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DEFROSTING ARRANGEMENT FOR REFRIGERATION SYSTEMS

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DEFROSTING ARRANGEMENT FOR REFRIGERATION SYSTEMS

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This invention relates to improvements in defrosting arrangements for refrigeration systems, and more particularly to re-evaporating provisions in the suction line, with controls therefor, in a compressor-condenser-evaporator type of system provided with a hot gas evaporator-defrosting circuit.

We are aware that numerous systems have heretofore been devised for utilizing either directly, hot gases discharged directly by the compressor, or condenser heat, for the purpose of melting away the frost and ice coating periodically accumulating on and near the usual refrigerant evaporators. However, as far as has been ascertained after a consideration of the patents and earlier arrangements, none of these has fully satisfactorily realized its intended purpose, at least without introducing to the system some unsatisfactory and objectionable performance characteristics. Principal among the objections experienced with earlier arrangements may be noted a considerable reduction in efficiency of the system; a tendency under defrosting conditions for liquid to slug over to the compressor and objectionably or dangerously high pressure conditions in parts of the system, sometimes including the compressor, to mention but a few of the difficulties heretofore experienced and usually accepted as necessary incidents of automatic defrosting. It is accordingly a major objective of the present improvements to obviate each and all of the difficulties noted, and to realize a fully automatic arrangement for periodically freeing the evaporator of frost accumulation.

A further valuable objective of the present improvements is realized in an arrangement for the general purpose noted, and which utilizes one of its controls for selectively interposing or excluding a re-evaporator in the suction side of the system, a thermostatic expansion valve which is introduced solely for the purpose of providing, for completeness, as bounded by walls W and shown as preferably, with the major operative elements of the system in a mechanical compartment MC. For completeness it may also be noted as desirable to provide, for removal of water resulting from defrosting, a drain line generally indicated at 17.

Although the specific instrumentalities for periodical defrosting constitute no part of the present improvements, it is noted for completeness that in the present system there is provided a defrost timer DT, the circuit of which is controlled thereby serving to energize the solenoid valve 13 for opening of same to supply the hot gas through the predetermined intervals. Although the arrangement shown in the accompanying drawing is merely suggestive of the possible variations, it will be understood that various circuits are not distinguished by dotted lines over the lines of tubing serving to complete the frost circuit between the several elements of the refrigeration system.

The points of major improvement in the present system are found in novel items of control apparatus and the arrangement thereof in the low pressure side of the system, sometimes referred to beyond the evaporator, as the suction line. It will be noted that the line SL is divided or branched, beginning at point 20. A first such branch, utilized primarily during the defrosting cycle, is identified with the line of tubing 21 containing and controlled by a thermostatic expansion valve TEV2, the same proceeding into and through a re-evaporator unit generally indicated at 22, the coil 23 within which forms a part of the branch 21 of the suction line. A further branch defined by a fan motor FM2 utilizes the usually relatively warm ambient air within the space MC as the heat exchange medium over the coils 23 of the unit 22, with the effect of vaporizing any liquid refrigerant which may exist in this portion of the suction line, thus effectively preventing the return of same to the compressor. A drain connection 24 is provided from the re-evaporator unit 22 to remove any condensate therefrom.

The branch 21 containing the re-evaporator unit 22 is continued therebeyond to a connection or fitting 25 of a bypass valve unit generally designated at 26, and hereinafter described in more detail. The line of suction line SLF between the bypass valve unit 26 and the compressor is shown as connected to the unit 22 through a single outlet fitting 27.

Referring now by characters of reference to the drawings, and first to Fig. 1, those units which are or may be of well known and conventional character and disposition in the flow circuit, are designated by reference letters, those including a motor driven compressor for the discharge of which is supplied to the condenser CN, thence to the receiver R, the liquid from which flows through the line LL to supply the main evaporator EV. In the line LL and forming a part thereof, the expansion valve X is shown diagrammatically as including a jacket portion 11 and an inner flow element 12 forming a part of the suction line, as will appear. From the jacket 11 liquid flow is conducted through a continuation of the line LL to a thermostatic expansion valve TEV1. This is or may be of a conventional type and requires no detailed description, it being noted that this unit is responsive to a fluid charge in its motor system connected to a bulb B1 in thermal exchange relation with the conduit or tubing at or near the evaporator out.

The evaporator outlet is connected to suction line SL, a part of which is constituted by the inner circuit 12 of the heat interchanger 10, whence the line SL is continued as will hereinafter be described.

The evaporator EV is shown in typical installation with its coils in the line of flow of the air stream from a propeller fan PF driven by fan motor FM. As a convenient means for supplying a source of heat to the evaporator for purposes of defrosting same, preferably at more or less definite yet regulable intervals, there is provided a hot gas line 13 leading directly from the compressor through a by-pipe 14 via a solenoid valve 15, the line 13 continuing into communication with the evaporator at a point 16 which is between the valve TEV4 and the evaporator 24. The control space is shown as preferably, with the major operative elements of the system in a mechanical compartment MC. For completeness it may also be noted as desirable to provide, for removal of water resulting from defrosting, a drain line generally indicated at 17.

Although the specific instrumentalities for periodical defrosting constitute no part of the present improvements, it is noted for completeness that in the present system there is provided a defrost timer DT, the circuit of which is controlled thereby serving to energize the solenoid valve 13 for opening of same to supply the hot gas through the predetermined intervals. Although the arrangement shown in the accompanying drawing is merely suggestive of the possible variations, it will be understood that various circuits are not distinguished by dotted lines over the lines of tubing serving to complete the flow circuit between the several elements of the refrigeration system.
additional valves, all indicated by usual legend, will serve to complete the system and to facilitate usual control operations and servicing of the several elements.

There has thus far been described only one of the dual branches of the suction line, namely that which provides flow through the re-evaporator, primarily under defrosting conditions. It should be noted that the normally used suction line or otherwise expressed, that portion of the line which serves to 34 return connection between the evaporator and compressor during normal refrigerant operation, comprises a branch or leg 30 originating at point 20 in line SL. The horizontal line between two evaporator inlet fittings 31 directed into the lowermost chamber 32 of the bypass valve unit, as will later be more fully described, it being presently noted that communication between line 30 via chamber 32 and fitting 27 into the final section SLF of the suction line, is under control of a valve element 33 subject to actuation by a fluid-charged bellows 34 in an upper chamber 35 of the unit 26, the valve opening actuation of bellows 34 being opposed by a valve return spring 36 which is or may be equipped with spring-loading adjustment means (not shown).

Proceeding now to further detail of the preferred form of bypass valve, particularly as shown by Fig. 2, it should first be noted that the suction line SL is of a generous cross section and that the high-compressibility of defrosters and outlet fittings particularly those designated at 31 and 27 are similarly of ample cross section, so as to realize only a minimum pressure-drop through the unit 26. The valve and valve port 26 are similarly designed so as to keep at a minimum, any obstruction to normal flow through this unit during the normal operating cycle. The valve unit generally designated at 26 includes in addition to the major elements hereinafter designated, a casing which for example, may be of a generally cylindrical form and designated at 37. Presupposing without limitation, a vertical mounting of the bypass valve, the units or shell will include a bolted sealed upper head 40, and a similar removable lower head 41. The metallic bellows 34 is located in the upper chamber 35 of the bypass unit, and includes end heads 42 by which the sealed thereto the metallic bellows structure of expandable-contractable character shown at 43. A charging tube 44 facilitates introduction of a fluid charge, the tube being sealed off as well known after supplying such fluid. This motor element for actuating the valve 33 is by preference supplied with a predetermined charge which approximates the characteristics of the refrigerant in the system, and a matter of usual convenience may consist of a finite quantity of such refrigerant.

A valve stem or push rod indicated at 45 is directly actuated by the lower head 42 of the bellows. It is guidedly constrained to reciprocal movement through a guide element 46 forming a part of a valve cage 47, it being noted that the element 46 may consist merely of a bridge extending diametrically of the cage 47 so as to present virtually no obstruction of freedom of flow between the upper and lower chambers 35 and 32 respectively, when the valve cage 47 is open. It will appear that the cage 47, threaded into a transverse partition 50, provides along its lower margin a valve seat 51 engaging the valve proper 33.

It is an important feature of the arrangement shown that the valve 33 and the valve port, the latter defined by seat 51, both be of ample dimensions for reasons stated, and it is generally preferred that the valve 33 be opened under expansion of the bellows, generally indicated at 34, in a direction against the flow from the evaporator to the compressor, or otherwise stated, from inlet fitting 31 via the valve port, to the compressor connection 27.

The function and operation of the several elements and their relation mutually and to the system, will have become at least in part apparent from the structure described; however, it may be noted for completeness that during normal refrigerating operation of the system, line 120 is in connection with line LL, and valve TEVI. Return flow will then occur through the leg 30 via the open valve 33, thence through line SLF to the compressor connection 27. During normal working, superheat values in branch 30 and pressure differentials across valve 33 are such as to cause bellows 34 to overcome spring 36 and to keep open the bypass valve 33.

During refrigeration, valve TEV2 will remain open as affected by bulb B2 responsive to superheat values beyond the re-evaporator. However, the much lower pressure-drop through line 30 than line 21, results in a preponderance of flow through leg 30, unit 26 and line SLF.

Defrosting is periodically initiated by timer DT, acting to open valve 33, releasing gas line 13 to the evaporator, relieving same of ice and frost accumulation. Evaporator pressure rises sharply during defrosting, which pressure increase coats with the spring 26 to close valve 33 against line 26. During the bypass branch 30—26. Valve TEV2 being open, the closure of valve 33 compels return flow during defrosting by way of the re-evaporator unit 22. During refrigeration, the pressure decreases, which fact further conduces to closing of valve 33. Since, under these conditions, defrosting return flow occurs solely through the unit 22, wet vapor or liquid acting on bulb B2 throttles valve TEV2, and produces a portion of liquid to the compressor. This situation prevails until shortly after the defrost cycle, wherein the rise in superheat and the decreasing pressure drop across valve 33 again causes full opening of both valves 33 and TEV2. It is noted that the re-evaporator line 21—23 is always opened into line SLF, through chamber 32 of the valve unit 26. Upon completion of the defrosting cycle and then for a period of time, and perhaps a short interval thereafter, the relations of the bypass valve and thermostatic expansion valve TEV2 will again be relatively reversed, so as to reestablish the refrigerating cycle. This will mean that the simultaneous closure of the solenoid valve 15, the normal refrigeration functions of the compressor, condenser and evaporator will of course be resumed.

Experience has shown that during and through a short period following the actual defrosting of the evaporator, liquid from the evaporator returns to the re-evaporator wherein it is vaporized and returned to the compressor. It is of course obviously necessary to prevent the return of liquid to the evaporator, either through the bypass line 30—26, or otherwise. It is for the purpose of regulating the amount of said liquid it is desired that a re-evaporator that the unit TEV2 is utilized. This or may be a conventional thermostatic expansion valve as described, under the thermal or sensing control of a bulb B2 which may be and is by preference, in accordance to the re-evaporator branch line after the outlet of unit 22 and ahead of the bypass valve 26 as shown.

It has been found highly desirable during the normal refrigerating cycle, to bypass the main flow of refrigerant around the re-evaporator line after the defrost cycle has been completed and after the evaporator EV is again inaugurated. This fulfills this purpose and function, in that it serves to prevent the return of liquid refrigerant to the compressor during the defrost cycle. The unit is also constructed to provide a portion of the low pressure-drop path between the evaporator EV and the compressor C during the normal refrigerating cycle. Furthermore, the construction in the unit 26, gas-charged to predetermined pressure, is such that it acts to limit the pressure in the compressor crank case to a predetermined maximum, this and the aforesaid results being accomplished fully automatically.

By way of further discussion of operation it may be noted that during and for a short time after the defrost cycle, when liquid is returned from the evaporator to the re-evaporator, the temperature of the suction line at the point where the bulb B2 is located, will show a superheat corresponding to the setting of the unit TEV2. It should be noted that the spring pressure in the bypass valve 26 should be such that the valve 33 will remain closed so long as superheat is of the order of 5°—10° or whatever range of temperature corresponds to the setting of the unit 26.

After the liquid in the suction line has been removed by the re-evaporator, the superheating at the outlet of unit 22 will increase to a value of the order of 15°, for example, whereverupon the pressure of the supply line 34 of the bypass valve will overcome the loading of spring 36 which fact and the reduced pressure differential across valve 33 will cause same to open, there being assumed to be a charging device therein charged as necessary in the system. Opening of valve 33 as noted, will reestablish flow through line 30, 33, 27 and SLF to the compressor. In case superheat reduces, for example from 15° to any considerably lower value, the valve 33 will again close.

The provision of a relatively large valve and valve
port in the bypass unit 26 assures a low pressure-drop path of flow of generous section fully between the evaporator and the compressor during operation. Also, by virtue of the relatively large port or valve seat aperture, there will be realized a highly favorable regulation of the bypass valve due to the relatively high evaporator pressure prevailing during and perhaps for a minor period of time following the defrost cycle.

Although none of the pressure or temperature values herein stated should be construed as necessary or indicative of exact conditions but rather as examples or illustrations, they are usually similarly proportioned in different systems. Thus it may be noted that during defrosting operation an evaporator pressure may not unexpectedly attain a value of fifty pounds, and will normally be reduced say to a ten pound value or lower, during the normal refrigeration cycle.

By reason of the fact that the flow of refrigerant through the bypass valve is in a valve-closing direction, it will exert a definite valve closing force of the order of 10–20 p.s.i. during the refrigeration cycle. This valve-closing effect requires extra superheat in the region of the valve motor bellows, and results in balancing of the bypass valve at a superheat higher than 15°. During the refrigeration cycle, the superheat of the liquid leaving the valve at 10 p.s.i. will be reduced to a value of the order of 1 p.s.i., which reduction of pressure across the valve disc prevents the valve being closed. By opening the valve further, the valve may be opened more widely with additional flow area through the port, all of which is desirable in minimizing pressure drop. For reasons stated it will appear as highly desirable that the valve 33 open in a direction against the direction of flow, as shown. It may be further noted that the arrangement described will permit, if desired, the key to be placed in the bypass valve operation when desired. For such purpose the liquid inlet to the evaporator is shut off, resulting in a higher superheat at the outlet end of the re-evaporator, such as quickly and fully to open the bypass valve to the motor and the bypass.