

SCROLL COMPRESSORS

This invention generally pertains to scroll compressors.

5 In a typical scroll compression apparatus, two interfitting involute scroll wraps are provided for forming a plurality of chambers moving from the radial outer ends of the scroll wraps to the radial inner ends of the scroll wraps. The chambers are formed by a plurality of moving line contacts generated between
10 the flanks of the scroll wrap elements, with the tip of each respective scroll wrap element in sliding engagement with the end plate of the opposing scroll element. In operation, one scroll wrap orbits with respect to the other scroll wrap, causing the
15 formation of a chamber at the radial exterior end into which fluid is drawn and compressed as the chamber grows smaller in volume toward the centre of the scroll wraps. The compressed fluid is then discharged through an aperture centrally disposed in at least one
20 of the end plates of the scroll wraps. Each chamber therefore discharges a pulse of compressed fluid, such that the output of compressed fluid from the scroll apparatus is pulsating in manner.

25 However, in order to maintain the desired pressure between the respective tips and end plates of

the scroll wraps to minimize leakage therebetween, it has been found desirable to apply fluid at discharge pressure to act upon at least one of the scroll wrap end plates on the side opposite from the scroll wrap.

5 The area to which the discharge pressure fluid is applied generally determines the pressure applied to the scroll wrap tips.

It has been found difficult to maintain the appropriate pressure due to variations in discharge pressure.

10 The discharge pressure varies in response to varying load conditions of the system in which the scroll compression apparatus is used. For example, in a refrigeration system the load experienced by the scroll compression apparatus is the flow of refrigerant fluid to be compressed. This flow varies in response to environmental temperature changes experienced by the condenser and evaporator, changes in refrigerant flow rate through the expansion valve, changes in the refrigeration system controller and other factors.

20 Furthermore, it is also desirable to minimize the effects of the occasional fluctuations in the suction pressure of the fluid to be compressed. When the suction pressure of the fluid is relatively higher or lower, it would be desirable to obtain a corresponding

slight compensatory increase or reduction in the pressure exerted between the scrolls. Typically, no provision is made for these fluctuations.

The present invention provides a scroll compressor comprising:

a first scroll member having an end plate and an upstanding involute wrap disposed on said end plate, said first scroll member end plate further including a discharge aperture;

a second scroll member having an end plate and an upstanding involute wrap disposed on said end plate for interleaving engagement with said upstanding involute wrap of said first scroll member;

a pressure regulation chamber arranged such that, in use, fluid pressure therein acts upon said first scroll end plate to bias said first scroll member toward said second scroll member, said discharge aperture of said first scroll member end plate providing flow communication to said chamber; and

a pressure regulation device responsive to suction and discharge pressure for adjusting the flow area of an outlet from said pressure regulation chamber for regulating fluid pressure in said pressure regulating chamber.

The pressure regulation device may comprise a piston having a portion movably disposed in said

outlet for adjusting said flow area.

5 The piston may comprise a first relatively large diameter section and a second relatively small diameter section, wherein the free end of said first section is exposed to fluid at suction pressure and the free end of said second section is disposed in said outlet and is exposed to fluid at discharge pressure.

10 Preferably, however, said piston is operably connected to a pressure differential controller.

The pressure differential controller may comprise a first element responsive to discharge pressure and a second element responsive to suction pressure.

15 In one embodiment the first element is a first, interior bellows member and said second element is a second, exterior bellows member, said first and second bellows members being concentric and interconnected to define a void of variable volume therebetween, said volume being substantially evacuated.

20 The compressor may further comprise a frame, wherein said frame and said first scroll member define said pressure regulation chamber. In this case, advantageously the compressor further comprises an annular seal element disposed about said pressure regulation chamber between said first scroll member
25 end plate and said frame for sealing said chamber and

a means for biasing said annular seal toward said first scroll member end plate.

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:

Figure 1 is a cross-section view of a hermetic scroll compressor comprising a pressure regulation chamber and a pressure regulating device;

Figure 2 is an enlarged cross-sectional view of a part of the compressor shown in Figure 1;

Figure 3 is a partial cross-section view of another hermetic scroll compressor comprising a pressure regulation chamber and a pressure regulating device;

Figure 4 is an enlarged cross-section of an annular seal element and annular spring for sealing the pressure regulation chamber of the scroll compressor of Figure 1, 3 or 5;

Figure 5 is a partial cross-section view of another hermetic scroll compressor including the pressure regulating device shown in Figure 7, wherein the compressor includes an internal pivot swing link compliance member;

Figure 6 is an enlarged cross-sectional view of the compressor of Figure 5 taken along section line 6-

6;

Figure 7 is an enlarged cross-sectional view of the pressure regulating device shown in Figures 3 and 5;

5 Figure 8 is a plan view of the annular sealing spring shown in Figure 4;

Figure 9 is a cross-sectional view of the annular spring of Figure 8 taken along section line 9-9; and

10 Figure 10 is a schematic representation of an air conditioning system provided with a compressor comprising a pressure regulation chamber and a pressure regulating device.

A compressor generally denoted by reference numeral 20 is shown in Figure 1. Compressor 20 is a
15 rotary compressor. A hermetic shell 22 of the compressor is generally cylindrical and comprises an upper portion 24, a lower portion 26 and a central portion 28. The central portion 28 includes a peripheral heat exchange portion comprised of a
20 plurality of spaced, parallel annular ribs 30 for providing heat exchange from the interior of the hermetic shell 22 to the exterior environment. The central portion 28 of the hermetic shell 22 also includes a frame portion 32 for separating the
25 hermetic shell 22 into a discharge pressure portion 34 and a suction pressure portion 36.

The central portion 28 preferably is secured by welding to the upper portion 24 and the lower portion 26 such that the shell 22 is suitably divided into the discharge and suction pressure portions.

5 A motor 40 is disposed in the discharge pressure portion 34 of the hermetic shell 22 supported by the central frame 32. The motor 40 is preferably an electric motor having a fixed stator 42 and a rotatable rotor 44 separated by an annular space. The
10 motor is not described in detail, as it is believed that the art of the electric motor is generally well understood. However, the motor 40 would generally preferably be an electric motor operating on single or three-phase alternating current. It would also be
15 possible to operate the compressor 20 as a variable speed device by including a suitable electric motor 40 or a suitable controller (not shown) for varying the speed of the motor 40.

 The compressor 20 is a scroll compressor of the
20 type having one fixed scroll wrap 50 and one relative orbiting scroll wrap 52. However, from the description of the preferred embodiment that follows herein, it will be apparent to those skilled in the art that the compressor could be readily modified to
25 a co-rotation scroll compressor, in which both scroll wraps 50 and 52 are rotated about parallel, non-

concentric axes. In the compressor 20, the fixed scroll wrap 50 is affixed to or formed as part of the lower hermetic shell portion 26 such that a portion of the lower hermetic shell portion 26 comprises a substantially planar surface acting as a second scroll end plate for sealing orbital engagement with the orbiting scroll wrap 52. The orbiting scroll wrap 52 is secured to or formed as part of an orbiting end plate 54.

The fixed scroll wrap 50 and the orbiting scroll wrap 52 are upstanding involutes generated from parallel axes. Each respective scroll wrap 50 and 52 has a radially inner end, a radially outer end, a tip 56 for sealingly engaging the opposing end plate and flank surfaces 58 for sealing line contact engagement with the flank surface 58 of the adjacent scroll wrap all as is generally known in the art.

The orbiting scroll end plate 54 also includes a circular drive stub 60 disposed opposite from the orbiting scroll wrap 52. Drive stub 60 is preferably cast as an integral part of the end plate 54, and located approximately in the centre of the end plate 54. A discharge port aperture 62 is defined through the end plate 54 and the drive stub 60 by a bore adjacent the inner radial end of the orbiting scroll wrap 52. This discharge port aperture 62 permits

fluid discharge from the scroll wraps 50 and 52 when fluid is compressed therein.

A drive shaft 70 is disposed within the hermetic shell 22. The drive shaft 70 extends through a frame aperture 72 in the central frame portion 32. This frame aperture 72 is substantially centrally located in the frame portion 32 so that the drive shaft 70 communicates between the discharge pressure portion 34 and the suction pressure portion 36. The drive shaft 70 has an upper end 74 which is in driving connection with the motor 40, by means of a press fit between the rotor 44 and the upper end 74 or by means of a common key and juxtaposed keyways in the rotor 44 and upper end 74 (not shown).

A lower end of the drive shaft 70 comprises a crank portion 76 disposed in the discharge pressure portion 34. The crank portion 76 includes an eccentric crankshaft member, crank stub 78, which is a cylindrical projection from the crank portion 76 on an axis parallel to the axis of the drive shaft 70. An integral counterweight is included in the crank portion 76 to dynamically balance the drive shaft 70 during operation. The crank stub 78 is in rotational engagement with the drive stub 60 for transmitting rotational motion to the orbiting scroll end plate 54. An Oldham coupling 80 or similar anti-rotation device

is included in the suction pressure portion 36 of the compressor assembly 20 for preventing rotation of the orbiting scroll end plate 54 while translating the rotational motion into a relative orbital motion.

5 Anti-rotation devices such as the Oldham coupling 80 are believed to be generally well understood in the art and are not disclosed in detail herein, as a detailed understanding of such devices is not believed necessary to the comprehension of the subject
10 invention.

An upper radial bearing 84 and a lower radial bearing 86 are disposed in the frame aperture 72 for rotational engagement with the drive shaft 70. These bearings 84 and 86 may be sleeve bearings formed, for
15 example, of sintered bronze, or may be roller or ball bearings.

In order to provide satisfactory lubrication for the bearings 84 and 86, the central frame portion 32 includes a depression defining a lubricant reservoir 90. A lubricant passage 92 is defined by a bore
20 extending through the central frame portion 32 between the lubricant reservoir 90 and the lower radial bearing 86, providing for lubricant passage to the lower radial bearing 86. A helical groove 94 extends
25 along drive shaft 70 between the lower radial bearing 86 and the upper radial bearing 84 to transmit

lubricant from the lower radial bearing 86 to the upper radial bearing 84. Finally, a metering aperture 96 is defined by a bore between the lubricant reservoir 90 and the suction pressure portion 36 for transmitting a measured quantity of lubricant to the suction pressure portion 36 to be entrained with the fluid to be compressed so that the Oldham coupling 80 and the scroll wraps 50 and 52 will receive adequate lubrication.

A circular sidewall 100 generally concentric with the frame aperture 72 defines a recess in the central frame portion 32 wherein the crank portion 76 of the drive shaft 70 is received for free rotation. A planar lower face 102 is provided on the central frame portion 32 in a spaced relationship with respect to the orbiting scroll end plate 54. Preferably, the lower face 102 is disposed so as to not interfere with the free orbital motion of the orbiting scroll end plate 54, but rather is disposed in a range of .030 to .060 inches (0.75 to 1.5mm) from the orbiting scroll end plate 54.

As shown in Figures 1, 3, 4, 5 and 6, an annular groove 110 is defined in the lower face 102 of the central frame portion 32. This annular groove 110 is defined by a circular interior side wall 112, a concentric exterior side wall 114 of relatively larger

diameter and a recessed planar surface 116 in the base of the groove 110 adjoining the interior side wall 112 and the exterior side wall 114. The interior side wall 112 is spaced radially outward from the circular side wall 100. An annular seal element 120 of rectangular cross-section is disposed within the annular groove 110. The annular seal 120 includes a first planar face 122 for engaging the orbiting scroll end plate 54 and a second, exterior surface 124 for engagement with the exterior side wall 114. The second surface 124 is normal to the plane of the first face 122. A third engagement face 126 is at the upper end of the second surface 124 and is parallel to the first face 122.

An annular biasing member in the form of an annular sealing spring 130 is disposed between the third face 126 of the annular seal 120 and the recessed surface 116 of the annular groove 110. The sealing spring 130, more particularly shown in Figures 8 and 9, is comprised of three portions; a first relatively planar radially exterior portion 132, a radially interior planar portion 134 and an angular portion 136 adjoining the exterior planar portion 132 with the interior portion 134. The exterior planar portion 132 and the interior planar portion 134 are parallel and spaced apart a distance determined by an

angle theta of the angular portion 136. Preferably, the spring 130 is a solid annulus having no holes or discontinuities, as shown in Figure 8. This contributes to the sealing efficiency of the combination of the seal 120 and spring 130 by causing the spring 130 to act as a barrier to fluid flow. The spring 130 may be formed of spring steel by such means as die-press operations, for example.

The second surface 124 of the annular seal 120 is sized to a diameter slightly larger than the exterior side wall 114 of the annular groove 110 such that when the annular seal 120 is inserted into the annular groove 110, the second surface 124 is slightly compressed in contact with the exterior side wall 114.

The annular sealing spring 130 is disposed between the annular seal 120 and the annular groove 110, with the interior planar portion 134 in contact with the recessed surface 116 and the exterior planar portion 132 in biasing contact with the third face 126 of the annular seal 120. When the compressor 20 is assembled, the orbiting end plate 54 is pressed into engagement with the first face 122 of the annular seal 120, causing the angle theta of the angular portion 136 to move to the angle θ_1 , so that the spring 130 biases the annular seal 120 out of the groove and toward the orbiting scroll end plate 54 to ensure

sealing contact therebetween. Thus, the circular side wall 100 and a top wall 104 of the recess in the frame 32, and the orbiting scroll end plate 54 are sealed by the annular seal 120 to comprise a pressure regulation chamber.

A bore defining a discharge regulation passage or outlet 106 extends from the top wall 104 to the upper surface of the central frame portion 32.

A regulation device bore 140 intersects and is substantially normal to the regulation passage 106. The regulation device bore 140 extends from the radial exterior of the central frame portion 32, and has a large diameter portion 142 and a small diameter portion 144 which intersects the regulation passage 106.

A pressure regulation device 150 is disposed in the regulation device bore 140 and comprises a piston 180 operably connected to a pressure differential controller. The pressure differential controller comprises an inner end plate 152, an outer end plate 154, and two interfitting pleated bellows elements. The first element, a pleated inner bellows 156, of relatively smaller diameter contains discharge pressure fluid in its interior, received through an orifice 158 in the inner end plate 152. The second element, pleated outer bellows 160 is of relatively

larger diameter and is disposed concentrically around the inner bellows 156. The exterior of the second, outer bellows is exposed to fluid at suction pressure communicated to the large diameter portion 142 of the regulation device bore 140 through a transmission passage 162. The suction pressure transmission passage 162 is a relatively small bore extending from the large diameter portion 142 to the suction pressure portion 36 of the hermetic shell 22.

For ease of manufacture, the outer end plate 154 has a bore 164 defining an aperture equal in diameter to that of the inner end plate orifice 158. This permits the inner bellows 156 and the outer bellows 160, which are preferably formed of a thin flexible material such as spring steel, to be secured to the inner end plate 152 and then secured to the outer end plate 154 by means of welding or brazing. An end cap 170 is then sealingly secured to the outer end plate 154 such that the bore 164 is thereby covered. A piston rod 172 extends from the end cap 170 through the interior of the inner bellows 156 and is secured to a piston 180 by such means as welding or threads in a correspondingly threaded aperture such that the piston is operably connected to the pressure differential controller. These components of the pressure regulation device 150 would preferably be

steel or a similar high strength metal so as to give the maximum service life and minimize maintenance requirements.

5 The piston 180 is disposed slidably within the small diameter portion 144 of the regulation device bore 140 such that the piston 180 may be moved into and out of the regulation passage 106. In turn, this movement of the piston 180 decreases or increases the available flow area through the regulation passage 106. A small discharge pressure transmission bore 182 is provided through the piston 180 coaxial with the pressure regulation device bore 140 for transmission of discharge pressure fluid therethrough to the interior of the inner bellows 156 of the pressure regulation device 150.

15 In use, the motor 40 is actuated so that the rotor 44 rotates the drive shaft 70, which in turn actuates the orbiting scroll end plate 54 through the inner action of the crank stub 78 and the orbiting end plate drive stub 60. The orbiting scroll end plate is restrained from rotational motion into relative orbital motion by the Oldham coupling 80. As the orbiting scroll wrap 52 orbits the fixed scroll wrap 50, a plurality of compression chambers moving toward 20 the radial inner end of the respective wraps are defined. The fluid to be compressed is drawn into the

radial outer ends of the respective wraps and compressed in these chambers and discharged through the discharge port aperture 62 and a crank aperture 77 provided in the crank stub 78 into the chamber defined by the circular side wall 100, the annular seal 120, the orbiting scroll end plate 54 and the top wall 104.

As the refrigerant or fluid is compressed, the discharge pressure fluid forces a small flow of lubricant through the lubricant metering aperture 96 and the lubricant passage 92. The lubricant entering the suction pressure portion 36 lubricates the Oldham coupling mechanism, any thrust bearings applied to the orbiting scroll end plate 54, and the tip 56 and flank 58 surfaces of the respective scroll wraps. Lubricant forced through the lubricant passage 92 lubricates the lower radial bearing 86 and is transmitted by the drive shaft groove 94 from the bearing 86 to the upper radial bearing 84 and thence into the discharge pressure portion 34. The lubricating oil in the suction pressure portion 36 is entrained by the refrigerant or fluid being compressed and is forced through the discharge port aperture 62 and the regulation passage 106 into the discharge pressure portion 34 wherein it disentrains from the compressed fluid or refrigerant, as the case may be, and flows downwardly through the annular space between the

stator 42 and rotor 44 into the lubricant reservoir 90.

5 Simultaneously, fluid at suction pressure is transmitted through the suction pressure transmission passage 162 to act upon the outer surface of the outer bellows 160 and fluid at discharge pressure is transmitted through the discharge pressure transmission bore 182 in the piston 180 to act upon the inner surface of the inner bellows 156. As the
10 respective bellows are restrained by the end plates 152 and 154 to act together, the outer end plate 154 is moved axially in the large diameter bore 142 by the pressure differential. Preferably, vacuum or near vacuum pressure is maintained in the variable volume
15 void between the bellows 156 and 160.

In response to the pressure differential between suction pressure and discharge pressure, the piston 180 is moved into or out of the regulation passage 106 to decrease or increase the available flow area, such
20 that an increase in discharge pressure will actuate the piston 180 to increase the available flow area and a relative decrease in discharge pressure will actuate the piston to decrease the flow area. The result of the piston actuation therefore causes the piston to
25 act to increase the discharge pressure fluid retained in the chamber when the discharge pressure decreases

and conversely to decrease the discharge pressure by allowing greater flow when the discharge pressure increases in the chamber. Therefore, the pressure of discharge fluid in the chamber remains substantially constant so that the discharge pressure balancing of the orbiting scroll end plate 54 does not undesirably fluctuate.

Additionally, the pressure regulation device is sensitive to variations in suction pressure. The relative pressure of the scroll wrap tips 56 upon the scroll end plate 54 is balanced by the actuation of the piston 180 to reduce the pressure of discharge fluid in the chamber when the suction pressure of the fluid in the suction pressure portion 36 decreases. Conversely, should an increase in suction pressure be experienced in the fluid to be compressed, the piston 180 will be actuated by the increased suction pressure to correspondingly increase the discharge pressure, maintaining the sealing between the scroll wraps 50 and 52.

In examining Figure 1, it will be apparent that fluid contained within the pressure regulating chamber exerts a force upon the back of the scroll end plate 54 within the area bounded by the annular seal element 120. This force acts to bias the orbiting scroll member toward the fixed scroll member formed by the

lower hermetic shell portion 26 and wrap 50. This
biasing force seals the chambers of the scroll wraps
50 and 52, acting against the commonly known
separating forces due to fluid pressure within the
scroll wraps 50 and 52. As noted above, the pressure
regulation device is responsive to both discharge
pressure and suction pressure, providing a
substantially constant regulated pressure in the
chamber at a given suction pressure and an increased
or decreased regulated pressure at an increased or
decreased suction pressure. In other words the
pressure regulation device enables the provision of a
pressure on the scroll end plate 54 which varies
adaptively to variations in discharge and suction
pressure.

An alternative form of the preferred pressure
regulation device shown in Figures 1 and 2 is shown in
Figures 3, 5 and 7 in a compressor 20'. In the
compressor 20', the reference numerals are consistent
with the preferred embodiment, with the addition of an
apostrophe to denote the alternative embodiment. The
compressor 20' as shown in Figures 3 and 5 includes
alternative arrangements for driving the orbiting
scroll member including radially compliant drive means
in the form of swing links 190', in addition to or in
lieu of axially compliant drive means.

In Figure 3, the swing link 190' is shown in an external pivot configuration wherein a crank stub 78' engages a bearing 192' for rotationally driving the swing link 190'. The motion of the swing link 190' is translated through a drive stub bearing 194' to a drive stub 60' of the orbiting scroll end plate 54'. The swing link 190' has an upper face 196' which is relatively spaced with respect to the crank portion 76', to permit free flow of fluid at discharge pressure from the discharge port aperture 62'.

In Figures 5 and 6, the swing link 190' is shown in an internal pivot configuration. As with the external configuration swing link 190', a crank bearing 192' engages the crank stub 78' at a drive angle B for translating rotational motion from the drive shaft 70' to the swing link 190'. The motion of the swing link 190' is then translated through a drive stub bearing 194' surrounding the circular exterior of the swing link 190' to an annular orbiting end plate drive stub 60', configured as an annular wall surrounding the swing link 190'. The swing link 190' is provided with a bore 198' to permit free flow of fluid from the discharge port aperture 62' and arranged such that an upper face 196' thereof is spaced relatively away from the crank portion 76' to permit free flow of discharge pressure fluid from the

discharge port aperture 62' into the pressure regulation chamber.

The alternative form of the pressure regulation device 150' comprises a piston which is substantially T-shaped in cross-section and includes a first relatively large diameter piston section 200' and a second relatively small diameter piston section 202'. The large diameter section 200' is disposed within the large diameter portion 142' of the regulation device bore 140' and is connected thereto in sliding, sealing engagement by an annular seal 204'. The small diameter section 202' is disposed within the small diameter portion 144' of the regulation device bore 140', and slidably sealingly engages the small diameter portion 144' with a second seal 206'. The volume between the first seal 204' and the second seal 206' is substantially evacuated, maintained at a vacuum by the operation of the seals 204' and 206'.

Preferably, the seals 204' and 206' are formed of a flexible elastomeric material and seated in corresponding annular grooves in the pressure regulation device 150'. The pressure regulation device 150' would be a suitable metal, such as steel.

In use, the operation of pressure regulation device 150' is substantially identical to that of the pressure regulation device 150' in the preferred

embodiment. This is due to the fact that the free end of the large diameter section 200' is exposed to fluid at suction pressure and the free end of the small diameter section 202' is exposed to discharge pressure, creating the same response to changes in pressure as in the preferred embodiment. However, because of the difficulty in maintaining a perfect, theoretical seal with sealing elements 204' and 206', it is not believed practical to operate the pressure regulation device 150' without means for maintaining a vacuum in the volume between the seals 204' and 206'.

Preferably, the compressor 20 or 20' would be utilized in a refrigeration or air conditioning system for circulating a refrigerant in closed loop connection, such a system having a condenser 220 for condensing refrigerant to a liquid form, an expansion valve 230 for receiving the liquid refrigerant from the condenser 220 and expanding the refrigerant, an evaporator 240 for receiving expanded refrigerant from the expansion valve 230 and evaporating the refrigerant, a suction line 250 for transferring the evaporated refrigerant to a suction port 252 in the lower portion 26 of the hermetic shell 22 such that the refrigerant is received in the suction pressure portion 36. The refrigerant is then compressed as

described above and discharged from the compressor 20 through a discharge port 254 and thence through a discharge line 256 to the condenser 220. A schematic representation of such a refrigeration or air conditioning system is shown in Figure 10.

It will be apparent to those skilled in the art that such a refrigeration or air conditioning system could include multiple compressors 20 or 20', or multiple other components as well as additional refinements such as hot gas defrost, all as is generally known to those skilled in the art.

From the foregoing it will be appreciated that each of the described embodiments comprises a scroll compressor provided with a pressure regulating device responsive to suction pressure and discharge pressure for regulating pressure in a pressure regulation chamber and a biased annular seal for maintaining a regulated discharge pressure in the chamber. In the scroll compressor shown in Figures 1 and 2 the pressure regulating device consists of a piston movably disposed in a bore so as to increase and decrease the size of the flow area of the outlet from the chamber in response to axial movement of an outer end plate of a pressure differential controller. The controller includes a first bellows and a second bellows connected to an inner and the outer end plate

and disposed concentrically of one another. A volume at vacuum or near-vacuum pressure is enclosed between the bellows. The bellows are constrained by the end plates to act together such that the outer end plate moves to drive the piston according to a pressure differential between suction and discharge pressure.

An annular groove having a rectangular cross-section is provided in the frame defining the pressure regulation chamber at a point which is radially outside the circumference of the chamber. The groove is sized to accommodate a rectangular cross-section annular seal element preferably formed of elastomeric material and to permit its free movement in the groove. An annular sealing spring is disposed within the groove for biasing the annular seal out of the groove, whereby the annular seal is forced into contact with a scroll wrap end plate to minimize the fluid leakage and maintain a regulated pressure in the chamber. It will be appreciated that not only does leakage make difficult the maintenance of the appropriate pressure in the compressor apparatus, but any such fluid must be recompressed, reducing the useful work output of the scroll compression apparatus.

It will be appreciated from the description of the embodiments above that some of the problems

associated with pressure balanced scroll apparatus are reduced. It can be seen that improved compressor performance is obtained by providing a proper balance of discharge pressure action upon the orbiting scroll end plate 54, 54' which is regulated by a pressure regulation device responsive to fluctuations in suction and discharge pressure. The action of the pressure regulating device is self regulating and does not require an external power source, thereby providing low maintenance costs and simple, automatic operation. It is also apparent that the annular seal cooperates with the pressure regulation device 150, 150' to further reduce the pressure variations in the pressure regulation chamber defined in the compressor assembly.

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

CLAIMS:

1. A scroll compressor comprising:

a first scroll member having an end plate and an upstanding involute wrap disposed on said end plate, said first scroll member end plate further including a discharge aperture;

a second scroll member having an end plate and an upstanding involute wrap disposed on said end plate for interleaving engagement with said upstanding involute wrap of said first scroll member;

a pressure regulation chamber arranged such that, in use, fluid pressure therein acts upon said first scroll end plate to bias said first scroll member toward said second scroll member, said discharge aperture of said first scroll member end plate providing flow communication to said chamber; and

a pressure regulation device responsive to suction and discharge pressure for adjusting the flow area of an outlet from said pressure regulation chamber for regulating fluid pressure in said pressure regulating chamber.

2. A compressor as claimed in claim 1, wherein said pressure regulation device comprises a piston having a portion movably disposed in said outlet for



adjusting said flow area.

5 3. A compressor as claimed in claim 2, wherein said piston comprises a first relatively large diameter section and a second relatively small diameter section, wherein the free end of said first section is exposed to fluid at suction pressure and the free end of said second section is disposed in said outlet and is exposed to fluid at discharge pressure.

10 4. A compressor as claimed in claim 2, wherein said piston is operably connected to a pressure differential controller.

15 5. A compressor as claimed in claim 4, wherein said pressure differential controller comprises a first element responsive to discharge pressure and a second element responsive to suction pressure.

20 6. A compressor as claimed in claim 5, wherein said first element is a first, interior bellows member and said second element is a second, exterior bellows member, said first and second bellows members being concentric and interconnected to define a void of variable volume therebetween, said volume being substantially evacuated.



7. A compressor as claimed in claim 6, wherein said first and second bellows members are secured to an inner end plate and an outer end plate, said outer end plate comprising a piston rod for providing said operable connection with said piston.

8. A compressor as claimed in any one of the preceding claims, further comprising a frame, wherein said frame and said first scroll member define said pressure regulation chamber.

9. A compressor as claimed in claim 8, wherein said frame is arranged to divide a hermetic shell of the compressor into a discharge pressure portion and a suction pressure portion.

10. A compressor as claimed in claim 9, wherein the frame is further operative to support a motor within said hermetic shell.

11. A compressor as claimed in claim 10 wherein the frame comprises a lubricant reservoir.

12. A compressor as claimed in claim 11, wherein the frame further comprises a lubricant metering aperture for metering flow communication of a lubricant from



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said lubricant reservoir to said suction pressure portion wherein said lubricant is entrained with the fluid therein.

5 13. A compressor as claimed in claim 12, wherein said motor includes a stator and a rotor defining an annular space in which the lubricant is disentrained from fluid discharged through said outlet, and through which the disentrained lubricant flows to said reservoir.

10 14. A compressor as claimed in claim 13, wherein the frame further comprises means for bearing rotational motion of a drive shaft of said motor.

15 15. A compressor as claimed in claim 14, wherein the frame further includes a lubricant passage from said lubricant reservoir to said bearing means.

16. A compressor as claimed in any one of claims 8 to 15, wherein said frame is provided with an aperture defining said outlet from said chamber.

20 17. A compressor as claimed in any one of claims 8 to 16, further comprising an annular seal element disposed about said pressure regulation chamber



between said first scroll member end plate and said frame for sealing said chamber and a means for biasing said annular seal toward said first scroll member end plate.

5 18. A compressor as claimed in claim 17, wherein said means for biasing said annular seal comprises an annular biasing member engaging said frame and said annular seal.

10 19. A compressor as claimed in claim 18, wherein said frame is provided with an annular groove for containing said annular biasing member and at least a portion of said annular seal element.

15 20. A compressor as claimed in claim 18 or 19, wherein said annular biasing member comprises an annular sealing spring.

21. A compressor as claimed in claim 20, wherein said annular sealing spring has no discontinuity.

20 22. A compressor as claimed in any one of the preceding claims, further comprising means for compliantly driving said first scroll member, said compliant drive means including an aperture for



accepting a stub on said end plate of said first scroll member.

23. A compressor as claimed in claim 22 when appended to any one of claims 10 to 15, wherein said motor has means for eccentrically engaging said compliant drive means.

24. A compressor as claimed in any one of claims 10 to 15, wherein said first scroll member has an annular upstanding drive stub on said end plate thereof extending oppositely from said upstanding involute wrap thereof, and said motor includes an eccentric crankshaft member; said compressor further comprising means for compliantly driving said first scroll member, said compliant drive means having an aperture for accepting said crankshaft member and a circular exterior rotationally interfitting said annular drive stub.

25. A compressor as claimed in any one of claims 10 to 15, comprising a drive shaft in connection with said motor, said drive shaft having an eccentric crank portion with a crank stub; means for compliantly driving said first scroll member, said compliant drive means being in rotational engagement with said crank



stub and a stub on said end plate of said first scroll member.

26. A scroll compressor substantially as hereinbefore described with reference to the accompanying drawings.



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