United States Patent [19]
Moody, Jr. et al.

BEST AVAILABLE COPY

[11] **3,913,346**
[45] **Oct. 21, 1975**

[54] **LIQUID REFRIGERANT INJECTION SYSTEM FOR HERMETIC ELECTRIC MOTOR DRIVEN HELICAL SCREW COMPRESSOR**

[75] Inventors: **Harold W. Moody, Jr.**, Farmington; **Clark B. Hamilton**, Wethersfield, both of Conn.

[73] Assignee: **Dunham Bush, Inc.**, West Hartford, Conn.

[22] Filed: **May 30, 1974**

[21] Appl. No.: **474,629**

[52] **U.S. Cl.** **62/197;** 62/505
[51] **Int. Cl.²** **F25B 31/02**
[58] **Field of Search** 62/510, 505, 196, 197

[56] **References Cited**

UNITED STATES PATENTS

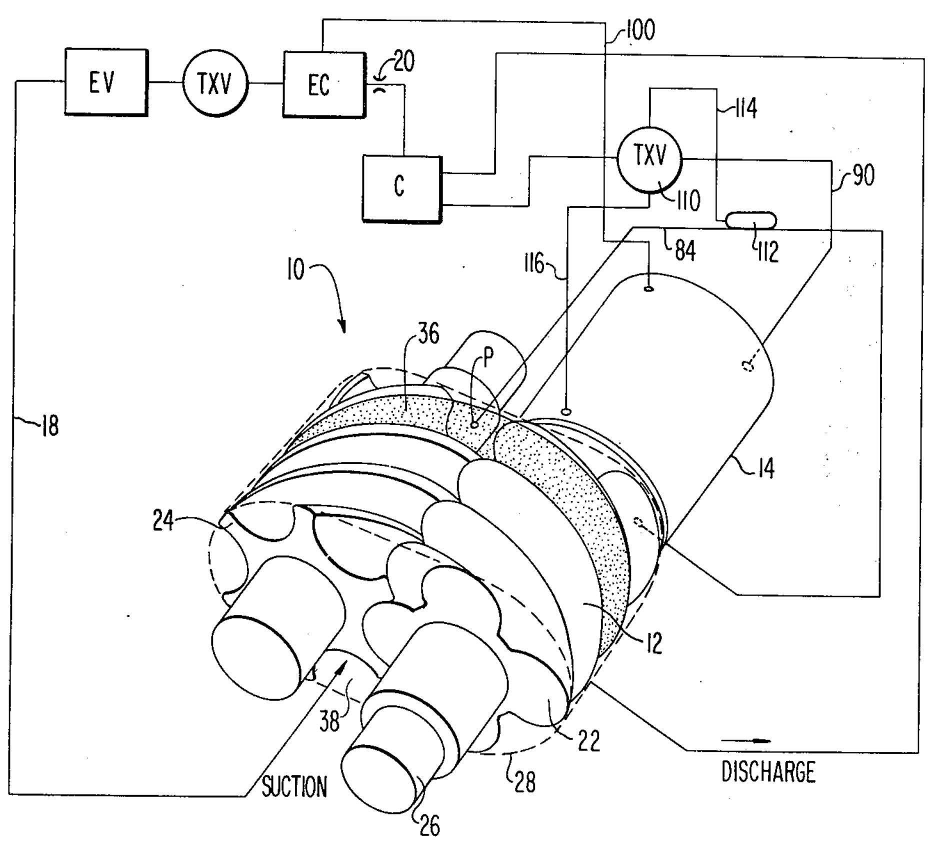
2,793,506	5/1957	Moody	62/505
2,921,446	1/1960	Zulinke	62/505
3,022,638	2/1962	Caswell	62/510
3,165,905	1/1965	Ware	62/505

Primary Examiner—William E. Wayner
Attorney, Agent, or Firm—Sughrue, Rothwell, Mion, Zinn & Macpeak

[57] **ABSTRACT**

An electric motor driven helical screw compressor of the hermetic type forms a closed refrigeration circuit including, downstream of the compressor, and in order, a condenser, a thermal expansion valve and evaporator means. The electric motor housing is hermetically sealed from the screw compressor and ambient, and the screw compressor housing is provided with a liquid refrigerant injection or bleed port opening to a closed screw compressor thread at a pressure intermediate of compressor suction and discharge which determines the pressure within the motor housing. High pressure liquid refrigerant bled from the condenser enters the hermetically sealed motor casing and rises to the level of the peripheral gap between the electric rotor and stator and is maintained at that level by the liquid refrigerant being picked up as result of rotor rotation and splashed against the stator for motor cooling by resultant vaporization. A fluid passage leads from the motor casing at the liquid level, normally defined by the gap position between the stator and rotor, to the bleed port to feed some of the liquid refrigerant to the closed threads for cooling the screw compressor by vaporization thereof during compression depending on the level of liquid refrigerant within the motor housing. Flash vapor resulting from liquid refrigerant subcooling within the system may be additionally fed to the motor casing for additional cooling of the motor windings and returned to the system through the compressor bleed port.

9 Claims, 4 Drawing Figures



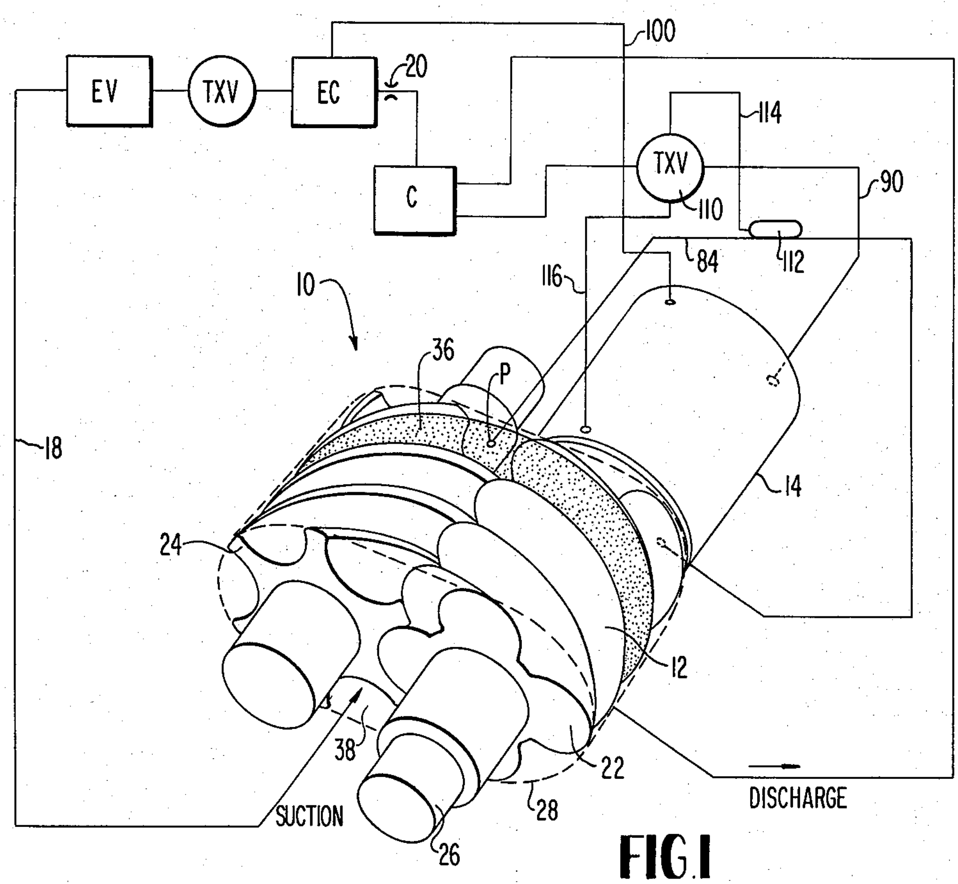


FIG. 1

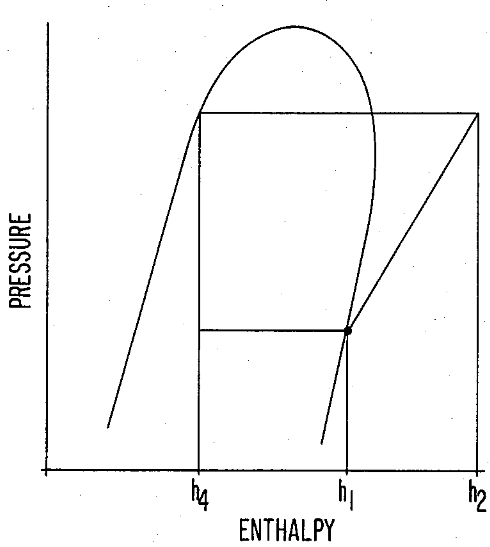


FIG. 3

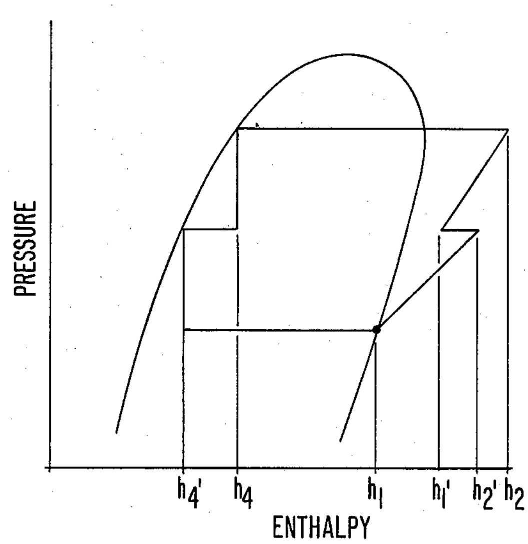
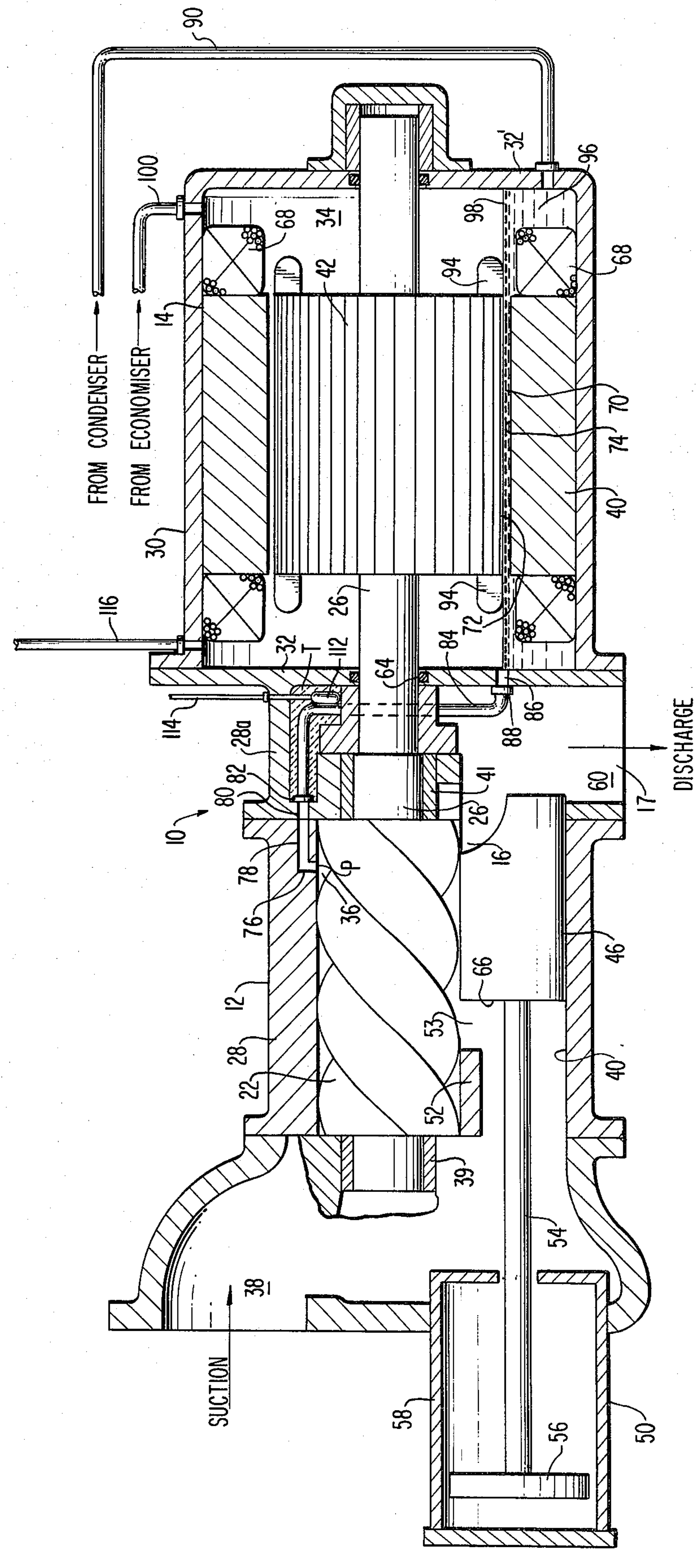


FIG. 4

FIG.2


90
100
FROM CONDENSER
FROM ECONOMISER
32'
96
98
34
68
42
94
14
70
74
40
30
116
26
72
32
T
112
64
84
114
86
88
28a
DISCHARGE
60
80
82
41
26'
17
10
16
78
p
76
36
12
46
66
53
28
40
22
52
39
54
38
SUCTION
58
56
50

LIQUID REFRIGERANT INJECTION SYSTEM FOR HERMETIC ELECTRIC MOTOR DRIVEN HELICAL SCREW COMPRESSOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to helical screw rotary compressors and more particularly, to compressor assembly wherein the helical screw compressor is driven by an electric motor hermetically sealed from the compressor.

2. Description of the Prior Art

Helical screw, rotary compressors driven by electric motors have been built in terms of hermetic units, wherein the electric motor rotor is directly coupled to the driving screw of the screw compressor by means of the rotor shaft, and wherein the motor is open to the compressor discharge with both units confined by a sealed casing defining the hermetic environment of the mechanically coupled motor and screw compressor. U.S. Pat. No. 3,408,826, assigned to the common assignee, is representative thereof. Where the screw compressor forms a component of a closed refrigeration circuit, the compressed gaseous refrigerant and oil exits from the discharge end of the screw compressor section of the unit and impinges against the stator and rotor winding to limit the temperature of the motor windings within acceptable limits. In order to favorably influence the efficiency of the machine and to lubricate the moving parts, some compressors have employed oil injectors within the compression area with the oil reducing the discharge temperature of the compressed gas, while at the same time acting as a seal between the rotating screw and the stationary compressor housing defining the compressor working area. Necessarily, the oil which is separated from the compressor working fluid, that is, the refrigerant, is required to be cooled prior to re-injecting into the compressor. The adjunct of extra oil cooler necessarily increases the size of the refrigeration unit, adds an additional unit to the system, and complicates system maintenance and operation.

Attempts have been made to inject liquid refrigerant into the refrigerant vapor or working fluid as it is being compressed such that the flashing of the liquid refrigerant within a closed thread of the helical screw compressor, further reduces the temperature of the working fluid compressor discharge, and in some cases has resulted in the elimination of the need for additionally cooling the oil after separation of the working fluid downstream of the compressor. U.S. patent application Ser. No. 285,695 filed Sept. 1, 1972 now U.S. Pat. No. 3,795,117 and U.S. patent application Ser. No. 433,418 filed Jan. 14, 1974, also assigned to the common assignee, are directed to such subject matter. While such arrangements have resulted in an improvement in efficiency without adversely affecting the volumetric capacity of the compressor or increasing the horsepower required, they have not been completely satisfactory, since the electric motor is required to operate in the discharge environment and cooling of the motor is achieved only with disadvantageous effects of higher windage losses and viscous drag and without change of state of the cooling medium.

Rather than having the compressor discharge gaseous refrigerant flow over the motor windings as a means for cooling the motor, attempts have been made to cool the electric drive motor in a hermetic rotary compressor combination by bleeding liquid refrigerant from the refrigeration circuit intermediate of the condenser and the evaporator and permitting the refrigerant to vaporize by contact with the hot motor components wherein the vaporized refrigerant is directed to the compressor suction for recompression. Such an arrangement is employed in U.S. Pat. No. 3,388,559 to Jonnson. In another form of hermetic rotary compressor for refrigeration use, flash gas resulting from an economizer, which subcools the liquid refrigerant downstream of the condenser, has been directed to the hermetically sealed motor casing which is at a pressure intermediate of the suction and discharge pressures of the rotary compressor, whereby, heat is absorbed by the flash gas prior to being introduced into the compressor and recompressed. This type of arrangement is the subject matter of U.S. Pat. No. 2,921,446 to Zulinke.

SUMMARY OF THE INVENTION

In general, the objects of the present invention are met by providing a hermetically sealed, electric motor driven screw compressor assembly in which the electric motor preferably has its axis of rotation horizontal and wherein a housing defines a chamber sealed from the compressor for the motor rotor and stator which is maintained at a pressure intermediate the screw compressor suction and discharge pressure. The motor driven screw compressor forms a part of a closed refrigeration circuit including at least a condenser, a thermal expansion valve and evaporator means in a series connection, in that order downstream of the compressor. The screw compressor includes a liquid refrigerant injection or bleed port opening to a closed screw of the compressor at a pressure intermediate of compressor suction and discharge. The improvement resides in bleeding high pressure liquid refrigerant from the system and delivering it to the motor casing such that the accumulation of liquid refrigerant in the casing reaches a predetermined level controlled by rotation of the rotor which picks up the liquid refrigerant during its rotation and splashes it against the stator for vaporized cooling of the motor coils. Conduit means leads from the housing, at the predetermined level of liquid refrigerant, normally defined by the lowermost gap between the stator and rotor, to the said liquid refrigerent injection port of the screw compressor to maintain the motor housing at an intermediate pressure relative to compressor discharge and suction pressure and permit some liquid refrigerant to flash within the sealed compression chamber to control compressor discharge temperature, such that the compressor discharge temperature is responsive to motor load, compressor load, motor housing discharge gas temperature and compressor discharge gas temperature.

The refrigeration system may further include a source of intermediate pressure refrigerant vapor as from a secondary evaporator, flash tank or system side load which is additionally ported to the motor housing to absorb heat from the motor during operation in addition to that absorbed by flashing of the liquid refrigerant within the motor housing and also promotes circulation. The liquid refrigerant injection port to the compressor is located such that the motor housing hermetic chamber defined by the motor housing is maintained at a pressure level intermediate of suction and discharge, and at a level such that refrigerant vapor moves under pressure differential automatically to the motor chamber from the economizer, secondary evaporator or side load. The liquid refrigerant flow through the motor housing may be further controlled by valve means responsive to compressor load, responsive to compressor discharge temperature, or responsive to discharge compressor superheat.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective, schematic view of an electric motor driven helical screw compressor with the motor hermetically sealed from the compressor and forming a part of a refrigeration system, incorporating the liquid refrigerant motor cooling and liquid refrigerant screw compressor injection system of the present invention in one form.

FIG. 2 is a sectional elevational view of the hermetically sealed motor driven screw compressor assembly of FIG. 1.

FIG. 3 is a pressure enthalpy diagram for a conventional helical screw compressor operating with Freon refrigerant.

FIG. 4 is a pressure enthalpy diagram of the hermetically sealed motor driven helical screw compressor of the present invention employing the liquid refrigerant injection cooling of the motor, and subcooling arrangement of the present invention, with similar Freon refrigerant.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Reference to FIGS. **1** and **2** illustrates by way of a partial, schematic perspective view and schematic block diagram, and a sectional elevation, a refrigeration system which incorporates as an element thereof, an electric motor driven, rotary screw compressor assembly indicated generally at **10,** which forms one component of a closed refrigeration circuit including in addition to the screw compressor **12,** driven by the electric motor **14,** in series and in order, from the discharge side identified by the arrow marked Discharge, a condenser C connected to the discharge port **16** of the compressor, and an economizer EC, a thermal expansion valve TXV, an evaporator EV, and all within line **18** which leads back to the suction side of the compressor **12** as indicated by the arrow marked Suction. A restrictor **20** may be provided in the line intermediate the condenser and the economizer for effecting a pressure drop resulting in vaporization of a portion of the liquid refrigerant within the economizer. The operation of the economizer EC is conventional and tends to maintain the refrigerant in liquid form for delivery to the evaporator via the TXV valve as well as to subcool the liquid relative to its temperature as it is discharged from the condenser C. The helical screw rotary compressor **12** comprises paired, intermeshed male and female screws as at **22** and **24** respectively and while either the male or female screw may be driven in a positive manner and wherein the screw which is coupled to the source of motive power acts as a driver for the other screw, it is not important to the present invention which screw is the driver and which screw is driven. In the illustrated embodiment, the male screw **22** is driven by means of a direct drive by way of its shaft **26** and the rotor **42** of the hermetic drive motor **14.**

In this respect, the screw compressor **12** is provided with a housing or casing **28** which effectively hermetically seals the screw compressor relative to electric motor **14.** In turn, the motor **14** is encased within a housing or casing **30** which is sealed from the compressor **12** by way of an end wall **32** which acts as a wall common to both compressor housing **28** and motor housing **30** but acts in conjunction with appropriate seals to seal off cavity or chamber **34** of the motor housing from the helical screw compressor **12.** The male screw support shaft **26** is shown as integral with the motor rotor support shaft of electric motor **14** and is suitably rotatably supported by bearings **39, 41,** FIG. **2.** The common shaft in this case extends through the end wall **32.**

For the purposes of the present invention, it is important only that the intermeshed helical screws **22** and **24** define in conjunction with the fixed housing **12** a series of closed threads or isolated compression chambers such as thread **36** which is sealed off from the suction side **38** of the screw compressor and from the discharge side as identified by discharge port **16.** In this machine, a liquid refrigerant injection or bleed port P is provided within screw compressor casing **28** opening up to the closed thread **36** at a point, wherein the refrigerant gas entering from suction **38** is sealed off, and partially compressed prior to discharge by that same thread opening up to the discharge port **16.** The exact location of the liquid refrigerant injection port P and its effect in reducing and lowering the temperature of the gas being compressed along with any oil entrained therein, is the subject matter of previously referred to copending U.S. application Ser. No. 433,418. In order to control the capacity of the screw compressor, conventionally a slide valve **46** is provided to the screw compressor supported within a slideway **40** formed within the compressor housing **28** and being moved axially by a hydraulic motor **50.** A hydraulic fluid such as pressurized lubricating oil may be selectively applied to respective faces of a piston **56** supported for reciproacting movement within cylinder **58,** and being coupled by way of shaft **54** to the slide valve **46.** The end face **66** of the slide valve cooperates with a fixed stop **52** and with an opening **53** formed thereby to open up the leading end of the compression area of the intermeshed helical screws, allowing the passage surrounding the shaft **54** to act as a bypass returning some of the refrigerant gas to the suction side of the screw compressor to effect compressor unloading. Again, the slide valve **46** and its manner of operation is conventional to the helical screw rotary compressor **12** and forms no part of the present invention. It is noted in FIG. **2** that housing **28** is comprised of several parts, including a section **28*a*** at the discharge side of the machine forming a discharge passage **60.** The housing section **28*a*** terminates in the common housing end wall **32,** through which shaft **26** protrudes. Shaft **26** is supported by bearing **41** at this point, and is sealed appropriately at **64,** such that cavity or chamber **34** of motor housing **30** is heremetically sealed from the discharge side of the screw compressor. The common shaft **26** supports to the side of the end wall **32,** remote from the compressor screws, electric motor rotor **42** which is concentrically carried within motor stator **40** fixed to motor casing **30.** The stator **40** is provided appropriately with motor windings having end turns at **68** while the rotor **42** may be of squirrel cage type. A narrow gap **70** separates the peripheries

72 and 74 of the motor rotor and stator, respectively.

Pertinent to the present invention is the fact that a fluid passage leading from motor housing chamber **34** to the liquid injection port P, is formed by way of intersecting passages **76** and **78**, within screw compressor housing section **28**, while housing section **28**a is provided with a drilled passage **80** coaxial with and open to passage **78**. Passage **80** terminates in a fitting **82** which sealably has coupled thereto, metal tube or conduit **84**. The other end of the tube or conduit **84** is fluid coupled in sealed fashion to a hole **86** extending through end wall **32** by way of a threaded coupling **88**. It is important to note that the hole **86** within wall **32** is in alignment with gap **70** at its lowermost position.

Further, the temperature control scheme of the present invention involves the utilization of a line such as line **90** which extends from the condenser and terminates at the motor casing **30**, for example at end wall **32'**, conduit **90** opening up to cavity **34** near the bottom thereof. Liquid refrigerant, from the condenser C, passes through the conduit **90** and enters cavity **34** tending to accumulate by way of gravity within the bottom of casing **30**.

The present invention is highlighted by the fact that the accumulation of liquid refrigerant will occur to the extent that liquid refrigerant reaches the rotor **42**. The liquid refrigerant in contacting the rotor **42** is picked up by the rotor **42** and is splashed against the stator and in fact the interior of the cavity **30** by the relative rotation between the rotor and stator. Preferably, the rotor **42** is provided with integral vanes or impellers as at **94** on both ends and at circumferentially spaced positions. The vanes **94** are oriented radially such that in sweeping by the stator **40** and in contacting the accumulated liquid refrigerant **96** the vanes **94** pick up the liquid refrigerant splashing it against the stator coils **68** that lie above the level **98** of liquid refrigerant resulting in vaporization of the liquid refrigerant and the absorption of the heat created by current flow through the windings of the motor components. Secondly, the location of the hole or passage **86** within casing **30** being preferably at the height of gap **70** between the rotor and stator, permits any liquid refrigerant reaching this level to be bled off to the liquid injection or bleed port P through conduit **84** and passages **80, 78** and **76** in that order. The liquid injection or bleed port P to the compressor is arranged so that the pressure of the closed thread or chamber **36** will determine the intermediate pressure within cavity or chamber **34** of the hermetically sealed motor and which will insure the delivery of liquid refrigerant through conduit **90** from the higher pressure condenser C to the intermediate pressure motor housing cavity or chamber **34** and then by the accumulation of liquid refrigerant, to the compressor itself. Thus, some liquid refrigerant **96** as well as gas vapor residing within cavity **34** above the level **98** of the liquid refrigerant is led to a closed thread location for the purpose of evaporating the liquid refrigerant in sealed thread compression chamber, to thereby control the compressor discharge temperature at **60**. The bleed port or injection port P is selected in the compressor rotor within housing **28** such that the motor housing will operate at a closely controlled pressure level intermediate of compressor suction and discharge. The intermediate pressure level may be 10 to 100 psi above that of compressor suction.

The motor housing pressure level is also selected so that refrigerant vapor can be bled to the motor housing from a secondary system source such as a flash tank for the purpose of producing subcooled liquid, a secondary evaporator or chiller that is operating at a pressure level above that of the primary system evaporator or chiller. In this respect, the economizer EC constitutes, as a non-limiting illustration, a flash tank for the purpose of producing subcooled liquid for the evaporator EV and a line **100** opens up to the economizer EC at a point where the vapor collects above the liquid refrigerant, this vapor being ported directly to the motor housing **30** by way of a fluid connection through line **100**. This preferably occurs well above the liquid refrigerant level **98**. It is important to note that in addition to providing more efficient motor cooling by vaporizing liquid refrigerant in and around the motor windings, the system capacity is not significantly affected by the bleeding of this vapor to a closed compressor thread which occurs in the absence of liquid refrigerant entering hole **86** within housing end wall **32** separating the compressor from the drive motor. In addition, the secondary vapor bled to the motor housing **32** from the flash tank or economizer EC will increase overall system capacity and will result in improvement in specific performance, that is, brake horse power per ton of refrigeration or kilowatt per ton. The refrigerant vapor entering the motor housing **30** through line **100** is also directed over and about the hermetic motor winding and absorbs heat from the motor **14**.

Multiple advantages are realized from the invention, being achieved by the cumulative effect of the features of the invention involving cooling of motor windings by the liquid refrigerant being splashed thereon, controlled by the accumulation of that liquid within the motor housing, the cooling effect of the refrigerant vapor being fed to the same casing or housing from the flash tank of the economizer or the like and the cooling effect achieved by the further flash of liquid refrigerant within a closed thread of the compressor with controlled movement of such liquid refrigerant to the bleed port of the screw compressor.

This arrangement is in contrast to a suction cooled motor, where the motor windings are subjected to the refrigerant vapor entering the compressor on the suction side which causes the motor loss to superheat the suction gas and be put through the compressor and results in further deterioration of the performance as determined by the compressor inlet condition. The invention avoids the losses associated with a "discharge cooled motor" where the motor is required to operate in a discharge atmosphere with higher windage losses and viscous drag associated therewith. The motor is more efficiently cooled as a result of direct impingement of liquid refrigerant onto the motor winding by bleeding liquid refrigerant from the high side of the system, in connection with an arrangement for bleeding, by maintenance of the motor housing intermediate pressure, the supplementary cooling of the motor winding by bled saturated refrigerant vapor. Again, both bleeds are achieved by maintaining a predetermined intermediate pressure within the motor housing cavity as determined by the location of the compressor bleed port relative to the compressor screw bore and opening that port to the motor housing. The control of refrigerant and the agitation and pick-up of the liquid refrigerant from the bottom of the motor housing is achieved automatically by the location of the bleed port from the motor housing which is located at the lowermost level of the gap between the rotor and stator peripheries in a horizontally oriented machine, so that liquid refrigerant upon reaching that level, is conducted or otherwise distributed by the rotor onto the stator at positions above the level of accumulated liquid refrigerant, while the further flow of liquid refrigerant to the bleed port associated with the compressor is self regulated by that accumulaion level. The provision of the port in the compressor housing at an intermediate pressure level insures vaporized liquid refrigerant from the motor housing, supplementary refrigerant gas vapor and liquid refrigerant is introduced to the compressor working chamber after the screw compressor working chamber has closed for each thread formed thereby. This arrangement increases the charge of refrigerant vapor to the compressor while not affecting the compressor suction volume or volumetric efficiency which determines the compressor capacity from the system's point of view. The provision of the bleed port permits less work to be required to raise the vapor from an intermediate pressure level to compressor discharge pressure, permits liquid refrigerant to vaporize within the closed thread to cool the main charge of the gas being compressed and this results in an improved compressor specific power for mass of refrigerant being pumped.

The increase in overall system capacity as well as the realization of that increase with a minor increase in horse power input may be seen by a comparison between FIGS. **3** and **4** which are pressure enthalpy diagrams for the compressor of FIGS. **1** and **2** operating with and without the system improvements of the present invention. In FIG. **3**, the compressor operates within the system of FIG. **1** and without the influence of vapor and liquid refrigerant injection within the screw compressor closed thread, and the advantageous effects of subcooling by way of the economizer EC. In both cases, the compressor operates with a conventional refrigerant such as Freon as the compressor working fluid.

Referring to FIG. **3**, this constitutes a standard pressure entahlpy diagram for an unmodified compressor and working fluid. The refrigeration effect H is equal to the value $(h_1 - h_4)$ per pound and the work of compressor W is equal to $(h_2 - h_1)$. By comparison, in FIG. **4** which is a diagram showing the effects of inclusion of gas and liquid refrigerant injection within the closed thread of the screw compressor and the effect of subcooling under the system arrangement of the illustrated embodiment, the increase in refrigeration effect H, in this case, may be seen from the formula $(h_1 - h_4')$ and the improvement in terms of percentage is equal to

$$\frac{h_1 - h_4'}{h_1 - h_4} \times 100$$

while the work of compression per pound may be determined from the formula

$$W = (h_2' - h_1) + (1 + y) \times (h_2 - h_1')$$

where: y is the vapor injected mass of refrigerant at the bleed port of the compressor, h_4' is the enthalpy resulting from subcooling, h_4 is the enthalpy of the refrigerant at the condenser, h_1 is the enthalpy at the suction side of the compressor, h_1' is the enthalpy at the closed thread after liquid refrigerant injection, h_2' is the enthalpy at the point of compression of the vapor available at compressor suction prior to the closed thread reaching the bleed port P, and h_2 is the enthalpy of the refrigerant under compressor discharge conditions prior to reaching the condenser.

Without giving specific values, it is apparent that a system capacity increase identified as the improvement percentage in terms of refrigeration effect may be visually appreciated by contrast in the diagrams of FIGS. **3** and **4**, particularly in terms of the small increase in horse power input which results from a proper selection of the hermetic motor housing intermediate pressure level as defined by the physical location of the bleed port P relative to the closed threads of the compressor which periodically opens up that port. The result is an improved system specific horse power per ton as compared to a system as shown in FIG. **3** that does not have this arrangement. The gain in system capacity is readily visually apparent by comparison of these two figures.

To control the liquid refrigerant flow via line **90** to motor housing **30** for the purpose of cooling the motor by means responsive to compressor load, responsive to compressor discharge temperature, or responsive to compressor discharge superheat, or a combination of these parameters, reference may be had to referred to co-pending U.S. application Ser. No. 285,695 entitled "Injection Cooling of Screw Compressor" which employs the utilization of the same parameters as the means for controlling liquid injection to the closed thread of the helical screw compressor by bleeding liquid refrigerant from the high side of the system downstream of the condenser.

Based on these principles, but a modification thereof, the present system employs in one form, a thermal expansion valve **110** within bleed line **90** constituting a thermal responsive modulation for variably controlling the flow of liquid refrigerant from condenser C to motor housing **30.** In this respect, a thermobulb **112** may be positioned in thermal energy transfer relation to conduit **84,** for instance, which permits the bled liquid refrigerant and/or vapor from within cavity **34** of the motor housing **30** to pass via bleed port P directly to the closed thread of the screw compressor **12.** The bulb **112** may carry a thermal expansive liquid or solid and fluid coupled by way of capillary tube **114** to the temperature expansion valve **110** such that the temperature expansive material, as in the referred to application, expanding in response to increase in temperature, variably shifts a movable valve element (not shown) within valve **110** to modulate the flow of liquid refrigerant (increase flow) to the injection or bleed port P of screw compressor **12.** A second input to the same valve is shown via tube **116** which opens up into the motor casing **30** so that the pressure of the intermediate gas vapor pressure within the hermetically sealed motor acts as a second input to valve **110** and may modify the input from the thermobulb **112** in the same manner as that in the referred application. If desired, the thermobulb **112** may be positioned within the discharge passage **60** of the compressor and thus responsive to compressor discharge temperature (proportional to load) and the pressure line **116** could open up to the same passage. In this respect, the valve then maintains a given superheat temperature differential between the condensing temperature and the discharge temperature of the refrigerant. The passage leading from intermediate chamber **34** of the motor housing, to injection port

P should be maintained thermally isolated from the compressor discharge, this being schematically achieved by means of the thermal insulation T surrounding the tube or conduit **84** within discharge passage **60.**

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that the foregoing and other changes in form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. In a refrigeration system employing an electric motor driven helical screw compressor forming a part of a closed refrigeration circuit which further includes downstream of the compressor and in order, a condenser, a thermal expansion valve, and evaporator means, wherein the electric motor includes a motor housing which hermetically seals the motor from the screw compressor and which carries a fixed stator and a rotatable rotor in concentric fashion, and the screw compressor housing is provided with a liquid refrigerant bleed port opening to a closed screw compressor thread at a pressure intermediate compressor suction and discharge, the improvement comprising:

means for bleeding liquid refrigerant from the high pressure side of the circuit, and delivering the liquid refrigerant to the bottom of the motor housing for gravity accumulation therein,

means responsive to accumulation of liquid refrigerant within said motor housing, for causing said motor rotor in response to rotation thereof, to pick up some liquid refrigerant and distribute it to that portion of said stator lying above the accumulated refrigerant to cool the same by vaporization and to thereby maintain said liquid refrigerant at a predetermined level, determined by initial contact of said rotor with said liquid refrigerant accumulating within said motor housing, and

fluid passage means coupled at one end to said injection port and opening at the other end within said housing at said predetermined level;

whereby, liquid refrigerant accumulating within said motor housing is simultaneously vaporized within said housing to cool said motor and is bled to the closed thread for injection into said compressor for cooling the screw compressor closed thread content by vaporization of said liquid refrigerant therein during compression thereof.

2. The system as claimed in claim **1,** further comprising: means within said system, downstream of said compressor, for providing vaporized refrigerant at a pressure intermediate compressor suction and discharge pressure, and means for delivering said vaporized refrigerant to said motor housing for impingement on said motor stator to additionally cool said motor prior to passing from said motor housing to said compressor via said bleed port.

3. The system as claimed in claim **2,** wherein said means within said system for providing vaporized refrigerant at a pressure intermediate compressor suction and discharge comprises: an economizer positioned within said system intermediate of said condenser and said thermal expansion valve, a fluid restrictor within the line leading from said condenser to said economizer for reducing pressure of the liquid refrigerant entering said economizer to cause flash gas resulting therefrom to subcool the remaining liquid refrigerant therein, resulting in creation of the vaporized refrigerant, and wherein said vapor delivering means comprises conduit means fluid coupling said economizer to said motor housing to supply the vaporized refrigerant thereto.

4. The system as claimed in claim **1,** wherein: said electric motor is oriented horizontally, said rotor is spaced relative to said fixed stator to form an annular gap between the peripheries thereof, and said fluid coupling means comprises a passage leading to said bleed port and opening into said motor housing at a height corresponding to the lowermost gap position.

5. The system as claimed in claim **2,** wherein: said electric motor is oriented horizontally, said rotor is spaced relative to said fixed stator to form an annular gap between the peripheries thereof, and said fluid coupling means comprises a passage leading to said bleed port and opening into said motor housing at a height corresponding to the lowermost gap position.

6. The system as claimed in claim **3,** wherein: said electric motor is oriented horizontally, said rotor is spaced relative to said fixed stator to form an annular gap between the peripheries thereof, and said fluid coupling means comprises a passage leading to said bleed port and opening into said motor housing at a height corresponding to the lowermost gap position.

7. The system as claimed in claim **1,** further comprising: a thermal expansion valve positioned within said circuit leading from said condenser to said motor housing for modulating the flow of liquid refrigerant between said condenser and said motor housing, and thermal energy sensing means positioned in heat transfer with respect to said means fluid coupling said bleed port to said motor housing interior and being operatively coupled to said thermal expansion valve for controlling valve operation.

8. The system as claimed in claim **7,** wherein: said valve further includes means responsive to vapor pressure within said motor housing for additionally modulating said flow of liquid refrigerant therethrough.

9. In a refrigeration system employing an electric motor driven helical screw compressor forming a part of a closed refrigeration circuit which further includes downstream of the compressor and in order, a condenser, a thermal expansion valve, and evaporator means, and wherein the electric motor includes a motor housing which hermetically seals the motor from the screw compressor and which carries a fixed stator and a rotatable rotor in concentric fashion, and the screw compressor housing is provided with a liquid refrigerant bleed port opening to a closed screw compressor thread at a pressure intermediate compressor suction and discharge, the improvement comprising:

means for bleeding liquid refrigerant from the high pressure side of the circuit, and delivering the liquid refrigerant to the bottom of the motor housing for gravity accumulation therein,

means responsive to accumulation of liquid refrigerant within said motor housing to a predetermined level, for causing liquid refrigerant to impinge upon portions of said motor stator and by rotation thereof to splash against portions of the motor stator above said predetermined level for cooling by vaporization of liquid refrigerant and to maintain the level of accumulated liquid refrigerant within said housing at said predetermined level defined by initial contact of said rotor with the liquid refrigerant accumulating within said motor housing in a closed fluid passage opening at one end to liquid injection port and at the other end directly to said motor housing at said predetermined level such that simulaneously in response to accumulation of liquid refrigerant to said predetermined level, vaporized liquid refrigerant within said housing deposited on the stator above the level of accumulated liquid refrigerant causes cooling of said motor and liquid refrigerant delivered to said port through said passage cools the screw compressor closed thread content by vaporization of said liquid refrigerant therein during compression thereof.

* * * * *