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(54) **CAPACITY MODULATED SCROLL COMPRESSOR**

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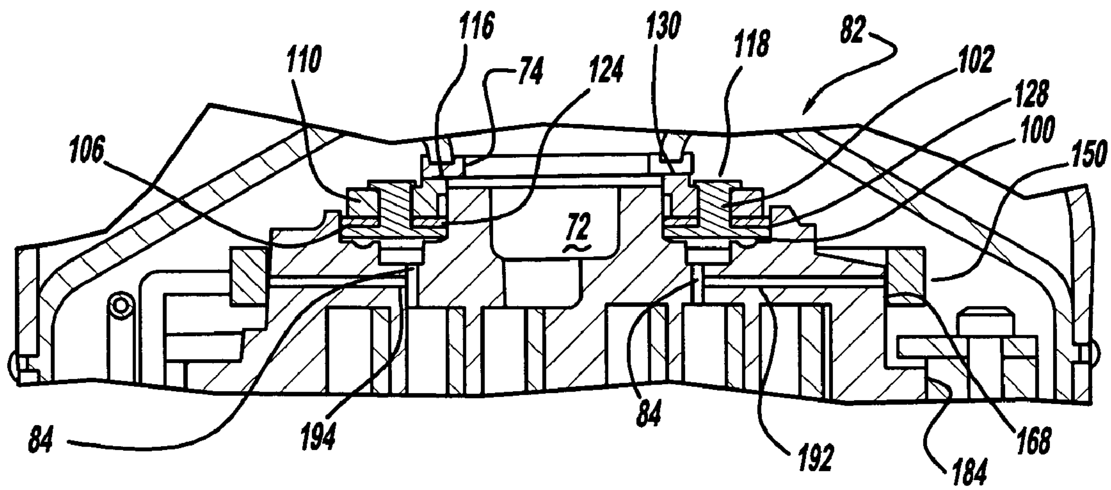
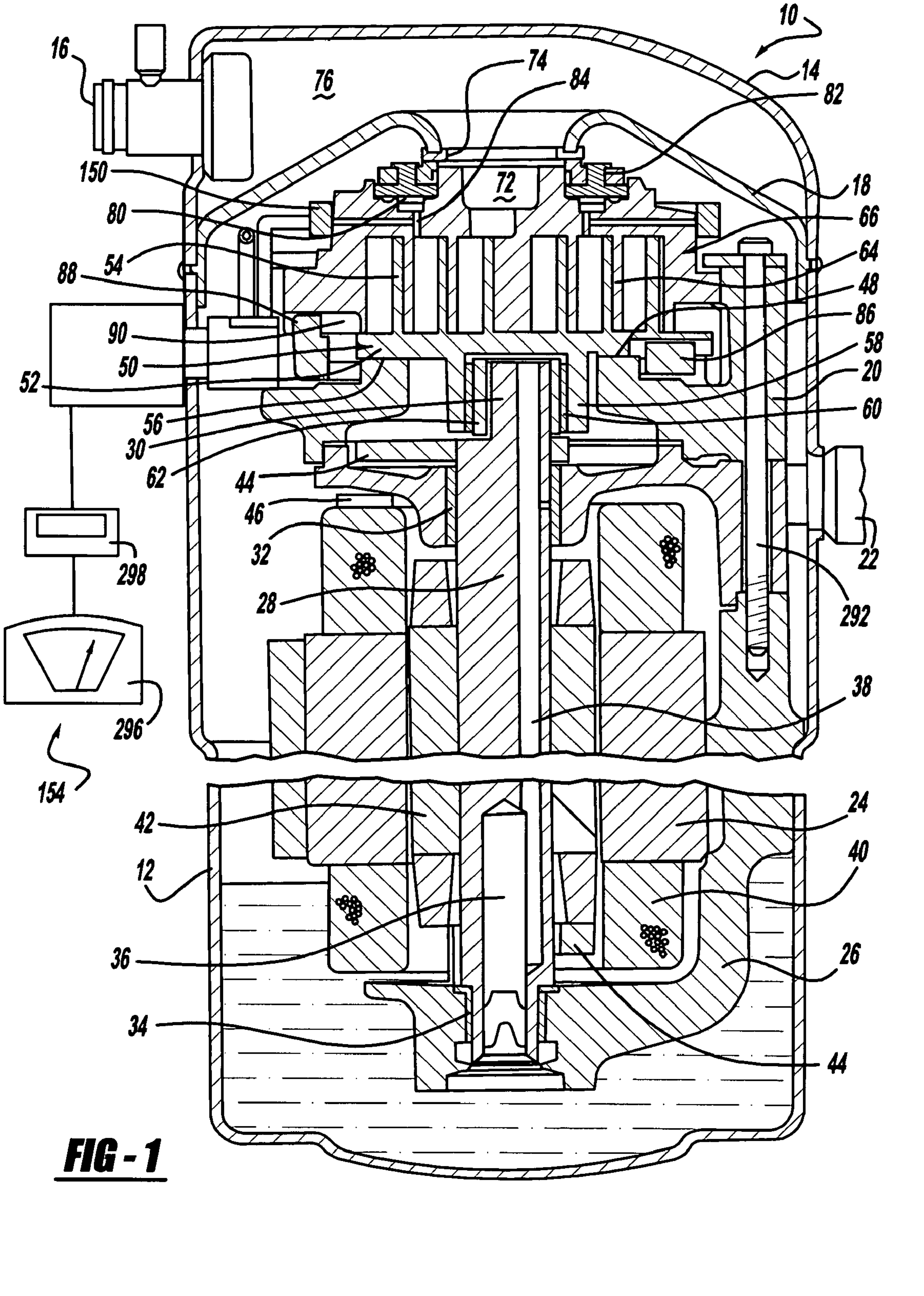
(57) **ABSTRACT**

A scroll compressor has a biasing chamber which contains a pressurized fluid. The pressurized fluid within the chamber biases the two scroll members together. A rotatable ring is attached to one of the scroll members to open and close a passage leading to this biasing chamber. When the ring opens the passage in one embodiment, this releases the pressurized fluid to remove the load, biasing the two scroll members together. When the biasing load is removed, the two scroll members separate, creating a leakage path between discharge and suction to reduce the capacity of the scroll compressor. When the ring opens the passage in another embodiment, a delayed suction passage is opened to reduce the capacity of the compressor.




10
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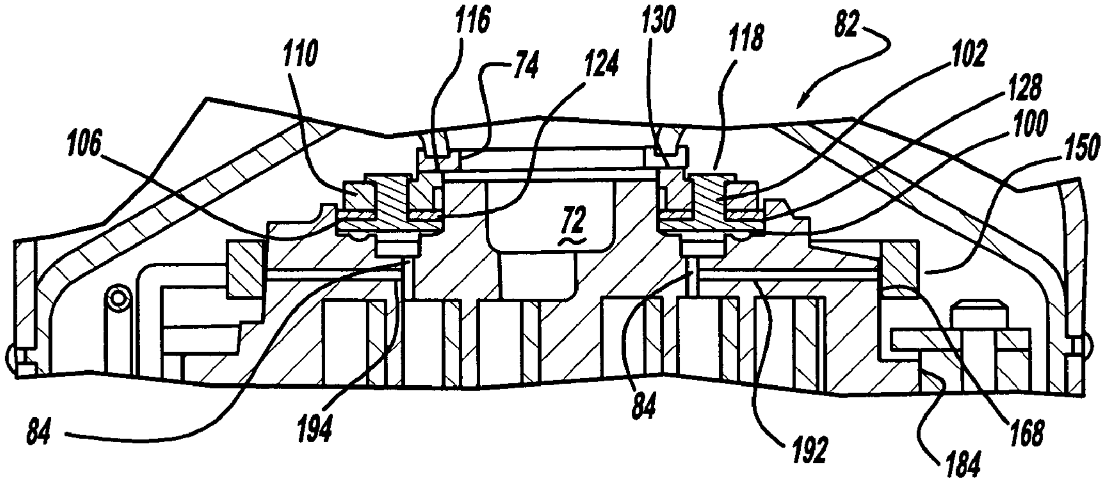
44

FIG - 1


116
130
118
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124
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194
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192
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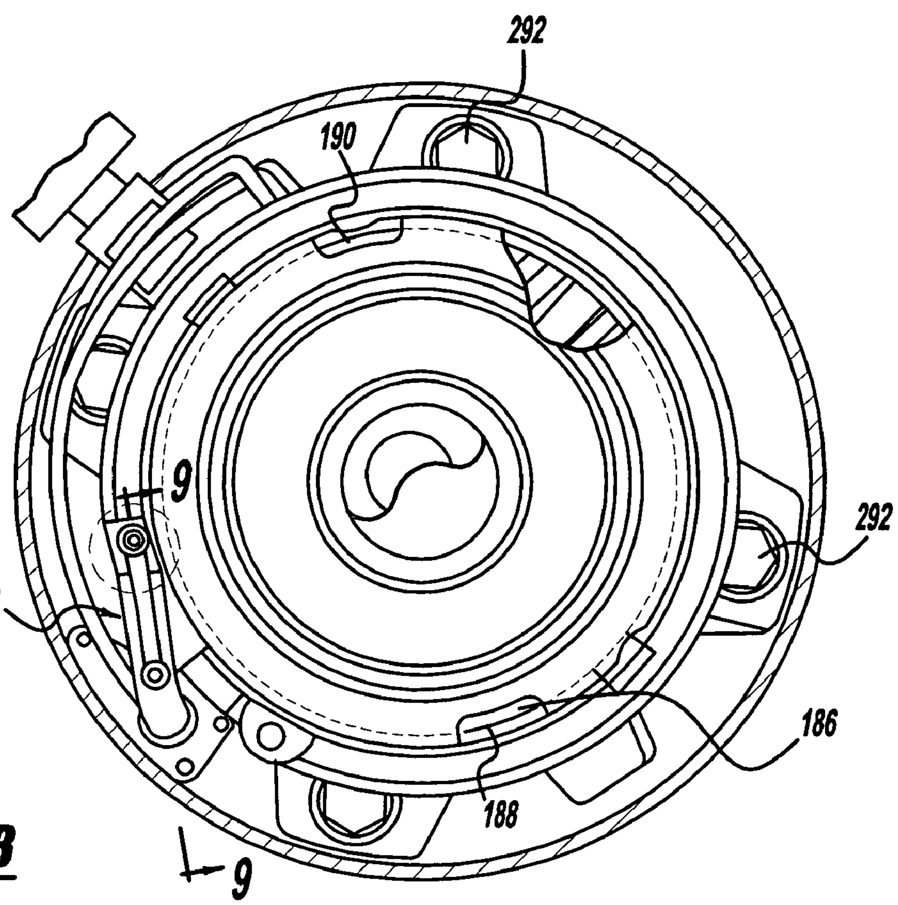
FIG - 2


292
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152
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9

FIG - 3

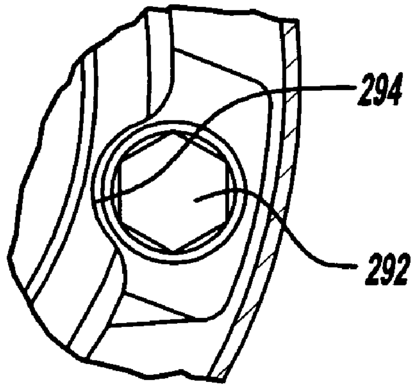


FIG - 4

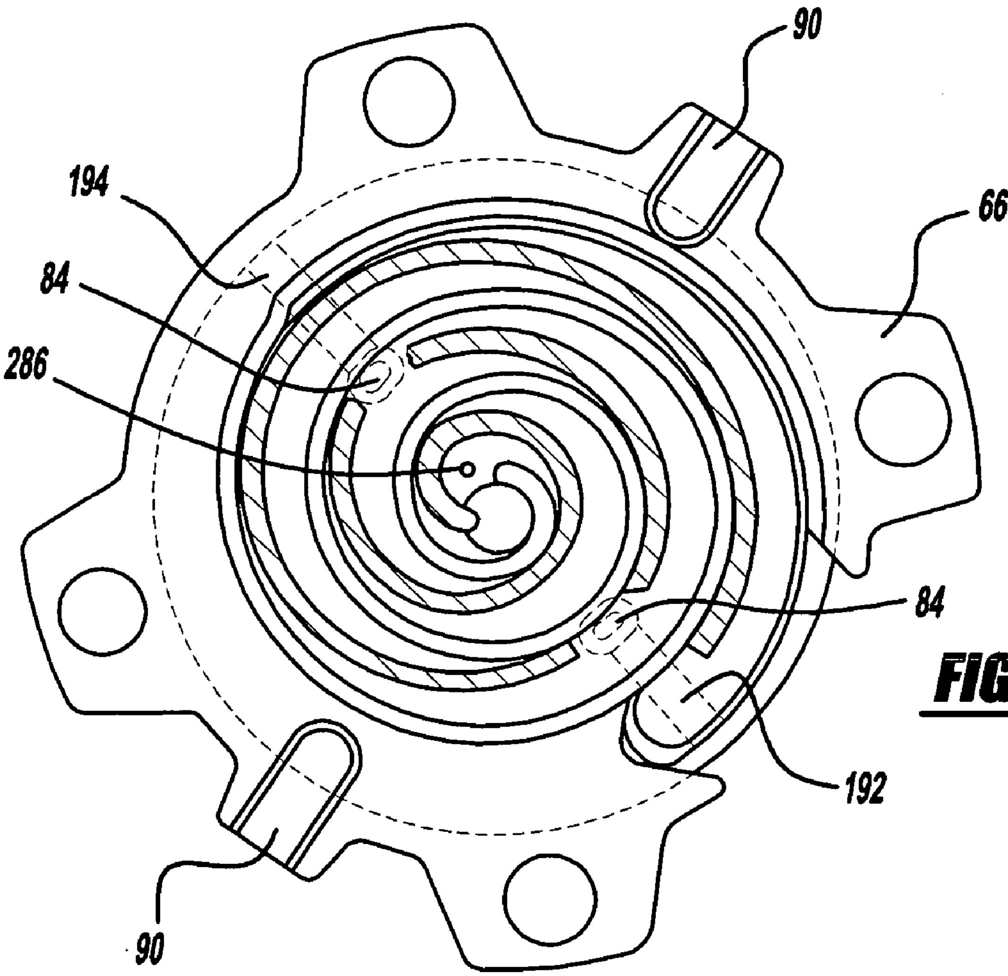
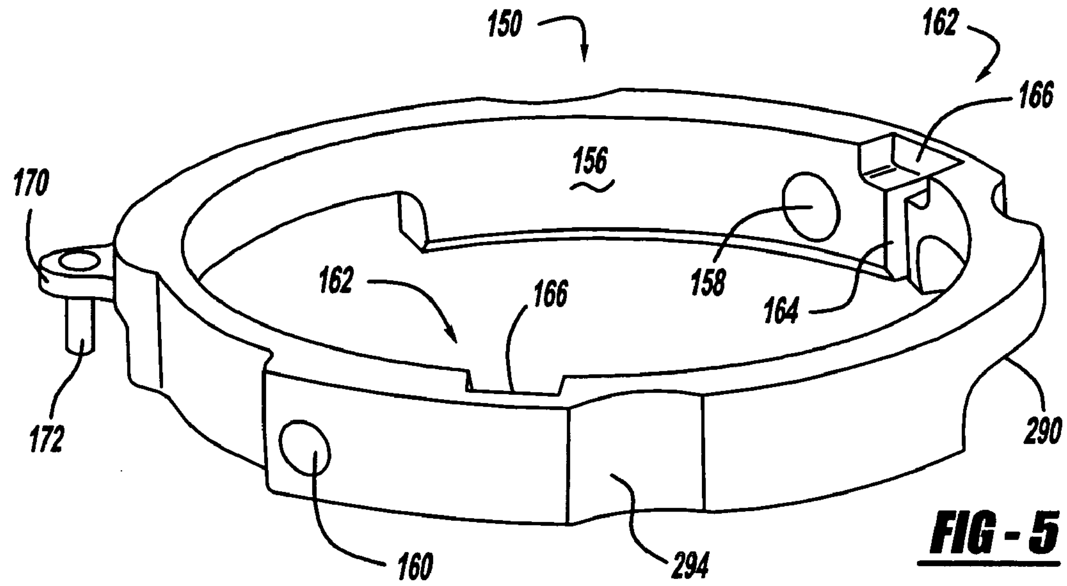


FIG - 6


150
162
166
156
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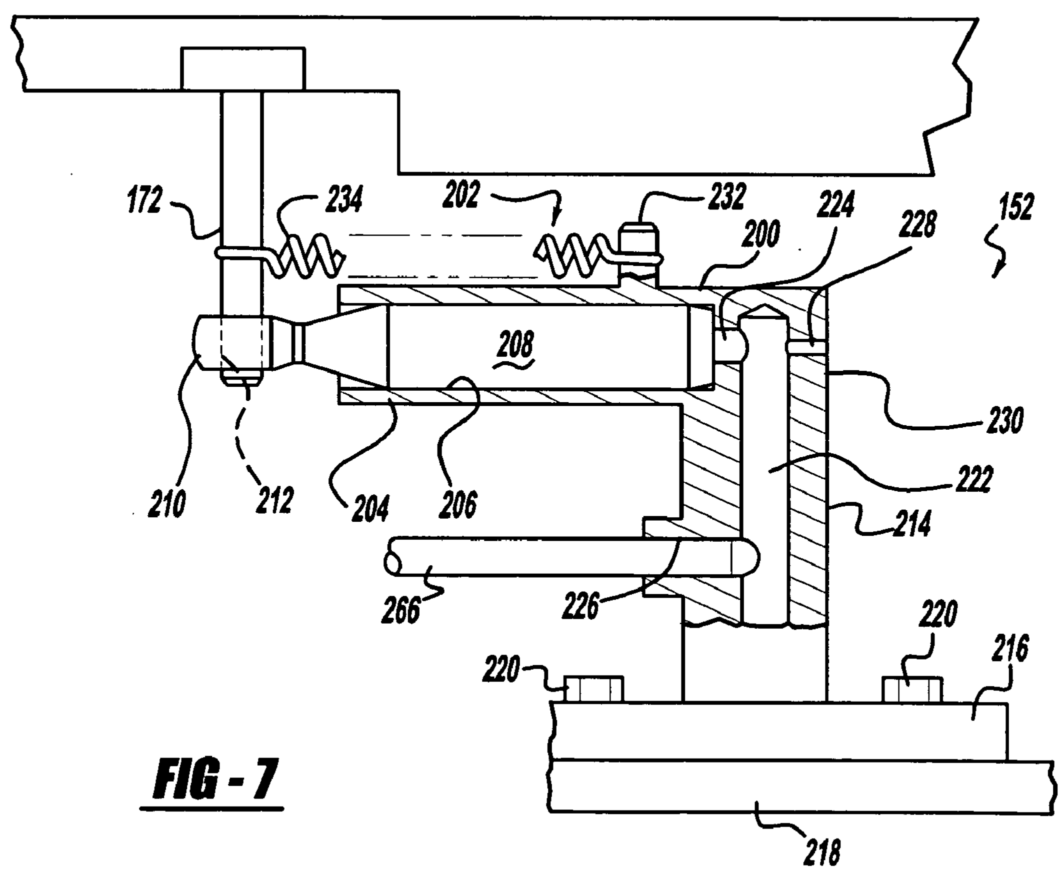
164
172
290
160
294

FIG - 5


172
234
202
232
224
200
228
152
208
230
222
210
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206
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266
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220
218

FIG - 7

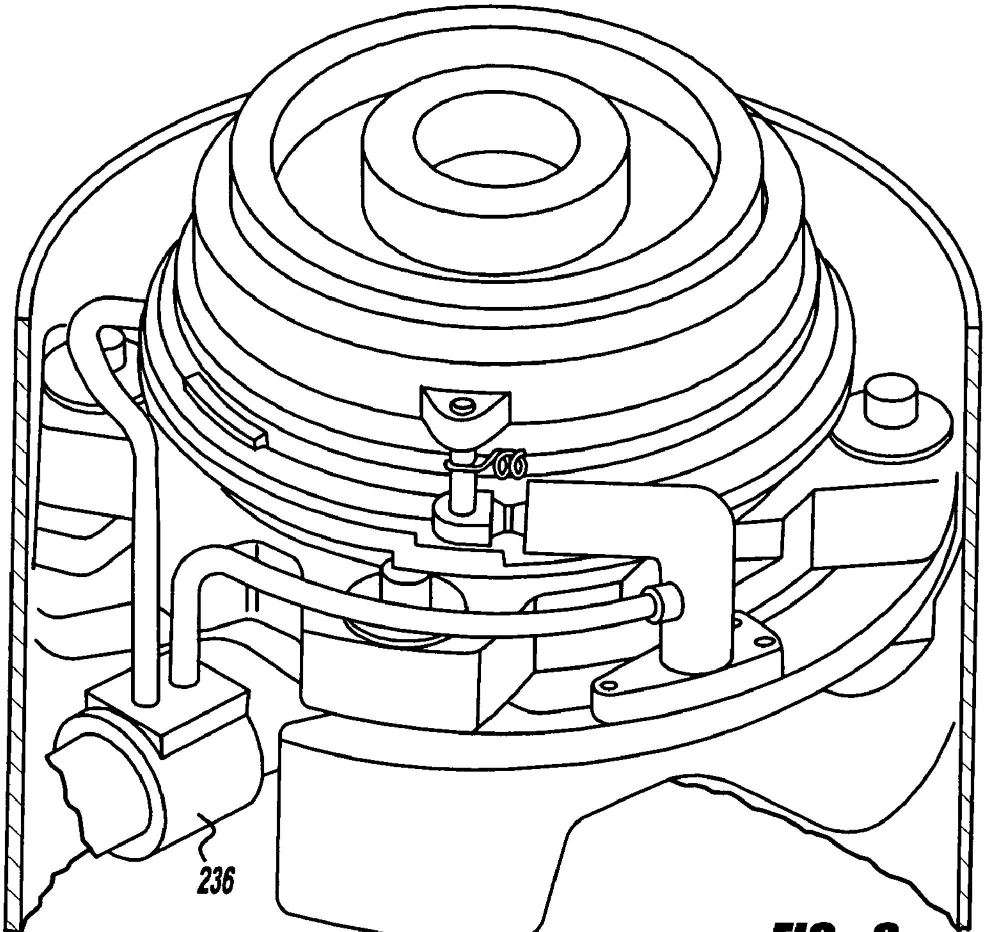


FIG - 8

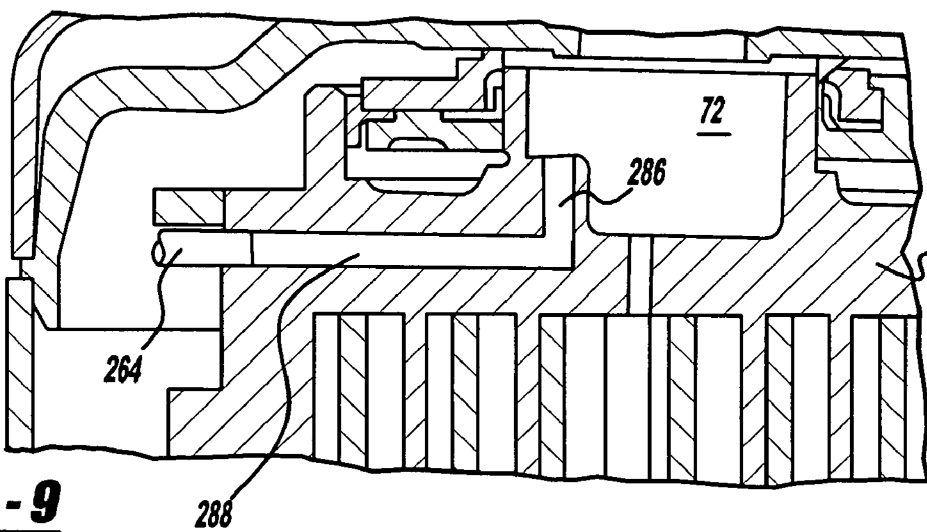
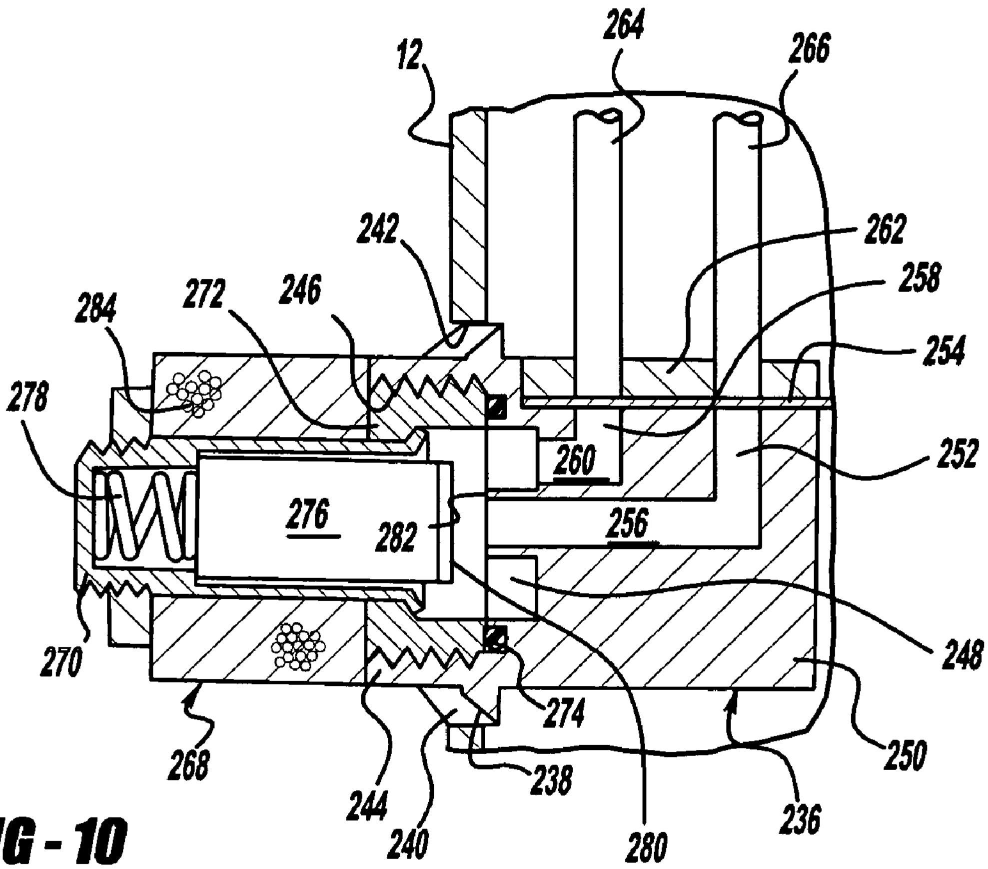


FIG - 9


12
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266
242
262
258
254
284
272
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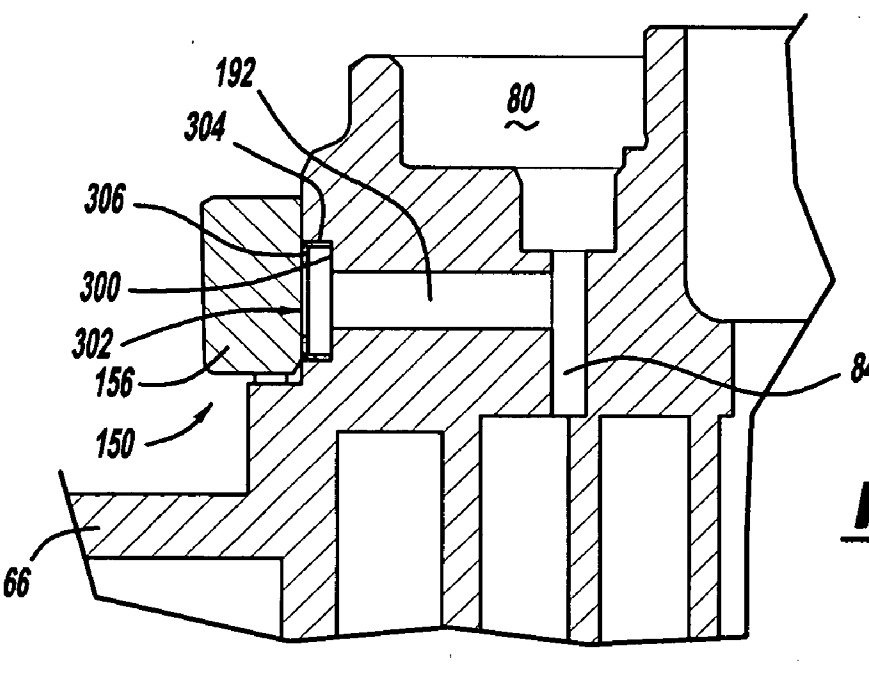
268
238
244
240
236
280

FIG - 10


192
80
304
306
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302
156
84
150
66

FIG - 11

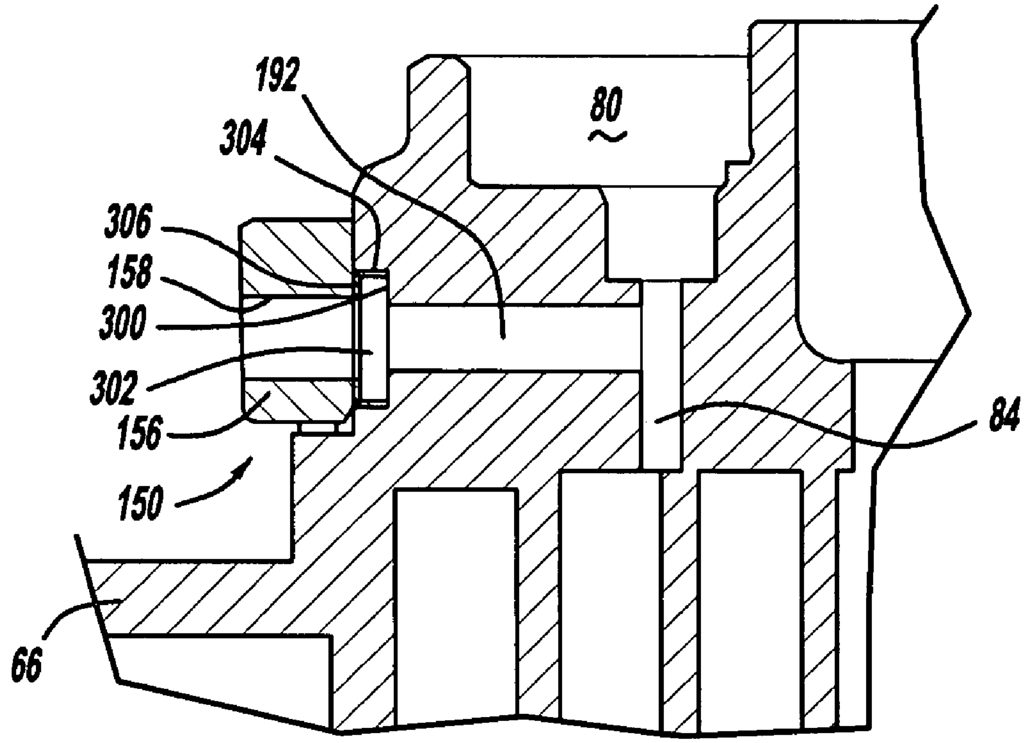

FIG - 12

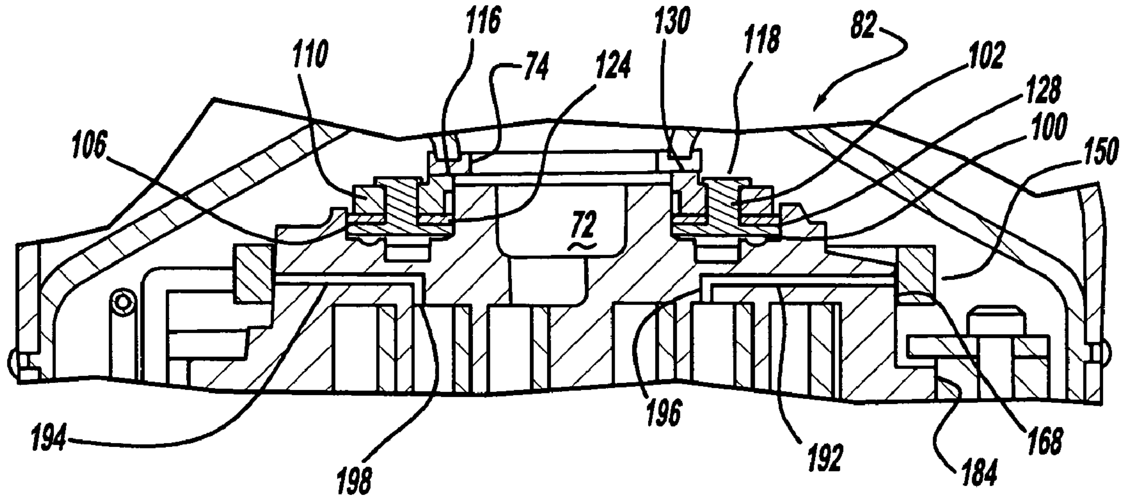
116
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FIG - 13

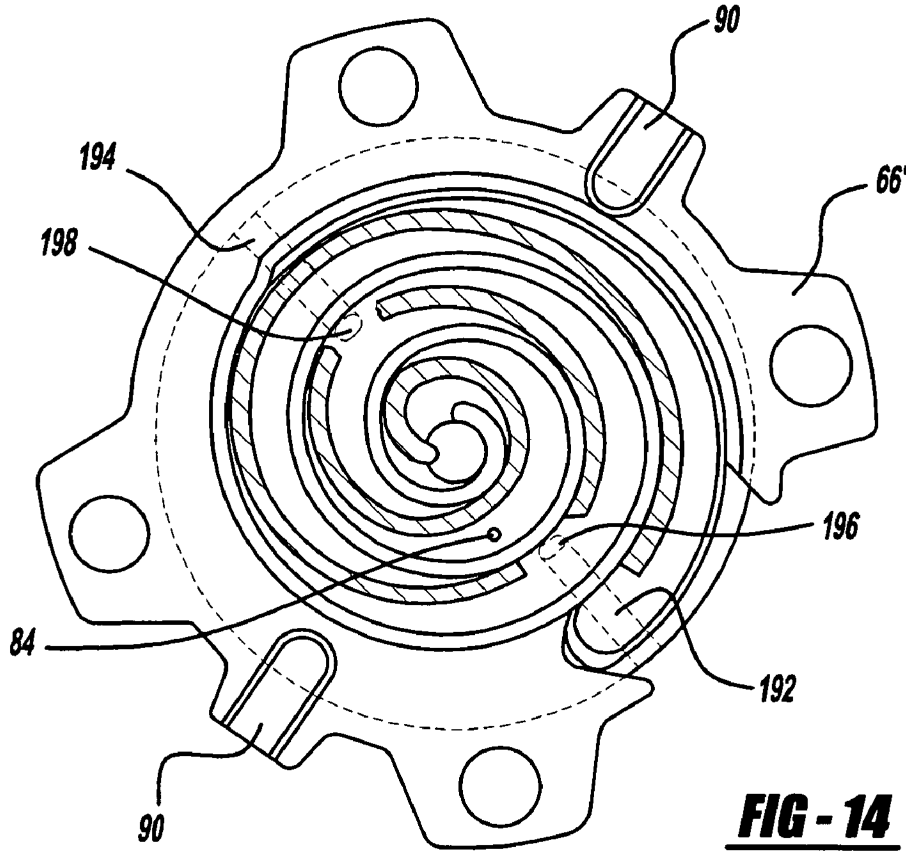
90
194
66'
198
196
84
192
90

FIG - 14

CAPACITY MODULATED SCROLL COMPRESSOR

FIELD OF THE INVENTION

[0001] The present invention relates to capacity modulation of compressors. More particularly, the present invention relates to the capacity modulation of a scroll compressor by controlling the fluid pressure in a chamber where the fluid pressure in the chamber biases the two scrolls together.

BACKGROUND AND SUMMARY OF THE INVENTION

[0002] Capacity modulation is often a desirable feature to incorporate into the compressors of air conditioning and refrigeration systems in order to better accommodate the wide range of loading to which the systems may be subjected. Many different approaches have been utilized for providing this capacity modulation feature. These approaches have ranged from control of the suction inlet of the compressor to bypassing compressed discharge gas back into the suction pressure zone of the compressor. With a scroll-type compressor, capacity modulation has often been accomplished by using a delayed suction approach which comprises providing ports at various positions extending through one of the base plates which, when opened, allow the initially formed compression chambers between the intermeshing scroll wraps to communicate with the suction zone of the compressor. This delays the point at which the sealed compression chambers are formed and, thus, delays the start of compression of the suction gas. This method of capacity modulation has the effect of actually reducing the compression ratio of the compressor. While these delayed suction systems are effective at reducing the capacity of the compressor, they are only able to provide a predetermined amount of compressor unloading with the amount being determined by the position of the unloading ports along the end plate. While it is possible to provide multiple step unloading by incorporating a plurality of unloading ports at different locations, this approach becomes costly and it requires additional space to accommodate the separate controls for opening and closing each set of ports. Even when using multiple unloading ports, it is typically not possible to control the capacity of the compressor between 0% and 100% using this delayed suction technique.

[0003] More recently, compressor unloading and, thus, capacity modulation has been accomplished by cyclically effecting axial or radial separation of the two scroll members for predetermined periods of time during the operating cycle of the compressor. In order to facilitate the axial unloading or axial separation of the two scroll members, a biasing chamber is formed in or adjacent one of the two scroll members; and this biasing chamber is placed in communication with a source of compressed fluid in a pressure chamber or the discharge chamber of the compressor. The fluid in the biasing chamber is cyclically released to the suction area of the compressor to facilitate the unloading of the compressor.

[0004] The continued development of capacity modulated scroll compressors has been directed towards the simplification of the capacity modulation devices in order to lower the costs of the capacity modulated systems, as well as simplifying the overall manufacture, design and development of these capacity modulated systems without sacrificing performance and more preferably increasing the performance and/or reliability of the capacity modulation system.

[0005] The present invention provides the art with a capacity modulated compressor which vents an existing intermediate pressurized chamber cyclically to suction to modulate the capacity of the compressor. The existing intermediate pressurized chamber is utilized in the compressor to bias the two scrolls together as well as to bias a floating seal into contact with a partition or the shell to seal a leakage passage between discharge pressure and the suction pressure zone of the compressor. A sealing system is incorporated into the scroll member defining the intermediate pressurized chamber. The sealing system incorporates a lip seal which improves both the performance and the reliability of the capacity modulation system.

[0006] Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while indicating the preferred embodiment of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] In the drawings which illustrate the best mode presently contemplated for carrying out the present invention:

[0008] FIG. **1** is a vertical section view of a scroll-type compressor incorporating a capacity modulation system in accordance with the present invention;

[0009] FIG. **2** is a fragmentary view of the compressor of FIG. **1** showing the capacity modulation system shown in FIG. **1**:

[0010] FIG. **3** is a plan view of the compressor shown in FIG. **1** with the top portion of the outer shell removed;

[0011] FIG. **4** is an enlarged view showing a portion of a modified valving ring;

[0012] FIG. **5** is a perspective view of the valving ring incorporated in the compressor of FIG. **1**;

[0013] FIG. **6** is a fragmentary section view showing the scroll assembly forming a part of the compressor of FIG. **1**;

[0014] FIG. **7** is an enlarged detailed view of the actuating assembly incorporated in the compressor of FIG. **1**;

[0015] FIG. **8** is a perspective view of the compressor of FIG. **1** with portions of the outer shell broken away;

[0016] FIG. **9** is a fragmentary section view of the compressor of FIG. **1** showing the pressurized fluid supply passages provided in the non-orbiting scroll;

[0017] FIG. **10** is an enlarged section view of the solenoid valve assembly incorporated in the compressor of FIG. **1**;

[0018] FIG. **11** is an enlarged view of the sealing system shown in FIG. **1** with the by-pass port closed;

[0019] FIG. **12** is an enlarged view of the sealing system shown in FIG. **1** with the by-pass port open;

[0020] FIG. **13** is a fragmentary view of a compressor incorporating a capacity modulation system in accordance with another embodiment of the present invention; and

[0021] FIG. **14** is a fragmentary section view showing the scroll assembly forming a part of the compressor of FIG. **13**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0022] The following description of the preferred embodiment(s) is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses.

[0023] While the present invention is suitable for incorporation in many different types of scroll machines, including hermetic machines, open drive machines and non-hermetic machines, for exemplary purposes it will be described herein incorporated in a hermetic scroll refrigerant motor-compressor **10** of the "low side" type (i.e., where the motor and compressor are cooled by suction gas in the hermetical shell, as illustrated in the vertical section shown in FIG. **1**). Generally speaking, compressor **10** comprises a cylindrical hermetic shell **12** which includes at the upper end thereof an end cap **14**. End cap **14** is provided with a refrigerant discharge fitting **16** optionally having the usual discharge valve therein. Other elements affixed to the shell include a transversely extending partition **18** which is welded about its periphery at the same point that end cap **14** is welded to shell **12**, a two-piece main bearing housing **20** which is affixed to shell **12** at a plurality of points in any desirable manner, and a suction gas inlet fitting **22** disposed in communication with the suction pressure zone of compressor **10** inside shell **12**.

[0024] A motor stator **24** is press fit into a frame **26** which is in turn press fit into shell **12**. A crankshaft **28** having an eccentric crank pin **30** at the upper end thereof is rotatably journaled in a bearing **32** in main bearing housing **20** and a second bearing **34** in frame **26**. Crankshaft **28** has at the lower end the usual relatively large diameter oil-pumping concentric bore **36** which communicates with a radially outwardly inclined smaller diameter bore **38** extending upwardly therefrom to the top of crankshaft **28**. The lower portion of the interior shell **12** is filled with lubricating oil in the usual manner and concentric bore **36** at the bottom of crankshaft **28** is the primary pump acting in conjunction with bore **38**, which acts as a secondary pump, to pump lubricating fluid to all the various portions of compressor **10** which require lubrication.

[0025] Crankshaft **28** is rotatively driven by an electric motor including stator **24** having windings **40** passing therethrough, and a rotor **42** press fit on crankshaft **28** and having one or more counterweights **44**. A motor protector **46**, of the usual type, is provided in close proximity to motor windings **40** so that if the motor exceeds its normal temperature range motor protector **46** will de-energize the motor.

[0026] The upper surface of main bearing housing **20** is provided with an annular flat thrust bearing surface **48** on which is disposed an orbiting scroll member **50** comprising an end plate **52** having the usual spiral vane or wrap **54** on the upper surface thereof, an annular flat thrust surface **56** on the lower surface, and projecting downwardly therefrom a cylindrical hub **58** having a journal bearing **60** therein and in which is rotatively disposed a drive bushing **62** having an inner bore in which crank pin **30** is drivingly disposed. Crank pin **30** has a flat on one surface (not shown) which drivingly engages a flat surface in a portion of the inner bore of drive bushing **62** to provide a radially compliant driving arrangement, such as shown in assignee's U.S. Pat. No. 4,877,382, the disclosure of which is herein incorporated by reference.

[0027] Wrap **54** meshes with a non-orbiting spiral wrap **64** forming a part of a non-orbiting scroll member **66** which is mounted to main bearing housing **20** in any desired manner which will provide limited axial movement of non-orbiting scroll member **66**. The specific manner of such mounting is not relevant to the present inventions. For a more detailed description of the non-orbiting scroll suspension system, see assignee's U.S. Pat. No. 5,055,010, the disclosure of which is hereby incorporated herein by reference.

[0028] Non-orbiting scroll member **66** has a centrally disposed discharge passageway communicating with an upwardly open recess **72** which is in fluid communication via an opening **74** in partition **18** with a discharge muffler chamber **76** defined by end cap **14** and partition **18**. A pressure relief valve is disposed between the discharge muffler chamber **76** and the interior of shell **12**. The pressure relief valve will open at a specified differential pressure between the discharge and suction pressures to vent pressurized gas from the discharge muffler chamber **76**. Non-orbiting scroll member **66** has in the upper surface thereof an annular recess **80** having parallel coaxial side walls in which is sealingly disposed for relative axial movement an annular floating seal **82** which serves to isolate the bottom of recess **80** from the presence of gas under suction and discharge pressure so that it can be placed in fluid communication with a source of intermediate fluid pressure by means of one or more passageways **84**. Non-orbiting scroll member **66** is thus axially biased against orbiting scroll member **50** by the forces created by discharge pressure acting on the central portion of non-orbiting scroll member **66** and those created by intermediate fluid pressure acting on the bottom of recess **80**. This axial pressure biasing, as well as various techniques for supporting non-orbiting scroll member **66** for limited axial movement, are disclosed in much greater detail in assignee's aforesaid U.S. Pat. No. 4,877,328.

[0029] Relative rotation of the scroll members is prevented by the usual Oldham coupling comprising a ring **86** having a first pair of keys **88** (one of which is shown) slidably disposed in diametrically opposed slots **90** (one of which is shown) in non-orbiting scroll member **66** and a second pair of keys (not shown) slidably disposed in diametrically opposed slots in orbiting scroll member **50**.

[0030] Referring now to FIG. **2**. Although the details of construction of floating seal **82** are not part of the present invention, for exemplary purposes floating seal **82** is of a coaxial sandwiched construction and comprises an annular base plate **100** having a plurality of equally spaced upstanding integral projections **102**. Disposed on plate **100** is an annular gasket **106** having a plurality of equally spaced holes which receive projections **102**. On top of gasket **106** is disposed an upper seal plate **110** having a plurality of equally spaced holes which receive projections **102**. Seal plate **110** has disposed about the inner periphery thereof an upwardly projecting planar sealing lip **116**. The assembly is secured together by swaging the ends of each of the projections **102**, as indicated at **118**.

[0031] The overall seal assembly therefore provides three distinct seals; namely, an inside diameter seal at **124**, an outside diameter seal at **128** and a top seal at **130**. Seal **124** is between the inner periphery of gasket **106** and the inside wall of recess **80**. Seal **124** isolates fluid under intermediate pressure in the bottom of recess **80** from fluid under discharge pressure in open recess **72**. Seal **128** is between the outer periphery of gasket **106** and the outer wall of recess **80**, and isolates fluid under intermediate pressure in the bottom of recess **80** from fluid at suction pressure within shell **12**. Seal **130** is between sealing lip **116** and an annular wear ring surrounding opening **74** in partition **18**, and isolates fluid at suction pressure from fluid at discharge pressure across the top of the seal assembly. The details of the construction of floating seal **82** is similar to that described in U.S. Pat. No. 5,156,539, the disclosure of which is hereby incorporated herein by reference.

[0032] The compressor is preferably the "low side" type in which suction gas entering gas inlet fitting **22** is allowed, in part, to escape into shell **12** and assist in cooling the motor. So long as there is an adequate flow of returning suction gas the motor will remain within desired temperature limits. When this flow drops significantly, however, the loss of cooling will eventually cause motor protector **46** to trip and shut the machine down.

[0033] As thus far described, scroll compressor **10** is typical of such scroll-type refrigeration compressors. In operation, suction gas directed to the lower chamber via suction gas inlet fitting **22** is drawn into the moving fluid pockets as orbiting scroll member **50** orbits with respect to non-orbiting scroll member **66**. As the moving fluid pockets move inwardly, this suction gas is compressed and subsequently discharged into discharge muffler chamber **76** via upwardly open recess **72** in non-orbiting scroll member **66** and discharge opening **74** in partition **18**. Compressed refrigerant is then supplied to the refrigeration system via discharge fitting **16**.

[0034] In selecting a refrigeration compressor for a particular application, one would normally choose a compressor having sufficient capacity to provide adequate refrigerant flow for the most adverse operating conditions to be anticipated for that application and may select a slightly larger capacity to provide an extra margin of safety. However, such "worst case" adverse conditions are rarely encountered during actual operation and thus this excess capacity of the compressor results in operation of the compressor under lightly loaded conditions for a high percentage of its operating time. Such operation results in reducing overall operating efficiency of the system. Accordingly, in order to improve the overall operating efficiency under generally encountered operating conditions while still enabling the refrigeration compressor to accommodate the "worse case" operating conditions, compressor **10** is provided with a capacity modulation system. The capacity modulation system allows the compressor to operate at the capacity required to meet the requirements of the system.

[0035] The capacity modulation system includes an annular valving ring **150** movably mounted on non-orbiting scroll member **66**, an actuating assembly **152** supported within shell **12** and a control system **154** for controlling operation of the actuating assembly.

[0036] As best seen with reference to FIGS. **2** and **5**, valving ring **150** comprises a generally circular shaped main body **156** having a pair of holes **158** and **160** extending therethrough. A pair of T-shaped slots **162** are formed into the inside diameter of main body **156**. T-shaped slots **162** include an axial portion **164** and a circumferential portion **166**. T-shaped slots **162** each accept a pin (not shown) extending from an outer surface **168** of non-orbiting scroll member **66**. Axial portion **164** allows for the assembly of valving ring **150** over the pins and onto non-orbiting scroll member **66**. Circumferential portion **166** restrict the rotational movement of valving ring **150** with respect to non-orbiting scroll member **66**. A flange **170** extend radially outward from main body **156** to support a pin **172** which is utilized to rotate valving ring **150** with respect to non-orbiting scroll member **66** as detailed below.

[0037] Non-orbiting scroll member **66** also includes a pair of diametrically opposed radial passages **192** and **194** opening to the outer surface **168** of non-orbiting scroll member **66**. Passages **192** and **194** extend radially inwardly through the end plate of non-orbiting scroll member **66**. One axially extending passage **84** places the inner end of passage **192** in fluid communication with annular recess **80** while another axially extending passage **84** places the inner end of passage **194** in fluid communication with annular recess **80**.

[0038] As best seen with reference to FIG. **7**, actuating assembly **152** includes a piston and cylinder assembly **200** and a return spring assembly **202**. Piston and cylinder assembly **200** includes a housing **204** having a bore defining a cylinder **206** extending inwardly from one end thereof and within which a piston **208** is movably disposed. An outer end **210** of piston **208** projects axially outwardly from one end of housing **204** and includes an elongated or oval-shaped opening **212** therein adapted to receive pin **172** forming a part of valving ring **150**. Elongated or oval opening **212** is designed to accommodate the arcuate movement of pin **172** relative to the linear movement of piston end **210** during operation. A depending portion **214** of housing **204** has secured thereto a suitably sized mounting flange **216** which is adapted to enable housing **204** to be secured to a suitable flange member **218** by bolts **220**. Flange **218** is in turn suitably supported within outer shell **12** such as by main bearing housing **20**.

[0039] A passage **222** is provided in depending portion **214** extending upwardly from the lower end thereof and opening into a laterally extending passage **224** which in turn opens into the inner end of cylinder **206**. A second laterally extending passage **226** provided in depending portion **214** opens outwardly through the sidewall thereof and communicates at its inner end with passage **222**. A second relatively small laterally extending passage **228** extends from fluid passage **222** in the opposite direction of fluid passage **224** and opens outwardly through an end wall **230** of housing **204**.

[0040] A pin member **232** is provided upstanding from housing **204** to which is connected one end of a return spring **234** the other end of which is connected to an extended portion of pin **172**. Return spring **234** will be of such a length and strength as to urge valving ring **150** and piston **208** into the position shown in FIG. **7** when cylinder **206** is fully vented via passage **228**.

[0041] As best seen with reference to FIGS. **1**, **8** and **10**, control system **154** includes a valve body **236** having a radially outwardly extending flange **238** including a conical surface **240** on one side thereof. Valve body **236** is inserted into an opening **242** in outer shell **12** and positioned with conical surface **240** abutting the peripheral edge of opening **242** and then welded to shell **12** with a cylindrical portion **244** projecting outwardly therefrom. Cylindrical portion **244** of valve body **236** includes an enlarged diameter threaded bore **246** extending axially inwardly and opening into a recessed area **248**.

[**0042**] Valve body **236** includes a housing **250** having a first passage **252** extending downwardly from a substantially flat upper surface **254** and intersecting a second laterally extending passage **256** which opens outwardly into the area of opening **242** in shell **12**. A third passage **258** also extends downwardly from surface **254** and intersects a fourth laterally extending passage **260** which also opens outwardly into recessed area **248** provided in the end portion of valve body **236**.

[**0043**] A manifold **262** is sealingly secured to surface **254** by means of suitable fasteners and includes fittings for connection of one end of each of fluid lines **264** and **266** so as to place them in sealed fluid communication with respective passages **258** and **252**.

[**0044**] A solenoid coil assembly **268** is designed to be sealingly secured to valve body **236** and includes an elongated tubular member **270** having a threaded fitting **272** sealingly secured to the open end thereof. Threaded fitting **272** is adapted to be threadedly received within bore **246** and sealed thereto by means of an O-ring **274**. A plunger **276** is movably disposed within tubular member **270** and is biased outwardly therefrom by a spring **278** which bears against a closed end of tubular member **270**. A valve member **280** is provided on the outer end of plunger **276** and cooperates with a valve seat **282** to selectively close off passage **256**. A solenoid coil **284** is positioned on tubular member **270** and secured thereto by means of a nut threaded on the outer end of tubular member **270**.

[**0045**] In order to supply pressurized fluid to actuating assembly **152**, an axially extending passage **286** extends downwardly from open recess **72** and connects to a generally radially extending passage **288** in non-orbiting scroll member **66**. Passage **288** extends radially and opens outwardly through the circumferential sidewall of non-orbiting scroll member **66** as best seen with reference to FIG. **11**. The other end of fluid line **264** is sealingly connected to third passage **258** whereby a supply of compressed fluid at discharge pressure may be supplied from open recess **72** to valve body **236**. A circumferentially elongated slot **290** is provided in valving ring **150** suitably positioned so as to enable fluid line **264** to pass therethrough while accommodating the rotational movement of valving ring **150** with respect to non-orbiting scroll member **66**.

[**0046**] In order to supply pressurized fluid from valve body **236** to actuating piston and cylinder assembly **200**, fluid line **266** extends from valve body **236** and is connected to passage **226** provided in depending portion **214** of housing **204** (FIG. **7**).

[**0047**] Valving ring **150** may be easily assembled to non-orbiting scroll member **66** by merely aligning axial portions **164** of T-shaped slots **162** with the respective pins extending from outer surface **168** of non-orbiting scroll member **66**. Thereafter valving ring **150** is rotated into the desired position with circumferential portions **166** of T-shaped slots **162** cooperating with the respective pins extending from outer surface **168** to control the rotation of valving ring **150** with respect to non-orbiting scroll member **66**. Thereafter, cylinder assembly **200** of actuating assembly **152** may be positioned on mounting flange **218** with piston end **210** receiving pin **172**. One end of spring **234** may then be connected to pin member **232**. Thereafter, the other end of spring **234** may be connected to pin **172** thus completing the assembly process.

[**0048**] While non-orbiting scroll member **66** is typically secured to main bearing housing **20** by suitable bolts **292** prior to assembly of valving ring **150**, it may in some cases be preferable to assemble this continuous capacity modulation component to non-orbiting scroll member **66** prior to assembly of non-orbiting scroll member **66** to main bearing housing **20**. This may be easily accomplished by merely providing a plurality of suitably positioned arcuate cutouts **294** along the periphery of valving ring **150** as shown in FIGS. **4** and **5**. These cutouts will afford access to securing bolts **292** with valving ring **150** assembled to non-orbiting scroll member **66**.

[**0049**] In operation, when system operating conditions as sensed by one or more sensors **296** indicate that full capacity of compressor **10** is required, control module **298** will operate in response to a signal from sensors **296** to energize solenoid coil **284** of solenoid coil assembly **268** thereby causing plunger **276** to be moved out of engagement with valve seat **282** thereby placing passages **256** and **260** in fluid communication. Pressurized fluid at substantially discharge pressure will then be allowed to flow from open recess **72** to cylinder **206** via passages **286**, **288** fluid line **264**, passages **258**, **260**, **256**, **252** fluid line **266** and passages **226**, **222** and **224**. This fluid pressure will then cause piston **208** to move outwardly with respect to cylinder **206** thereby rotating valving ring **150** so as to move main body **156** into sealing overlying relationship to passages **192** and **194** as illustrated in FIG. **11**. This will then prevent intermediate pressurized gas disposed within recess **80** from being exhausted or vented through passages **192** and **194**. Compressor **10** will then operate at its full capacity.

[**0050**] When the load conditions change to the point that the full capacity of compressor **10** is not required, sensors **296** will provide a signal indicate thereof to controller **298** which in turn will deenergize solenoid coil **284** of solenoid coil assembly **268**. Plunger **276** will then move outwardly from tubular member **270** under the biasing action of spring **278** thereby moving valve member **280** into sealing engagement with seat **282** thus closing off passage **256** and the flow of pressurized fluid therethrough. It is noted that recessed area **248** will be in continuous fluid communication with open recess **72** and hence continuously subject to discharge pressure. This discharge pressure will aid in biasing valve member **280** into fluid tight sealing engagement with valve seat **282** as well as retaining same in such relationship.

[**0051**] The pressurized gas contained in cylinder **206** will bleed back into the suction zone of compressor **10** via vent passage **228** thereby enabling spring **234** to rotate valving ring **150** back to a position in which passages **192** and **194** are aligned with holes **158** and **160** of valving ring **150** as illustrated in FIG. **12**. Spring **234** will also move piston **208** inwardly with respect to cylinder **206**. In this position, the intermediate pressure within annular recess **80** will be exhausted or vented through passages **192** and **194** and holes **158** and **160**. The venting of the intermediate pressurized fluid removes the biasing force urging non-orbiting scroll member **66** into sealing engagement with orbiting scroll member **50** to create a leak between the discharge pressure zone and the suction pressure zone. This leak causes the capacity of compressor **10** to move to zero capacity. A spring urges floating seal **82** upwards and maintains the sealing relationship at top seal **130**. Thus, by controlling solenoid coil assembly **268** in a pulsed width modulation mode, the capacity of compressor **10** can be set anywhere between zero capacity and full capacity.

[**0052**] It should be noted that the speed with which valving ring **150** may be moved between the modulated position and the unmodulated position will be directly related to the relative size of vent passage **228** and the supply lines. In other words, because passage **228** is continuously open to the suction pressure zone of compressor **10**, when solenoid coil **284** of solenoid coil assembly **268** is energized a portion of the pressurized fluid flowing from open recess **72** will be continuously vented to suction pressure. The volume of this fluid will be controlled by the relative sizing of passage **228**. However, as passage **228** is reduced in size, the time required to vent cylinder **206** will increase thus increasing the time required to switch from reduced capacity to full capacity.

[**0053**] While actuating assembly **152** has been illustrated including piston and cylinder assembly **200** and return spring assembly **202**, it is within the scope of the present invention to utilize a solenoid valve assembly attached directly to pin **172** as actuating assembly **152** and controlling the solenoid valve assembly using PWM (pulse width modulation) or by using direct control to effect the rotation of valving ring **150** if desired.

[**0054**] Efficient operation of the capacity modulation system of the present invention requires the proper sealing between main body **156** of valving ring **150** and passages **192** and **194** extending into non-orbiting scroll member **66**.

[**0055**] As best illustrated in FIGS. **11** and **12**, non-orbiting scroll member **66** defines a counterbore **300** located at the outer end of passages **192** and **194**. Disposed within each counterbore **300** is an annular lip seal **302**. When valving ring **150** is rotated such that main body **156** closes passages **192** and **194** as illustrated in FIG. **11**, lip seal **302** has a cylindrical portion **304** having a first lip seal that seals against counterbore **300** and annular portion **306** that has a second lip seal that seals against main body **156** of valving ring **150**. Lip seal **302** is a self-actuating seal. Intermediate pressurized fluid within passages **192** and **194** will urge cylindrical portion **304** of lip seal **302** into sealing engagement with counterbore **300**. Also, the intermediate pressurized fluid within passages **192** and **194** will urge annular portion **306** into sealing engagement with main body **156** of valving ring **150**.

[**0056**] As illustrated in FIG. **12**, when valving ring **150** is rotated to a position where holes **158** and **160** are aligned with passages **192** and **194**, respectively, intermediate pressurized fluid in passages **192** and **194** and annular recess **80** will be vented to the suction pressure zone of compressor **10**. The diameter of holes **158** and **160** are sized to be the same as the internal diameter formed by annular portion **306** of lip seal **302**. Thus, annular portion **306** never completely loses contact with main body **156** of valving ring **150**. Main body **156** of valving ring **150** retains lip seal **302** within counterbore **300** due to this continued contact.

[**0057**] Referring now to FIGS. **13** and **14**, a capacity modulation system in accordance with the present invention is illustrated. The capacity modulation system described above has the capability to modulate the capacity of compressor **10** between zero capacity and full capacity. The capacity control system illustrated in FIGS. **13** and **14** has the ability to modulate the capacity of compressor **10** between full capacity and a selected reduced capacity.

[**0058**] FIGS. **13** and **14** illustrate non-orbiting scroll member **66'** which is the same as non-orbiting scroll member **66** except that the one or more passageways **84** which extend from a source of intermediate fluid pressure to recess **80** are no longer in communication with radial passages **192** and **194**. Thus, recess **80** is continuously supplied with intermediate pressurized fluid from passageway **84**.

[**0059**] Non-orbiting scroll member **66'** defines a first axially extending passage **196** and a second axially extending passageway **198**. Axially extending passage **196** extends between an intermediate pressurized moving pocket defined by scroll wraps **54** and **64** and radial passage **192**. Axial extending passage **198** extends between an intermediate pressurized moving pocket defined by scroll wraps **54** and **64** and radial passage **194**. Preferably passages **196** and **198** will be oval in shape so as to maximize the size of the opening thereof without having a width greater than the width of wrap **54** of orbiting scroll member **50**.

[**0060**] In operation, when system operating conditions as sensed by one or more sensors **296** indicate that full capacity of compressor **10** is required, control module **298** will operate in response to a signal from sensors **296** to energize solenoid coil **284** of solenoid coil assembly **268** thereby causing plunger **276** to be moved out of engagement with valve seat **282** thereby placing passages **256** and **260** in fluid communication. Pressurized fluid at substantially discharge pressure will then be allowed to flow from open recess **72** to cylinder **206** via passages **286**, **288** fluid line **264**, passages **258**, **260**, **256**, **252** fluid line **266** and passages **226**, **222** and **224**. This fluid pressure will then cause piston **208** to move outwardly with respect to cylinder **206** thereby rotating valving ring **150** so as to move main body **156** into sealing overlying relationship to passages **192** and **194** as illustrated in FIG. **11**. This will then prevent intermediate pressurized gas disposed within the moving pockets defined by scroll wraps **54** and **64** from being exhausted or vented through passages **192**, **194**, **196** and **198**. Compressor **10** will then operate at its full capacity.

[**0061**] When the load conditions change to the point that the full capacity of compressor **10** is not required, sensors **296** will provide a signal indicate thereof to controller **298** which in turn will deenergize solenoid coil **284** of solenoid coil assembly **268**. Plunger **276** will then move outwardly from tubular member **270** under the biasing action of spring **278** thereby moving valve member **280** into sealing engagement with seat **282** thus closing off passage **256** and the flow of pressurized fluid therethrough. It is noted that recessed area **248** will be in continuous fluid communication with open recess **72** and hence continuously subject to discharge pressure. This discharge pressure will aid in biasing valve member **280** into fluid tight sealing engagement with valve seat **282** as well as retaining same in such relationship.

[**0062**] The pressurized gas contained in cylinder **206** will bleed back into the suction zone of compressor **10** via vent passage **228** thereby enabling spring **234** to rotate valving ring **150** back to a position in which passages **192** and **194** are aligned with holes **158** and **160** of valving ring **150** as illustrated in FIG. **12**. Spring **234** will also move piston **208** inwardly with respect to cylinder **206**. In this position, the moving pockets defined by scroll wraps **54** and **64** will be exhausted or vented through passages **192**, **194**, **196** and **198** and holes **158** and **160**. The venting of the moving pockets reduces the capacity of compressor **10** by delaying the point at which compression begins by delaying the point at which the sealed chambers are formed. This has the effect of reducing the compression ratio of the compressor by a predetermined amount. The predetermined amount of the reduction of the compression ratio of the compressor can be controlled by the location of axial passages **196** and **198**.

[**0063**] Passages **196** and **198** may be located so that they are in communication with the respective suction pockets at any point up to 360° inwardly from the point at which the trailing flank surfaces move into sealing engagement. If they are located further inwardly than this, compression of the fluid in the pockets will have begun and hence venting thereof will result in lost work and a reduction in efficiency.

[**0064**] The description of the invention is merely exemplary in nature and, thus, variations that do not depart from the gist of the invention are intended to be within the scope of the invention. Such variations are not to be regarded as a departure from the spirit and scope of the invention.

What is claimed is:

1. A scroll machine comprising:

a first scroll member having a first spiral wrap projecting outwardly from a first end plate, said first scroll member defining a recess and a fluid passage extending from said recess to an outer surface of said first scroll member;

a second scroll member having a second spiral scroll wrap projecting outwardly from a second end plate, said second spiral wrap being intermeshed with said first spiral wrap, said first scroll member being mounted for limited axial movement with respect to said second scroll member, said first scroll member being biased toward said second scroll member by a pressurized fluid disposed within said recess;

a drive member for causing said scroll members to orbit relating to one another whereby said spiral wraps will create pockets of progressively changing volume between a suction pressure zone at suction pressure and a discharge pressure zone at discharge pressure;

a ring rotatably disposed on said outer surface of said first scroll member for opening and closing said fluid passage, said pressurized fluid being released when said ring opens said fluid passage whereby said first scroll member will move axially with respect to said second scroll member to open a leakage path between said suction pressure zone and said discharge pressure zone; and

a seal disposed between said first scroll member and said ring, said seal sealing said fluid passage when said ring closes said fluid passage.

2. The scroll machine according to claim 1, wherein said pressurized fluid is released to said suction pressure zone of said scroll machine.

3. The scroll machine according to claim 1, wherein said valve assembly is a solenoid valve.

4. The scroll machine according to claim 3, wherein said solenoid valve is operated in a pulsed manner to modulate the capacity of said scroll machine.

5. The scroll machine according to claim 1, wherein said pressurized fluid is at a pressure between said suction pressure and said discharge pressure.

6. The scroll machine according to claim 1, further comprising a linear actuator for rotating said ring.

7. The scroll machine according to claim 1, further comprising a valve member for rotating said ring.

8. The scroll machine according to claim 7, wherein said valve member is a solenoid valve.

9. The scroll machine according to claim 8, wherein said solenoid valve is operated in a pulsed manner to modulate the capacity of the scroll machine.

10. The scroll machine according to claim 1, wherein said seal comprises a first lip seal in engagement with said ring.

11. The scroll machine according to claim 10, wherein said seal comprises a second lip seal in engagement with said first scroll member.

12. The scroll machine according to claim 1, wherein said seal comprises a lip seal in engagement with said first scroll member.

13. The scroll machine according to claim 1, wherein said seal engages said first scroll member and said ring when said ring opens said fluid passage.

14. The scroll machine according to claim 1, wherein said seal is disposed within a counterbore defined by said first scroll member.

15. The scroll machine according to claim 14, wherein said seal comprises a first lip seal in engagement with said ring.

16. The scroll machine according to claim 15, wherein said seal comprises a second lip seal in engagement with said first scroll member.

17. The scroll machine according to claim 14, wherein said seal comprises a lip seal in engagement with said first scroll member.

18. The scroll machine according to claim 14, wherein said seal engages said first scroll member and said ring when said ring opens said fluid passage.

19. The scroll machine according to claim 14, wherein said seal is a self-actuating seal.

20. The scroll machine according to claim 1, wherein said seal is a self-actuating seal.

21. A scroll machine comprising:

a first scroll member having a first spiral wrap projecting outwardly from a first end plate;

a second scroll member having a second spiral scroll wrap projecting outwardly from a second end plate, said second spiral wrap being intermeshed with said first spiral wrap;

a drive member for causing said scroll members to orbit relating to one another whereby said spiral wraps will create pockets of progressively changing volume between a suction pressure zone at suction pressure and a discharge pressure zone at discharge pressure;

a ring rotatably disposed on an outer surface of said first scroll member for opening and closing a fluid passage, extending from a first fluid pocket to the outer surface of said first scroll member; and

a seal disposed between said first scroll member and said ring, said seal sealing said fluid passage when said ring closes said fluid passage.

22. The scroll machine according to claim 21, wherein said fluid passage communicates with said suction pressure zone of said scroll machine when said ring opens said fluid passage.

23. The scroll machine according to claim 21, wherein said valve assembly is a solenoid valve.

24. The scroll machine according to claim 21, further comprising a linear actuator for rotating said ring.

25. The scroll machine according to claim 21, further comprising a valve member for rotating said ring.

26. The scroll machine according to claim 25, wherein said valve member is a solenoid valve.

27. The scroll machine according to claim 21, wherein said seal comprises a first lip seal in engagement with said ring.

28. The scroll machine according to claim 27, wherein said seal comprises a second lip seal in engagement with said first scroll member.

29. The scroll machine according to claim 21, wherein said seal comprises a lip seal in engagement with said first scroll member.

30. The scroll machine according to claim 21, wherein said seal engages said first scroll member and said ring when said ring opens said fluid passage.

31. The scroll machine according to claim 21, wherein said seal is disposed within a counterbore defined by said first scroll member.

32. The scroll machine according to claim 31, wherein said seal comprises a first lip seal in engagement with said ring.

33. The scroll machine according to claim 32, wherein said seal comprises a second lip seal in engagement with said first scroll member.

34. The scroll machine according to claim 31, wherein said seal comprises a lip seal in engagement with said first scroll member.

35. The scroll machine according to claim 21, wherein said seal is a self-actuating seal.

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