My invention relates to refrigerating systems wherein a liquid refrigerant is supplied to an evaporator and there vaporized to reduce the temperature of air adjacent to or flowing over the evaporator. My invention relates particularly to means and methods for removing frost or ice from the coils, fins, baffles, drip pans or other surfaces associated with the evaporator.

The accumulation of frost and ice on the surfaces of an evaporator lowers the refrigerating efficiency very considerably by reducing the rate of heat transfer from the adjacent air to the evaporator and by obstructing the flow of air over the surface of the evaporator. In the usual household or commercial refrigerator used to maintain air at temperatures in the neighborhood of 40°F, defrosting is usually effected by cutting off the flow of refrigerant to the evaporator and allowing heat from the air adjacent to the coils and fins to melt the frost or ice. This method of defrosting is slow and troublesome to the housewife or others and cannot be employed at all when the refrigerating system is used to maintain the air adjacent the evaporator at temperatures below freezing.

In order to overcome difficulties inherent in prior methods of defrosting evaporators it has been suggested that electrical heating elements be employed for raising the temperature of the coils and fins periodically to melt the ice thereon. However, such systems require the use of such heavy current loads that they are uneconomical and have even been known to melt the evaporator and to cause fire and explosion of the refrigerant gas.

It has also been suggested that hot refrigerant from the compressor be passed directly to the evaporator to melt the ice which has accumulated. However, the amount of ice on the coils and fins and the amount of heat required to melt such ice are frequently so great as to prolong the defrosting operation unduly. Moreover, the amount of heat carried by the compressed refrigerant gas is quite limited and the gas soon condenses in the evaporator and cannot be reused as a defrosting agent until it has again been vaporized by the application of heat and sensible heat thereto. Oil laden with the refrigerant or a leaky or sticky valve also may cause liquid refrigerant to be carried to the compressor thus impairing the operation of the compressor.

In one method, wherein hot refrigerant is supplied to the evaporator for defrosting purposes, an element is provided for storing heat in a body of liquid or other heat storage medium during the normal refrigerating period, and this heat is used to vaporize the refrigerant passing from the evaporator to the compressor during the defrosting cycle. However, the temperature of such a heat storage medium is reduced rapidly during the defrosting operation so that its effectiveness is diminished in a short period of time and when the operation is prolonged the stored heat is often expended before the removal of frost and ice from the evaporator surfaces has been completed. This situation is encountered most frequently when the evaporator is exposed to contact with moist air and the accumulation of ice is most troublesome.

In order to overcome these objections to methods and constructions of the prior art, I have developed a system for removing frost and ice from the surfaces of an evaporator which is rapid in operation and economical to use. Moreover, the defrosting operation may be continued indefinitely without decrease in effectiveness and for as long as may be necessary to insure complete defrosting of the evaporator under any conditions which may be encountered. In this way complete defrosting of the evaporator is assured, the heat reservoir herefore necessary is eliminated, and the length of time required for defrosting the evaporator is materially reduced.

In the preferred form of my invention herein described, the heat for vaporizing the refrigerant is obtained from waste sources such as the compressor or motor employed in the system and the heat used to evaporate the refrigerant is actually generated during the defrosting operation. Heat contained in the air outside of or passing to the refrigerated space also may be used. The over-all efficiency of the system is thereby increased and the defrosting operation can be continued indefinitely.

One of the objects of my invention is to provide novel methods and means for removing frost and ice from the surfaces of an evaporator.

Another object of my invention is to increase the efficiency of refrigerating systems.

A further object of my invention is to provide means for defrosting the coils, fins and other surfaces of an evaporator more quickly and effectively than herefore.

A particular object of my invention is to utilize heat herefore lost in a refrigerating system for removing frost and ice from the surfaces of an evaporator.

These and other objects and features of my invention will appear from the following de-
scription thereof in which reference is made to the figures of the accompanying drawing.

In the drawing:

Fig. 1 is a diagrammatic illustration of a typical refrigerating system embodying my invention; and

Figs. 2 and 3 each illustrate a different alternative construction embodying my invention.

That form of my invention illustrated in Fig. 1 is embodied in a conventional refrigerating system including a compressor 2 driven by a motor 4 for supplying refrigerant to condenser 6 through the pressure line 5. Liquefied refrigerant from the condenser passes to the receiver 10 and is supplied to the evaporator 12 through the supply line 14 under control of the expansion valve 16. The refrigerant is vaporized in the evaporator and returns to the compressor through the return line 18. A reheating element 20 is contained in the return line 18 between the evaporator and compressor for insuring complete vaporization of the refrigerant returning to the compressor. Further in order to defrost the evaporator 12, a by-pass line 22 extends from the pressure line 5 to the supply line 14 and is controlled by the valve 24. In accordance with my invention the reheater is supplied with novel means for insuring a continuing and adequate supply of heat thereto for defrosting the evaporator. This heat may be derived wholly or in part from the air outside the refrigerated space and the air preferably is heated by elements such as the motor, compressor, condenser or the like.

The operation of the elements described is as follows:

During normal refrigerating operation the compressor serves to compress a gaseous refrigerant and forces it through the pressure line 5 to the condenser 6. The heat generated by compression of the gas and the latent heat of vaporization are dissipated in the condenser whereupon the refrigerant condenses and passes to the receiver 10 and hence to the supply line 14. The expansion valve 16 controls admission of the liquefied refrigerant to the evaporator where the refrigerant is vaporized taking up heat as latent heat of vaporization and reducing the temperature of the air adjacent the evaporator. The vaporized refrigerant then passes through the return line 18 and reheater 20 to the suction side of the compressor. The cycle is continued during refrigeration until the air adjacent the evaporator is reduced to a predetermined temperature or until it is necessary to defrost the evaporator.

When it is desired to defrost the evaporator the valve 24 in by-pass line 22 is opened. The hot refrigerant from the compressor then flows directly to the evaporator where it gives up its heat in melting the ice and frost on the coils, fins and other surfaces associated with the evaporator. The by-pass line through which the hot refrigerant flows is preferably soldered or otherwise arranged in heat transferring relation with the drip pan 25, drain 26 and trap 27 so as to melt the ice in these elements to prevent overflow and insure free passage of water out of the refrigerating space.

The hot refrigerant passed to the evaporator gives up both sensible and latent heat in melting the ice on the coils and other surfaces and is condensed as it is cooled so that it passes to the return line 18 as a liquid. The compressor is not ordinarily designed to receive and handle the refrigerant in liquid form and in any event the latent heat of vaporization must be supplied to the refrigerant in order for it to be converted into a gas so that it can be compressed and passed to the evaporator for defrosting purposes. The liquid refrigerant from the evaporator is therefore passed through the reheater 20 to cause it to be completely re-vaporated before it is supplied to the compressor. The defrosting cycle can then be continued as long as necessary and until the evaporator is cleared of ice and frost.

On completion of the defrosting operation the valve 24 is closed to re-establish the refrigerating operation.

The general principle of operation of the elements described above is well known in theory but has not been used extensively in actual practice because no practical and economical means have heretofore been provided for supplying heat to the reheater in sufficient amounts or for a sufficient length of time to insure effective defrosting of the evaporator. In particular, when defrosting systems using hot refrigerant from the compressor are employed for defrosting evaporator coils on which ice tends to build up rapidly, the defrosting operation must be repeated frequently or continued for a longer time than that of electrical heating elements is very costly. On the other hand, the heat stored in a heat accumulator during the refrigerating cycle is withdrawn rapidly as the defrosting operation continues. The temperature of the heat storage medium therefore is lowered since no additional heat is supplied to the reheater during the defrosting cycle. For this reason the rate at which ice and frost are melted becomes slower and slower prolonging the defrosting operation and in many cases the supply of heat is inadequate to insure complete defrosting of the evaporator. Under such circumstances the ice remaining at the end of each defrosting cycle builds up until the system becomes inoperative or at least very defective in operation.

A typical construction in which this situation is sometimes arises is shown and described in the copending application of MacMaster and Smith, Serial No. 713,384 filed November 30, 1946, which issued as Patent No. 2,494,481, January 10, 1950, wherein a self service display case which is open at the top for access to customers is maintained at temperatures below 10° F. for the preservation of frozen foods. In such installations ice often accumulates on the coils and fins of the evaporator to such an extent that prior defrosting systems are inadequate or prohibitive in expense of operation. In other installations, even where the relative humidity of the air is low and the temperature of the air adjacent the evaporator is above freezing the time required for defrosting the evaporator is objectionably prolonged, when defrosting means heretofore available are employed.

In accordance with my invention heat contained in air from outside the refrigerated space and heat produced by the motor, compressor or other elements operated during the defrosting cycle is supplied to the reheater. Since the compressor is operated during the defrosting cycle and heat contained in the ambient atmosphere are continuously available the defrosting operation may be continued indefinitely until the evaporator and other surfaces are cleared of ice. Moreover, the heat supplied to the reheater is drawn from the atmosphere or is waste heat from the motor, compressor, blower, condenser or other elements by which heat is generated or from
which heat is rejected as an incident to the normal operation of the system. Therefore, no additional expense of operation is encountered and but little additional equipment is required.

In the construction illustrated in Fig. 1 a housing 29 in the form of an open-faced or tubular casing extends about the compressor 2, motor 4, condenser 6 and reheater 20. The condenser is located at the right hand end of the casing 29 as seen in Fig. 1 and the reheater is located at the left hand end. A fan 35 driven by a motor 32 or from the compressor motor 4 is positioned in the casing adjacent the condenser and serves to cause a current of air from outside the refrigerated space to flow through the casing 29 and over the condenser, motor and compressor to the reheater. The air thus circulated supplies ample heat to the reheater 20 so as to insure continued evaporation of the refrigerant in the reheater. The refrigerant therefore is continuously and completely vaporized before it passes to the compressor during the defrosting cycle. Heat drawn from the atmosphere alone is in some cases sufficient for this purpose, but for more rapid defrosting I utilize the heat of the motor 4 or practically all electric motors used in operating the compressors of refrigerating systems develop losses in the form of heat amounting to from 20 to 50% of the power input. The compressor also develops heat in operation whereas the condenser gives up the residual heat retained thereby when the defrosting cycle is initiated. These and other elements generate or give up heat which would otherwise be wasted and lost to the system. In fact the dissipation of such waste heat has itself presented a problem heretofore, whereas I utilize such waste heat in a manner to increase the over-all efficiency of the system and insure rapid and effective defrosting of the evaporator. Furthermore, the heat utilized by the reheater is largely if not entirely generated during the continuance of the defrosting operation so that there is no diminution in the amount of heat supplied for vaporizing the refrigerant as the defrosting cycle continues and the rate at which ice is melted from the evaporator is the same at the end of the defrosting cycle as when the defrosting cycle is initiated. Rapid and complete defrosting of the evaporator is thus assured.

As shown in Fig. 1 the compressor, motor, condenser, reheater and blower may be so housed as to form a neat, compact unit which is readily installed in the system and can be produced economically for application to existing refrigerated constructions.

In the construction shown in Fig. 2 the reheater is formed with a series of coils 44 which are positioned adjacent the coils 46 of the condenser 6. The coils of the reheater and condenser are preferably provided with common heat conducting fins so that they can be assembled as a unit. The air or fluid circulated over the reheater and condenser can be used to remove heat from the coils of the condenser during the refrigerating cycle and to supply heat to the coils of the reheater during the defrosting cycle. It is generally believed that this construction is preferable to the conventional arrangement where a separate motor and fan is required. By virtue of this construction, a condenser and reheater are in fact the same unit and are indicated at 52. As in the other systems illustrated, hot refrigerant from the compressor 2 passes to condenser-reheater unit 52 through supply line 8 and liquid refrigerant passes from collector 10 to evaporator 12 through the expansion valve 16. The return line 54 conducts refrigerant from the evaporator back to the low pressure side of compressor 2. In accordance with this form of my invention return line 54 is provided with a cut-off valve 56 and a by-pass line 58 is provided which extends from the evaporator 12 into supply line 8 and is provided with a valve 60. An alternate return line 62 controlled by the fan 35 extends from the condenser-reheater unit 52 to the intake side of the compressor 2. The by-pass line 22 and valve 24 of the other constructions described are included in the system.

When using this construction during the refrigerating cycle, the hot gaseous refrigerant from the compressor 2 passes through the pressure line 8 to the condenser where it gives up its latent heat and passes to the receiver 10 in the form of a liquid. The liquid refrigerant passes to the evaporator through the evaporation valve 16 and after being vaporized returns to the compressor through return line 54 to complete the refrigerating cycle. There is generally no need for the reheater during normal refrigerating operation and therefore the condenser-reheater unit 52 functions only as a condenser during the refrigerating cycle.

When it is desired to defrost the evaporator, valve 56 in return line 54 is closed and valve 60 in the by-pass line 58 is opened. At the same time valve 54 in the alternate return line 52 is opened and valve 24 in the by-pass line 22 is opened. When thus regulated, the hot gaseous refrigerant from the compressor flows through by-pass line 22 to the evaporator where it gives up sensible and latent heat to melt the ice on the evaporator. The refrigerant is thus condensed and returns through the by-pass line 22 to the condenser-reheater unit 52 which then acts as a reheater to vaporize the refrigerant. From the unit 52 the gaseous refrigerant passes through the alternate return line 62 to the intake side of compressor 2 to complete the defrosting cycle.

As in the other forms of my invention described, heat from the motor, compressor or other element operating during the defrosting cycle is supplied to the reheater by means of a fan 65 or other circulating means so that continued effective operation of the reheater is assured even though the defrosting operation is prolonged.

While I have illustrated and described several typical forms of my invention it will be apparent that numerous other arrangements and constructions of the various elements in the combination may be employed and that the invention is applicable to both industrial and household refrigerators and to systems in which the temperature of the air adjacent to or flowing over the evaporator is either below or above freezing temperature.

In view thereof, it should be understood that the embodiments of my invention herein shown and described are intended to be illustrative only and are not intended to limit the scope thereof.

I claim:

1. A refrigerating system comprising an evaporator, a compressor, an electric motor for driving said compressor, a condenser, conduits leading from the evaporator to said compressor, from said compressor to said condenser and from said condenser back to said evaporator for direct-
ing the flow of refrigerant during the refrigerating cycle of said system, a bypass conduit leading from the compressor to the evaporator for allowing the discharge of refrigerant in a hot gaseous state from the compressor directly into the evaporator so as to defrost said evaporator, valve means positioned in said conduits for controlling the flow of said refrigerant, a portion of the conduit leading from the evaporator to the compressor being formed into a reheating coil continuously connected in series therein, an open ended casing in which said reheating coil and the compressor motor are located, and a fan for directing air over said compressor motor to said reheating coil.

2. A refrigerating system comprising a compressor, condenser and evaporator, a reheater connected between the evaporator and the compressor for vaporizing refrigerant returning to the compressor, said condenser and reheater embodying tubes connected together by common heat radiating fins and a blower positioned to circulate air at a temperature above the boiling point of the refrigerant into heat exchanging relation with said tubes and fins.

3. A refrigerating system having a refrigerating and a defrosting cycle, comprising a compressor, an evaporator, a condenser-reheater unit connected between the compressor and evaporator, means for directing refrigerant through said condenser-reheater in its passage from the compressor to the evaporator during the refrigerating cycle, and means for directing refrigerant through the condenser-reheater in its return from the evaporator to the compressor during the defrosting cycle and a blower positioned to circulate air at a temperature above the boiling point of the refrigerant into heat exchanging relation with said condenser-reheater.

4. A refrigerating system comprising a compressor, a condenser and an evaporator connected together in series arrangement by conduit means, an electric motor for actuating said compressor, a by-pass conduit for connecting the compressor to the evaporator so as to by-pass the condenser, a valve in said by-pass conduit movable from a closed position maintained during a refrigerating cycle to an open position for initiating a defrosting cycle and allowing hot refrigerant gas to flow from said compressor to the evaporator through said by-pass conduit to raise the temperature of the evaporator and melt any ice or frost which has accumulated thereon during the refrigerating cycle, a reheater coil continuously connected in series between the evaporator and compressor as a part of said conduit means so that all refrigerant returning to the compressor passes through the reheater coil during both the refrigerating cycle and the defrosting cycle, and a blower located in position to direct air at a temperature above the boiling point of the refrigerant into heat exchanging relation with the reheater coil to give up heat thereto and re-vaporize the liquid refrigerant returning to the compressor from the evaporator.

VICTOR W. SMITH.

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