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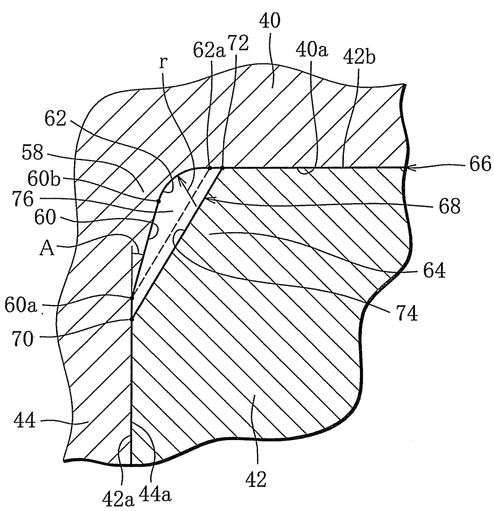
(54) SCROLL TYPE FLUID MACHINE

(57) A scroll type fluid machine (1) comprises a root portion (58) having a tapered surface (60) tilting from a taper end (60a) located on a side face (44a) of a wrap (44) toward a plate surface (40a) on which the wrap (44) stands, and a chamfer (68) on a wrap (42) paired with the wrap (44) having the root portion (58), formed by chamfering from a chamfer end (70) located on a side face (42a) of the wrap (42) toward an end face (42b) of the wrap (42). The chamfer (68) is formed to have a size ensuring that, with a sliding contact plane (66) defined, the chamber is separated from the root portion (58) and the distance from the chamfer end (70) to the sliding contact plane (60) is greater than or equal to the distance from the taper end (60a) to the sliding contact plane (66).

FIG. 2



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Description

Technical Field

[0001] This invention relates to a scroll type fluid machine, and specifically, a scroll type fluid machine suited for use in refrigerators, air-conditioners and heat pump water heaters.

Background Art

[0002] A scroll type fluid machine of this type, for example a sealed scroll compressor carries out a process of suction, compression and discharge of a working fluid (hereinafter referred to as "refrigerant") by a movable scroll doing an orbital motion in relation to a fixed scroll inside a housing.

[0003] Specifically, the movable and fixed scrolls each includes a spiral wrap standing on a plate surface of an end plate. The wraps cooperate to define a compression chamber, and the above process is carried out by reducing the volume of the compression chamber. A technique of forming a chamfer at an end portion of the wrap is publicly known (see Japanese Utility Model Application KOKAI Publication Sho 62-76185, Japanese Patent Application KOKAI Publication 2001-329972, Japanese Patent Application KOKAI Publication 2004-76629 and Japanese Utility Model Application KOKAI Publication Sho 62-82391, for example).

[0004] Generally, the wrap is formed by cutting with a cutting tool such as an endmill, and when an aging cutting tool worn at the forward end is used, a tapered surface is produced at a root portion of the wrap, corresponding to the wear of the cutting tool.

[0005] The above-mentioned prior techniques, however, give no special consideration to such machining error at the root portion of the wrap caused by wear of the cutting tool, and therefore suffers the problem that poor contact between the wraps causes an increase in the amount of the refrigerant leaking from the compression chamber, resulting in a decrease in volumetric efficiency of the compressor.

Disclosure of the Invention

[0006] The present invention has been made in view of problems as mentioned above. The primary object of the present invention is to provide a scroll type fluid machine capable of preventing an increase in the amount of refrigerant leakage caused by poor contact between the wraps of the movable and fixed scrolls, thereby providing an improved volumetric efficiency.

[0007] In order to achieve the above object, the scroll type fluid machine according to claim 1 is a scroll type fluid machine comprising a fixed and movable scrolls arranged inside a housing and each having a pair-forming spiral wrap standing on a plate surface of an end plate, said fixed and movable scrolls carrying out a process from suction to discharge of a working fluid, by the movable scroll doing an orbital motion in relation to the fixed scroll, with an end face of one of the paired wraps in sliding contact with the plate surface of the other wrap, thus defining a sliding contact plane, wherein either or both of the fixed and movable scrolls have a root portion of the wrap having a tapered surface tilting from a taper end located on a side face of the wrap toward the plate surface on which the wrap stands, and a chamfer is formed on the wrap paired with the wrap having said root portion by chamfering from a chamfer end located on a side face of the wrap toward an end face of the wrap, wherein the chamfer is formed to have a size ensuring that, with said sliding contact plane defined, the chamfer is separated from said root portion and the distance from the chamfer end to the sliding contact plane is greater than or equal to the distance from the taper end to the sliding contact plane.

[0008] In the above-described scroll type fluid machine, the chamfer has a size large enough to avoid coming in contact with the root portion of the wrap paired with the wrap having the chamfer, which ensures that, with the sliding contact plane defined, the side faces of the paired wraps can make secure contact with each other. Thus, even though wear of a cutting tool such as an endmill, used in forming a wrap by cutting, produces a tapered surface at the root portion of the wrap, an increase in the amount of refrigerant leakage caused by poor contact between the wraps is prevented, resulting in an improved volumetric efficiency of the fluid machine.

[0009] In a preferred embodiment of the waste heat utilization device for the internal combustion engine [*sic*], the root portion further has a round surface formed by rounding from said tapered surface to the plate surface and having an round end located on the plate surface, and said chamfer has a second chamfer end on the end face, and is formed to have a size ensuring that, with said sliding contact plane defined, said chamfer is separated from said root portion and the distance from said second chamfer end to the side face of the wrap having said root portion is greater than or equal to the distance from said round end to said side face.

[0010] In this configuration, although the root portion has a round surface in addition to the tapered surface, an increase in the amount of refrigerant leakage caused by poor contact between the wraps is prevented, resulting in a further improved volumetric efficiency of the fluid machine.

[0011] In a preferred embodiment of the waste heat utilization device for the internal combustion engine [*sic*], said chamfer is provided such that, with said sliding contact plane defined, said chamfer end coincides with the taper end and said second chamfer end coincides with the round end.

[0012] This configuration reduces the volume of a dead space between the wraps, namely the space between the chamfer and the root portion which does not constitute the compression chamber, thereby reducing the amount of the refrigerant leaking from the compression chamber through the dead space, which results in a further improved volumetric efficiency of the fluid machine.

[0013] In a preferred embodiment of the waste heat utilization device for the internal combustion engine [*sic*], the chamfer includes two or more tapered surfaces in tiers.

[0014] This configuration allows the chamfer to be formed nearer to the root portion, which results in a further reduction in dead volume, and thus, a further improved volumetric efficiency of the fluid machine.

[0015] In a preferred embodiment of the waste heat utilization device for the internal combustion engine [*sic*], the chamfer includes an arc surface.

[0016] This configuration allows the chamfer to be formed further nearer to the root portion, which results in a minimized dead volume, and thus, a further improved volumetric efficiency of the fluid machine.

[0017] In a preferred embodiment of the waste heat utilization device for the internal combustion engine [*sic*], the working fluid is a refrigerant consisting of carbon dioxide.

[0018] This configuration provides a more remarkable improvement in volumetric efficiency of the fluid machine, because, when carbon dioxide is used as a refrigerant, the fluid machine operates at higher pressure and higher speed, compared with when another refrigerant is used, so that, normally, an increase in the amount of refrigerant leakage is concerned about.

Brief Description of the Drawings

[0019]

FIG. 1 is a vertical cross-sectional view of a sealed scroll compressor according to a first embodiment of the present invention,

FIG. 2 is a diagram showing a chamfer in the first embodiment of the present invention in an enlarged scale, and

FIG. 3 is a diagram showing a chamfer in a second embodiment of the present invention in an enlarged scale.

Best Mode of Carrying out the Invention

[0020] Referring to the drawings, embodiments of the present invention will be described below.

[0021] First, a first embodiment will be described.

[0022] FIG. 1 shows a sealed scroll compressor, which is an example of a fluid machine according to an embodiment of the present invention. This compressor 1 is incorporated in a refrigeration circuit of a refrigerator, an air-conditioner or a heat pump water heater. The circuit includes a circulation line along which a refrigerant consisting of carbon dioxide, an example of a working fluid, circulates. The compressor 1 draws in the refrigerant from the circulation line, compresses and discharges it to the circulation line.

[0023] The compressor 1 has a housing 2. Specifically, upper and lower covers 6, 8 air-tightly fit in a body 4 of the housing 2, at the upper and lower ends, respectively, to seal the body 4, so that there exists a refrigerant discharge pressure inside the housing 2. An intake pipe 10 through which the refrigerant is drawn in from the circulation line is joined to the body 4 at an appropriate location, while a discharge pipe 12 through which the compressed refrigerant is discharged from inside the housing 2 to the circulation line is joined to the upper cover 6 at an appropriate location.

[0024] An electric motor 14 is arranged inside the body 4, and a rotating shaft 16 is arranged inside the motor 14. The rotating shaft 16 is driven by supplying current to the motor 14. At the upper end, the rotating shaft 16 is rotatably fitted to a primary axial frame 18 by means of a bearing. The main axial frame 18 is integrally fixed to the housing 2.

[0025] At the lower end, the rotating shaft 16 is rotatably fitted to a secondary axial frame 20 by means of a bearing. An oil pump 22 is fitted to the lower end of the rotating shaft 16. The pump 22 draws up a lubricant from a lubricant storage chamber 24 inside the lower cover 8. The lubricant moves upward in a lubricant supply passage 26 axially extending inside the rotating shaft 16, and is supplied to the motor 14, a scroll unit 28, etc. from the upper end of the rotating shaft 16. The lubricant helps smooth motion of sliding-contact components, bearings, etc. and establishes sealing between sliding-contact surfaces. Here, the refrigerant discharge pressure acting on the surface of the lubricant in the lubricant storage chamber 26 helps the lubricant move upward in the lubricant supply passage 26. The secondary axial frame 20 has a lubricant introduction port 30 at an appropriate location, through which the lubricant supplied to the sliding-contact components of the motor 1 returns to the lubricant storage chamber 24.

[0026] The unit 28 is arranged above the motor 14 inside the body 4, and carries out a process of suction, compression and discharge of the refrigerant.

[0027] Specifically, the unit 28 consists of a movable scroll 34 and a fixed scroll 36. The movable scroll includes an end plate 38 and a spiral wrap 42 standing on a plate surface 38a of the end plate 38a toward an end plate 40 of the fixed scroll 36. The fixed scroll 36 also has a spiral wrap 44 standing on a plate surface 40a of an end plate 40 toward the end plate 38.

[0028] The wraps 42, 44 cooperate to draw in the refrigerant from a space around the end plate 38 and an intake chamber connecting to the intake pipe 10 and define a compression chamber. With an orbital motion of the movable scroll 34 in relation to the fixed scroll 36, the compression chamber moves from the radially outer side toward the center of the wraps 42, 44, reducing in volume.

[0029] In order to allow the movable scroll 34 to do the orbital motion, the end plate 38 has a boss 46 on the rear side, and the boss 46 is rotatably mounted on an eccentric shaft 48 formed integrally at the upper end of the rotating shaft 16, by means of a bearing. The movable scroll 34 is prevented from rotating about its axis by a rotation prevention pin not shown.

[0030] The fixed scroll 36 is fixed to the primary axial frame 18, and the end plate 40 separates the compression chamber from the discharge chamber 50. The fixed scroll 36 has a discharge hole 52 in its central area, at an appropriate location, which connects to the compression chamber and extends through the end plate 40. The discharge hole 52 is opened and closed by a discharge valve 54 provided on the discharge chamber 50 side of the fixed scroll 36. A discharge head 56 covers the discharge chamber 50 side of the fixed scroll 54 including the discharge valve 54. The discharge head 56 reduces noise while the discharge valve 54 is opened.

[0031] In the above-described compressor 1, the rotation of the rotating shaft 16 causes the movable scroll 34 to do an orbital motion without rotation. This orbital motion of the movable scroll 34 causes the refrigerant entering the body 3 through the intake pipe 10 to be drawn from the intake chamber into the unit 28, compressed within the unit 28 and discharged through the discharge hole 52. The refrigerant discharged through the discharge hole 52 flows inside the housing 2 and reaches the discharge chamber 50 and is sent from the compressor 1 through the discharge pipe 12.

[0032] As seen in FIG. 2 which shows the wraps 42, 44 on an enlarged scale, the wrap 44 has a root portion 58 on a side face 44a connecting to the plate surface 40a. The root portion 58 is formed during cutting work with a cutting tool such as an endmill to form the wrap 44, and includes a tapered surface 60 and a round surface 62.

[0033] The tapered surface 60 is formed to extend from a taper end 60a located on the side face 44a toward the plate surface 40a at a specified angle A of inclination with respect to the axial direction of the fixed scroll 36. The location of the taper end 60a and the angle A of inclination is determined by the degree of wear of the forward end of an endmill or the like used in cutting. Thus, provided that an endmill of a specified model is constantly used and that the frequency of replacement is predetermined considering the endmill use conditions, variation in the taper end 60a location and the inclination angle A is predictable to some extent.

[0034] The round surface 62 is formed by rounding to extend from a boundary 60b between the tapered surface 60 and the round surface to the plate surface 40a, with a specified radius r. The round end 62a, namely the end of the round surface 62 is located on the plate surface 40a. Thus, the round surface 62 is a circular arc surface of radius r smoothly connecting the plate surface 40a and the tapered surface 60.

[0035] The wrap 42, on the other hand, has an end portion 64 having a side face 42a and an end face 42b. During the orbital motion of the movable scroll 34, the end face 42b is in sliding contact with the plate surface 40a, thereby defining a sliding contact plane 66.

[0036] Here, a chamfer 68 is formed at the end portion 64. The chamber 68 consists of a tapered surface 74 formed by chamfering from a side face taper end (chamber end) 70 located on the side face 42a to an end face taper end (second chamfer end) 72 located on the end face 42b.

[0037] The tapered surface 74 is provided such that, with the sliding contact plane 66 defined, the side face taper end 70 is at a greater or equal distance from the plate surface 40a, compared with the taper end 60a, in the axial direction of the movable scroll 34, and the end face taper end 72 is at a greater or equal distance from the side face 44a of the wrap 44, compared with the round end 62a, in the radial direction of the movable scroll 34.

[0038] Thus, in the present embodiment, considering the possible variation in the location of the taper end 60a and the angle A of inclination of the tapered surface 60 at the root portion 58 of the wrap 44, the chamfer 68 is formed to be large enough to avoid coming in contact with the root portion 58, or the tapered surface 70 and the round surface 62. This allows the side faces 42a, 44a of the wraps 42, 44 to make secure contact with each other while the movable scroll 34 is doing the orbital motion defining the sliding contact plane 66. Thus, even though wear of the forward end of a cutting tool such as an endmill, used in forming the wrap 44 by cutting, produces the tapered surface 60 at the root portion 58 of the wrap 44 formed, an increase in the amount of the refrigerant leaking from the compression chamber caused by poor contact between the wraps 42, 44 is prevented, resulting in an improved volumetric efficiency of the compressor 1.

[0039] Here, when the location of the taper end 60a and the angle A of inclination can be identified in advance, as in the case of forming the wrap 42 after the wrap 44 or reshaping or altering the wrap 42, it is desirable to form a chamfer 68 such that, with the sliding contact plane 66 defined, the side face taper end 70 coincides with the taper end 60a and the end face taper end 72 coincides with the round end 62a, as indicated in broke line in FIG. 2. This reduces the dead volume V, namely the volume of the dead space between the movable and fixed wraps 42, 44 which does not constitute the compression chamber.

[0040] Since the pressure in the dead space V is lower than that in the compression chamber, greater dead volume V means that greater volume of the refrigerant leaking from the compression chamber in the unit 28 can be received in the dead space, which is a factor causing an accelerated increase of the refrigerant leaking from the compression chamber. Reduction in dead volume removes this factor and therefore provides a further improved volumetric efficiency of the compressor 1.

[0041] Next, a second embodiment will be described.

[0042] As shown in FIG. 3, in the second embodiment, a chamfer 78 consists of a first and second tapered surfaces (tapered surfaces in tiers) 80, 82. In the other respects, the second embodiment is similar to the above-described first embodiment. Thus, the explanation will be given mainly to this difference.

[0043] The first tapered surface 80 is formed by tapering from a side face taper end 70 toward an end face 42b at a specified angle A1 of inclination with respect to the axial direction of a fixed scroll 36. The second tapered surface 80, on the other hand, is formed by tapering from a boundary 80a between the first tapered surface 80 and the second tapered surface 80 to an end face taper end 72 at a specified angle A2 of inclination. Thus, the chamber 78 consists of a two-tiered tapered surface which, with a sliding contact plane 66 defined, protrudes toward a root portion 58, where at least the angle A1 of inclination is greater than the angle A of inclination of a tapered surface 60 and the angle A2 is set to a size ensuring that the boundary 80a is not in contact with, namely separated from the root portion 58.

[0044] In FIG. 3, the chamfer 78 is provided such that, with the sliding contact plane 66 defined, the side face taper end 70 coincides with a taper end 60a and the end face taper end 72 coincides with a round end 62a. However, what is at least required is that the side face taper end 70 be at a greater or equal distance from a plate surface 40a, compared with the taper end 60a, in the axial direction of the movable scroll 34, and that the end face taper end 72 be at a greater or equal distance from a side face 44a, compared with the round end 62a, in the radial direction of the movable scroll 34.

[0045] Thus, as in the first embodiment, in the compressor 1 according to the second embodiment, it is ensured that, with the sliding contact plane 66 defined, the side faces 42a, 44a of the wraps 42, 44 can make secure contact with each other. Consequently, an increase in the amount of refrigerant leakage from the compression chamber is prevented, resulting in an improved volumetric efficiency of the compressor 1.

[0046] Particularly, compared with the chamber 68 in the first embodiment, the chamfer in the second embodiment allows a further reduction in dead volume V, resulting in a further improved volumetric efficiency of the compressor 1.

[0047] The tapered surface provided by the chamfer 78 is not restricted to a two-tiered tapered surface, but may be a multiple, or more than two-tiered tapered surface which, with the sliding contact plane 66 defined, protrudes toward the root portion 58. This is favorable, since this allows a further reduction in dead volume V, resulting in a further improved volumetric efficiency of the compressor 1.

[0048] In the above, embodiments of the present invention have been described. The present invention is however not restricted to the described embodiments but can be modified in various ways without departing from the scope and sprit of the present invention.

[0049] For example, although in the described embodiments, the chamfer at the end portion 64 of the wrap 42 provides a tapered surface or a multiple-tiered tapered surface, the chamfer may provide a curved surface, namely an elliptic or circular arc surface (arc surface) which, with the sliding contact plane 66 defined, protrudes toward the root portion 58. Further, the chamfer at the end portion 64 may include a tapered surface and a curved surface in combination. These alternative configurations likewise ensure that, with the sliding contact plane 66 defined, the side faces 42a, 44a of the wraps 42, 44 can make secure contact with each other, and allow minimization of the dead volume V. This reliably prevents an increase in the amount of refrigerant leakage from the compression chamber, resulting in a greatly improved volumetric efficiency of the compressor 1.

[0050] Further, in the described embodiments, the wrap 44 of the fixed scroll 36 has a root portion while the wrap 42 of the movable scroll 34 has a chamfer. The present invention is, however, applicable to the converse arrangement that the wrap 42 has a root portion while the wrap 44 has a chamfer, and also to an arrangement that each of the wraps 42, 44 has both a root portion and a chamfer.

[0051] Further, although in the described embodiments, the refrigerant consisting of carbon dioxide is used, the refrigerant is not restricted to this. However, when carbon dioxide is used as a refrigerant, the movable scroll rotates at high speed under high pressure, so that the compressor operates at higher speed and higher pressure, compared with when another refrigerant is used, so that an increase in the amount of refrigerant leakage is concerned about. The described embodiments can prevent this, thereby providing a more remarkable improvement in the volumetric efficiency of the compressor 1.

[0052] The described embodiments are each a sealed scroll compressor incorporated in a refrigeration circuit of a refrigerator, an air-conditioner, a heat pump water heater or the like. The present invention is however not restricted to this but applicable to other scroll type fluid machines, such as compressors other than the sealed type, expanders, etc. in a variety of fields.

Claims

1. A scroll type fluid machine, comprising:

> a fixed and movable scrolls arranged inside a housing and each having a pair-forming spiral wrap standing on a plate surface of an end plate, said fixed and movable scrolls carrying out a process from suction to discharge of a working fluid, by the movable scroll doing an orbital motion in relation to the fixed scroll, with an end face of a first one of the paired wraps in sliding contact with the plate surface of the other, second wrap, thus defining a sliding contact plane, wherein
>
> at least said first one of the wraps has a root

portion having a tapered surface tilting from a taper end located on a side face of the wrap toward the plate surface on which the wrap stands,
the wrap paired with said wrap having said root portion has a chamfer formed by chamfering from a chamfer end located on a side face of the wrap to the end face of the wrap, and
said chamfer is formed to have a size ensuring that, with said sliding contact plane defined, said chamber is separated from said root portion and the distance from said chamfer end to said sliding contact plane is greater than or equal to the distance from said taper end to said sliding contact plane.

2. The scroll type fluid machine according to claim 1, wherein
said root portion further has a round surface formed by rounding from said tapered surface to the plate surface and having an round end on the plate surface, and
said chamfer has a second chamfer end on the end face, and is formed to have a size ensuring that, with said sliding contact plane defined, said chamfer is separated from said root portion and the distance from said second chamfer end to the side face of the wrap having said root portion is greater than or equal to the distance from said round end to said side face.

3. The scroll type fluid machine according to claim 2, wherein
said chamfer is provided such that, with said sliding contact plane defined, said chamfer end coincides with said taper end and said second chamfer end coincides with said round end.

4. The scroll type fluid machine according to any of claims 1 to 3, wherein
said chamfer includes two or more tapered surfaces in tiers.

5. The scroll type fluid machine according to any of claims 1 to 4, wherein
said chamfer includes an arc surface.

6. The scroll type fluid machine according to any of claims 1 to 5, wherein
said working fluid is a refrigerant consisting of carbon dioxide.

FIG. 1

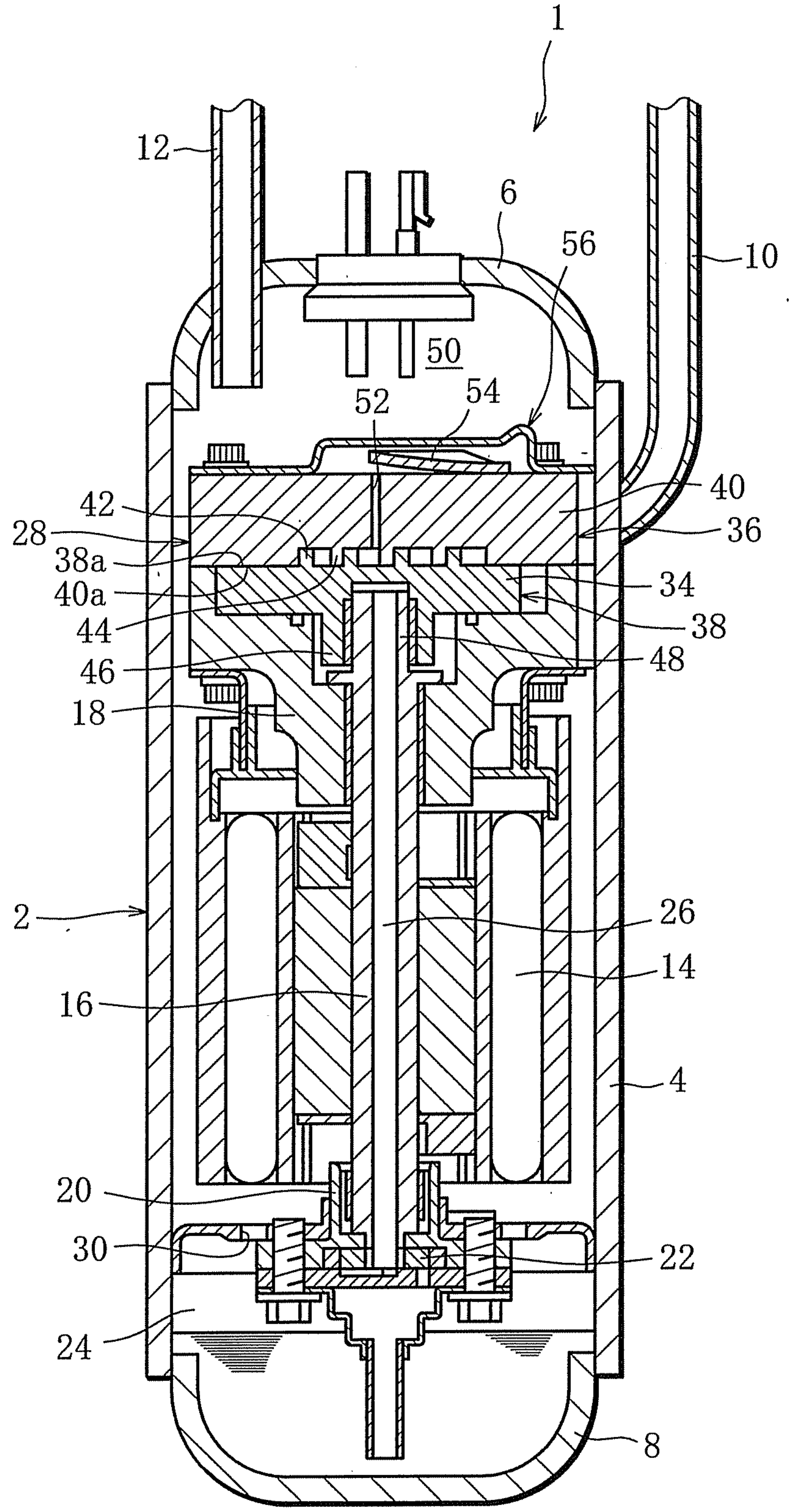

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FIG. 2

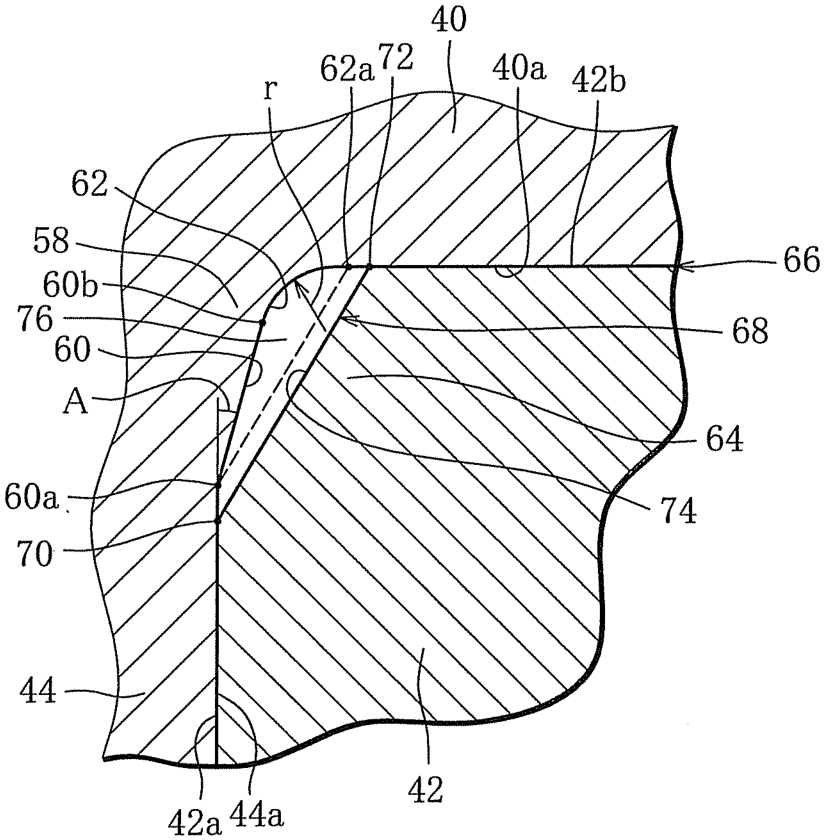
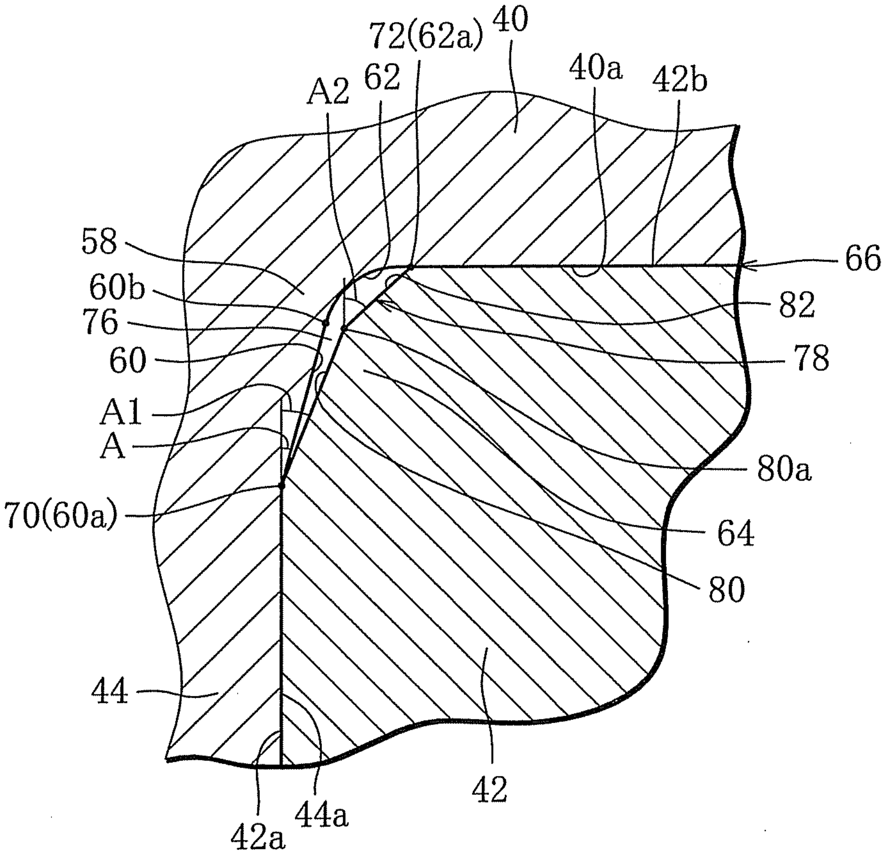


FIG. 3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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/059360

A. CLASSIFICATION OF SUBJECT MATTER
F04C18/02(2006.01)i

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)
F04C18/02

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2008
Kokai Jitsuyo Shinan Koho	1971-2008	Toroku Jitsuyo Shinan Koho	1994-2008

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 161002/1984(Laid-open No. 76185/1986) (Hitachi, Ltd.), 22 May, 1986 (22.05.86), Figs. 5 to 9, 16 (Family: none)	1-6
A	JP 5-187371 A (Hitachi, Ltd.), 27 July, 1993 (27.07.93), Figs. 1, 2, 5, 6 & US 5304045 A	1-6

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

* Special categories of cited documents:

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Date of the actual completion of the international search	Date of mailing of the international search report
24 June, 2008 (24.06.08)	08 July, 2008 (08.07.08)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/059360

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 9-217688 A (Hadsys, Inc.), 19 August, 1997 (19.08.97), Fig. 3 (Family: none)	1-6
A	JP 61-131809 A (Mitsubishi Heavy Industries, Ltd.), 19 June, 1986 (19.06.86), Fig. 4 & US 4666380 A & US 4696084 A & GB 2161218 A & DE 3521943 A1 & FR 2566060 A1	1-6
A	JP 2001-342979 A (Denso Corp.), 14 December, 2001 (14.12.01), Fig. 2 (Family: none)	3-6

Form PCT/ISA/210 (continuation of second sheet) (April 2007)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP SHO6276185 B **[0003]**
- JP 2001329972 A **[0003]**
- JP 2004076629 A **[0003]**
- JP SHO6282391 B **[0003]**