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

(11) EP 1 239 158 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
11.09.2002 Bulletin 2002/37

(51) Int Cl.7: **F04C 18/02**

(21) Application number: **02004861.7**

(22) Date of filing: **04.03.2002**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **05.03.2001 JP 2001059976**

(71) Applicant: **Kabushiki Kaisha Toyota Jidoshokki**
Kariya-shi, Aichi-ken (JP)

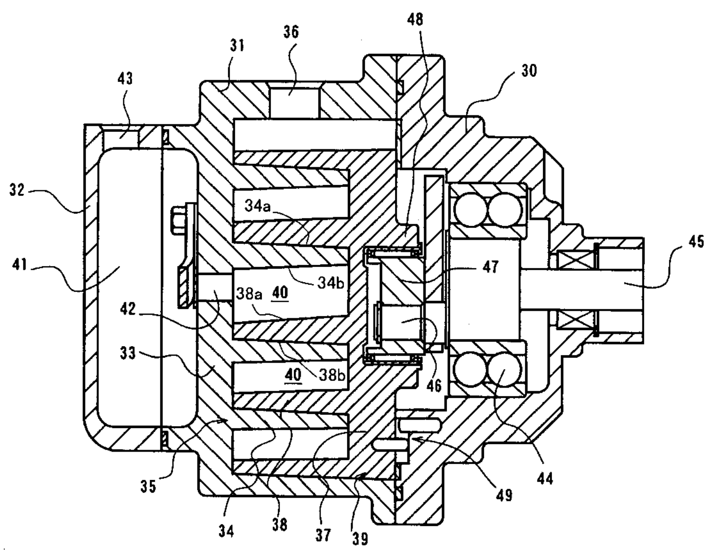
(72) Inventors:
- **Mori, Tatsushi**
  Kariya-shi, Aichi-ken (JP)
- **Iguchi, Masao**
  Kariya-shi, Aichi-ken (JP)
- **Asou, Shinsuke**
  Kariya-shi, Aichi-ken (JP)
- **Fujita, Yoshio**
  Kariya-shi, Aichi-ken (JP)
- **Yoshida, Yoshiharu**
  Kariya-shi, Aichi-ken (JP)

(74) Representative:
Leson, Thomas Johannes Alois, Dipl.-Ing.
Tiedtke-Bühling-Kinne & Partner GbR,
TBK-Patent,
Bavariaring 4
80336 München (DE)

(54) **Scroll type compressor**

(57) A scroll type compressor has a fixed scroll member and a movable scroll member. The fixed scroll member has a fixed scroll base plate and a fixed scroll wall extending from the fixed scroll base plate. The movable scroll member has a movable scroll base plate and a movable scroll wall extending from the movable scroll base plate. The fixed scroll member and the movable scroll member cooperatively form a compression region. The movable scroll member orbits relative to the fixed scroll member to compress refrigerant in the compression region. Each scroll wall is formed in a taper shape from each base plate toward each distal end of the scroll wall. The distal end is non-contact with the opposing scroll base plate. Clearance between the distal end and the opposing scroll base plate is less than or equal to the limit clearance value which maintains airtight performance.

FIG. 1



EP 1 239 158 A2

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a scroll type compressor and more particularly to structure of a fixed scroll member and a movable scroll member which constitute a compression mechanism in a volute shape.

[0002] In general, the scroll type compressor has a housing in which the fixed scroll member and the movable scroll member are provided. The fixed scroll member has a fixed scroll base plate and a fixed scroll wall that extends from the fixed scroll base plate. The movable scroll member has a movable scroll base plate and a movable scroll wall that extends from the movable scroll base plate. Each scroll wall is engaged with each other. The fixed scroll member and the movable scroll member cooperatively form a plurality of compression chambers as a compression region. As the movable scroll member orbits about an axis of the fixed scroll member, the compression chambers move radially inward while their volume decreases.

[0003] Since bending moment is applied to each scroll wall by high pressure generated in the compression chambers due to the compression performance, the bending moment deforms each scroll wall. Therefore, clearance between the scroll walls is increased and compressed fluid leaks through the clearance. Accordingly, high compression performance is not obtained.

[0004] To obtain the high compression performance by preventing the compressed fluid from leaking, as shown in FIG. 4A, a scroll wall 1 was conventionally created in a taper shape from a joining portion to a base plate 2 toward a distal end of the scroll wall 1.

[0005] Still referring to FIG. 4A, in the above constitution, the scroll wall 1 is strengthened against bending moment. Therefore, clearance between the scroll walls 1 was effectively restrained from increasing. There, such a constitution was employed that a tip seal 3 slides the surface of the opposing base plate 2 to ensure sealing performance in the clearance between the distal end of the scroll wall 1 and the opposing base plate 2.

[0006] However, as it is taken into consideration that the compressor used in high speed vehicles is nowadays required to be compact and lightweight for its fuel efficiency, the following problem has occurred in the above prior art. The thickness of the scroll wall 1 is increased when the tip seal 3 is used. As a result, configuration of the compressor is increased in size.

[0007] As shown in FIG. 4A, when the distal end of the scroll wall 1 is provided with the tip seal 3, thickness c of the distal end of the scroll wall 1 is determined as follows. $c=a+2*b$ where width of the tip seal 3 is expressed by a, and thickness of an outer wall of a groove formed in the distal end is expressed by b. Thickness of the portion joining to the scroll wall 1, which is expressed by d, is also determined to be relatively thick due to increase of the thickness c.

[0008] On the contrary, as shown in FIG. 4B, when the distal end of the scroll wall 1 has similar thickness to the width a of the tip seal 3 in size, thickness e of the portion joining to the base plate 2 becomes relatively small. Accordingly, the compressor including the scroll wall 1 shown in FIG. 4A, has less capacity in the compression chambers than that of FIG. 4B, because of an increase in thickness of the scroll wall 1 provided with the tip seal 3. To maintain the capacity in the compression chambers, the configuration of the compressor is inevitably increased in size.

SUMMARY OF THE INVENTION

[0009] The present invention addresses a scroll type compressor which is hard, compact and lightweight with high quality sealing performance.

[0010] According to the present invention, A scroll type compressor has a fixed scroll member and a movable scroll member. The fixed scroll member has a fixed scroll base plate and a fixed scroll wall extending from the fixed scroll base plate. The movable scroll member has a movable scroll base plate and a movable scroll wall extending from the movable scroll base plate. The fixed scroll member and the movable scroll member cooperatively form a compression region. The movable scroll member orbits relative to the fixed scroll member to compress refrigerant in the compression region. Each scroll wall is formed in a taper shape from each base plate toward each distal end of the scroll wall. The distal end is non-contact with the opposing scroll base plate. Clearance between the distal end and the opposing scroll base plate is less than or equal to the limit clearance value which maintains airtight performance between the distal end and the opposing scroll base plate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The features of the present invention that are believed to be novel are set forth with particularity in the appended claims. The invention together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

FIG. 1 is a diagram in a cross-sectional view illustrating a first preferred embodiment of the scroll type compressor according to the present invention;

FIG. 2 is a diagram in a partial enlarged view illustrating first and second preferred embodiments of the scroll type compressor according to the present invention;

FIG. 3 is a graph illustrating a relation between clearance in the direction of an axis and a ratio of

COP according to the present invention;

FIG. 4A is a diagram in a partial cross-sectional view illustrating a scroll wall with a tip seal according to the prior art; and

FIG. 4B is a diagram in a partial cross-sectional view illustrating a scroll wall without a tip seal according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0012] A scroll type compressor according to a first preferred embodiment of the present invention will be described with reference to Figs. 1 through 3.

[0013] As shown in FIG. 1, a front housing 30, a center housing 31 and a rear housing 32 are connected to form a configuration of the compressor. A fixed scroll member 35 is integrally formed with the center housing 31. The fixed scroll member 35 has a fixed scroll base plate 33 and a fixed scroll wall 34 that extends from the fixed scroll base plate 33. An inlet 36 for introducing refrigerant is also formed in the center housing 31 and is connected to an external refrigerant circuit. A movable scroll member 39 is accommodated in a space defined by the center housing 31 and the front housing 30. The movable scroll member 39 has a movable scroll base plate 37 and a movable scroll wall 38 that extends from the movable scroll base plate 37. The fixed scroll wall 34 and the movable scroll wall 38 engage with each other. Thereby, a plurality of compression chambers 40 is defined as a compression region between the fixed scroll member 35 and the movable scroll member 39. A discharge hole 42 is formed substantially at the center of the fixed scroll base plate 33. Compressed refrigerant in the compression chambers 40 is discharged into a discharge chamber 41 defined between the center housing 31 and the rear housing 32 through the discharge hole 42. An outlet 43 is formed in the rear housing 32 to flow refrigerant in the discharge chamber 41 into the external refrigerant circuit.

[0014] Still referring to FIG. 1, one end of a drive shaft 45 is rotatably supported in the front housing 30 by bearing 44 and the other end of the drive shaft 45 extends outside of the configuration of the compressor. A crankshaft 46 is mounted on one end of the drive shaft 45. The crankshaft 46 is received by a bushing 47, which is inserted in a boss 48 of the movable scroll member 39. A self rotation preventing mechanism 49 prevents the movable scroll member 39 from rotating about its axis, while allowing the movable scroll member 39 to orbit about an axis of the fixed scroll member 35.

[0015] As shown in FIG. 2, the fixed scroll wall 34 and the movable scroll wall 38 are respectively formed in a taper shape from portions joining to the scroll base plates 33 and 37 toward the respective distal ends. The fixed scroll wall 34 has a pair of side surfaces 34a and 34b which incline by angles of θ_1 and θ_2 with respect to the direction of an axis of the drive shaft 45 (which is perpendicular to the scroll base plates 33 and 37), respectively. In a similar manner, the movable scroll wall 38 has a pair of side surfaces 38a and 38b which incline by angles of θ_3 and θ_4 with respect to the direction of the axis of the drive shaft 45 (which is perpendicular to the scroll base plates 33 and 37), respectively. At this time, the side surfaces 34b and 38a which face each other are equal in inclination angle. That is, θ_2 equals θ_3. In a similar manner, the side surfaces 34a and 38b which face each other are also equal in inclination angle. That is, θ_1 equals θ_4. In addition, when the side surfaces 34a and 34b of the fixed scroll wall 34 are equal in inclination angle, θ_1 equals θ_2. In a similar manner, when the side surfaces 38a and 38b of the movable scroll wall 38 are equal in inclination angle, θ_3 also equals θ_4. In this case, the fixed scroll wall 34 and the movable scroll wall 38 are equal in inclination angle. The above inclination angle is formed not only by cutting but also by utilizing a draft upon casting.

[0016] Still referring to FIG. 2, when the compressor is assembled by engaging the movable scroll member 39 with the fixed scroll member 35, the distal end of the fixed scroll wall 34 and the opposing surface of the movable scroll base plate 37 are maintained to have clearance G_1 therebetween so as not to contact with each other. In a similar manner, the distal end of the movable scroll wall 38 and the opposing surface of the fixed scroll base plate 33 are maintained to have clearance G_2 therebetween so as not to contact with each other. The clearance G_1 generally equals the clearance G_2.

[0017] Now, a method for searching the optimal value of the clearance G_1 and G_2 will be explained with reference to FIG. 3. In this graph the value of x-axis represents length of clearance G_1 and G_2 in the direction of the axis expressed by unit of micrometer or μ m and the value of y-axis represents a ratio of Coefficient of Performance or COP of a compressor according to the present invention, which is not provided with the tip seal, to that of a compressor which is provided with the tip seal. In both cases that oil circulating inside exists and doesn't exist, relation between the length of clearance and the ratio of COP is respectively drawn by line graph. Even in the case that the distal end is provided with the tip seal, the length of the clearance represents distance between the distal end of the scroll wall and the opposing surface of the scroll base plate.

[0018] Still referring to FIG. 3, note that efficiency of load L which is required due to a heat absorption in an evaporator is generally expressed by COP as follows. $COP = Q_{er}/L$, where Q_{er} denotes efficiency of refrigeration.

[0019] In view of total performance of the compressor, the ratio of COP is allowable if it is more than or equal to 0.9. At this time, in the case that the oil circulating inside exists, FIG. 3 reads that the length of the clearance is less than or equal to 60 μ m. In the case that no oil circulating inside exists, FIG. 3 reads that the length of the clearance is less than or equal to 47 μ m. Accordingly, it is required that the clearance G_1 and G_2 are each less than or equal to the above upper limit value.

[0020] Then, function of the first preferred embodiment will be explained. As shown in FIG. 1, when the drive shaft 45 that extends outside of the configuration of the compressor is rotated by driving force of an external drive source such as a vehicle engine, which is connected to the drive shaft 45 through a pulley which is not shown, the movable scroll member 39 orbits about the axis of the fixed scroll member 35. Refrigerant gas introduced from the external refrigerant circuit through the inlet 36 is compressed to be predetermined pressure in the compression chambers 40 and discharged into the discharge chamber 41 through the discharge hole 42 by the orbital movement. The pressurized refrigerant gas discharged into the discharge chamber 41 is sent to the external refrigerant circuit through the outlet 43.

[0021] As shown in FIG. 2 in combination with FIG. 1, during the above compression process, bending moment is applied to the scroll walls 34 and 38 due to compression movement in the compression chambers 40. In this constitution, however, the fixed scroll wall 34 and the movable scroll wall 38 are respectively formed in a taper shape from the portions joining to the scroll base plates 33 and 37 toward the respective distal ends, while having relatively sufficient thickness of the portions. Accordingly, the fixed scroll wall 34 and the movable scroll wall 38 are restrained from being deformed, thus effectively maintaining a sealing performance therebetween.

[0022] Still referring to FIG. 2, while the distal ends of the fixed scroll wall 34 and the movable scroll wall 38 are not in contact with the respective opposing surfaces of the movable scroll base plate 37 and the fixed scroll base plate 33, sealing performance is respectively ensured since the distance therebetween is less than or equal to the upper limit clearance value which maintains airtight performance. Thus, total sealing performance in the compression region is relatively and sufficiently maintained. Therefore, high compressing performance is obtained. Besides, since the distal ends of the scroll wall 34 and 38 and the respective opposing surfaces of the scroll base plates 37 and 33 are prevented from directly contacting, power loss is also restrained to be extremely small while the compressor is driven.

[0023] Especially, as shown in FIG. 3 in combination with FIG. 1, in the case that the oil circulating inside exists when the clearance in the direction of the axis of the drive shaft 45 is less than or equal to 36 μ m, the ratio of COP is more than or equal to 1. In a similar manner, in the case that no oil circulating inside exists when the clearance in the direction of the axis of the drive shaft 45 is less than or equal to 30 μ m, the ratio of COP is also more than or equal to 1. These mean that the compressor according to the present invention has superior efficiency of refrigeration to the compressor provided with the tip seal when the clearance G_1 and G_2 are less than or equal to the foregoing upper limit value. This is regarded because the compressor provided with the tip seal losses power due to sliding friction generated between the tip seal and the opposing surface of the scroll base plate. Accordingly, in the above description while the clearance G_1 and G_2 are less than or equal to 60 μ m, more preferably, in the case that the oil circulating inside exists, the clearance G_1 and G_2 are less than or equal to 36 μ m. In a similar manner, while the clearance G_1 and G_2 are less than or equal to 47 μ m, more preferably, in the case that no oil circulating inside exists, the clearance G_1 and G_2 are less than or equal to 30 μ m.

[0024] Referring back to FIG. 2, in this embodiment, since the distal ends of the scroll walls 34 and 38 are not provided with the tip seal, while provided in the prior art, the thickness of the distal ends of the scroll walls 34 and 38 is prevented from inevitably increasing by providing the tip seal. Accordingly, the thickness of the scroll wall is determined to be minimized. In spite of the relatively sufficient thickness of the joint portion, the configuration of the compressor is not increased in size.

[0025] In this embodiment the following effects are obtained. Firstly, still referring to FIG. 2, since the scroll walls 34 and 38 are restrained from being deformed to resist to bending moment by relatively and sufficiently ensuring the thickness of the joint portions of the scroll walls 34 and 38, sealing performance is ensured. In addition, sealing performance is also ensured in clearance between the distal ends of the scroll walls 34 and 38, and the respective opposing surfaces of the scroll base plates 37 and 33. As a result, total sealing performance in the compression region is relatively and sufficiently maintained. Thus, high compressing performance is obtained.

[0026] Secondly, since sealing performance is sufficiently ensured therebetween while the distal ends of the scroll walls 34 and 38 are not in contact with the respective opposing surfaces of the scroll base plates 37 and 33, relatively sufficient efficiency of compression is ensured by the distal ends of the scroll walls 34 and 38 with necessary minimal thickness, and the scroll walls 34 and 38, as a whole, have necessary minimal thickness. Accordingly, capacity in the compression region is increased, and in its turn, the compressor is, as a whole, reduced in size and weight.

[0027] Thirdly, the side surface 34a of the scroll wall 34 and the side surface 38b of the scroll wall 38 facing each other are equal in inclination angle. Also, the side surface 34b of the scroll wall 34 and the side surface 38a of the scroll wall 38 facing each other are equal in inclination angle. Therefore, airtight constitution in the compression region is easily obtained by a draft upon casting. In addition, the side surfaces 34a and 34b of the scroll wall 34 are each equal in inclination angle. Also, the side surfaces 38a and 38b of the scroll wall 38 are equal in inclination angle. Moreover, since these side surfaces 34a, 34b, 38a and 38b are each set to be equal in inclination angle even between the scroll members 35 and 39, molding for casting is easily manufactured.

[0028] Fourthly, since the inclination angles of the side surfaces 34a, 34b, 38a and 38b of the scroll walls 34 and 38 are formed by utilizing a draft upon casting, cutting process is not required. Therefore, person-hour for manufacturing is reduced. In addition, since casting surface or surface as forged is used in this case, the compressor which is high in surface hardness and durability is obtained.

[0029] A scroll type compressor according to a second preferred embodiment of the present invention will be described with reference to FIG. 2. In this embodiment, the side surfaces 34a, 34b of the scroll wall 34 are different in inclination angle. Also, the side surfaces 38a, 38b of the scroll wall 38 are different in inclination angle. That is, inclination angles θ_1, θ_2 of the side surfaces 34a, 34b of the scroll wall 34 are different from each other. Also, inclination angles θ_3, θ_4 of the side surfaces 38a, 38b of the scroll wall 38 are different from each other. However, the side surfaces 34a, 38b and 34b, 38a of the scroll walls 34 and 38 which are facing each other are equal in inclination angle. That is, the relation between θ_1, θ_2, θ_3 and θ_4 is expressed as follows. $\theta_2 = \theta_3$. $\theta_1 = \theta_4$.

[0030] As described above, side surfaces of a scroll wall are different in inclination angle. When the scroll member is formed, for example, by casting, it may be required that the side surfaces of the scroll wall are different in draft in a casting plan. Accordingly, inclination angles of the side surfaces are predetermined differently. The other constitution of the second embodiment is similar to the constitution of the first embodiment, and the overlapped explanation is omitted.

[0031] As constituted above, since each pair of side surfaces 34a, 38b and 34b, 38a of the scroll walls 34 and 38 facing each other is equal in inclination angle even if the side surfaces 34a, 34b and 38a, 38b of the scroll walls 34 and 38 are each different in inclination angle, sealing performance in the compression chambers 40 is ensured. Thus, compression cycle in the compression chambers 40 is performed without obstruction.

[0032] In this embodiment, the above described effects of the first embodiment are obtained. In addition, the following effect is also obtained. Since it is possible that each side surface of the scroll wall of the scroll member is different in inclination angle, a design in a casting plan is relatively freely performed. As a result, the scroll member is easily manufactured.

[0033] In the present invention, the following embodiment is also practiced. The scroll type compressor according to the above embodiments has the drive shaft which protrudes outside of the configuration of the compressor and is operatively connected to the external drive source such as an engine. However, the above external drive source may be built in type or canned motor type. That is, electric motor for driving the drive shaft may be installed in the compressor.

[0034] As described above, in the present invention, since thickness of the joint portion of the scroll wall is larger than that of the distal end of the scroll wall, the scroll wall is prevented from being deformed. In addition, sealing performance is ensured in clearance between the distal end of the scroll wall and the opposing surface of the scroll base plate. Therefore, airtight performance in the compression region is, as a whole, maintained. As a result, high compressing performance is obtained. Moreover, since the distal end is not provided with the tip seal, the scroll wall has, as a whole, relatively small thickness. As a result, the scroll wall becomes compact and lightweight. Thus, various prominent effects are obtained.

[0035] The present examples and preferred embodiments are to be considered as illustrative and not restrictive and the invention is not to be limited to the details given herein but may be modified within the scope of the appended claims.

[0036] A scroll type compressor has a fixed scroll member and a movable scroll member. The fixed scroll member has a fixed scroll base plate and a fixed scroll wall extending from the fixed scroll base plate. The movable scroll member has a movable scroll base plate and a movable scroll wall extending from the movable scroll base plate. The fixed scroll member and the movable scroll member cooperatively form a compression region. The movable scroll member orbits relative to the fixed scroll member to compress refrigerant in the compression region. Each scroll wall is formed in a taper shape from each base plate toward each distal end of the scroll wall. The distal end is non-contact with the opposing scroll base plate. Clearance between the distal end and the opposing scroll base plate is less than or equal to the limit clearance value which maintains airtight performance.

Claims

1. A scroll type compressor comprising:

a fixed scroll member having a fixed scroll base plate and a fixed scroll wall extending from the fixed scroll base plate; and

a movable scroll member having a movable scroll base plate and a movable scroll wall extending from the movable scroll base plate, wherein the fixed scroll member and the movable scroll member cooperatively form a compression region, and wherein the movable scroll member orbits relative to the fixed scroll member to compress refrigerant in the compression region, and wherein each scroll wall is formed in a taper shape from each base plate toward each distal end of the scroll wall, the distal end being non-contact with the opposing scroll base plate, clearance between the distal end and the opposing scroll base plate being less than or equal to the limit clearance value which maintains airtight performance between the distal end and the opposing scroll base plate.

2. The scroll type compressor according to claim 1 wherein the side surface of the fixed scroll wall and the side surface of the movable scroll wall, which are facing each other, have an equal inclination angle with respect to the direction of an axis which is perpendicular to the base plate.

3. The scroll type compressor according to claim 2 wherein the side surfaces of the fixed scroll wall and the movable scroll wall have an equal inclination angle with respect to the direction of the axis.

4. The scroll type compressor according to claim 1 wherein the limit clearance value is less than or equal to 60 μ m when circulating oil exists in the compression region.

5. The scroll type compressor according to claim 4 wherein the limit clearance value is less than or equal to 36 μ m.

6. The scroll type compressor according to claim 1 wherein the limit clearance value is less than or equal to 47 μ m when no circulating oil exists in the compression region.

7. The scroll type compressor according to claim 6 wherein the limit clearance value is less than or equal to 30 μ m.

8. The scroll type compressor according to claim 1 wherein each scroll wall is formed in a taper shape from each base plate toward each distal end of the scroll wall by utilizing a draft upon casting.

9. A scroll fluid machine comprising:

a fixed scroll member having a fixed scroll base plate and a fixed scroll wall extending from the fixed scroll base plate; and
a movable scroll member having a movable scroll base plate and a movable scroll wall extending from the movable scroll base plate, wherein the fixed scroll member and the movable scroll member cooperatively form a compression region, and wherein the movable scroll member orbits relative to the fixed scroll member to compress fluid in the compression region, and wherein each scroll wall is formed in a taper shape from each base plate toward each distal end of the scroll wall, the distal end being non-contact with the opposing scroll base plate, clearance between the distal end and the opposing scroll base plate being less than or equal to the limit clearance value which maintains airtight performance between the distal end and the opposing scroll base plate.

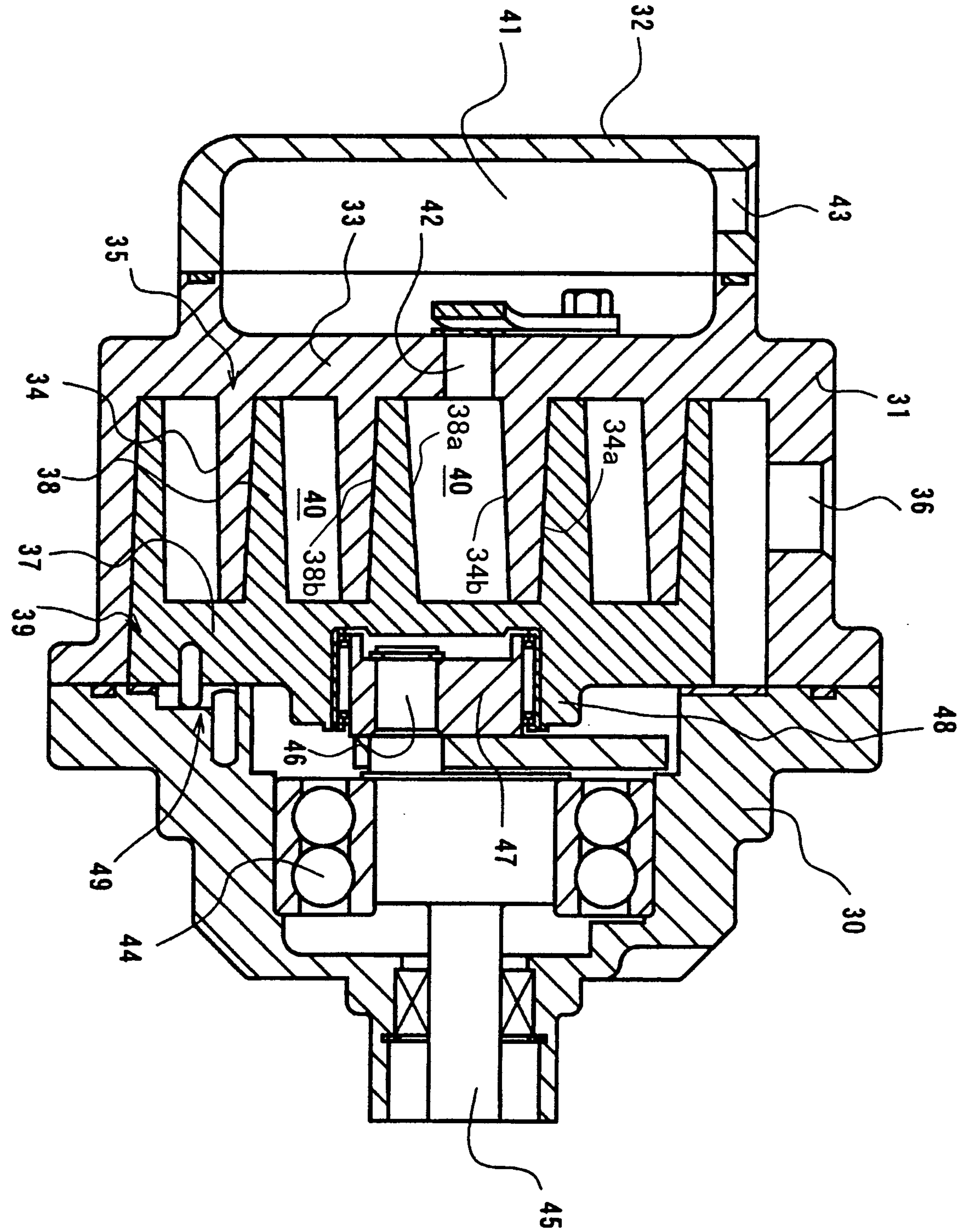

41
32
43
33
42
35
31
34
38
38a
40
34a
36
40
38b
34b
37
39
48
46
47
49
44
30
45

FIG. 1

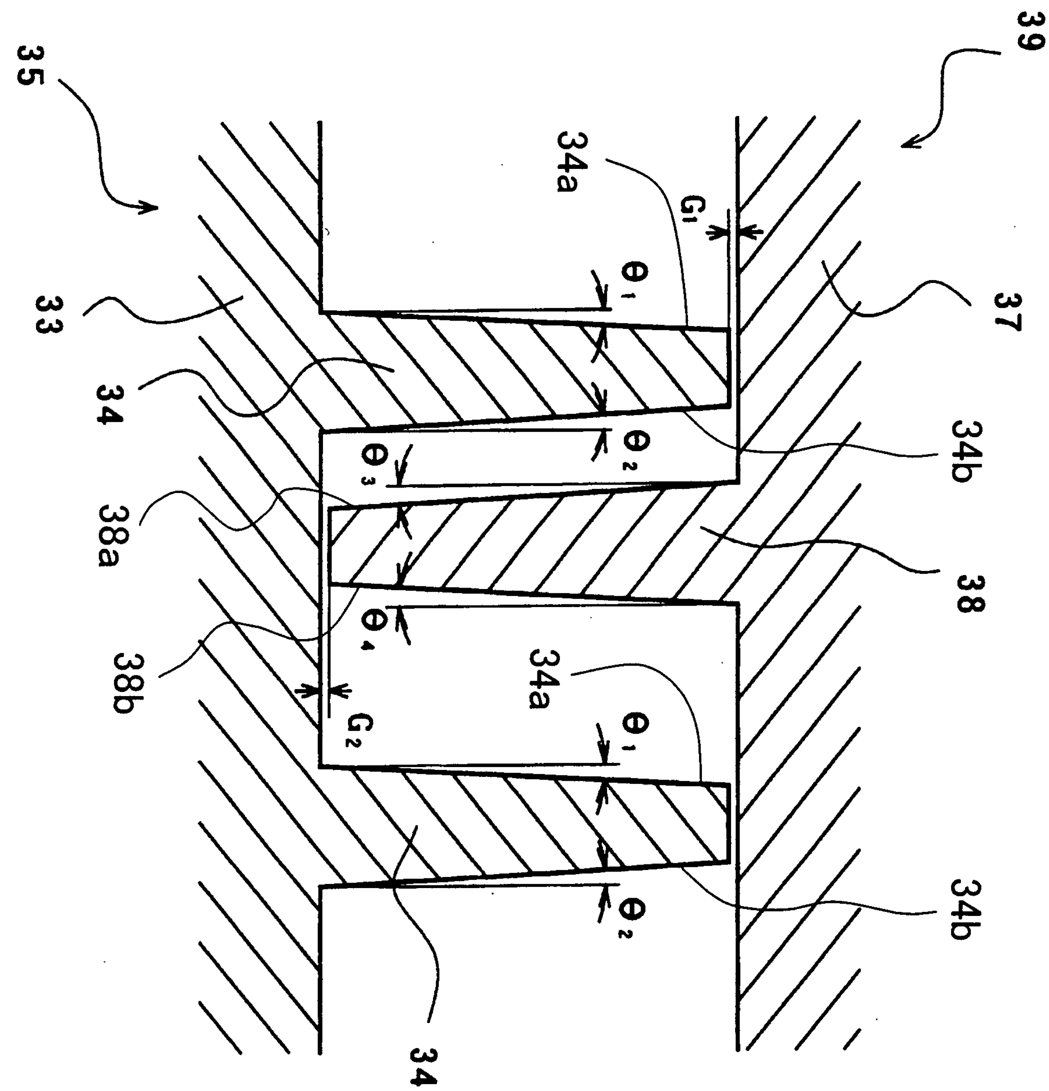


FIG. 2

FIG. 3

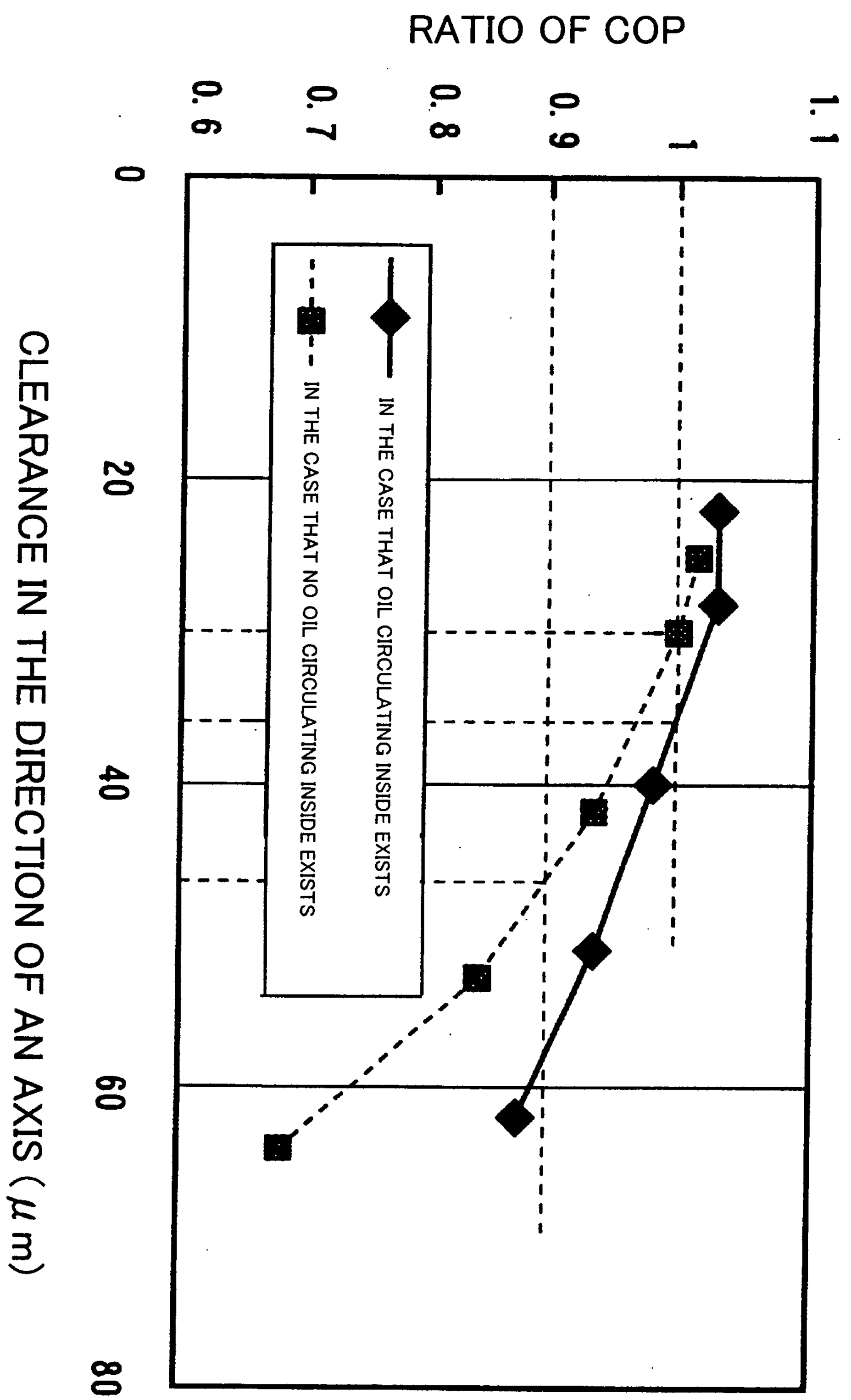

RATIO OF COP
1.1
1
0.9
0.8
0.7
0.6
0
20
40
60
80
IN THE CASE THAT OIL CIRCULATING INSIDE EXISTS
IN THE CASE THAT NO OIL CIRCULATING INSIDE EXISTS
CLEARANCE IN THE DIRECTION OF AN AXIS (μm)

FIG. 4A (PRIOR ART)

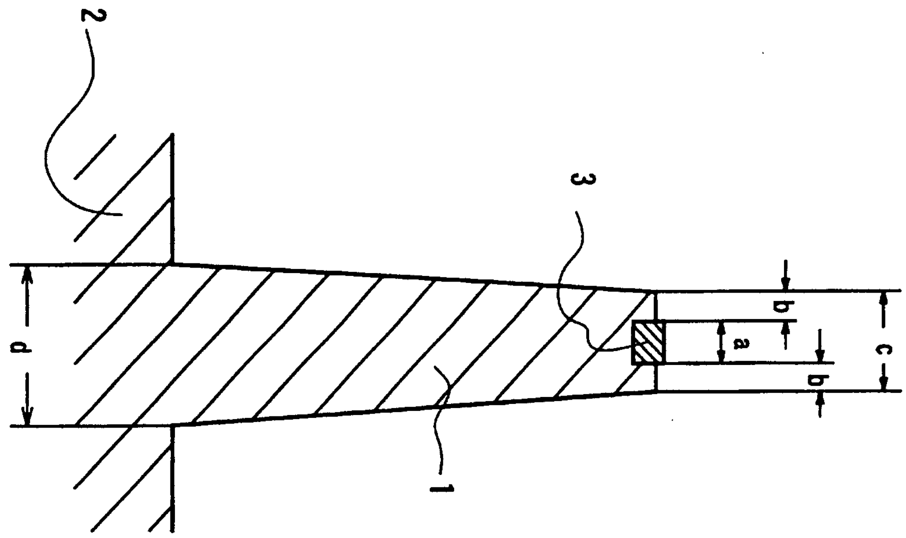


FIG. 4B