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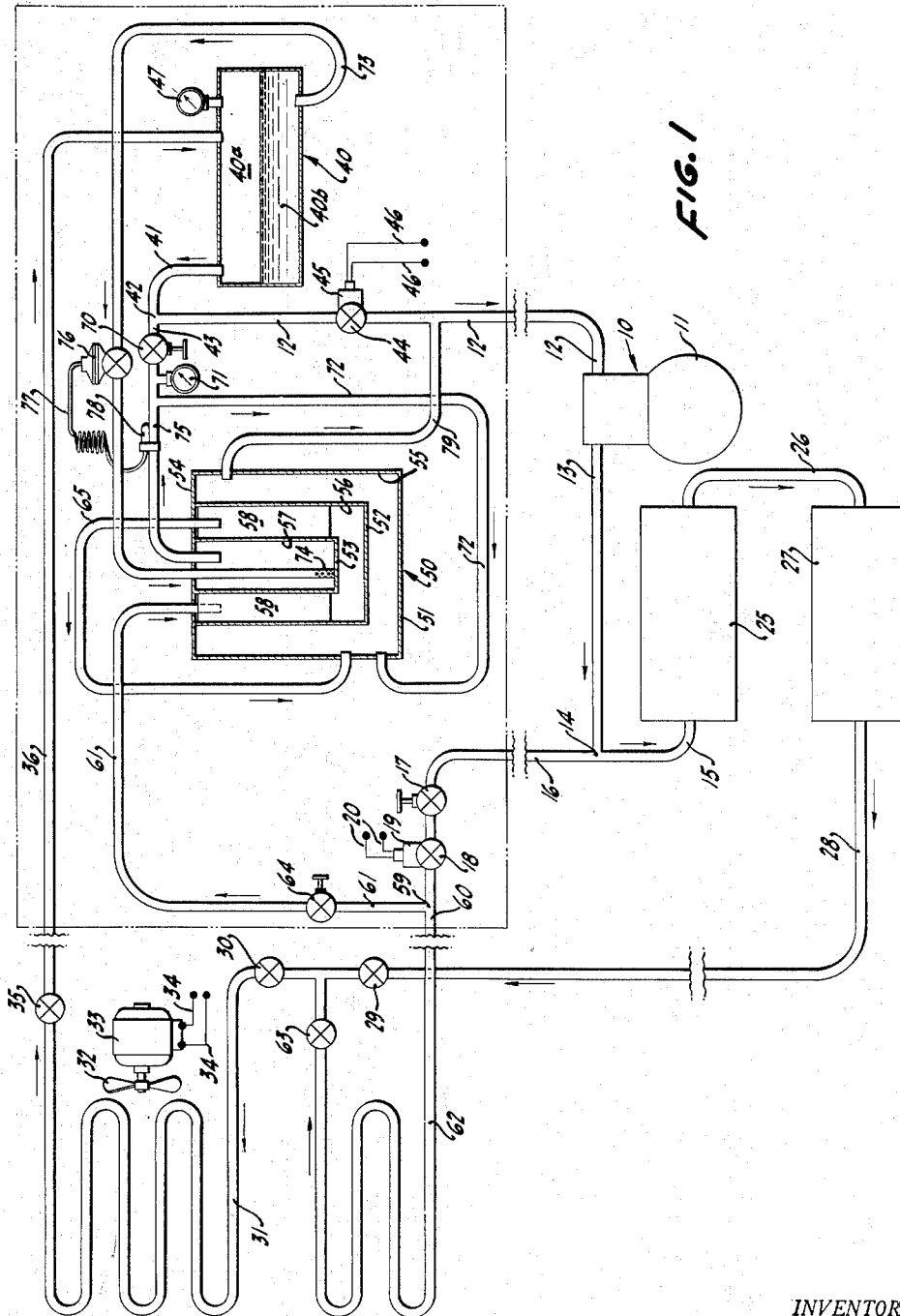
E. TOOTHMAN

2,729,950

HOT GAS DEFROSTING SYSTEM

Filed March 18, 1953

3 Sheets-Sheet 1



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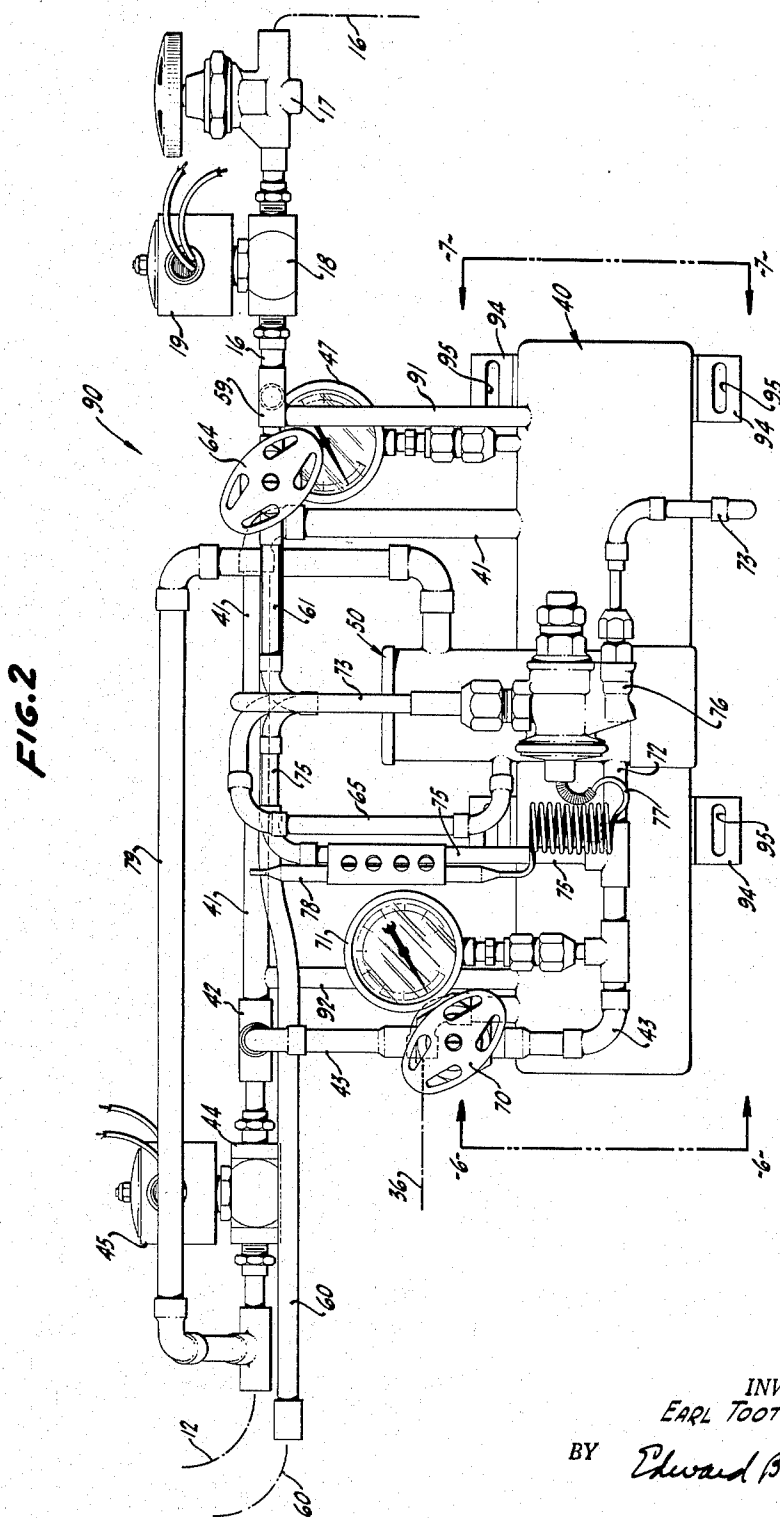
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## HOT GAS DEFROSTING SYSTEM

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3 Sheets-Sheet 2



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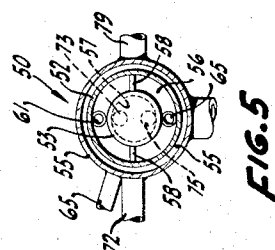
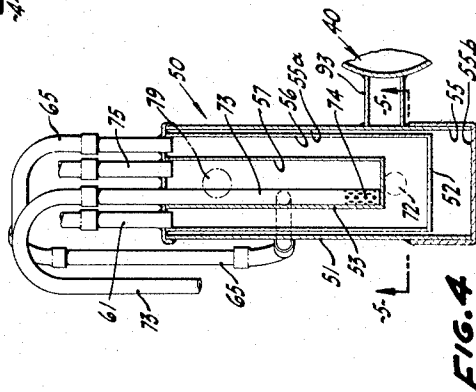
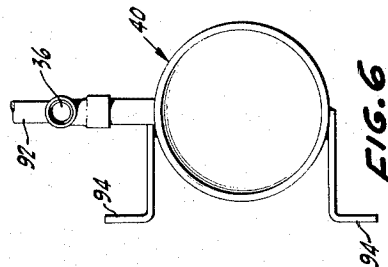
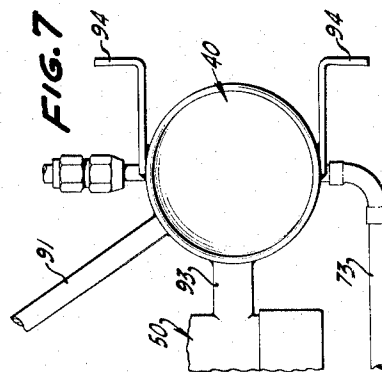
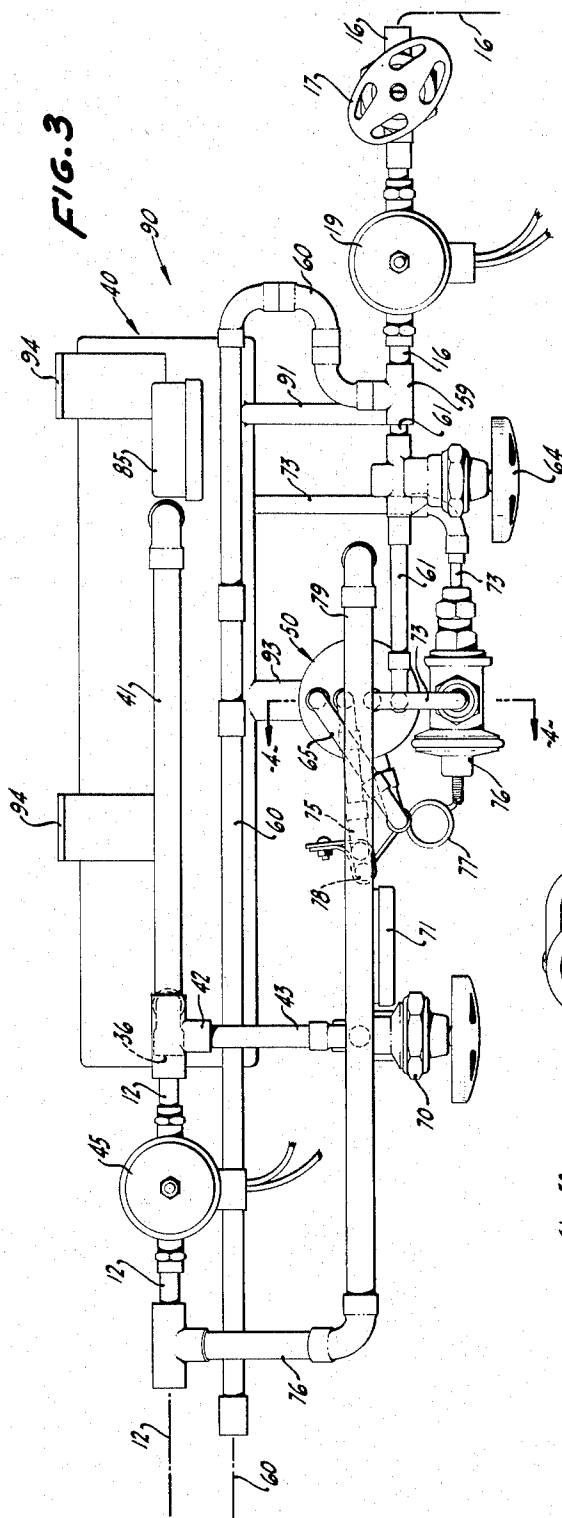
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HOT GAS DEFROSTING SYSTEM

Filed March 18, 1953

3 Sheets-Sheet 3



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2,729,950

## HOT GAS DEFROSTING SYSTEM

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Application March 18, 1953, Serial No. 343,108

13 Claims. (Cl. 62—3)

This invention relates to a hot gas defrosting system.

This application is a continuation-in-part of my copending application Serial No. 224,319, filed May 3, 1951, now Patent No. 2,693,683, granted November 9, 1954, entitled "Defrosting Machine" and of my copending application Serial No. 277,555, filed March 20, 1952, now Patent No. 2,693,678, granted November 9, 1954, entitled "Automatic Defrosting System."

In a refrigeration system it is desirable to provide automatic defrosting means for periodically and automatically heating the evaporator coils of the system to defrost the same.

Various automatic defrosting systems have been proposed heretofore, some of which are in use. For example, electric heating means have been proposed heretofore wherein an electric heating element is inserted in or adjacent to the evaporator coils. A circuit is provided which is operated by a timer to energize the heating element at regular intervals and for a predetermined period of time. A disadvantage of electric defrosting is that the heating element employed is rapidly corroded. Also there is no satisfactory means of limiting pressure in an electric defrosting system; i. e., the heating element may overheat the evaporator coils and create too high a pressure.

Hot gas defrosting has been proposed heretofore and is, in fact, used extensively. Hot gas defrosting makes use of the heat contained in compressed gas from the compressor of the refrigeration system to heat and defrost the coils. Periodically the condenser of the refrigeration system is by-passed and hot compressed gas from the compressor is sent to the evaporator coils to accomplish defrosting. The spent gas is then returned to the suction line of the compressor. Hot gas defrosting has the advantages that corrodible heating elements are avoided and that the compressor provides an automatic pressure control.

Difficulties are encountered, however, in hot gas defrosting. Thus during the refrigeration cycle and/or during the initial part of the defrosting cycle, gaseous refrigerant is condensed in the evaporator coils and tends to collect and lie in these coils. During the defrosting cycle hot gas from the compressor pushes this liquid refrigerant from the coils. If it is returned to the suction line of the compressor along with gaseous refrigerant, slugging will occur. Slugging imposes a severe strain on the return lines and compressor, and it may rip lines off a wall and/or blow the head off the compressor. Also, if only liquid refrigerant is returned to the compressor, no hot gas will be produced by the compressor.

To avoid such difficulties, it has been proposed to trap liquid refrigerant pushed out of the evaporator coils by the hot gas during the defrosting cycle, and to evaporate the trapped liquid refrigerant by means of heat which is stored in a body of liquid during the refrigeration cycle. This system is disadvantageous because the heat required to accomplish re-evaporation of liquid refrigerant, especially during the initial part of the defrosting cycle when a great quantity of such liquid is pushed out of the evaporator coils, may be in excess of the heat that can, in practice, be supplied by a body of preheated liquid. This is a particularly great difficulty in cold weather. Also, this system is difficult to balance for

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summer and winter operation, and the liquid storage means or reservoir and the means for heating the liquid during the refrigeration cycle are relatively expensive.

In another hot gas defrosting system, heat is transferred directly from the hot gas to the cold refrigerant during the defrosting cycle, thereby avoiding the necessity of preheating a body of liquid during the refrigeration cycle to store up heat for use in re-evaporating liquid refrigerant during the defrosting cycle. In this system, however, the heat transfer means and the control means for controlling, adjusting and operating the hot gas defrosting system are unsatisfactory.

With both such hot gas defrosting systems, i. e., that system in which a body of liquid is preheated during the refrigeration cycle, and that system in which direct heat transfer between hot gas and cold refrigerant is accomplished during the defrosting cycle, still another difficulty has been encountered, as follows: The lubricant employed to lubricate the compressor of a refrigeration system inevitably and necessarily reaches the evaporator coils. Such lubricant is freely miscible with liquid refrigerants commonly used in refrigeration systems, e. g., Freon, which is the trademark of Kinetic Chemicals Co., a subsidiary of E. I. du Pont de Nemours Co., Wilmington, Delaware. Various grades of Freon are used, one of which, dichloro difluoromethane, is illustrative. During the defrosting cycle, when liquid refrigerant is pushed out of the evaporator coils the accumulated compressor lubricant is pushed out with the refrigerant. Heretofore no satisfactory means of returning this liquid lubricant to the compressor has been provided. Thus neither of the hot gas defrosting systems mentioned above provides a satisfactory means of returning the compressor lubricant to the compressor.

It is an object of the present invention to provide improved automatic defrosting means.

It is another object of the invention to provide improved automatic hot gas defrosting means.

Yet another object of the invention is to provide a hot gas defrosting system of the type in which hot gas is used for defrosting the coils and to re-evaporate condensed refrigerant, and wherein difficulties such as those mentioned above and previously encountered in hot gas defrosting systems are obviated.

Yet another object of the invention is to provide improved means for heat transfer in a hot gas defrosting system, to more effectively reheat the spent refrigerant and re-evaporate condensed refrigerant.

A further object of the invention is to provide an improved control means for a hot gas defrosting system of the character described, particularly of the character wherein the hot gas is employed to heat and re-evaporate condensed refrigerant.

A further object of the invention is to provide an improved means of returning compressor lubricant to the compressor.

These and other objects of the invention will be apparent from the ensuing description and the appended claims.

One form of the invention is illustrated by way of example in the accompanying drawings wherein,

Figure 1 is a diagrammatic view of a complete refrigeration system incorporating the hot gas defrosting system of the present invention.

Figure 2 is a view in side elevation of a defrosting unit constructed in accordance with the present invention.

Figure 3 is a top plan view of the same.

Figure 4 is a vertical, longitudinal section taken along the line 4—4 of Figure 3, showing the interior construction of the re-evaporator.

Figure 5 is a horizontal, transverse section taken along the line 5—5 of Figure 4.

Figures 6 and 7 are fragmentary views in end elevation as seen along the lines 6—6 and 7—7, respectively, of Figure 2.

Referring now to Figure 1 of the drawings a refrigeration system is there shown including a compressor 10 having a crankcase 11.

The compressor 10 is supplied with gaseous refrigerant through a suction line 12 and it delivers hot, compressed, gaseous refrigerant through a hot gas line 13. The hot gas line 13 divides at a T 14 into a first branch 15, and into a second branch 16. The second branch 16 is provided with a hand valve 17 and with a normally closed solenoid valve 18 which is operated by a solenoid 19 energized through leads 20.

The branch 15 is connected to a condenser 25 which in turn is connected through a line 26 with a receiver 27. The receiver 27 is connected by means of a line 28 containing an expansion valve 29 with a header 30, which distributes refrigerant to evaporator coils 31. It will be understood, of course, that more than one set of evaporator coils may be employed. A fan 32 is illustrated which is driven by a motor 33 energized through leads 34. The purpose of the fan 32 is to circulate air over the evaporator coils and to effect refrigeration of a large space such as a walk-in cooler or other large refrigerated space. The defrosting system of the present invention is, however, also adapted for use with smaller refrigeration systems such as household refrigerators.

The evaporator coils 31 are connected through a header 35 to a return line 36 which is connected to a receiving vessel 40. The receiving vessel 40 forms a part of the defrosting system of the present invention, as described more fully hereinafter. Refrigerant vapor passes from the receiving vessel 40 through a vapor line 41 which divides at a T 42 into a branch 43 and the above-mentioned suction line 12. A normally open solenoid valve 44 is located in the suction line 12 and is operated by a solenoid 45 which is energized through leads 46. As will be seen, the receiving vessel 40 is also provided with a gauge 47.

During the refrigeration cycle, and by virtue of an electrical timing system (not shown), the solenoid 19 is de-energized (hence the valve 18 is closed) and the solenoid 45 is energized (hence the valve 44 is open). Any suitable electrical timing system may be employed for this purpose, several of which are well known. A circuit such as that illustrated in my copending application Serial No. 277,555, now Patent No. 2,693,678, granted November 9, 1954, may be employed.

It will be apparent that, during the refrigeration cycle, hot compressed gas delivered by the compressor 10 through the hot gas line 13 will pass through the branch 15 to the condenser 25 wherein it will be condensed, as by means of air cooling, water cooling or other suitable means. Condensed refrigerant will then pass through the line 26 to the receiver 27 which acts as a storage vessel for liquid refrigerant. Liquid refrigerant then passes through the line 28 and is expanded by means of the expansion valve 29. In accordance with well known, conventional technique the expansion valve 29 may be controlled and regulated by a feeler bulb (not shown) to maintain proper expansion and flow of refrigerant to the evaporator coils. The expanded refrigerant, now largely or entirely in the form of cold vapor, passes through the header 30 into the evaporator coils 31. Spent refrigerant passes through the other header 35 into the return line 36, thence into the receiving vessel 40. Refrigerant vapor then returns through the vapor line 41 to the suction line 12, thence to the compressor where it is recompressed.

The defrosting system of the present invention includes the above-mentioned receiving vessel 40 and it also includes a re-evaporator 50 together with various connecting lines and control means described in detail hereinafter. The defrosting system is outlined in Figure 1 by the dot-dash lines. The re-evaporator 50 is a multiple compart-

ment vessel including an outer vessel 51, an intermediate vessel 52 and an inner vessel 53. A gas tight lid or cover 54 is provided and the entire re-evaporator, including the several vessels, are of gas tight construction except for the intercommunicating lines hereinafter described. As will be seen the arrangement of the vessels 51, 52 and 53 is such as to provide an outer compartment or chamber 55 between the outer vessel 51 and the intermediate vessel 52, an intermediate compartment or chamber 56 between the intermediate vessel 52 and the inner vessel 53 and an inner compartment or chamber 57 within the inner vessel 53. As will also be seen baffles 58 are provided within the inner chamber 57 which extend downwardly from the top of the intermediate vessel 52 to a point close to but spaced somewhat above the bottom of such vessel.

The remaining elements of the defrosting system of the present invention will be best understood in connection with the operation of the defrosting system, which will now be described. It is assumed that the system has previously been regulated.

The defrosting cycle is initiated by the timing system to occur at predetermined intervals, each cycle having a predetermined duration. In a typical, large commercial installation the defrosting cycle may have a duration of thirty minutes and may be initiated once every twelve hours. When the defrosting cycle is initiated, the valve 18 opens and the valve 44 closes. Hot gas from the compressor 10 therefore by-passes the condenser 25 and passes, instead, through the branch line 16. The compressed hot gas divides at a T 59. A portion of the hot gas passes through a branch 60 and another portion through a branch 61. The portion of hot gas passing through the branch 60 enters drip pan coils 62, then passes through a check valve 63 to the line 28 at a point between the expansion valve 29 and the header 30. It will be apparent that the hot gas is not expanded and that it remains in a hot, compressed state until it reaches the evaporator coils. The drip pan coils 62 are an optional feature insofar as the defrosting system of the present invention is concerned. If desired, the hot gas may be supplied directly to the evaporator coils 31 without first passing through the drip pan coils 62. However, the arrangement shown is preferred.

In the evaporator coils 31 the hot gas accomplishes defrosting in the manner explained hereinabove. After passing through the coils, the hot gas passes through the header 35 into the return line 36, thence into the receiving vessel 40. As explained above, during the refrigeration cycle and/or during the initial portion of the defrosting cycle, gaseous refrigerant is condensed to liquid in the evaporator coils 31, and during the defrosting period hot gas pushes the accumulated refrigerant from the coils. This liquid refrigerant is delivered, along with spent refrigerant vapor, to the receiving vessel 40. As also explained hereinabove, during operation of the refrigeration system lubricant from the compressor 10 passes into the system and a certain portion thereof collects in the evaporator coils 31. It is pushed out of the coils by the hot gas during the defrosting cycle and is introduced through the return line 36 into the receiving vessel 40.

It is a purpose of the receiving vessel 40 to separate spent refrigerant vapor from liquid refrigerant which are shown, respectively, at 40a and 40b. It is also a purpose of the receiving vessel 40 to serve as a reservoir for holding liquid refrigerant. It is a purpose of the re-evaporator 50 to re-evaporate liquid refrigerant and it is another purpose of this re-evaporator to convert the compressor lubricant contained in the liquid refrigerant to a form such that it can be returned to the compressor without difficulty. These functions are carried out in the manner and by the means which will now be described.

Hot gas passing through the branch line 61 and through a hand valve 64 contained in the line 61 enters the intermediate chamber 56 of the re-evaporator 50. As will be seen the line or pipe 61 extends only a short distance into

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the upper end of the intermediate compartment 46 and is located on one side of the baffles 58. A pipe 65 is provided which is connected at one end to the intermediate chamber 56 and at its other end to the outer chamber 55. As will be seen the pipe 65 extends only a short distance into the upper end of the intermediate chamber 56 and is located on the opposite side of the baffles 58 with respect to the pipe 61. As will also be seen, the other end of the pipe 65 communicates with the outer chamber 55 near the bottom thereof and at the left as viewed in Figure 1. Spent refrigerant vapor coming from the receiving vessel 40 through the line 41 passes into the pipe 43 which contains a manually operated control valve 70 and to which is connected a pressure gauge 71. Refrigerant vapor then passes through a pipe 72 into the outer chamber 55 of the heat exchanger 50. Preferably, as indicated, the pipe 72 connects with the outer chamber 55 near the bottom thereof and adjacent the pipe 65. Liquid refrigerant, together with compressor lubricant contained therein, are removed from the receiving vessel 40 through a pipe 73. The pipe 73 extends into the inner chamber 57 of the re-evaporator 50, to a point near the bottom of the chamber. At its lower end, within the chamber 57, the pipe 73 is formed with small holes 74 to provide, in effect, a restricted orifice or nozzle for spraying liquid refrigerant. A pipe 75 is provided one end of which extends into the upper end of the inner chamber 57. At its other end the pipe 75 is connected to the pipe 72. As will be seen, an expansion valve 76 is located in the pipe 73 and is connected by a coil 77 to a feeler bulb 78 which is attached to the pipe 75.

During the defrosting cycle, hot gas diverted through branch line 61 provides the heat necessary for reheating spent gaseous refrigerant and for re-evaporation of liquid refrigerant. The proportion of hot gas diverted for this purpose is controlled by the valve 64. The major portion of the heat given up by the hot gas for this purpose, is given up in the intermediate chamber 56 from which heat flows to the inner chamber 57 and to the outer chamber 55 by conduction through the walls separating these chambers.

Refrigerant vapor from the receiving vessel 40 passes through pipes 41 and 72 into the outer chamber 55 of heat exchanger 50 where it is heated indirectly by hot gas in the intermediate chamber 56 (i. e., by conduction through the walls of compartment 53), and where it is also heated by direct mixture with hot gas entering through pipe 65. The juxtaposition of the outlets of pipes 65 and 72 promotes such mixing of hot gas and spent refrigerant.

Meanwhile liquid refrigerant from receiving vessel 40 enters the inner chamber 57 through pipe 73 and nozzle 74. It is sprayed into the inner chamber by reason of the restricted character of the holes 74 and it is expanded to the vapor state by reason of the expansion valve 76. It is also heated by heat absorbed from the hot gas in intermediate chamber 56. The combined effects of expansion, spraying and heating the liquid refrigerant into inner chamber 57 are such that the liquid refrigerant is rapidly and completely vaporized and the lubricant is dispersed in the vapor in the form of small particles, i. e., as a mist. In this form the lubricant can be safely returned to the compressor without slugging and without the necessity of trapping it and returning it to the crankcase.

The resulting mist, or suspension of lubricant in refrigerant vapor, is further heated by passage through pipes 75 and 72 into the outer chamber 55, where it is heated directly by mixture with hot gas and indirectly by conduction through the walls of vessel 52.

Finally, heated, re-evaporated refrigerant, and lubricant dispersed therein, are returned to the compressor through pipe 79 and suction line 12.

At the conclusion of the defrosting cycle, the valve 18 is closed and the valve 44 is opened, thus renewing the refrigeration cycle.

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The operation thus described assumes that the system has been properly regulated. At the outset, after installation of the defrosting system of my invention, it is, of course, necessary to regulate the system to obtain optimum performance. It is an important advantage of my invention that such regulation can be easily accomplished and that, when it has been accomplished, the system will continue to operate efficiently for a long period of time.

The functions of the solenoid valves 18 and 44 have been explained; they automatically initiate and terminate the defrosting cycle. The hand valve 17 is a service valve which can be operated manually to allow servicing the solenoid valve 18 without shutting down the system.

In starting the refrigeration system of Figure 1, the defrost cycle is initiated manually and valves 64 and 70 are closed. Then valve 70 is opened until gauge 71 reads about five pounds per square inch gauge pressure. (Pressures hereinafter will be understood to be gauge pressures rather than absolute pressures.) The valve 64 is opened until no further frosting of pipe 75 is observed. The setting of valve 70 will generally be such that gauge 71 registers about fifteen pounds during defrosting. This pressure is generally adequate for efficient operation of the compressor, and for efficient defrosting. However, if the suction line 12 is long, the valve 70 is preferably opened to produce a pressure reading of twenty to twenty-five pounds on gauge 71.

The expansion valve 76 and its coil 77 and feeler bulb 78 may be of known construction and operation. As is well known, a volatile fluid, such as a small quantity of the refrigerant used in the refrigeration system, is used in the coil and it assumes the temperature of the feeler bulb, hence the corresponding pressure, and exerts a pressure on a diaphragm in the valve. In the system of the present invention, the valve 76 is selected and adjusted to open when a predetermined temperature differential exists between the fluid in the pipe 75 and the fluid in the pipe 73 ahead of the valve 76. Preferably, the predetermined temperature differential is about 8 to 10° F. By this means, liquid refrigerant is expanded and sprayed into the inner chamber 57, only to the extent that it can be evaporated by heat from hot gas in the chamber 56.

The recirculation of refrigerant vapor from chamber 57 through pipes 75 and 72, and of refrigerant vapor from receiving vessel 40 through pipes 41, 43 and 72, to the outer chamber 55, provides an extra factor of safety; any liquid refrigerant remaining in the gas is vaporized, and the gas leaving re-evaporator 50 through pipe 76 is dry except for suspended lubricant.

The adjustments noted above may, of course, be varied in the light of existing circumstances. The valve 64 controls the amount of heat diverted from the evaporator coils to the re-evaporator. The valve 70 controls the back pressure on the compressor, i. e., the pressure at the inlet of the compressor. The expansion valve 76 controls the rate of expansion and spraying of liquid refrigerant into the evaporator. By a modicum of trial and error, optimum settings of these valves can be determined.

Another feature that may be noted is that external piping may be diminished in the case of the re-evaporator 50. Thus, a direct opening may be provided between the chambers 56 and 55, instead of providing the external pipe 65. In such case, provision should be made for intimate mixing of warm gas from the chamber 56 with cold, and possibly wet gas from the receiving vessel 40 and inner chamber 57.

As stated above the defrosting system of the present invention is that portion of the refrigeration system shown in Figure 1 which is enclosed or boxed in by the dot-dash lines. It is there shown in diagrammatic form, and the breaks in the lines 12, 16, 28, 60 and 36 indicate that these lines may be of greater or lesser length, depending

upon circumstances. Thus the compressor 10, the condenser 25 and the receiver 27 and their connecting lines constitute a unit which may be in one location, e. g., in an engine house. The evaporator coils 31, drip pan coils 62, fan 32 and motor 33 constitute another unit which will, of course, be located in the refrigerated space, which may be close to the compressor-condenser-receiver unit, or which may be located at a considerable distance therefrom. Similarly the defrosting unit may be located in close proximity to the compressor-condenser-receiver unit and/or to the evaporator coils, or it may be situated at a considerable distance from either or both of these units. It is an important advantage of the defrosting system of the present invention that it can be located close to or far from the other units of a refrigeration system without encountering serious difficulties.

The separate components of the defrosting system of the present invention may be built as a single integral unit or they may be built as separate units and spaced some distance apart. However, it is preferred that the defrosting system of the present invention be built as an integral unit with means for mounting it at any desired location. Such an integral unit is shown in Figures 2 to 7.

Referring now to these figures, and more particularly to Figures 2 and 3, parts which are the same as parts shown in Figure 1 are similarly numbered.

Referring now to Figures 2 to 7 and more particularly to Figures 2 and 3, the defrosting unit of the present invention is generally designated by the numeral 90. It comprises the receiving vessel 40 and the re-evaporator 50. The receiving vessel 40 is provided with the gauge 47 and to it is connected the return line 36 for supplying cold or spent refrigerant from the evaporator coils. The portion of the return line 36 shown in Figures 2 and 3 is, of course, provided with a fitting which is connected to the remainder of the line when an actual installation is made. The receiving vessel 40 is also provided with the vapor return line 41 which is connected by the T 42 to the pipe 43 and to the suction line 12. The manual control valve 70 and the gauge 71 are connected to the pipe 43, and the pipe 43 is connected to the pipe 72 which is connected to the re-evaporator 50. The receiving vessel 40 is also provided with the liquid refrigerant pipe 73 which is also connected to the re-evaporator 50 and which is provided with the expansion valve 76. Also shown in Figures 2 and 3 is the hot gas line 16 which is provided with the manual service valve 17 and the solenoid valve 18 which is operated by the solenoid 19. The line 16 may also be provided with a second solenoid valve and solenoid (not shown) ahead of the service valve 17, i. e., to the right thereof as viewed in Figures 2 and 3. Preferably such solenoid valve, if employed, is located close to the T 14 (see Figure 1) and it is closed during the refrigeration cycle and open during the defrosting cycle. Its purpose is to prevent hot gas from condensing in the line 16 during the refrigeration cycle and would be employed most advantageously if the line 16 happens to be a long line.

The T 59 shown in Figure 3 connects the line 16 with the lines 60 and 61. The line 60 is, of course, connected by an extension thereof to the evaporator coils as explained hereinabove. The line 61 is connected to the re-evaporator 50 and is provided with the manual control valve 64. As is also shown in Figures 2 and 3, the pipe 65 is provided to interconnect different portions of the re-evaporator 50, and the pipe 75 connects the re-evaporator with the pipe 72. The feeler bulb 78 attached to the pipe 75 serves to control the expansion valve 76. Also shown in Figures 2 and 3 are the solenoid valve 45 which is located in the suction line 12 and is operated by the solenoid 45, and the pipe 79 which by-passes the solenoid valve 44 during the defrosting cycle and which serves to supply re-evaporated, dry refrigerant to the inlet of the compressor.

The defrosting unit 90 is built as a sturdy unit which is

mounted in the position shown in Figure 2. A rod 91 is welded at one end to the receiving vessel 40 and at its other end to the T 59. Another rod 92 is provided which is welded at one end to the receiving vessel 40 and at its other end to the pipe 41. Also a short length of pipe 93 is welded to the re-evaporator 50 and the receiving vessel 40. The rods 91 and 92 and the length of pipe 93, together with the piping illustrated, provide a sturdy bracing to hold together the components of the unit. As shown in Figures 2 and 3 and also in Figures 6 and 7, brackets 94 are provided which are welded to the vessel 40 and which have slots 95 formed at their outer ends by means of which the entire unit can be mounted on a wall or other permanent structure.

Referring now to Figures 4 and 5, the inner structure of the re-evaporator 50 is there shown in detail. As illustrated the outside diameter of the intermediate vessel 52 is only slightly less than the inside diameter of the outer vessel 51. Also the bottom of the intermediate vessel 52 is spaced a substantial distance from the bottom of the outer vessel 51. As a consequence the outer chamber 55 of the re-evaporator 50 comprises a very narrow annular space 55a and a relatively large space 55b. This arrangement promotes efficient mixing of the warm gas (which is introduced into the outer chamber through the pipe 65) with the cold or wet gas (which is introduced through the pipe 72). It also promotes efficient heat transfer from the hot gas in the intermediate chamber 56 through the walls of the intermediate vessel 52 to the cold or wet gas in the outer chamber 55.

It will, therefore, be apparent that a hot gas defrosting system has been provided which has a number of desirable features. A unit such as that shown at 90 in Figures 2 and 3 is sturdy and can be mounted on a wall or other permanent structure. The unit can be located, for example, in an engine room adjacent the compressor, condenser and receiver, or it may be located in or near the refrigerated space in proximity to the evaporator coils, or it may be located separately and apart from both the compressor, etc., and the evaporator. The unit is automatic in its operation, it has the advantages which are inherent in a hot gas defrosting system and, at the same time, it overcomes or alleviates difficulties which have been encountered in connection with hot gas defrosting systems.

Among such difficulties is the difficulty mentioned above in connection with the tendency of compressor lubricant to accumulate in the evaporator coils. As noted above, this difficulty is solved by the system of the present invention by expanding and spraying liquid refrigerant containing compressor lubricant into the re-evaporator 50, thereby forming a mist of the lubricant which can then be safely returned to the inlet of the compressor.

Another feature of the system resides in the controls furnished by the valves 64, 70 and 76. By proper selection and setting of the expansion valve 76 and by proper adjustment of the manual control valves 64 and 70 the system can be made to operate efficiently for an indefinitely long period of time, even under greatly varying conditions, e. g., summer heat and winter cold. Also these controls, together with other features of the system, permit satisfactory operation even with long lines. For example the line 60 for supplying hot gas to the evaporator coils and the line 36 for returning cold refrigerant from the evaporator coils to the defrosting unit, may be lines of considerable length. Another advantage of the system is the efficient heat transfer accomplished by the re-evaporator 50.

I claim:

1. In a refrigeration system comprising a compressor for compressing a gaseous refrigerant to produce hot, compressed gas, a condenser for condensing the hot gas to produce liquid refrigerant, an evaporator and means for expanding liquid refrigerant into said evaporator, the

improvement which comprises a hot gas defrosting system comprising means for by-passing said condenser during a defrosting cycle to pass hot gas from the compressor through the evaporator to defrost the same, a receiving vessel for receiving and holding liquid refrigerant expelled from the evaporator, means connecting said receiving vessel with said evaporator to conduct liquid refrigerant expelled from the evaporator to the receiving vessel, a re-evaporator, means for diverting a portion of the hot gas from said compressor to said re-evaporator to heat and evaporate liquid refrigerant, means for conducting liquid refrigerant from said receiving vessel to said evaporator, and control means effective to regulate the rate of delivery of hot gas and of liquid refrigerant to said re-evaporator to completely evaporate the liquid refrigerant therein, and means connecting said re-evaporator with said compressor to supply refrigerant vapor to the compressor.

2. In a refrigeration system comprising a compressor for compressing a gaseous refrigerant to produce hot compressed gas, a condenser for condensing the hot gas to produce liquid refrigerant, an evaporator and means for expanding liquid refrigerant into said evaporator, the improvement which comprises a hot gas defrosting system comprising means for by-passing said condenser during a defrosting cycle to pass hot gas from the compressor through the evaporator to defrost the same, a receiving vessel for receiving and holding liquid refrigerant expelled from the evaporator, means connecting said receiving vessel from said evaporator to conduct liquid refrigerant expelled from the evaporator to the receiving vessel, a re-evaporator, means for diverting a portion of the hot gas from said compressor to said re-evaporator to heat and evaporate liquid refrigerant, means for conducting liquid refrigerant from said receiving vessel to said re-evaporator, means for also conducting cold refrigerant vapor from said evaporator to said re-evaporator, and control means effective to regulate the rate of delivery of hot gas, of cold refrigerant vapor and of liquid refrigerant to said re-evaporator to completely evaporate liquid refrigerant, to warm the cold refrigerant vapor and to vaporize liquid refrigerant suspended in the cold vapor, and means connecting said re-evaporator with said compressor to supply refrigerant vapor to the compressor.

3. A hot gas defrosting system comprising a receiving vessel for receiving cold refrigerant vapor and liquid refrigerant from the evaporator of a refrigeration system during a defrosting cycle, a re-evaporator for heating said cold refrigerant vapor and for evaporating said liquid refrigerant, means for by-passing the condenser of said refrigeration system during such defrosting cycle and for passing hot gas from the compressor to the evaporator to defrost the same, hot gas supply means for simultaneously diverting a portion of such hot gas to said re-evaporator to supply the heat necessary for such heating and re-evaporating, means connecting said receiving vessel with said re-evaporator to supply refrigerant vapor thereto, means also connecting said receiving vessel with said re-evaporator to supply liquid refrigerant thereto, control means for each said connecting means to control the rate of supply of refrigerant vapor and of liquid refrigerant to said re-evaporator, and control means for said hot gas supply means to control the rate of supply of hot gas to said re-evaporator; said various control means being adjustable to maintain the supply of refrigerant to the suction inlet of the compressor in a completely dry condition except for suspended lubricant and at a substantially constant pressure adequate for efficient operation of the compressor and for rapid, efficient defrosting.

4. A hot gas defrosting system comprising a receiving vessel for receiving cold refrigerant vapor and liquid refrigerant from the evaporator of a refrigeration system during a defrosting cycle, a re-evaporator for heating said cold refrigerant vapor and for evaporating said liquid

refrigerant, means for by-passing the condenser of said refrigeration system during such defrosting cycle and for passing hot gas from the compressor to the evaporator to defrost the same, hot gas supply means for simultaneously diverting a portion of such hot gas to said re-evaporator to supply the heat necessary for such heating and re-evaporating, vapor supply means connecting said receiving vessel with said re-evaporator to supply refrigerant vapor thereto, liquid supply means also connecting said receiving vessel with said re-evaporator to supply liquid refrigerant thereto, an adjustable control valve for said vapor supply means to control the rate of supply of refrigerant vapor to said re-evaporator, an expansion valve for said liquid supply means for regulating the supply of liquid refrigerant to and for expanding it into said re-evaporator, and an adjustable control valve for said hot gas supply means to control the rate of supply of hot gas to said re-evaporator; said various control means being operable to maintain the supply of refrigerant to the suction inlet of the compressor in a completely dry condition except for suspended lubricant and at a substantially constant pressure adequate for efficient operation of the compressor and for rapid, efficient defrosting.

5. In a hot gas defrosting system comprising means for automatically by-passing the condenser of a refrigeration system to supply hot gas to the evaporator of such system and thereby defrost the same, and means for returning refrigerant from the evaporator to the compressor, the improvement which comprises a multiple compartment vessel for heating cold refrigerant vapor and for re-evaporating liquid refrigerant expelled from said evaporator, said vessel comprising a first hot gas chamber, a second liquid refrigerant chamber and a third refrigerant vapor chamber, said liquid refrigerant and refrigerant vapor chambers being in heat exchange relation with said hot gas chamber to absorb heat therefrom, means for diverting a portion of the hot gas from the compressor to said hot gas chamber during the defrosting cycle and means for separating the bulk of liquid refrigerant expelled from the evaporator from cold refrigerant vapor and for supplying the separated vapor to said vapor chamber and for spraying the separated liquid into said liquid refrigerant chamber.

6. In a hot gas defrosting system comprising means for automatically by-passing the condenser of a refrigeration system to supply hot gas to the evaporator of such system and thereby defrost the same and means for returning refrigerant from the evaporator to the compressor, the improvement which comprises a multiple compartment vessel for heating cold refrigerant vapor and for re-evaporating liquid refrigerant expelled from said evaporator, said vessel comprising a first hot gas chamber, a second liquid refrigerant chamber and a third refrigerant vapor chamber, said liquid refrigerant and refrigerant vapor chambers being in heat exchange relation with said hot gas chamber to absorb heat therefrom, means for diverting a portion of the hot gas from the compressor to said hot gas chamber, means for separating the bulk of liquid refrigerant expelled from the evaporator from cold refrigerant vapor, means for supplying the separated vapor to said vapor chamber, and means for expanding the separated liquid and for spraying it into said liquid refrigerant chamber.

7. In a hot gas defrosting system comprising means for automatically by-passing the condenser of a refrigeration system to supply hot gas to the evaporator of such system and thereby defrost the same and means for returning refrigerant from the evaporator to the compressor, the improvement which comprises a multiple compartment vessel for heating cold refrigerant vapor and for re-evaporating liquid refrigerant expelled from said evaporator, said vessel comprising a first hot gas chamber, a second liquid refrigerant chamber and a third refrigerant vapor chamber, said liquid refrigerant and refrigerant vapor chambers being in heat exchange relation with said gas chamber to

absorb heat therefrom, means for diverting a portion of the hot gas from the compressor to said hot gas chamber, means for conducting partially spent gas from said hot gas chamber to said liquid refrigerant chamber, means for separating the bulk of liquid refrigerant expelled from the evaporator from cold refrigerant vapor, means for supplying the separated vapor to said vapor chamber, means for expanding the separated liquid and for spraying it into said liquid refrigerant chamber, and means for conducting the reheated vapor from said vapor chamber and the re-evaporated refrigerant from said liquid refrigerant chamber to the inlet of said compressor.

8. A hot gas defrosting system comprising a vaporizing chamber for expansion and vaporization of liquid refrigerant expelled from the evaporator of a refrigeration system, a reheating chamber for reheating cold refrigerant vapor expelled from such evaporator and for vaporizing any residue of liquid refrigerant contained in such vapor, heating means supplied with hot gas from the compressor of such refrigeration system for heating said vaporizing chamber, means communicating said heating means with said reheating chamber to conduct partly spent hot gas from said heating means to said reheating chamber to thereby heat said chamber, means for conducting vaporized refrigerant and reheated refrigerant vapor to said compressor, means for conducting cold refrigerant vapor expelled from said evaporator into said reheating chamber and means for expanding liquid refrigerant expelled from said evaporator into said liquid refrigerant chamber.

9. A hot gas defrosting system comprising a vaporizing chamber for expansion and vaporization of liquid refrigerant expelled from the evaporator of a refrigeration system, a reheating chamber for reheating cold refrigerant vapor expelled from such evaporator and for vaporizing any residue of liquid refrigerant contained in such vapor, heating means supplied with hot gas from the compressor of such refrigeration system for heating said vaporizing chamber, means communicating said heating means with said reheating chamber to conduct partly spent hot gas from said heating means to said reheating chamber to thereby heat said chamber, means for conducting vaporized refrigerant and reheated refrigerant vapor to said compressor, means for conducting cold refrigerant vapor expelled from said evaporator into said reheating chamber and means for expanding and spraying liquid refrigerant expelled from said evaporator into said liquid refrigerant chamber.

10. A hot gas defrosting system comprising a re-evaporator and reheater for re-evaporating liquid refrigerant and reheating cold refrigerant expelled from the evaporator of a refrigeration system, said re-evaporator and reheater comprising a first hot gas chamber, and a second liquid refrigerant chamber and a third refrigerant vapor chamber in heat exchange relation with said first chamber; a receiving vessel communicating with said evaporator to receive liquid refrigerant and refrigerant vapor expelled therefrom; hot gas supply means for diverting a portion of the hot gas from the compressor of said refrigeration system to said first chamber during the defrosting cycle, said hot gas supply means comprising an adjustable valve for adjusting and controlling the rate of supply of hot gas to said first chamber; a conduit communicating said first chamber with said third chamber to supply partly spent hot gas thereto; means communicating said receiving vessel with said second chamber, such means including an expansion valve and a nozzle for expanding liquid refrigerant and spraying it into said second chamber; vapor supply means communicating said receiving vessel and said second chamber with said third chamber to supply cold vapor from both such sources to said third chamber; feeler means for sensing the temperature of vapor expelled from said second chamber, such feeler means controlling said expansion valve to regulate the rate of expansion of liquid refrigerant into said second chamber; and means communicating said third chamber

with the inlet of said compressor to supply the compressor with a mixture of re-evaporated liquid refrigerant and reheated refrigerant vapor expelled from the evaporator together with spent hot gas diverted to said first chamber.

11. A re-evaporator and reheater for a hot gas defrosting system comprising an outer vessel, an intermediate vessel and an inner vessel in nested arrangement to provide a relatively narrow outer annular chamber between the outer and intermediate vessels, an intermediate annular chamber between the intermediate and inner vessels and an inner chamber with said inner vessel; means for introducing hot gas from the compressor of a refrigeration system into said intermediate chamber; means for circulating partly spent hot gas from said intermediate chamber to said outer chamber; means for expanding and spraying liquid refrigerant into said inner chamber; means for conducting cold refrigerant vapor expelled from the evaporator of such refrigeration system, together with re-evaporated liquid refrigerant from said inner chamber, to said outer chamber; and means for conducting the resulting mixture of reheated refrigerant vapor, re-evaporated liquid refrigerant and partly spent hot gas to the inlet of said compressor.

12. A re-evaporator and reheater for a hot gas defrosting system comprising an outer vessel, an intermediate vessel and an inner vessel in nested arrangement to provide a relatively narrow outer annular chamber between the outer and intermediate vessels, an intermediate annular chamber between the intermediate and inner vessels and an inner chamber within said inner vessel; means for introducing hot gas from the compressor of a refrigeration system into said intermediate chamber; means for circulating partly spent hot gas from said intermediate chamber to said outer chamber; means for expanding and spraying liquid refrigerant into said inner chamber; means for conducting cold refrigerant vapor expelled from the evaporator of such refrigeration system, together with re-evaporated liquid refrigerant from said inner chamber, to said outer chamber; and means for conducting the resulting mixture of reheated refrigerant vapor, re-evaporated liquid refrigerant and partly spent hot gas to the inlet of said compressor; said re-evaporator and reheater also comprising control valves to adjust and control the rate of supply of hot gas to said intermediate chamber, of refrigerant vapor to said outer chamber and of expanded liquid refrigerant to said inner chamber.

13. A refrigeration system comprising a compressor, a condenser and an evaporator and means interconnecting the same to provide a closed circuit wherein refrigerant vapor is compressed in the compressor, condensed refrigerant gas is condensed in the condenser, condensed refrigerant is evaporated in the evaporator and refrigerant vapor is returned from the evaporator to the suction of the compressor; said system also comprising hot gas defrosting means for defrosting the evaporator including a hot gas defrosting circuit for supplying hot refrigerant gas from the compressor to the evaporator to heat and defrost the same, means for returning spent gas from the evaporator to the suction of the compressor and a heat exchanger heated by hot gas from the compressor, said heat exchanger being interposed between the evaporator and the suction of the compressor for heating the spent gas and for evaporating liquid refrigerant removed from the evaporator with said spent gas; said defrosting means also including a trap interposed between said evaporator and heat exchanger for entrapping liquid refrigerant and compressor lubricant, and means for conducting such liquid from said trap and expanding and spraying it into said heat exchanger.

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