My invention relates to a method and means of defrosting a cold diffuser. In general the invention is concerned with a method of defrosting a refrigerant heat exchanger or other cold diffuser by a heating medium, when the surface of the diffuser has accumulated a layer of frost or ice which effectively reduces its heat transfer capacity.

In particular my invention is concerned with the combination of a refrigerant system and a control device which is responsive to a condition of the cold diffusing heat exchanger that is indicative of excessive frosting, which condition may for example be a differential between the surface temperature of the diffuser and the space temperature ambient to the diffuser, and which because of excessive frosting of the diffuser is not properly cooled.

This application is a continuation in part of my previous application Ser. No. 470,306 filed December 26, 1942, and its successor Ser. No. 698,657 filed September 9, 1946, both of which became abandoned.

In the operation of refrigerating systems involving a cold diffuser that is in heat exchange relationship with the atmosphere of an enclosed space, the diffuser through contact with moisture carried by the air gradually accumulates a deposit of frost or ice on its outer surface, which acts as an insulating layer and must be periodically removed in order to efficiently transfer heat between the air and the cold diffuser. The frosting of cold diffusers has long been recognized as a deterrent to proper heat exchange and numerous means have been used heretofore to periodically defrost the outer surface of the diffuser. It is well known to use such heating mediums as hot water or electrical heaters and other forms of transferring heat from a source of heat to the cold diffuser. It is further well known to use steam or air at temperatures above the dew point to defrost the cold diffuser.

In the operation of this invention, the refrigerating system is shown as incorporating the combination of a compressor, condenser and evaporator which are interconnected in such a manner that the compressed refrigerant which is supplied by a compressor that is in continuous operation during the defrosting cycle, may be used to accomplish the defrosting of the evaporator. However, my invention is not restricted to any particular type of refrigerating system nor to any particular medium for defrosting the same, since it is applicable to any form of cold diffuser in which defrosting is accomplished through the use of a medium capable of transferring heat from a source of heat to the cold diffuser, and wherein the only problem resides in the control of a second control device that is capable of controlling the flow of the heat transferring medium.

In particular, in the present invention a primary control device is used to control the operation of a secondary control device which regulates the flow of the heating medium to the diffuser, which medium in the present invention consists of the heated compressed refrigerant fluid that has been heated by the action of the compressor or by heat emanating from the prime mover that drives the compressor. The hot gas is introduced into the refrigerant heat exchanger either by reversing the normal path of the refrigerant fluid, or by modifying the path of the fluid so that the same enters the heat exchanger at a suitable point between the inlet and outlet where the fluid therein is most likely to be in a saturated gaseous condition, and will not result in the forcing of liquid refrigerant into the compressor to cause injury thereto.

The primary control device is composed of a pair of thermal motors, one of which responds to the surface temperature of the cold diffuser, and the other responds to the temperature of the space adjacent the diffuser. In refrigerating an enclosed space, by circulating the air thereinto in contact with the cold diffuser, either by a thermal cycle or by the forced movement of air, a substantial differential will exist between the air temperature and the surface temperature of the heat exchanger. The two thermal motors utilize this temperature differential as a means of control so that when the differential is substantially varied, as will occur when the diffuser becomes excessively frosted, the joint action of the two thermal motors is utilized to bring about a defrosting operation. A linkage is provided in the primary control device between the two thermal motors, and the movement of this linkage in either one of two directions is utilized to operate a switching mechanism that is electrically connected to the secondary con-
control, which in turn controls the flow of the heat transferring medium. A safety linkage is provided in the primary control device to prevent operation of the switching mechanism under unusual conditions, such as might exist momentarily after the refrigerating system is initially placed in operation. Means are also provided in the primary control device for adjusting the setting of the differential between the thermal motors.

The subject of the present invention is not primarily concerned with maintaining the correct temperature within an enclosed space, but rather is only concerned with defrosting the cold diffuser when an accumulation of frost on the surface of the latter precludes proper cooling of the enclosed space.

In refrigerating a compartment, the desired temperature of the enclosed space is determined by presetting of a thermostat which controls the operation of the refrigerating system and is independent of the present invention. Assuming for example that the desired temperature is 45°F, the heat exchanger when operative will have a surface temperature considerably below the space temperature and may for example be about 25°F. In this example, to maintain the space at a temperature of 45°F with the surface temperature of the diffuser being 25°F, a differential of 20° will exist between the surface temperature of the diffuser and the temperature of the controlled space. In the present invention, one of the thermal motors through a suitable temperature responsive means responds to the space temperature, while the other thermal motor through a suitable temperature responsive means responds to the surface temperature of the cold diffuser, and the two motors operate on a differential which in the foregoing example is 20°. If for any reason the temperature of the heat exchanger is lowered, as for example by changing the setting of the space thermostat, and there is efficient heat exchange with the enclosed space, both of the thermal motors will respond to the temperature variation and the differential will remain substantially unchanged. When, however, the heat exchanger accumulates a layer of frost or ice, the latter forming an insulating layer which diminishes heat exchange, this frost layer will cause the surface temperature of the heat exchanger beneath the layer to be reduced through inefficient heat transfer, while the space temperature will gradually rise since the air is brought into contact with the frost layer having a temperature of about 32°F, which is generally incapable of sufficiently cooling the air within the enclosed space.

As this condition will be aggravated by the progressive thickening of the layer, the differential between the two thermal motors will gradually exceed the predetermined differential of 20°, whereupon the conjoinction section of the two thermal motors will rotate the linkage to the extent that the latter will move the switching mechanism to a position to effect defrosting.

In those refrigerating systems which utilize means for forcibly circulating air from the enclosed space into contact with the refrigerating heat exchanger, it may be desirable to terminate the flow of air during defrosting so as to prevent blowing the melted moisture into the enclosed space where it may cause damage to products stored therein. To this extent a double throw switch is provided which breaks a circuit to an airflow control means, such as a damper or a fan motor, before it makes another circuit to the control device that initiates the flow of the heating medium to defrost the cold diffuser. During initial stages of defrosting the surface temperature of the diffuser will remain at substantially 32°F until all of the frost has been removed, whereafter as a result of continued heating, the surface temperature of the diffuser rises rapidly so as to substantially reduce the differential between the two thermal motors below the predetermined differential. When this occurs the switch operating linkage is moved in an opposite direction to terminate defrosting and if necessary re-initiate the circulation of air.

The primary control device is not normally concerned with the temperature involved in a specific refrigeration plant but is pre-set to operate on a specific differential which may be desired in a specific application. Accordingly, therefore, means are provided for adjusting the differential between the two motors, and normally this is a factory setting or by an experienced service man.

As it is recognized that under certain circumstances a considerable differential between the two thermal motors may exist for a short time after a refrigeration system, which has been inactive and is initially started, safety latching means are provided to prevent a defrosting period from occurring until after the refrigeration plant has been in operation for a sufficient length of time for the surface temperature of the evaporator to be below the freezing temperature of water.

Two different refrigerating systems are shown which incorporate the control device. In one instance a mechanical refrigerating system is shown in which a complete reversal of flow of the refrigerant is effected by the control device. In the other instance hot gas is introduced into an evaporator at an area between the inlet and the outlet and in such a manner as to divide the contents of the evaporator into a liquid portion and a gaseous portion, the former being returned to a liquid receiver, and the latter being withdrawn by a compressor.

The principal object of the invention is to provide in combination with a refrigeration system of the compressor, condenser, evaporator type means which are independent of the system for automatically introducing hot gas from the high pressure side of the compressor into the evaporator, when the latter is in need of defrosting.

Another object is to provide in combination with a refrigerating system of the compressor, condenser, evaporator type that is provided with flow control means for modifying the path of refrigerant flow to effect defrosting of the evaporator, a control device which is independent of the operation of the compressor and responsive to a condition of excessive frosting of the evaporator, to effect the flow of hot gas into the evaporator to defrost the same and thereafter terminate the flow of the hot gas as soon as defrosting is completed.

Another object is to provide a method of defrosting the evaporator of a mechanical refrigerating system in which a liquid refrigerant is evaporated at reduced pressure, by introducing heated refrigerant vapors into the evaporator above the liquid level therein so as to divide the contents of the evaporator into two portions, one of which returns to a liquid receiver and the other of which is withdrawn by a compressor.
whereby both portions are replaced by the heated vapors. Another object is to provide a method of defrosting a cold diffuser by measuring the difference between the surface temperature thereof and the space ambient thereto, and utilizing a variation in this differential to effect defrosting and thereafter a return to normal refrigeration.

Another object is to provide a refrigerant control device, utilizing a pair of thermal motors, one of which responds to the surface temperature of the cold diffuser and the other of which responds to the temperature of the space ambient to the diffuser, and wherein the joint efforts of the two thermal motors are utilized to effect defrosting of the cold diffuser when the latter has accumulated an excessive layer of frost.

Another object is to provide in combination with a refrigerant plant including two heat exchangers and having a control valve which when opened is capable of modifying or reversing the path of the fluid refrigerant so as to defrost one of the heat exchangers, together with means for controlling the circulation of air from an enclosed space over the said heat exchanger, a control device which is responsive to a condition of excessive frosting of the heat exchanger and is capable of simultaneously opening the control valve and terminating the flow of the circulated air over the one heat exchanger during defrosting and thereafter reversing the operation as soon as defrosting is completed.

Another object is to provide in combination with a refrigerant heat exchanger having air passages through a control device, a thermal responsive element mounted on the surface of the heat exchanger, and a second thermal responsive element which responds to the temperature of air drawn through the passages, means for directing air through the passages to control the second thermal responsive device when the heat exchanger becomes frosted to the extent that the passage of air therethrough is precluded.

A further object is to provide in a refrigerant control device composed of a pair of thermal motors which operate on a differential principle, and a switching device, a linkage interconnecting the two motors and which is capable of operating the switching device, together with a safety latching mechanism which is cooperative with one of the motors for restraining the action of the same under unusual conditions.

Other and further objects may become apparent from the following description and claims and in the appended drawings in which:

Fig. 1 is a side elevation of a refrigerant control device showing its relationship to a refrigeration system that is schematically shown;
Fig. 2 is a detail view of a part of the structure shown in Fig. 1;
Fig. 3 is a plan view of a part of the structure shown in Fig. 2;
Fig. 4 is a perspective of a commercial refrigerating system incorporating the structure shown in Fig. 1; and,
Fig. 5 is a schematic showing of another type of commercial refrigerating system incorporating the control device shown in Fig. 1.

Referring first to Fig. 1, general reference numeral 20 indicates a set of refrigerating system of which a practical commercial aspect is shown in Fig. 4. Reference character 12 indicates a prime mover that is suitably connected to a compressor 14. The operation of the prime mover, which may be either an internal combustion engine or an electric motor, is controlled in response to the temperature within an enclosed space, not shown. Extending from the high pressure side of compressor 14 is a conduit 16 which joins the inlet of a condenser 18. Condenser 18 in turn is joined at its outlet to a refrigerant receiver 20.

Extending from receiver 20 is a conduit 21 which at its other end is joined to the inlet end of an evaporator 22. Conduit 21 contains an expansion valve 23 which is connected by a tube 24 to a thermostatic bulb 25. Joined to conduit 21 on either side of valve 23 is a by-pass 26 containing a check valve 27. A conduit 28 extends from the outlet end of evaporator 22 to the low pressure side of compressor 14, and conduit 28 is in heat transfer relationship with bulb 25. A conduit 30 extends from a junction 17 on conduit 16 to a junction 31 located at a central area in evaporator 22. Conduit 30 contains a flow control valve 32 which is operated by an electric operator 34. In practice valve 32 would be a two-position solenoid valve.

Fig. 1 indicates a prime mover that is suitably connected to a compressor 4. The operation of the prime mover, which may be either an internal combustion engine or an electric motor, is controlled in response to the temperature within an enclosed space, not shown. Extending from the high pressure side of compressor 14 is a conduit 16 which joins the inlet of a condenser 18. Condenser 18 in turn is joined at its outlet to a refrigerant receiver 20.

Extending from receiver 20 is a conduit 21 which at its other end is joined to the inlet end of an evaporator 22. Conduit 21 contains an expansion valve 23 which is connected by a tube 24 to a thermostatic bulb 25. Joined to conduit 21 on either side of valve 23 is a by-pass 26 containing a check valve 27. A conduit 28 extends from the outlet end of evaporator 22 to the low pressure side of compressor 14, and conduit 28 is in heat transfer relationship with bulb 25. A conduit 30 extends from a junction 17 on conduit 16 to a junction 31 located at a central area in evaporator 22. Conduit 30 contains a flow control valve 32 which is operated by an electric operator 34. In practice valve 32 would be a two-position solenoid valve.

For reasons which will be explained hereinafter, it is important that the interior cross-sectional area of conduit 33, valve 32 and junctions 17 and 31, be at least as great as conduit 18.

Also shown in Fig. 1 and indicated by the general reference numeral 35 is a control device composed of a casing 33 which houses a pair of thermal motors shown as expandable bellows members 40 and 42. Bellows 40 on its lower end is sealed by a cap 44 to which is secured a projection 45. Adjustably extending from projection 46 is a threaded adjustable actuating member 48. Extending from the other end of bellows 40 is a tube 50 which at its outer end carries a bulb 52 that is suitably secured to one of the coils of evaporator 22. Bellows 42 is provided with a cap 54 from the center of which extends an upstanding guide rod 55 that passes through a tube 56. Tube 58 is provided with external threads 60 on its outer surface and is secured at its upper end in a bracket 51, supported by casing 35. Surrounding tube 56 is coil spring 62, whose opposite end engages washers 63, 64. A nut 65 engages the threads 60 on tube 56 and is provided for adjusting the tension on spring 62. At its other end bellows 42 is connected to a tube 66 which at its outer end carries a bulb 68 that is positioned adjacent the evaporator 22 and responds to the temperature of air flowing over the evaporator.

A floating lever 70 extends between the inner ends of bellows 40 and 42 and is pivotally secured at 72 to rod 56 and at 74 to projection 46. Lever 70 at its center is pivotally secured at 76 to a link 78 whose lower end is pivotally secured at 80 to a second lever 82. At one end lever 72 is pivotally secured at 84 to a rod 86 that is mounted in the lower surface of the casing 33. At its other end lever 72 carries a threaded adjustable actuator 87.

Also mounted within casing 35 is a latch 88 which is pivoted at 90. Latch 88 is a first projection 92 which extends beneath the actuator 48, and a second projection 94. Secured at one end to latch 88 is a spring 96, which at its other end is secured to an adjustable eye bolt 98 that extends through a bracket 100 and carries an adjustable nut 102 in contact with the upper surface of the bracket 100. Associated with latch 88 within casing 35 is a second latching member 104 which is pivoted at 106. Latch 104 carries a hook-shaped projection 108 and an up-standing
finger 118 which is positioned in the path of the projection 94 of latch 88. A spring 112 is secured at one end to casing 38 and at its other end to a portion of the latch member 104. A stop pin 114 is supported by the casing 38 to engage a portion of latch 104 adjacent the lower end of spring 112.

Referring now to a portion of Fig. 1 in conjunction with Figs. 2 and 3, it is shown a switching device designated by general reference numeral 116, which is carried by casing 38. The switching device 116 consists of a movable switch-actuating member 118 having a hook-shaped portion 120 at one end and a hammer-like contact member 122 at its other end. The actuator 118 is supported on a block 124 by a pivot 126. A curved opening 128 is provided in the actuator 118 and a pin 130 carried by block 124 extends through the opening 128. A spring 132 extends between pins 130 and a second pin 134 carried by the actuator 118 and is intended to provide an over-center snap action to the actuator 118 when the latter moves between its two positions, as indicated by the full line and dotted line disclosures of Fig. 2. Carried by block 124 on either side of the hammer-like portion 122 are a pair of switches 136, 138 which in practice may be conventional snap switches. A branched conductor 140 extends from a source of power, not shown, to one end of each of the switches 136, 138 to supply current to these switches. A conductor 142 extends from switch 136 to one pole of the motor operator 34 of valve 32. A conductor 144 extends from the other pole of motor 34 to ground, as shown in Fig. 1. Under certain circumstances it may be necessary in a refrigeration control device to provide means for controlling the flow of air over the evaporator 22 and under these conditions switch 136 is connected by a conductor 146 to an electrical control device which controls the flow of air and in Fig. 1 such a device might be a motor, not shown, which is provided to drive fan 148.

The operation of the refrigeration system 10 in conjunction with the control device 36 will now be explained. With the parts in the position shown, it will be assumed that the refrigerating system 10 has not been in operation but is about to be started. The prime mover 12, which, as previously explained, may be either an electric motor or an internal combustion engine, by means, not shown but explained in part in conjunction with the unit shown in Fig. 4, will be placed in operation by a call for refrigeration in an enclosed space surrounding the evaporator 22. When started, the prime mover will intermittently operate the compressor for a sufficient period of time to bring the temperature in the space adjacent evaporator 22 down to a level where the need of refrigeration is satisfied. Assuming, therefore, that prime mover 12 has been started and is now driving the compressor 14, and further assuming that fan 148 is in operation and is circulating air over the evaporator. Under these conditions the temperature of the air and the surface temperature of the evaporator will be substantially identical until the compressor has operated long enough to reduce the pressure within the evaporator to cause evaporation of refrigerant fluid present therein. With the surface temperature of the evaporator being equal to the ambient temperature, the expansion valve 28 under the influence of thermostatic bulb 25, which is in contact with conduit 28, will permit liquid refrigerant within the receiver 20 to flow into the evaporator 22 because of the low pressure created by the compressor. Except for the presence of flash gases which quickly separate themselves from the liquid, the liquid level within the evaporator is not ordinarily more than about one-third of the internal capacity of the evaporator. A middle portion of the evaporator cooling liquid along with gas in what may be regarded as a saturated condition, and the remaining portion of the evaporator, which is generally not more than about one-third, will contain refrigerant in a gaseous condition which is continuously being removed by the compressor and when compressed, driven through the condenser where it is converted to liquid and returned to the receiver 20.

Considering now the control device 36, which is shown in Fig. 1, in its normally inoperative condition as it would exist immediately before the starting of the system 10, and with bulb 52 in contact with the evaporator, and bulb 68 in the path of the air stream flowing from fan 148. Under these conditions bulbs 52 and 68 are subjected to substantially the same temperature conditions, and are a pair of switches 136, 138 which in practice may be conventional snap switches. A branched conductor 140 extends from a source of power, not shown, to one end of each of the switches 136, 138 to supply current to these switches. A conductor 142 extends from switch 136 to one pole of the motor operator 34 of valve 32. A conductor 144 extends from the other pole of motor 34 to ground, as shown in Fig. 1. Under certain circumstances it may be necessary in a refrigeration control device to provide means for controlling the flow of air over the evaporator 22 and under these conditions switch 136 is connected by a conductor 146 to an electrical control device which controls the flow of air and in Fig. 1 such a device might be a motor, not shown, which is provided to drive fan 148.

The operation of the refrigeration system 10 in conjunction with the control device 36 will now be explained. With the parts in the position shown, it will be assumed that the refrigerating system 10 has not been in operation but is about to be started. The prime mover 12, which, as previously explained, may be either an electric motor or an internal combustion engine, by means, not shown but explained in part in conjunction with the unit shown in Fig. 4, will be placed in operation by a call for refrigeration in an enclosed space surrounding the evaporator 22. When started, the prime mover will intermittently operate the compressor for a sufficient period of time to bring the temperature in the space adjacent evaporator 22 down to a level where the need of refrigeration is satisfied. Assuming, therefore, that prime mover 12 has been started and is now driving the compressor 14, and further assuming that fan 148 is in operation and is circulating air over the evaporator. Under these conditions the temperature of the air and the surface temperature of the evaporator will be substantially identical until the compressor has operated long enough to reduce the pressure within the evaporator to cause evaporation of refrigerant fluid present therein. With the surface temperature of the evaporator being equal to the ambient temperature, the expansion valve 28 under the influence of thermostatic bulb 25, which is in contact with conduit 28, will permit liquid refrigerant within the receiver 20 to flow into the evaporator 22 because of the low pressure created by the compressor. Except for the presence of flash gases which quickly separate themselves from the liquid, the liquid level within the evaporator is not ordinarily more than about one-third of the internal capacity of the evaporator. A middle portion of the evaporator cooling liquid along with gas in what may be regarded as a saturated condition, and the remaining portion of the evaporator, which is generally not more than about one-third, will contain refrigerant in a gaseous condition which is continuously being removed by the compressor and when compressed, driven through the condenser where it is converted to liquid and returned to the receiver 20.

Considering now the control device 36, which is shown in Fig. 1, in its normally inoperative condition as it would exist immediately before the starting of the system 10, and with bulb 52 in contact with the evaporator, and bulb 68 in the path of the air stream flowing from fan 148. Under these conditions bulbs 52 and 68 are both subjected to substantially the same temperature conditions, and are a pair of switches 136, 138 which in practice may be conventional snap switches. A branched conductor 140 extends from a source of power, not shown, to one end of each of the switches 136, 138 to supply current to these switches. A conductor 142 extends from switch 136 to one pole of the motor operator 34 of valve 32. A conductor 144 extends from the other pole of motor 34 to ground, as shown in Fig. 1. Under certain circumstances it may be necessary in a refrigeration control device to provide means for controlling the flow of air over the evaporator 22 and under these conditions switch 136 is connected by a conductor 146 to an electrical control device which controls the flow of air and in Fig. 1 such a device might be a motor, not shown, which is provided to drive fan 148.

The operation of the refrigeration system 10 in conjunction with the control device 36 will now be explained. With the parts in the position shown, it will be assumed that the refrigerating system 10 has not been in operation but is about to be started. The prime mover 12, which, as previously explained, may be either an electric motor or an internal combustion engine, by means, not shown but explained in part in conjunction with the unit shown in Fig. 4, will be placed in operation by a call for refrigeration in an enclosed space surrounding the evaporator 22. When started, the prime mover will intermittently operate the compressor for a sufficient period of time to bring the temperature in the space adjacent evaporator 22 down to a level where the need of refrigeration is satisfied. Assuming, therefore, that prime mover 12 has been started and is now driving the compressor 14, and further assuming that fan 148 is in operation and is circulating air over the evaporator. Under these conditions the temperature of the air and the surface temperature of the evaporator will be substantially identical until the compressor has operated long enough to reduce the pressure within the evaporator to cause evaporation of refrigerant fluid present therein. With the surface temperature of the evaporator being equal to the ambient temperature, the expansion valve 28 under the influence of thermostatic bulb 25, which is in contact with conduit 28, will permit liquid refrigerant within the receiver 20 to flow into the evaporator 22 because of the low pressure created by the compressor. Except for the presence of flash gases which quickly separate themselves from the liquid, the liquid level within the evaporator is not ordinarily more than about one-third of the internal capacity of the evaporator. A middle portion of the evaporator cooling liquid along with gas in what may be regarded as a saturated condition, and the remaining portion of the evaporator, which is generally not more than about one-third, will contain refrigerant in a gaseous condition which is continuously being removed by the compressor and when compressed, driven through the condenser where it is converted to liquid and returned to the receiver 20.
linkage to make an untimely movement of the switch operator 118 to bring about defrosting when the same is not desired.

Assuming now the refrigeration system to be in normal operation, as air is circulated over the evaporator coil 22, moisture therein will collect on the cold surface of the evaporator and form a progressive layer of frost which will not only cover the evaporator 22 but also bulb 52. As the frost layer increases, the vapor pressure of the air to the evaporator is diminished and bulb 52 will register a gradually decreasing temperature, whereas bulb 68 will gradually register an increase in temperature since the layer of frost will preclude proper cooling of the air. When this condition has progressed to the point where the differential between bellows 40 and 42 exceeds the predetermined setting, the floating lever 70 will rise in a generally horizontal direction and through its connection by link 76 to the lever 82, will cause lever 83 to rotate on its pivot 84 and will move the actuator 116 of the switching device 116. The actuator 118 through pivot 126 and spring 123 through its connection between pins 120 and 134 will provide an over-center snap action to the actuator 116 moving the hammer-like portion 122 from engagement with switch 38 into engagement with switch 36. When this occurs a circuit will be established from conductor 40 through switch 36 and conductor 42 to the motorizing device 34 of the valve 32 so that the water valve will quickly move to its fully open position to initiate a defrosting operation.

As previously explained, the prime mover 12 will almost always be in operation whenever the temperature in the enclosed space is above a predetermined setting, and as the evaporator becomes frosted, such a condition will likely exist as will be evident by the fact that as previously explained bulb 68 is recording a higher than normal temperature. It will be assumed, therefore, that compressor 14 is in operation when valve 32 is opened. When valve 32 opens, the high pressure side of the compressor through conduct 16 and the junction 17 through conductor 30 and valve 32 to the junction 31 where it enters the evaporator 22 at an area between the opposite ends of the evaporator and above the liquid level therein. When the internal cross-sectional area of conductor 30 and its associated connections is at least equal to the internal cross-sectional area of conduit 16, the volume of hot gas entering the evaporator is sufficient to reduce the pressure in the condenser 18 and substantially raise the pressure in evaporator 22, allowing being made for the fact that these pressures will never be exactly equal because of the continuing operation of compressor 14. An initial portion of the hot compressed refrigerant entering evaporator 22 will be condensed by the low temperature of the evaporator and thereby be converted into a liquid state where it will flow by gravity to the lower portion of the evaporator and join the liquid refrigerant therein. As the hot gas continues to enter the evaporator, the mechanical effect of compressor 14 will draw a portion of the gas upwardly from the central area and back to the compressor. Except in an instance which will be mentioned hereinafter, the expansion valve 23 will most likely be at least partially open at the time defrosting occurs and when the pressure in evaporator 22 is raised by the entry of the hot gas, liquid refrigerant in the lower or initial part of the evaporator will flow by gravity back into the receiver 20 so that in a relatively short time the evaporator will only contain gaseous refrigerant which will quickly defrost the entire area of the evaporator. In certain applications, and particularly where relatively low temperatures are desired in the space surrounding evaporator 22, the expansion valve 23 may be of a type which will close off the flow of pressure within the evaporator and which would normally prevent the liquid refrigerant from returning to the receiver 20. When such an arrangement exists, a by-pass 26 is provided to circumvent the expansion valve 23 and check valve 27 will become operative to permit refrigerant to flow around the closed expansion valve. Thus in either instance the evaporator is quickly freed of any liquid refrigerant which might maintain a low temperature in the evaporator and is replaced by gaseous refrigerant. It will be apparent that when the hot gas is introduced into the evaporator at an area above the liquid level, it tends to separate the refrigerant therein into two phases so that none of the refrigerant existing in a liquid state is forced through the outlet end of the evaporator where it would cause injury to the mechanism of the evaporator.

During defrosting the temperature of the evaporator will remain substantially constant at about 32° F. until all of the frost is removed, whereafter it is rapidly heated by the hot gas. The heat of the hot gas will be rapidly transmitted to the bulb 68 which will then cause expansion of the fluid within the closed system composed of bulb 83 and tube 56 to cause bellows 40 to expand, without necessarily causing retraction of bellows 42 because of the fact that bulb 68 is not in direct contact with the evaporator. As bellows 40 expands, the linkage forming lever 70, link 76 and lever 82 will return to a position approaching that shown in Figure 1 and the actuator 48 will engage actuator 116 to move the same downwardly in an over-center snap action to return the movable member 122 to the position shown in Fig. 1, whereupon a new refrigerating cycle will commence. Bellows 42 will expand and contract in accordance with the change in temperature adjacent bulb 68, and its purpose is to maintain a differential with respect to bellows 40 so that the control device can be used under varying conditions.

The links 88 and 104 will oscillate slightly during the normal operation of the control device, but hook 106 will not normally be permitted to rotate to a position where it will prevent movement of actuator 116 until the refrigeration system has been shut down and the parts of the control device 35 have assumed a position similar to that shown in Fig. 1.

Referring now to Fig. 4 is shown a practical commercial application of the refrigeration system shown in Fig. 1 and which, at least insofar as defrosting is concerned, is controlled by the control device 35. The structure shown in Fig. 4 is a perspective view of a portable transport refrigeration unit which is fully disclosed and claimed in my Reissue Patent No. 23,960. In general, the structure is designated by general reference character 150 and consists of a casing 192 that generally surrounds all of the operating portions of the mechanism but which is divided by a partition 154 that separates the operating mechanism, including the prime mover, compressor, condenser and receiver, from the
The evaporator and its associated elements. Reference character 156 designates an engine which through a starter generator 150 is operably connected to a compressor 160. Extending from the high pressure side of compressor 160 is a conduit 162 which connects to a condenser 164. Suitably connected to condenser 164 are a pair of inter-connected receiver tanks 165, 167 that receive the compressed condensed refrigerant fluid. A conduit 168 extends from receiver 166 to an expansion valve 170. Valve 170 is connected by a tube 171 to a thermostatic bulb 172. A by-pass 174 extends around valve 170 and contains a check valve 175. Connected to the expansion valve 174 is a distributor 178, having a multiplicity of capillary tubes designated severally at 180 which extend to one end of each of several coils making up a multiple coil evaporator 182. Extending from conduit 162 is a hot gas line 184 carrying the solenoid valve 32 having the electrical operator 34. The other end of conduit 164 joins a manifold 186 from which a plurality of small connecting tubes 188 each extend to a central point on each of the several multiple coils making up the composite evaporator 182. The outlet end of the multiple coils of evaporator 182 are connected by small pipes 190 to a manifold 192 that is connected to conduit 194 which extends in heat exchange relationship with conduit 160 in the rear in part 154 and until the conduit 194 joins the low pressure side of the compressor 160. A shrouded fan 196 is supported in rear of partition 154 and through a shaft 198 and a belt 200 is driven by engine 156.

Mounted above evaporator 182 is an outlet air duct 202 which has its inlet end in communication with the discharge side of the fan 196, and is provided to discharge conditioned air into a compartment such as a storage room or the body of a cargo carrier, the air being drawn inwardly through the evaporator. Within duct 202 is a damper 204 that is connected to a flow control device 205 which in turn is operated by a servomechanism 206. A return spring 209 cooperates with the link 210 for moving the damper in an opposite direction. Extending between the multiplicity of coils making up the composite evaporator 182 and at a plurality of fins 210. Between two of the several fins is a tube 212 which has one end projecting beyond the outer limits of the fins and which at its other end carries a funnel-shaped member 214 that projects about bulb 228 adjacent the intake side of the shrouded fan 196.

The control device 215 is also utilized with the system disclosed in Fig. 4 and the casing 220 is suitably supported on any satisfactory part of the structure 150. The control bulb 52 is secured to one of the composite coils making up the evaporator 162, to the bulb 68 is secured to the in-take side of the fin 210 so as to be in contact with the air drawn through the evaporator 162. However, in the disclosure of Fig. 4, the multiplicity of coils making up evaporator 162, as well as the multiplicity of fins 210, necessitates the incoming air to pass in very close heat exchange relationship with the evaporator. In the event that the evaporator becomes frosted to the extent that air will not satisfactorily pass through the small openings, the fan 196 tends to create a low pressure in rear of the evaporator and air will be drawn in through the tube 212 and discharged directly on the bulb 228 by the funnel-like structure 214. Also the switch-
a T 280 and contains a check valve 282. A single conduit 264 extends from one side of T 280 to the opening 262 in the valve casing 220. The conduit 264 constitutes a schematic showing of a multiple coil evaporator designated at 266. It will be seen that T 280, 268, 246 are in contact with each other to form a heat exchanger designated at 288. A conduit 290 extends between another side of T 280 to T 254 and contains a check valve 292. A conduit 294 extends from the center of T 246 to an expansion valve 296 and contains a check valve 298. Expansion valve 296 is provided with a thermostatic bulb 300. A conduit 302 extends between one side of valve 296 and the center of T 258. A conduit 304 extends from the opening 282 in the valve casing 220 to a T 306. Another conduit 308 extends from T 305 to the inlet side of a control device indicated by the general reference numeral 310, which will be briefly described hereinafter. A conduit 312 extends from the outlet side of the control device 310 to the low pressure side of the compressor 216. The control device 310 is a pressure operated governor controlling unloaded valve which is fully disclosed and claimed in my copending application Ser. No. 31,591, filed June 7, 1948, now Patent No. 2,581,956, granted January 8, 1952.

To control the movement of the piston 238 within chamber 240, a solenoid operated valve indicated at 314 is mounted in a conduit 316 which extends from the high pressure side of the compressor 216 to T 306. The valve body is also connected to the chamber 240 by a short conduit 320.

The operation of the fluid circuit will now be explained. With the parts in the position shown, the system is set for the normal refrigeration cycle with coil 286 serving as an evaporator and coil 243 serving as a condenser. Under these conditions, liquid refrigerant in the receiver 260 leaves by the connection 262, through conduit 264, T 280, conduit 270, to the expansion valve 272. Assuming the bulb 276 is calling for refrigeration, the liquid passes through conduit 270 to T 280. Assuming a compressor 216 to be in operation, the fluid will enter the evaporator conduit 264 because of the lowered pressure within said conduit. When evaporated, the refrigerant gas will pass from conduit 264 into the valve body 220 through the opening 264 and thence through opening 268 to the conduits 304, 308 to the control device 310, whose operation will be explained hereinafter, and thence through the conduit 312 to the low pressure side of compressor 216. When compressed, the gas passes through conduits 242 to the opening 264 of the valve 220, from whence it passes through condenser conduit 244 to the T 246 and conduit 250 to the T 254, from whence it passes through the conduit 256 and connection 258 to receiver 260.

As to other valves in the system, it will be noted that check valves 280 and 282 will permit free flow one in the direction indicated by the arrows and, therefore, these valves will prevent the condensed refrigerant from passing through these valves. While valve 292 would permit the passage of refrigerant from conduit 272 into conduit 298, the lowered pressure in the evaporator will cause the refrigerant to follow the path of least resistance. The bulb 300 of the valve 296 is in contact with conduit 304 and this conduit will be quite cold during the refrigerating cycle, therefore, the expansion valve 296 is closed, but whether it is closed or not is not highly important since there would be a substantially balanced condition in the T's 268 and 246. It should also be understood that the expansion valve 272, controlled by bulb 276 in contact with the return port of conduit 284 will control the flow of refrigerant into the evaporator 268 in a conventional manner to maintain proper refrigerating conditions.

Assuming now that with the system in actual operation as described above, and the control device 36 requires reversal of flow to defrost the evaporator, the action of the control device would be the same as previously explained and valve 32 would be replaced by the solenoid operated control valve 314. When energized, the control device 314 opens conduit 316 and high pressure gas from the compressor passes through this conduit into the conduit 318 to push the piston 238 to the left within chamber 240, to thereby shift valves 232, 234 to the left to terminate communication between openings 222, 224 and openings 226, 228 into open communication between openings 224, 226, and by passage 230 between the openings 226, 228. With the current through the refrigerant circuit will be established as follows: The high pressure gas, which is in a heated condition, passes from the compressor 216 through conduit 242 to the opening 224 of valve 229, thence through opening 226 to the conduit 228, which is now acting as a condenser, passing downwardly to the T 280. The check valve 282 will prevent reverse passage of the fluid, which may include liquid as well as gas. However, the fluid can pass from the T 280 through the conduit 256 past the valve 258 to the T 254 and thence through conduit 258 and connection 258 into the receiver 260, because the valve 258 will check further travel in the direction of T 246. From receiver 260, refrigerant will pass through connection 262, conduit 264 to T 268, and thence through conduit 302 to the expansion valve 296. Valve 296 is controlled by the bulb 300 which is in contact with conduit 304 and, as will be explained hereinafter, this conduit will conduct heated gas so that in a few moments after reversal of flow, valve 272 will open under the influence of heat to permit the refrigerant to enter conduit 296 passing through the check valve 296 to T 246 and into the conduit 256, which now has become an evaporator or an absorber of heat. In tracing the circuit from T 280, it should be understood that the fluid will follow the path of least resistance and will enter conduit 294 rather than conduit 270, where it would eventually meet the resistance of the high pressure fluid leaving T 280. Returning now to the valve 216, the fluid leaving conduit 244 will enter opening 222 of the valve body 220 and pass through the passage 230 to the openings 222 and thence through conduits 304, 308 to the control device 310, whence it passes through conduit 312 to the low pressure side of compressor 216 whence it is recirculated in the manner just described.

The control device 310, while only schematically shown here, is fully described in Patent 2,381,956, serves to prevent overloading the compressor such as might occur when the unit is initially started, or immediately after the valve 216 is switched from the refrigeration circuit to the defrosting cycle.

The apparatus shown in Fig. 5 is provided with a fan 314 that is operated from an independent source of power in a manner similar to fan 150 of Fig. 4 and is here shown as being positioned
above evaporator 286 for blowing air downwardly over the evaporator. Positioned beneath fan 314 are a plurality of dampers 316 that are pivotally connected to a common rod 318. Rod 318 through a linkage designated at 320 is connected by a solenoid operator 322. A return spring 324 is connected to rod 318 to move the dampers in a closed position when the solenoid operator 322 is de-energized. The control device indicated by general reference numeral 36 is provided to control the defrosting of evaporator 286 and its bulbs 52 and 68 are shown in a relationship similar to that disclosed in Fig. 1. The operation of the control device insofar as the disclosure of Fig. 5 is concerned, is substantially identical to that disclosed with respect to the structure shown in Fig. 4, and as previously explained provides for a complete reversal of refrigerant fluid to effect defrosting. In normal operation insofar as Fig. 5 is concerned, the switch actuator 122 will normally be in engagement with switch 135 to energize the solenoid operator 322 to hold the dampers 316 in an open position. When the actuator 122 is moved into engagement with switch 138 the control device 314 is actuated to reverse the direction of refrigerant fluid and the solenoid operator 322 is de-energized so that spring 324 will move the dampers 318 to a closed position.

The principal advantage of my invention resides in providing in combination with a refrigeration system containing a cold diffuser, and a flow control device which when operative permits a heating medium to pass through a conductor to the cold diffuser to defrost the same, and a temperature responsive control device which is capable of actuating the flow control device when the diffuser is in need of defrosting.

Another advantage resides in providing a means of defrosting an evaporator by introducing hot gas at an area which is above the level of liquid refrigerant so as to divide the refrigerant into two phases, one of which is returned to a liquid receiver and the other drawn off by the compressor and replaced by hot gas.

My invention is defined in the terms of the appended claims.

I claim:

1. In combination with a refrigeration plant having a high pressure side and a low pressure side, means for circulating air in contact with the low pressure side, a conduit connecting said sides for conducting hot gas from the high pressure side to defrost the outer surface of the low pressure side, a two-position valve in said conduit for controlling the flow of said gas, means for continuously withdrawing said gas from the low pressure side and returning it to the high pressure side when said valve is in an open position, a first thermal motor responsive to the surface temperature of the low pressure side, a second thermal motor responsive to the temperature of the air moved in contact with the low pressure side, a sensor connected to said valve, a two-position operator for controlling said switch, and a pair of levers extending on opposite sides of said operator for moving the same, a first of said levers being joined at its opposite ends to said thermal motors, the second of said levers being pivotally joined to a center point of said first lever.

2. In a refrigeration plant, in combination, a high pressure side, a low pressure side, means for circulating air into contact with the low pressure side, a conduit for conducting hot gas from the high pressure side to the low pressure side to defrost the same, a two-position valve in said conduit for controlling the flow of said hot gas, electric motor means connected to said valve for actuating the same, means for continuously withdrawing gas from the low pressure side and returning it to the high pressure side, a thermal motor responsive to the temperature of the moving ambient air to the low pressure side, a first lever secured to said pressure motors on opposite sides of its outer ends, a second lever substantially parallel to and spaced from said first lever, means pivotally anchoring one end of the second lever to provide free movement of its other end, a link pivotally connecting the center portions of each of said levers, and a switch operatively connected to the electric motor means, said switch having a movable actuator extending between the free end of the second lever and one end of the first lever for movement in opposite directions by said levers.

4. A refrigeration control device, comprising a casing, a first lever within said casing, a pair of oppositely extending thermal motors within said casing and connected to opposite ends of the outer ends of the lever in such a manner as to provide rotation of the lever about its center when both of said motors expand, a second lever extending in parallel spaced relation to the first lever, means for pivotally anchoring one end of the second lever to the casing, a link pivotally joining the center portion of each of said levers in such a manner that when one of the motors expands and the other motor contracts the free end of the second lever moves relative to the first lever, and a movable switch actuator extending between one end of the first lever and the free end of the second lever for actuation by the movement of one of said levers.

5. A refrigeration control device, comprising a casing, a first lever within said casing, a pair of oppositely extending thermal motors within said casing and connected to opposite ends of the outer ends of the lever in such a manner as to provide rotation of the lever about its center when both of said motors expand, a second lever extending in parallel spaced relation to the first lever, means for pivotally anchoring one end of the second lever to the casing, a link pivotally joining the center portion of each of said levers in such a manner that when one of the motors expands and the other motor contracts the free
end of the second lever moves relative to the first lever, a movable switch actuator extending between one end of the first lever and the free end of the second lever, the actuation by the movement of one of said levers, and adjustable switch engaging means on said levers for adjusting the distance between said levers and said switch actuator.

6. In a refrigeration plant, in combination, a condenser having an inlet and an outlet, an evaporator coil having an inlet and an outlet at its opposite ends, a first conduit connecting the outlet of the condenser and the inlet of the evaporator for conducting liquid refrigerant from the condenser to the evaporator, a second conduit forming communication between the condenser adjacent its inlet end and the evaporator at a site of the latter between its opposite ends, a two-position valve in said last named conduit and when opened permits hot gas to flow into the evaporator to defront the surface thereof, a compressor connected between the outlet end of the evaporator and the inlet of the second conduit adjacent the inlet of the condenser, said compressor being continuously operated when the valve is in an open position for circulating hot gas through the evaporator, a thermal motor operatively connected to said valve and responsive to a condition of the evaporator indicating a need of defrosting the evaporator for opening the valve when the condition varies beyond a predetermined range.

7. In combination with a cold diffuser, a first control device which when operative permits air to pass in heat exchange contact with the cold diffuser, a second control device which when operative effects defrosting of the cold diffuser, switching means for automatically connecting to the ends of said control devices and adapted to alternately energize one or the other of said devices, and means for operating said switching means including a first lever, a pair of opposed thermal motors connected to the opposite sides of the outer ends of said lever, one of said motors being responsive to the surface temperature of the cold diffuser and the other of said motors being responsive to the air temperature only adjacent said cold diffuser, a second lever, means pivotally anchoring one end of the second lever to the link pivotally joining both of said levers, and a snap-acting switch actuator extending between the free end of the second lever and one end of the first lever to alternately energize said control devices in response to the combined action of both of said thermal motors.

8. A refrigeration control device, comprising a casing, a first lever within said casing, a pair of oppositely extending thermal motors within said casing and connected to opposite sides of the outer ends of the lever, a second lever extending in parallel spaced relation to the first lever, means for pivotally anchoring one end of the second lever to the casing, a link pivotally joining the center portion of each of said levers, a movable switch actuator extending between one end of the first lever and the free end of the second lever, the actuation by movement of one of said levers, and latching means within said casing cooperating with said switch actuator and one end of the first lever to prevent movement of said switch by the expansion of one of said thermal motors.

9. A method of controlling the defrosting of a cold diffuser on which a progressive layer of frost is deposited from a body of circulated air, comprising mechanically measuring the direct surface temperature of the frost layer, mechanically measuring the temperature of the air after the same has passed in contact with the diffuser, there being a normal differential between said measurements which increases with the progressive deposition of the frost layer, and mechanically combining the two measurements to form a single measurement of the increase of the differential between the first named measurements, utilizing said last named measurement to mechanically terminate normal operation of the cold diffuser and introduce a heating fluid to pass in heat exchange relationship with the cold diffuser when said measurement exceeds a predetermined limit, and thereafter utilizing said last named measurement to mechanically terminate flow of heating fluid and initiate normal operation of the diffuser when the differential is less than the predetermined limit.

10. In a refrigerant plant embodying a cold diffuser formed of a plurality of closely spaced tube sections through which a refrigerant medium is circulated, a fan positioned on one side of the diffuser for directing the outflow of said tube sections, a conduit for transferring heat to said diffuser, means for pivotally anchoring one end of the second lever to said conduit, means for moving one of said thermal motors to rotate said conduit and means for moving the other of said thermal motors to rotate said conduit, a second lever extending transversely between the tube sections, said conduit being adapted to receive a progressive layer of frost on its outer surface to the extent of impeding the passage of air between the tube sections, said conduit having an inner end terminating adjacent said temperature sensitive element and forming a bypass for air between the tube sections to direct impeded air over the temperature sensitive element when the frost layer effectively blocks passage between the tube sections.

11. In an air conditioning unit embodying a refrigerant condenser having an inlet and an outlet, a liquid receiver connected to the outlet of the condenser, an evaporator coil having an inlet and an outlet at its opposite ends, a first conduit connecting the receiver with the inlet end of the evaporator, a valve in said conduit for controlling the flow of liquid refrigerant from the receiver to the evaporator, a compressor connected between the outlet end of the evaporator and the inlet of the condenser, said evaporator being adapted to receive a progressive layer of frost on its outer surface, in combination with said unit of means for defrosting said evaporator consisting of a second conduit having an inlet extending from the junction of the compressor with the condenser and an outlet connected with the evaporator at a site spaced outwards a substantial distance from the inlet end of the evaporator to admit gaseous refrigerant into the evaporator between its opposite ends and divide the contents of the evaporator into two bodies, and a valve in said conduit between its opposite ends, said compressor being in continuous operation when said last named valve is open to permit the flow of compressed superheated gases into the evaporator.

12. In a refrigeration plant embodying a cold diffuser formed of a plurality of relatively closely
spaced tube sections through which a cooling medium is circulated, a fan on one side of said diffuser for drawing air through the spaces between said tube sections, defrosting means operably associated with said diffuser, control means for connecting said defrosting means comprising a temperature responsive member positioned between the diffuser and the fan and responsive to the temperature of air passing between the tube sections, said diffuser being adapted to receive a progressive layer of frost on its outer surface to the extent of impeding the passage of air between the tube sections, in combination with said diffuser of a normally open tube having one end terminating adjacent said temperature responsive member and forming a by-pass for air between the tube sections to direct impeded air into contact with the temperature responsive member when the layer effectively blocks passage between the tube sections.

FREDERICK M. JONES.