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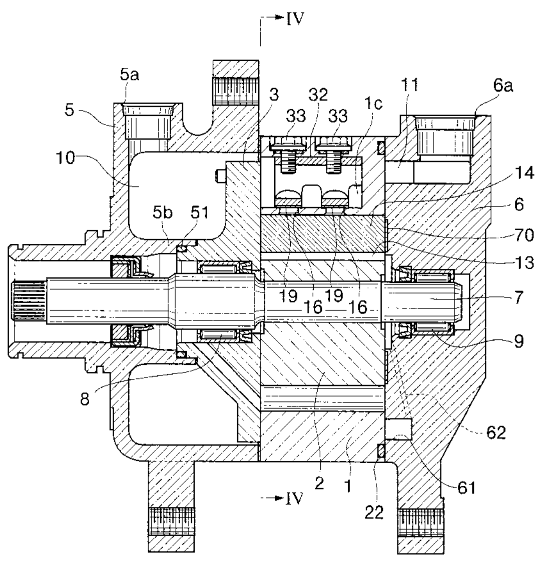
(54) Vane Compressor

(57) A vane compressor which is capable of preventing degradation of the sliding characteristics of its rotor (2) due to tolerances of the rotor (2) and parts associated therewith, and at the same time reducing the manufacturing costs and weights of the compressor. The vane compressor includes a cam ring (1), a rotor (2) rotatably received in the cam ring (1), a plurality of vane slits (13) formed in the rotor (2), vanes (14) slidably received in respective ones of the vane slits (13), and side members (3, 6) secured to respective end faces of the cam ring (1), at least the rotor (2) and the side members (3, 6) being formed of an aluminium-based material. A spacer (70) of annular shape is arranged between at least one of the end faces of the rotor (2) and a rotor-side end face of a corresponding one of the side members (3, 6). The spacer (70) is formed of a material which is harder than the aluminium-based material and smaller in outer diameter than an outer diameter of the rotor (2).

FIG.1



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to a vane compressor, and more particularly to a vane compressor which is capable of reducing possibility of seizure of its rotor.

Description of the Prior Art

Conventionally, vane compressor of this kind has been proposed by Japanese Laid-Open Patent Publication (Kokai) No. 57-151091.

The proposed vane compressor includes a cam ring, a rotor rotatably received in the cam ring, a drive shaft on which is rigidly fitted the rotor, vanes slidably received within a plurality of vane slits formed in the rotor, a front side block secured to a front-side end face of the cam ring, and a rear side block secured to a rear-side end face of the cam ring. The rotor and the front and rear side blocks are formed of an aluminum-based material.

The cam ring, the front side block and the rear side block are tightened in a longitudinal direction by through bolts to form a one-piece assembly.

The vane compressor has one thin plate arranged between the rear-side end face of the cam ring and a rotor-side end face of the rear side block, and another thin plate between the front-side end face of the cam ring and a rotor-side end face of the front side block. The thin plates are both formed of a ferrous material. The thin plates keep both the end faces of the rotor from contact with the rotor-side end faces of the side blocks, whereby possibility of seizure of the rotor is reduced.

However, the proposed conventional vane compressor suffers from the following problem: If the opposite end faces of the rotor and the rotor-side end faces of the side blocks are not machined with a required machining accuracy, particularly in respect of flatness thereof, or if the rotor and the side blocks are not assembled with sufficient accuracy (e.g. when the drive shaft is not strictly perpendicular to the rotor-side end faces of the side blocks), the end faces of the rotor are partially brought into pressure contact with the thin plates, which degrades sliding characteristics of the rotor, causing abrasion of the end faces of the same.

Further, since each thin plate is required to have such a large size as to cover the whole rotor-side end face of each side block, it takes a considerable amount of a ferrous material to form the thin plate, which results in an increase in manufacturing costs of the compressor as well as an increase in weight of the same.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a vane compressor which is capable of preventing degradation of the sliding characteristics of its rotor due to tolerances of machining of the rotor and component parts associated therewith, and at the same time reducing the manufacturing costs and weight of the compressor.

To attain the above object, the present invention provides a vane compressor including a cam ring, a rotor rotatably received in the cam ring, a plurality of vane slits formed in the rotor, vanes slidably received in the vane slits, respectively, and side members secured respectively to end faces of the cam ring, at least the rotor and the side members being formed of an aluminum-based material.

The vane compressor according to the present invention is characterized by comprising a spacer having an annular shape and arranged between at least one of the end faces of the rotor and a rotor-side end face of a corresponding one of the side members, the spacer being formed of a material which is higher in hardness than the aluminum-based material and smaller in outer diameter than an outer diameter of the rotor.

According to this vane compressor, the annular spacer formed of a material which is higher in hardness than the aluminum-based material and smaller in outer diameter than an outer diameter of the rotor is arranged between the end face of the rotor and the rotor-side end face of the corresponding one of the side members, whereby a constant clearance is maintained between the end face of the rotor and the rotor-side end face of the side member, so that machining errors or tolerances of the end faces of the rotor and the rotor-side end faces of the side members as well as assembly errors or tolerances of the rotor and the side members are accommodated to reduce abrasion of the end faces of the rotor. Further, the clearance between the end faces of the rotor and the rotor-side end faces of the side members can be made narrower than when the spacer is not employed, which makes it possible to improve the performance of the compressor. Moreover, since the outer diameter of the spacer is smaller than that of the rotor, the amount of material required to form the spacer is reduced compared with the conventional vane compressors.

Preferably, the material which is higher in hardness than the aluminum-based material is a ferrous material.

Alternatively, the material which is higher in hardness than the aluminum-based material is a polytetrafluoroethylene (PTFE)-based material.

Alternatively, the material which is higher in hardness than the aluminum-based material comprises a coating of a polytetrafluoroethylene (PTFE) -based material.

Preferably, the rotor-side end face of the corresponding one of the side members is formed with back pressure grooves through which a first fluid is supplied to a bottom of each of the vanes, and a low-pressure chamber located radially outward of the back pressure grooves, for supplying a second fluid having a lower pressure than the first fluid to compression chambers each formed between ones of the vanes adjacent to each other in a rotational direction of the rotor, the spacer being arranged between the back pressure grooves and the low-pressure chamber.

According to the preferred embodiment, since the spacer is arranged between the back pressure grooves and the low-pressure chamber, it is possible to prevent the first fluid from escaping from the back pressure grooves to the low-pressure chamber, whereby pressure exerted on the bottom of each of the vanes can be maintained at a high level.

More preferably, the rotor-side end face of the corresponding one of the side members is formed with an annular recess at a location between the back pressure grooves and the low-pressure chamber, the spacer having a shape of an annular disk, and being fitted in the annular recess.

Alternatively, the spacer is arranged radially inward of the back pressure grooves.

According to this preferred embodiment, the spacer, which is smaller in outer diameter than the rotor, is arranged at a location radially inward of the back pressure grooves, so that the outer diameter of the spacer is even smaller. Therefore, the amount of material required to form the spacer is largely decreased.

More preferably, the vane compressor includes a drive shaft on which the rotor is rigidly fitted, and the corresponding one of the side members is formed with a hole into which the drive shaft extends, the rotor-side end face of the corresponding one of the side members having a portion in which the hole opens, the portion having an annular stepped portion formed in a manner such that the hole is radially expanded, the spacer having a shape of an annular disk, and being fitted in the annular stepped portion.

Alternatively, the vane compressor includes a drive shaft on which the rotor is rigidly fitted, a bearing arranged in the corresponding one of the side members for rotatably supporting the drive shaft, and a ferrous bushing cast in a space surrounding the bearing, the spacer being formed by an extended portion of the bushing, which slightly projects from the rotor-side end face of the corresponding one of the side members.

Preferably, the corresponding one of the side members is a rear-side side member arranged on a rear side of the vane compressor, the spacer being arranged between a rotor-side end face of the rear-side side member and a rear-side end face of the rotor.

According to the preferred embodiment, during operation of the compressor, the rotor is urged toward the rear side by the urging force of an electromagnetic clutch, but the spacer holds the rotor substantially in the center of the compressor in an axial direction, so that the clearance between the rotor-side end face of the rear head and the rear-side end face of the rotor is maintained substantially equal to that between a rotor-side end face of a front head and a front-side end face of the rotor, whereby leakage of refrigerant gas is reduced as a whole.

The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal cross-sectional view showing the whole arrangement of a vane compressor according to a first embodiment of the invention;

FIG. 2 is an end view of a front-side end face of a rear head appearing in FIG. 1;

FIG. 3 is an enlarged sectional view of the FIG.2 rear head;

FIG. 4 is an end view taken on line IV-IV of FIG. 1;

FIG. 5 is an end view showing a front-side end face of a rear head of a vane compressor according to a second embodiment of the invention;

FIG. 6 is an enlarged sectional view of the FIG. 5 rear head;

FIG. 7 is an end view of a front-side end face of a rear head of a vane compressor according to a variation of the second embodiment of the invention; and

FIG. 8 is an enlarged sectional view of the FIG. 7 rear head.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Next, the invention will now be described in detail with reference to drawings showing preferred embodiments thereof.

FIG. 1 shows a vane compressor, in longitudinal cross section, according to a first embodiment of the invention. FIG. 2 shows a front-side end face of a rear head appearing in FIG. 1. FIG. 3 shows the rear head in cross section on an enlarged scale, and FIG. 4 shows a front-side end face of a cam ring appearing in FIG. 1, taken on line IV-IV of FIG. 1.

The vane compressor is comprised of the cam ring 1, a rotor 2 rotatably received within the cam ring 1, a drive shaft 7 on which is rigidly fitted the rotor 2, a front head 5 secured to a front-side end face of the cam ring 1, the rear head (rear side member) 6 secured to a rear-side end face of the cam ring 1 via an O ring 22, and a front side block (side member) 3 received in the front head 5. The cam ring 1, the front side block 3, the front head 5 and the rear head 6 are tightened in a longitudinal direction by through bolts, not shown, to form a one-piece assembly. The drive shaft 7 has a front-side end thereof rotatably supported by a radial bearing 8 arranged in the front-side block 3 and a rear-side end thereof by a radial bearing 9 arranged in the rear head 6.

Component parts of the compressor, such as the cam ring 1, the rotor 2, and the front and rear heads 5 and 6, are formed of an aluminum-based material. As the aluminum-based material, there is employed e.g. a material coded as JDC14 according to JIS.

The front side block 3 has its rear-side end face secured to the front-side end face of the cam ring 1 in a manner closing a front-side opening of the cam ring 1. A front-side end of the front side block 3 is rigidly fitted in a boss 5b formed on a front-side end wall of the front head 5 via an O ring 51. An inner wall surface of the front head 5, an outer peripheral surface of the front-side block 3, and the front-side end face of the cam ring 1 define a discharge chamber 10 to which high-pressure refrigerant gas is delivered from a plurality of compression chambers, referred to hereinafter.

The rear head 6 is formed therein with a suction port 6a via which refrigerant gas is drawn into the compressor, a suction chamber (low-pressure chamber) 11 into which the low-pressure refrigerant gas is drawn via the suction port 6a, a pair of refrigerant inlet ports 11a via which the refrigerant gas (second fluid) within the suction chamber 11 is supplied to the compression chambers, and a high-pressure chamber 61 to which high-pressure oil/refrigerant is introduced from the discharge chamber 10.

The rear head 6 has its rotor-side end face formed therein with a pair of back pressure grooves 60 for supplying back pressure as oil/refrigerant (first fluid) to the bottom of each of vanes 14, referred to hereinafter. High-pressure oil/refrigerant is introduced from the high-pressure chamber 61 into the back pressure grooves 60 through a high pressure-introducing passage 62. The high-pressure chamber 61 formed in the rear head 6 communicates with a high-pressure chamber (not shown) formed in the cam ring 1, which in turn communicates with the discharge chamber 10.

Between the rotor-side end face of the rear head 6 and the rear-side end face of the cam ring 1, there is mounted an annular disk-shaped spacer 70, which is formed of a ferrous material or a polytetrafluoroethylene (PTFE)-based material. The outer diameter of the spacer 70 is smaller than that of the rotor 2. The ferrous material forming the spacer 70 is e.g. a Swedish steel. Alternatively, the spacer may be a member coated with the polytetrafluoroethylene (PTFE)-based material.

As shown in FIG. 2, the spacer 70 is received in a recess 70a formed on the rotor-side end face of the read head 6 between the pair of back pressure grooves 60 and the refrigerant inlet ports 11a in a manner surrounding the back pressure grooves 60 and separating the same from the refrigerant inlet ports 11a. The spacer 70 has an axial thickness slightly larger than the depth of the recess 70a. That is, the spacer 70 slightly projects toward the front side from the rotor-side end face of the rear head 6 so as to keep the rotor-side end face of the rear head 6 from contact with the rear-side end face of the rotor 2. The spacer 70 has an inner periphery thereof provided with a stopper 71 which is engaged with one of the back pressure grooves 60 to thereby inhibit the spacer 70 from rotating.

A pair of compression spaces 12 are defined by an inner peripheral surface of the cam ring 1 and an outer peripheral surface of the rotor 2, at respective diametrically opposite locations as shown in FIG. 4. The rotor 2 has its outer peripheral surface formed therein with a plurality of axial vane slits 13 at circumferentially equal intervals, in each of which a vane 14 is radially slidably fitted. The compression spaces 12 are divided by the vanes 14 into compression chambers, the volume of each of which is varied with rotation of the rotor 2.

Further, the cam ring 1 is formed therein with the discharge spaces (discharge valve-receiving chambers) 1c, each of which accommodates discharge valves 19, referred to hereinafter. A front-side end of each discharge space 1c is open to the discharge chamber 10. FIG. 1 shows only one of the discharge spaces 1c. Two pairs of refrigerant outlet ports 16 are formed through opposite lateral side walls of the cam ring 1, which separate the discharge spaces 1c and the compression spaces 12 from each other, in a fashion corresponding to the compression spaces 12 (only one pair of the refrigerant outlet ports 16 are shown in FIG. 1). When the refrigerant outlet ports 16 open, high-pressure refrigerant gas is delivered from compression chambers via the refrigerant outlet ports 16, and flows into the discharge chamber 10 through the discharge spaces 1c.

Each discharge space 1c accommodates a valve stopper 32 arcuate in cross section, with the discharge valves 19 also arcuate in cross section mounted on the outer peripheral surface of the valve stopper 32, as best shown in FIG. 4. The discharge valves 19 and the valve stopper 32 are fixed to an inner wall surface of the discharge space 1c by two bolts 33 screwed from outside through respective through holes formed in the cam ring 1.

Next, the operation of the vane compressor constructed as above will be explained.

As torque is transmitted from an engine, not shown, to the drive shaft 7, the rotor 2 is driven for rotation. Refrigerant gas flowing out of a refrigerant outlet port of an evaporator, not shown, is drawn into the suction chamber 11 via the suction port 6a. The refrigerant gas is drawn into the compression spaces 12 from the suction chamber 11 via the refrigerant inlet ports 11a.

The compression spaces 12 are each divided by the vanes 14 into five compression chambers, each of which is varied in capacity with rotation of the rotor 2, whereby refrigerant gas trapped in each compression chamber is compressed, and the compressed refrigerant gas opens the discharge valves 19 to flow out via the refrigerant outlet ports 16 into the discharge space 1c.

The high-pressure refrigerant gas flowing into the discharge spaces 1c further flows into the discharge chamber 10, followed by being discharged via a discharge port 5a formed in the front head 5.

According to the first embodiment described above, the annular disk-shaped spacer 70 formed of a ferrous material or a PTFE-based material is arranged between the rotor-side end face of the rear head 6 and the rear-side end face of the cam ring 1, so that a constant clearance is maintained between the rear-side end face of the cam ring 1 and the rotor-side end face of the rear head 6 as well as between the front-side end face of the cam ring 1 and the rotor-side end face of the front side block 3. As a result, machining errors or tolerances of the end faces of the rotor 2 and the rotor-side end face of the rear head 6 as well as assembly errors or tolerances of the rotor 2 and the rear head 6 are accommodated, whereby abrasion of the end faces of the rotor 2 is reduced. Further, the clearance between the rear-side end face of the cam ring 1 and the rotor-side end face of the rear head 6 and that between the front-side end face of the cam ring 1 and the rotor-side end face of the front side block 3 can be made narrower than when the spacer 70 is not employed, which makes it possible to improve the performance of the compressor.

Further, since the outer diameter of the spacer 70 is smaller than that of the rotor 2, it is possible to reduce the manufacturing costs and weight of the compressor.

Still further, since the spacer 70 is arranged in a manner surrounding the back pressure grooves 60 and separating the same from the refrigerant inlet ports 11a, oil/refrigerant is prevented from escaping from the back pressure grooves to the refrigerant inlet ports 11a, which enables constant back pressure to be supplied to the bottoms of the vanes 14.

FIG. 5 shows a front-side end face of a rear head of a vane compressor according to a second embodiment of the invention. FIG. 6 shows the rear head in cross section on an enlarged scale. Component parts and elements corresponding to those of the first embodiment are designated by identical reference numerals, and description thereof is omitted.

The second embodiment is distinguished from the first embodiment in which the spacer 70 is arranged at a location radially outward of the back pressure grooves 60 in that a spacer 170 is arranged at a location radially inward of back pressure grooves 160, as best shown in FIG. 6. More specifically, the spacer 170 is fitted in an annular stepped portion 170a formed on a portion of the rotor-side end face of the rear head 6 in which opens a hole 7a into which the drive shaft 7 extends, such that the hole 7a is radially expanded.

Further, in the present embodiment, the spacer 170 has an outer periphery thereof provided with a stopper 171 which is engaged with one of the back pressure grooves 160 to thereby inhibit the spacer 170 from rotating, as shown in FIG. 5.

The spacer 170 has an axial thickness which is slightly larger than an axial depth of the stepped portion 170a, such that the spacer 170 slightly projects toward the front side from the rotor-side end face of the rear head 6 so as to keep the rotor-side end face of the rear head 6 from contact with the rear-side end face of the rotor 2.

The second embodiment can provide the same advantageous effects as obtained by the first embodiment, except that it is impossible to prevent oil/refrigerant from escaping from the back pressure grooves 160 to the refrigerant inlet ports 11a.

Further, the spacer 170 also plays the role of centering means to hold the rotor 2 in the center of the compressor, so that leakage of refrigerant gas is reduced, and hence the performance of the compressor is improved. More specifically, during operation of the compressor, the rotor 2 is urged toward the rear side by the urging force of an electromagnetic clutch, not shown. However, the spacer 170 prevents the rotor from coming into contact with the rotor-side end face of the rear head 6, so that the clearance between the rotor-side end face of the rear head 6 and the rear-side end face of the rotor 2 is maintained substantially equal to that between the rotor-side end face of the front head 5 and the front-side end face of the rotor 2, whereby leakage of refrigerant gas is reduced as a whole.

FIG. 7 shows a front-side end face of a rear head of a vane compressor according to a variation of the second embodiment of the invention. FIG. 8 shows the rear head in cross section on an enlarged scale. Component parts and elements corresponding to those of the above embodiments are designated by identical reference numerals, and description thereof is omitted.

In this variation, a radial bearing 9 is formed of a ferrous material, while a rear head 206 is formed of an aluminum-based material. The rear head 206 has a space 206a formed therein in a manner surrounding the bearing 9, and a ferrous bushing 231 is cast in the space 206a so as to prevent the bearing 9 from becoming loose due to a difference in thermal expansion between the bearing 9 and the rear head 206. The ferrous bushing 231 has a portion (abutting portion) 270 which slightly projects toward the rotor 2 from the rotor-side end face of the rear head 206. The abutting portion 270, which has an annular shape in cross section as best shown in FIG. 7, is formed at a location radially inward of back pressure grooves 260, similarly to the spacer 170 in the second embodiment.

The vane compressor according to this variation can provide the same effects as obtained by the compressor of the second embodiment. Further, it is capable of preventing the radial bearing 9 from becoming loose.

Although in each of the above embodiments, the spacer is provided only in the rear side of the compressor, this is not limitative, but another spacer may be provided in the front side of the same.

Further, although the spacer is provided with a stopper for preventing the spacer from rotating, it is possible to dispense with the stopper and permit the spacer to rotate in unison with the rotor.

It is further understood by those skilled in the art that the foregoing is the preferred embodiment of the invention, and that various changes and modification may be made without departing from the spirit and scope thereof.

Claims

1. A vane compressor including a cam ring (1), a rotor (2) rotatably received in the cam ring (1), a plurality of vane slits (13) formed in the rotor (2), vanes (14) slidably received in respective ones of the vane slits (13), and side members (3, 6) secured to respective end faces of the cam ring (1), at least the rotor (2) and side members (3, 6) being formed of an aluminium-based material,

    characterised in that a spacer (70) having an annular shape and arranged between at least one of said end faces of the rotor (2) and a rotor-side end face of a corresponding one of the side members (3, 6) is formed of a material which is harder than said aluminium-based material and smaller in outer diameter than an outer diameter of the rotor (2).

2. A vane compressor according to claim 1, wherein the material which is harder than the aluminium-based material, is a ferrous material.

3. A vane compressor according to claim 1, wherein the material which is harder than the aluminium-based material is a polytetrafluoroethylene (PTFE) - based material.

4. A vane compressor according to claim 1, wherein the material which is harder than the aluminium-based material comprises a coating of a polytetrafluoroethylene (PTFE) - based material.

5. A vane compressor according to any preceding claim, wherein the rotor-side end face of the corresponding one of the side members (3, 6) is formed with back pressure grooves (60) through which a first fluid can be supplied to a bottom of each of the vanes (14), and wherein a low-pressure chamber (11) is located radially outwardly of the back pressure grooves (60), for supplying a second fluid having a lower pressure than the first fluid to compression chambers (12) each formed between respective ones of the vanes (14) adjacent each other in a rotational direction of the rotor (2), the spacer (70) being arranged between the back pressure grooves (60) and the low-pressure chamber (11).

6. A vane compressor according to claim 5, wherein the rotor-side end face of the corresponding one of the side members (3, 6) is formed with an annular recess between the back pressure grooves (60) and the low-pressure chamber (11), the spacer (70) being in the shape of an annular disc and being fitted in the annular recess.

7. A vane compressor according to any of claims 1 to 4, wherein the rotor-side end face of the corresponding one of the side members (3, 6) is formed with back pressure grooves (60) through which a first fluid can be supplied to a bottom of each of the vanes (14), and wherein a low-pressure chamber (11) is located radially outwardly of the back pressure grooves (60), for supplying a second fluid having a lower pressure than the first fluid to compression chambers (12) each formed between respective ones of the vanes (14) adjacent each other in a rotational direction of the rotor (2), the spacer (70) being arranged radially inwardly of the back pressure grooves (60).

8. A vane compressor according to any preceding claim including a drive shaft (7) on which the rotor (2) is rigidly fitted, wherein a corresponding one (6) of the side members (3, 6) is formed with a hole (7a) into which the drive shaft (7) extends, the rotor-side end face of the corresponding one (6) of the side members (3, 6) having a portion into which the hole (7a) opens and which has an annular stepped portion (170a) formed such that the hole (7a) is radially expanded, the spacer (170) being in the shape of an annular disc and being fitted in the annular stepped portion (170a).

9. A vane compressor according to any preceding claim including a bearing (9) arranged in a corresponding one (206) of the side members for rotatably supporting a or the drive shaft (7), and a ferrous bushing (231) cast in a space (206a) surrounding the bearing (9), wherein the spacer (270) is formed by an extended portion of the bushing (231), which projects slightly from the rotor-side end face of the corresponding side member (206).

10. A vane compressor according to any preceding claim, wherein a corresponding one of the side members is a rear-side side member (6, 206) arranged on a rear side of the vane compressor, the spacer (70, 170, 270) being arranged between a rotor-side end face of the rear-side side member and a rear-side end face of the rotor (2).

FIG.1

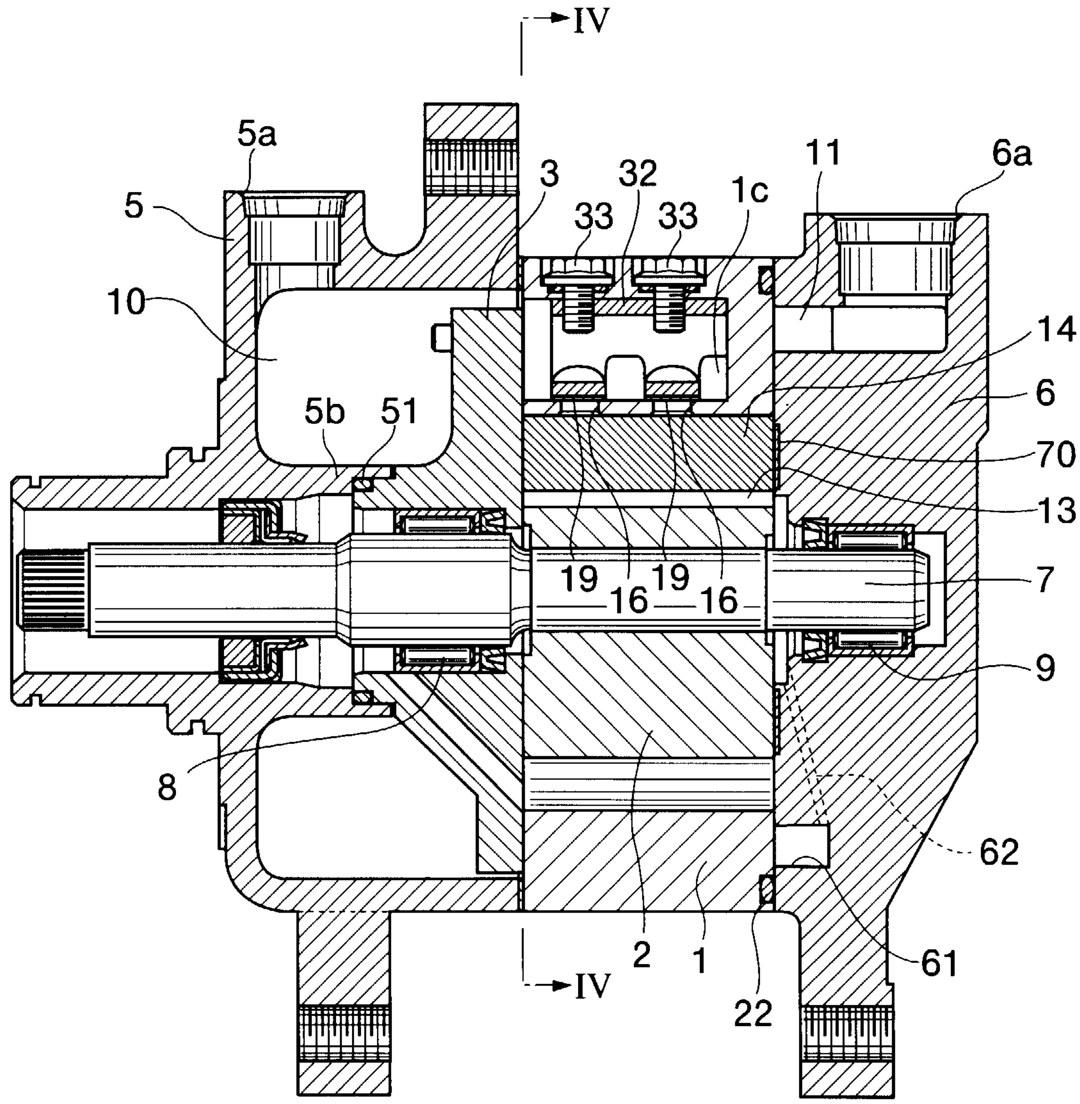

IV
5a
5
10
5b
51
3
32
33
33
1c
11
6a
14
6
70
13
7
19
16
19
16
9
8
62
61
2
1
22
IV

FIG.2

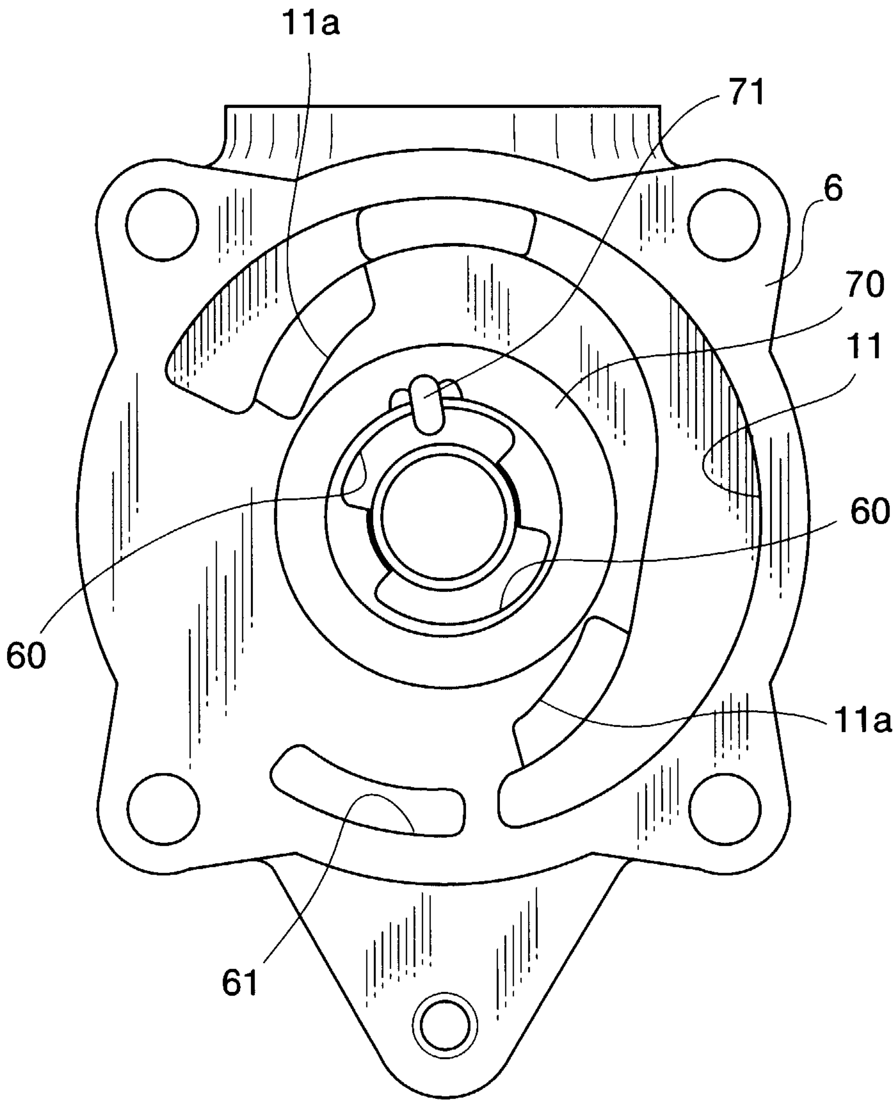


FIG.3

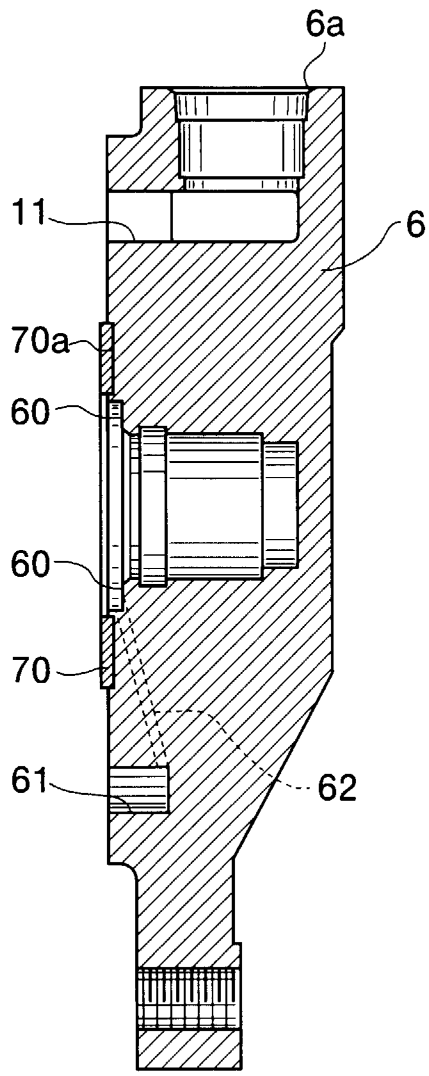


FIG.4

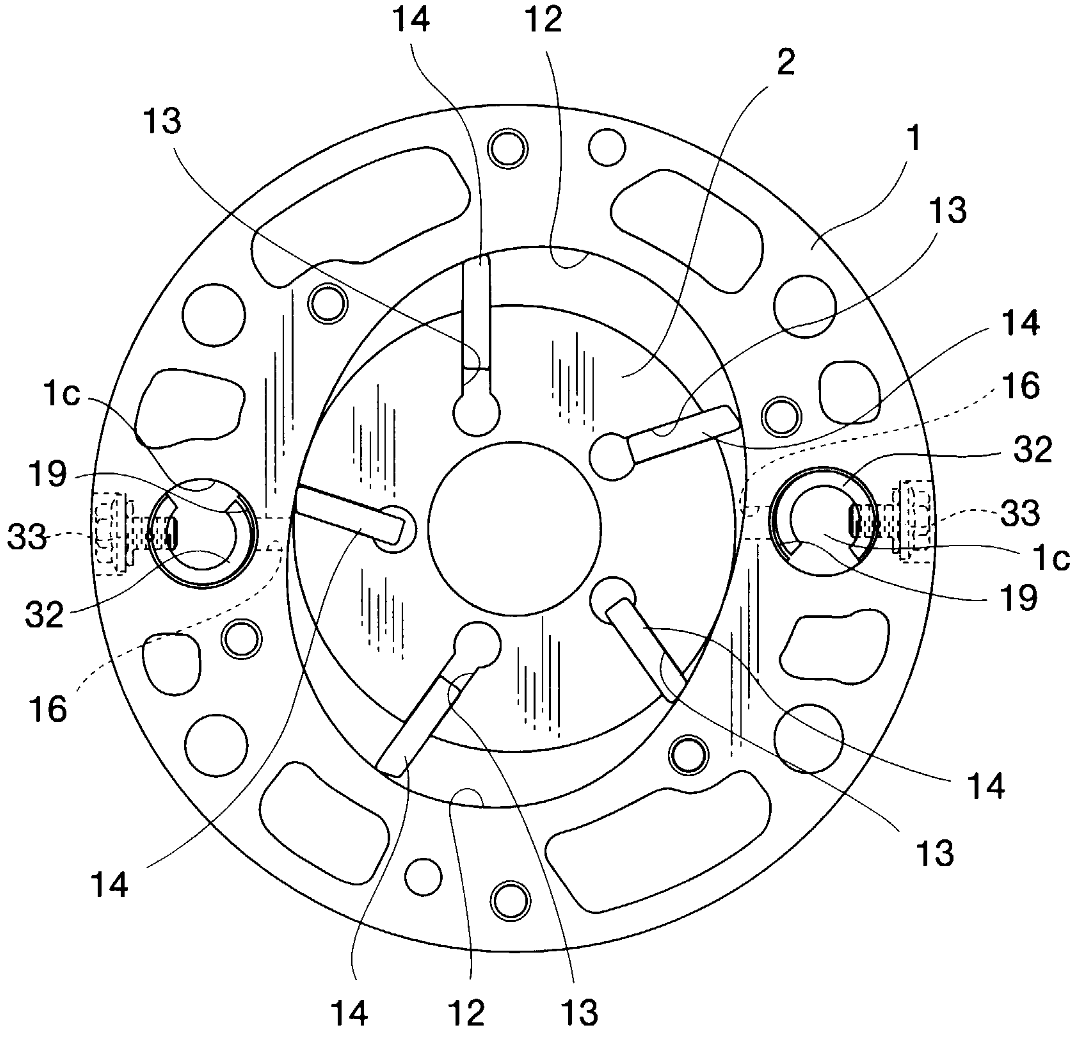


FIG.5

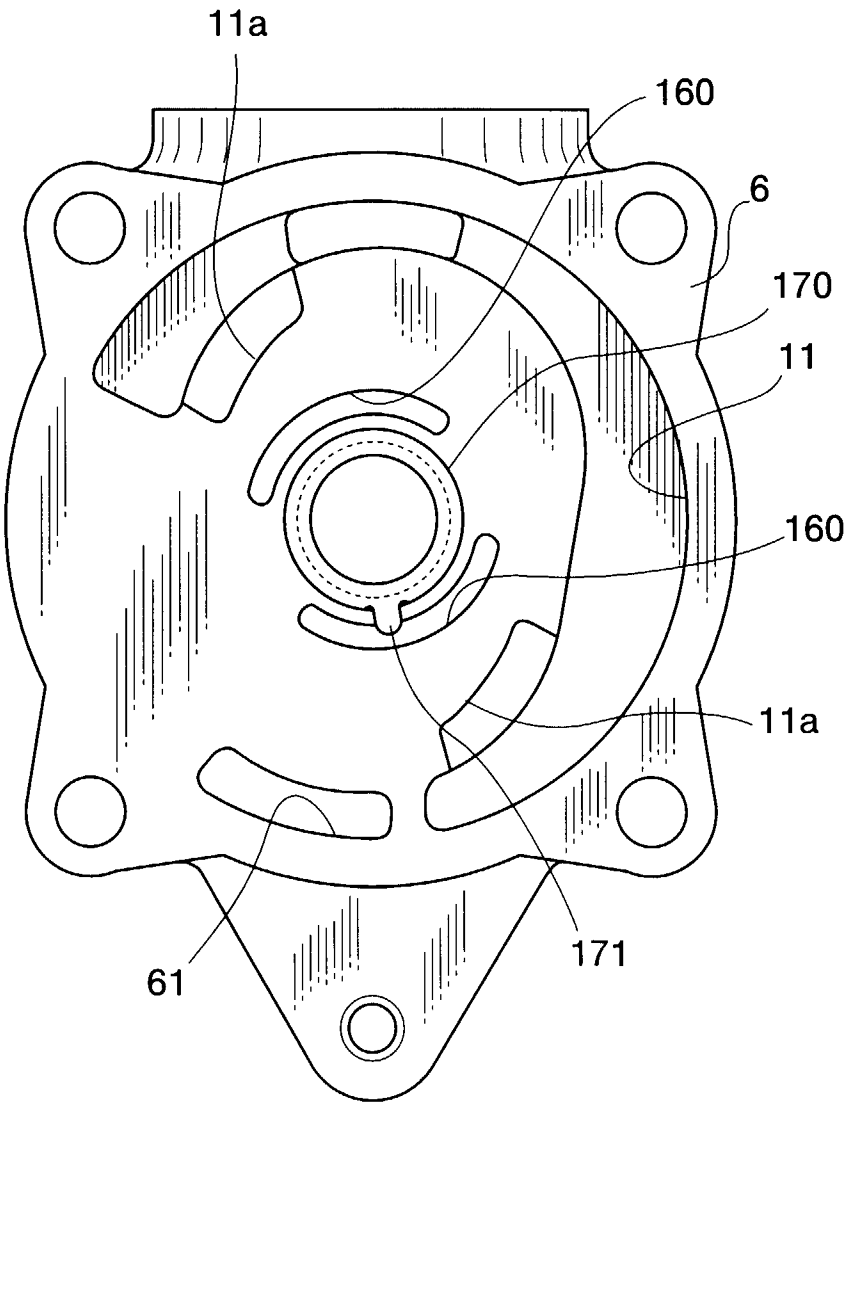


FIG.6

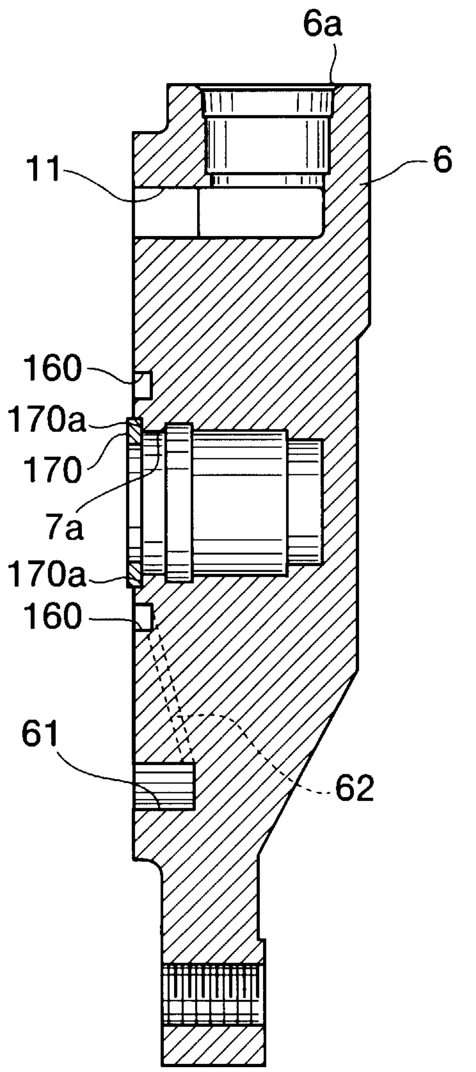


FIG.7

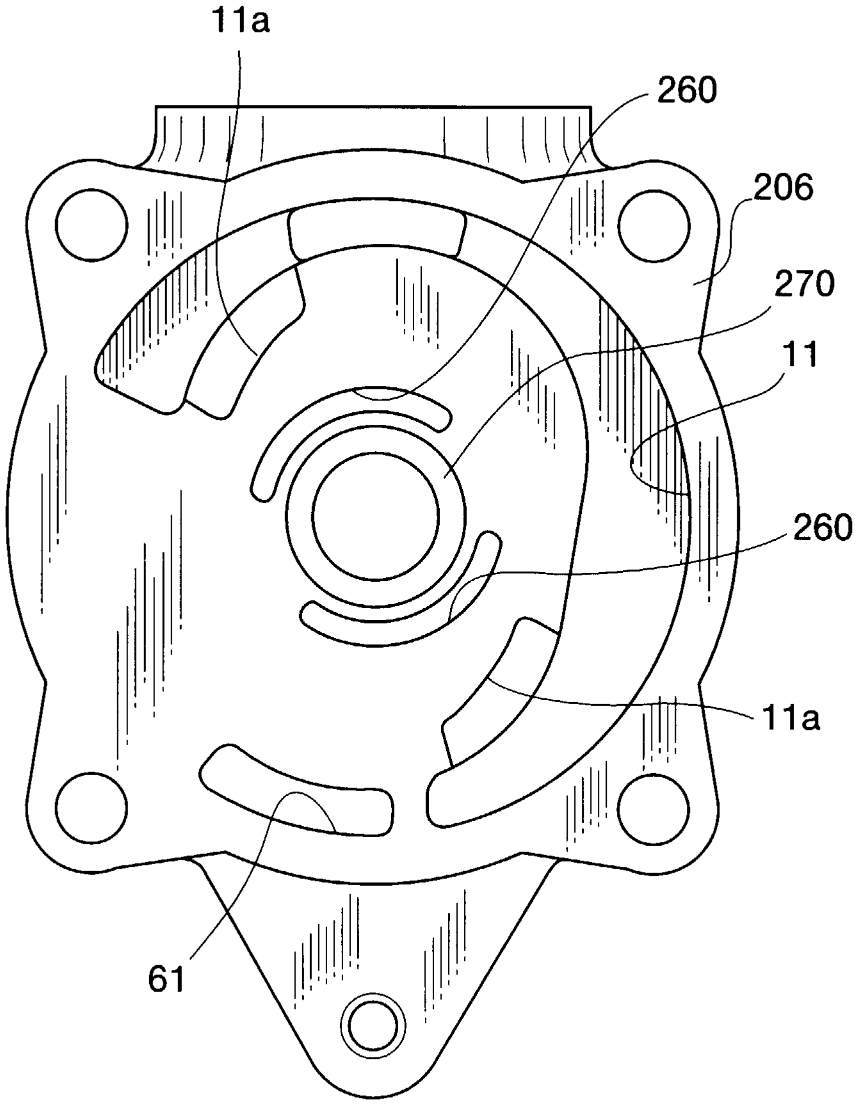
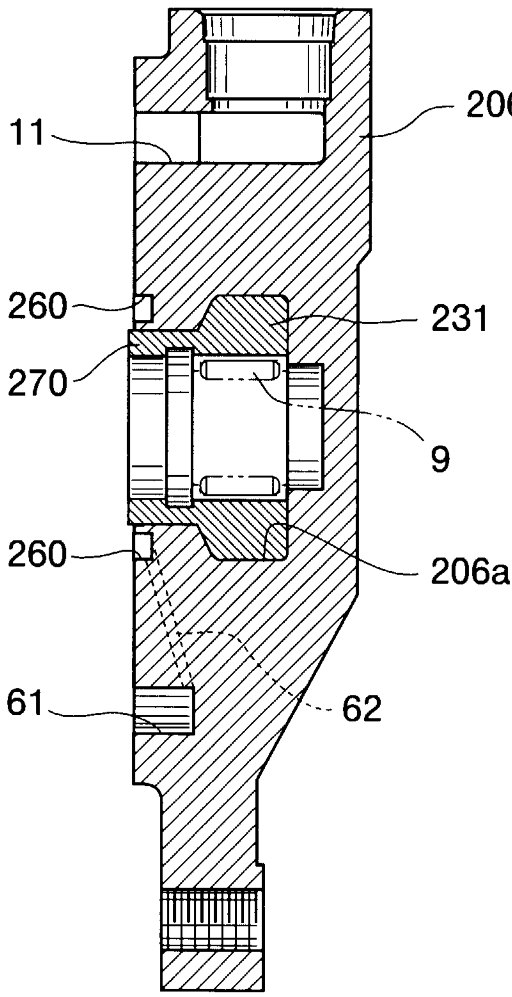


FIG.8



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 30 8426

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	21 January 1998	Dimitroulas, P

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DOCUMENTS CONSIDERED TO BE RELEVANT

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A	PATENT ABSTRACTS OF JAPAN vol. 8, no. 50 (M-281) '1487! , 7 March 1984 & JP 58 204990 A (MATSUSHITA DENKI SANGYO K.K.), 29 November 1983, * abstract * -----	1,3	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)

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