This invention relates to refrigeration and air conditioning and more particularly to a combination accumulator-heat exchanger designed to improve the efficiency of operation of a system and which will allow condition responsive control components (particularly the refrigerant flow control and condenser cooling medium control) greater latitude of operation.

While the advantages of an accumulator or surge tank have been known, hitherto, as well as the general idea of heat exchange between the high pressure liquid and the suction side, the present invention provides an accumulator-heat exchanger combination which is particularly adapted to insure the precociling of the super heated refrigerant leaving the discharge side of the compressor and which may be employed in the improvement of present methods of defrosting systems.

The technical progress which has been made in the refrigeration and air conditioning industry in recent years has resulted in a tremendous increase in the installation of fully automatic refrigeration and air conditioning systems. In fact at the present time the system operated under the supervision of an engineer is the exception rather than the rule.

The fully automatic system usually consists of a compression side and cooling coils controlled by various automatic unloaders which control the flow of liquid refrigerant to the cooling coils, the operating cycle of the compression equipment, and in a water cooled system, the flow of water through the condenser. Within the limitations of the control components it is possible to obtain a fairly balanced system under ordinary operating conditions. There is, however, a wide gap between the results obtained by such automatic control devices and those obtained by the operating engineer who adjusts each one to meet the need as it develops.

This situation has led to a demand for other control devices of various types either to control the flow of liquid refrigerant to the cooling coils or to regulate the capacity of the compressor or both. Many of the devices developed to meet this need are complex and expensive. The need exists for a simple device, preferably without moving parts, which will permit the utilization of the full capacity of the cooling coils under all conditions and insure against liquid refrigerant passing through the suction line to the compressor. An added feature of the device would provide for increasing the capacity of the condensing unit and protect the unit from overloading. The device would preferably accomplish these results without requiring an increase in the energy input to the system.

It is well known that a refrigeration system has a relatively low efficiency ratio. This is due partly to the fact that mechanical friction and the molecular friction of compression raise the temperature of the discharge gas above the temperature at which the gas may condense. Also in uncondensed evaporators a portion of the effective heat absorbing surface of the cooling coil is lost in “dryig” the refrigerant.

Accordingly, it is an object of the invention to provide means for increasing the efficiency ratio of a refrigeration system by cooling the discharge gas to or near its condensing temperature before it flows to the condenser, without increasing the energy input to the system, through the use, in a water cooled system of the waste water of the condenser, or in an air cooled system by utilizing the high ratio of heat exchange between the ambient air and the discharge gas.

A further object is to provide a combination accumulator and heat exchanger useful as a basic accessory to improve the operation of a refrigeration or air conditioning system.

A further object is to provide a means of increasing the condensing capacity of the system, thus insuring against motor overload.

A further object is to provide a means of lowering the required motor input, thus reducing the operating cost, through lower head pressures made possible by increased condenser capacity which is gained by passing super-heated gas from the compressor through the heat exchanger-accumulator.

A further object is to provide, through the operation of the combination accumulator-heat exchanger, means to insure that the refrigerant from the condenser is returned to the compressor in a “dry” state with maximum effective use of the cooling coils, thus insuring that the compressor operates at maximum efficiency for its operating back pressure without re-expansion occurring in the compressor body or cylinders.

A further object is to provide within the accumulator-heat exchanger combination means to efficiently distribute heavily saturated refrigerant gas or liquid refrigerant flowing from the cooling coils, thus insuring rapid expansion and means for receiving the expanded refrigerant within the accumulator-heat exchanger in a manner to avoid “short circuits” therewith.

A further object of the invention is to provide an accumulator-heat exchanger through the operation of which the system may be balanced or “stabilized,” and whereby, through regulation of the liquid refrigerant control, the capacity of the cooling coils may be adjusted to insure maximum efficiency of the heat absorbing surface without danger of “flooding” the system; further, the capacity of the compressor may be regulated by adjustment of means controlling the flow of the cooling medium passing through the heat exchanger in the accumulator.

A further object is to provide, within the accumulator-heat exchanger, means to insulate the heat exchanger to the desired degree to permit only the desired amount of heat (depending on the operating back pressure) to be passed to the suction gas, the amount of heat flowing thereto being proportioned to the operating back pressure.

In a fluid defrosting system, when the temperature of the fluid is below 50 degrees F., the defrosting action is relatively inefficient. In such a system heat and pressure applied internally to the cooling coils increases the efficiency of the defrosting action.

Accordingly, it is a further object of the invention to provide heating means for the defrosting fluid and means for furnishing warm refrigerant under pressure to the internal surface of the cooling coil.

A still further object is to provide a refrigeration system adapted to operate at high efficiency with its major components in balance, without the use of complex control means or the attendance of an operator.

A further object is to provide an accumulator-heat exchanger which is adapted to efficiently assist in the hot gas defrosting of the evaporator.

A further object of the invention is to provide an accumulator-heat exchanger which is adapted to efficiently assist in the electric defrosting of the evaporator.
A further object of the invention is to provide an accumulator-heat exchanger embodying means to effect heat exchange between super heated refrigerant leaving the compressor and the condensing medium, also between the suction gas leaving the evaporator and the high side liquid.

A further object is the provision of an accumulator-heat exchanger adapted to efficiently assist in the defrosting of a refrigeration system by including means to provide heat for a separate fluid used in the melting of frost from the evaporator and/or the drain pan.

A further object of the invention is to provide an accumulator heat exchanger having a restricted outlet at its bottom for attachment to the compressor suction by means of which oil and a limited or metered quantity of liquid refrigerant may be drawn into the suction line in order to bring the suction gas nearer saturation with the advantages resulting therefrom. These advantages include:

(a) Improving the coefficient of performance of the system;
(b) Increasing the quantity of refrigerant available both for pre-cooling of compressors of the hermetic or semi-hermetic type and for defrosting;
(c) Lowering the compression ratio;
(d) Reducing the work necessary to be done by the compressor.

The foregoing advantages are especially applicable to low temperature systems and systems in which automatic operation is necessary, it being desirable to operate at high efficiency under widely variable operating conditions and without the danger of bringing slugs of refrigerant into the compressor.

The said other objects of the invention will become apparent from the following description in conjunction with the accompanying drawings in which:

Fig. 1 is a longitudinal section through a preferred form of an embodiment of the invention;
Fig. 2, a longitudinal section through a modification thereof;
Fig. 3, a schematic diagram of a refrigeration system using my combination accumulator-heat exchanger;
Fig. 4, a schematic diagram illustrating the employment of my device in a system adapted for hot gas defrosting;
Figs. 4a and 4b illustrate the position of the valves of Fig. 4 in the position for normal operation;
Fig. 5, a schematic diagram of my device in a system in which both hot gas and electrically heated coils are provided for defrosting purposes;
Fig. 5a, a diagram of the valve in the position for defrosting;
Fig. 6, a schematic diagram illustrating my device in a system having provision for both hot gas and spray water defrosting;
Figs. 6a and 6b illustrate the position of the valves in defrosting position;
Fig. 7, a schematic diagram of my device used with a refrigeration system having an air cooled compressor in which a separate closed fluid circuit is provided to sub-cool the compressor discharge;
Fig. 8 is a schematic diagram of the separate fluid circuit portion of a system similar to that of Fig. 7 in which the condensers of the main circuit and the secondary circuit are in heat exchange relation;
Fig. 9, a schematic diagram similar to Fig. 8 in which the condensers are cooled by the same fan but are otherwise separate;
Fig. 10, a schematic diagram of a system similar to Fig. 6 except that instead of provision being made for the line from the heat exchanger to be connected to a spray over the evaporator, a connection is provided to the evaporator drip pan;

Figs. 10a and 10b illustrate the position of the four-way valves of Fig. 10 in defrosting position;
Fig. 11, a section through a combination accumulator-heat exchanger similar to Fig. 1 except that the shell 16 is partially evacuated for insulation purposes instead of having connections 19 and 20 as in Fig. 1; and
Fig. 12, a section on the line 12—12 of Fig. 11.

Referring to the drawings, particularly Fig. 1, the invention includes an insulated housing 10 having a side wall 11, preferably of cylindrical configuration, and end walls 12 and 13. Extending substantially axially of the housing 10 is a central conduit 14 having a shell 15. A second shell 16 extends axially of the housing and about the shell 15. The shell 15 has connections 17 and 18 at its ends and protrudes substantially outside the end walls 12 and 13 of the housing 10. The shell 16 likewise has connections 19 and 20 at its ends but is disposed entirely within the confines of the end walls of the housing 10.

Disposed parallel to the axis of the cylinder and oppositely from each other are a pair of pipes 21 and 22 which extend into the housing from opposite ends thereof, the pipe 21 entering the end wall 13 and the pipe 22 entering the end wall 12. The ends of the pipes are positioned against the opposite end walls and are closed by plugs 23 and 24 respectively. The pipes 21 and 22 are provided with apertures 25 and 26 on their sides next to the interior wall of the housing.

Referring more particularly to Fig. 3, a diagrammatic circuit is shown illustrating the application of the device to a conventional refrigeration system. The system includes a compressor 30 having a discharge conduit 31 and a suction conduit 32. The conduit 31 is attached to the conduit 14 of the housing 10, the other end of conduit 14 being attached to pipe 33 leading to a water-cooled condenser-receiver 34. From condenser-receiver 34 the liquid refrigerant passes through line 35 to expansion valve 36 and to the evaporator 37. From the evaporator the refrigerant is drawn through line 38 and T 39 to pipe 22 within the housing. The refrigerant leaves pipe 22 through apertures 26, passing within the housing through apertures 25 into pipe 21 from whence it flows in the suction line 32 back into the compressor.

A branch line 40 having a one-way valve 41 therein extends from the T 39 to the connection 20 of the shell 16 within the housing. At the other end of the shell 16 a line 42 extends from the connection 19 to the suction line 32. A one-way valve 27 is placed in suction line between pipe 21 and the junction with line 42. An oil drain line 44 extends from the connection 45 at the bottom of the housing to the suction line 32. In use liquid refrigerant is also drawn into the line 44 and is metered to the suction line 32.

A water line 47 having a control valve 46 extends to conduit 48 within the condenser-receiver 34. From the condenser-receiver 34, line 49 extends to the connection 17 of the shell 15 within the housing 10. A connection 18 at the other end of the shell 15 carries the water to a drain pipe 50.

In the operation of the device shown in Fig. 3, refrigerant discharges from the compressor 30 through line 31 and into conduit 14. In conduit 14 it passes through the housing 10 in heat exchange relation with the water passing through the shell 15 coming from condenser-receiver 34. The water temperature is still sufficiently below that of the discharge gas from the compressor to remove heat therefrom in order to effectively increase the capacity of the condenser.

Suction gas from the evaporator 37 passes into and through the housing 10 which thus serves as an accumulator. Because of the one-way valve 41 the suction gas from the evaporator is prevented from flowing into shell 16. However, since the shell is connected by line 42 to the compressor suction line 32 the pressure in
the shell will approximate that of the suction. As a result, shell 16 in effect, insulates or reduces heat transfer from shell 15 to the interior of the housing. Instead of connecting the shell 16 to the suction of the compressor, the invention also contemplates merely evacuating the shell the necessary amount, as shown in Fig. 11, or the substitution of other insulating media therefor to obtain the desired reduced heat transfer therethrough.

As described above, the system shown in Fig. 3 is an example of an embodiment of the invention in an otherwise conventional system.

The invention, however, has particular utility for changing the system from normal operation to defrosting, hot compressed gas being made available for passage through the evaporator coils to effect or assist in such defrosting operation.

Referring to Fig. 4, the system includes the compressor 50, discharge conduit 51, central conduit 14 and conduit 52 leading to a four-way valve 53, shown in the position for defrosting. Within the valve 53, conduit 52 is connected by passage 54 to conduit 55, which is connected to shell 16 by line 42. From the shell 16 the refrigerant gas flows through branch line 40, and valve 41 to T 83 in conduit 56. Conduit 56 is connected by T 57 to branch lines 58, 59 leading to evaporators 60, 61, respectively, arranged in parallel.

In the evaporator 60 and 61, the gas gives up heat to melt the frost therefrom and in so doing, all or a part of the refrigerant is condensed. From evaporator 60, refrigerant passes through T 62 to conduit 63 and T 64. Similarly, refrigerant from evaporator 61 passes through T 61 to conduit 65 and T 66. From T 64 the combined flow passes through conduit 67 to four-way valve 68, shown in the defrosting position. Four-way valves 53 and 68 are shown in Figs. 4a and 4b respectively, in their normal position for refrigeration operation. In valve 68, the refrigerant from conduit 67 flows through passageway 69 to conduit 70, to the condenser receiver 34. In condenser-receiver 34 the refrigerant is warmed by the water passing through the conduit 48 therein and is then drawn through conduit 71, passageway 72 in valve 53, and conduit 73 into the compressor 30.

During defrosting, hot compressed refrigerant in passing through conduit 14 may be slightly cooled, but not enough to prevent its subsequent defrosting action. The refrigerant then passes on through the coils 60 and 61, melting the frost therefrom and in so doing being entirely condensed. From the coils it flows into the condenser receiver 34, where it is returned to the gaseous phase for subsequent return to the compressor.

In the normal or refrigerating operation of the system, the valves 53 and 68 are rotated approximately 90 degrees to the positions shown in Figs. 4a and 4b. In such position the refrigerant flows from the compressor, passes through conduits 51, 14 and 52 to the valve 53 and through the valve and conduit 71 to the condenser receiver 34. From the receiver 34 the liquid refrigerant flows through conduit 70, valve 68 and conduit 75 to T 76. From T 76 the flow separates into conduits 77 and 78 to expansion valves 79 and 80 respectively. From the expansion valves, the refrigerant flows through evaporators 60 and 61 to conduit 56, to pipe 22 shown in the lower part of the housing 10. From pipe 22, the gaseous refrigerant flows into pipe 21 to conduit 55 and valve 53 to conduit 73, the suction line of the compressor 30, shell 16 being under suction pressure to insulate it as described above.

Fig. 5 illustrates an application of the present invention, in which electric heating coils 90 are employed to supplement the hot gas defrosting of the Fig. 4 embodiment. The valve 53 is shown in the system in the position for normal refrigeration operation. In Fig. 5a it is shown in the position for defrosting. Inasmuch as only one evaporator coil is shown in Fig. 5, a valve similar to valve 68 in Fig. 4 is not required.

In order that during defrosting refrigerant may circulate through evaporator 37 back to condenser-receiver 34, a bypass 91 is connected around the evaporator 35 and preferably has a pressure operated one-way valve 92 therein, which is set to open at a predetermined minimum pressure.

In Fig. 6, a system is shown which is adapted to defrost through both use of the hot gas and also by water which has been warmed through heat exchange with the hot gas. The system includes elements similar to those of Figs. 3, 4, and 5 and, in addition, means for conveying water from the shell 16 to the coils of the evaporator. Conduit 50 from the discharge end of shell 15 extends to a four-way valve 101. In Fig. 6 the valves are shown in position for normal refrigeration operation and in Figs. 6a, 6b for defrosting. Accordingly, with the valves in the position shown in Fig. 6, the water flows through its passageway 102 to pipe 103 and out through the drain 104.

When valve 101 is in the position for defrosting, the water flows from conduit 102 through the valve to conduit 105 and then to a spray or other distribution means 106. From the spray 106, the water passes downwardly over the evaporator 37 to the drain pan 108 and is discharged through the drain 104.

In the defrosting operation of the system, the refrigerant flows in a circuit similar to that of Figs. 3, 4 and 5. The water entering through conduit 47 is cooled in passing through conduit 48 within the receiver-condenser and then flows in the shell 16 around the central conduit 14 and in counter-flow to the hot gaseous refrigerant passing therethrough. In so doing, the water picks up more heat than was lost in conduit 48, including that from friction losses in the compressor, so that it may efficiently remove frost from the outside of the evaporator coils 37. At the same time, the hot gaseous refrigerant flows into the coils 37 supplying heat thereto, in order to assist in the melting of the accumulated frost.

In accordance with the present invention, the system is equipped with an evaporator 37 which flows around the expansion valve through bypass 91 and valve 92 back into the line going to the receiver. In accordance with a second method, the compressor 30 is preferentially connected to the receiver. In accordance with another method of operating the device, however, the bypass around the expansion valve is set to remain closed during normal defrosting so that flow of refrigerant back to the receiver from the coils is prevented. Under this latter method the compressor keeps pumping against the pressure in the line but the refrigerant circuit is closed. Defrosting, however, is carried out by the water coming in through the pipe 47 supplemented by the heat obtained from the refrigerant with whose temperature is raised somewhat as a result of being under pressure. The operation of the device in accordance with this second method is somewhat simpler than that first described, both however, permitting the compressor to run continuously. Thus there is provided a single coil gas defrosting system in which the compressor may operate continuously.

Whether it is preferable to have the system defrost by permitting flow of refrigerant flows through bypass 91 depends on several factors. Generally, if the evaporator is so constructed as to require a relatively long time for defrosting, the by-pass will have to be open to permit the refrigerant to circulate and provide additional heat. If a relatively short defrost period is adequate, as for example, in an evaporator with few coils, enough heat may be obtained from the gas under pressure in the evaporator to defrost without full circulation.

Fig. 10 is similar to Fig. 6 except that instead of having a hook-up for spraying water over the coils as in Fig. 6, line 109 extends from the four-way valve 101 to the drip pan 108. During normal operation the water from line 50 is directed through the valve out the drain lines 103.
During defrosting, the four-way valves may be positioned as shown in Figs. 10a and 10b, the valve 101 in such position diverting the water into the drip pan.

The water will thus assist in melting fragments of ice dropping from the coils and thus prevent clogging of the drain.

Fig. 7 illustrates the application of the device of my invention to a system similar to that of Fig. 3, except that an air-cooled condenser is employed instead of using water for removing some of the superheat from the refrigerant in conduit 14, a separate closed fluid system is employed. In Fig. 7, compressor 30 discharges refrigerant through conduit 31 to condenser 110 and then through conduit 51 to conduit 14 within the housing, the condenser being in the line ahead of conduit 14 for greater efficiency. From conduit 14 the refrigerant passes to receiver 51 and conduit 35, to the evaporator 37. From the evaporator, the return flow to the compressor 30 is the same as described above in connection with Fig. 3.

In order to supply cooling fluid to shell 15 about conduit 14, a separate system is provided having a condenser 112 and receiver 113. From receiver 113, the fluid passes through conduit 114 to restrictor 115. From restrictor 115, the flow is through conduit 116 to connection 18 of shell 15. After flowing through shell 15 and being evaporated by heat from the refrigerant passing through conduit 14, the fluid from the shell discharges through connection 17 to conduit 117 and is then returned to the condenser 112.

Instead of having the condenser 110 of the refrigeration system separate from the condenser 112 of the separate fluid cooling system, the invention contemplates the combining of features as shown in Figs. 8 and 9. In Fig. 8 the conduit 117 from the shell 15 enters one end of a shell 120 of a tube condenser 121. After passing the length of the shells 120, 122 and 123 of the condenser, the fluid is discharged to the receiver 113 through conduit 117. The refrigerant from the compressor, after passing through the central conduit 14, passes through the tube 124 of the shell and tube condenser 121 to the receiver 111, the flow through the tube 124 being counter to that of the fluid through the shells 120, 122 and 123.

Fig. 9 discloses a system similar to that of Fig. 8, except that instead of employing a shell and tube condenser for heat exchange between the fluid in the shells and the refrigerant in the tube, separate condenser coils are used.

The device of Figure 2 is a modification of that of Fig. 1 and includes a housing 210 having a side wall 211 and end walls 212 and 213. Conduit 214 extends axially and centrally of the housing and has shell 215 which does not extend beyond the housing as in Fig. 1 but is instead entirely therewithin. Connections 217 and 218 are attached to either end of the shell 215. Shell 216 surrounds shell 215 and is similar to shell 16 of Fig. 1 having connections 219 and 220. Pipes 221 and 222 are likewise disposed oppositely to each other as with pipes 21 and 22 in Fig. 1. Instead of having circular apertures as with the pipes of Fig. 1, saw tooth apertures 225 and 226 are provided. It is of course understood that apertures of various shapes may be employed.

Fig. 10 differs from Fig. 1 chiefly in that Fig. 2 illustrates a combined accumulator-heat exchanger disposed within a water cooled condenser. Accordingly, spaced walls 230 and 231 which conform generally to the shape of the housing 210 enclose within the housing the conduits and pipes described above. Connections 232 and 233 are connected to the outer wall 231 in order that the space between the walls 230 and 231 may be evacuated to the degree necessary to afford the desired amount of insulation. It is contemplated, however, that other means of insulating the space may be provided.

Wrapped around the wall 231 is coil 235 adapted to carry cooling water which enters the end 236 of the tube and leaves by the end 237 from which it is passed by a return bend (not shown) to a connection 217 for flow through shell 218 about the conduit 214. Space 239 between the wall 231 and the walls 212 and 213 of the housing 210 is adapted to have the refrigerant pass through it, after precooling in conduit 214, in order to be condensed by heat exchange with the liquid flowing through the pipes 235. Accordingly an inlet connection 241 is provided at the top of the condenser and a discharge connection 242 at the bottom.

Fig. 11 discloses an accumulator heat exchanger unit similar to Fig. 1 except that the connections 19 and 20 of Fig. 1 are omitted and the shell 16' of Fig. 11 is evacuated to produce the desired degree of insulation. Instead of evacuating shell 16', other insulating means may be provided.

Figs. 11 and 12 also illustrate the use of fins 245 on the conduit 14 and shell 15, the provision thereof obviously being within the scope of the invention.

While the device of my invention is shown in several particular applications, it is understood that its use is not restricted to those but that it may be used in others as well. It is further understood that the invention is not limited to the particular construction of the illustrated embodiments but that various modifications and substitutions are within the scope of the invention.

What is claimed is:

1. For use with a refrigeration system having a compressor, condenser, and evaporator, an accumulator heat exchanger comprising a central conduit for the passage of compressed refrigerant, said central conduit being provided for passing refrigerant from the compressor to the condenser, said condenser being fluid cooled, a first shell about said central conduit for the passage of said cooling fluid leaving the condenser, inlet and outlet connections in said first shell for said cooling fluid, insulating means about said first shell, a housing around said central conduit, said first shell, and said insulating means, said housing having inlet and outlet ports communicating with each other within said housing, said inlet port being provided for connection to the discharge of the evaporator for receiving refrigerant therefrom, said housing having a storage space for liquid refrigerant, said outlet port being provided for connection to the compressor and being spaced from said storage space to prevent flow of liquid therethrough, the insulating means limiting exchange of heat between the refrigerant and fluid in the conduit and first shell, respectively, and the refrigerant returning from the evaporator.

2. The structure of claim 1, said insulating means comprising a second shell about said first shell, said second shell having a connecting means adjacent to each of its ends, one of said connecting means being provided for connection to the compressor suction, the other of said connecting means being provided for connection to the evaporator discharge.

3. In a refrigeration system, a first cooling means for compressed refrigerant in which superheat is removed therefrom, a fluid cooled condenser in which the cooled compressed refrigerant is condensed, means for passing compressed refrigerant from said first cooling means to said condenser, means for passing cooling fluid from the condenser to said first cooling means for condensing and for removing superheat from the compressed refrigerant, respectively, a housing around the first cooling means, said housing having a storage space for liquid refrigerant and an outlet to the compressor suction, the outlet being spaced from the storage space to prevent flow of liquid therethrough, means connecting the housing to the evaporator whereby refrigerant returning from the evaporator passes through the housing on its way to the compressor suction, said means limiting heat transfer within the housing between said returning refrigerant and said compressed refrigerant and cooling fluid.

4. The structure of claim 3, a second outlet to the compressor suction, said second outlet being restricted
and being positioned adjacent to the lower portion of the housing whereby liquid collecting in the lower portion of the housing may be metered into the compressor suction.

5. For use with a refrigeration system having a compressor, condenser, and evaporator, an accumulator heat exchanger comprising a central conduit, a first shell about said central conduit, inlet and outlet connections in said first shell, insulating means about said first shell, a housing around said central conduit, said first shell, and said insulating means, said housing having inlet and outlet ports communicating with each other within said housing, said inlet port being provided for connection to the discharge of the evaporator for receiving refrigerant therefrom, said housing having a storage space for liquid refrigerant, said outlet port being provided for connection to the compressor and being spaced from said storage space to prevent flow of liquid therethrough, the insulating means limiting exchange of heat between the refrigerant and fluid in the conduit and first shell, respectively, and the refrigerant returning from the evaporator.

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