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(54) **Variable displacement compressors**

(57) Variable displacement compressor may include a swash plate (8). The inclination angle of the swash plate can be changed to change the compressor output discharge capacity. A rotor (7) is coupled to the drive shaft so that the rotor rotates together with the drive shaft. A hinge mechanism (20) connects the swash plate with the rotor by means of a guide on a rotary disk of the rotor. The rotor preferably includes a set

of functional parts defined by a rotary disk (22), a guide (23) disposed on the rotary disk and a weight (24) disposed on the rotary disk to adjust the weight balance of the rotor. At least one of the functional parts is formed by pressing and punching a metal plate. In addition or in the alternative, two or more of the functional parts may be integrally and seamlessly manufactured by pressing and punching a metal plate.

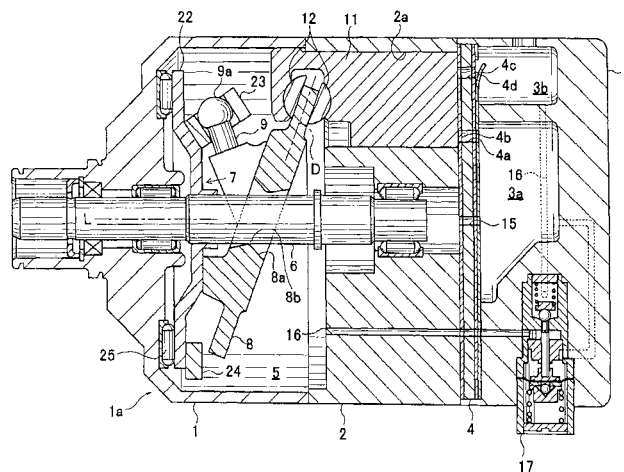


FIG. 1

Description

BACKGROUND OF THE INVENTION

Technical Field

[0001] The present invention relates to variable displacement compressors that utilize a rotating swash plate to the output discharge capacity of a compressed refrigerant. More particular, the present invention relates to compressors that may rotate the swash plate using a relatively simple and lightweight structure and to methods for making such compressors. Such compressors may be utilized in air conditioning systems and more preferably in automobile air conditioning systems.

Description of the Related Art

[0002] One type of variable displacement compressor is described in Japanese Laid-open Patent Publication No. 11-264371. This known variable displacement compressor is reproduced herein in Fig. 15 and includes a swash plate 104 coupled to a driving shaft 102 that is disposed within a driving chamber 101b. A compressor front housing 101 encloses the swash plate 104 and pistons 105 are slidably supported within respective cylinder bores 101a provided within a cylinder block 106. A shoe 110 engages the end portion of each piston 105 with the swash plate 104. A hinge mechanism 107 inclinably and slidably coupled the swash plate 104 to a rotor 103.

[0003] The rotor 103 is also coupled to the driving shaft 102. When the pressure within the driving chamber 101b increases or decreases in order to change the inclination angle of the swash plate 104, the length of the piston stroke is changed in response to the change of the inclination angle of the swash plate 104. As the result, the compressor output discharge capacity changes. The hinge mechanism 107 includes a guide 109 and a guide protrusion 108. The guide 109 is provided on the rotor 103 and has a guide hole 109a. The guide protrusion 108 is provided on the swash plate 104 and has a guide pin 108a. The guide pin 108a is slidably engaged with the guide hole 109a. Further, a thrust bearing 112 is disposed between the rotor 103 and the front housing 101.

[0004] The rotor 103 also includes a rotary disk 103a. A weight 111 is disposed on the rotary disk 103 to adjust the weight balance of the rotor 103. Also, the guide 109 is disposed on the rotary disk 103. The weight 111 and the guide 109 are molded by simultaneously casting these parts together with the rotary disk 103. The rotor 103 and hinge mechanism 107 rotate together with the drive shaft 102. Thus, the rotor 103 and hinge mechanism 107 are required to be relatively light in view of the centrifugal force exerted to the rotor 103 and hinge mechanism 107 due to the rotation together with the drive shaft 102. On the other hand, because it is rela-

tively difficult to mold a complicated and thin shape using casting techniques, it has been difficult to reduce the weight of the rotor 103 and the hinge mechanism 107 using the known art.

SUMMARY OF THE INVENTION

[0005] It is, therefore, an object of the present invention to provide variable displacement compressors that may utilize lighter weight parts for the torque transmitting structure disposed between the drive shaft and the swash plate. Methods of making such lighter weight parts are also described.

[0006] According to the present teachings, the functional parts of the rotor, such as the rotary disk, the guide and the weight may preferably be manufactured by pressing and punching a piece of plate metal. Each functional part may be separately manufactured in this manner or two or more parts may be preferably manufactured in an integral or seamless manner using these techniques.

[0007] Because the functional part(s) may be manufactured by pressing a plate, the thickness of the rotor can be reduced, as compared to known manufacturing techniques, without reducing the strength or integrity of the rotor. Thus, the weight of the torque transmitting structure between the drive shaft and the swash plate can be reduced. Preferably, the functional part(s) actually have greater strength and integrity than rotors manufactured using known techniques.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Fig. 1 shows a variable displacement compressor according to the first representative embodiment.

[0009] Fig. 2 shows the torque transmitting structure of the first representative embodiment.

[0010] Fig. 3 schematically shows the hinge mechanism.

[0011] Fig. 4 shows a perspective view of the rotor.

[0012] Fig. 5 (A) to Fig. 5 (C) show a representative process for manufacturing the rotary disk by pressing a plate.

[0013] Fig. 6 (A) to Fig. 6 (C) show a representative process for manufacturing the guide by pressing a plate.

[0014] Fig. 7 (A) and Fig. 7 (B) show a representative process for manufacturing the weight by pressing a plate.

[0015] Fig. 8 shows the torque transmitting structure according to the second representative embodiment.

[0016] Fig. 9 shows the torque transmitting structure according to the third representative embodiment.

[0017] Fig. 10 shows a perspective view of the rotor manufactured using a press.

[0018] Fig. 11 (A) to Fig. 11 (C) show a representative process for manufacturing the rotary disk together with the weight.

[0019] Fig. 12 (A) to Fig. 12 (C) show a representative process for manufacturing the guide.

[0020] Fig. 13 shows a perspective view of the rotor manufactured by pressing a plate according to the third embodiment.

[0021] Fig. 14 (A) to Fig. 14 (C) show a representative process for manufacturing the guide by pressing a plate.

[0022] Fig. 15 shows the torque transmitting structure according to a known variable displacement compressor.

DETAILED DESCRIPTION OF THE INVENTION

[0023] Representative variable displacement compressors according to the present teachings may include a drive shaft, a swash plate, a piston, a rotor and a hinge mechanism. The swash plate may be inclinably coupled to the drive shaft. The piston may be disposed within a cylinder bore and the end portion of the piston may be connected to a peripheral edge of the swash plate by utilizing a shoe. The piston can reciprocate within the cylinder bore to compress the refrigerant in response to rotation of the inclined swash plate. The inclination angle of the swash plate can be changed. When the inclination angle is changed, the compressor output discharge capacity can be changed. The rotor may be coupled to the drive shaft and the rotor may rotate together with the rotating drive shaft.

[0024] The rotor may include functional parts, such as a rotary disk, a guide disposed on the rotary disk and a weight disposed on the rotary disk. The weight may be utilized to adjust the weight balance of the rotating rotor. According to the present teachings, at least one of the functional parts can be formed by pressing and punching a plate of metal. The hinge mechanism may connect the swash plate with the rotor by means of the guide on the rotary disk of the rotor.

[0025] The hinge mechanism transmits torque from the driving shaft to the swash plate, regardless of the inclination angle of the swash plate. Because at least one of the functional parts is manufactured by pressing and punching a plate, the thickness of the rotor can be reduced and the weight of the torque transmitting structure between the drive shaft and the swash plate can be reduced.

[0026] Although each functional part may be separately manufacture by pressing and punching a plate, any two of the functional parts may be integrally or seamlessly manufactured by pressing and punching a plate. For example, the rotary disk and the weight, or the weight and the guide may be integrally manufactured by pressing and punching a plate.

[0027] According to the another aspect of the present teachings, a hinge mechanism may connect the swash plate with the rotor in order to transmit torque from the driving shaft to the swash plate. For example, a guide member may be engaged with a guide protrusion. Moreover, either the guide member or the guide protrusion

may preferably be manufactured independent from the rotary disk and may then be integrally joined to the rotary disk. Preferably, the rotary disk and/or the guide may be manufactured by pressing and punching a plate in order to reduce the weight of the torque transmitting structure.

[0028] Each of the additional features and method steps disclosed above and below may be utilized separately or in conjunction with other features and method steps to provide improved variable displacement compressors and air conditioning systems and methods for making and using such variable displacement compressors and air conditioning systems. Representative examples of the present invention, which examples utilize many of these additional features and method steps in conjunction, will now be described in detail with reference to the drawings. This detailed description is merely intended to teach a person of skill in the art further details for practicing preferred aspects of the present teachings and is not intended to limit the scope of the invention. Only the claims define the scope of the claimed invention. Therefore, combinations of features and steps disclosed in the following detail description may not be necessary to practice the invention in the broadest sense, and are instead taught merely to particularly describe some representative examples of the invention, which detailed description will now be given with reference to the accompanying drawings.

[0029] Although the following detailed representative embodiments are preferably utilized in an air conditioning system for an automotive, other uses of the present teachings are naturally contemplated.

[0030] The first representative embodiment will now be described in further detail with reference to Figs. 1 to 7. As shown in Fig.1, the representative compressor 1a includes a compressor housing defined by a front housing 1, a cylinder block 2 and a rear housing 3. The front housing 1 is coupled to the front end of the cylinder block 2. The rear housing 3 is coupled to the rear end of the cylinder block 2. A valve plate 4 is provided between the cylinder block 2 and the rear housing 3.

[0031] A crank chamber 5 is defined by a space within the front housing 1. A drive shaft 6 is rotatably supported within the crank chamber 5. Although it is not particularly shown in the drawings, the drive shaft 6 is preferably connected to an automotive engine by an electromagnetic clutch. That is, the engine causes the drive shaft 6 to rotate when clutch mechanism couples the driving force of the engine to the drive shaft 6.

[0032] Within the crank chamber 5, a rotating swash plate 8 is inclinably and slidably coupled to the drive shaft 6 via a rotor 7. The rotor 7 is coupled to the drive shaft 6 and can rotate together with the drive shaft 6. The drive shaft 6 extends through a penetration hole 8a formed in the center of the swash plate 8. A hinge mechanism 20 is provided between the rotor 7 and the swash plate 8 in order to transmit torque from the drive shaft 6 to the swash plate 8, which swash plate 8 may rotate at various inclination angles.

[0033] In order to allow the swash plate 8 to incline, the penetration hole 8a preferably has a support point 8b. The hinge mechanism 20 preferably includes a guide member 23 disposed on the rotor 7 and a guide pin 9 disposed on the swash plate 8. The guide member 23 corresponds to a "rotor-side member". The guide member 23 and the guide pin 9 are mutually engaged to connect the swash plate 8 with the rotor 7.

[0034] The cylinder block 2 preferably includes six cylinder bores 2a that are disposed in six pistons 11. However, Fig. 1 only shows one piston for purposes of illustration. Each piston 11 is reciprocally and slidably supported each cylinder bore 2a. The piston 11 is coupled to the swash plate 8 via a shoe 12. The rotational movement of the swash plate 8 is converted into reciprocating movement of the pistons 11 via the shoe 12.

[0035] A suction chamber 3a and a discharge chamber 3b are respectively defined by spaces within the rear housing 3. A suction port 4a, a suction valve 4b, a discharge port 4c, and a discharge valve 4d are preferably disposed on the valve plate 4. When the piston 11 reciprocates, refrigerant in the suction chamber 3a is drawn into the cylinder bore 2a from the suction port 4a via the suction valve 4b. Then, the refrigerant is compressed and the compressed refrigerant is discharged from the discharge port 4c to the discharge chamber 3b via the discharge valve 4d.

[0036] The crank chamber 5 preferably communicates with the discharge chamber 3b via a capacity control passage 16. The capacity control passage 16 is opened and closed by a capacity control valve 17. The pressure state within the crank chamber 5 is controlled by opening and closing the capacity control passage 16. In addition, a bleeding passage 15 preferably connects the crank chamber 5 and the suction chamber 3a.

[0037] As shown in Fig. 4, the rotor 7 preferably includes functional parts, such as a rotary disk 22 coupled to the drive shaft 6, the guide member 23 and a weight 24. As described above, the guide member 23 and the guide pin 9 together define the hinge mechanism 20. The weight 24 offsets any weight imbalance of the rotor 7 caused by the guide member 23 when the rotor rotates together with the drive shaft 6. In this representative embodiment, each functional part is formed independently of the others. As shown in Fig. 2, the rotary disk 22 has a disk-like shape and an insertion hole 22a is defined substantially in the center of the rotary disk 22. Further, the rotary disk 22 is mounted to the drive shaft 6 by inserting the drive shaft 6 into the insertion hole 22a. The insertion hole 22a is formed in a tube-like shape that extends toward the rear of the rotary disk 22 along the drive shaft 6. A thrust bearing 25 is disposed between the front face of the rotary disk 22 and the front housing 1, which thrust bearing 25 circumferentially surrounds the drive shaft 6. In addition, the thrust bearing 25 preferably includes a roller 25a that directly contacts the rotary disk 22. Thus, the compressive reaction force generated by the reciprocation of the pistons 11 is received

by the front housing 1 through the shoe 12, the swash plate 8, the hinge mechanism 20, and the thrust bearing 25.

[0038] As shown in Fig. 2, the guide member 23 is fixed to the rear face of the rotary disk 22 in order to correspond to the upper dead point D of the swash plate 8. The upper dead point of the swash plate 8 defines the top clearance of the pistons 11. Fig. 3 shows a plan view of the hinge mechanism 20, in which each end of the guide member 23 substantially has a curved shape that defines a support 23a for receiving the guide pin 9. Further, the guide member 23 has a plane that defines a connecting portion 23b that affixes the guide member 23 to the rotary disk 22. The central axis S of the support 23a extends parallel to the plane that includes the rotational axis L of the drive shaft 6 and the position corresponding to the upper dead point D of the swash plate 8. The guide member 23 is fixed to the rotary disk 22 by spot welding at a plurality of points.

[0039] As shown in Fig. 2, the weight 24 is fixed to the bottom part on the rear face of the rotary disk 22. Because the guide member 23 is fixed to the rotor 7, the center of gravity of the rotor 7 is shifted from the rotational axis L of the drive shaft 6. In order to rectify this weight imbalance, the weight 24 is provided on the lower rear edge of the rotor 7 at a position that is opposite to the guide member 23. Thus, the center of gravity of the rotor 7 is adjusted to correspond to the axis of rotation defined by the axis L of the drive shaft 6. In this embodiment, the weight 24 is preferably fixed to the rotary disk 22 by spot welding, although other attaching methods may naturally be utilized.

[0040] As shown in Fig. 4, the rotary disk 22, the guide member 23, and the weight 24 are manufactured independently of one another and then, joined together to form the rotor 7. Therefore, each part can be made of a different material that may be appropriate for the particular application, and each part can be manufactured differently in order to provide optimal properties for each of the functional parts. Representative manufacturing methods for each functional part of the rotor 7 are respectively shown in Figs. 5 to 7. For example, Fig. 5 (A) to Fig. 5 (C) show a representative manufacturing process for the rotary disk 22. In order to make the rotary disk 22, a plate W is first prepared by pressing a cold-rolled steel plate or carbon steel, such as S35C or S45C, into an appropriate thickness (see Fig. 5 (A)). Then, the plate W is punched with an appropriate cutting device, e.g. a die, in order to form a disk A1 having a circular insertion hole defined in the center of the disk A1 (see Fig. 5 (B)). Thereafter, the rotary disk 22 is manufactured by deeply drawing the disk A1 (see Fig. 5 (C)).

[0041] Figs. 6 (A) to Fig. 6 (C) show a representative manufacturing process for the guide member 23. First, a plate W is prepared by pressing a cold-rolled steel plate or carbon steel, such as S35C or S45C, to an appropriate thickness (see Fig. 6 (A)). Then, the plate W is punched to form a rectangular plate B1 (see Fig. 6

(B)). Thereafter, the guide member 23 is manufactured by utilizing a bending machine (see Fig. 6 (C)). Figs. 7 (A) and (B) show a representative manufacturing process for the weight 24. As with the previous representative techniques, a plate W is pressed to an appropriate thickness (see Fig. 7 (A)) and then the plate W is punched provide the weight 24 having a semicircular shape (see Fig. 7 (B)).

[0042] After the above-described manufacturing process, any distortions are removed from the supports 23a and the supports 23a are surface-treated with induction hardening in order to improve the strength and wear-resistance of the supports 23a. Similarly, a thrust bearing receiver 22c of the rotary disk 22 is surface-treated with induction hardening. Because each functional part of the rotor 7 is individually manufactured, such surface-treating process can be easily performed. After the manufacturing process is completed, the guide member 23 and the weight 24 are welded to the rotary disk 22 (see Fig.4) in order to provide the rotor 7.

[0043] The guide pin 9 corresponds to a "guide protrusion" as utilized herein. As shown in Fig. 2, a pair of guide pins 9 protrudes from the front face of the swash plate 8 toward the guide member 23. The guide pins 9 straddle the position corresponding to the upper dead point D of the swash plate 8. A spherical portion 9a is formed on the top of each guide pin 9. The spherical portion 9a is inserted into and engaged with the guide member 23. The radius of curvature of the spherical portion 9a is slightly less than the radius of curvature of the support 23a. Thus, the swash plate 8 can slide while inclining toward the drive shaft 6 in the direction of the axis L of the drive shaft 6, due to the slide-guide relationship between the spherical portions 9a of the guide pins 9 and the supports 23a of the guide member 23, as well as due to the slide-support action by the drive shaft 6 by way of the insertion hole 8a.

[0044] In the first representative embodiment, the rotary disk 22, the rotor-side member 23, and the weight 24 are independently manufactured and each functional part is manufactured with a press and a punch. Therefore, each part may be hardened and lightened. Further, the thickness of the rotor can be reduced as compared to known rotors.

[0045] Because the rotary disk 22 is manufactured with a press, material having high wear resistance can be utilized for the rotary disk 22. Therefore, the roller 25a of the thrust bearing 25 can directly contact the rotary disk 22 during operation of the compressor. In other words, because it is not necessary to provide a race with the thrust bearing 25, a reduction in the number of parts can be achieved.

[0046] The second representative embodiment is shown in Fig. 8, in which the rotary disk 22 and the weight 22d are integrally formed as one part. That is, rotary disk 22 and the weight 22d are manufactured at the same time using a press machine and there are no seams between the rotary disk 22 and the weight 22d.

As the result, the weight 22d is formed in a unitary manner on the lower rear face of the rotary disk 22.

[0047] In addition, a different type of the hinge mechanism is utilized in the second representative embodiment. In this case, the guide member 23 has a plate-like shape and includes an elongated hole 26. The swash plate 8 includes a pin 27 that is engaged in the elongated hole 26. As the result, the hinge mechanism is defined by a link-and-pin mechanism. All other features of the second representative embodiment are substantially identical to the corresponding features of the first representative embodiment. According to the second representative embodiment, because the functional parts of the rotor 7 are integrally (seamlessly) manufactured at the same time using a press, the number of parts of the torque transmitting structure can be reduced.

[0048] The third representative embodiment is shown in Figs. 9 to 13. As shown in Figs. 9 and 10, the rotary disk 22 and the weight 22d are manufactured at the same time using a press in the second representative embodiment. The weight 22d is provided on the outer circumference of the lower rear face of the rotary disk 22. As described above, the weight 22d can correct the weight imbalance of the rotor 7 when the hinge mechanism 20 rotates together with the drive shaft 6.

[0049] In the third embodiment, a link-type hinge mechanism 20 is utilized. As shown in Fig. 10, an insertion hole 23c is defined within the guide member 23 and link parts 23d are disposed on the right and left sides of the guide member 23. Each link part 23d includes an elongated hole 26. The inner diameter of the insertion hole 23c is defined to correspond to the outer circumferential diameter of a cylindrical boss part 22f of the rotary disk 22. By inserting the boss part 22f to the insertion hole 23, the guide member 23 is coupled to the rotary disk 22. As shown in Fig. 9, a guide pin 27 is provided on the swash plate 8 and is engaged with the elongated hole 26. All other features of the third representative embodiment are substantially identical to the features of the first representative embodiment as described above.

[0050] A representative manufacturing process for the rotary disk 22 with the weight 22d is shown in Fig. 11 (A) to Fig. 11 (C). First, a plate W is prepared by pressing a cold-rolled steel plate or carbon steel, such as S35C or S45C, into an appropriate thickness (see Fig. 11 (A)). Then, the plate W is punched to form a disk A2 having a circular insertion hole in the center of the disk A2 (see Fig. 11 (B)). Thereafter, the rotary disk 22 with the weight 22d is manufactured by bending and drawing the disk A2 (see Fig. 11 (C)). A representative manufacturing process for the guide member 23 is shown in Fig. 12 (A) to Fig. 12 (C). First, a plate W is prepared by pressing a cold-rolled steel plate or carbon steel, such as S35C or S45C, to an appropriate thickness (see Fig. 12 (A)). Then, the plate W is punched to form a disk B2 having a insertion hole formed in the center of the disk B2 (see Fig. 11 (B)). Thereafter, link parts

23d are formed by bending the disk B2 (see Fig. 12 (C)). After the rotary disk 22 and the guide member 23 are independently manufactured, the guide member 23 is fixed to the rotary disk 22 by joining the cylindrical boss part 22f of the rotary disk 22 to the insertion hole 23c of the guide member 23. After the joining, the guide member 23 is welded to the rotary disk 22.

[0051] A thrust bearing receiving portion 22c (see Fig. 9) and the inner circumferential surface of the elongated hole 26 are preferably treated by induction hardening in order to increase the strength and the wear resistance of these parts. All other features of the third representative embodiment are substantially identical to the features of the first representative embodiment as described above. According to the third representative embodiment, a relatively lightweight rotor 7 can be easily manufactured.

[0052] The fourth representative embodiment is shown in Figs. 13 and 14. According to the fourth embodiment, the guide member 23 and the weight 22d are integrally and seamlessly manufactured using a press. All other features of the fourth representative embodiment are substantially identical to the features of the first representative embodiment as described above.

[0053] A representative manufacturing process for the guide member 23 with the weight 22d is shown in Fig. 14 (A) to Fig. 14 (C). First, a plate W is prepared by pressing a cold-rolled steel plate or carbon steel, such as S35C or S45C, to an appropriate thickness (see Fig. 11 (A)). Then, the plate W is punched to form a disk B3 (see Fig. 14 (B)). Thereafter, the guide member 23 with the weight 22d is manufactured by bending and drawing the disk B3 (see Fig. 14 (C)). The joining of the guide member 23 (with the weight 22d) and the rotary disk 22 is completed by welding.

[0054] Various modifications can be made to the representative embodiments. For example, the support 23a of the guide member 23 may be formed to have a cylindrical shape. Further, the functional parts of the rotor 7 can be fixed with each other by utilizing a screw or rivet, instead of welding.

[0055] Moreover, the guide member may be provided with the swash plate 8. In the alternative, the guide protrusion (guide pin) may be provided with the rotor 7.

Claims

1. A variable displacement compressor comprising:

a drive shaft,
 a swash plate inclinably coupled to the drive shaft,
 a piston disposed within a cylinder bore, an end portion of the piston connected to a peripheral edge of the swash plate by a shoe, the piston reciprocating within the cylinder bore to compress the refrigerant in response to rotation of

the inclined swash plate, wherein the inclination angle of the swash plate can be changed to change the compressor output discharge capacity,

a rotor coupled to the drive shaft, wherein the rotor rotates together with the rotating drive shaft, the rotor includes functional parts defined by a rotary disk, a guide disposed on the rotary disk and a weight disposed on the rotary disk to regulate the weight balance of the rotating rotor,

a hinge mechanism connecting the swash plate with the rotor by means of the guide on the rotary disk of the rotor, the hinge mechanism transmitting torque from the driving shaft to the swash plate regardless of the inclination angle of the swash plate,

characterized in that at least one of the functional parts is formed by pressing a plate.

2. A variable displacement compressor according to claim 1, wherein each functional part is separately manufactured by pressing and punching a plate.
3. A variable displacement compressor comprising:

a drive shaft,
 a swash plate inclinably coupled to the drive shaft,

a piston disposed within a cylinder bore, an end portion of the piston connected to a peripheral edge of the swash plate by a shoe, the piston reciprocating within the cylinder bore to compress the refrigerant in response to rotation of the inclined swash plate, wherein the inclination angle of the swash plate can be changed to change the compressor output discharge capacity,

a rotor coupled to the drive shaft, wherein the rotor rotates together with the rotating drive shaft, the rotor includes functional parts defined by a rotary disk, a guide disposed on the rotary disk and a weight disposed on the rotary disk to adjust the weight balance of the rotating rotor,

a hinge mechanism connecting the swash plate with the rotor by means of the guide on the rotary disk of the rotor, the hinge mechanism transmitting torque from the driving shaft to the swash plate regardless of the inclination angle of the swash plate,

characterized in that at least two of the functional parts are integrally and seamlessly manufactured by pressing and punching a plate.

4. A variable displacement compressor according to

claim 3, wherein the rotary disk and the weight are integrally and seamlessly manufactured by pressing and punching a plate.

5. A variable displacement compressor according to claim 3, wherein the weight and the guide are integrally and seamlessly manufactured by pressing and punching a plate. 5
6. A variable displacement compressor comprising: 10
- a drive shaft,
 - a swash plate inclinably coupled to the drive shaft,
 - a piston disposed within a cylinder bore, an end portion of the piston connected to a peripheral edge of the swash plate by a shoe, the piston reciprocating within the cylinder bore to compress the refrigerant in response to rotation of the inclined swash plate, wherein the inclination angle of the swash plate can be changed to change the compressor output discharge capacity, 15
 - a rotor that includes a rotary disk rotatably coupled to the drive shaft and 20
 - a hinge mechanism that includes a guide member and a guide protrusion that receives the guide member, the hinge mechanism connecting the swash plate with the rotor to transmit torque from the driving shaft to the swash plate by means of the guide member engaged with the guide protrusion regardless of the inclination angle of the swash plate, 25
- characterized in that** at least one of the guide member and the guide protrusion is manufactured independent from the rotary disk and is then integrally joined to the rotary disk. 30
7. A variable displacement compressor according to claim 6, wherein the rotary disk is manufactured by pressing and punching a plate. 40
8. A variable displacement compressor according to claim 6, wherein the guide is manufactured by pressing and punching a plate. 45
9. A variable displacement compressor according to any one of claims 1 to 6 further comprising a thrust bearing that includes a roller to rotatably support the rotor, wherein the thrust bearing is provided between the inner surface of the compressor housing and the rotor and the roller directly contacts the front surface of the rotor. 50
10. A method of manufacturing a variable displacement compressor according to claim 1 **characterized by** pressing and punching a metal plate in order to form 55

at least one functional part, wherein the functional parts are then joined in order to form the rotor.

11. A method of manufacturing a variable displacement compressor according to claim 2 **characterized by** separately pressing and punching a plurality of metal plates in order to form the functional part, wherein the functional parts are then joined in order to form the rotor.
12. A method of manufacturing a variable displacement compressor according to claim 3 **characterized in that** at least two functional parts are integrally and seamlessly manufactured using at least two types of manufacturing processes defined by pressing and punching a plate.
13. A method according to claim 12, wherein the rotary disk and the weight are integrally and seamlessly manufactured.
14. A method according to claim 12, wherein the weight and the guide are integrally and seamlessly manufactured.
15. A method for manufacturing a compressor **characterized by** the steps of:
- forming a rotary disk by pressing a metal plate W to a thickness corresponding the final thickness of the rotary disk, punching the metal plate to form an intermediate disk part and then deeply drawing the intermediate disk part to form the rotary disk, and
 - assembling the rotary disk with a guide member and a weight on a drive shaft of the compressor.
16. A method for manufacturing a compressor **characterized by** the steps of:
- forming a guide member by pressing a metal plate W to a thickness corresponding the final thickness of the guide member, punching the metal plate to form an intermediate guide part and then bending the intermediate guide part to form the guide member, and
 - assembling the guide member with a rotary disk and a weight on a drive shaft of the compressor.
17. A method for manufacturing a compressor **characterized by** the steps of:
- forming a balancing weight by pressing a metal plate W to a thickness corresponding the final thickness of the rotary disk, punching the metal plate to form the balancing weight, and
 - assembling the balancing weight with a rotary disk and a guide member on a drive shaft of the

compressor.

- 18.** A method as in claim 17, wherein the balancing weight is integrally and seamlessly manufactured with the rotary disk by pressing and punching the metal plate to form an intermediate disk part and then bending and drawing the intermediate disk part to form the balancing weight and the rotary disk. 5
- 19.** A method as in claim 18, further comprising forming link parts by bending the intermediate disk part. 10
- 20.** A method as in claim 17, wherein the balancing weight is integrally and seamlessly manufactured with the guide member by pressing and punching the metal plate to form an intermediate disk part and then bending and drawing the intermediate disk part to form the balancing weight and the guide member. 15
- 21.** A method as in any one of claims 15 to 20, wherein the metal plate is cold-rolled steel plate or carbon steel, such as S35C or S45C. 20

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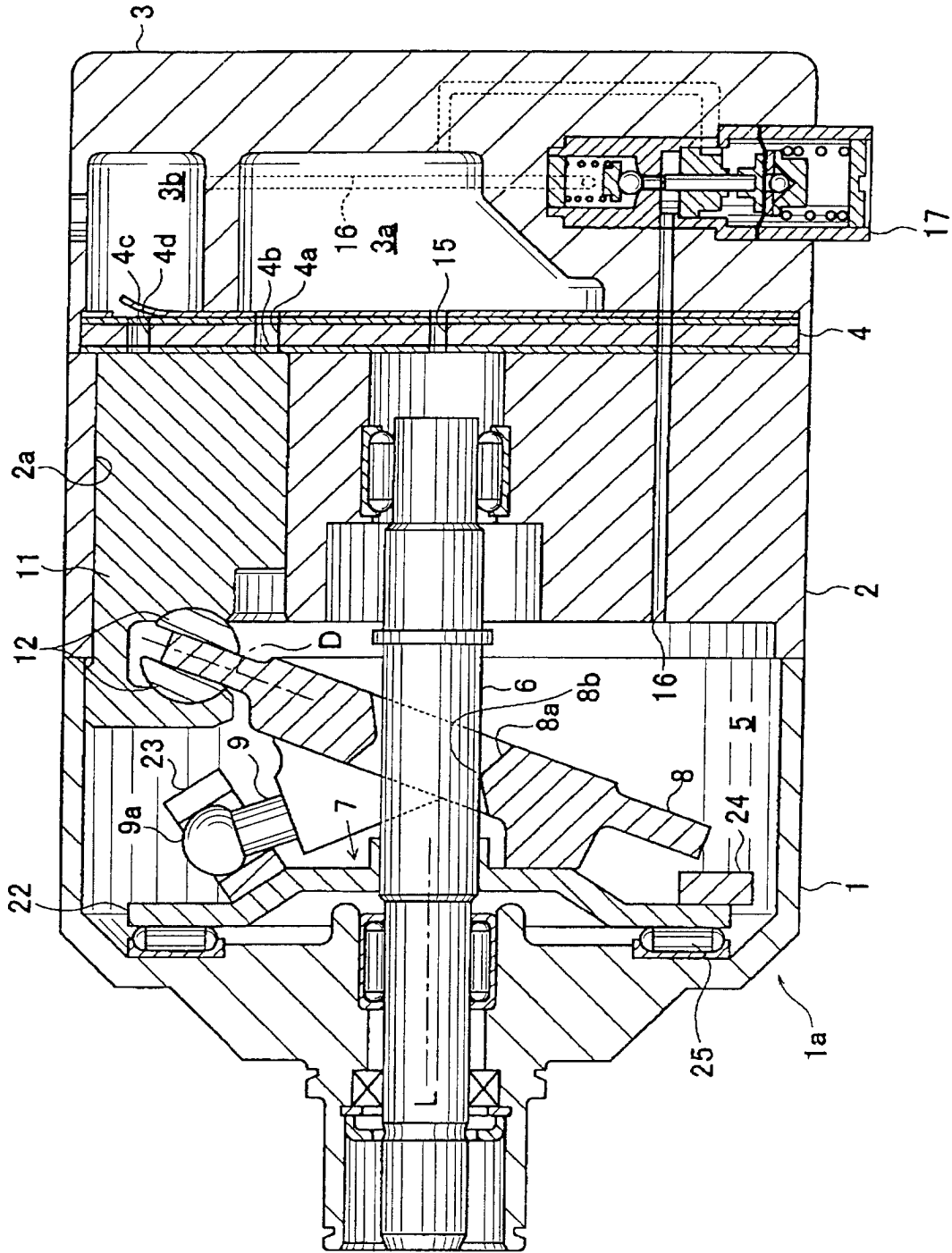


FIG.1

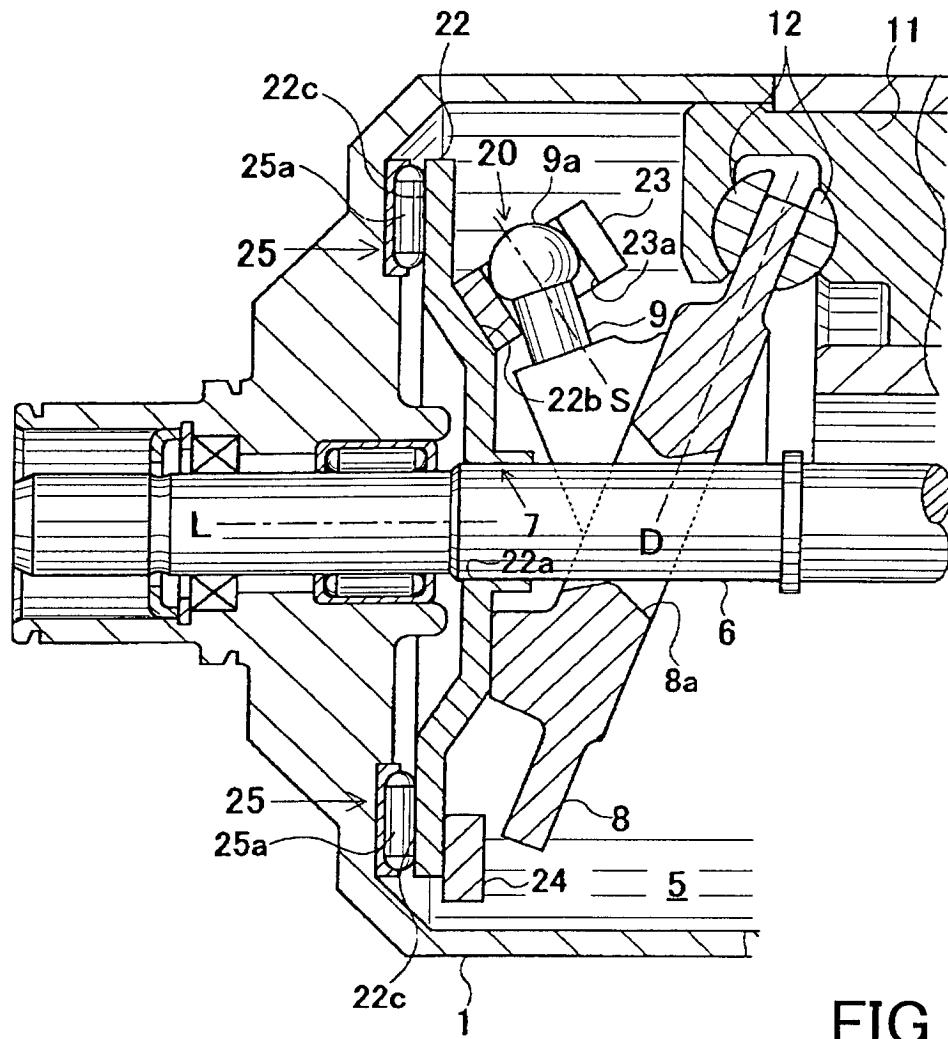


FIG. 2

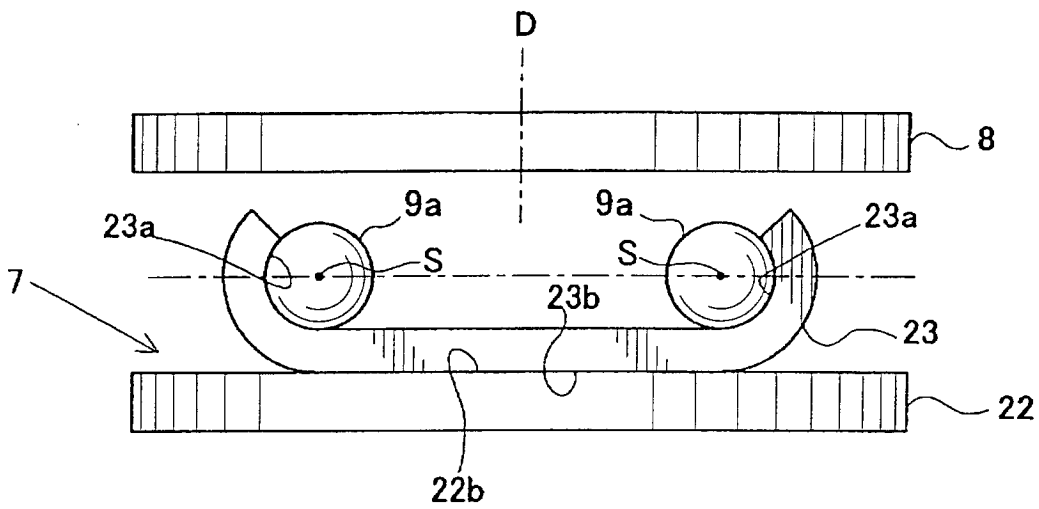


FIG. 3

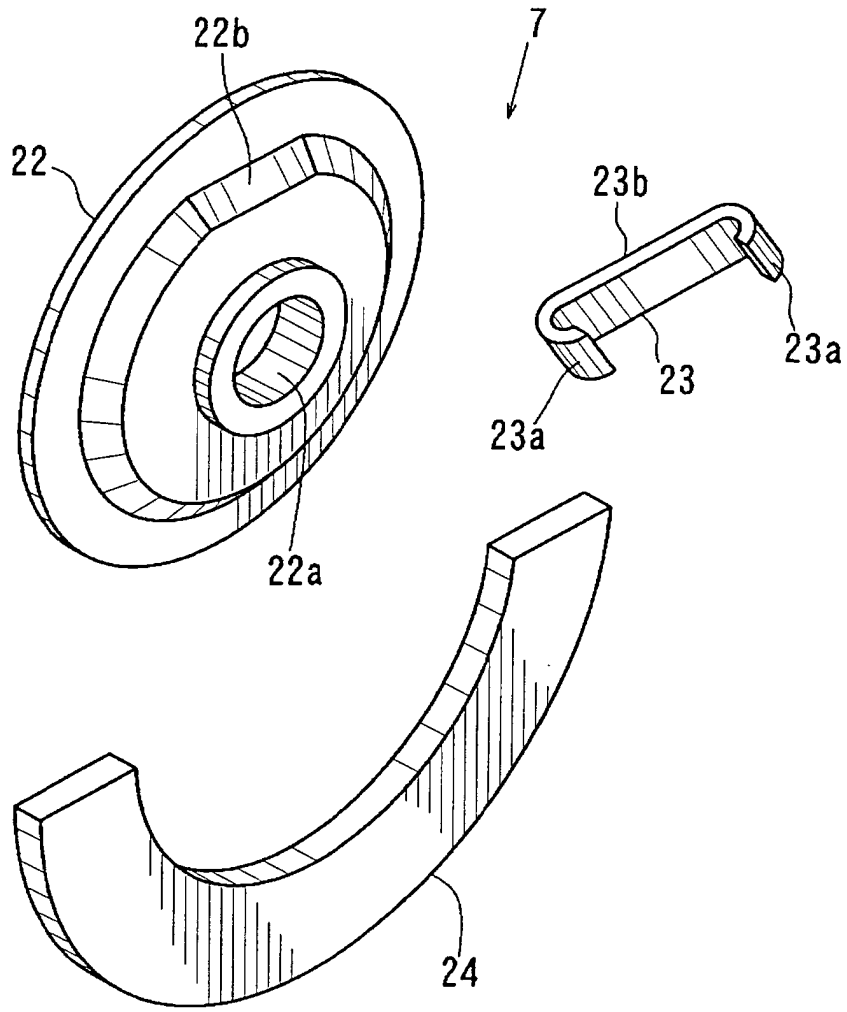


FIG.4

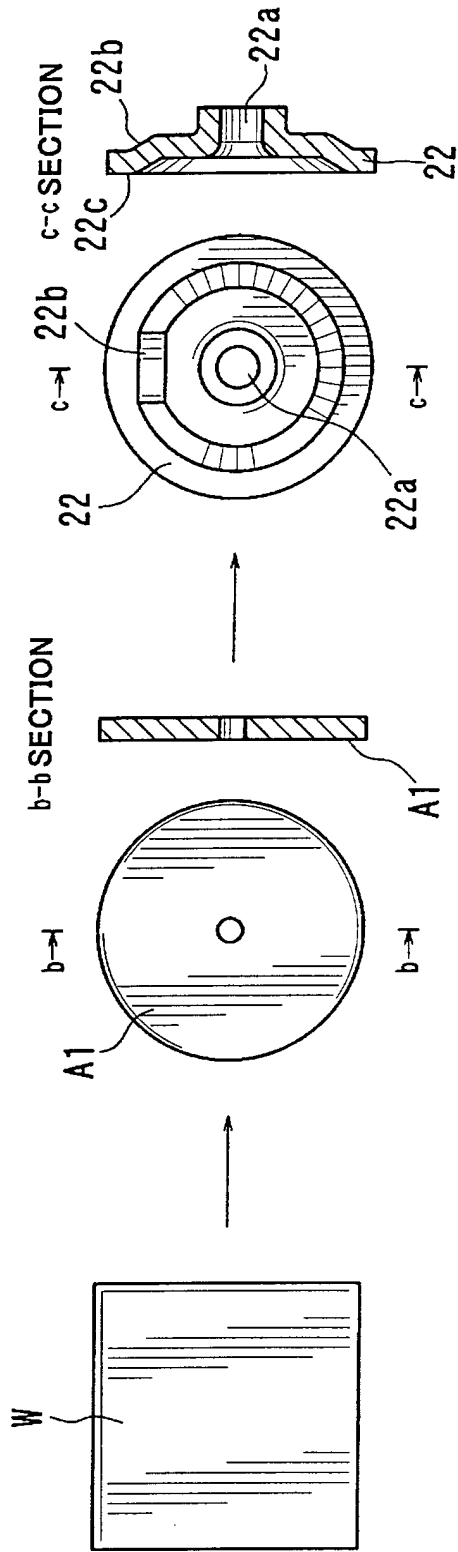


FIG.5(A)

FIG.5(B)

FIG.5(C)

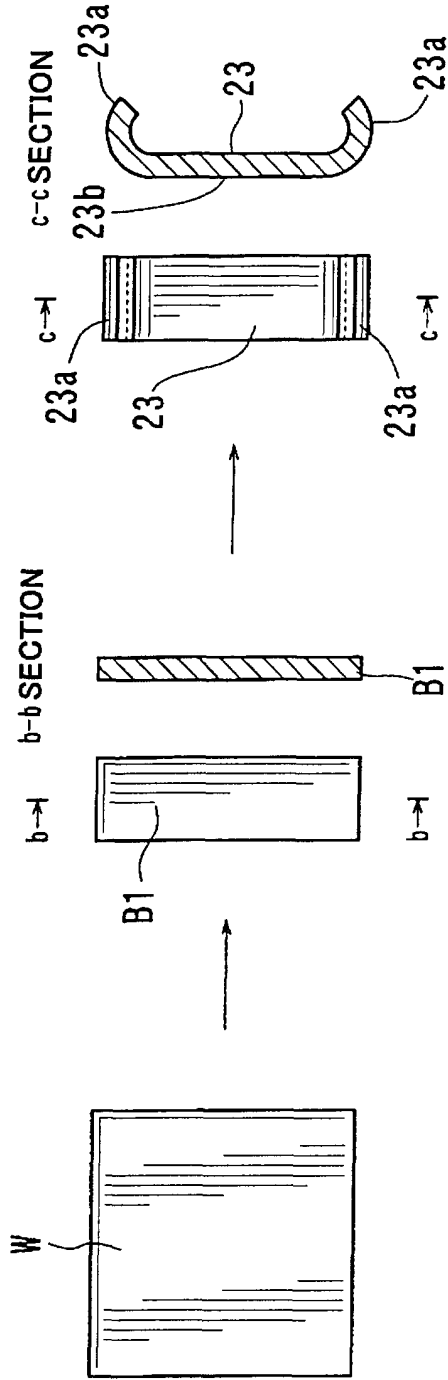


FIG.6(A)

FIG.6(B)

FIG.6(C)

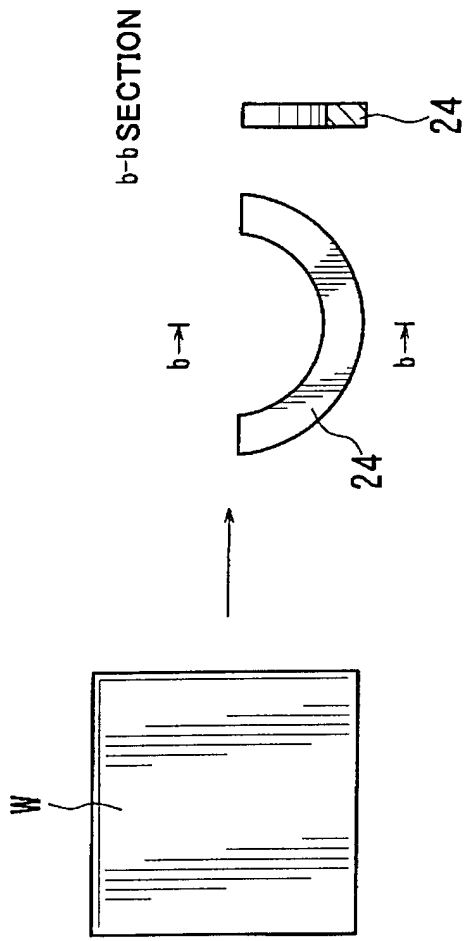


FIG.7(A)

FIG.7(B)

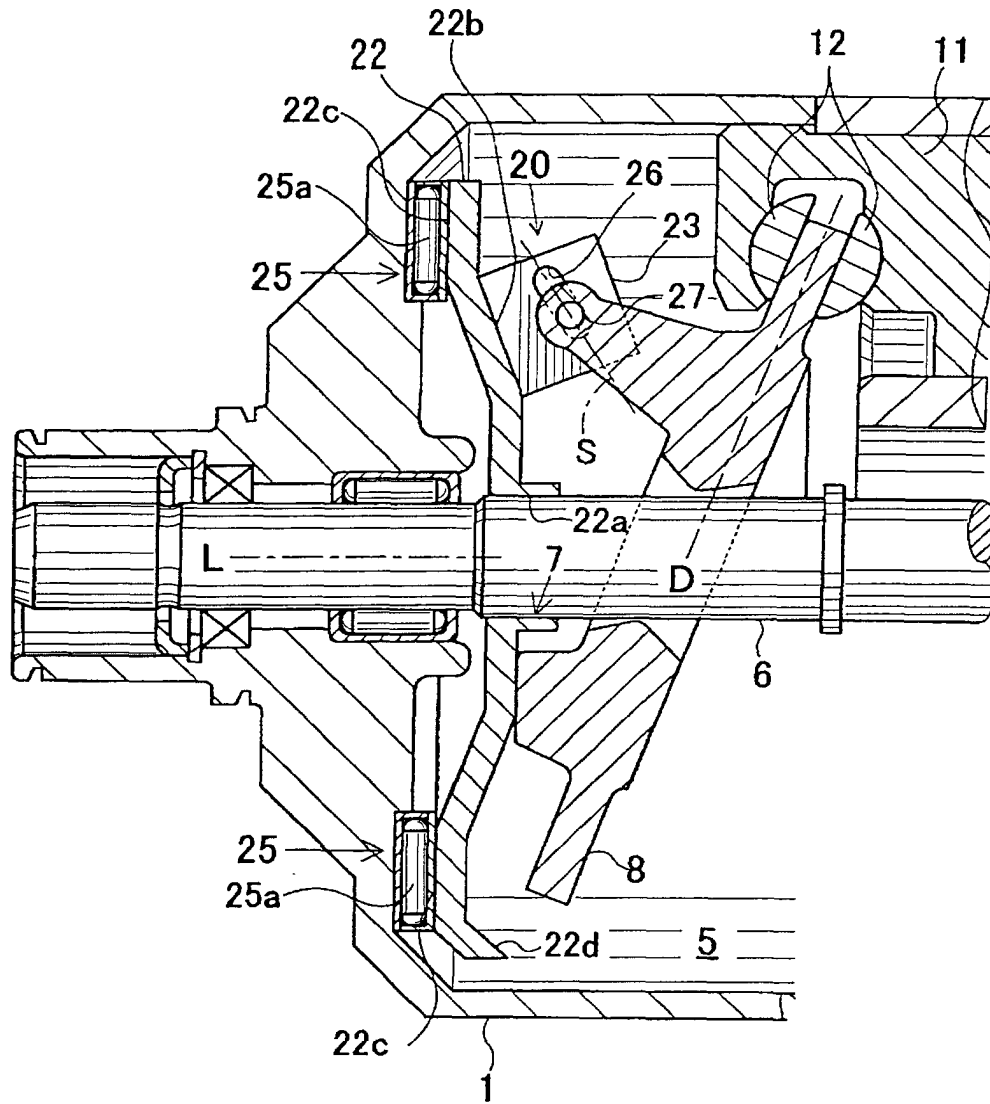


FIG.8

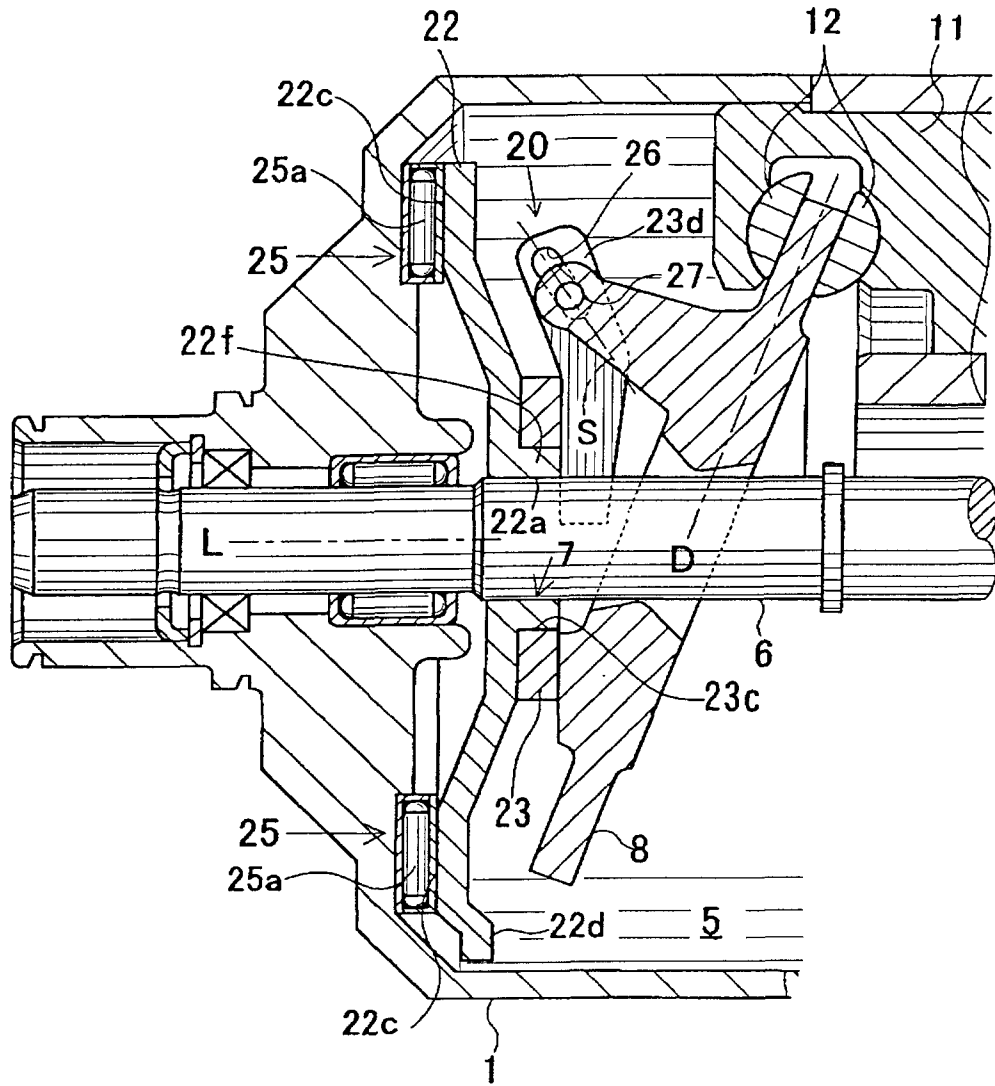


FIG. 9

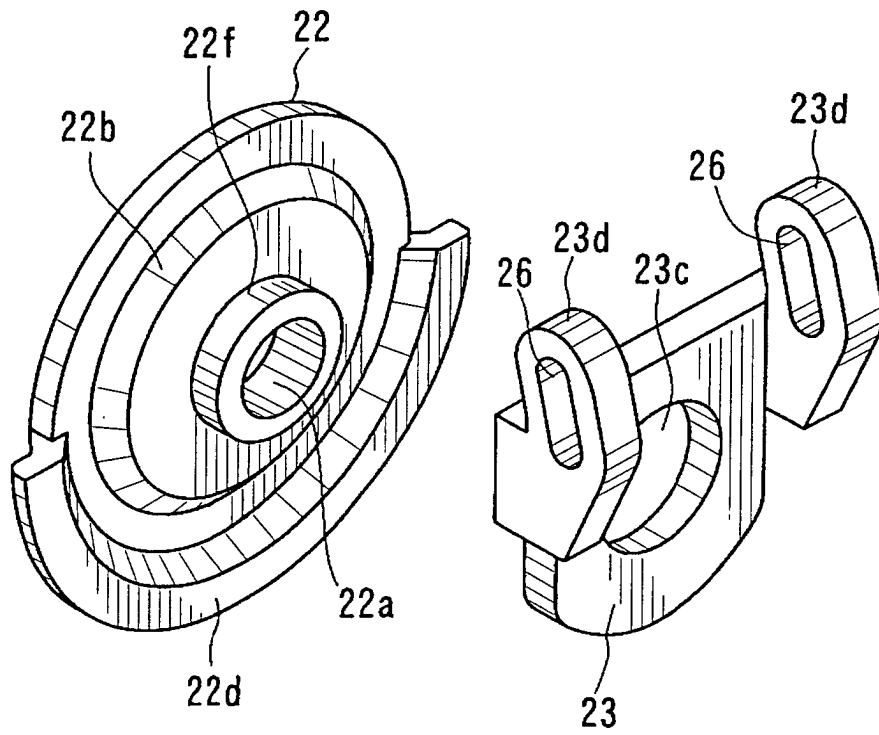


FIG.10

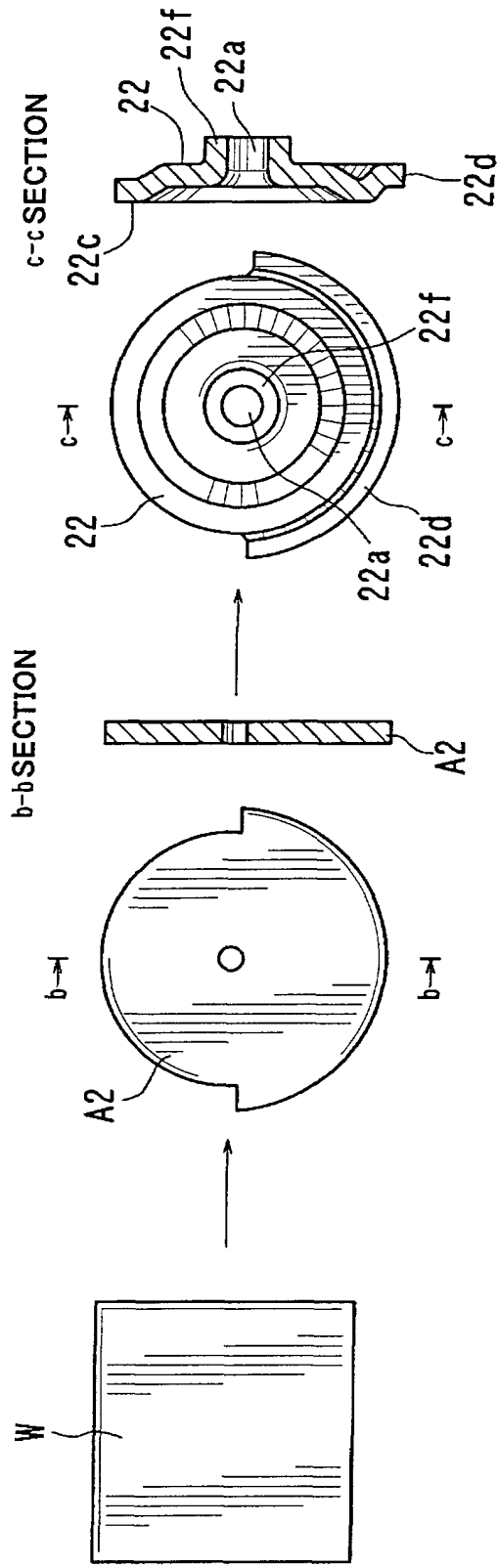


FIG.11(A)

FIG.11(B)

FIG.11(C)

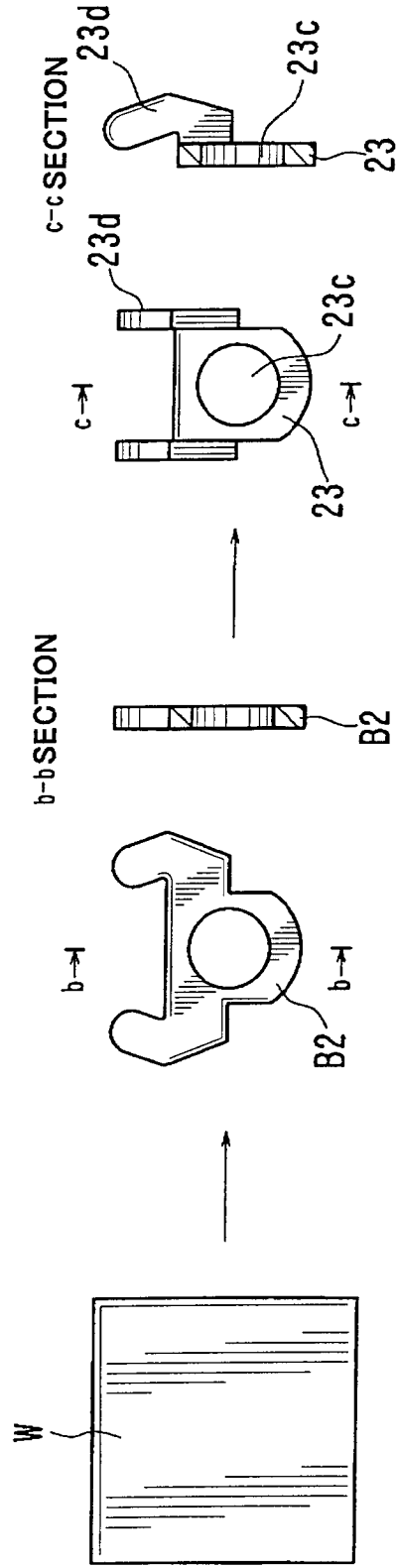


FIG.12(A)

FIG.12(B)

FIG.12(C)

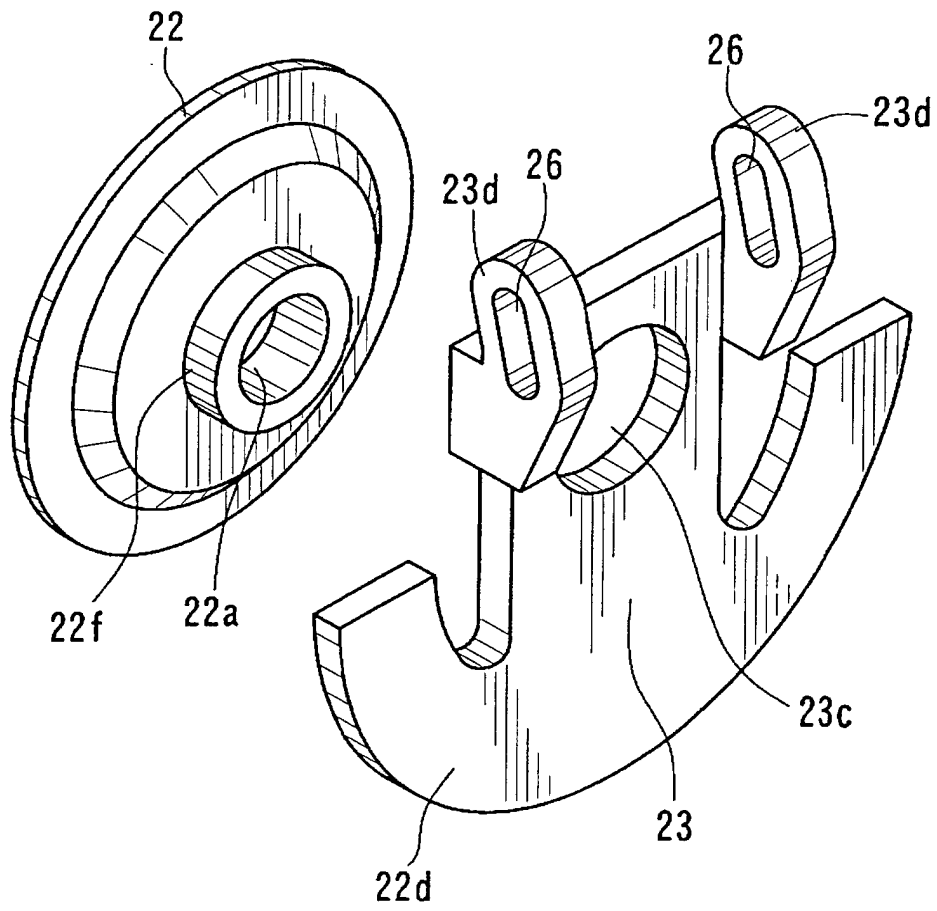


FIG.13

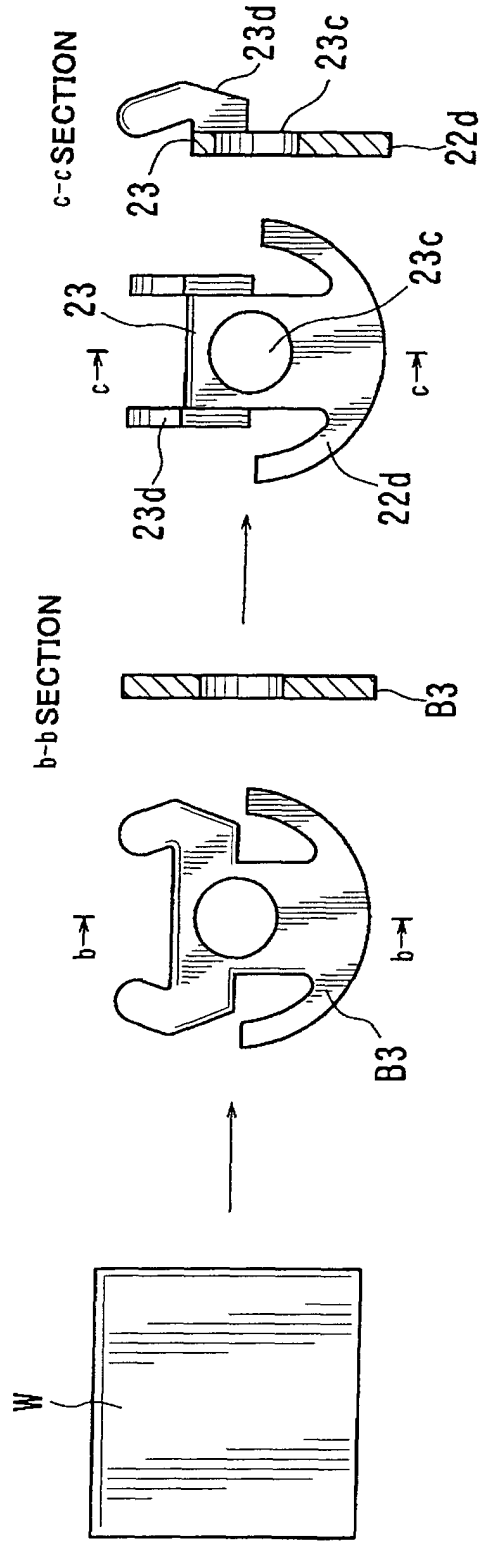


FIG.14(A)

FIG.14(B)

FIG.14(C)

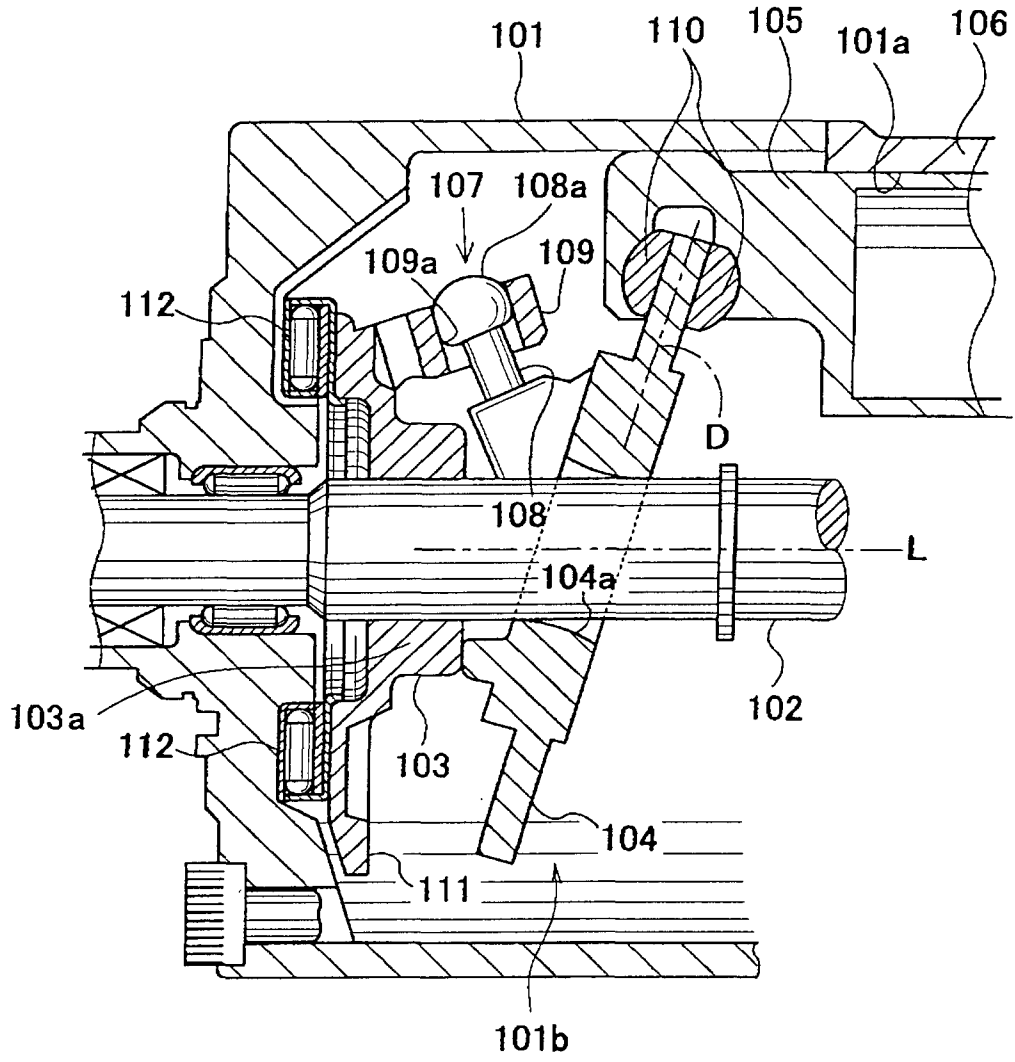


FIG.15
PRIOR ART



| DOCUMENTS CONSIDERED TO BE RELEVANT | | | |
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| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int.Cl.7) |
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| Place of search MUNICH | | Date of completion of the search 4 February 2002 | Examiner Pinna, S |
| <p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons</p> <p>& : member of the same patent family, corresponding document</p> | | | |

EPO FORM 1503 03 82 (P04C01)



The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. Claims: 1,2,10-11, 15-21

A variable displacement compressor where at least one of the functional parts (rotary disk, guide, and balancing weight) are realised by pressing a plate and a method to manufacture such a compressor.

2. Claims: 3-5,12-14

A variable displacement compressor where at least two of the functional parts (rotary disk, guide, balancing weight) are manufactured integrally and seamlessly, by pressing and punching a plate.

3. Claims: 6-9

A variable displacement compressor where at least one of the guide member and the guide protrusion is manufactured independent from the rotary disk and is then integrally joined to the rotary disk.

The first group of claims is concerned with a variable displacement compressor of the swash-plate type (cf. claims 1,2) and with a method to manufacture the compressor (cf. claims 10-11, 15-21). The special technical feature of claim 1 is that at least one of the functional parts (rotary disk, guide, weight) is realised by pressing a plate.

The second group of claims is concerned with a variable displacement compressor of the swash-plate type (cf. claims 3-5) and with a method to manufacture it (cf. claims 12-14).

The special technical features of claim 3 are that two functional parts of the compressor are manufactured integrally and seamlessly by pressing and punching a plate.

Claims 6-9 are concerned with a variable displacement compressor of the swash-plate type.

The special technical feature of claim 6 is that at least one of the guide member and the guide protrusion is manufactured independently from the rotary disk, and is then integrally joined to the rotary disk.

The closest prior art is identified e.g. in the description on pages 1 and 2 and figure 15.

The problem solved by the first group of claims could be determined as to facilitate the manufacturing of at least one of the functional parts, reducing at the same time its weight, the at least one functional part being realised by pressing a metal plate.

The problem solved by the second group of inventions could be determined as to manufacture two functional parts out from one single metal plate, thus sparing the seaming times and costs.



The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

The problem to be solved by the third group of inventions could be determined as to obtain different mechanical properties for the guide members and the rotary disk, thus realising them separately and successively integrally joining them.

As the potential special features are not the same and do not correspond as they solve different problems, a technical relationship as required by Rule 30 EPC is not present and therefore the requirement of unity of invention are not fulfilled.

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 01 12 1683

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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