Sept. 27, 1966 R. M. ANDERSON ETAL 3,274,793

HEAT PUMP DEFROST SYSTEM

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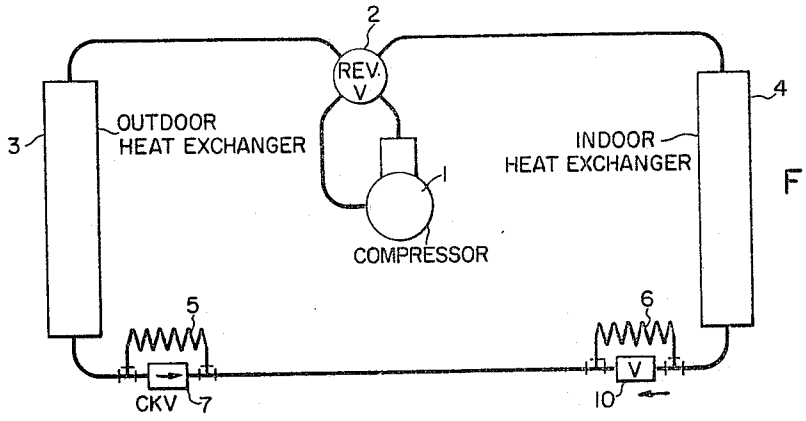

FIG.1.

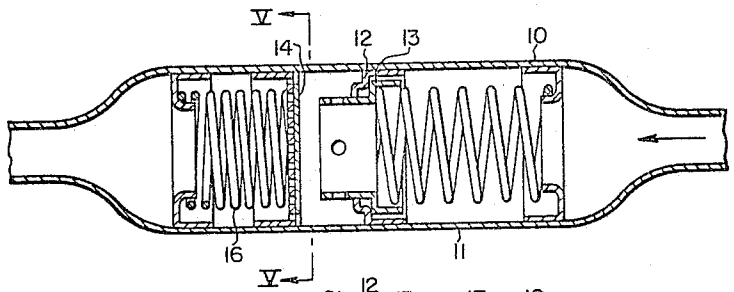

FIG.2.

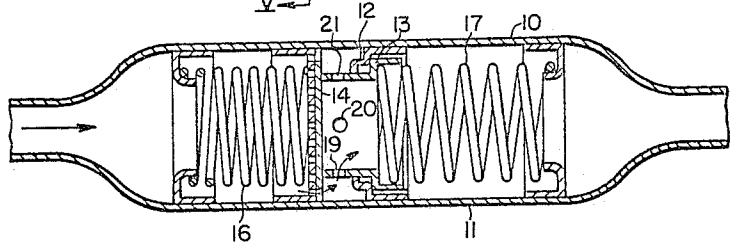

FIG.3.

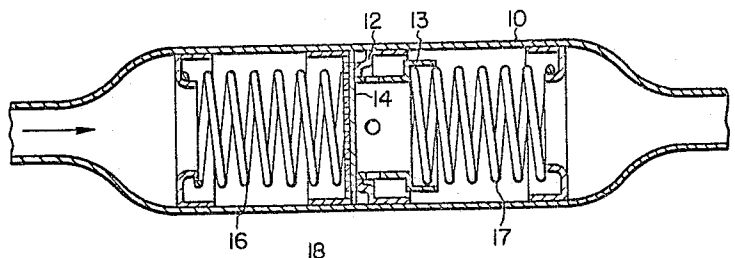

FIG.4.

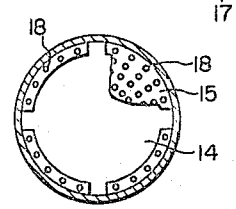

FIG.5.

WITNESSES

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HEAT PUMP DEFROST SYSTEM

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The present invention relates to heat pump systems and more particularly to a defrosting arrangement for a heat pump system.

As is well known, a heat pump system comprises both an indoor heat exchanger and an outdoor heat exchanger which interchangeably function as an evaporator or a condenser depending upon the setting of a reversing valve to selectively produce the desired heating or cooling function by the indoor exchanger. A single charge of refrigerant, which is usually a compromise selected to work most effectively for a particular function, either heating or cooling but usually cooling, is used, and some arrangement for providing different refrigerant metering and expansion for heating and cooling functions must therefore be provided. One of the difficulties with heat pump systems when arranged to operate for heating the indoor exchanger is that ice forms on the coils of the outdoor heat exchanger greatly reducing the efficiency of the system. It is therefore desirable to periodically reverse the system for a so-called defrost cycle time that is long enough to defrost the outdoor heat exchanger.

When a conventional heat pump system is first reversed from an indoor heating function for example, to defrost the outdoor exchanger, the restriction is required to be used with the preset charge of refrigerant for cooling the indoor exchanger and heating the outdoor exchanger may be excessively restricting for the quality, i.e. the temperature and pressure, liquid, and/or gas phase conditions of the refrigerant at that time and the result is an initial starving of the outdoor exchanger which slows down its heating and defrosting thus requiring an undesirable long defrost cycle time before refrigerant pressure builds up across the restriction and the outdoor exchanger is defrosted.

It is a principal object of the present invention to provide an improved heat pump system having a novel defrost arrangement that will quickly heat the outdoor exchanger and will therefore reduce the defrost cycle time as may take place from time to time during the operation of the heat pump system generally as for heating the indoor exchanger.

A feature of the invention is the provision in a novel manner of a differential pressure and flow responsive check valve connected in parallel with the restriction or metering device that is used for cooling the indoor exchanger and heating the outdoor exchanger. The valve as used by the system of the invention is provided with three automatically selected operative positions, i.e. open, partly closed, and fully closed, and is connected to be flow responsive to be open for bypassing the restriction when the refrigerant flow between the heat exchanger is in a direction to cool the outdoor heat exchanger and heat the indoor heat exchanger. Upon operation of the heat pump system reversing valve in a manner to reverse the refrigerant flow, such as for the defrost purposes to heat the outdoor heat exchanger, the aforementioned check valve is first both flow responsive and pressure responsive to be moved to the partly closed position in response to the then direction of refrigerant flow under relatively low pressure. Thus, the refrigerant restriction or metering device is at first partly bypassed so as to permit a more rapid loading and heating of the outdoor heat exchanger. As the temperature of the outdoor heat exchanger and the pressure of the refrigerant is thereafter increased, the valve is moved in response to such increased pressure and direction of refrigerant flow to the fully closed position, thus removing any bypass for the restriction which is then fully effective for continued heating of the outdoor heat exchanger. By using the aforementioned valve in the heat pump system of the invention, it is thus possible to quickly heat the outdoor exchanger and thereby provide a minimum defrost cycle time.

Further objects, features and the attendant advantages of the invention will be apparent with reference to the following specification and drawing in which:

FIGURE 1 is a block diagram of the heat pump system of the invention;

FIG. 2 is a sectional view of the differential pressure responsive check valve as used in the system of the invention with the valve shown in the fully open position;

FIG. 3 is a view similar to FIG. 2 but showing the valve in the partly closed position;

FIG. 4 is a view similar to FIGS. 2 and 3 but showing the valve in the fully closed position; and

FIG. 5 is a sectional view taken on the line V—V of FIG. 2.

Referring now to FIG. 1 of the drawing the heat pump system of the invention is comprised of the conventional compressor **1** connected in circuit with the reversing valve **2** to the outdoor heat exchanger **3** and the indoor heat exchanger **4** in series with an outdoor restriction or capillary **5** and an indoor restriction or capillary **6**. A conventional check valve **7** is connected in parallel with the restriction **5** while, in accordance with the invention, a differential pressure responsive check valve **10** is connected in parallel with the restriction **6**. When the reversing valve **2** is arranged to continuously direct refrigerant under pressure through the outdoor heat exchanger **3** and to the indoor heat exchanger **4** for purposes of imparting heat to the outdoor heat exchanger **3** and thereby cooling the indoor heat exchanger **4** the check valve **7** is normally open to bypass the restriction **5** and the bypass valve **10** is normally closed to place the restriction or metering device such as the capillary tube **6** fully in the circuit. On the other hand when the reversing valve **2** is adjusted to reverse the system to flow refrigerant from the indoor heat exchanger **4** to the outdoor heat exchanger for purposes of cooling the outdoor heat exchanger **3** and heating the indoor heat exchanger **4** the bypass valve **10** is normally open and the check valve **7** is closed so as to place the restriction **5** effectively in the system and remove the restriction **6** from the system. In other words the restriction **5** is a metering device calibrated for controlling the flow conditions of the refrigerant when it is desired to heat the indoor heat exchanger **4** and cool the outdoor heat exchanger **3**. On the other hand the restriction **6** is a metering device or capillary tube that is intended to restrict the flow of refrigerant in the other direction for purposes of cooling the indoor heat exchanger **4** and heating the outdoor heat exchanger **3**.

Although separate metering devices **5** and **6** are shown, it should be understood that the invention is not limited to a system having separate metering devices as alternate arrangements with one or more metering devices, are known to those skilled in the art.

Assuming now that the heat pump system of the invention has been operating in a manner to heat the indoor heat exchanger **4** and cool the outdoor heat exchanger **3** and the ambient conditions for the outdoor heat exchanger **3** are such that ice has accumulated on the exchanger surface to the extent that the efficiency of the system is impaired it is necessary to temporarily reverse the heat pump cycle for purposes of defrosting the

outdoor heat exchanger **3** as is well known in the art. Assuming that any suitable cycle response mechanism (not shown) but well known to those skilled in the art has moved the reversing valve **2** to the position for providing the flow of refrigerant in the direction to heat and defrost the outdoor heat exchanger **3**, it is found that at such time the quality of the refrigerant tending to flow through the restriction **6** is such that the flow of refrigerant through such restriction is excessively impeded thus effectively starving the heat pump system and preventing the rapid buildup of heat and pressure in the outdoor heat exchanger **3** as is desirable for a quick defrost operation. In accordance with the invention, the differential pressure responsive check valve **10** is at that time, i.e., when the reversing valve is first reversed as described above, moved from the open position shown by FIG. 2 of the drawings to a partly closed position shown by FIG. 3 of the drawings so that the restriction **6** is only partially effective and partially bypassed. Thus, a rapid buildup of heat and refrigerant under pressure in the outdoor heat exchanger **3** is obtained. As the temperature of the outdoor heat exchanger **3** rises and the pressure of refrigerant therein builds up, the refrigerant pressure differential across the bypass valve **10** increases to move the valve to the fully closed position shown by FIG. 4 of the drawings and the restriction **6** is then completely unbypassed and fully effective for the purpose of maintaining the heat pump system in the function of heating the outdoor heat exchanger **3** and cooling the indoor heat exchanger **4**. After the ice on the outdoor heat exchanger **3** is melted by the heat imparted thereto, the defrost cycle may be terminated by reversing the reversing valve **2** to again flow the refrigerant between the two heat exchangers in a manner to impart heat to the indoor heat exchanger **4** and cool the outdoor heat exchanger **3**. Because of such reversal of refrigerant flow therethrough at this time, the bypass valve **10** assumes the fully open position shown by FIG. 2 of the drawing and the check valve **7** is at the same time closed to place the outdoor heat exchanger restriction or capillary tube **5** fully in the circuit while at the same time bypassing the indoor heat exchanger metering device or capillary tube **6**.

An example of a preferred embodiment of differential pressure responsive check valve **10** as may be used in the defrost cycle of the heat pump system of the invention is shown in detail in connection with FIGS. 2–5 of the drawings. The check valve **10** may be provided with a tubular body portion **11** having a fixed valve seat **12** secured to the body portion in any suitable manner, a movable valve seat **13**, and a movable valve diaphragm **14** supported on a movable supporting mesh or screen **15**. In the closed position of the valve as shown by FIG. 4 of the drawing, the movable diaphragm **14** is seated against the fixed seat **12** as determined by the relative spring pressures of the compression springs **16** and **17**, it being assumed that the direction of fluid flow is in the direction of the arrow shown by FIG. 4 of the drawings. However, it should be pointed out that the relative forces for the compression springs **16** and **17** are so selected that only when the pressure difference of fluid flow in the direction of the arrow for FIG. 4 of the drawing is relatively large, will the valve diaphragm **14** be seated against the fixed valve seat **12** to fully close the valve. If the differential pressure for fluid flow in the direction of the arrow shown by FIG. 3 or FIG. 4 of the drawing is relatively low so that the combined pressure of the fluid flow and the force of the spring **16** is not great enough to overcome the force of the spring **17**, the valve diaphragm **14** will be seated only against the movable valve seat **13** as shown by FIG. 3 of the drawing. Under such conditions the bypass valve **10** may be said to be partly open since the flow of fluid will be restricted through the many outer perforations such as the perforation **18** of the mesh support member **15** and through the perforations such as shown at **19**, **20** or **21** of the movable valve seat **13**. Thus until the pressure of fluid flow in the direction of the arrow for either FIG. 3 or FIG. 4 of the drawing increases to an amount sufficient to overcome the force of the spring **17** bearing against the movable valve seat **13**, the bypass valve **10** will remain in the partly open position. As previously mentioned after the pressure of fluid flow in the direction of the arrow of FIG. 4 of the drawing has increased sufficiently to overcome the force of the spring **17** then the movable valve seat **13** will be moved back until the valve diaphragm **14** is resting against the fixed valve seat **12** to completely close the valve.

When the direction of the fluid flow is reversed such as shown by the arrow of FIG. 2 of the drawing, the fluid pressure moves the diaphragm **14** away from the fixed and movable valve seats **12** and **13** to the valve open position shown by FIG. 2 of the drawing. It will be understood that the force of the compression spring **16** is sufficiently low relative to the area of the valve diaphragm **14** that any appreciable fluid flow in the direction of the arrow of FIG. 2 will cause the bypass valve **10** to assume the fully open position shown by FIG. 2 of the drawing.

Considering the aforementioned description of the bypass valve **10**, it will be understood that such valve is effectively a valve that will be automatically opened when the fluid flow therethrough is in one direction and that will be selectively and automatically moved to either a partly closed or fully closed position when the flow of fluid therethrough is in the opposite direction depending upon the differential pressure of fluid flow across the valve in that direction. In other words a fluid flow of relatively low pressure in the direction of the arrow shown by FIG. 3 of the drawing will cause the valve to assume the partly closed position and a fluid flow in the same direction but under relatively high pressure differential will cause the valve to assume the fully closed position of FIG. 4 of the drawing. Although there has been described a preferred embodiment of differential pressure responsive check valve that may be used as the bypass valve **10** in the heat pump defrosting system of the invention, it should be understood that the invention is not limited to the precise form of differential pressure operated check valve as described but any similar valve functioning in a similar manner may be used therefor. It is not believed necessary to tabulate the refrigerant pressure conditions and accordingly the desired spring pressure calibrations for the bypass valve of the invention since obviously such parameters of the heat pump system may vary widely depending upon the choice of refrigerant used and the expected optimum conditions of operation. It is believed that anyone skilled in the art can readily determine the desired calibration characteristics for the bypass valve as may be required to cause it to automatically assume the desired modes of operation when the reversing valve **2** of the heat pump system is operated to change the heat pump system from a heating to a cooling function or to a defrosting function as may be required. No description has been made of a control system for operating the reversing valve **2** automatically at desired times for changing the system to either defrost the outdoor heat exchanger or to reverse the operation of the system as the season changes since it is believed that such control systems are well known to those skilled in the art.

Various modifications may be made within the spirit of the invention.

We claim as our invention:

1. A heat pump system comprising, an indoor heat exchanger, an outdoor heat exchanger, means for restricting the flow of refrigerant between said exchangers, and a differential pressure responsive bypass check valve connected in parallel with said restriction means and having means adapted to have an open position together with

a partly closed position and a fully closed position to be responsive to the flow of refrigerant between said exchangers in a direction to cool said outdoor heat exchanger to move said check valve to the open position and responsive to the flow of refrigerant under relatively low pressure between said exchanger in a direction to heat said outdoor exchanger to move said check valve to the partly closed position thereby partially bypassing said restriction to accelerate the loading and heating of said outdoor heat exchanger for defrosting purposes and to be responsive to the flow of refrigerant under relatively high pressure between said exchangers in the direction to heat said outdoor heat exchanger to thereby move said check valve to the fully closed position for continued operation and heating of said outdoor heat exchanger.

2. A heat pump system comprising, an indoor heat exchanger, an outdoor heat exchanger, means for restricting the flow of refrigerant between said exchangers in a direction to heat said outdoor heat exchanger and cool said indoor heat exchanger, and a differential pressure responsive bypass check valve connected in parallel with said restriction means and having means adapted to have an open position together with a partly closed position and a fully closed position to be responsive to the flow of refrigerant between said exchangers in a direction to heat said indoor heat exchanger to move said check valve to the open position and responsive to the flow of refrigerant under relatively low pressure between said exchangers in a direction to heat said outdoor exchanger to move said check valve to the partly closed position thereby partially bypassing said restriction to accelerate the loading and heating of said outdoor heat exchanger for defrost purposes and to be responsive to the flow of refrigerant under relatively high pressure between said exchangers in the direction to heat said outdoor heat exchanger to thereby move said check valve to the fully closed position for continued operation and heating of said outdoor heat exchanger.

3. A heat pump system comprising, an indoor heat exchanger, an outdoor heat exchanger, a compressor, a

reversing valve, an indoor exchanger refrigerant flow restriction, an outdoor exchanger refrigerant flow restriction, a check valve connected in parallel with said outdoor exchanger restriction to be closed when said reversing valve is in the position to flow refrigerant to said indoor exchanger for heating said indoor exchanger, and a differential pressure responsive bypass check valve connected in parallel with said indoor restriction and having means adapted to have an open position together with a partly closed position and a fully closed position to be responsive to the flow of refrigerant between said exchangers in a direction to heat said indoor heat exchanger to move said differential pressure check valve to the open position and responsive to the flow of refrigerant under relatively low pressure when said reversing valve is in the position to flow refrigerant between said exchangers in a direction to heat said outdoor exchanger to thereby move said differential pressure check valve to the partly closed position and thereby partially bypass said restriction to accelerate the loading and heating of said outdoor heat exchanger for defrosting purposes and to be responsive to the continued flow of refrigerant under relatively high pressure under control of said reversing valve between said exchangers in the direction to heat said outdoor heat exchanger to thereby move said differential pressure check valve to the fully closed position for continued operation and heating of said outdoor heat exchanger.

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WILLIAM J. WYE, *Primary Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,274,793 September 27, 1966

Richard M. Anderson et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

In the heading to the printed specification, lines 4 and 5, for "assignors to Westinghouse Electric Corporation, Pittsburgh, Pa., a corporation of Pennsylvania" read -- assignors, by mesne assignments, to Luxaire Incorporated, a corporation of Delaware --.

Signed and sealed this 22nd day of August 1967.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents