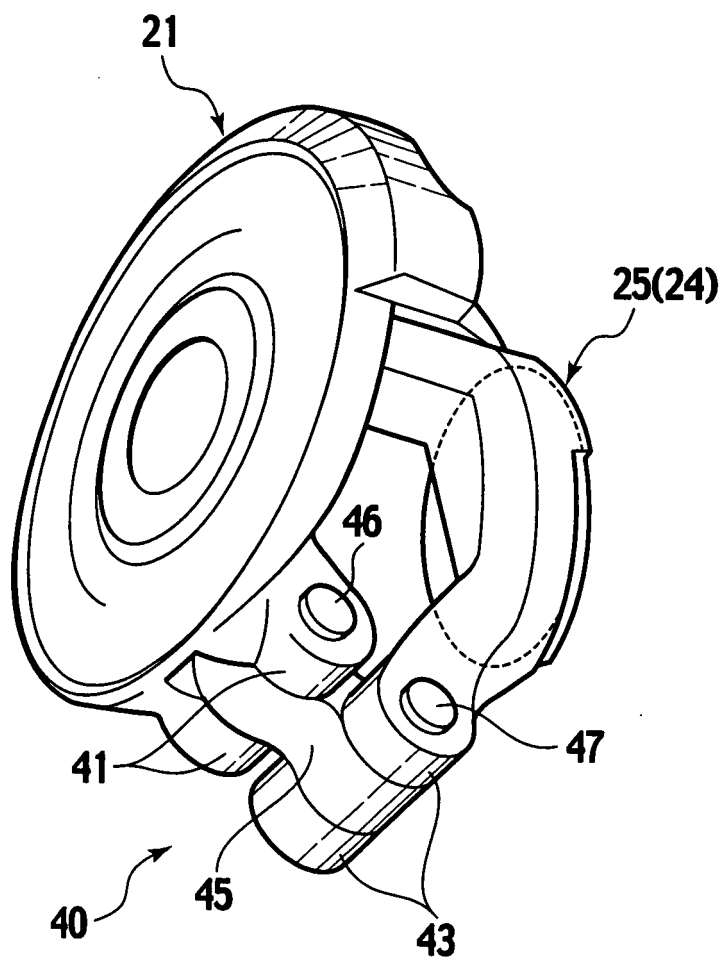


FIG. 5



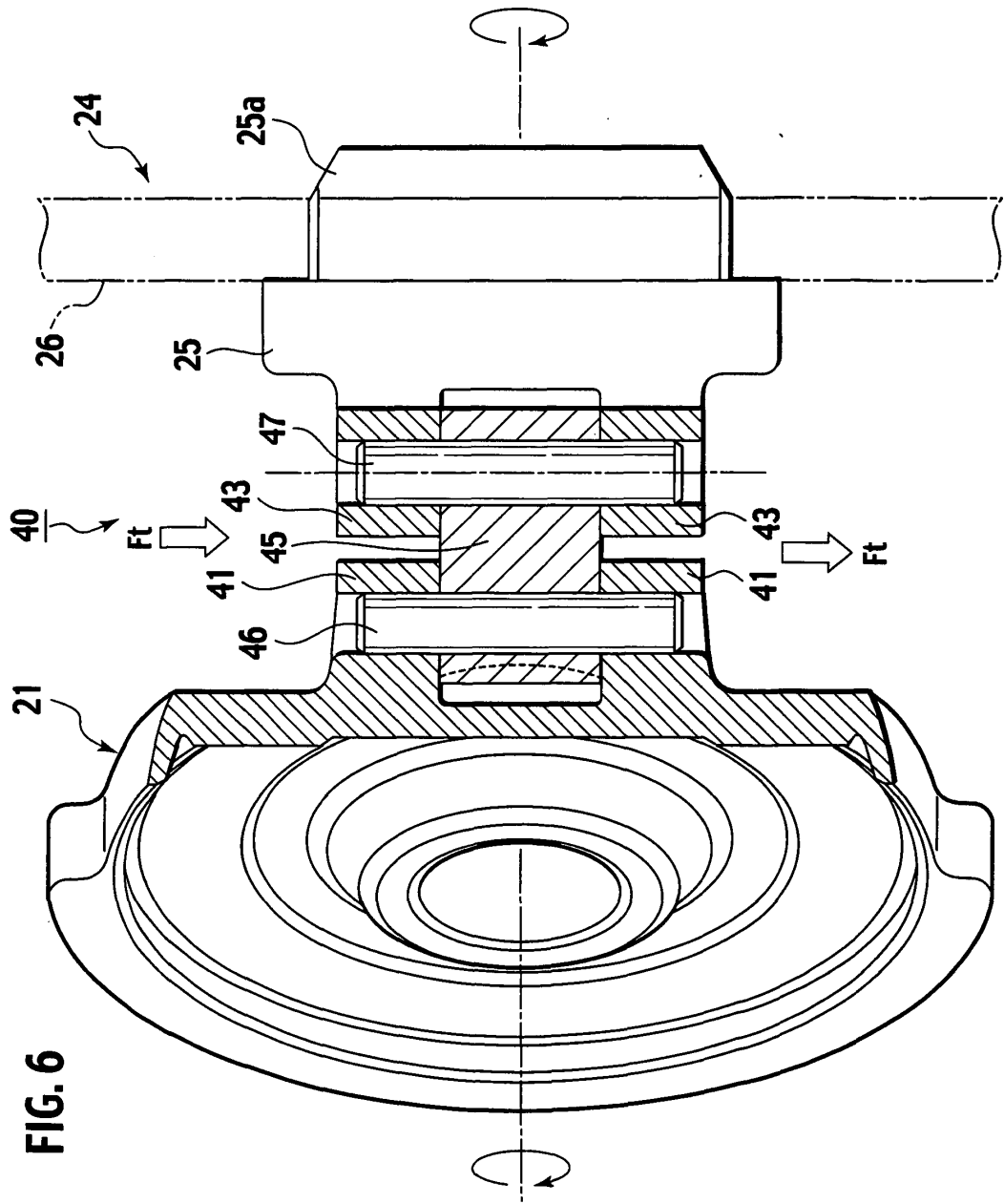


FIG. 7

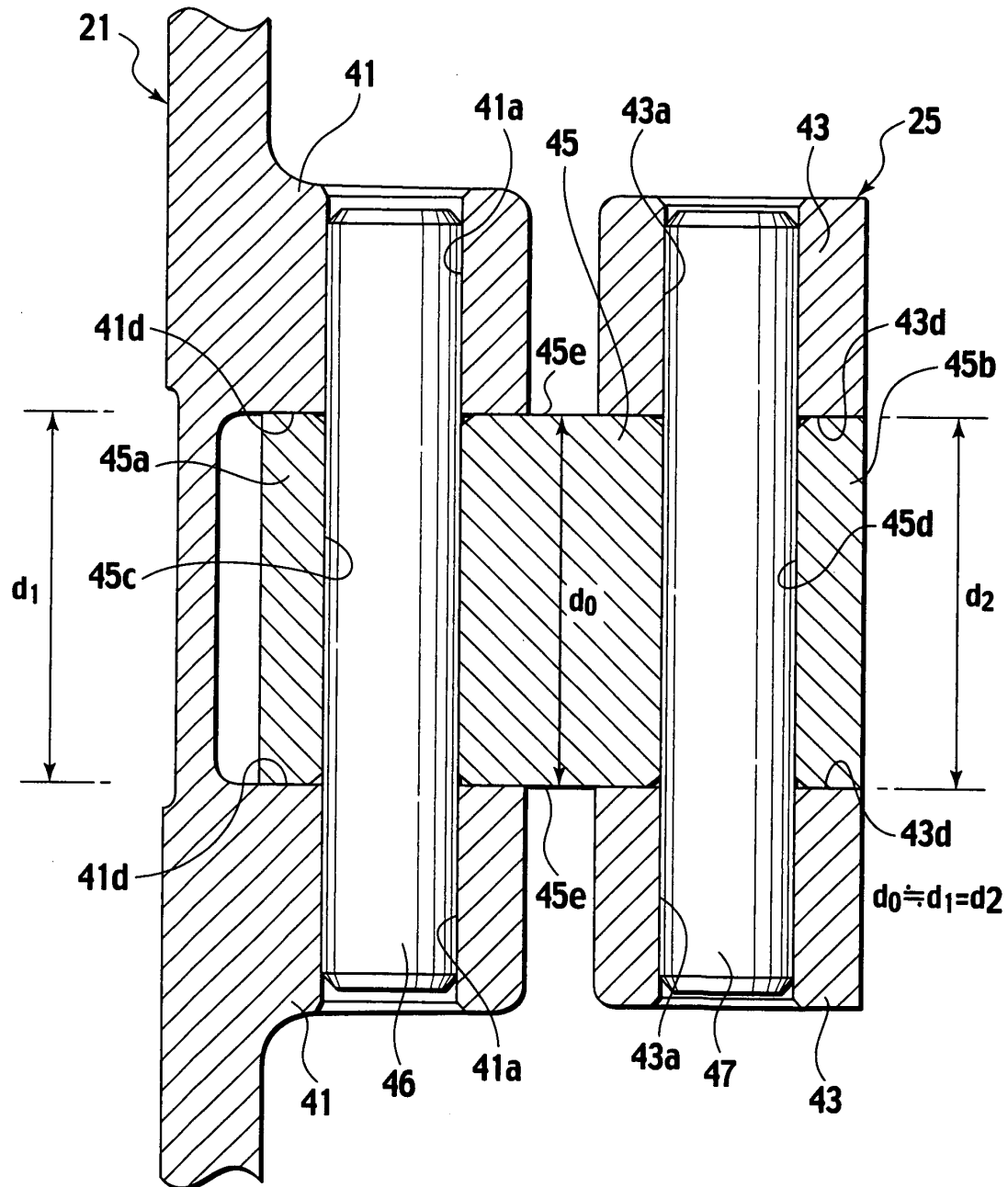


FIG. 8

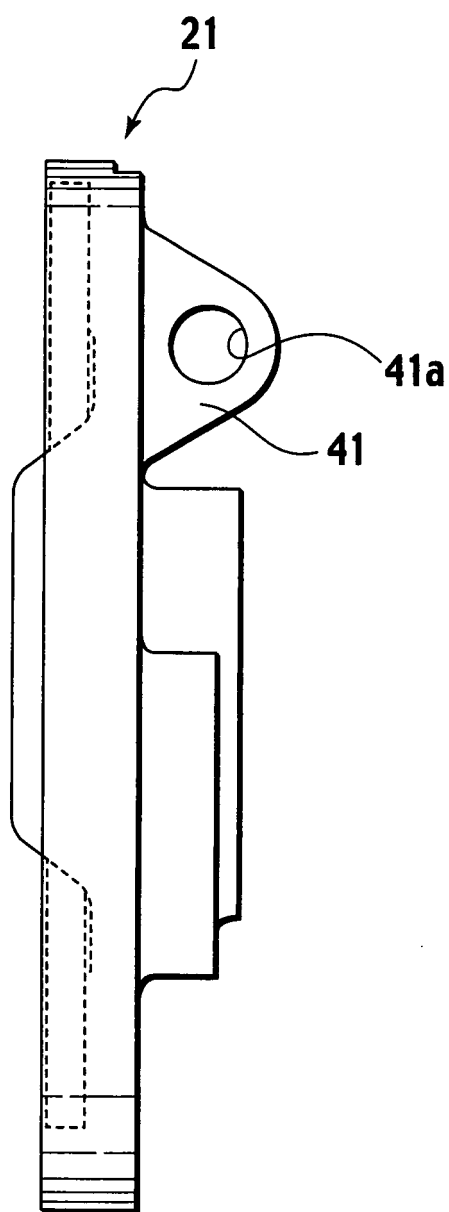


FIG. 9

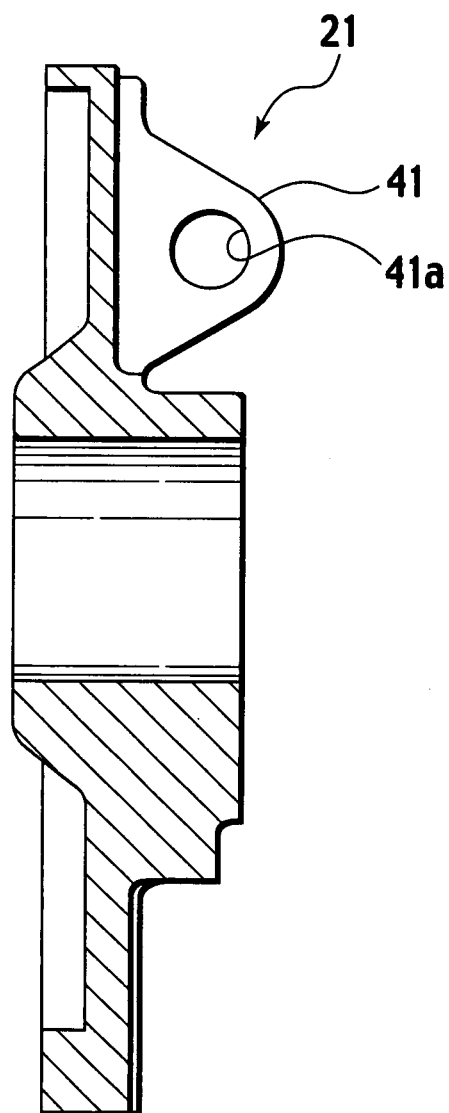


FIG. 10

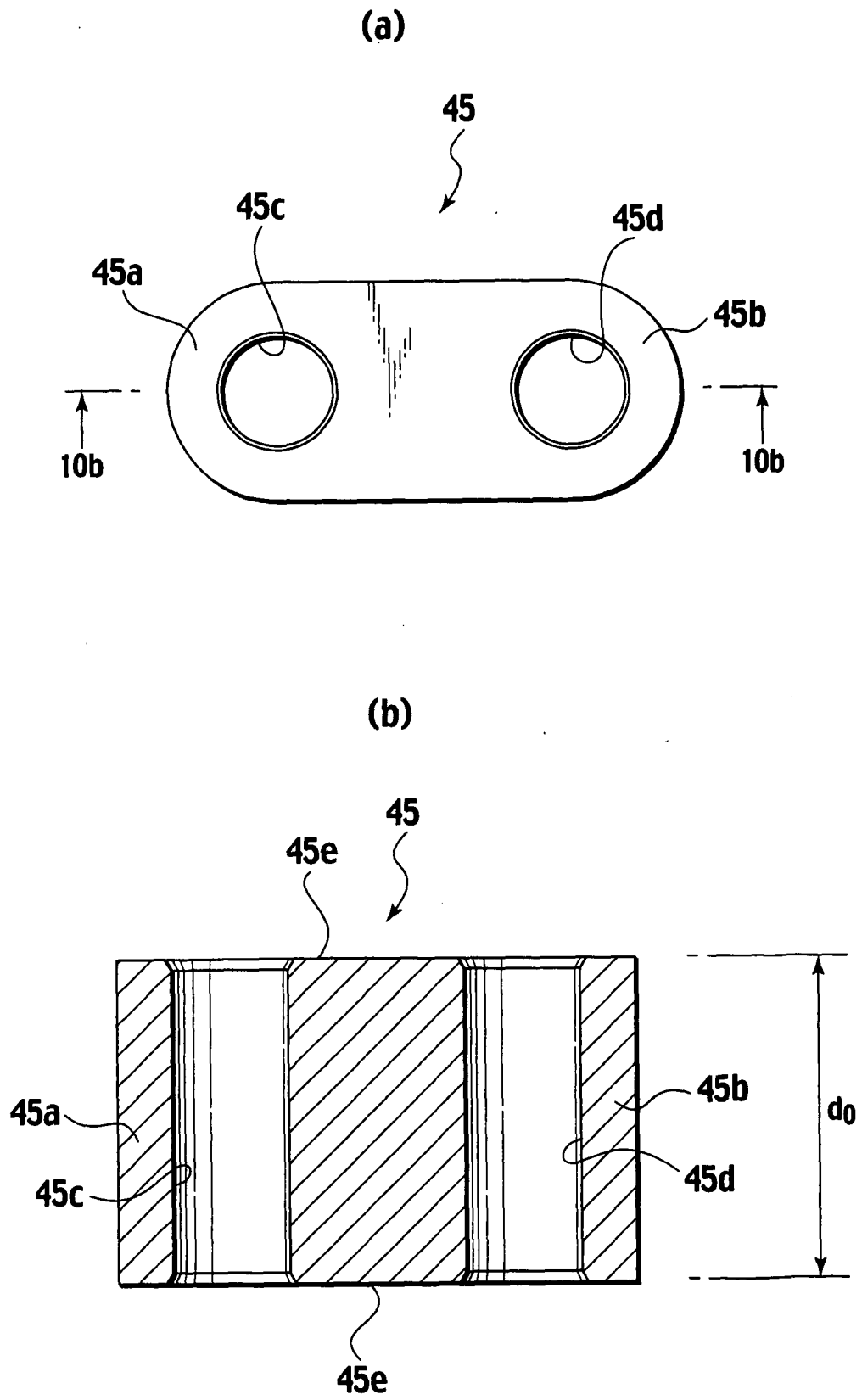


FIG. 11

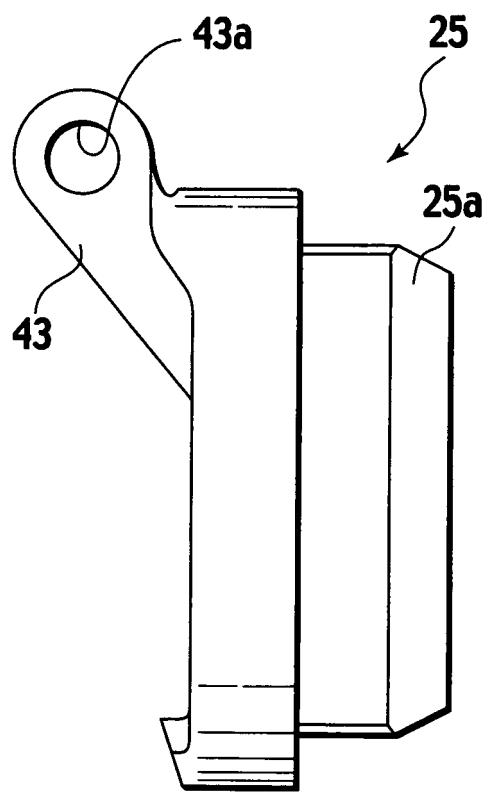


FIG. 12

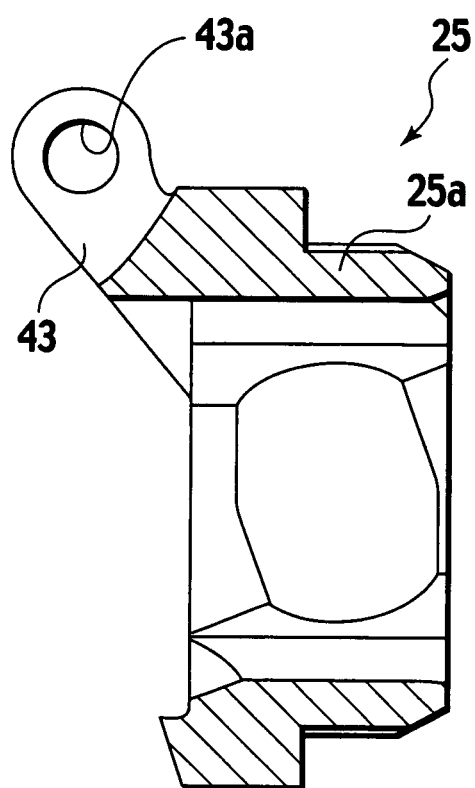


FIG. 13

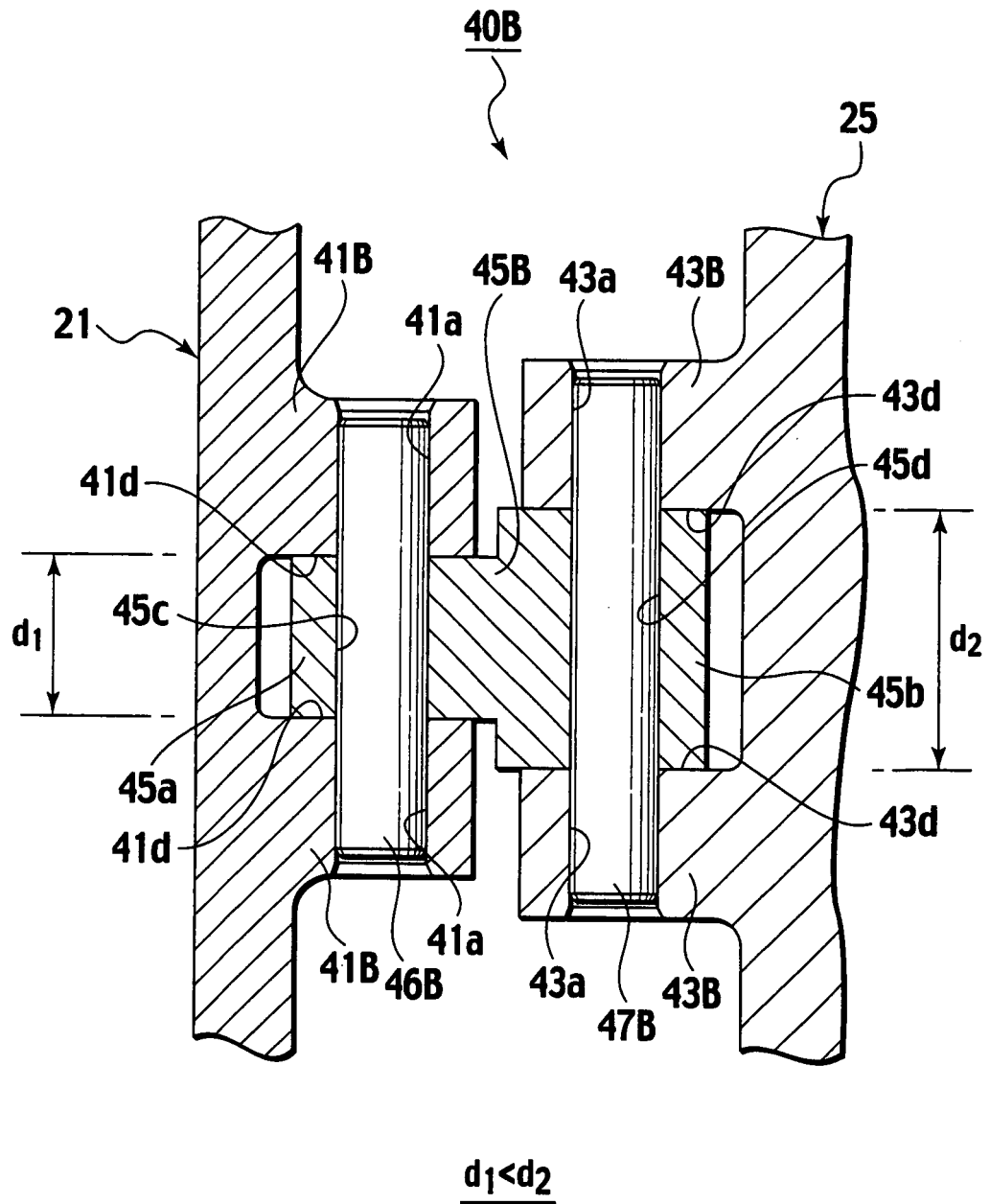
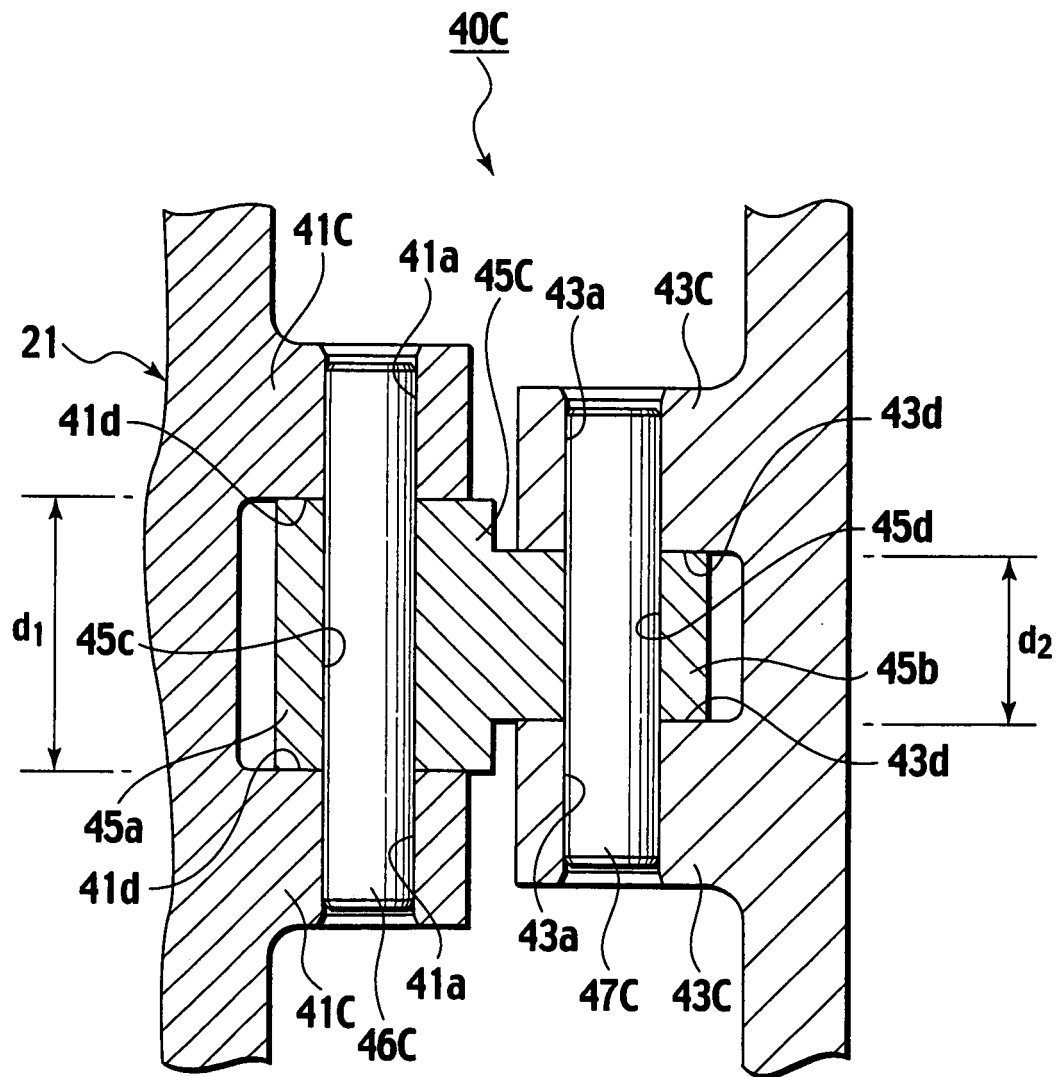


FIG. 14



$$d_1 > d_2$$

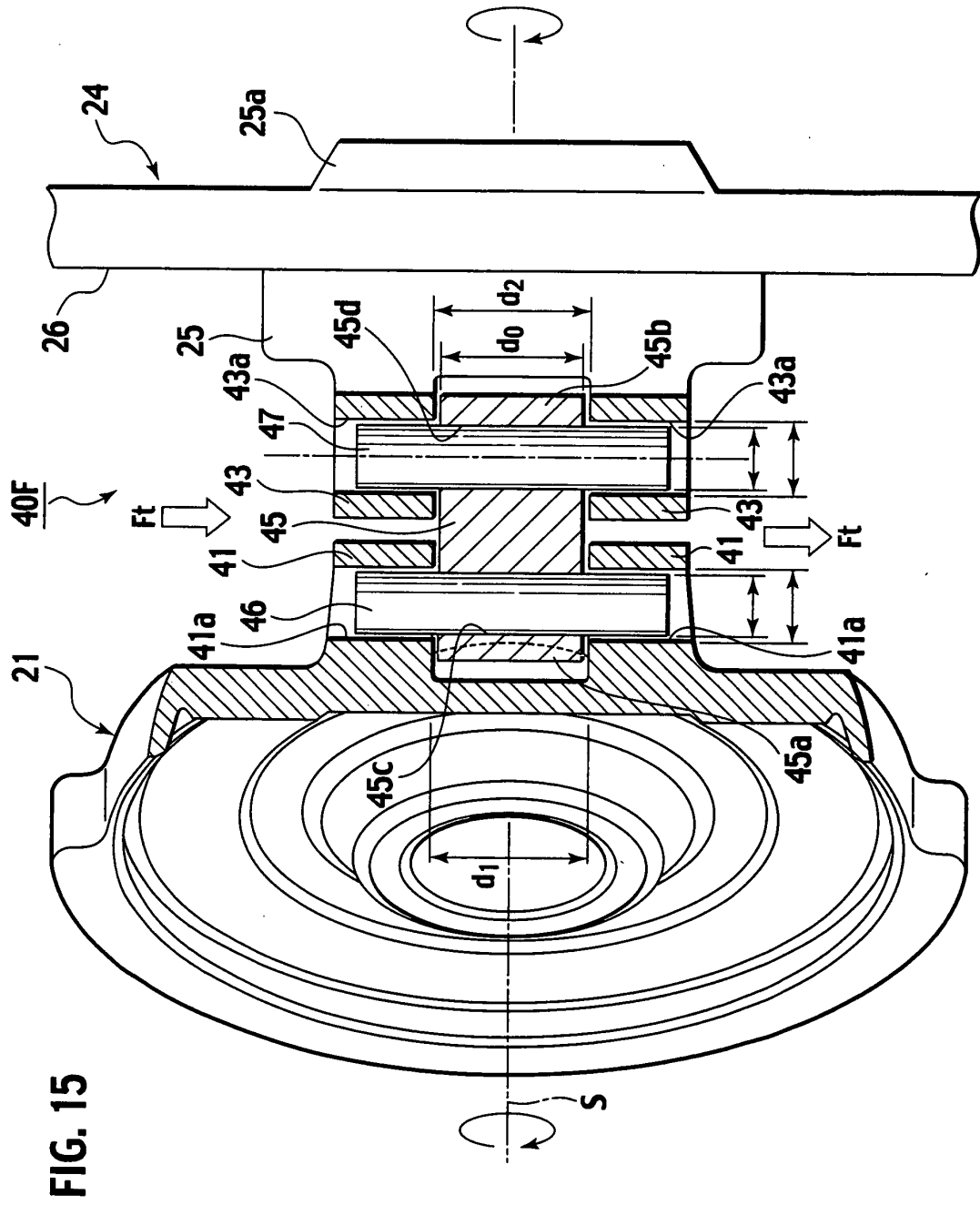


FIG. 16

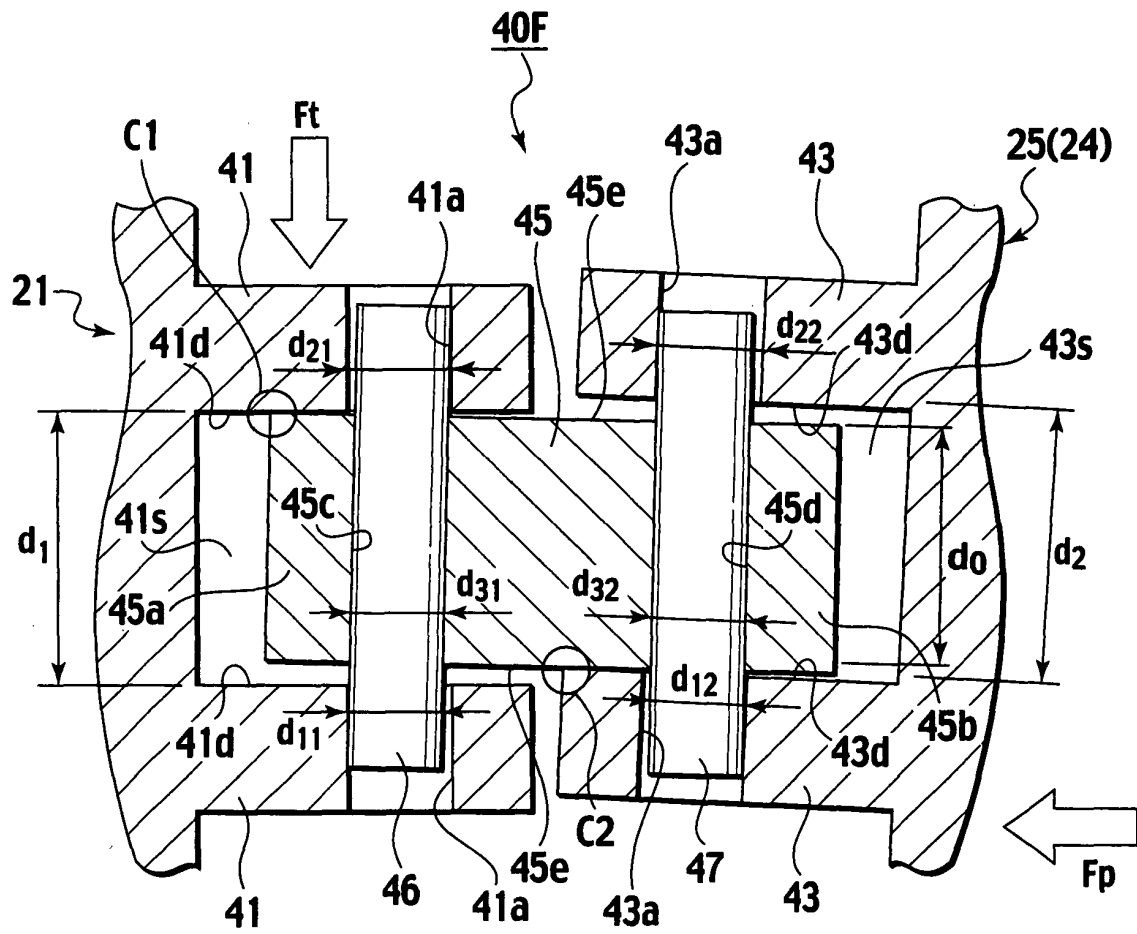


FIG. 17

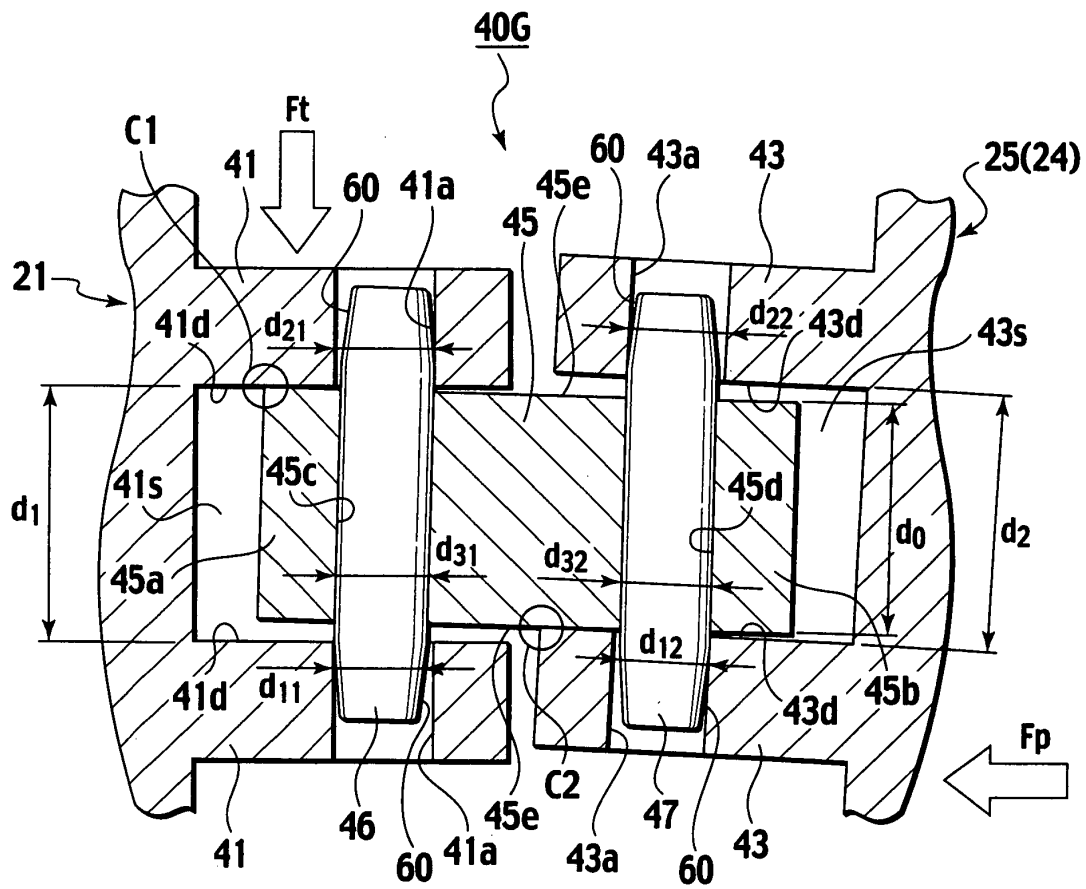


FIG. 18

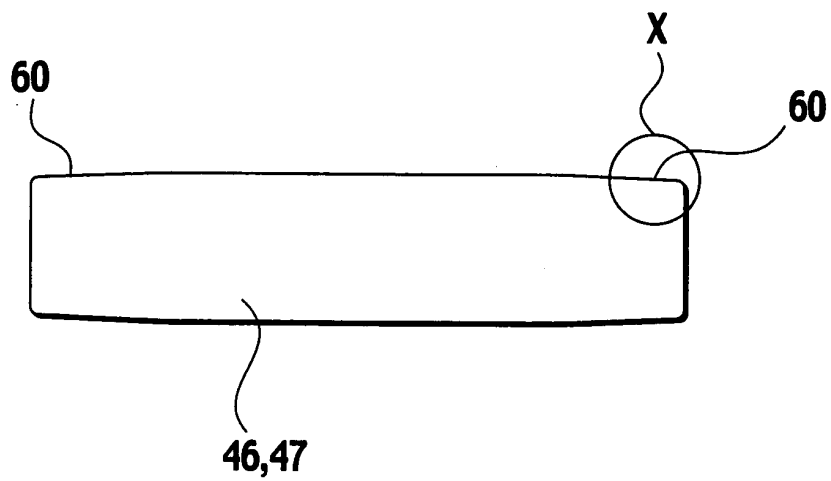


FIG. 19

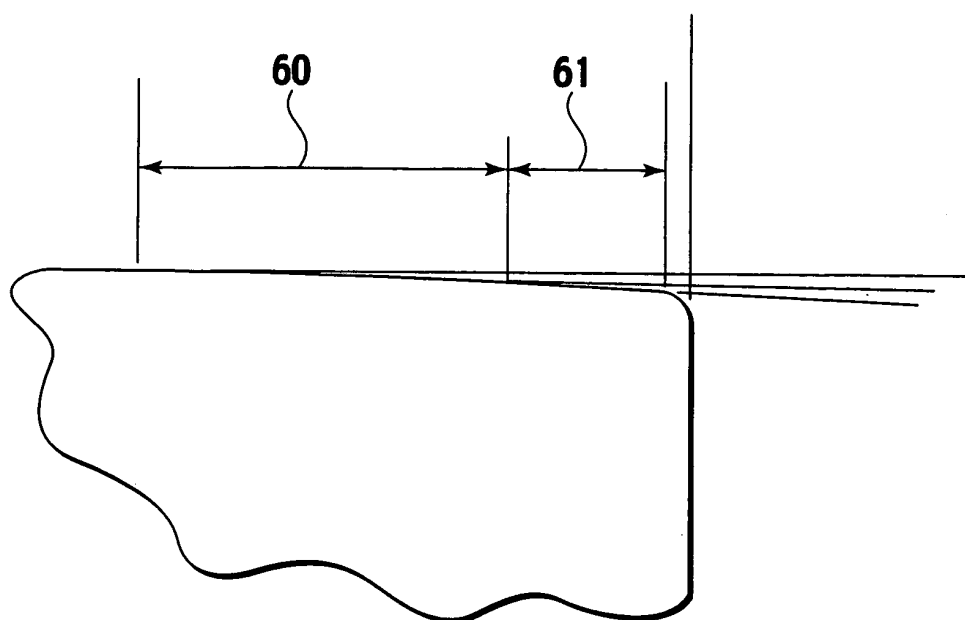


FIG. 20

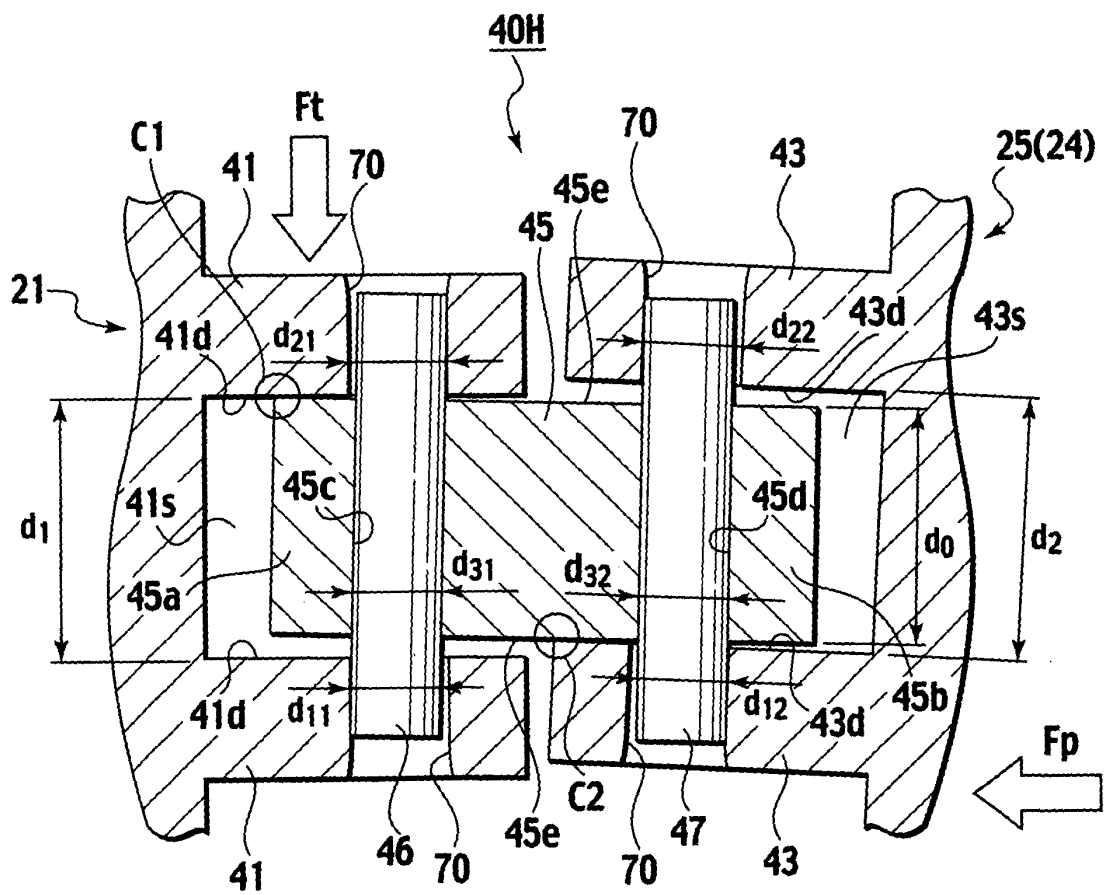


FIG. 21

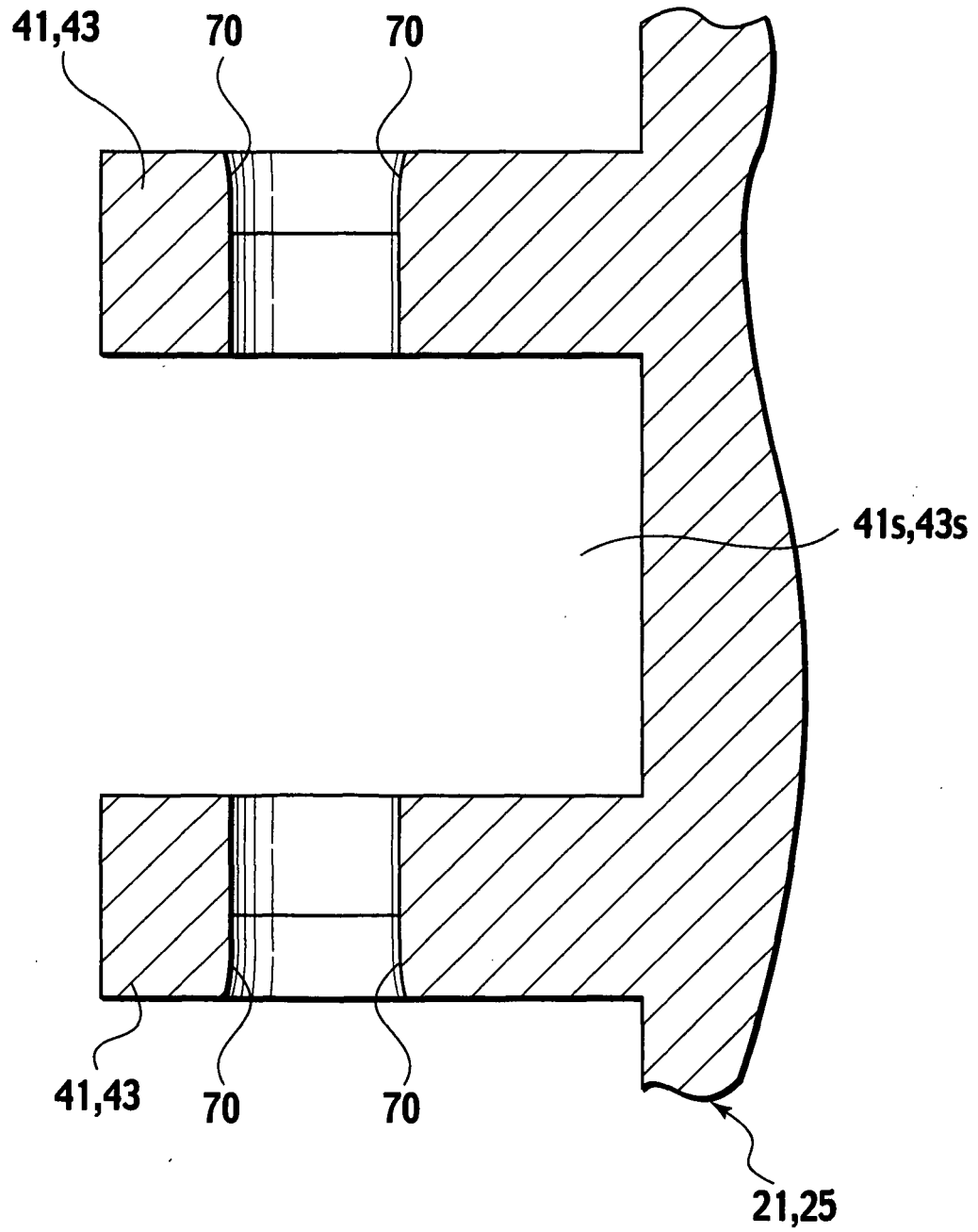


FIG. 22

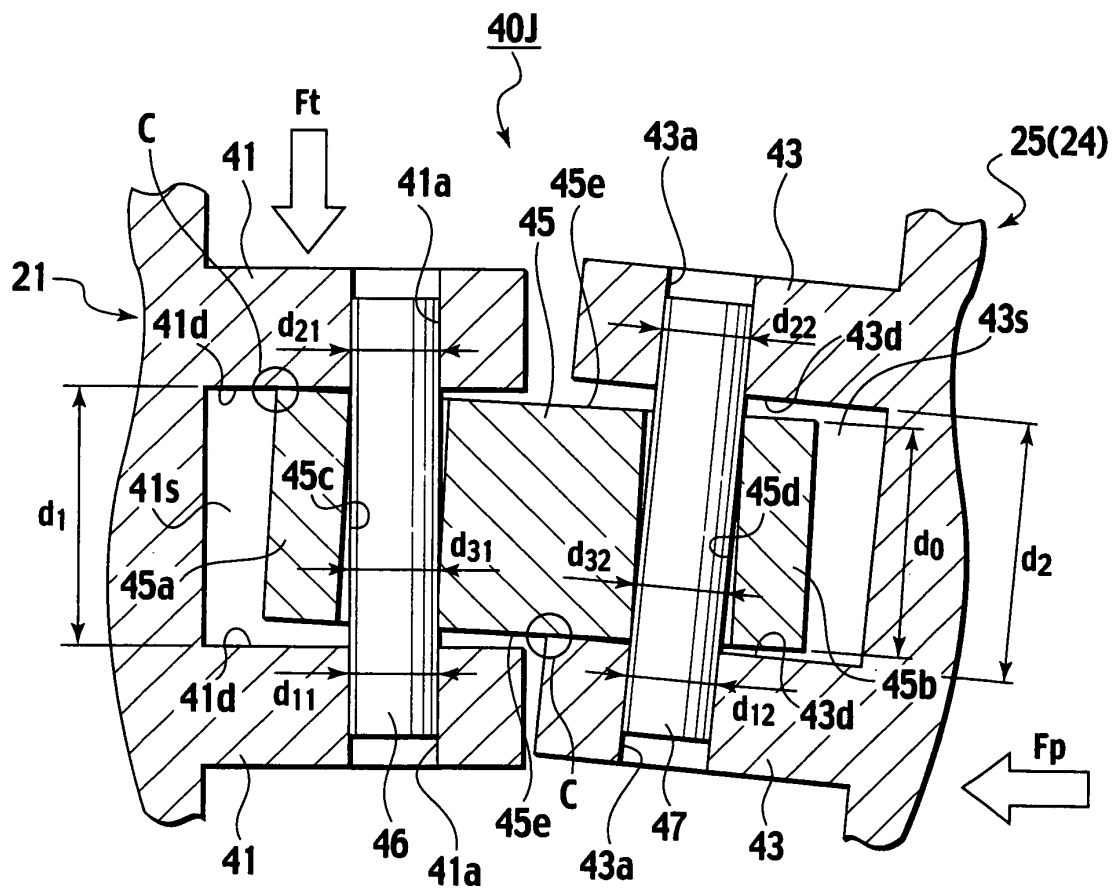


FIG. 23

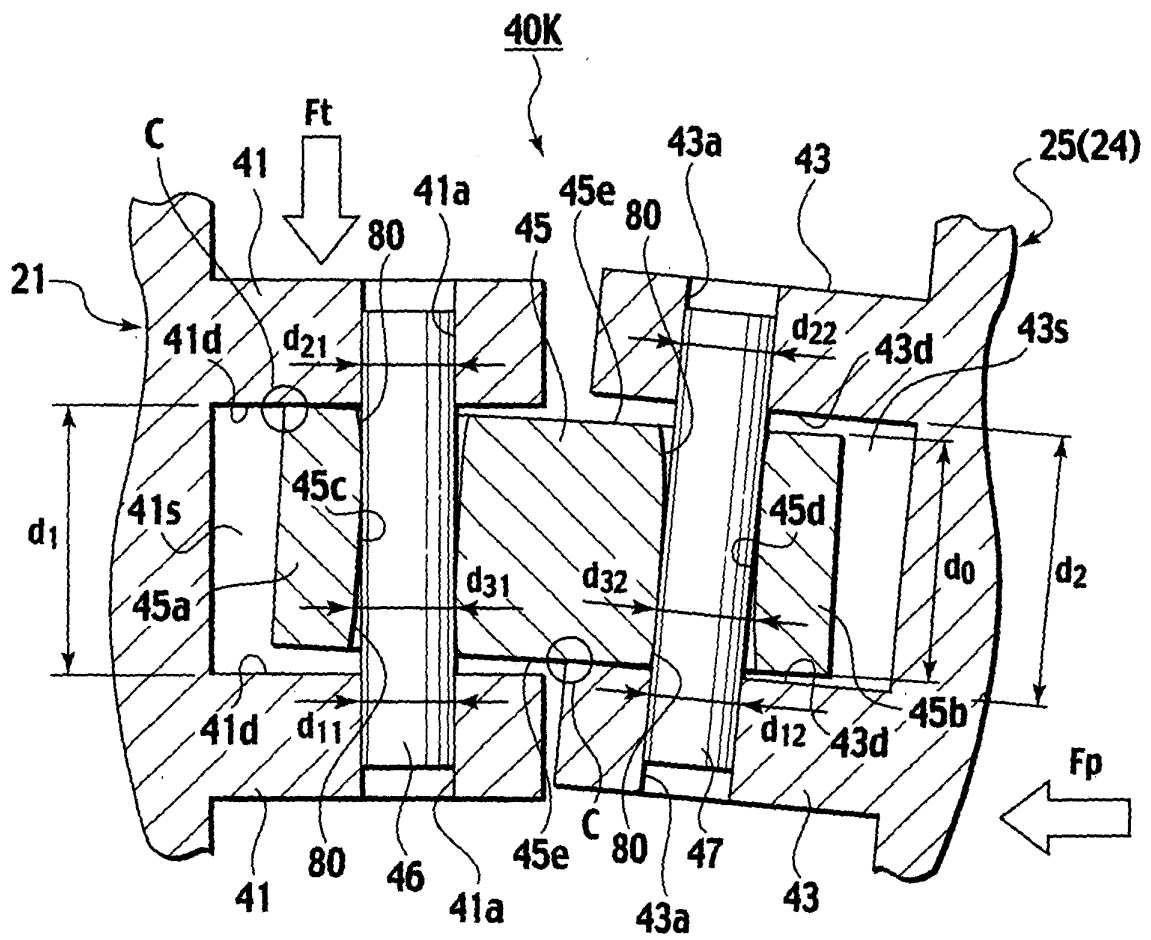


FIG. 24

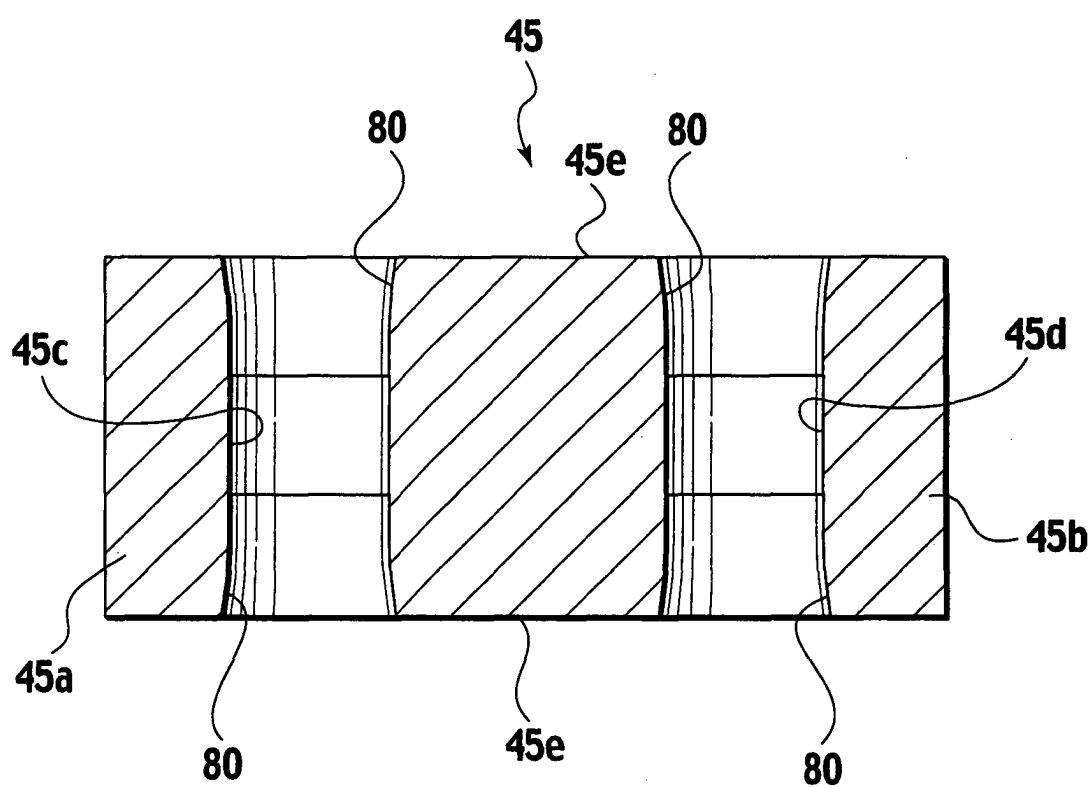


FIG. 25

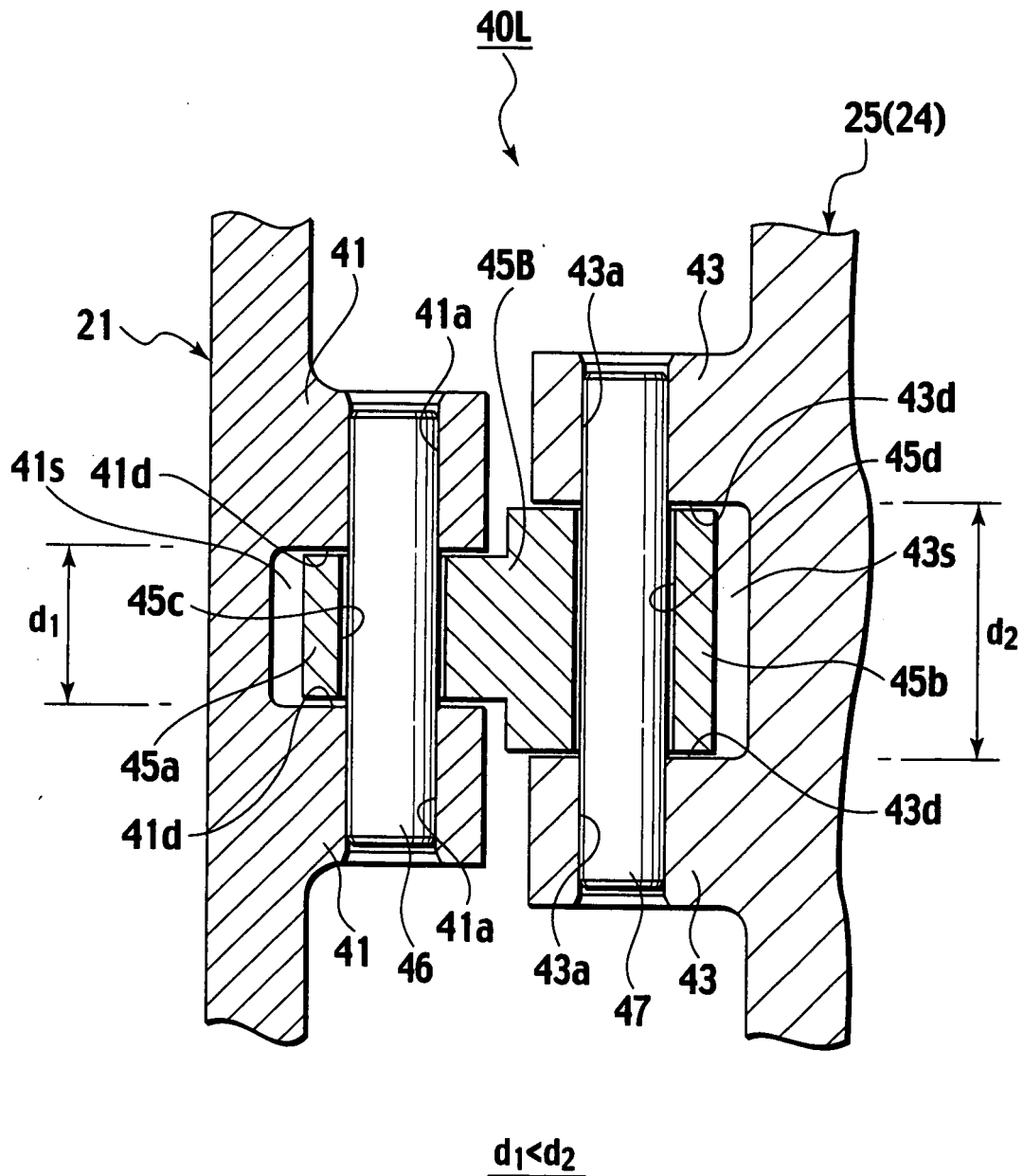
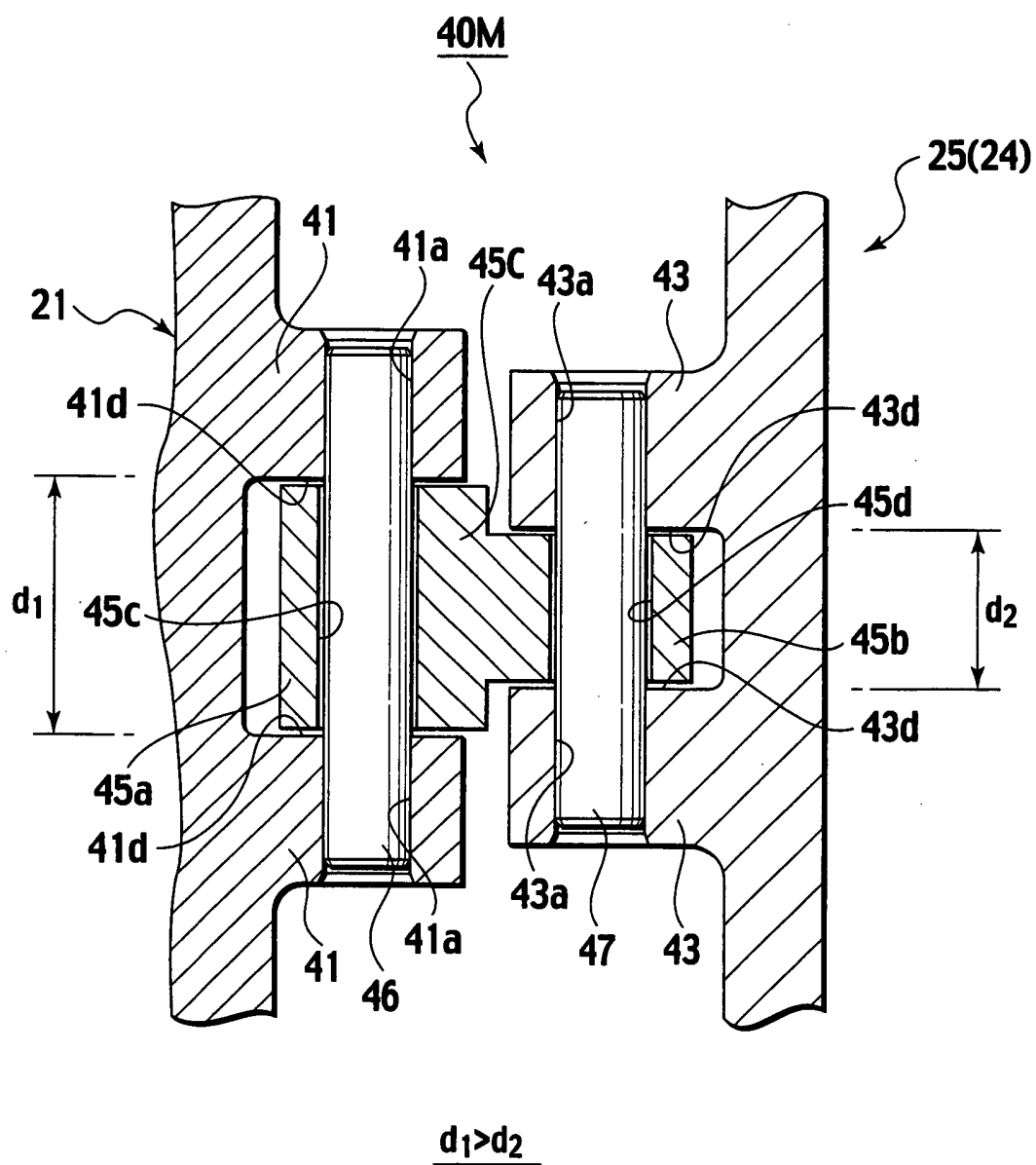
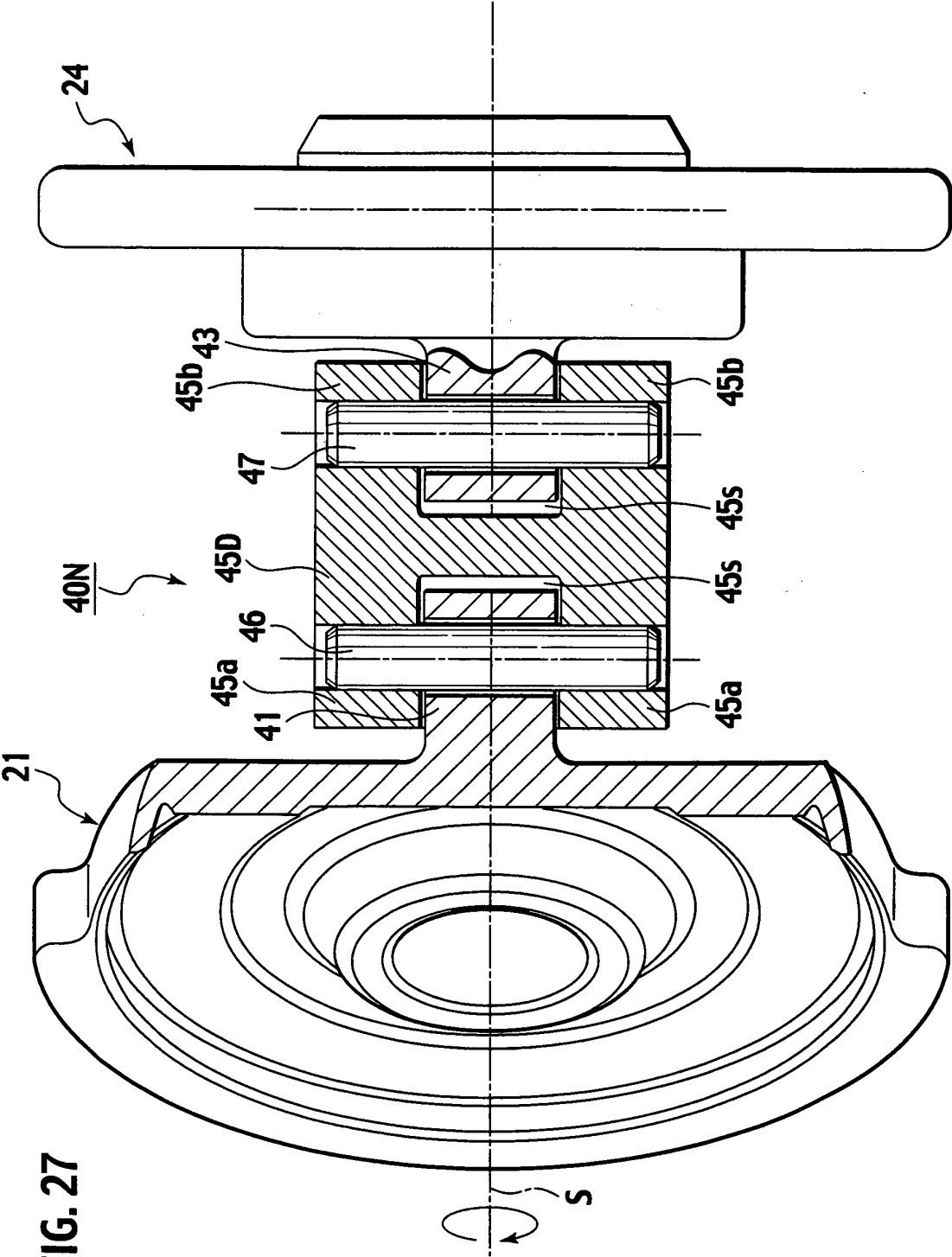


FIG. 26





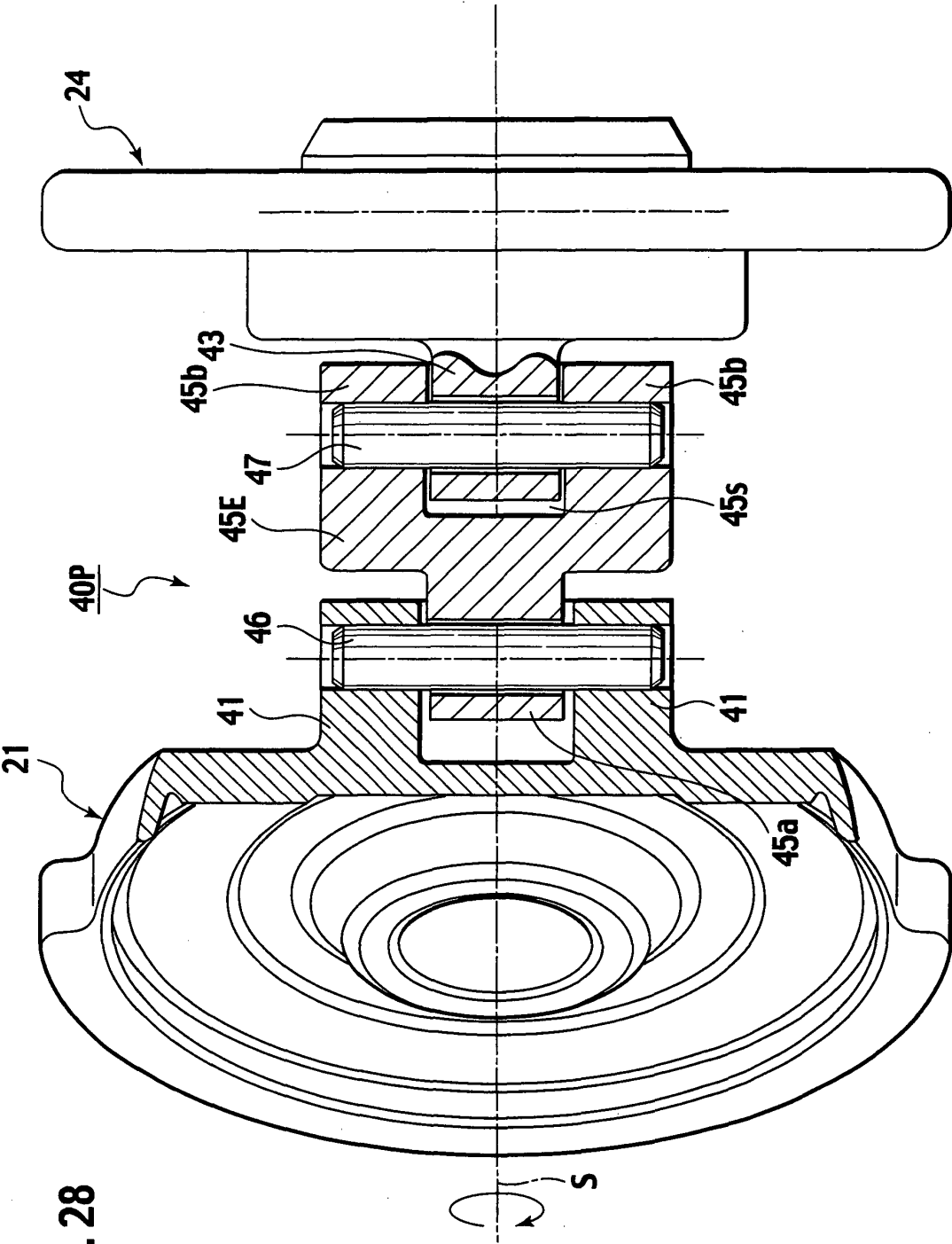
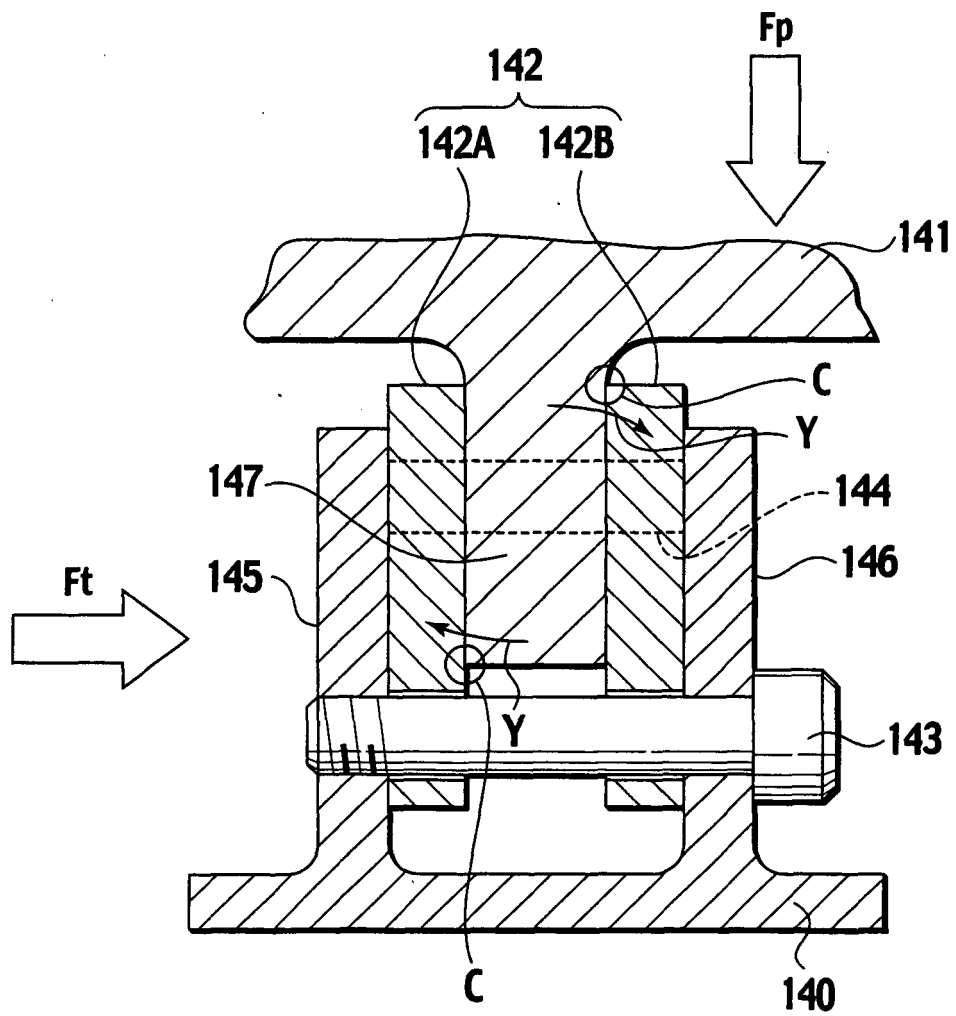


FIG. 28

FIG. 29



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2005/005888

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl.⁷ F04B27/08

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)
Int.Cl.⁷ F04B27/08Documentation 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 1996-2005
Kokai Jitsuyo Shinan Koho 1971-2005 Toroku Jitsuyo Shinan Koho 1994-2005

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	JP 2001-41153 A (Kabushiki Kaisha Zexel Vareo Kuraimeto Control), 13 February, 2001 (13.02.01), Par. Nos. [0006], [0089] to [0097]; Figs. 5 to 6, 12 (Family: none)	1-2, 5-6, 9, 13, 16, 20, 23, 27, 30, 34 3-4, 7-8, 10-12, 14-15, 17-19, 21-22, 24-26, 28-29, 31-33, 35-36
A		
E, X	JP 2005-83325 A (Toyota Industries Corp.), 31 March, 2005 (31.03.05), Par. Nos. [0058] to [0059] (Family: none)	1-9, 13-16, 20-23, 27-30, 34-36

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

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"O" document referring to an oral disclosure, use, exhibition or other means

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"&" document member of the same patent family

Date of the actual completion of the international search
20 June, 2005 (20.06.05)Date of mailing of the international search report
05 July, 2005 (05.07.05)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2005/005888

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 10-176658 A (Zexel Corp.), 30 June, 1998 (30.06.98), Full text; Figs. 1 to 3 & US 5947002 A & DE 19755066 A1 & CN 1186168 A	1-36
A	JP 2003-172417 A (Sanden Corp.), 20 June, 2003 (20.06.03), Full text; Figs. 1 to 2 (Family: none)	1-36

Form PCT/ISA/210 (continuation of second sheet) (January 2004)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2003172417 A [0002] [0008] [0052] [0058] [0062] [0064] [0064] [0078]
- JP 10176658 A [0002] [0008] [0052] [0058] [0062] [0064] [0064] [0078]
- WO 2003172417 A [0003]
- WO 10176658 A [0005]