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CO-ROTATIONAL SCROLL APPARATUS
WITH IMPROVED SCROLL MEMBER BIASING

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The invention relates to pressure biasing of a scroll member in a co-rotational scroll apparatus.

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Scroll apparatus for fluid compression or expansion are typically comprised of two upstanding interfitting involute spirodal wraps which are generated about respective axes. Each respective involute wrap is mounted upon an end plate and has a tip 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 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 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 put in

relative orbital motion by a drive mechanism which constrains the scrolls to relative non-rotational motion. The general principles of scroll wrap generation and operation are discussed in numerous patents, such as U.S. Patent Number 801,182.

Numerous attempts have been made to develop co-rotational scroll apparatus. Such apparatus provides for concurrent rotary motion of both scroll wraps on parallel, offset axis to generate the requisite orbital motion between the respective scroll wrap elements. However, most commercially successful scroll apparatus to date have been of the fixed scroll-orbiting scroll type due to various difficulties in achieving success with co-rotating scroll apparatus.

Typically, a number of rotary bearings are required in a co-rotational scroll apparatus, which decreases the reliability and efficiency of the machine. Furthermore, the typical co-rotating scroll apparatus have required a thrust bearing acting upon each of the scroll end plates to prevent axial scroll separation, thus substantially increasing the power requirements of the machine as well as substantially reducing the reliability of the machine.

An additional problem which must be dealt with in scroll apparatus, whether used for compression or decompression of fluid, are the forces which result from the fluid trapped in the chambers formed in the scroll wraps. These forces include an axial separation force component resulting from the fluid pressure upon the scroll element end plates and a radial separation force resulting from the fluid pressure upon the scroll wraps themselves.

The separation forces due to the fluids compressed within the scroll elements vary cyclicly as the scroll elements rotate. This cyclic variation is a function of two factors.

5 The first is the instantaneous location of the compression chambers formed by the scroll wraps during each revolution with respect to the center of the scroll element. As the scroll wraps orbit, the center of the compression chamber moves either inward or outward with respect to the axis of the scroll members. The second factor is the actual pressure of the
10 compressed fluid, which also varies according to the instantaneous location of the compression chamber in which the fluid is contained, decreasing from the inner ends of the respective scroll wraps to the outer ends thereof. Both these factors combine to produce a torque load or moment, the product
15 of the instantaneous center of the compression chamber location and the instantaneous fluid pressure, both in an axial direction and in a radial direction, at that location. The resulting net moment upon the scroll member is the net effect of the torque loads developed in each compression chamber. The
20 net torque load acts perpendicularly to the axis of rotation of the scroll member to cause the tipping of the scroll element. Since the tipping is more pronounced at various points during the rotation of the scroll element, and may not occur at some points, it is observable as a rocking or nutation of the scroll
25 member during rotation.

Typically, this is dealt with by the provision of an axial force acting to compress the end plates of the scroll elements together, in opposition to the separating fluid forces and by the provision of relatively larger bearings. These
30 compressive axial forces are typically induced either mechanically by such means as thrust bearings or springs, or by fluid pressure imposed upon the opposite side of the scroll end plate.

Prior scroll apparatus typically deal with the axial separation effect and the nutation effect by simply increasing the axial force loading upon the scroll end plate until the axial components of the separation effects are overcome. Hence, there are often unnecessarily high pressures acting upon the scroll wrap tips during the scroll cycle, with resulting unnecessary friction and wear as well as excessive power consumption and loss of overall efficiency, as well as high axial loading which must be overcome during compressor startup.

Another typical response to these tipping or nutation causing moments is to increase the size of the bearings in the scroll apparatus until the effects of these moments are no longer observable. This solution, however, increases the friction and heat losses in the operating efficiency of the apparatus due to the increased size of the bearings, with concurrently increased initial cost due to the cost of larger bearings and larger motors to operate the apparatus, and increased maintenance costs.

One alternative technique in the co-rotational scroll apparatus is to provide an annular chamber in a chamber defining element which is attached to one scroll member and disposed opposite the other scroll member such that fluid in the chamber acts upon the scroll end plate to force the scroll end plates together. The fluid in the chamber is provided from one of the compression chambers via a passage through the scroll end plate subject to the force of the fluid. U.S. Patent 4,600,369 issued July 15, 1986 to Blain is representative of this approach.

One limitation arising from this approach is that the chamber defined in the chamber defining element must have a width equal at least to one orbit diameter of the scroll members plus the width of the vent passage, or the fluid will vent from the passage into the low pressure area surrounding the scrolls, resulting in a temporary loss of force on the scroll end plate and separation of the scroll wraps. This width is a critical dimension, in that the annular width and diameter of the chamber determines the area upon which the fluid pressure acts to produce the force exerted on the scroll end plate.

The provision of the chamber defining element also introduces other considerations. The chamber defining element must be of substantial thickness to accomodate the axial movement of the chamber seals, adding substantial mass to the scroll apparatus. The consequent increased inertial resistance requires a relatively more powerful motor. Also, since the provision of the chamber in the chamber element requires substantial additional machining, in that an entire component must be fabricated and extensively machined to close tolerances, the manufacturing time and expense of the scroll apparatus is increased. Furthermore, additional fluid routing must be provided in the chamber element to direct the seals against the scroll end plate from which the fluid is directed. The fluid is transferred from the pressure chamber and therefore acts upon the seals at the pressure of the fluid in the pressure chamber.

It is an object of the present invention to provide a co-rotational scroll apparatus having improved fluid pressure biasing of the scroll elements.

Accordingly, the invention provides a co-rotational scroll apparatus comprising:

a first scroll member having an end plate and a scroll wrap which is disposed on said end plate;

5 a second scroll member having an end plate and a scroll wrap which is disposed on a surface of said end plate, said scroll wraps cooperating to define a compression chamber, said second scroll end plate being provided with a recess in a surface thereof
10 opposite said surface on which said second scroll wrap is disposed and being further provided with a passage opening into said recess and communicating with said compression chamber;

means for ensuring concurrent rotation of said
15 scroll members;

a pressure plate disposed adjacent said recess and secured to said first scroll member for rotation therewith; and

sealing means in sliding engagement with opposing
20 walls of said recess and with said pressure plate; said sealing means and said recess cooperating to at least partially define a pressure chamber between said second scroll member and said pressure plate.

The invention also includes a co-rotational
25 scroll apparatus comprising:

a first scroll member having an end plate and a scroll wrap disposed on said end plate;

a second scroll member having an end plate and a
30 scroll wrap which is disposed on a surface of said end plate, said scroll wraps cooperating to define a compression chamber and said second scroll end plate being provided with a recess in a surface thereof and

having a shaft disposed centrally on said surface, said second scroll end plate being further provided with a passage communicating between said recess and said compression chamber;

5 means for ensuring concurrent rotation of said scroll members;

a pressure plate element rotatable with said first scroll member and disposed adjacent said recess; and

10 a piston element disposed in said recess in sliding engagement with said pressure plate element, said recess and piston element cooperating to define a pressure chamber between said second scroll member and said pressure plate element.

15 The invention also includes a co-rotational scroll apparatus comprising:

a first scroll member having a first scroll end plate and a scroll wrap disposed on said end plate;

20 a second scroll member having an end plate and a scroll wrap disposed on said end plate, said scroll wraps cooperating to define a compression chamber, said second scroll end plate being provided with a recess in a surface thereof and having a shaft disposed centrally on said surface, said recess having
25 a first wall and a second wall opposed to said first wall with each said wall being radially spaced from said shaft, said second scroll end plate being further provided with a passage communicating between said compression chamber and said recess;

30 means for ensuring concurrent rotation of said scroll members;

drive means for driving one of said scroll members;

a pressure plate element disposed adjacent said

recess and secured to said first scroll member; and

a sealing element in sealing engagement with said first and second walls and in sliding engagement with said pressure plate element; said recess and said sealing element cooperating to at least partially define a pressure chamber between said second scroll member and said pressure plate element.

The invention also includes a co-rotational scroll apparatus comprising:

a first scroll member having an end plate and a scroll wrap disposed on said end plate;

a second scroll member having an end plate and a scroll wrap disposed on said end plate, said scroll wraps cooperating to define a compression chamber, said second scroll end plate being provided with a recess in a surface thereof from which surface a centrally disposed shaft extends, said recess having a first wall and a second wall, each said wall being radially spaced from said shaft, said second scroll end plate being further provided with a passage extending from said compression chamber to said recess;

means for ensuring concurrent rotation of said scroll members;

drive means for rotating one of said scroll members;

a pressure plate element disposed adjacent said recess and secured to said first scroll member;

an inner seal ring member disposed in said recess, said inner seal ring member being in axial sliding engagement with said first wall and in sliding engagement with said pressure plate element; and

an outer seal ring member disposed in said recess, said outer seal ring member being in axial sliding engagement with said second wall and in

sliding engagement with said pressure plate; said inner and outer seal ring members, said recess and said pressure plate element cooperating to define a pressure chamber in flow communication with said compression chamber.

The invention also includes a co-rotational scroll apparatus comprising:

a first and a second scroll member, each of said scroll members having an end plate and a scroll wrap extending from one side of said end plate, said scroll wraps interfitting with each other, said first scroll member having a drive shaft extending from the side of its end plate opposite the side from which said scroll wrap extends and a passage extending through said drive shaft for discharging fluid from between said scroll wraps and said second scroll member being provided with a recess in the side of its end plate opposite the side from which said scroll wrap extends;

bearing means for supporting said first and second scroll members;

means for linking said scroll members for concurrent rotation;

means, carried by said first scroll member, which means comprises a pressure biasing surface; and

sealing means operatively disposed in sealing engagement with said second scroll member and said pressure biasing surface to in cooperation with said second scroll member and said pressure biasing surface define a pressure chamber in flow communication with said recess, said recess being provided with an inlet opening for receiving a fluid under pressure to act concurrently against said pressure biasing surface and said second scroll member so as to bias said second scroll member toward said first scroll member, wherein in use of the apparatus, said inlet is radially

stationary with respect to said sealing means.

5 The invention also includes a co-rotational scroll apparatus comprising two interleaving scroll wraps secured to respective end plates, a pressure plate secured to one end plate and disposed opposite to and spaced from the other end plate outwardly of the scroll wraps, and sealing means in sliding engagement with said other end plate and said pressure plate and defining at least partially pressure chamber means between said other end plate and said pressure plate, said sliding engagement with said other end plate allowing movement of said sealing means relative to said other end plate in the direction of the axes of said scroll wraps, said one end plate comprising an aperture for discharging fluid from compression chamber means defined between said scroll wraps, said other end plate being provided with passage means for the passage of fluid from said compression chamber means to said pressure chamber means to urge the pressure plate and said other end plate apart, said passage means comprising an inlet to said pressure chamber means which in use of the apparatus maintains a fixed radial position with respect to said sealing means.

25 In order that the invention may be well understood, some embodiments thereof, which are given by way of example only, will now be described with reference to the accompanying drawings, in which:

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

Figure 2 is an enlarged partial cross-sectional view of the scroll apparatus of Figure 1;

35 Figure 3 is an enlarged partial cross-sectional view of an alternative embodiment of the scroll apparatus of Figure 1;

Figure 4 is an enlarged partial cross-sectional view of a second alternative embodiment of the scroll apparatus of Figure 1;

Figure 4A shows a modification of the second alternative embodiment;

Figure 4B shows an alternative seal means for the embodiment of Figure 4;

Figure 4C shows another alternative seal means for the embodiment of Figure 4;

Figure 4D shows yet another alternative seal means of Figure 4;

Figure 5 is an enlarged partial cross-sectional view of a third alternative embodiment of the scroll apparatus of Figure 1;

Figure 6 is an enlarged partial cross-sectional view of a fourth alternative embodiment of the scroll apparatus of Figure 1;

Figure 7 is an enlarged partial cross-sectional view of a fifth alternative embodiment of the scroll apparatus of Figure 1;

Figure 7A is an enlarged partial cross-sectional view of the seal means of Figure 7; and

Figure 8 is a schematic representation of a refrigeration system employing scroll apparatus.

A co-rotational scroll type fluid apparatus generally shown in Figure 1 and Figure 2 as a scroll compressor assembly is referred to by reference numeral 20. As the preferred embodiment of the scroll apparatus is a hermetic scroll compressor assembly, the scroll apparatus 20 is interchangeably referred to as a scroll compressor 20 or as a compressor assembly 20. It will be readily apparent that the features of the compressor assembly 20 will lend themselves equally readily to use in a scroll apparatus acting as a fluid expander, a fluid pump, or to scroll apparatus

which are not of the hermetic type.

In the preferred embodiment, the compressor assembly 20 includes a hermetic shell 22 having an upper portion 24, a lower portion 26, and an intermediate, central frame portion 28 affixed between the upper portion 24 and lower portion 26. 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.

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 frame portion 28 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 motor 40 would be equally suitable for application in the scroll apparatus 20. For example, the stator 42 could be secured within the scroll apparatus 20 by a plurality of long bolts or cap screws 46 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 scroll arrangement includes a first or drive scroll member 76 and a second or idler scroll member 78, each having an upstanding involute scroll wrap for interfitting engagement with the other respective scroll wraps. The first scroll 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 centrally disposed first scroll member drive shaft 84 extending oppositely the upstanding involute scroll wrap 80. A discharge gallery 86 is defined by a bore 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 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 fit therebetween or a power transmitting key in juxtaposed keyways.

The second or idler scroll member 78 includes a second, idler scroll wrap 100 which is disposed in interfitting contact with the drive scroll wrap 80. The idler scroll wrap 100 is an upstanding involute extending from an idler end plate 102. Two rectilinear idler key stubs (not shown) extend upwardly on the idler end plate 102. The idler key stubs are disposed at radially opposed positions outside the idler scroll wrap 100. A centrally disposed second scroll member idler stub shaft 104 extends from the back portion 106 of the idler end plate 102 oppositely the idler scroll wrap 100.

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 or other suitable 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 the preferred embodiment, the drive scroll end plate 82 includes two radially opposed extension members 120 extending parallel the scroll wrap 80, and the idler scroll end plate includes the two radially opposed idler key stubs extending parallel the scroll wrap 100. The idler key stubs are not visible in the cross-sectional views. The extension members 120 extend from positions near the outer periphery of the drive scroll end plate 82. The extension members 120 are also disposed at positions which are generally 90 degrees removed angularly from the positions of the idler key stubs when the scrolls 80 and 100 are in interleaving engagement. Each extension member 120 also includes a drive portion 122 and a tip portion 124 which is preferably threaded to accept a fastener 126.

A drive ring 130 serves as the means for engaging the drive portion 122 of the extension members 120 and the idler key stubs to ensure concurrent rotation of the scroll members 76 and 78. The drive ring 130 extends circumferentially about the scroll wraps 80 and 100 and includes four equally radially spaced slots which are slidably engaged by the drive portions 122 and the idler key stubs, respectively. It is believed that the general construction and operation of the drive ring 130 is well understood by those skilled in the art, and therefore no detailed discussion is believed necessary. Also, it is believed that it will be apparent that there are other means available for ensuring concurrent rotation of the drive scroll 76 and the idler scroll 78.

A planar or substantially planar pressure plate 140 having two radially opposed holes 142 is provided adjacent the back portion 106 of the second scroll member 78. The holes 142 are radially opposed so that

the pressure plate 140 may be secured by the fasteners 126 to the extension members 120 so as to be carried by the first scroll member for rotation therewith. It will be appreciated by those skilled in the art that while the pressure plate 140 is desirably planar, other configurations of the pressure plate 140 may be equally suitable where at least a portion including a planar surface 144 is provided. The planar pressure plate 140 is preferably formed of metal and is of simple manufacture, substantially enhancing the simplicity of manufacture of the scroll apparatus 20. It will also be appreciated that other suitable means for securing the pressure plate to the scroll member 76 are available and not limited to the use of extension members 120.

A recess 150 is provided in the back portion 106 of the second scroll member 78, as shown in Figure 2. This recess 150 is defined by an inner, or first wall 152, an outer, or second wall 154 and an interior wall 156 which joins the inner wall 152 and the outer wall 154. The inner wall 152 and the outer wall 154 are opposed to one another and perpendicular or substantially perpendicular to the back portion 106 so as to be generally parallel to the axis of the scroll member 78. A fluid passage 158 is defined through the second scroll end plate 102 to permit fluid communication between the compression chamber C and the recess 150.

Preferably, the inner wall 152 is circular and concentric with the shaft 104, and the second wall 154 is also circular and concentric with the shaft 104 of the scroll member 78 to provide a recess 150 of a suitable width. However, it is not necessary for either the first wall 152 or the second wall 154 to be concentric with the shaft 104, nor is it necessary

that either the first wall 152 or the second wall 154 be circular. The radial spacing of the first wall 152 and the second wall 154 may be varied about the shaft 104 to provide a recess 150 which varies in width W at each radial position. This allows the width W of a pressure chamber partially defined by the recess 150 to be adapted to provide a lesser or greater force, and therefore a lesser or greater stabilizing torque or moment, due to the pressure of fluid in the pressure chamber at those crank angle positions at which the scroll apparatus 20 is most likely to experience nutation due to nutation producing moments resulting from the compressed fluids within the compression chamber C. However, in the preferred embodiment, the recess 150 has a constant width W and is concentric with the shaft 104 for simplicity of manufacture.

A first seal element, or member 172 is disposed in axial sliding engagement with the first wall 152 and a second seal element, or member 174 is disposed in axial sliding engagement with the second wall 154. The seals 172 and 174 comprise a sealing means 170 for sealing the pressure chamber. Preferably, the seals 172 and 174 are analogous to the annulus of a cylinder so that a cross-section thereof taken through the axis of the scroll apparatus 20 appears as rectangular. It is also desirable to form the sealing means 170 of flexible material so that the pressure of fluid within the chamber will ensure a fluid tight contact between the respective wall and seal element. Also, the first and second seal elements 172 and 174 must be formed so as to permit reasonably free sliding engagement with the respective first and second wall surfaces 152 and 154 to permit axial movement of the pressure plate 140 with respect to the back portion 106.

In operation of the scroll apparatus 20, the motor 40 will be started, causing rotation of the first scroll member 76 and concurrent rotation of the second scroll member 78 through the drive ring means 130. The scroll wraps 80 and 100 will form a series of compression chambers C in which fluid will be compressed. Fluid will be forced from one compression chamber C through the fluid passage 158 into the recess 150. The pressure of the fluid in the recess 150 will force the seals 172 and 174 to engage the respective first and second walls 152 and 154 to form a fluid tight seal. The pressure of the fluid will also force the seals 172 and 174 away from the interior wall 156 and into sliding, sealing engagement with the planar portion 144 of the pressure plate 140. The sealing means, recess and pressure plate element cooperate to define the pressure chamber between the second scroll member and the pressure plate element and the pressure of the fluid contained therein will act to force the pressure plate 140 away from the second scroll member back portion 106. This biasing of the pressure plate 140 will act through the extension members 120 to direct the first scroll member 76 toward the second scroll member 78. Thus the axial separation forces generated within the compression chambers C are overcome, ensuring that the compression chambers C are closed and that fluid compression can occur therein.

In the following description of some alternative embodiments of the scroll apparatus 20, it should be noted that when the same part or feature is shown in a figure representing or disclosing an alternative embodiment it is labelled with the same reference numeral, followed by a numeric suffix to correspond with the designation of that alternative embodiment in

the specification. The numeric designation of the alternative embodiment does not correspond to its preference. Furthermore, reference should be had to all of the figures necessary to aid in the understanding of the specification even where a particular figure is referred to, as all reference numerals are not displayed in all figures in order to minimise confusion.

Turning now to Figure 3, a first alternative embodiment of the scroll compressor assembly is shown. In the first alternative embodiment, a piston element 180-1 in sliding engagement with the pressure plate 140-1 is provided in lieu of the seal elements 172 and 174. The piston element 180-1 includes two downwardly extending legs 182-1 and a pressure surface 184-1, and is in sealing contact with the inner wall 152 and the outer wall 154. The piston element 180-1 and recess 150-1 cooperate to define a pressure chamber between the second scroll member and the pressure plate. Other forms of the piston element 180-1 may be suitably employed, and need not include the legs 182-1. In this alternative embodiment, the fluid from the compression chamber C is transferred through the fluid passage 158-1 into the recess 150-1, but acts on the pressure surface 184-1 of the piston element 180-1. This forces the piston element 180-1 against the pressure plate 140-1 and thus biases the scroll elements 76-1 and 78-1 as in the preferred embodiment. However, in this alternative embodiment, there is no fluid pressure acting against the pressure plate 140-1 since the biasing force is transmitted by the piston element 180-1. In all other respects, the operation of the scroll apparatus 20-1 is identical with that of the preferred embodiment.

Optionally, biasing means may be provided in the

recess for biasing the piston element 180-1 against the pressure plate element.

Turning now to Figure 4, a second alternative embodiment of the scroll apparatus 20-2 is disclosed.

5 In this embodiment, the second scroll member includes a first seal retainer element 202-2 and a second seal retainer element 204-2.

10 The first seal retainer element 202-2 is spaced from the first wall 152-2 to form a first seal chamber 212-2 in which the first seal element 172-2 is disposed, and the second seal retainer element 204-2 is spaced from the second wall 154-2 to form a second seal chamber 214-2 in which the second seal 174-2 is disposed. The first seal chamber 212-2 and the second seal chamber 214-2 are sized to sealingly accept in
15 sliding engagement the first seal element 172-2 and the second seal element 174-2, respectively. The first seal element, the second seal element, the pressure plate 140-2 and the recess 150-2 cooperate to
20 define a pressure chamber to define a pressure chamber between the second scroll member and pressure plate.

The first seal chamber 212-2 receives pressurized fluid through a first seal pressure passage 220-2, while the second seal chamber 214-2 receives fluid
25 through a second seal pressure passage 222-2. In Figure 4, the first seal chamber 212-2 receives pressure from a compression chamber C1 which is at slightly higher pressure than the pressure transmitted through the second seal passage 222-2 to the second
30 seal chamber 214-2 from the compression chamber C2. Alternatively, as shown in Figure 4A, both the first seal chamber 212-2 and the second seal chamber 214-2 may receive fluid through a common seal pressure passage 224-2 from a single compression chamber C3.

35 It will be apparent to those skilled in the art

that because of the multitude of available pressures in the compression chambers C, each seal element 172-2 and 174-2 may be subjected to a pressure which is higher or lower or equal to the pressure contained in the pressure chamber or the pressure to which the other respective seal element 172-2 or 174-2 is exposed. Therefore, the foregoing description should be considered exemplary rather than limiting.

In operation, the second alternative embodiment is substantially identical to that of the preferred embodiment. As the scrolls 76-2 and 78-2 are rotated, the fluid in the respective compression chambers C will flow through the passages 158-2, 220-2 and 222-2 to respectively provide the desired pressure in the pressure chamber, the first seal chamber 212-2 and the second seal chamber 214-2. Where the pressure in the seal chambers is lower than the pressure in the pressure chamber, the life of the seals 172-2 and 174-2 will be enhanced, and on the other hand, where the pressure in the chambers 212-2 and 214-2 is greater than that in the pressure chamber, the seal elements 172-2 and 174-2 will be forced securely against the pressure plate 140-2 to ensure positive sealing of the pressure chamber. The fluid contained with the pressure chamber then acts to bias the scroll elements together to enable the desired fluid compression.

According to the preferred embodiment and the alternative embodiments discussed in Figures 1-4, the scroll apparatus is disposed such that the axis of rotation is in a substantially vertical position. In the vertical position, gravity will act upon the seals 172 and 174 or the piston 180 to aid the sealing action thereof. This is especially important at time of startup of the scroll apparatus 20, since at startup the fluid pressure in the compression chambers

C will often be equal to the suction pressure. In this condition, compressed fluid entering the pressure chamber will attempt to seep between the seals 172 and 174 and the pressure plate biasing surface 144 before the fluid pressure exerted on the seals 172 and 174 is sufficient to ensure suitable sealing therebetween. Where the mass of the seals 172 and 174 is insufficient to ensure sealing action at startup, such seepage may occur and will prevent proper sealing of the pressure chamber. Improper sealing of the pressure chamber may result in less efficient compression in the compression chambers C or may result in a lack of compression altogether.

Therefore, it is desirable in certain situations, to provide means for biasing the sealing means against the pressure biasing surface 144 to ensure that such seepage does not occur upon startup of the scroll apparatus 20. By way of illustration, sealing means including a biasing means 228 are disclosed in various drawing Figures. This is not intended to indicate that such biasing means are required for suitable operation of these alternative embodiments. Rather, those skilled in the art will understand that the application of such biasing means to the sealing means is dependent on a number of interrelated factors. These factors include the mass of the seals 172 and 174, the axial orientation of the scroll apparatus 20 and the resulting availability of gravity to ensure proper sealing, the fluid pressure to be contained within the pressure chamber and the fluid pressure to be applied to the seal element 172 and 174, and the magnitude of the axial separating force generated by the fluid in the compression chambers C.

Turning now to Figure 5, a third alternative embodiment of the scroll apparatus is disclosed. A

single generally H-shaped one piece seal element 230-3 serves as the sealing means 170-3. The sealing means 170-3 is optionally biased against the pressure plate 140-3 by spring biasing means 228 shown by way of example as coil springs 232-3. A number of coil springs 232-3 are disposed at relatively equal angular intervals in the recess 150-3. The seal element 230-3 includes four seal faces: an annular inner wall seal face 234-3 for sealingly engaging the inner wall 152-3; an annular outer wall seal face 236-3 for sealingly engaging the outer wall face 154-3; and an annular inner tip seal 238-3 and an annular outer tip seal 240-3 disposed radially outward from the inner tip seal 238-3, each of the seal tips 238-3 and 240-3 being in sliding engagement with the pressure plate 140-3. A central web portion 242-3 of the seal element 230-3 connects and provides structural support for the seal faces 234-3, 236-3, 238-3 and 240-3. The web portion 242-3 has a surface facing the second scroll member and a surface facing the biasing surface 144-3 of the pressure plate 140-3. The seal element 230-3, recess 150-3 and pressure plate 140-3 cooperate to define a pressure chamber between the second scroll member and the pressure plate, which chamber is divided into first and second areas which are in flow communication through one or more fluid vents 244-3. The vents 244-3 are provided in the web portion 242-3 to permit the fluid in the pressure chamber to contact the pressure biasing surface 144-3. The inner tip seal 238-3 extends oppositely from the inner wall seal face 234-3 and the outer tip seal 240-3 extends oppositely from the outer wall seal face 236-3 for engaging the pressure biasing surfaces 144-3.

In operation, the third alternative embodiment is similar to the preferred embodiment, varying only in

that the seal tips 238-3 and 240-3 may not move independently. This assures that no undesirable radial displacement can occur which could cause loss of sealing of the pressure chamber. Furthermore, it will be noted that the annular inner wall seal face 234-3 and the annular outer wall seal face 236-3 can be formed so as to have a slightly greater width than the nominal width between the inner wall 152-3 and the outer wall face 154-3 of the recess 150-3, where the material used to manufacture the seal is compliant. This ensures that the respective seal faces and walls will sealingly engage when assembled due to a preload or bias therebetween.

As is shown in Figure 5, the width of seal tips 238-3 and 240-3 are preferably relatively narrow. This minimizes the force loading actually carried by the seal tips in engaging the pressure biasing surface 144-3 to that necessary to assure sufficient sealing. Any increase in width of the seal tips above the necessary force loading results in increased friction with the pressure plate 140-3, with consequential reduction in seal life and power requirements upon the motor. This is true for the preferred embodiment as well, and for any alternatives in which fluid pressure is employed for biasing the pressure plate directly.

Figure 6 discloses a fourth alternative embodiment of the scroll apparatus 20-4. In this embodiment, the sealing means 170-4 is in the form of annular integrally spring-loaded seals 172-4 and 174-4, referred to as internal and external faceseals. Such seals are typically U or V shaped in cross-section, with the base of the U or V oriented toward the respective recess wall 152-4 and 154-4. One arm of the U or V is disposed in contact with the recess base 156-4 and the other is in sealing engagement with

the pressure biasing surface 144-4. Pressure within the pressure chamber cooperatively defined by the recess 150-4, pressure plate 140-4 and sealing means 170-4 will operate to assist the sealing action of the face seals 172-4, 174-4. One example of suitable face seals which are commercially available is the series S60010, manufactured by American Variseal Corporation. Operation of this embodiment is similar to the operation of the preferred and second alternative embodiments, where biasing means are employed to bias the sealing means. An advantage of this embodiment is that the biasing means is integral to the sealing means, resulting in a reduction of the number of components required.

Figure 7 discloses a fifth alternative embodiment of the scroll apparatus 20-5 in which annular tip seal members are employed. The sealing means 170-5 includes an inner seal ring member 250-5 and an outer seal ring member 252-2. As seen in Figure 7A which is an enlarged partial cross-sectional view of the inner seal ring member 250-5, an intermediate seal channel 256-5 is formed in the inner seal ring member 250-5 adjacent the inner chamber wall 152-5 and an intermediate seal 258-5 is seated in the channel 256-5 to permit movement of the inner seal ring member 250-5 in the recess 150-5. A biasing means 228-5 such as coil springs 232-5 is also provided to engage recess wall 156-5 and the inner seal ring member 250-5 to ensure contact between the pressure biasing surface 144-5 and the inner seal ring member 250-5. Although not shown in enlarged detail, it can be seen in Figure 7 that substantially the same features are provided in the outer seal ring member 252-5. This permits compliant movement of the inner seal ring member 250-5 and separate compliant movement of the outer seal ring

member 252-5, which in this embodiment are formed from relatively inflexible material such as aluminum or steel. The recess, inner seal ring member, outer seal ring member and pressure plate cooperatively define a pressure chamber between the second scroll member and the pressure plate.

Figures 4B, 4C and 4D disclose in more detail exemplary biasing means 228, as applied for purposes of illustration only to the embodiment disclosed in Figure 4. In Figure 4B, a sealing means 170, composed of a laminate of materials such as spring steel or spring steel and rubber, is depicted. As with the seal element 230-3 in Figure 5, a number of coil springs 232 are disposed to provide a force biasing the sealing means 170 toward the pressure biasing surface 144. In Figure 4C, a flexible compressible element such as an O-ring is employed as the biasing means 228. Such O-rings are readily available commercially and provide an additional sealing capability. A canted coil spring disposed longitudinally along the sealing means 170 serves as the biasing means 228 in Figure 4D. Those skilled in the art will recognize that other biasing means such as leaf springs or Bellville springs may be employed with equally suitable results.

In Figure 8, the scroll compressor assembly 20 is shown connected at the discharge aperture 50 in the upper hermetic shell portion 24 and the suction aperture 52 in the lower hermetic shell portion 26 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 detailed explanations of the devices and mechanisms suitable for the operation and construction of such a refrigeration system need not be provided 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.

5 In the above-described embodiments, a co-rotational scroll apparatus comprises a scroll member, or element, which at least partially defines a pressure chamber. In the preferred embodiment, seals are provided which engage a pressure plate secured to
10 the other scroll member to enclose the pressure chamber. Fluid enters the pressure chamber through one or more passages from a compression chamber to provide the desired pressure to bias the pressure plate away from the scroll element and thereby bias
15 the scroll elements together.

 In alternative embodiments described hereinbelow, seal elements are provided which operate in chambers exposed to a selected pressure transmitted through a separate passage or the seal elements are replaced by
20 a piston element directly exposed to the pressure in the pressure chamber and acting in turn upon the pressure plate.

 The embodiments of the co-rotational scroll apparatus provide fluid pressure biasing which can be
25 simply and inexpensively implemented with a minimum of machining and fabrication; by modification of one scroll element. It will also be appreciated that in some of the embodiments, a configuration is provided which permits the application of selective fluid
30 pressure to the seal elements.

 It will be understood that the sealing means slidably engage with one of the scroll members and a pressure biasing surface of a pressure plate secured to the other scroll member. The sealing means in
35 cooperation with the one scroll member at least

partially define a pressure chamber between the one scroll member and the pressure plate, the pressure chamber being in flow communication with a chamber C defined between the scroll wraps. It will be understood that in each of the embodiments, a fluid passage 158 forming an inlet to the pressure chamber is radially stationary with respect to the sealing means.

Furthermore, although the subject invention is exemplified in a hermetic scroll compressor 20, it will be undoubtedly appreciated that the subject invention is useful in all applications of the co-rotational scroll apparatus 20, with like improvement in performance and reduction of expense.

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:



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CLAIMS:

1. A co-rotational scroll apparatus comprising:

a first scroll member having an end plate and a scroll wrap which is disposed on said end plate;

5 a second scroll member having an end plate and a scroll wrap which is disposed on a surface of said end plate, said scroll wraps cooperating to define a compression chamber, said second scroll end plate being provided with a recess in a surface thereof
10 opposite said surface on which said second scroll wrap is disposed and being further provided with a passage opening into said recess and communicating with said compression chamber;

means for ensuring concurrent rotation of said
15 scroll members;

a pressure plate disposed adjacent said recess and secured to said first scroll member for rotation therewith; and

sealing means in sliding engagement with opposing
20 walls of said recess and with said pressure plate; said sealing means and said recess cooperating to at least partially define a pressure chamber between said second scroll member and said pressure plate.

2. A co-rotational scroll apparatus as claimed in



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claim 1, wherein one of said opposing walls is circular.

3. A co-rotational scroll apparatus as claimed in claim 2, wherein the other of said opposing walls is circular.

4. A co-rotational scroll apparatus as claimed in claim 2 or 3, wherein said second scroll member further includes a centrally disposed shaft and one or each of said opposing walls is non-concentric with respect to said shaft.

5. A co-rotational scroll apparatus as claimed in claim 4, wherein said recess varies in width.

6. A co-rotational scroll apparatus as claimed in any one of claims 1 to 5, wherein said sealing means is a generally H-shaped sealing element.

7. A co-rotational scroll apparatus as claimed in any one of claims 1 to 6, wherein said sealing means divides said pressure chamber into first and second areas which are in flow communication through a vent hole provided in said sealing means.



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8. A co-rotational scroll apparatus as claimed in any one of claims 1 to 5, wherein said sealing means comprises a first seal element disposed in said recess and being in sliding engagement with one of said opposing walls and a second seal element disposed in said recess and being in sliding engagement with the other of said opposing walls, said sliding engagement of the first and second seal elements allowing movement of the sealing means in the direction of the axes of the scroll wraps.

9. A co-rotational scroll apparatus as claimed in claim 8, wherein said second scroll member end plate includes a respective seal retainer element spaced apart from each said opposing wall to define a respective seal chamber between the respective seal retainer element and wall.

10. A co-rotational scroll apparatus as claimed in claim 9, wherein said second scroll member end plate includes a seal pressure passage which communicates said compression chamber with the respective seal chambers.

11. A co-rotational scroll apparatus as claimed in claim 9, wherein said second scroll member end plate



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includes a respective seal pressure passage for each said seal chamber extending from said compression chamber to the respective seal chambers.

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12. A co-rotational scroll apparatus as claimed in any one of the preceding claims, wherein said pressure plate includes a substantially planar portion.

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13. A co-rotational scroll apparatus as claimed in any one of the preceding claims, further comprising biasing means for biasing said sealing means toward said pressure plate.

14. A co-rotational scroll apparatus as claimed in claim 13, wherein said biasing means comprises a spring.

15

15. A co-rotational scroll apparatus comprising:
a first scroll member having an end plate and a scroll wrap disposed on said end plate;

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a second scroll member having an end plate and a scroll wrap which is disposed on a surface of said end plate, said scroll wraps cooperating to define a compression chamber and said second scroll end plate being provided with a recess in a surface thereof and having a shaft disposed centrally on said surface,



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said second scroll end plate being further provided with a passage communicating between said recess and said compression chamber;

5 means for ensuring concurrent rotation of said scroll members;

a pressure plate element rotatable with said first scroll member and disposed adjacent said recess; and

10 a piston element disposed in said recess in sliding engagement with said pressure plate element, said recess and piston element cooperating to define a pressure chamber between said second scroll member and said pressure plate element.

15 16. A co-rotational scroll apparatus as claimed in claim 15, wherein said piston element comprises two legs for engaging said pressure plate element.

17. A co-rotational scroll apparatus as claimed in claim 15 or 16, further comprising biasing means disposed in said recess for biasing said piston element against said pressure plate element.

20 18. A co-rotational scroll apparatus as claimed in claim 15, 16 or 17, wherein said recess comprises a first and a second wall, said first and second walls



being circular and concentric with said shaft.

19. A co-rotational scroll apparatus as claimed in claim 15, 16 or 17, wherein said recess is non-concentric with respect to said shaft.

5 20. A co-rotational scroll apparatus comprising:

a first scroll member having a first scroll end plate and a scroll wrap disposed on said end plate;

10 a second scroll member having an end plate and a scroll wrap disposed on said end plate, said scroll wraps cooperating to define a compression chamber, said second scroll end plate being provided with a recess in a surface thereof and having a shaft disposed centrally on said surface, said recess having a first wall and a second wall opposed to said first wall with each said wall being radially spaced from said shaft, said second scroll end plate being further provided with a passage communicating between said compression chamber and said recess;

15 means for ensuring concurrent rotation of said scroll members;

20 drive means for driving one of said scroll members;

a pressure plate element disposed adjacent said recess and secured to said first scroll member; and



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a sealing element in sealing engagement with said first and second walls and in sliding engagement with said pressure plate element; said recess and said sealing element cooperating to at least partially define a pressure chamber between said second scroll member and said pressure plate element.

21. A co-rotational scroll apparatus as claimed in claim 20, further comprising means for biasing said sealing element toward said pressure plate element.

22. A co-rotational scroll apparatus as claimed in claim 20 or 21, wherein said sealing element is generally H-shaped.

23. A co-rotational scroll apparatus comprising:

a first scroll member having an end plate and a scroll wrap disposed on said end plate;

a second scroll member having an end plate and a scroll wrap disposed on said end plate, said scroll wraps cooperating to define a compression chamber, said second scroll end plate being provided with a recess in a surface thereof from which surface a centrally disposed shaft extends, said recess having a first wall and a second wall, each said wall being radially spaced from said shaft, said second scroll



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end plate being further provided with a passage extending from said compression chamber to said recess;

5 means for ensuring concurrent rotation of said scroll members;

drive means for rotating one of said scroll members;

a pressure plate element disposed adjacent said recess and secured to said first scroll member;

10 an inner seal ring member disposed in said recess, said inner seal ring member being in axial sliding engagement with said first wall and in sliding engagement with said pressure plate element; and

15 an outer seal ring member disposed in said recess, said outer seal ring member being in axial sliding engagement with said second wall and in sliding engagement with said pressure plate; said inner and outer seal ring members, said recess and said pressure plate element cooperating to define a
20 pressure chamber in flow communication with said compression chamber.

24. A co-rotational scroll apparatus as claimed in claim 23, wherein said inner seal ring member comprises a channel and a seal disposed in said
25 channel for sliding engagement with said first wall.



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25. A co-rotational scroll apparatus as claimed in claim 23 or 24, wherein said outer seal ring member comprises a channel and a seal disposed in said channel for sliding engagement with said second wall.

5 26. A co-rotational scroll apparatus as claimed in claim 23, 24 or 25, further comprising means for biasing said inner ring seal member toward said pressure plate element.

10 27. A co-rotational scroll apparatus as claimed in any one of claims 23 to 26, further comprising means for biasing said outer ring seal member toward said pressure plate element.

15 28. A co-rotational scroll apparatus as claimed in any one of claims 23 to 27, wherein said recess is non-concentric with respect to said shaft.

29. A co-rotational scroll apparatus as claimed in any one of claims 23 to 28, wherein the width of said recess varies.

20 30. A co-rotational scroll apparatus comprising:
a first and a second scroll member, each of said scroll members having an end plate and a scroll wrap



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extending from one side of said end plate, said scroll wraps interfitting with each other, said first scroll member having a drive shaft extending from the side of its end plate opposite the side from which said scroll wrap extends and a passage extending through said drive shaft for discharging fluid from between said scroll wraps and said second scroll member being provided with a recess in the side of its end plate opposite the side from which said scroll wrap extends;

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bearing means for supporting said first and second scroll members;

means for linking said scroll members for concurrent rotation;

means, carried by said first scroll member, which

15 means comprises a pressure biasing surface; and

sealing means operatively disposed in sealing engagement with said second scroll member and said pressure biasing surface to in cooperation with said second scroll member and said pressure biasing surface

20 define a pressure chamber in flow communication with said recess, said recess being provided with an inlet opening for receiving a fluid under pressure to act concurrently against said pressure biasing surface and said second scroll member so as to bias said second

25 scroll member toward said first scroll member, wherein in use of the apparatus, said inlet is radially



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stationary with respect to said sealing means.

31. A co-rotational scroll apparatus as claimed in claim 30, wherein said sealing means divides said pressure chamber into a first area adjacent said second scroll member and a second area adjacent said pressure biasing surface.

32. A co-rotational scroll apparatus as claimed in claim 31, wherein said sealing means has a central web portion.

33. A co-rotational scroll apparatus as claimed in claim 32, wherein said central web portion comprises at least one vent hole.

34. A co-rotational scroll apparatus as claimed in claim 32 or 33, wherein said web portion has a surface facing said second scroll member and a surface facing said pressure biasing surface.

35. A co-rotational scroll apparatus as claimed in any one of claims 30 to 34, wherein said sealing means is a one piece seal element.

36. A co-rotational scroll apparatus as claimed in



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any one of claims 30 to 36, wherein said sealing means has four sealing surfaces.

37. A co-rotational scroll apparatus as claimed in claim 36, wherein two of said four sealing surfaces contact said pressure biasing surface.

38. A co-rotational scroll apparatus as claimed in claim 37, wherein said recess has inner and outer walls and of the other two of said four sealing surfaces, one seals against said inner wall and the other seals against said outer wall.

39. A co-rotational scroll apparatus as claimed in any one of claims 30 to 38, wherein said sealing means is fabricated from a compliant material.

40. A co-rotational scroll apparatus as claimed in claim 30, wherein said sealing means comprises integral biasing means for biasing said sealing means toward said pressure plate.

41. A co-rotational scroll apparatus comprising two interleaving scroll wraps secured to respective end plates, a pressure plate secured to one end plate and disposed opposite to and spaced from the other end



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plate outwardly of the scroll wraps, and sealing means in sliding engagement with said other end plate and said pressure plate and defining at least partially pressure chamber means between said other end plate and said pressure plate, said sliding engagement with said other end plate allowing movement of said sealing means relative to said other end plate in the direction of the axes of said scroll wraps, said one end plate comprising an aperture for discharging fluid from compression chamber means defined between said scroll wraps, said other end plate being provided with passage means for the passage of fluid from said compression chamber means to said pressure chamber means to urge the pressure plate and said other end plate apart, said passage means comprising an inlet to said pressure chamber means which in use of the apparatus maintains a fixed radial position with respect to said sealing means.

42. Any of the co-rotational scroll apparatus substantially as herein described with reference to the accompanying drawings.
