A fitting is secured to a shell of an apparatus. A tube is fixedly and sealingly attached to the fitting by either forming the fitting into engagement with the tube or forming the tube into engagement with the fitting. In both embodiments, engagement between the tube and a contoured surface defined by the fitting creates the fixed and sealed attachment.
SCROLL COMPRESSOR WITH VAPOR INJECTION

FIELD OF THE INVENTION

[0001] The present invention relates to scroll type machines. More particularly, the present invention relates to scroll compressors incorporating a vapor injection system which utilizes a crimped tube design for the piping of the fluid injection system.

BACKGROUND AND SUMMARY OF THE INVENTION

[0002] Refrigeration and air conditioning systems generally include a compressor, a condenser, an expansion valve or equivalent, and an evaporator. These components are coupled in sequence in a continuous flow path. A working fluid flows through the system and alternates between a liquid phase and a vapor or gaseous phase.

[0003] A variety of compressor types have been used in refrigeration systems, including but not limited to reciprocating compressors, screw compressors and rotary compressors. Rotary compressors can both include the vane type compressors, the scroll machines as well as other rotary machines. Scroll machines are constructed using two scroll members with each scroll member having an end plate and a spiral wrap. The spiral wraps are arranged in an opposing manner with the two spiral wraps being interlaced. The scroll members are mounted so that they may engage in relative orbiting motion with respect to each other. During this orbiting movement, the spiral wraps define a successive series of enclosed spaces, each of which progressively decreases in size as it moves inwardly from a radially outer position at a relatively low suction pressure to a central position at a relatively high pressure. The compressed gas exits from the enclosed space at the central position through a discharge passage formed through the end plate of one of the scroll members.

[0004] Refrigeration systems are now incorporating fluid injection systems where a portion of the refrigerant is injected into the enclosed spaces at a pressure which is intermediate the low suction pressure and the relatively high pressure or what is termed discharge pressure. This refrigerant is injected into the enclosed spaces through injection ports extending through one or more of the two scroll members. The injection of this refrigerant has the effect of cooling the compressor and/or increasing both system capacity and the efficiency of the compressor. The source for supplying the intermediate pressurized refrigerant is typically provided from a different portion of the refrigeration system which is located outside of the hermetic shell of the compressor. Typically a flash tank, an economizer, an accumulator or a different component in the refrigerant cycle is the source for the intermediate pressurized refrigerant.

[0005] When developing the fluid injection system, the development engineer must ensure that the intermediate pressurized refrigerant that is being injected is routed from the component outside the hermetic shell, through the hermetic shell and to the fluid injection ports. Piping or tubing extends between the component supplying the intermediate pressurized refrigerant to a pipe or tube fitting that is sealingly secured to and that extends through the hermetic shell of the compressor assembly and then to an internal pipe or tube which extends between the pipe or tube fitting and the injection port on one of the components of the compressor. When the pipe or tube is assembled or connected between the injection port and the pipe or tube fitting on the hermetic shell, the connection must be a sealed connection to avoid the leaking of the refrigerant to the internal space of the hermetic shell and to the environment.

[0006] Thus, the continued development of fluid injection systems is directed towards providing more efficient and lower cost connection designs for use between the pipe or tubing and the pipe or tubing fitting.

[0007] The present invention provides the art with a fluid injection system which utilizes a crimped fitting for the attachment of the pipe or tube to the pipe or tube fitting. The refrigerant tube is assembled to the fitting and then a tool engages the fitting and/or the tube to create a sealed connection without having to solder or braze the connection.

[0008] 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

[0009] The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0010] FIG. 1 is a vertical cross-section of a scroll compressor incorporating the unique fluid injection system in accordance with the present invention;

[0011] FIG. 2 is a horizontal sectional view of the scroll compressor of the present invention taken just below the partition in FIG. 1;

[0012] FIG. 3 is a plan view of the non-orbiting scroll of the present invention viewed from the vane side of the non-orbiting scroll;

[0013] FIG. 4 is a plan view of the scroll members positioned at the point of initially sealing off the first enclosed space;

[0014] FIG. 5 is a plan view of the scroll members positioned at the point of initially sealing off the second enclosed space;

[0015] FIG. 6 is a plan view of the scroll members positioned at the point where the vapor injection port is open to two enclosed spaces;

[0016] FIG. 7 is an enlarged cross-sectional view of the through-the-shell fitting prior to the forming operation;

[0017] FIG. 8 is a view similar to FIG. 7, but after the forming operation used to create the connection for the through-the-shell fitting;

[0018] FIG. 9 is an enlarged cross-sectional view of the through-the-shell fitting in accordance with another embodiment of the present invention; and

[0019] FIG. 10 is a view similar to FIG. 9, but after the forming operation used to create the connection for the through-the-shell fitting.
DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] 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.

[0021] Referring now to the drawings in which like reference numerals designate like or corresponding parts throughout the several views, there is shown in FIG. 1, a scroll compressor which incorporates the unique fluid injection system in accordance with the present invention and which is designated generally by the reference numeral 10. The following description of the preferred embodiment is merely exemplary in nature and is in no way intended to limit the invention, its application or its uses.

[0022] Scroll compressor 10 comprises a generally cylindrical hemispherical shell 12 having welded at the upper end thereof a cap 14 and at the lower end thereof a base 16 having a plurality of mounting feet (not shown) integrally formed therewith. Cap 14 is provided with a refrigerant discharge fitting 18 which may have the usual discharge valve therein (not shown). Other major elements affixed to shell 12 include a transversely extending partition 20 which is welded about its periphery at the same point cap 14 is welded to shell 12, an inlet fitting 22, a main bearing housing 24 which is suitably secured to shell 12 and a lower bearing housing 26 having a plurality of radially outwardly extending legs each of which is suitably secured to shell 12. A motor stator 28 which is generally square in cross-section but with the corners rounded off is press fit into shell 12. The flats between the rounded corners on motor stator 28 provide passageways between motor stator 28 and shell 12 which facilitate the return flow of the lubricant from the top of shell 12 to its bottom.

[0023] A drive shaft or crankshaft 30 having an eccentric crank pin 32 at the upper end thereof is rotatably journaled in a bearing 34 in main bearing housing 24 and in a bearing 36 in lower bearing housing 26. Crankshaft 30 has at the lower end thereof a relatively large diameter concentric bore 38 which communicates with a radially outwardly located smaller diameter bore 40 extending upwardly therefrom to the top of crankshaft 30. Disposed within bore 38 is a stirrer 42. The lower portion of the interior shell 12 is filled with lubricating oil and bores 38 and 40 act as a pump to pump the lubricating oil up crankshaft 30 and ultimately to all of the various portions of compressor 10 which require lubrication.

[0024] Crankshaft 30 is rotatably driven by an electric motor which includes motor stator 28 having motor windings 44 passing therethrough and a motor rotor 46 press fitted onto crankshaft 30 and having upper and lower counterweights 48 and 50, respectively. A motor protector 52, of the usual type, is provided in close proximity to motor windings 44 so that if the motor exceeds its normal temperature range, motor protector 52 will de-energize the motor.

[0025] The upper surface of main bearing housing 24 is provided with an annular flat thrust bearing surfaces 54 on which is disposed an orbiting scroll member 56. Orbiting scroll member 56 comprises an end plate 58 having the usual spiral valve or wrap 60 on the upper surface thereof and an annular flat thrust surface 62 on the lower surface thereof. Projecting downwardly from the lower surface is a cylindrical hub 64 having a journal bearing 66 therein and in which is rotatably disposed a drive bushing 68 having an inner bore within which crank pin 32 is drivenly disposed. Crank pin 32 has a flat on one surface (not shown) which drivingly engages a flat surface in a portion of the inner bore of drive bushing 68 to provide a radially compliant drive arrangement such as shown in assignee's U.S. Patent No. 4,877,382, the disclosure of which is incorporated herein by reference.

[0026] Wrap 60 meshes with a non-orbiting scroll wrap 72 forming part of a non-orbiting scroll member 74. During orbital movement of orbiting scroll member 56 with respect to non-orbiting scroll member 74 creates moving pockets of fluid which are compressed as the pocket moves from a radially outer position to a central position of scroll member 56 and 74. Non-orbiting scroll member 74 is mounted to main bearing housing 24 in any desired manner which will provide limited axial movement of non-orbiting scroll member 74. The specific manner of such mounting is not critical to the present invention.

[0027] Non-orbiting scroll member 74 has a centrally disposed discharge port 76 which is in fluid communication via an opening 78 in partition 20 with a discharge chamber 80 defined by cap 14 and partition 20. Fluid compressed by the compression chambers or moving pockets between scroll wraps 60 and 72 discharges into discharge chamber 80 through port 76 and opening 78. Non-orbiting scroll member 74 has in the upper surface thereof an annular recess 82 having parallel coaxial sidewalls within which is sealing disposed for relative axial movement an annular seal assembly 84 which serves to isolate the bottom of recess 82 so that it can be placed in fluid communication with a source of intermediate fluid pressure by means of a passageway 86. Non-orbiting scroll member 74 is thus axially biased against orbiting scroll member 56 by the forces created by discharge pressure acting on the central portion of non-orbiting scroll member 74 and the forces created by intermediate fluid pressure acting on the bottom of recess 82. This axial pressure biasing, as well as the various techniques for supporting non-orbiting scroll member 74 for limited axial movement, are disclosed in much greater detail in assignee's aforementioned U.S. Patent No. 4,877,382.

[0028] Relative rotation of scroll members 56 and 74 is prevented by the usual Oldham coupling 88 having a pair of key slidable disposed in diametrically opposing slots in non-orbiting scroll member 74 and a second pair of keys slidable disposed in diametrically opposed slots in orbiting scroll member 56.

[0029] Compressor 10 is preferably of the "low side" type in which suction gas entering shell 12 is allowed, in part, to assist in cooling the motor. So long as there is an adequate flow of returning suction gas, the motor will remain within the desired temperature limits. When this flow ceases, however, the loss of cooling will cause motor protector 52 to trip and shut compressor 10 down.

[0030] The scroll compressor, as thus broadly described, is either known in the art or it is the subject matter of other pending applications for patent by Applicant's assignee. The details of construction which incorporate the principles of the present invention are those which deal with a unique fluid injection system identified generally by reference
Fluid injection system 100 is used to inject refrigerant for cooling and/or increasing the capacity and efficiency of compressor 10.

Referring now to FIGS. 1-3, fluid injection system 100 comprises a fluid injection passage 102 extending through an end plate of a non-orbiting scroll member 74, a single fluid injection port 104 opening into the enclosed fluid pockets, a connecting tube 106, a fluid injection port 108 extending through shell 12 and a fluid injection fitting 110 secured to the outside of shell 12, and a connecting tube 112 located between fluid injection fitting 110 and the source of intermediate pressurized fluid.

Fluid injection passage 102 is a cross drilled feed hole which extends generally horizontal through non-orbiting scroll member 74 from a position on the exterior of non-orbiting scroll member 74 to a position where it communicates with fluid injection port 104. Fluid injection port 104 extends generally vertically from passage 102 through non-orbiting scroll member 74 to open into the enclosed spaces or pockets formed by wraps 60 and 72 as detailed below. Connecting tube 106 extends from fluid injection passage 102 to fluid injection port 108 where it extends through fluid injection port 108 to be sealingly secured to fluid injection fitting 110. While not shown, the source of the intermediate pressurized refrigerant fluid from a refrigeration system (not shown) is in communication with fluid injection fitting 110 through connecting tube 112 to provide the refrigerant fluid for injection.

Referring now to FIGS. 4 and 5, the positioning of fluid injection port 104 is illustrated in relation to scroll wraps 60 and 72. As can be seen in FIGS. 4 and 5, scroll wraps 60 and 72 are asymmetrically designed. Non-orbiting scroll wrap 72 extends an additional angular amount to provide the asymmetrical profile. In the preferred embodiment, non-orbiting scroll wrap 72 extends 170° further than orbiting scroll wrap 60. The asymmetrical profile of scroll wraps 60 and 72 causes the two fluid pockets created by wraps 60 and 72 to be initially sealed off at different positions or at different times during the orbiting motion of orbiting scroll member 56. FIG. 4 illustrates the initial sealing point of an enclosed space 120 which is sealed when an outer surface 122 of orbiting scroll wrap 60 engages an inner surface 124 of non-orbiting scroll wrap 72. Just prior to the time of sealing enclosed space 120, fluid injection port 104 is sealed off or closed by orbiting scroll wrap 60 as shown in FIG. 4. This ensures that there will not be any intermediate pressurized refrigerant fluid that is allowed to migrate to the suction chamber of compressor 10. Simultaneous with the sealing of enclosed space 120 by surfaces 122 and 124, orbiting scroll wrap 60 begins to uncover or open fluid injection port 104 to begin the injection of refrigerant fluid into enclosed space 120. While FIG. 4 is illustrated with fluid injection port 104 opening simultaneously with the sealing of enclosed space 120, it is within the scope of the present invention to open fluid injection port 104 prior to or subsequent to the sealing of enclosed space 120 if desired.

FIG. 5 illustrates the initial sealing point of an enclosed space 130 which is sealed when an inner surface 132 of orbiting scroll wrap 60 engages an outer surface 134 of non-orbiting scroll wrap 72. Just prior to the time of sealing enclosed space 130, fluid injection port 104 is sealed off or closed by orbiting scroll wrap 60 as shown in FIG. 5. This ensures that there will not be any intermediate pressurized refrigerant fluid that is allowed to migrate to the suction chamber of compressor 10. Simultaneous with the sealing of enclosed space 130 by surfaces 132 and 134, orbiting scroll wrap 60 begins to uncover or open fluid injection port 104 to begin the injection of refrigerant fluid into enclosed space 130. While FIG. 5 is illustrated with fluid injection port 104 opening simultaneously with the sealing of enclosed space 130, it is within the scope of the present invention to open fluid injection port 104 prior to or subsequent to the sealing of enclosed space 130 if desired.

As can be seen in FIG. 6, the size of fluid injection port 104 is significantly larger than the width of orbiting scroll wrap 60. This means that during a portion of the cycle for orbiting scroll member 56, fluid injection port 104 will be open to both enclosed space 120 and enclosed space 130. This does not present a problem to the operation and function of fluid injection system 100 because the pressure of refrigerant fluid at fluid injection port 104 is always larger than the pressure of refrigerant in enclosed spaces 120 and 130. The increased size for fluid injection port 104 allows for the unique ability of a single port being able to open to both enclosed spaces 120 and 130 simultaneously to the sealing of the respective enclosed space. In addition, the increased size of fluid injection port 104 allows for the injection of an increased amount of intermediate pressurized gas to increase the capacity and efficiency of compressor 10.

Referring now to FIGS. 7 and 8, attachment of connecting tube 106 to fluid injection fitting 110 is illustrated in greater detail. Fluid injection fitting 110 is a metal component that is attached to shell 12 using a brazing, soldering or welding process or by any other process known in the art. Fluid injection fitting 110 defines a circular extension 140 which is disposed within fluid injection port 108 extending through shell 12. A contoured surface in the form of a groove 142 extends into circular extension 140 within which connecting tube 106 is located. An inner diameter 144 of circular extension 140 is formed to create deformations 146 in both fluid injection fitting 110 and connecting tube 106 to retain and seal the connection between fluid injection fitting 110 and connecting tube 106. Deformations 146 in connecting tube 106 cause engagement between connecting tube 106 and the outside diameter of groove 142 and deformations on inner diameter 144 cause engagement between fluid injection fitting 110 and connecting tube 106.

FIGS. 7 and 8 illustrate the process used to form the inner diameter 144. Connecting tube 106 is first located within groove 142 of circular extension 140. Next, a forming tool 148 is inserted into the open end of fluid injection fitting 110 and an expandable die portion 150 of forming tool 148 forms the inner diameter 144 of fluid injection fitting 110 to create deformations 146. There can be multiple deformations 146 formed around the circumference of inner diameter 144 or there can be one continuous deformation 146 extending around the entire circumference of inner diameter 144.

Referring now to FIGS. 9 and 10, attachment of connecting tube 106 to a fluid injection fitting 210 is illustrated. Fluid injection fitting 210 is a metal component that is attached to shell 12 using a brazing process or by any other process known in the art. Fluid injection fitting 210
defines a circular extension 240 which is disposed within fluid injection port 108 extending through shell 12. A contoured surface 242 is formed within circular extension 240. The end of connecting tube 106 is formed into contoured surface 242 to create a deformation to retain and seal the connection between fluid injection fitting 210 and connecting tube 106.

[0039] FIGS. 9 and 10 illustrate the process used to form the end of connecting tube 106. Connecting tube 106 is first located within circular extension 240 of fluid injection fitting 210 adjacent contoured surface 242 as illustrated in FIG. 9. Next a forming tool 248 having a contoured surface 250 is inserted into the open end of fluid injection fitting 210. Contoured surface 250 of tool 248 corresponds to contoured surface 242 of fluid injection fitting 210. Contoured surface 250 of forming tool 248 engages the end of connecting tube 106 to expand or form the end of connecting tube 106 onto contoured surface 242 of fluid injection fitting 210 to retain and seal the connection.

[0040] 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. An apparatus comprising:

a shell;

a fitting secured to said shell, said fitting defining an inner diameter and a contoured surface disposed radially outward from said inner diameter;

a tube extending through said inner diameter, one of said tube and said fitting defining a deformation which fixedly secures said tube to said fitting.

2. The apparatus according to claim 1, wherein said contoured surface forms a groove extending into said fitting, said tube being disposed within said groove.

3. The apparatus according to claim 2, wherein said inner diameter of said fitting defines said deformation such that said fitting engages an inside diameter of said tube.

4. The apparatus according to claim 1, wherein said tube defines said deformation such that an outside diameter of said tube engages said fitting.

5. The apparatus according to claim 1, further comprising a compressor disposed within said shell, said tube extending between said fitting and said compressor.

6. The apparatus according to claim 5, wherein said contoured surface forms a groove extending into said fitting, said tube being disposed within said groove.

7. The apparatus according to claim 6, wherein said inner diameter of said fitting defines said deformation such that said fitting engages an inside diameter of said tube.

8. The apparatus according to claim 5, wherein said tube defines said deformation such that an outside diameter of said tube engages said fitting.

9. The apparatus according to claim 5, wherein said tube is in communication with a compression chamber defined by said compressor.

10. The apparatus according to claim 5, further comprising a fluid injection system communicating with said compressor, said tube forming a part of said fluid injection system.

11. The apparatus according to claim 1, further comprising:

a first scroll member disposed within said shell, said first scroll member having a first spiral wrap extending from a first end plate;

a second scroll member disposed within said shell, said second scroll member having a second spiral wrap extending from a second end plate, said second scroll member being intermeshed with said first scroll wrap, said first spiral wrap engaging said second spiral wrap to define at least one compression chamber; wherein said tube extends between said fitting and one of said first and second scroll members.

12. The apparatus according to claim 11, wherein said contoured surface forms a groove extending into said fitting, said tube being disposed within said groove.

13. The apparatus according to claim 12, wherein said inner diameter of said fitting defines said deformation such that said fitting engages an inside diameter of said tube.

14. The apparatus according to claim 11, wherein said tube defines said deformation such that an outside diameter of said tube engages said fitting.

15. The apparatus according to claim 13, further comprising a fluid injection system communicating with said one of said first and second scroll members, said tube forming a part of said fluid injection system.

16. A method for fixedly attaching a tube to a shell, the method comprising:

attaching a fitting to said shell;

positioning a tube adjacent a contoured surface defined by said fitting;

forming a deformation in one of said tube and said fitting to fixedly attaching said tube to said fitting by having engagement between said tube and said contoured surface.

18. The apparatus according to claim 17, wherein said attaching step includes brazing, soldering or welding said fitting to said shell.

19. The apparatus according to claim 17, wherein said forming step includes forming said fitting into engagement with an inside diameter of said tube.

20. The apparatus according to claim 17, wherein said forming step includes forming said tube to engage an outside diameter of said tube with said contoured surface.

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