Nov. 10, 1953 V. W. SMITH 2,658,357

REFRIGERATING SYSTEM

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Fig. 1.

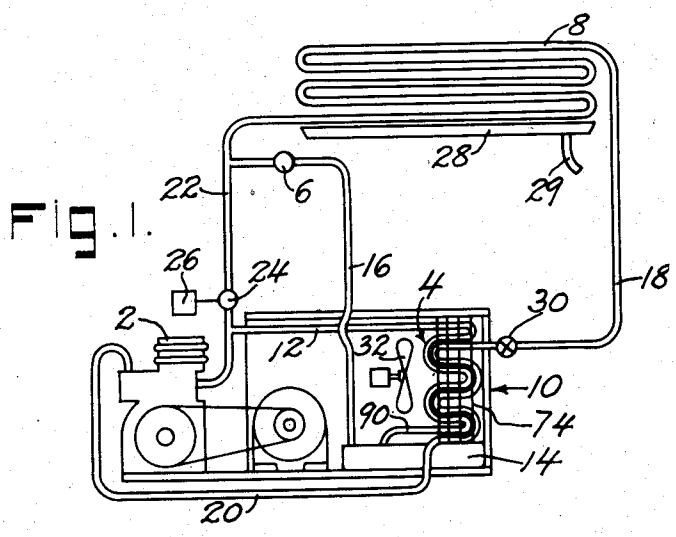
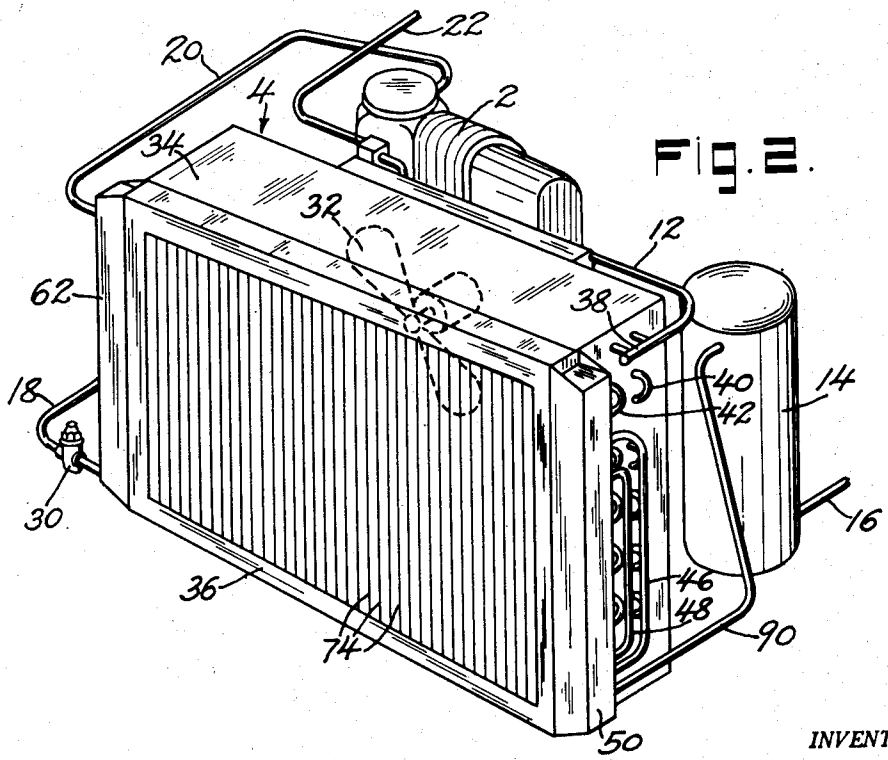


Fig. 2.



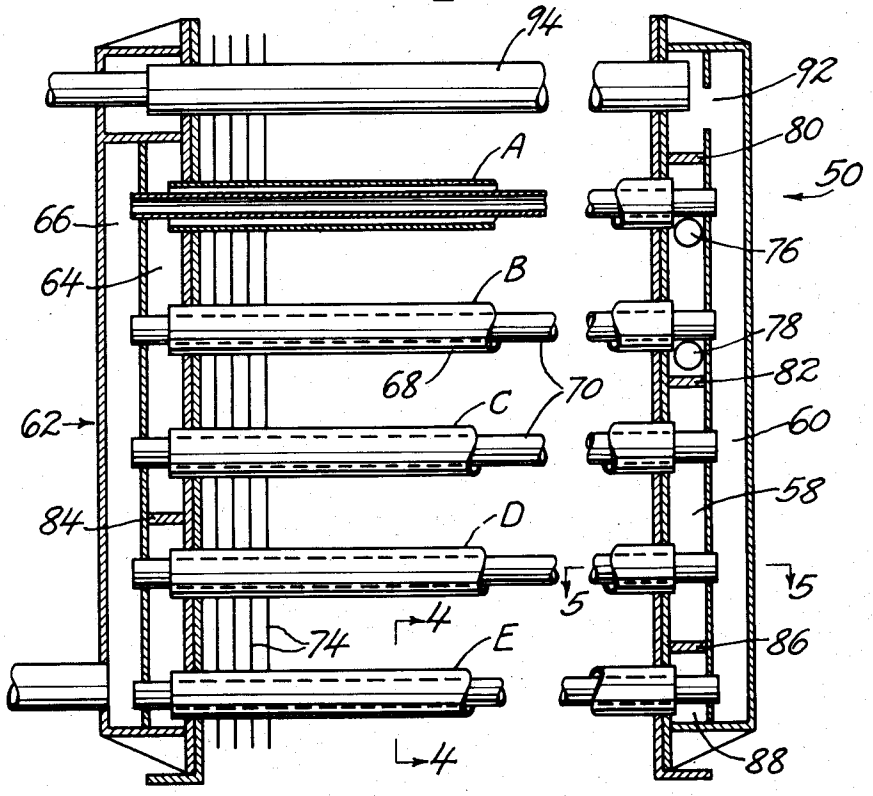
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Fig. 3



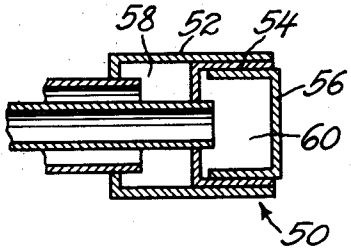


Fig. 5.

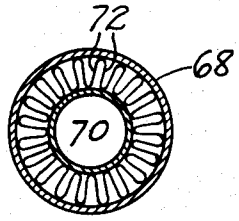


Fig. 4.

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2,658,357

REFRIGERATING SYSTEM

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Application May 17, 1950, Serial No. 162,501

3 Claims. (Cl. 62—117.55)

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This invention relates to refrigerating systems of the type wherein a compressor, condenser and evaporator are employed and means are provided for defrosting the evaporator periodically. This application is a continuation in part of my co-pending application Serial No. 752,031 filed June 3, 1947, now Patent No. 2,555,161, May 29, 1951.

It is a characteristic of all refrigerating systems in which the evaporator is raised to an elevated temperature for defrosting purposes, that the initial period of refrigeration following a defrosting cycle imposes a heavy load upon the compressor, condenser and other elements of the system. This is due to the fact that the evaporator is relatively warm at the conclusion of the defrosting cycle and relatively large amounts of refrigerant are introduced into the evaporator. The refrigerant gas returning to the compressor under such conditions is at a higher temperature and pressure than usual and as a result the re-compression of the refrigerant gas raises it to an abnormally high temperature and pressure. The condenser is then called upon to dissipate an excessive amount of heat so that it may be, at least temporarily, overloaded and its temperature rises causing back pressure to be imposed on the system and placing a heavy load on the motor by which the compressor is driven.

In the systems described in said co-pending applications, defrosting of the evaporator is accomplished by passing hot refrigerant gas from the compressor to the evaporator, by-passing the condenser, during the defrosting cycle whereby ice and frost are melted from the coils, fins, drip pan and adjacent surfaces of the evaporator. The refrigerant is partially condensed by giving up heat to the evaporator and therefore means are interposed between the evaporator and the compressor to re-evaporate the liquid refrigerant before it reaches the compressor. In one form of the invention disclosed in said application Serial No. 752,031, now Patent No. 2,555,161, May 29, 1951, the coils or passages of the revaporizer are arranged in heat exchanging relation with the coils of the condenser and in the construction of application Serial No. 109,335, now Patent No. 2,632,303 March 24, 1953, a restrictor or expansion valve is located adjacent the inlet to the revaporizer to insure expansion and vaporization of the returning liquid refrigerant. Further, in both of said applications ambient air is blown over both coils, causing moisture from the air to condense on the coils of the revaporizer, and give up its latent heat of vaporization to the evaporating liquid refrigerant.

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In accordance with the present invention such heat exchange between the revaporizer and the condenser is further utilized to reduce the load on the compressor during the initial stages of the refrigeration cycle. This is accomplished by arranging the coils of the revaporizer and condenser in such heat exchanging relation that the condenser coils will be cooled sufficiently by expansion of gas in the revaporizer during the defrost cycle to cause moisture to deposit and ice to form on the condenser. Thereafter during the initial period of the refrigerating cycle the condenser gives up heat in melting such ice or frost and evaporating the moisture whereby the rate of heat dissipation by the condenser is increased at the very time when overloading of the condenser and other elements of the system would otherwise tend to occur.

The unlimited availability of air for heat exchange with the revaporizer also permits the defrosting operation of the present invention to be prolonged sufficiently to cause the evaporator to function as a heat ejecting means or radiator when desired. The temperature of air in an enclosure or conduit can therefore be raised or lowered as required by reversible action of the evaporator in any situation where it is desired to maintain temperatures within predetermined limits.

The construction of the present invention further makes it possible to reduce the size and cost of the condenser and revaporizer and the whole assembly may be made more compact and simple in construction.

One of the objects of the present invention is to provide an improved form of defrosting equipment for use in refrigerating systems of the type employing a compressor, condenser and evaporator.

Another object of the invention is to reduce the loads to which the compressor, condenser and other elements of refrigerating systems are subjected during the initial stages of a refrigerating cycle following a defrosting cycle.

A further object of the invention is to provide an improved form of condenser-revaporizer assembly for use in refrigerating systems.

Another object of the invention is to provide a system wherein continued and reversible heat transfer through the evaporator is possible.

These and other objects and features of the present invention will appear from the following description 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 form of refrigerating system embodying the present invention;

Fig. 2 is a perspective view of a preferred form of compressor, condenser and revaporizer assembly adapted for use in the system illustrated in Fig. 1;

Fig. 3 is a vertical sectional view of the condenser-revaporizer shown in Fig. 2;

Fig. 4 is a sectional view of a detail of the construction taken on the line 4—4 of Fig. 3; and

Fig. 5 is a horizontal sectional view of one of the headers taken on the line 5—5 of Fig. 3.

In the refrigerating system illustrated in Fig. 1 there is a compressor 2, a condenser 4, an expansion valve 6, an evaporator 8 and revaporizer coils 10. These elements are connected together in series and during the normal refrigeration cycle hot refrigerant gas from the compressor flows through the high pressure line 12 to the condenser 4 where it is cooled and condensed to a liquid. The liquid refrigerant passes from the condenser to the receiver 14 from which it is supplied through the refrigerant line 16 to the expansion valve 6. The refrigerant passing the expansion valve is vaporized in the evaporator 8 where it takes up heat from the air and surfaces adjacent the evaporator. From the evaporator the refrigerant gas flows through the return line 18 to the revaporizer 10 and returns to the intake side of the compressor through the low pressure line 20.

For defrosting purposes and to permit the evaporator to function as a heat ejecting means or radiator, a by-pass line 22 is provided and extends from the high pressure line 12 to the evaporator 8 so as to by-pass the condenser, receiver and expansion valve. A control valve 24 is located in the by-pass line 22 for initiating and terminating the defrosting operation. The control valve may be actuated by a suitable means indicated generally at 26 and consisting of a time clock, pressure or temperature responsive means or a combination of these or other control devices.

During the defrosting operation hot refrigerant gas passes from the compressor 2 and high pressure line 12 through the by-pass line 22 to the evaporator 8. Heat is thus supplied to the evaporator and to the drip pan 28, drain 29 and other surfaces in heat exchanging relation with the by-pass line to melt the ice and frost thereon. In giving up its heat to melt the ice the hot refrigerant gas is cooled and at least a portion thereof is generally condensed to a liquid. The mixed gas and liquid refrigerant flows through the return line 18 to the revaporizer 10. It is preferable to provide a restrictor 30 in the return line adjacent the revaporizer 10 as shown and described more fully in my co-pending application Serial No. 109,335 filed August 9, 1949, now Patent No. 2,632,303. Air is blown over the coils, fins, and other surfaces of the reheater 10 by means of a blower 32 whereby moisture contained in the air is caused to condense on the surfaces adjacent the revaporizer giving up its latent heat of vaporization to the liquid refrigerant whereby the refrigerant is completely evaporated before it returns through the low pressure line 20 to the compressor 2.

At the conclusion of the refrigerating cycle the valve 24 in by-pass line 22 is closed so that refrigerant gas again passes from the compressor to the condenser. However, by arranging the coils of the condenser and revaporizer in intimate heat exchanging relation the moisture which was condensed and the ice which has accumulated on the surfaces of the condenser-revaporizer unit absorb heat as latent heat of fusion and latent heat of vaporization from the hot gas flowing to the condenser. Sensible heat is also given up by the condenser to the coils, fins, and other surfaces of the revaporizer. In this way there is immediate and unusual dissipation of heat by the condenser during the initial period of refrigeration following the defrosting cycle and until the ice and moisture on the surfaces of the condenser-revaporizer unit has been removed. Thereafter the demand for heat dissipation by the condenser is reduced and the normal flow of air from the blower 32 over the coils and fins of the condenser is adequate to condense the refrigerant and prevent overloading of the system.

The construction shown in Figs. 2 to 5 of the drawings embodies a condenser section 34 and a condenser-revaporizer section 36. The refrigerant gas from the compressor passes from the high pressure line 12 to the small header 38 of the condenser section and then flows in parallel through two sets of coils 40 and 42 which extend back and forth from the upper to the lower portion of the condenser section 34. These coils are provided with fins 44 for increasing their heat exchanging surface, and the lower ends of the coils 40 and 42 turn upward as shown at 46 and 48 and enter the side of the header 50 shown at the right hand side of the condenser-revaporizer section 36.

As shown in Fig. 5 the header 50 is preferably formed of an outer U-shaped channel member 52, a reversely facing intermediate channel member 54 and an inner channel member 56. These channel members are brazed or otherwise connected together to form an inner header section 58 and an outer header section 60. The opposite end of the condenser-revaporizer is provided with a similar header 62 which is formed with an inner header section 64 and an outer header section 66. Two series of tubes of different diameter are arranged one within the other and extend between the headers 50 and 62 with the tubes 68 of larger diameter communicating with the inner header sections 58 and 64 and the tubes 70 of smaller diameter communicating with the outer header sections 60 and 66. Webs or loops of conducting material 72 radiate from the inner tubes 70 to the outer tubes 68 providing effective heat conductivity therebetween while imposing very little obstruction to the flow of gas through the space between the tubes. The tubes are also provided with the usual external fins 74 to provide added heat transfer surfaces over which air from the blower 32 is passed.

The flow of condensing refrigerant from the compressor through the condenser-revaporizer during the refrigerating cycle takes place as follows:

After passing in parallel through the coils 40 and 42 of the condensing section the refrigerant flows upward through the vertical tubes 46 and 48 and enters the side of the header 50 at the points 76 and 78 in the inner header section 58 between an upper partition 80 and an intermediate partition 82. It then flows in parallel through the space between the tubes 68 and 70 which form the passes indicated A and B to the inner header section 64 of header 62. The latter section is provided with an intermediate partition 84 which serves to cause the refrigerant received from both

passes A and B to return to header 50 through the single pass C. A lower partition 86, in the inner section of header 50 separates pass D from pass E and therefore the refrigerant flows through pass D to header 62 and back through pass E to the chamber 88 below partition 86. From chamber 88 the now fully condensed and liquified refrigerant passes through the liquid line 90 to the receiver 14.

The refrigerant gas returning to the compressor 2 from the evaporator 8 flows through return line 18 and restrictor 30 so as to enter the outer header section 66 of header 62. From the latter header the refrigerant flows in parallel through the smaller diameter tubes 70 to the outer header section 60 of the header 50 and then flows upward through the port 92 and the uppermost pass 94 which functions as a de-superheater. The vaporized and conditioned refrigerant gas then flows to the low pressure line 29 leading to the intake side of compressor 2.

The restrictor valve 30 through which the returning refrigerant enters the header 62 is preferably of the type shown and described in copending application Serial No. 109,335 and operates in response to the pressure of the gas on the intake side of the compressor to impose little or no resistance to the flow of refrigerant therethrough during the normal refrigerating cycle when the pressure of gas in the evaporator and return line is relatively low. However, when the pressure on the intake side of the compressor is relatively high, as it is during the defrost cycle, and during the initial period of refrigeration following the defrost cycle, the valve 30 tends to close and functions as an expansion valve to insure vaporization of the liquid refrigerant in the tubes 70 of the condenser-revaporizer section 36.

With this construction heat is supplied, during the defrosting cycle, to the refrigerant flowing through the smaller tubes 70 by conduction through the webs 72 and the exposed surfaces of the larger tubes 68 and fins 74. Air is blown over the condenser and the larger tubes of the condenser-revaporizer unit by blower 32, which is shown in Figs. 1 and 2. The liquid refrigerant flowing through the revaporizer tubes during the defrosting cycle is expanded in a gaseous form by passage through the nearly closed restrictor 30 and generally is reduced thereby to a temperature below 0° F. The temperature of the larger diameter tubes 68 is therefore reduced by the flow of heat through webs 72 and as a result moisture from the air condenses on the surface of the larger tubes and fins giving up its latent heat of vaporization to revaporize the refrigerant returning to the compressor through the tubes 70. There is little or no flow of refrigerant through the condenser and larger tubes 68 during the defrosting cycle so that as the defrosting cycle continues the condensed moisture on the exposed surfaces of the tubes and fins generally is congealed to form ice or frost whereby additional heat is given up as latent heat of fusion of the moisture condensed from the air.

In most cases it is this latent heat which is relied upon primarily for revaporizing the returning liquid refrigerant during the defrosting cycle, since it can be readily shown in a typical installation that nearly 300 times as much heat is given up to the refrigerant as latent heat of vaporization of moisture condensing from the air and freezing on the exposed surfaces than is given up as sensible heat in cooling the air flowing over the unit. The condensed and frozen moisture continues to accumulate on tubes 68 and fins 74 during the defrosting operation and therefore builds up to serve in effect as a cold storage means which thereafter operates automatically to increase the effective capacity of the condensing elements when hot refrigerant gas again is passed to the condenser on renewing the refrigerating cycle.

Thereafter when the refrigerating cycle is initiating the hot refrigerant gas from the compressor first flows through the condenser section 34 and then flows through the ice covered tubes 68 of the condenser-revaporizer unit. The ice and frost which has accumulated on the exposed surfaces is then melted, absorbing latent heat of fusion, and the resulting moisture is evaporated absorbing latent heat of vaporization. The accelerated rate of heat absorption resulting from such melting and evaporation insures more rapid condensation of the refrigerant during the initial period of refrigeration following a defrosting cycle and a reduction in the back pressure imposed on the compressor and condenser. At the same time the refrigerant gas returning to the compressor through the restrictor and the inner tubes 70 of the condenser-revaporizer serve to cool the condensing refrigerant further withdrawing heat therefrom. Such unusual dissipation of heat by the condenser continues until all of the ice, frost and moisture on the surfaces of the tubes 68 and fins 74 has been dissipated. However, by that time the temperature of the evaporator will be reduced and the load on the compressor and the demand for dissipation of heat by the condenser is greatly reduced. The restrictor 30 will then return to its normal position for the refrigeration operation in which it imposes little or no resistance to the flow of the refrigerant returning to the compressor.

In order to reduce the super heat of refrigerant gas returning to the compressor after heat exchange with the condensing refrigerant during the refrigerating cycle, the uppermost pass 94 of the condenser-revaporizer is provided to afford heat exchange by convection with the ambient air and by conduction through fins 74. The returning refrigerant is thus cooled sufficiently prior to its entry into the compressor to insure efficient operation of the compressor.

The construction described is thus seen to serve in effect as a reversible heat exchange and cold storage means which reduces the load and increases the efficiency of operation during both the defrosting and refrigerating cycle. Moreover, the system automatically accommodates itself to the atmospheric conditions by reason of the fact that on those days and in those territories where the air has a high humidity causing rapid formation of frost on the evaporator coils, the condensation of moisture on the coils and fins of the condenser-revaporizer during the defrosting cycle will take place more rapidly and revaporizing of the refrigerant will be more effective.

The defrosting cycle may be continued as long as necessary to insure complete defrosting of the evaporator since the supply of moisture containing air relied upon for condensing moisture on the condenser-revaporizer is unlimited. In fact the defrosting cycle may be continued long after ice has been melted from the evaporator to cause heat to be supplied to air in any enclosure or conduit in which the evaporator is located. At such times the evaporator functions as a radiator and it may prevent over-cooling of an enclosure just as it operates to prevent overheat-

ing on the normal refrigerating cycle. Thermostatic or other suitable control of valve 24 will therefore convert the system into a complete temperature control or air conditioning unit having a great variety of applications.

The compact arrangement and effective heat interchange afforded by the condenser-revaporizer unit serves to reduce the cost of the entire assembly by permitting the use of a smaller condenser and revaporizer, and the nesting of one of these elements within the other. The cost of the installation is reduced and its efficiency of operation is increased, whereas the strains and loads on the system are minimized.

It should be understood, however, that the particular form, arrangement and construction of the elements employed in carrying out the present invention is capable of many variations particularly when adapting the invention to particular installations and refrigerating problems. In view thereof it will be evident, that the invention is not limited to the particular construction shown in the drawing and herein described but that such embodiment has been chosen only for purposes of indicating the nature of the invention and illustrating a typical form thereof.

I claim:

1. A refrigerating system comprising a compressor, an evaporator, a condenser connected in series between said compressor and evaporator, a revaporizer connected in series between said evaporator and compressor, said condenser and revaporizer being combined into a single unit having a pair of headers located adjacent one end of the unit and another pair of headers located adjacent the opposite end of the unit, the condenser including tubes extending in parallel from a header adjacent one end of the unit to a header adjacent the opposite end of the unit, the revaporizer including tubes extending from the other header at one end of the unit to the other header at the other end of the unit, the tubes of the condenser and revaporizer being arranged directly in heat conducting relation with each other and means for circulating moisture containing air in heat exchanging relation with said condenser and revaporizer.

2. A refrigerating system comprising a compressor, and an evaporator, a condenser embodying a series of tubes connected in series between the compressor and the evaporator, a revaporizer comprising a series of tubes connected in series between the evaporator and the compressor, the tubes of said condenser and revaporizer being combined into a single unit wherein said tubes are arranged in parallel relation and directly in heat conducting relation with each other, by-pass means for conducting refrigerant from the compressor to the evaporator so as to by-pass the condenser, means for controlling the flow of gas through said by-pass, a restrictor connected between the evaporator and revaporizer and located adjacent the revaporizer, and means for circulating moisture containing air over the tubes of said condenser and revaporizer.

3. A refrigerating system comprising a compressor, a condenser, an evaporator and a revaporizer connected together in series, said revaporizer and condenser embodying tubes arranged in direct heat conducting relation, by-pass means for conducting refrigerant from the compressor to the evaporator so as to by-pass the condenser, means for controlling the flow of gas through said by-pass, a restrictor connected between the evaporator and revaporizer and located adjacent the revaporizer, and means for circulating moisture containing air in heat exchanging relation with said condenser and revaporizer.

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