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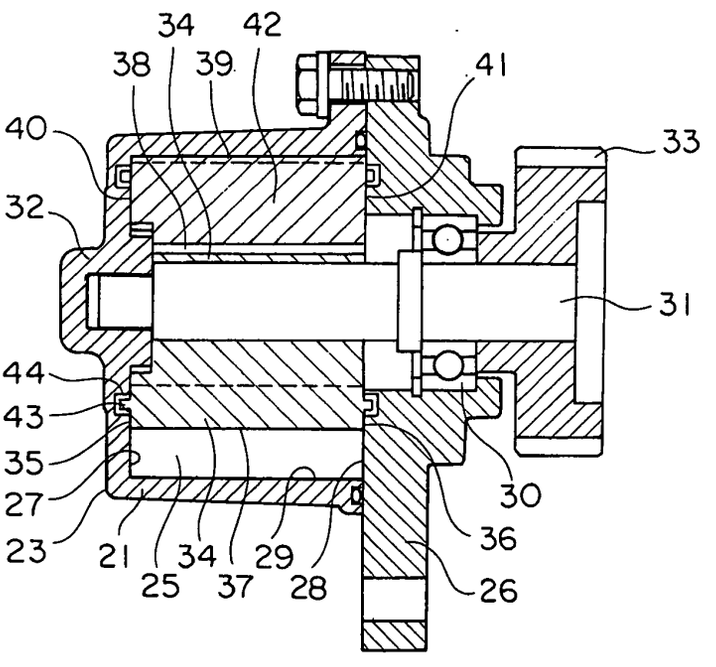
(54) VANE TYPE VACUUM PUMP

(57) A vane-type vacuum pump including a rotor that rotates with vanes in a sliding contact with a housing comprises a labyrinth seal disposed between the housing and the rotor and extending over an entire circumference and including at least one pair of a circular ring-shaped groove and a circular ridge-shaped projection ring concentrically disposed to the rotary shaft. The groove and the projection ring are continuous on the casing side but they are discontinuous on the rotor side so that a radial movement of the vane is not impeded.

FIG. 1



EP 1 553 301 A1

Description

TECHNICAL FIELD

[0001] This invention relates to a vane-type vacuum pump and, more particularly, to a vane-type vacuum pump for evacuating a tank for use in vehicles.

BACKGROUND ART

[0002] The conventional vane-type vacuum pump shown in section in Figs. 12 and 13 comprises a housing 1, which comprises a cup-shaped main body 3 including a suction port 2 and a discharge port 4 with a valve and a bracket 6 closing an open end of the main body 3 for defining a pump chamber 5 therein. The pump chamber 5 is a cylindrical space defined in the housing 1 by two parallel end faces 7 and 8, and a cylindrical surface 9 between the end faces 7 and 8. A bearing 10 of the bracket 6 supports a rotary shaft 11 in an eccentric relationship with respect to a central axis of the cylindrical pump chamber 5, and an inner end of the rotary shaft 11 is supported by a bearing 12 of the main body 13. Secured to an outer end of the rotary shaft 11 are a pinion, a pulley, a sprocket, cum and the like 13 for receiving a driving power from an external drive unit (not illustrated) such as gears.

[0003] Within the housing 1, a rotor 14 is housed in a concentric relationship with the rotary shaft 11 and therefore in an eccentric relationship with the pump chamber 5 (housing 1). The rotor 14 is a substantially cylindrical member having two end surfaces and a cylindrical surface and is rotated by the rotary shaft 11 within the housing 1. The rotor 14 is provided with four slots 15 radially extending from one end surface to the other, the slots 15 each has inserted therein a vane 16 radially slidable and capable of being brought into a slidable contact at its tip with a cylindrical surface 9 of the housing 1

[0004] In the vehicular vane-type vacuum pump as above described, when the rotor 14 is rotated in clockwise direction in Fig. 11, the vanes 16 in the slots 15 moves outward due to the centrifugal force, the tips of the vanes 16 slide along the cylindrical surface 9 of the pump chamber 5 while they are kept contacting. Since the rotary shaft 11 of the rotor 14 iS eccentric to the center of the pump chamber 5, the volume of the compression chamber defined between the vanes 16 are changed as the rotation of the rotor 14, the air is sucked from the suction port 2 of the housing 1 and pumped to the discharge port 4 and a vacuum is generated on the side of the suction port 2 connecting to the unillustrated tank. At this time, engine oil is supplied to various sliding contact portions of the vane-type vacuum pump such as those portions of the vanes 16 that is sliding-contacting with other portions such as the rotor 14, the end surfaces 7 and 8 and the cylindrical surface 9 and also to the bearing portions and those sliding contact portions are lubricated.

[0005] The portions between the side end surfaces 7 and 8 of the housing 1 and the axial end surfaces of the rotor 14 are also sliding portions, in which engine oil films are interposed to prevent abrasion between these portions and to establish hermetic seal between the rotor and the housing. However, the oil films in these sliding portions can be locally broken. Once the oil films are broken, not only the problem of friction arises, but also the effect of hermetic seal is reduced, causing the problem of degrading the vacuum characteristics of the vane-type vacuum pump.

[0006] While it is possible to increase the pump capacity or rotor speed in order to solve the above problems, the former measure increases the overall dimensions of the vane-type vacuum pump and poses the problems such as poor mountability of the engine and increase the weight and the latter measure poses the problems such as shortened life due to increased vibration, increased mechanical wear and the like.

DISCLOSURE OF INVENTION

[0007] Accordingly, the object of the present invention is to provide a vane-type vacuum pump of small size that is improved in hermetic seal between the rotor and the housing to exhibits good vacuum characteristics, a sufficient lubrication can be maintained to reduce wear.

[0008] In order to achieve this object, the vane-type vacuum pump of the present invention has the construction as described bellow.

(1) A vane-type vacuum pump comprising, a housing having a cylindrical pump chamber including a suction port and a discharge port, a rotor eccentrically accommodated within said pump chamber, a rotary shaft secured to said rotor for rotating said rotor within said pump chamber, and a vane radially movably inserted into said rotor while maintaining a sliding contact with said housing within said pump chamber, wherein the air within said pump chamber is pumped from said suction port to said discharge port by the rotation of said rotor to generate a vacuum on the side of said suction port side, characterized by a labyrinth seal disposed between said housing and said rotor to extending over an entire circumference and including at least one pair of a circular ring-shaped groove and a circular ridge-shaped projection ring concentrically disposed to said rotary shaft, said groove and said projection ring engage together and relatively movable to each other in circumferential direction.

(2) The circular ridge-shaped projection ring may be disposed on the end surface of said rotor and said circular ring-shaped groove may be disposed in said rotor.

(3) The circular ring-shaped groove may be disposed in a side end surface of said rotor and said

circular ridge-shaped projection ring may be disposed on the rotor, and wherein a groove may be provided in the side end surface of said vane for receiving said projection ring not to impede the radial movement of said vane.

(4) The labyrinth seal may be concentrically provided in a plurality of pairs.

(5) The labyrinth seal may be disposed on both side end faces of said rotor.

(6) The rotary shaft may be an output rotary shaft of a vehicular alternator.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

Fig. 1 is a schematic sectional view taken along line 1-1 of Fig. 2 showing the vane-type vacuum pump according to the first embodiment of the present invention.

Fig. 2 is a schematic sectional view taken along the plane perpendicular to the shaft of the vane-type vacuum pump shown in Fig. 1.

Fig. 3 is schematic sectional view showing the details of the labyrinth seal of the vane-type vacuum pump shown in Fig. 1.

Fig. 4 is a partial perspective view showing the rotor and the vane of the present invention.

Fig. 5 is a schematic sectional view showing the vane-type vacuum pump according to the second embodiment of the present invention.

Fig. 6 is a schematic sectional view showing the details of the labyrinth seal of the vane-type vacuum pump shown in Fig. 5.

Fig. 7 is a partial perspective view showing the rotor and the vane of the present invention.

Fig. 8 is a schematic sectional view showing the vane-type vacuum pump according to the third embodiment of the present invention.

Fig. 9 is a schematic sectional view showing the vane-type vacuum pump according to the fourth embodiment of the present invention.

Fig. 10 is a schematic sectional view showing an example in which the vane-type vacuum pump of Fig. 4 is directly connected to a. c. generator.

Fig. 11 is a graph showing the results of the comparison tests of the vacuum degree of the vane-type vacuum pump of the present invention shown in Figs. 1 to 4 with that of the conventional vane-type vacuum pump shown in Figs. 12 and 13.

Fig. 12 is a schematic sectional view showing the conventional vane-type vacuum pump taken along line 12-12 of Fig. 13.

Fig. 13 is a schematic sectional view of the vane-type vacuum pump taken along the plane perpendicular to the shaft of Fig. 12.

BEST MODE FOR CARRYING OUT THE INVENTION

[0010] A vane-type vacuum pump of the present invention illustrated in Figs. 1 to 3 comprises a housing 21, which comprises a cup-shaped main body 23 having a suction port 22 and a discharge port 24 both with a valve, and a bracket 26 closing an open end of the main body 23 to define a pump chamber 25 therein. The pump chamber 25 is a space defined by two parallel end surfaces 27 and 28 of the housing 21 and a cylindrical surface 29 between the end surfaces 27 and 28. A bearing 30 of the bracket 26 supports a rotary shaft 31 disposed extending through the cylindrical pump chamber 25 and the inner end of the rotary shaft 31 is supported in an eccentric relationship relative to a central axis of the pump chamber 25. An outer end of the rotary shaft 31 has secured thereto a pinion 33, pulley, sprocket, cum or the like for receiving a driving force from an external drive unit (not illustrated) such as gears or the like.

[0011] Within the housing 21, a rotor 34 concentric to the rotary shaft 31 and therefore eccentric to the pump chamber 25 (the housing 21) is accommodated. The rotor 34 is a substantially cylindrical member having two flat end surfaces 35 and 36 and a cylindrical surface 37 and the rotor 34 is caused to rotated by the rotary shaft 31 within the housing 21. The rotor 34 is provided with four slots 38 extending through the rotor 34 in the radial direction from one end surface to the other. These slots 38 each has inserted therein a plate shaped vane 42 that can be brought into sliding contact at its tip end 39 with the cylindrical surface 29 of the housing 21 and that is in sliding contact at flat end surfaces 40 and 41 with the end surfaces 27 and 28 of the housing 21, the vanes 42 being slidable in the slots 38 in the radial direction.

[0012] As best shown in Figs. 3 and 4, the rotor 34 has provided on the end surfaces 35 and 36, except at the position where the slot 38 is formed, with an annular ridge or projection ring 43 concentric with the rototary shaft 31. On the end surfaces 27 and 28 of the housing 21, a continuous annular groove 44 is provided at the position corresponding to the annular projection ring 43 for receiving therein the projection ring 43. The clearance 45 in the radial direction as well as the clearance 46 in the radial direction between the groove 44 and the projection ring 43 are made greater than the clearances between the end surfaces 35, 36 of the rotor 34 and the end surfaces 27, 28 of the housing 21, .and the axial clearance 46 is made greater than the radial clearance 45. Therefore, a space for maintaining engine oil is defined between the annular projection ring 43 and the annular groove 44. Since this space is defined between the projection ring 43 and the groove 44, it is a labyrinth seal for preventing the engine oil from flowing in the radial direction.

[0013] When the rotor 34 is rotated in the counter clockwise direction in Fig. 2, the vane 42 moves within the slot 38 into the radially outward direction by the centrifugal force and the tips 39 of the vanes 42 abut against

and slide along the cylindrical surface 29 of the pump chamber 25. Since the rotary shaft 31 of the rotor 34 is eccentric to the center of the pump chamber 25, the volumes of the compression chambers defined between the vanes 42 vary as the rotor 34 rotates and air is sucked from the suction port 22 of the housing 21 to be pumped to the discharge port 24 to generate vacuum at the side of the suction port 22 connected to an unillustrated tank.

[0014] At this time, various sliding portions within the vane-type vacuum pump, particularly those portions to which the vanes 42 are brought into the sliding contact, such as the rotor 34, the end surfaces 27, 28 and the cylindrical surface 29 of the housing 1 and further the bearing portion are supplied with engine oil from the outside, thereby to lubricate the sliding contact portions.

[0015] According to the present invention, the sliding contact portion between the side end surfaces 27 and 28 of the housing 1 and the axial end surfaces 35 and 36 of the rotor 34 are provided with the annular projection ring 43 concentric to the rotary shaft 31 and the annular continuous groove 44 for receiving the projection ring 43 therein, whereby a U-shaped bent labyrinth-like seal is defined therebetween and at the same time a space in which engine oil can be maintained is defined. Therefore, this labyrinth-like seal can prevent the engine oil from flowing out through the sliding portion and the oil film from being broken, and the oil reservoir space can continue to supply engine oil, so that the wearing of the sliding contact portion can be prevented and the hermetic seal between the rotor and the housing can be maintained.

[0016] Figs. 5 to 7 illustrate an example in which an annular projection ring 47 is disposed on the side walls 27 and 28 of the housing 21 and an annular groove 48 is disposed in the end surfaces 35 and 36 of the rotor 34. The projection ring 47 on the housing 21 is a continuous annular ridge-shaped projection having a substantially rectangular cross-section and concentric to the rotary shaft 31 of the rotor 34. The groove 48 in the rotor 34 is an annular groove concentric to the rotary shaft 31 for receiving the projection ring 47 therein, but is discontinuous at the position where the slots 38 for accommodating the vanes 42 are located. In the end surfaces 40 of the vane 42, recesses 49 as escape grooves are provided for allowing the vanes 42 to be slidably movable within the slots 38 in the radial direction relative to the rotor 34 without interfering with the projection ring 47 on the housing 21.

[0017] Also in this vane-type vacuum pump, the sliding contact portion between the side end surfaces 27 and 28 of the housing 1 and the axial end surfaces 35 and 36 of the rotor 34 are provided with the annular projection ring 47 on the housing 21 and the annular continuous groove 48 for receiving the projection ring 47 therein at the side of the rotor 34, whereby a U-shaped bent labyrinth-like seal is defined between the groove 48 and the projection ring 47, and at the same time a space in which engine oil can be maintained is defined. Therefore, the wearing of the sliding contact portion can be prevented and the hermetic seal between the rotor and the housing can be maintained.

[0018] In the vane-type vacuum pump illustrated in Fig. 8, rotor 34 is provided at the end surfaces with two annular projection rings 51 and 52 and the housing 21 is provided with two annular grooves 53 and 54. Each of the projection rings 51 and 52 and the grooves 53 and 54 has similar structure to those shown in Figs. 1 to 4. In this vane-type vacuum pump, labyrinth-like seal and the oil reservoir space are doubled, so that the sealing function is significantly improved as compared to that of the previous embodiments.

[0019] In the vane-type vacuum pump illustrated in Fig. 9, rotor 34 is provided at the end surfaces with two annular grooves 55 and 56 and the housing 21 is provided with two annular projection rings 57 and 58. Each of the grooves 55 and 56 and the projection rings 57 and 58 has similar structure to those shown in Figs. 5 to 7. Escape grooves 59 provided in the end surfaces 47 and 48 of the vanes 42 have a radial dimension large enough to prevent interference with the doubled projection rings 55 and 56 and the doubled grooves 57 and 58. In this vane-type vacuum pump, labyrinth-like seal and the oil reservoir space are doubled, so that the sealing function is significantly improved as compared to that of the previous embodiments.

[0020] Fig. 10 is a schematic sectional view showing an example in which the vane-type vacuum pump shown in Figs. 1 to 4 is directly connected to a vehicular ac generator. In the illustrated example, the vehicular ac generator 60 comprises a stator 62 supported within a housing 61 and a rotor 66 having a rotary shaft 65 supported by bearings 63 and 64 mounted to the housing 61, the rotary shaft 65 extends at its left-hand end as viewed in the figure to the outside of the housing 61 and into the housing 71 of the vane-type vacuum pump 70 of the present invention. That is, the bracket 72 of the housing 71 of the vane-type vacuum pump 70 is attached to the housing 61 of the vehicular ac generator 60, and, while the bracket 72 has no bearing, the bracket 72 has attached thereto a housing main body 73 to constitute the housing 71 of the pump. Attached to the rotary shaft 65 within the housing 71 is the rotor 34 of the vane-type vacuum pump 70 and the annular projection rings 43 and the annular grooves 44 of the present invention are disposed between the rotor 34 and the housing 71, whereby a labyrinth-like seal extending in substantially entire circumference is provided.

[0021] Fig. 11 is a graph showing the comparison test results as to the vacuum degree of the vane-type vacuum pump shown in Figs. 1 to 4 and the conventional vane-type vacuum pump shown in Figs. 12 and 13. Two curves A and B show the degrees of vacuum expressed in the height (mmHg) of a mercury column at the suction side of the vane-type vacuum pump as plotted against the operation time (seconds) on abscissa, the curve A

representing the vacuum characteristics of the vane-type vacuum pump of the present invention and the curve B representing the vacuum characteristics of the conventional vane-type vacuum pump. It is understood from this graph that the difference between the degrees of vacuum gradually increases from the starting of the pump until the pump reaches to its constant operational state, where the degrees of vacuum themselves are also constant, and that the degree of vacuum according to the present invention is higher by from about 12% to about 15%.

[0022] As has been described in the foregoing description, the vane-type vacuum pump of the present invention comprises a labyrinth seal extending over an entire circumference, the labyrinth seal including at least one pair of circular ring-shaped grooves 44 and 48 and circular ridge-shaped projection rings 43 and 44 disposed concentrically to the rotary shaft 31 between the housing 21 and the rotor 34, the grooves and the projection rings engaging together and being relatively movable to each other in circumferential direction.

[0023] The circular projection rings 43 may be disposed on the end surfaces of the rotor 34 and the circular ring-shaped grooves 44 may be disposed in the housing 21, the circular ring-shaped grooves 48 may be disposed in side end surfaces of the rotor 34 and the circular ridge-shaped projection rings 47 may be disposed on the housing 21, and wherein grooves 49 may be provided in the side end surfaces of the vane 42 for receiving the projection rings 476 not to impede the radial movement of the vane 42. The labyrinth seal may be concentrically provided in a plurality of pairs, or the labyrinth seal may be disposed on both side end surfaces of the rotor.

INDUSTRIAL APPLICABILITY

[0024] As has been described, the vane-type vacuum pump of the present invention is useful as a vacuum pump for evacuating a tank constituting a vehicular brake assistor, for example.

Claims

1. A vane-type vacuum pump comprising;

a housing having a cylindrical pump chamber including a suction port and a discharge port;
a rotor eccentrically accommodated within said pump chamber;
a rotary shaft secured to said rotor for rotating said rotor within said pump chamber; and
a vane radially movably inserted into said rotor while maintaining a sliding contact with said housing within said pump chamber;

wherein the air within said pump chamber is pumped from said suction port to said discharge port by the rotation of said rotor to generate a vacuum on the side of said suction port side; **characterized by** a labyrinth seal disposed between said housing and said rotor to extending over an entire circumference and including at least one pair of a circular ring-shaped groove and a circular ridge-shaped projection ring concentrically disposed to said rotary shaft, said groove and said projection ring engage together and relatively movable to each other in circumferential direction.

2. A vane-type vacuum pump as claimed in claim 1, wherein said circular ridge-shaped projection ring is disposed on the end surface of said rotor and said circular ring-shaped groove is disposed in said housing.

3. A vane-type vacuum pump as claimed in claim 1, wherein said circular ring-shaped groove is disposed in a side end surface of said rotor and said circular ridge-shaped projection ring is disposed on the housing, and
wherein a groove is provided in the side end surface of said vane for receiving said projection ring not to impede the radial movement of said vane.

4. A vane-type vacuum pump as claimed in any one of claims 1 to 3,
wherein said labyrinth seal is concentrically provided in a plurality of pairs.

5. A vane-type vacuum pump as claimed in any one of claims 1 to 3,
wherein said labyrinth seal is disposed on both side end faces of said rotor.

6. A vane-type vacuum pump as claimed in any one of claims 1 to 3,
wherein said said rotary shaft is an output rotary shaft of a vehicular alternator.

FIG. 1

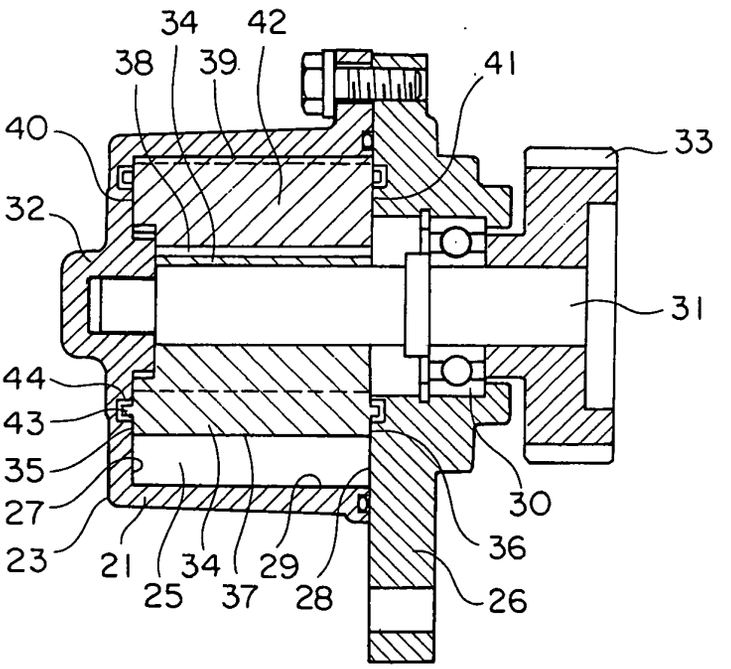

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FIG. 2

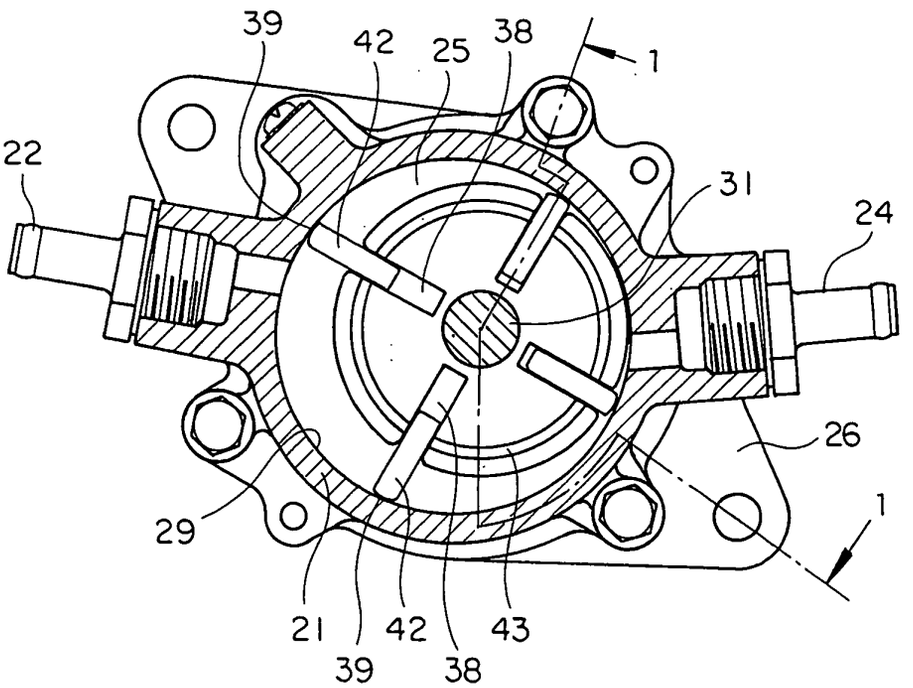
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FIG. 3

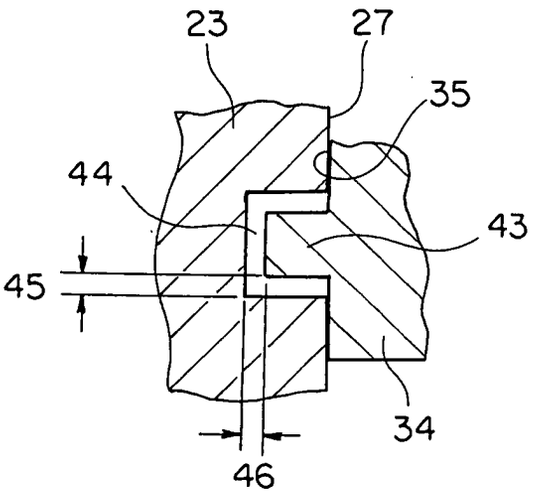


FIG. 4

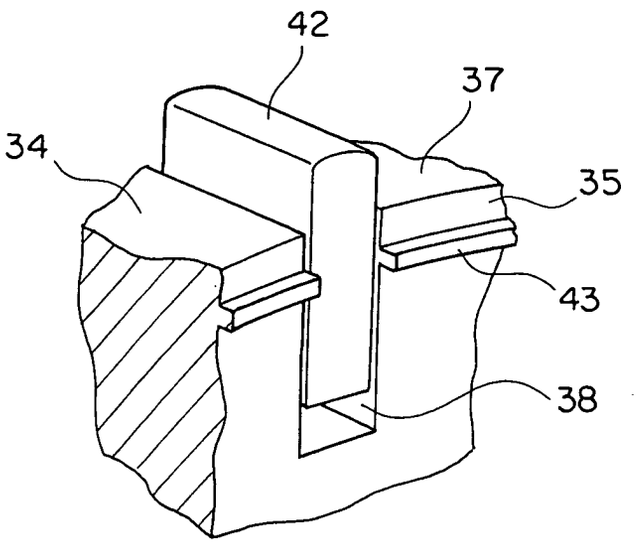


FIG. 5

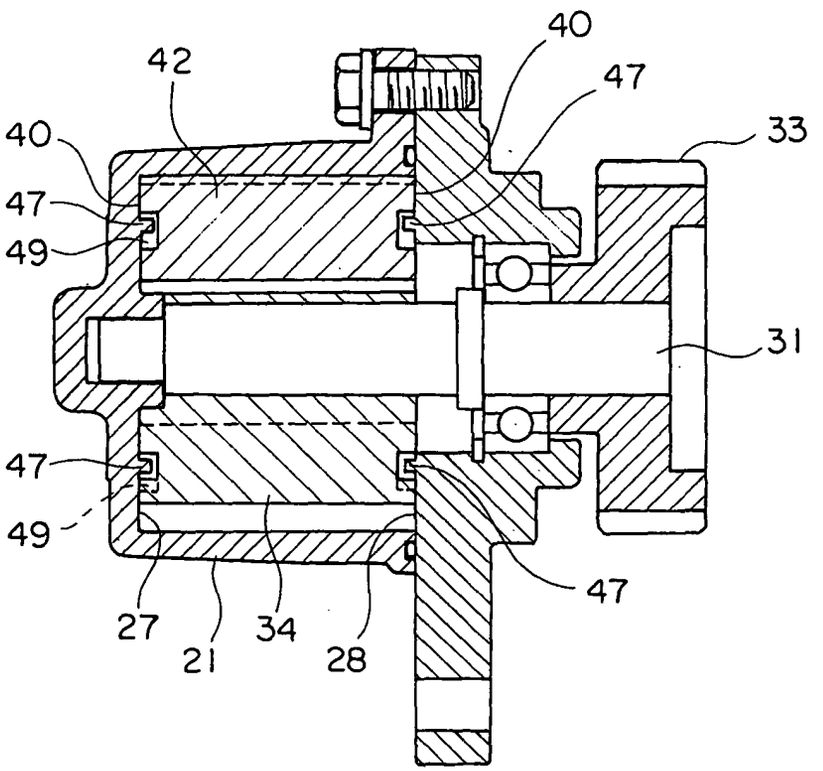


FIG. 6

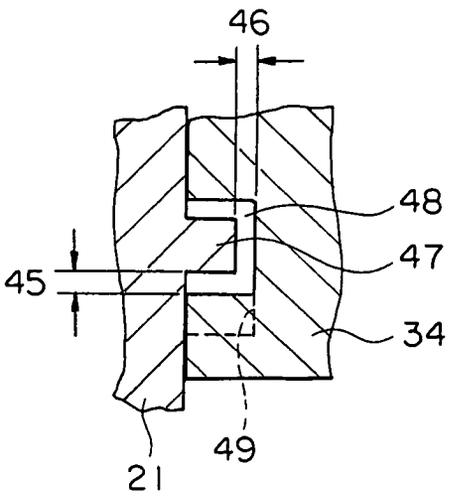


FIG. 7

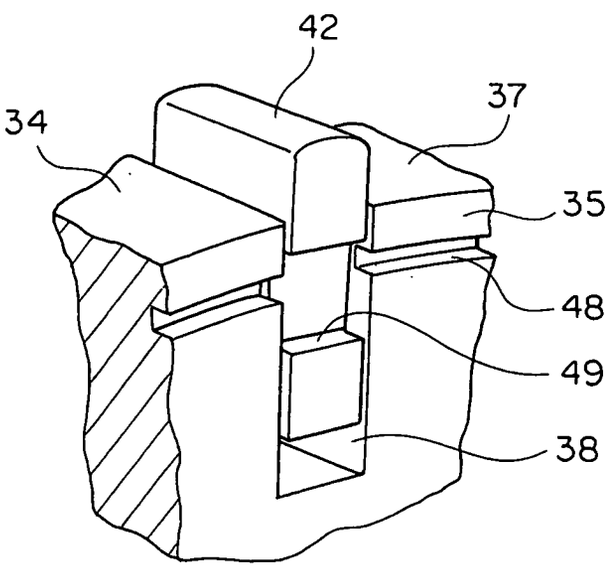


FIG. 8

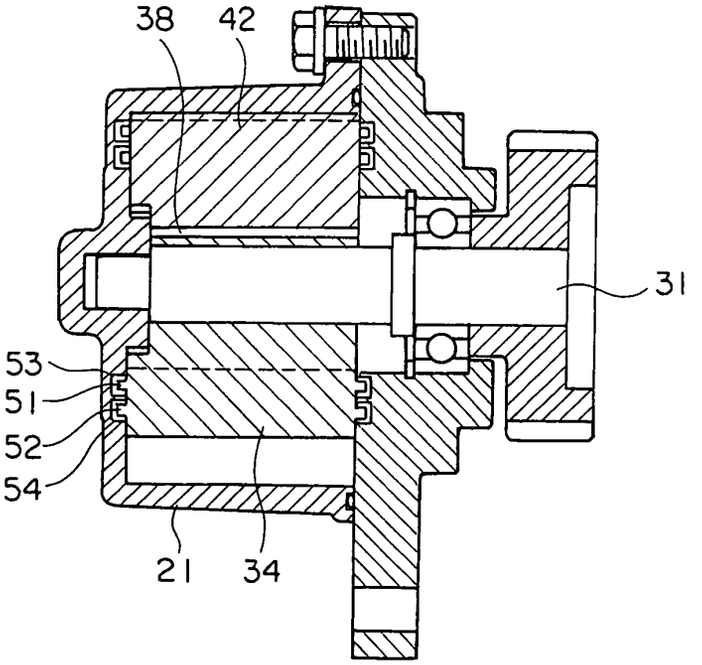


FIG. 9

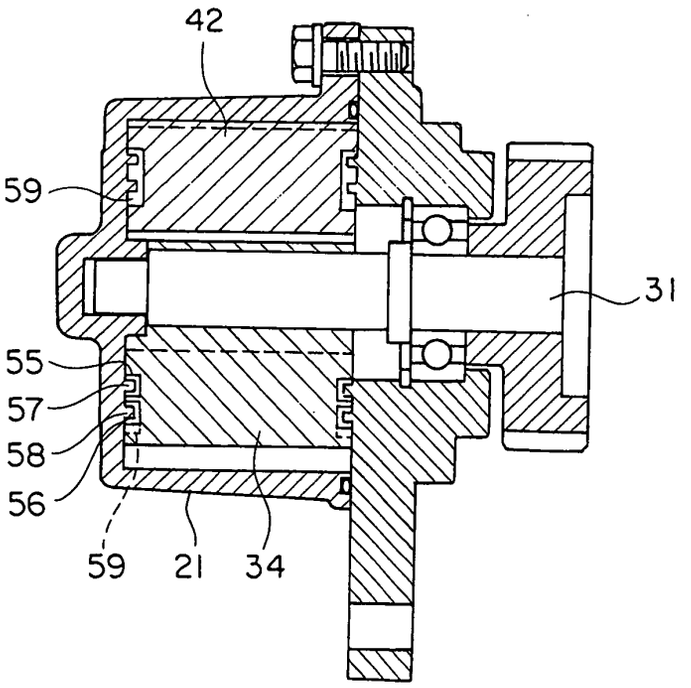


FIG. 10

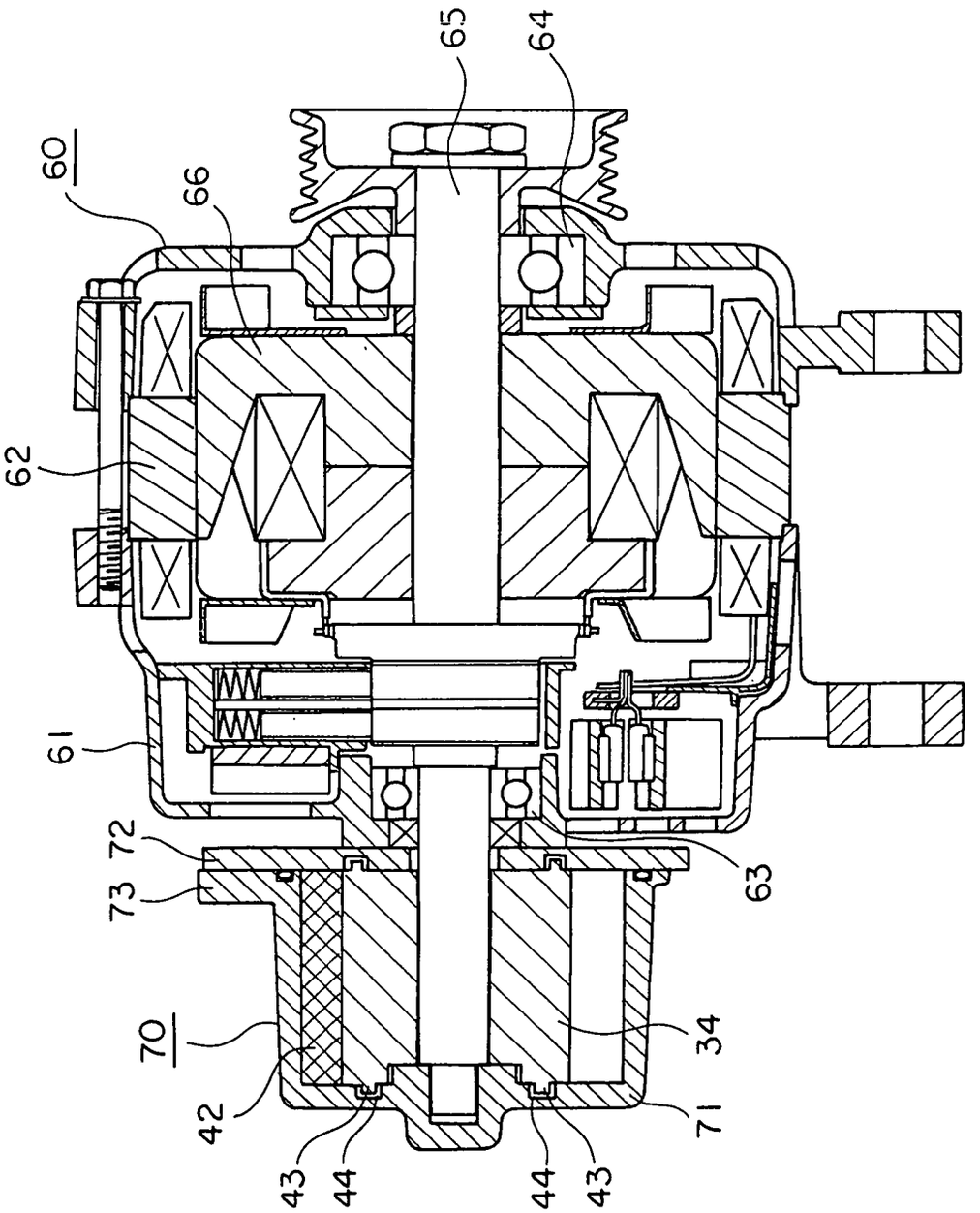
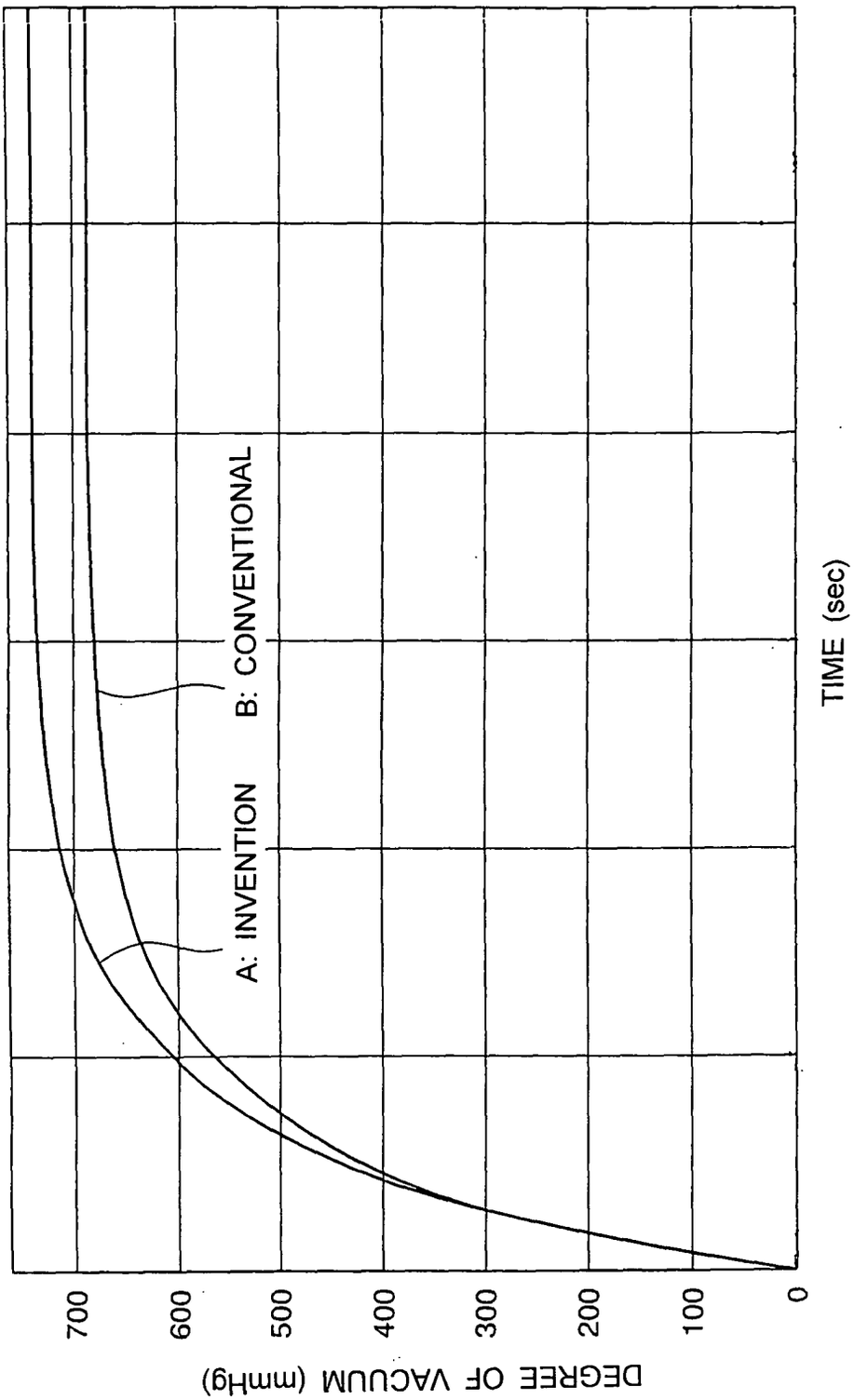


FIG. 11


DEGREE OF VACUUM (mmHg)
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600
500
400
300
200
100
0
TIME (sec)
A: INVENTION
B: CONVENTIONAL

FIG. 12

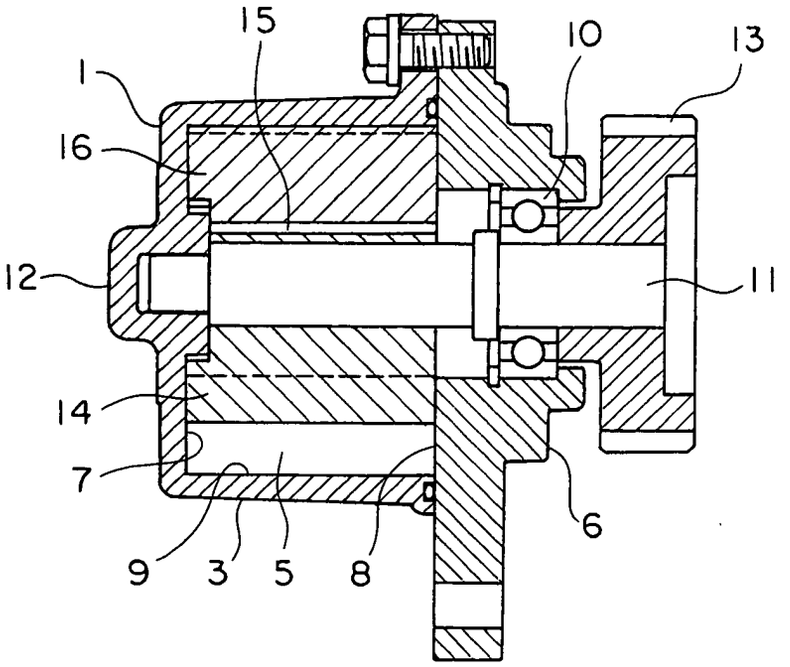
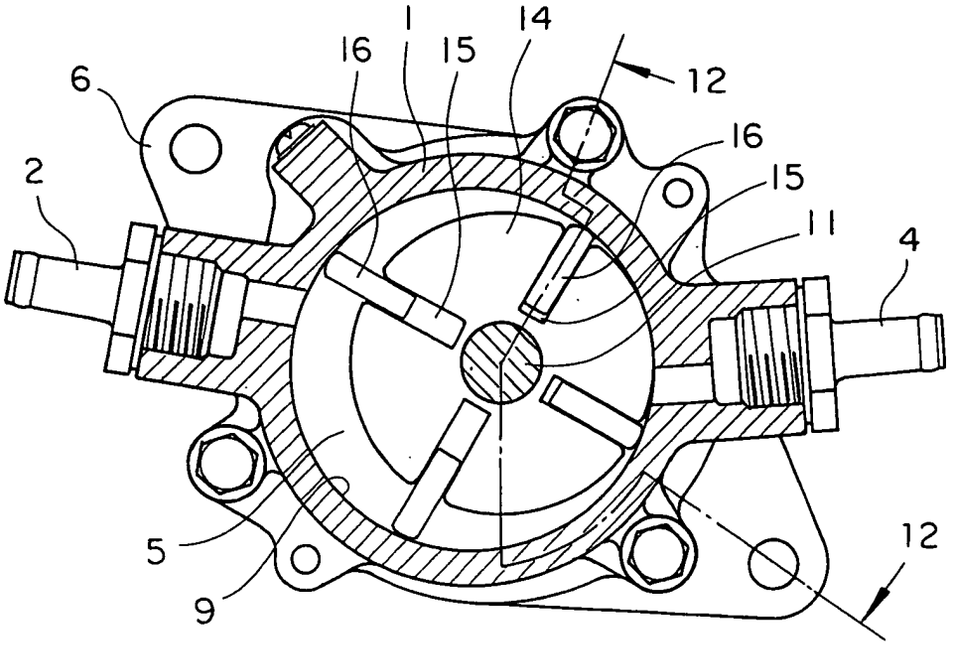


FIG. 13



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP02/10661

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] F04C18/344, F04C25/02

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] F04C18/344, F04C25/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1926-1996	Toroku Jitsuyo Shinan Koho	1994-2002
Kokai Jitsuyo Shinan Koho	1971-2002	Jitsuyo Shinan Toroku Koho	1996-2002

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 7-317674 A (Shuichi KITAMURA), 05 December, 1995 (05.12.95), Full text; all drawings (Family: none)	1-6
Y	JP 7-279678 A (Tochigi Fuji Sangyo Kabushiki Kaisha), 27 October, 1995 (27.10.95), Full text; all drawings (Family: none)	1-6
Y	JP 2947030 B2 (Matsushita Electric Industrial Co., Ltd.), 13 September, 1999 (13.09.99), Full text; all drawings (Family: none)	4

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 November, 2002 (12.11.02)	26 November, 2002 (26.11.02)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP02/10661

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2002-161881 A (Denso Corp.), 07 June, 2002 (07.06.02), Full text; all drawings (Family: none)	6

Form PCT/ISA/210 (continuation of second sheet) (July 1998)