Feb. 22, 1944. E. R. WOLFERT 2,342,566

AIR CONDITIONING APPARATUS

Filed Jan. 17, 1944 2 Sheets-Sheet 1

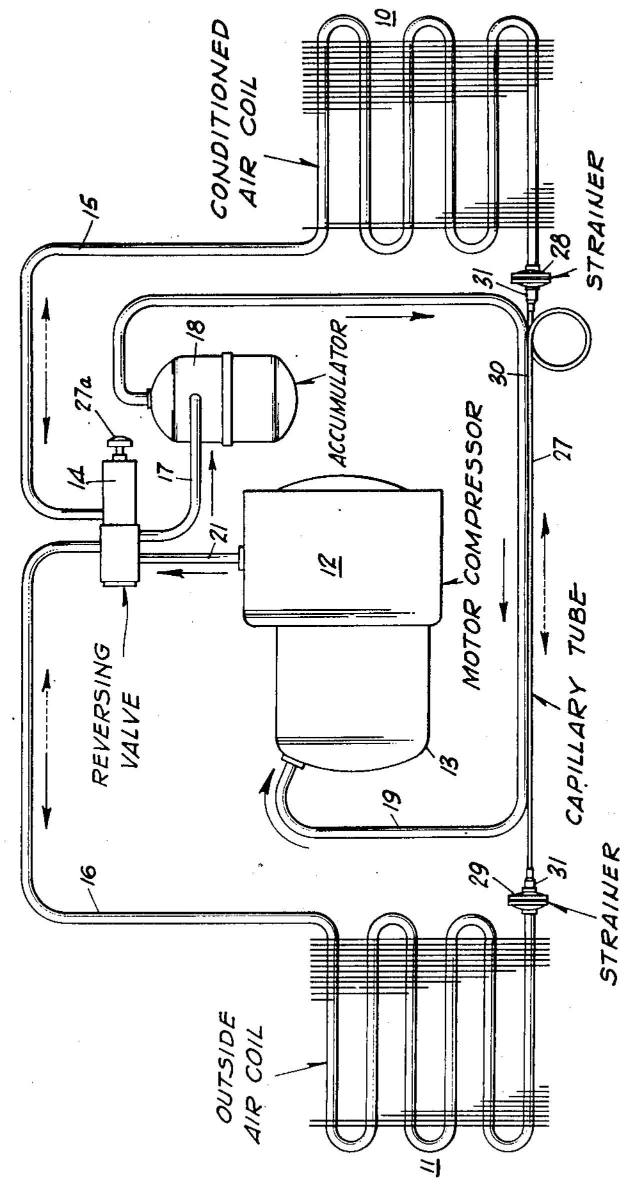

FIG. 1.

Inventor
EDWARD R. WOLFERT

[signature]
Attorney

Feb. 22, 1944. E. R. WOLFERT 2,342,566

AIR CONDITIONING APPARATUS

Filed Jan. 17, 1944 2 Sheets-Sheet 2

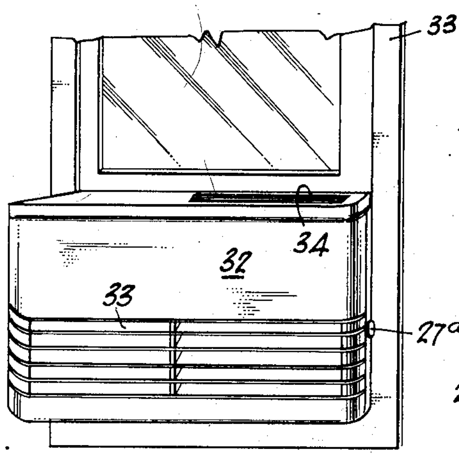

FIG. 4.

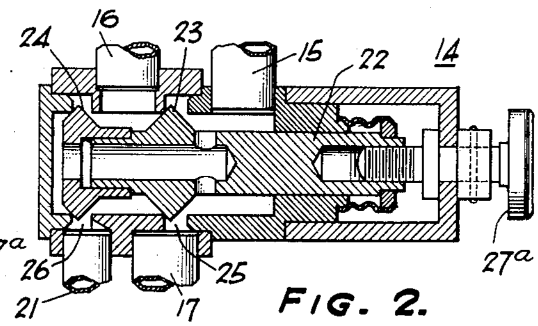

FIG. 2.

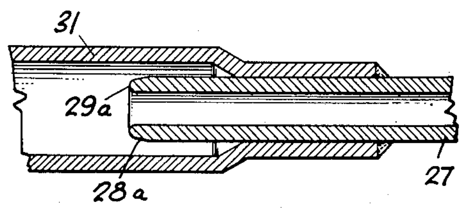

FIG. 3.

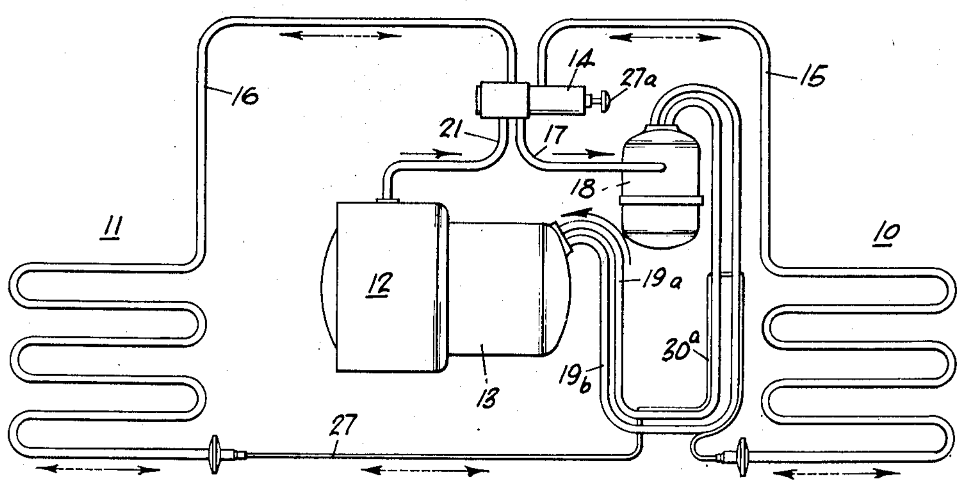

FIG. 5.

INVENTOR
EDWARD R. WOLFERT

BY [signature]
ATTORNEY

UNITED STATES PATENT OFFICE

2,342,566

AIR CONDITIONING APPARATUS

Edward R. Wolfert, Springfield, Mass., assignor to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

Application January 17, 1944, Serial No. 518,513

9 Claims. (Cl. 62—129)

This application is a continuation-in-part of my application Serial No. 400,161, filed June 28, 1941.

My invention relates to air conditioning apparatus, more particularly to a reversible cycle refrigerating system for either heating or cooling air for comfort, and it has for an object to provide improved apparatus of the character set forth.

Another object is to provide a reversible cycle refrigerating system which is simple, inexpensive and reliable.

A more particular object is to provide a reversible cycle refrigerating system, for either heating or cooling an enclosure, which may be manufactured at only a small additional cost above that of a refrigerating system adapted for cooling only.

A further object is to provide a reversible cycle refrigerating system for either heating or cooling an enclosure, and which system has provision for transferring heat from the condensed refrigerant to the expended refrigerant in the suction conduit during both the heating and the cooling cycle.

The reversible cycle refrigerating system of my invention comprises the usual compressor, two heat exchangers to serve as the condenser and the evaporator, and an expansion device connected between the two heat exchangers. The expansion device comprises a passage of considerable length and restricted flow area and which is constantly open and provides constant restriction to flow. Such device is preferably a tube which is commonly referred to in the art as a capillary tube. Means including a reversing valve is provided for connecting the compressor discharge to one heat exchanger to serve as the condenser and connecting the compressor suction or inlet to the other heat exchanger which serves as the evaporator during the heating cycle, and for reversing the connections to the two heat exchangers for the cooling cycle. The connecting means just mentioned includes a suction conduit which is connected between the compressor suction or inlet and the reversing valve and which contains suction gas during both cycles of operation. This conduit is arranged in heat transfer relation to the expansion device to provide transfer of heat from the expanding gas to the suction gas during both cycles of operation.

These and other objects are effected by my invention as will be apparent from the following description and claims taken in accordance with the accompanying drawings, forming a part of this application, in which:

Fig. 1 is a diagrammatic view of a reversible cycle refrigerating system in accordance with my invention;

Fig. 2 is a sectional view of the reversing valve;

Fig. 3 is a detail sectional view showing the shaped end of the capillary tube;

Fig. 4 is a perspective view of a window-mounted unit containing a reversible cycle refrigerating system in accordance with my invention; and

Fig. 5 is a diagrammatic view of a reversible cycle refrigerating system incorporating a modified form of heat exchanger.

Referring to the drawings in detail, I show a reversible cycle refrigerating system including two heat exchangers 10 and 11 which may be of the conventional cross-finned serpentine coil type. Provision is made for conveying air over the coil 10 and delivering the same to the enclosure to be air conditioned. The coil 10 serves as the evaporator during the cooling cycle and as the condenser during the heating cycle. Provision is also made for conveying outside air over the coil 11 and for discharging the same to outdoors or other place exterior of the enclosure. The coil 11 serves as the condenser during the cooling cycle and as the evaporator during the heating cycle. The runs or tubes of each coil are preferably connected to provide a refrigerant path extending from the top through the successively lower adjacent runs to the bottom of the coil, so that, when the coil is serving as the condenser, the condensed refrigerant flows by gravity to the bottom of the coil.

The refrigerating system also includes a motor-compressor unit 12 which is preferably enclosed within a fluid-tight casing 13, as shown, and as is now well known in the art. It further includes a reversing valve 14 which is adapted to place the compressor suction and discharge in communication with the coils 10 and 11, respectively, or with the coils 11 and 10, respectively. Conduits 15 and 16 connect the reversing valve with the upper ends of the coils 10 and 11, respectively. A suction line, including a conduit 17, a reservoir or accumulator 18 and a conduit 19, connects the reversing valve to the compressor suction or inlet, and a discharge conduit 21 connects the reversing valve to the compressor discharge. The accumulator 18 is adapted to retain larger particles and bodies of liquid, while the vaporized refrigerant, together with some finer particles of liquid entrained therein, readily passes from the top of the accumulator into the conduit 19.

While any suitable construction of reversing valve may be used so far as the present invention is concerned, I prefer to use the one which is shown in Fig. 2 and which will be readily apparent from the drawings. It includes an axially-movable valve member 22 having annular ribs or ridges 23 and 24 which extend into annular recesses 25 and 26 communicating with the conduits 17 and 21, respectively. The reversing valve is provided with a knob 27 which is screw-threaded into the movable member 22 and which is adapted to move the same axially. When the movable valve member 22 is moved to the left so that the ribs 23 and 24 seat against the left-hand sides of the recesses 25 and 26, as shown in Fig. 2, the conduit 16 is placed in communication with the conduit 21 and the conduit 15 is placed in communication with the conduit 17. When the movable valve member 22 is moved to the right to seat the ribs 23 and 24 against the righthand sides of the recesses, the conduit 16 is placed in communication with the conduit 17, and the conduit 15 is placed in communication with the conduit 21 through the passage and the ports formed in the valve member 22, as shown in Fig. 2.

In accordance with the present invention, I provide an expansion device which comprises a passage of considerable length and restricted flow area, and which is constantly open and provides constant restriction to flow. I prefer a tube having such characteristics and which is commonly referred to in the art as a capillary tube. The capillary tube serves as the expansion device during both the heating and the cooling cycle, the direction of flow being different for the two cycles. The tube is shown at 27 and is connected at its opposite ends to the lower ends of the coils 10 and 11.

The capillary tube 27 is of suitable length and bore to provide the desired impedance or restriction to flow. For example, I have used and found satisfactory a tube twenty-eight inches long and having a bore of .055 inch, in a window-mounted unit of the type shown in Fig. 4 having a capacity of 6000 B. t. u. per hour when operating as an air-cooled room cooler and circulating 1.57 cubic feet per minute of "Freon 12" or dichlorodifluoromethane at 39 pounds per square inch and 72 degrees F.

A strainer 28 is connected between the coil 10 and the tube 27 to strain the refrigerant when flowing from the former to the latter, and a strainer 29 is connected between the coil 11 and the tube 27 for straining the refrigerant when flowing to the tube in the opposite direction. Each end of the tube 27 is shaped to provide a suitable inlet. This shaping is preferably in accordance with Patent No. 2,134,542 of C. F. Alsing, and is shown in Fig. 3. The end or edge of the wall forming the tube is preferably of somewhat reduced thickness, which is preferably provided by tapering or inclining the outer surface of the tube wall, as indicated at 28*a*. The end or edge is rounded, as indicated at 29*a*, the curving or rounding extending from the inner surface or bore of the tube to the inclined or tapered outer surface. The end of the capillary tube 27 extends into a connecting conduit portion 31 whose internal diameter is somewhat greater than the external diameter of the tube 27. By rounding the edge, the accumulation of lint or other foreign particles at the inlet is practically eliminated, since any such particles, by reason of the rounding, slide off the rounded edge and are either drawn into the bore of the tube and carried through, or slide off the outside into the larger space provided by the connecting conduit portion 31.

The capillary tube 27 is arranged in heat transfer relation to the conduit 19, which is always a part of the suction line, preferably by soldering the two together for a suitable length, thereby providing a heat exchanger 30.

The system shown and described may be mounted in any suitable air conditioning unit or installation. It is well suited to be incorporated in a portable self-contained unit, such as the unit 32 shown in Fig. 4, mounted in a window 33*a*, as is well known in the art. The unit is shown from the interior of the room which it serves, the room air inlet being shown at 33 and the outlet being shown at 34. The knob 27*a* for actuating the reversing valve 14 is seen at the right-hand end of the unit. The apparatus is arranged within the unit 32 in any suitable manner, the coil 10 contacting the room air flowing from the inlet 33 to the outlet 34 and the coil 11 contacting outside air which enters and leaves through the outdoor side of the unit. For example, the arrangement disclosed and claimed in the patent of J. L. Ditzler and R. E. Holmes, No. 2,329,342, issued September 14, 1943, may be used.

Operation

When the refrigerating system is to be used for cooling the enclosure, the reversing valve 14 is positioned as shown in Fig. 2, in which position the compressor discharge conduit 21 is placed in communication with the conduit 16 leading to the outside air coil 11 and the suction conduit 17 is placed in communication with the conduit 15 leading to the conditioned air coil 10. The refrigerant compressed by the motor-compressor unit 12 now flows as indicated in Fig. 1 by the solid line arrows, first through the conduit 21, through the connecting passage in the reversing valve 14 and the conduit 16 to the outdoor air coil 11. In the latter, the high-pressure, high-temperature refrigerant gives up heat to a stream of outdoor or outside air circulated over the coil and is thereby condensed. The condensed refrigerant then flows through the strainer 29 and enters the capillary tube at the left-hand end. As it flows through the tube 27, its pressure is gradually reduced. The refrigerant discharged from the capillary tube 27 flows through the strainer 28 in reverse direction and enters the conditioned air coil 10 at the lower end. It then flows through the successive turns until it reaches the upper end. As it flows through the coil 10, it cools the air flowing over the coil, and is vaporized by the heat extracted therefrom. The vaporized refrigerant is discharged from the top of the coil and passes through the conduit 15, the connecting passage of the reversing valve 14 and the suction line (including the conduits 17 and 19 and the accumulator 18) to the inlet or suction conduit of the motor-compressor unit 12.

In the heat exchanger 30, the vaporized refrigerant flowing through the suction conduit 19 extracts heat from the expanding refrigerant flowing in the capillary tube 27, whose temperature is substantially above the temperature of the vaporized refrigerant since its pressure has not yet been fully reduced. The heat extracted from the refrigerant in the capillary tube increases by like amount to the capacity of the refrigerant to absorb heat in the coil 10. During the cooling cycle, the streams of refrigerant flow in opposite or counterflow relation through the heat exchanger 30 thereby providing more efficient and effective heat transfer.

To heat the enclosure, the reversing valve 14 is moved to the right, thereby placing the discharge conduit 21 in communication with the conduit 15 and placing the suction conduit 17 in communication with the conduit 16. The direction of flow of refrigerant through the compressor and the suction and discharge conduits remains the same as during the cooling cycle, but the direction of flow through the coils and the capillary tube is reversed and is indicated by the dotted-line arrows.

The compressed refrigerant flows through the discharge conduit 21, the connecting passage of the reversing valve 14 and the conduit 15 into the conditioned air coil 10. As it flows through the coil 10, it gives up superheat and latent heat to the air circulating over the coil and is condensed. The heated air is delivered to the enclosure to maintain the latter at a comfortably warm temperature. The condensed refrigerant flows through the successive tubes to the bottom of the coil 10 from which it flows through the strainer 28 and enters the right-hand end of capillary tube 27. It is discharged from the latter at the left-hand end, flows through the strainer 29 in reverse direction, and enters the lower end of the outside air coil 11. As it flows through the latter, it absorbs heat from the outside air flowing over the coil 11 and is thereby vaporized. The vaporized refrigerant is discharged from the upper end of the coil, flows through the conduit 16, the connecting passage of the reversing valve 14, the suction conduit 17, the accumulator 18, and the suction conduit 19 to the motor-compressor unit 12, wherein it is recompressed.

As the vaporized refrigerant flows through the portion of the suction conduit 19 which is in heat transfer relation to the capillary tube 27 it extracts heat from the expanding refrigerant in the latter. During the heating cycle, the flow of refrigerant through the capillary tube 27 is reversed, while the vaporized refrigerant continues to flow in the same direction through the suction conduit 19. The two streams flow in the same direction, from right to left, as seen in Fig. 1. Accordingly, the amount of heat transferred from the expanding refrigerant in the capillary tube to the vaporized refrigerant in the suction conduit is not as great as during the cooling cycle, when the streams flow in opposite directions. However, a substantial amount of heat is transferred to the vaporized refrigerant, by which it is carried as superheat to the coil 10 where it is transferred to the air being heated.

Fig. 5

In Fig. 5, I show a reversible cycle refrigerating system in which the heat exchanger has been modified to provide the same heat transfer from the expanding refrigerant in the capillary tube to the vaporized refrigerant in the suction line for both the heating and the cooling cycle.

The heat exchanger designated 30*a*, comprises two suction conduits, 19*a* and 19*b*, which convey the vaporized refrigerant from the accumulator 18 to the motor-compressor unit 12. The capillary tube 27 has a portion soldered to each of the conduits 19*a* and 19*b* in what may be termed a symmetrical arrangement. The capillary tube 27 extends from the left-hand end, first along an unattached portion, then along the conduit 19*a* in upstream direction, along the conduit 19*b* in downstream direction, and then along an unattached portion to the right-hand end. The remainder of the refrigerating system shown in Fig. 5 is similar to that shown in Figs. 1 to 4.

Fig. 5—Operation

The operation of the embodiment shown in Fig. 5 is the same as that of the first embodiment except as to the heat transfer taking place in the heat exchanger 30*a*. During the cooling cycle, the expanding refrigerant in the capillary tube flows in counterflow heat transfer relation to the vaporized refrigerant in the conduit 19*a* and then flows in heat transfer relation to the vaporized refrigerant in the suction conduit 19*b* in concurrent flow relation. During the heating cycle, the condensed refrigerant enters the right-hand end of the capillary tube, flows in counterflow heat transfer relation to the vaporized refrigerant in the suction conduit 19*b* and then in concurrent flow heat transfer relation to the vaporized refrigerant in the conduit 19*a*. The character of the heat flow is the same for both cycles, first counterflow and then concurrent flow.

While I have shown my invention in several forms, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various other changes and modifications without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereupon as are specifically set forth in the appended claims.

What I claim is:

1. In a reversible cycle refrigerating system for heating or cooling air for an enclosure, the combination of a compressor first and second heat exchangers, the second heat exchanger being arranged to heat or cool air for the enclosure, a capillary tube connected between said heat exchangers and serving to expand refrigerant from condensing pressure to evaporating pressure during both the heating and the cooling cycle, a suction conduit connected to the suction of said compressor, and means including a reversing valve for selectively connecting said suction conduit and the discharge of said compressor to said first and said second heat exchanger, respectively, during the heating cycle, or to said second and said first heat exchanger, respectively, during the cooling cycle, said suction conduit and said capillary tube being arranged in heat transfer relation to transfer heat from the expanding refrigerant in the capillary tube to the expended refrigerant in the suction conduit during both the heating cycle and cooling cycle.

2. In a reversible cycle refrigerating system for heating or cooling air for an enclosure, the combination of a compressor, first and second heat exchangers, the second heat exchanger being arranged to heat or cool air for the enclosure, a suction conduit connected to the suction of said compressor, means including reversing valve mechanism for selectively connecting said suction conduit and the discharge of said compressor to said first and second heat exchanger, respectively, for heating air for the enclosure, or to said second and said first heat exchanger, respectively, for cooling air for the enclosure, and means providing a passage of considerable length

and restricted bore and arranged for at least a portion of its length in heat transfer relation to said suction conduit for expanding refrigerant from condensing pressure to evaporating pressure during the heating cycle and providing a passage of considerable length and restricted bore and arranged for at least a portion of its length in heat transfer relation to said suction conduit for expanding the refrigerant from condensing pressure to evaporating pressure during the cooling cycle.

3. In a reversible cycle refrigerating system for heating and cooling air for an enclosure, the combination of a compressor, first and second heat exchangers, the second heat exchanger being arranged to heat or cool air for the enclosure, an expansion device having a constantly open passage of considerable length and restricted flow area providing constant restriction to flow, said passage being connected between said heat exchangers and serving to expand refrigerant from condensing pressure to evaporating pressure during both the heating and the cooling cycle, a suction conduit connected to the suction or inlet of said compressor and means including a reversing valve for selectively connecting said suction conduit and the discharge of said compressor to said first and said second heat exchanger, respectively, during the heating cycle, or to said second and said first heat exchanger, respectively, during the cooling cycle, said suction conduit and said passage being arranged in heat transfer relation for transferring heat from the expanding refrigerant in said passage to the expended refrigerant in said suction conduit during both the heating cycle and the cooling cycle.

4. In a reversible cycle refrigerating system for heating or cooling air for an enclosure, the combination of a compressor, first and second heat exchangers, the second heat exchanger being arranged for heating or cooling air for an enclosure, an expansion device having a constantly open passage of considerable length and restricted flow area providing constant restriction to flow, said passage being connected between said heat exchangers and serving to expand refrigerant from condensing pressure to evaporating pressure during both the heating and the cooling cycle, means including a reversing valve for connecting the suction or inlet and the discharge of the compressor to said first and said second heat exchanger, respectively, during the heating cycle and to said second and said first heat exchanger, respectively, during the cooling cycle, and a reservoir or accumulator connected in the suction line between the reversing valve and the suction or inlet of the compressor for separating and retaining liquid portions from the refrigerant received from that heat exchanger which is serving as the evaporator.

5. In a reversible cycle refrigerating system for heating or cooling air for an enclosure, the combination of a compressor, first and second heat exchangers, the second heat exchanger being arranged for heating or cooling air for an enclosure, capillary tube means connected between said heat exchangers and providing a constant restriction to flow when operating on the heating cycle and providing a constant restriction to flow when operating on the cooling cycle, means including reversing valve mechanism for connecting the suction and the discharge of the compressor to said first and said second heat exchanger, respectively, during the heating cycle and to the said second and said first heat exchanger, respectively, during the cooling cycle, and accumulator means disposed between each heat exchanger and the suction of the compressor for retaining therein variable quantities of liquid refrigerant occasioned by variation in operating conditions.

6. In a reversible cycle refrigerating system for heating or cooling air for an enclosure, the combination of a compressor, first and second heat exchangers, the second heat exchanger being arranged for heating or cooling air for an enclosure, a capillary tube connected between said heat exchangers and providing a constant restriction expansion device during both the heating and the cooling cycle, means including a reversing valve for connecting the suction and the discharge of the compressor to said first and said second heat exchanger, respectively, during the heating cycle and to said second and said first heat exchanger, respectively, during the cooling cycle, and a reservoir or accumulator connected in the suction line between the reversing valve and the suction or inlet of the compressor for separating and retaining liquid portions from the refrigerant received from that heat exchanger which is serving as the evaporator.

7. The combination set forth in claim 6 wherein said capillary tube is in heat transfer relation to a portion of the suction line between the accumulator and the compressor inlet.

8. In a reversible cycle refrigerating system for heating or cooling air for an enclosure, the combination of a compressor, first and second heat exchangers, the second heat exchanger being arranged to heat or cool air for the enclosure, a capillary tube connected between said heat exchangers and serving to expand refrigerant from condensing pressure to evaporating pressure during both the heating and the cooling cycle, a suction conduit connected to the inlet of said compressor and comprising two parallel branches for at least a portion of the length thereof, and means including a reversing valve for selectively connecting said suction conduit and the outlet of said compressor to said first and said second heat exchanger, respectively, for the heating cycle, or to said second and said first heat exchanger, respectively, for the cooling cycle, said capillary tube being arranged in heat transfer relation to said branches of the suction conduit in such manner that the refrigerant flowing through the capillary tube flows in counterflow relation to the refrigerant in one branch and in concurrent flow relation to the refrigerant in the other branch.

9. The combination set forth in claim 8 wherein the refrigerant flowing through the capillary tube flows first in counterflow relation to the refrigerant in one branch of the suction conduit and then in concurrent flow relation to the refrigerant in the other branch.

EDWARD R. WOLFERT.