

SCROLL MEMBER WITH A GROOVE FOR A TIP SEAL

The invention relates to a scroll member for scroll-type fluid apparatus which member is provided with a groove for accommodating a tip seal.

5 Scroll apparatus for fluid compression or expansion are typically comprised of two scroll members including upstanding interfitting involute spiroidal or scroll wraps which are generated about respective axes. Each respective involute wrap is
10 mounted upon or integral with an end plate and has a tip surface disposed in contact or near-contact with the end plate of the other respective scroll wrap. Each scroll wrap further has flank surfaces which adjoin in moving line contact, or near contact, the
15 flank surfaces of the other respective scroll wrap to form a plurality of moving chambers. Depending upon the relative orbital motion of the scroll wraps, the chambers move from the radial exterior end of the scroll wraps to the radially interior ends of the
20 scroll wraps for fluid compression, or from the radially interior end of the

respective scroll wraps for fluid expansion. The scroll wraps, to accomplish the formation of the chambers, are placed in interleaving engagement and put in relative orbital motion by a drive mechanism which constrains the scrolls to relative non-rotational motion. This is true whether both scrolls are in rotation or one scroll is fixed. The general principles of scroll wrap generation and operation are discussed in numerous patents, such as U.S. Patent Number 801,182.

Scroll apparatus are also typically provided with a tip seal disposed in the tip surface of the scroll wrap. The tip seal is usually disposed in a tip seal groove formed in the tip surface, the groove being typically slightly wider than the tip seal to permit compliant movement of the tip seal within the tip seal groove. Compliant movement of the tip seal is necessary in many scroll apparatus to ensure sealing contact between the tip seal of the scroll wrap and the end plate of the opposing scroll member, since there are often minor variations in the scroll apparatus arising due to manufacturing tolerances. These variations may include imperfect parallelism between the scroll end plates, scroll wrap height variations in the scroll wrap supporting the tip seal and imperfect surface flatness of the opposing scroll end plate.

While there are many variations of the tip seal and corresponding tip seal groove cross-sectional conformation, the most typical tip seal is rectangular, and may be formed from metal, plastic or rubber compounds. The tip seal may be either one-piece, but more typically the tip seal is a composite of laminated strips for greater strength and resistance to failure. The tip seal is usually formed in a continuous strip so that it may be cut to the desired length.

The typical rectangular groove is formed by milling a slot in the tip surface of the scroll wrap member, which results in the tip seal groove having a hemicylindric inner and outer end with a radius equal to the radius of milling cutter used to form the slot. The hemicylindric ends of the tip seal groove have presented a problem, however, in that the tip seal, when moving within the groove, may be forced into the hemicylindric end of the groove. This can result in a temporary "pinching" or binding of the tip seal within the groove at that end, which also temporarily prevents the necessary compliant movement of the tip seal and can deform the tip seal at the ends. This binding effect is often exacerbated at the inner end of the tip seal, as the tip seal is formed to the smallest radii at this point and hence the tip seal material is the stiffest in this portion of the tip seal.

An object of the invention is to at least partially overcome the above-described problems associated with scroll apparatus having scroll wrap tip seals.

Accordingly the invention provides a scroll member for a scroll apparatus, said member comprising a scroll wrap disposed on an end plate means and having a groove in the tip surface of the scroll wrap for accommodating a tip seal, said groove having a portion of an enlarged width at its outer end.

Preferably, the portion comprises a planar end wall.

The groove may have a portion of an enlarged width at its inner end.

The groove width is defined by an inner groove wall and an outer groove wall, and the enlarged width portion at the inner end is preferably defined by a

step formed in the inner groove wall.

The inner groove wall may be parallel with the outer groove wall in the enlarged width portion at the groove inner end.

5 Preferably, the length of the enlarged width portion at the groove inner end is substantially greater than the length of the enlarged width portion at the groove outer end.

10 The invention also includes a scroll apparatus comprising:

 a hermetic shell having a suction pressure portion for containing a suction pressure fluid and a discharge pressure portion for containing a discharge pressure fluid;

15 a first scroll member disposed in said hermetic shell, said first scroll member having an upstanding scroll wrap disposed on an end plate means, said scroll wrap having a tip surface provided with a tip seal groove having a central portion extending between
20 an inner end portion and an outer end portion, said inner and outer end portions each having a width greater than the width of said central portion;

 a second scroll member disposed in said hermetic shell, said second scroll member having an upstanding
25 scroll wrap disposed on end plate means for interleaving engagement with said first scroll wrap; and

 means for causing relative orbital motion between said first scroll member and said second scroll
30 member.

 The apparatus may comprise drive means for ensuring concurrent rotation of said first and second scroll members.

 The invention further includes a refrigeration
35 system for circulating refrigerant in closed loop

connection comprising:

a condenser for condensing refrigerant to liquid form;

5 an expansion device for receiving liquid refrigerant from said condenser and expanding the refrigerant;

an evaporator for receiving the refrigerant from said expansion device and evaporating the refrigerant to vapour form;

10 a compressor for receiving the refrigerant from the evaporator, compressing the refrigerant, and sending the refrigerant to the condenser, said compressor comprising;

15 a hermetic shell having a suction pressure portion for containing a suction pressure fluid and a discharge pressure portion for containing a discharge pressure fluid;

20 a first scroll member disposed in said hermetic shell, said first scroll member having an upstanding scroll wrap disposed on end plate means, said scroll wrap having a tip surface provided with a tip seal groove having a central portion extending between an inner end portion and an outer end portion, said inner and outer end portions each having a width greater than the width of said central portion;

25 a second scroll member disposed in said hermetic shell, said second scroll member having an upstanding scroll wrap disposed on end plate means for interleaving engagement with said first scroll wrap; and

30 means for causing relative orbital motion between said first scroll member and said second scroll member.

35 In order that the invention may be well understood, an embodiment thereof, which is given by

way of example only, will now be described with reference to the accompanying drawings, in which:

Figure 1 is a cross-sectional view of a co-rotational scroll apparatus;

5 Figure 2 is a schematic representation of a refrigeration system;

Figure 3 is a cross-sectional view taken along section line 3-3 in Figure 1;

10 Figure 4 is a partial cross-sectional view taken along the line 4-4 of Figure 3;

Figure 5 is an enlarged view of the inner end portion of the tip seal groove shown in Figure 3; and

Figure 6 is an enlarged view of the outer end portion of the tip seal groove shown in Figure 3.

15 A scroll-type fluid apparatus 20 having a first and second scroll member 76, 78 each provided with a groove for a tip seal is shown in Figure 1 as a hermetic scroll compressor assembly and is interchangeably referred to as a compressor assembly
20 20. It will be readily apparent that the scroll members of the scroll apparatus 20 will lend themselves equally readily to use in a scroll apparatus acting as a fluid expander, a fluid pump, or to scroll apparatus not of the hermetic type.

25 The compressor assembly 20 includes a hermetic shell 22 having an upper portion 24, a lower portion 26, a central exterior shell 27 extending between the upper portion 24 and lower portion 26, and an intermediate, central frame portion 28 affixed within
30 the central exterior shell 27. The exterior shell 27 is a generally cylindrical body, while the central frame portion 28 is defined by a generally cylindrical or annular exterior portion 30 and a central portion 32 disposed across one end thereof. The annular
35 exterior portion 30 of the central frame portion 28 is

sized to sealingly fit within the exterior shell 27 so that it may be mated thereto by a press fit, by welding, or by other suitable means.

5 It will be apparent that the hermetic shell comprises a suction pressure portion for containing a suction pressure fluid and a discharge pressure portion for containing a discharge pressure fluid.

Integral with the central frame portion 28 is a generally cylindrical upper bearing housing 34, which is substantially coaxial with the axis of the annular exterior portion 30. A drive shaft aperture 36 extends axially through the center of the upper bearing housing 34, and an upper main bearing 38 is disposed radially within the drive shaft aperture 36. Preferably, the upper main bearing 38 is made, for example, of sintered bronze or similar material, but may also alternatively be a roller or ball-type bearing, for accepting a rotating load therein.

A motor 40 is disposed within the upper portion 24 and central shell portion 27 of the hermetic shell 22. The motor 40 is preferably a single-phase or three-phase electric motor comprised of a stator 42 which is circumferentially disposed about a rotor 44, with an annular space formed therebetween for permitting free rotation of the rotor 44 within the stator 42 as well as the flow of lubricant or refrigerant fluid.

It will be readily apparent to those skilled in the art that alternative types of motors 40 and means of mounting the motor 40 would be equally suitable for application in the scroll compressor 20. For example, the stator 42 could be secured within the central shell portion 27 by a press fit therebetween. Alternatively, a plurality of long bolts or cap screws (not shown) may be provided through appropriate apertures in the stator plates into threaded apertures in the central frame portion 28 for securing the motor 40 within the hermetic shell 22.

The first scroll

5 member 76 includes an upstanding first involute scroll wrap 80
which is integral with a generally planar drive scroll end
plate 82. The drive scroll end plate 82 includes a central
drive shaft 84 extending oppositely the upstanding involute
scroll wrap 80. A discharge gallery 86 is defined by bore
10 extending centrally through the axis of the drive shaft 84.
The discharge gallery 86 is in flow communication with a
discharge aperture 88 defined by a generally central bore
through the drive scroll end plate 82. The drive shaft 84
further includes a first, relatively large diameter portion 90
15 extending axially through the upper main bearing 38 for a free
rotational fit therein, and a second relatively smaller
diameter portion 92 which extends axially through the rotor 44
and is affixed thereto. The rotor 44 may be affixed to the
rotor portion 92 of the drive shaft 84 by such means as a press
20 fit therebetween or a power transmitting key in juxtaposed
keyways. The first scroll member 76 also includes two radially
opposed extension members 96 extending adjacent the scroll wrap
80 near the outer periphery of the scroll end plate 82.

The second or idler scroll member 78 includes a
25 second, idler scroll wrap 100 which is disposed in interfitting
contact with the driven scroll wrap 80. The idler scroll wrap
100 is an upstanding involute extending from an idler end plate
102. Two rectilinear idler key stubs extend upwardly on the
idler end plate 102. The idler key stubs (not shown) are
30 disposed at radially opposed positions outside the idler scroll
wrap 100. An idler stub shaft 104 extends from the idler end
plate 102 oppositely the idler scroll wrap 100.

An annular drive ring 130 is disposed in sliding contact with the idler end plate 102. The drive ring 130 includes four equally radially spaced slots 132, with two slots 132 in sliding engagement with the extension members 96 and two slots 132 (not shown) in sliding engagement with the idler key stubs (not shown). The extension members 96 transfer drive torque through the drive ring 130 to the idler key stubs 103, thus functioning as a drive means and ensuring concurrent rotation of the first and second scroll members 76 and 78.

There are various equally suitable alternative drive means for rendering operational the co-rotational scroll apparatus 20, and no further detailed discussion of the drive means is believed to be necessary herein.

The designation of the drive scroll member 76 as the first scroll member and the idler scroll member 78 as the second scroll member must be understood as arbitrary, made for the purposes of ease of description and therefore not as a limitation. It would be equally accurate to designate the idler scroll member 78 as the first scroll member and the drive scroll member 76 as the second scroll member.

An annular bearing 110, which may be a sleeve bearing made of sintered bronze material or other similar material, or may be of the roller or ball-type, is disposed within an annular wall defining an idler bearing housing 112 which is integral with the lower hermetic shell portion 26 as a support means for rotationally supporting the second or idler scroll member 78.

In Figure 2, the scroll compressor assembly 20 is shown connected at the discharge aperture 50 and the suction aperture 52 to a fluid system such as generally is used in refrigeration or air conditioning systems. Those skilled in the art will appreciate that this is but one fluid system in which the scroll compressor assembly 20 could suitably be utilized, and that application of the scroll compressor assembly 20 in refrigeration and air conditioning systems is to be taken as exemplary rather than as limiting.

The refrigeration system, shown generally in schematic representation in Figure 2 in connection with the scroll compressor assembly 20, includes a discharge line 54 connected between the shell discharge aperture 50 and a condenser 60 for expelling heat from the refrigeration system and in the process typically condensing the refrigerant from vapor form to liquid form. A line 62 connects the condenser 60 to an expansion device 64. The expansion device 64 may be a thermally actuated or electrically actuated valve operated by a suitable controller (not shown), a capillary tube assembly, or other suitable means of expanding the refrigerant in the system. Another line 66 connects the expansion device 64 to an evaporator 68 for transferring expanded refrigerant from the expansion device 64 to the evaporator 68 for the acceptance of heat and typically the evaporation of the liquid refrigerant to a vapor form. Finally, a refrigeration system suction line 70 transfers the evaporated refrigerant from the evaporator 68 to the compressor assembly 20, wherein the refrigerant is compressed and returned to the refrigeration system.

It is believed that the general principles of refrigeration systems capable of using suitably a scroll compressor apparatus 20 are well understood in the art, and that further detailed explanations of the devices and

mechanisms suitable for constructing such a refrigeration system need not be discussed in detail herein. It is believed that it will also be apparent to those skilled in the art that such refrigeration or air conditioning systems may include multiple units of the compressor assembly 20 in parallel or series type connection, as well as multiple condensers 60, evaporators 68, or other components and enhancements such as subcoolers and cooling fans and so forth as are believed known in the art.

Figure 3 is a cross-sectional view taken through a tip seal groove 140 of the idler scroll wrap 100 at the tip seal groove base 142. Figure 4, which is a partial cross-sectional view of the assembled scroll members taken along line 4-4 of Figure 3, shows the tip seal groove 140 more clearly. The tip seal groove 140 is preferably identical in both the driven scroll wrap 80 and the idler scroll wrap 100 and is disposed in a respective tip surface 148 of the scroll wraps. Each tip seal groove 140 includes a groove base 142, an inner groove wall 144 and an outer groove wall 146 which is spaced a width W from the inner wall 144 in the central portion of the groove. The groove walls 144 and 146 are preferably parallel to each other and perpendicular to both the tip seal groove base 142 and to the tip surface 148 of the respective scroll wraps 80, 100. The tip seal groove 140 has an inner end portion and an outer end portion 158 separated from the inner end portion by a central portion. The inner and outer end portions are shown in Figures 5 and 6, respectively, and described more fully hereinafter.

A tip seal 160 is shown disposed in the tip seal groove 140 of each scroll wrap 80 and 100. As shown, the tip seal 160 is a laminate which is rectangular in cross-section, extending out of the tip seal groove

140 to contact the opposing scroll end plate. To enable compliant movement of the tip seal 160, the height of the tip seal 60 is less than that of the tip seal groove base 142 to the opposing scroll end plate and the width of the tip seal 160 is less than that of the space between the inner and outer tip seal groove walls 144 and 146. This also provides a bypass space into which fluid may flow from the higher pressure adjoining compression chamber. The fluid in the bypass space acts on the tip seal 160 to improve the sealing action. It must be understood that the width of the tip seal 160 can be only slightly less than the width of the tip seal groove 140, or the likelihood of leakage past the tip seal 160 is greatly increased.

Figure 5 is an enlarged view of the inner end portion 152 of the groove 140. The inner end portion 152 extends from a groove inner end 150 for a length L along the inner wall 144. The inner end portion 152 has a wall portion which is also parallel to the groove outer wall 146, but which is spaced a width W2 from the groove outer wall 146 such that the enlarged width inner end portion is defined by a step formed in the inner groove wall 144. Since the tip seal 160 is typically manufactured from a fairly stiff material, such as steel, it becomes progressively more difficult to conform the tip seal 160 to the tip seal groove 140 as the radius of the required bend decreases toward the groove inner end 150, and the tip seal 160 therefore tends to be progressively less compliant. The width W2 of the tip seal groove 140 in the portion L is greater than the width W of the groove central portion and permits the tip seal 160 greater space for compliant movement in that portion of the tip seal 160 which is conformed to the smallest radius. The length L of the inner end portion 152 is preferably

relatively short so as to prevent twisting of the tip seal 150 in the tip seal groove 140. In the embodiment, the length L is substantially equivalent to the diameter of the discharge port 88.

5 Figure 6 is an enlarged view of the groove outer end portion 158. The outer end portion 158 is generally perpendicular to the tangent of the tip seal groove 140. The outer end portion 158 of the groove is wider than the central portion width W and
10 therefore serves as a relief space for the outer end of the tip seal 160. Also, because the outer end portion 158 is wider than the central portion of the tip seal groove 140, the outer wall 159 of the outer end portion 158 serves as a planar outer end for the
15 groove 140. Since the outer end of the tip seal 160 is typically planar and perpendicular to the groove walls 144 and 146, the outer end of the tip seal 160 is parallel to the planar outer wall 159. In the event that the tip seal 160 moves within the tip seal
20 groove 140 and comes into contact with the planar outer wall 159, the tip seal 160 will not be deformed or otherwise prevented from the necessary compliant movement.

 It will be apparent to those skilled in the art
25 that the tip seal groove 140 shown in Figures 3, 5 and 6 can be readily produced. Since many scroll manufacturing processes are completed on numerically controlled or microprocessor driven machines, it will be appreciated that the groove can be formed by
30 appropriately directing the cutter employed. For example, in forming the tip seal groove 140, a vertical mill may be employed with a cutter having a diameter less than the central portion width W. The cutter centerline is set to pass one-half of the
35 cutter diameter from the outer wall 146 and then to

make a second cutting pass with the centerline set one-half of the cutter diameter from the cutter inner wall 144. In order to form the inner end portion 152 according to Figure 5, the cutter is set toward the inner groove wall 144 an additional distance equal to the difference between W2 and W. In order to form the outer end portion 158, the cutter is stopped at the outer groove end 156 and moved along a line perpendicular to the tangent of the tip seal groove 140 at that point for a distance sufficient to form the planar outer end 159 of width W.

An alternative method of manufacture would involve the casting of the scroll wraps 80 and 100 with the tip seal groove 140 and its inner and outer end portions 152, 158 included such that further machining operations are not required.

However manufactured, it will be apparent to those skilled in the art that a scroll member having a tip seal groove with an enlarged inner and outer end portion is suitable for mass production and thus may be relatively inexpensive to produce. The provision of the outer and inner end portions of enlarged width provides substantial improvement in the operation of tip seal 160 in the scroll apparatus 20 by improving the compliance of the tip seal 160 while preventing undesirable deformation thereof to provide a scroll apparatus which is of high efficiency and high operating reliability.

From the above, it will be appreciated that the illustrated scroll members each have a scroll wrap which has a groove in the tip surface thereof for accommodating a tip seal. The tip seal groove has an inner end portion disposed generally adjacent the discharge port and an outer end portion separated from the inner end portion by a central portion. The inner

end portion of the tip seal groove is larger in width than the central portion which is wider than the tip seal. This enlarged width inner end portion provides increased space for the tip seal in the region thereof which must be formed to the smallest radii, thus improving the compliant movement of the tip seal in the inner end portion and preventing "pinching" or binding of the tip seal at the innermost end thereof.

It will thus be appreciated that the configuration of the tip seal groove is such that the tip seal is not subject to binding at the ends thereof.

It is to be understood that although the described embodiment is a co-rotational scroll wrap apparatus, a scroll member having a tip seal groove according to the present invention may be used in a conventional scroll apparatus or any scroll apparatus having means for causing relative orbital motion between respective scroll wraps.

Modifications to the preferred embodiments of the subject invention will be apparent to those skilled in the art within the scope of the claims that follow.

CLAIMS:

1. A scroll member for a scroll apparatus, said member comprising a scroll wrap disposed on an end plate means and having a groove in the tip surface of the scroll wrap for accommodating a tip seal, said groove having a portion of an enlarged width at its outer end.
2. A scroll member as claimed in claim 1, wherein said portion comprises a planar end wall.
3. A scroll member as claimed in claim 1 or 2, wherein said groove has a portion of an enlarged width at its inner end.
4. A scroll member as claimed in claim 1, 2 or 3, wherein the groove width is defined by an inner groove wall and an outer groove wall.
5. A scroll member as claimed in claim 4 when dependent on claim 3, wherein said enlarged width portion at the groove inner end is defined by a step formed in said inner groove wall.
6. A scroll member as claimed in claim 5, wherein



said inner groove wall is parallel with said outer groove wall in the enlarged width portion at the groove inner end.

5 7. A scroll member as claimed in any one of claims 3 to 6, wherein the length of the enlarged width portion at the groove inner end is substantially greater than the length of the enlarged width portion at the groove outer end.

8. Scroll apparatus comprising:
10 a hermetic shell having a suction pressure portion for containing a suction pressure fluid and a discharge pressure portion for containing a discharge pressure fluid;

15 a first scroll member disposed in said hermetic shell, said first scroll member having an upstanding scroll wrap disposed on an end plate means, said scroll wrap having a tip surface provided with a tip seal groove having a central portion extending between an inner end portion and an outer end portion, said
20 inner and outer end portions each having a width greater than the width of said central portion;

a second scroll member disposed in said hermetic shell, said second scroll member having an upstanding scroll wrap disposed on end plate means for



interleaving engagement with said first scroll wrap;
and

means for causing relative orbital motion between
said first scroll member and said second scroll
5 member.

9. Scroll apparatus as claimed in claim 8,
comprising drive means for ensuring concurrent
rotation of said first and second scroll members.

10. Scroll apparatus as claimed in claim 8 or 9,
10 wherein said outer end portion comprises a planar end
wall.

11. Scroll apparatus as claimed in claim 8, 9 or 10,
wherein the groove width is defined by an inner groove
wall and an outer groove wall.

15 12. Scroll apparatus as claimed in claim 11, wherein
said inner end portion is defined by a step formed in
said inner groove wall.

13. Scroll apparatus as claimed in claim 10 or 11,
wherein said inner groove wall is parallel with said
20 outer groove wall in said inner end portion.



14. Scroll apparatus as claimed in any one of claims 8 to 13, wherein the length of said inner end portion is substantially greater than the length of said outer end portion.

5 15. A refrigeration system for circulating refrigerant in closed loop connection comprising:

a condenser for condensing refrigerant to liquid form;

10 an expansion device for receiving liquid refrigerant from said condenser and expanding the refrigerant;

an evaporator for receiving the refrigerant from said expansion device and evaporating the refrigerant to vapour form;

15 a compressor for receiving the refrigerant from the evaporator, compressing the refrigerant, and sending the refrigerant to the condenser, said compressor comprising;

20 a hermetic shell having a suction pressure portion for containing a suction pressure fluid and a discharge pressure portion for containing a discharge pressure fluid;

25 a first scroll member disposed in said hermetic shell, said first scroll member having an upstanding scroll wrap disposed on end plate means, said scroll



wrap having a tip surface provided with a tip seal groove having a central portion extending between an inner end portion and an outer end portion, said inner and outer end portions each having a width greater than the width of said central portion;

a second scroll member disposed in said hermetic shell, said second scroll member having an upstanding scroll wrap disposed on end plate means for interleaving engagement with said first scroll wrap; and

means for causing relative orbital motion between said first scroll member and said second scroll member.

16. A scroll member substantially as herein described with reference to Figures 1 and 3 to 6 of the accompanying drawings.



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