June 13, 1967 J. R. HARNISH 3,324,671

REFRIGERATION SYSTEMS

Filed April 19, 1966

FIG. 1.

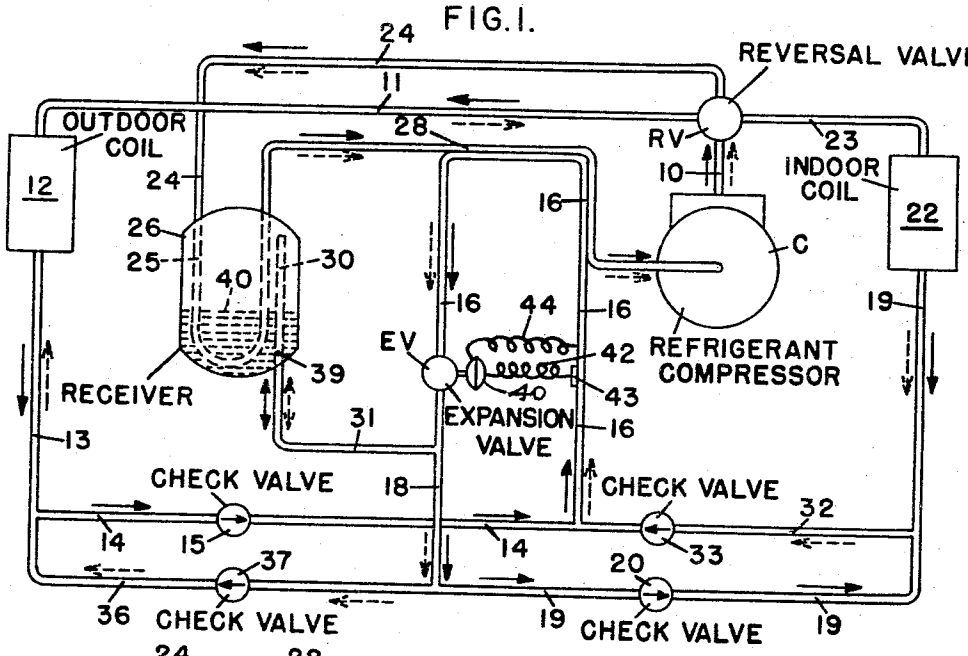


FIG. 2.

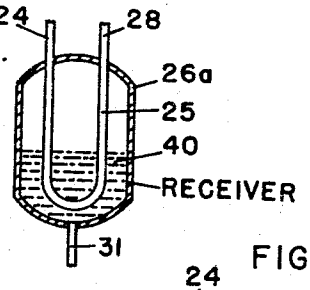


FIG. 3.

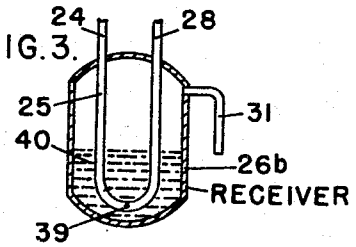
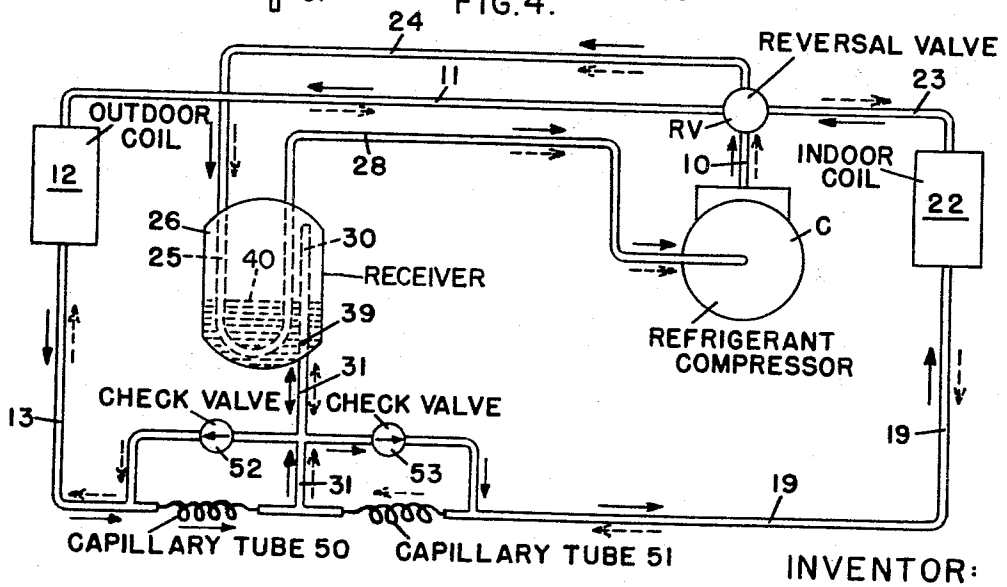


FIG. 4.



INVENTOR:
JAMES R. HARNISH,
BY Robert J. Palmer
ATTORNEY

United States Patent Office 3,324,671
Patented June 13, 1967

3,324,671

REFRIGERATION SYSTEMS

James R. Harnish, Staunton, Va., assignor to Westinghouse Electric Corporation, Pittsburgh, Pa., a corporation of Pennsylvania

Filed Apr. 19, 1966, Ser. No. 549,122
14 Claims. (Cl. 62—174)

This invention relates to refrigeration systems in which receivers are used to store refrigerant liquid, and has as an object to control the quantity of refrigerant liquid stored in such a receiver in accordance with superheat in suction gas.

It is well known that in heat pumps more refrigerant is required during cooling operation than during heating operation, and high pressure receivers with heat exchangers have been used to condense and store a portion of the refrigerant charge during heating operation, and to evaporate and return that portion into the systems during cooling operation. Such heat pumps using such receivers are disclosed in Patent No. 3,006,155 of H. G. Vanderlee et al., and in Patent No. 3,110,164 of G. A. Smith. In the receivers of these patents, refrigerant is condensed by suction gas flowing through their heat exchangers during heating operation, and is stored. During cooling operation, all of the stored refrigerant is evaporated by heat from discharge gas flowing through their heat exchangers, and is forced back into the systems at the inlet sides of their operating expansion means. Thus, these receivers do not store refrigerant during cooling operation.

The heat pump of Patent No. 3,163,016 of E. C. Kennedy uses two storage receivers, one for storing refrigerant during cooling operation, and the other for storing refrigerant during heating operation. As in the previously mentioned patents, refrigerant is condensed for storage by suction gas, and is evaporated for return to the system by discharge gas.

This invention is an improvement on that of the above mentioned Kennedy patent when embodied in a heat pump in that it requires only a single low pressure receiver for storing refrigerant during both cooling and heating operation.

A feature of this invention is that a heat exchanger through which suction gas flows at all times, is arranged to heat or cool refrigerant in a low pressure receiver, with the interior of the receiver connected to the outlet side of the operating expansion means. When the suction gas has too much superheat, it heats the refrigerant within the receiver, increasing its vapor pressure, and forcing some of the refrigerant from the receiver into an operating evaporator where it reduces the superheat. When there is insufficient superheat in the suction gas, it cools the refrigerant within the receiver, reducing its vapor pressure so that refrigerant is sucked from the tubing connected to the evaporator, into the receiver, preventing that refrigerant from entering the evaporator, and thereby increasing the superheat. Thus, refrigerant is added to or drawn from the receiver until thermal equilibrium is reached.

Another feature of another and preferred embodiment of this invention is that a subcooling control valve operating as an expansion valve, maintains a predetermined amount of subcooling of the condensed liquid, and keeps the operating condenser adequately drained while preventing the operating evaporator from becoming starved at low outdoor temperatures to which the operating condenser is exposed. When embodied in a heat pump, the subcooling control valve is the only expansion valve required.

This invention will now be described with reference to the annexed drawings, of which:

FIG. 1 is a diagrammatic view of a preferred heat pump embodying this invention;

FIG. 2 is a diagrammatic sectional view of another form of receiver which may be used instead of the one shown by FIG. 1;

FIG. 3 is a diagrammatic sectional view of still another form of receiver which may be used, and

FIG. 4 is a diagrammatic view of another heat pump embodying this invention.

Description of FIGS. 1, 2 and 3

Referring first to FIG. 1, the discharge side of a refrigerant compressor C is connected by discharge gas tube **10** to a conventional refrigerant reversal valve RV which is connected by tube **11** to an outdoor coil **12**. The coil **12** is connected by tube **13**, tube **14** containing a check-valve **15**, and tube **16** to the refrigerant inlet side of an expansion valve EV, the refrigerant outlet side of which is connected by tube **18** and tube **19** containing a check-valve **20** to indoor air coil **22**. The coil **22** is connected by tube **23** to the reversal valve RV which is also connected by tube **24** to one end of heat exchanger **25** within low pressure receiver **26**. The other end of the heat exchanger **25** is connected by suction gas tube **28** to the suction side of the compressor C. Portions of the tubes **16** and **28** are in heat exchange contact. A tube **30** extends from the bottom of the interior of the receiver **26** to near the top of the latter, and has an open top. The bottom of the tube **30** is connected by tube **31** to the tube **18**. The bottom of the tube **30** also has an oil bleed hole **39** therein. The junction of the tubes **14** and **16** is connected by tube **32** containing a check-valve **33** to the tube **19** between the indoor coil **22** and the check-valve **20**. The tube **13** is also connected by tube **36** containing a check-valve **37** to the junction of the tubes **18** and **19**. The heat pump is overcharged with refrigerant so that there is normally a liquid level **40** within the receiver **26**.

Preferably, the expansion valve EV is a subcooling control valve such as is disclosed in detail in my Patent No. 3,171,263. The valve EV has a diaphragm chamber **41**, the outer portion of which is connected by a capillary tube **42** to thermal bulb **43** in heat exchange contact with the tube **16**, and the inner portion of which is connected by capillary equalizer tube **44** to the interior of the tube **16** although the valve EV could be internally equalized. The valve EV responds to the temperature of the refrigerant liquid flowing through the tube **16**, and to the pressure of the liquid flowing through the tube **16**, or through the valve EV, and maintains a predetermined amount of subcooling, which may be 10° subcooling at a condensing temperature of 100° F., of that liquid. This maintains the coil operating as a condenser adequately drained for good heat transfer. The coil operating as an evaporator is prevented from being overfed by the valve EV through the action of the heat exchanger **25** within the receiver **26** as will be described later.

Referring now to FIG. 2 of the drawings, receiver **26*a*** is similar to the receiver **26** of FIG. 1 except that it does not contain the tube **30**, refrigerant flow into and from the interior of the receiver **26*a*** being directly through the tube **31**.

Referring now to FIG. 3 of the drawings, receiver **26*b*** is similar to the receiver **26** of FIG. 1 except that the tube **30** is omitted; an oil bleed hole **39** is within the bottom of the heat exchanger **25** within the receiver **26*b***, and the tube **31** instead of being connected to the bottom of the tube **30**, is connected to the interior of the receiver **26*b*** above the liquid level **40** therein.

Cooling operation of FIGS. 1, 2 and 3

The solid-line arrows alongside the tubes of FIG. 1 show the direction of refrigerant flow during cooling operation. The compressor C supplies discharge gas through the tube **10**, the reversal valve RV which is adjusted for cooling operation, and the tube **11** into the outdoor coil **12** operating as a condenser. Liquid flows from the coil **12** through the tubes **13** and **14**, the check-valve **15**, the tube **16**, the expansion valve EV, the tubes **18** and **19**, and the check-valve **20** into the indoor coil **22** operating as an evaporator. Gas flows from the coil **22** through the tube **23**, the reversal valve RV, the tube **24**, the heat exchanger **25**, and the tube **28** to the suction side of the compressor C.

Superheat in the suction gas flowing through the heat exchanger **25** heats or cools the refrigerant within the receiver **26**. If there is too much superheat, heat from the gas flowing through the heat exchanger **25** boils liquid within the receiver **26**, changing such liquid to gas and increasing its vapor pressure so that gas is forced from the receiver into the open top of the tube **30**, and through the tubes **30**, **31**, **18** and **19**, and the check-valve **20** into the indoor coil **22** to reduce the superheat in the suction gas leaving the coil **22**. If there is insufficient superheat in the suction gas, the vapor pressure of the refrigerant within the receiver is reduced so that liquid refrigerant is sucked through the tubes **30** and **31** from the tube **18** connected to the outlet side of the expansion valve, preventing that refrigerant from entering the coil **22**, thereby increasing the superheat in the suction gas. Thus, refrigerant is withdrawn from or added to the refrigerant within the receiver **26** until there is thermal equilibrium. The coil **22** cannot be overfed by the expansion valve EV because the receiver **26** and its heat exchanger **25** operate to maintain superheat in the suction gas.

Heat from the high pressure liquid flowing through the tube **16** also superheats the suction gas flowing from the heat exchanger **25** through the tube **28** to the suction side of the compressor C, through the heat exchange contact of portions of the tubes **16** and **28**, the liquid flowing through the tube **16** being further subcooled by this action.

The expansion valve EV supplies sufficient refrigerant liquid to the coil **22** to prevent the latter from becoming starved at low outdoor temperatures to which the coil **12** is exposed, and maintains the coil **22** filled with refrigerant liquid at higher outdoor temperatures.

In the receiver **26*a*** of FIG. 2, when there is too much superheat in the suction gas, heat from the heat exchanger **25** boils liquid within the receiver **26*a***, increasing its vapor pressure, and forcing liquid from the receiver **26*a*** through the tubes **31**, **18** and **19**, and the check-valve **20** into the indoor coil **22** to reduce the superheat. If there is insufficient superheat, the vapor pressure of the refrigerant within the receiver **26*a*** is reduced so that liquid is sucked through the tube **31** from the tube **18**, preventing that liquid from entering the coil **22**, thereby increasing the superheat.

In the receiver **26*b*** of FIG. 3, when there is too much superheat in the suction gas, heat from the heat exchanger **25** boils liquid within the receiver **26*b***, changing it to gas and increasing its vapor pressure so that gas flows from the interior of the receiver **26*b*** through the tubes **31**, **18** and **19**, and the check-valve **20** into the indoor coil **22** to reduce the superheat. If there is insufficient superheat, the vapor pressure of the refrigerant within the receiver **26*b*** is reduced so that refrigerant liquid is sucked through the tube **31** from the tube **18**, into the receiver **26*b***, preventing that liquid from entering the coil **22**, and thereby increasing the superheat.

Heating operation of FIGS. 1, 2 and *3*

The dashed-line arrows alongside the tubes of FIG. 1 show the direction of refrigerant flow during cooling operation. The compressor C supplies discharge gas through the tube **10**, the reversal valve RV which is adjusted for heating operation, and the tube **23** into the indoor coil **22** operating as a condenser. Liquid flows from the coil **22** through the tubes **19** and **32**, the check-valve **33**, the tube **16**, the expansion valve EV, the tubes **18** and **36**, and the check-valve **37** into the outdoor coil **12** operating as an evaporator. Gas flows from the coil **12** through the tube **11**, the reversal valve RV, the tube **24**, the heat exchanger **25**, and the tube **28** to the suction side of the compressor C.

The operation of the receiver **26** of FIG. 1, the receiver **26*a*** of FIG. 2, and the receiver **26*b*** of FIG. 3, is the same as that described in the foregoing in connection with cooling operation, except that the suction gas flows from the outdoor coil **12** instead of from the indoor coil **22**. Also, the refrigerant not required during heating operation is stored in the operating receiver.

Description of FIG. 4

The components of FIG. 4 which are the same as those of FIG. 1 are given the same reference characters. Refrigerant compressor C is connected by discharge gas tube **10** to reversal valve RV which is connected by tube **11** to outdoor coil **12**. The coil **12** is connected by tube **13** to one end of capillary tube **50**, the other end of which is connected to one end of capillary tube **51**. The junction of the tubes **50** and **51** is connected by tube **31** to the bottom of tube **30** within low pressure receiver **26**, the tube **30** having an open top near the top of the interior of the receiver **26**. A check-valve **52** is connected across the capillary tube **50**, and a check-valve **53** is connected across the capillary tube **51**. The other end of the capillary tube **51** is connected by tube **19** to indoor air coil **22** which is connected by tube **23** to the reversal valve RV. The valve RV is connected by tube **24** to one end of heat exchanger **25** within the receiver **26**, the other end of which is connected by tube **28** to the suction side of the compressor C.

The capillary tubes **50** and **51** are refrigerant expansion means, the tube **50** serving to expand refrigerant into the indoor coil **22** when the latter is operating as an evaporator, and the tube **51** serving to expand refrigerant into the outdoor coil **12** when the latter is operating as an evaporator.

Cooling operation of FIG. 4

The solid-line arrows alongside the tubes of FIG. 4 show the direction of refrigerant flow during cooling operation. The compressor C supplies discharge gas through the tube **10**, the reversal valve RV, and the tube **11** into the outdoor coil **12** operating as a condenser. Liquid flows from the coil **12** through the tube **13**, the capillary tube **50**, the check-valve **53**, and the tube **19** into the indoor coil **22** operating as an evaporator. Gas flows from the coil **22** through the tube **23**, the reversal valve RV, the tube **24**, the heat exchanger **25** within the receiver **26**, and the tube **28** to the suction side of the compressor C.

When there is too much superheat in the suction gas flowing through the heat exchanger **25**, heat from the latter increases the vapor pressure of the refrigerant within the receiver **26**, forcing gas into the open top of the tube **30**, and through the tubes **30** and **31**, the check-valve **53** and the tube **19** into the indoor coil **22**, thereby decreasing the superheat in the suction gas leaving the latter. If there is insufficient superheat in the suction gas flowing through the heat exchanger **25**, the latter cools the refrigerant within the receiver **26**, reducing its vapor pressure, so that refrigerant is sucked through the tubes **30** and **31** from the outlet of the capillary tube **50**, preventing that refrigerant from entering the indoor coil **22**, and thereby increasing the superheat in the suction gas leaving the latter.

Heating operation of FIG. 4

The dashed-line arrows alongside the tubes of FIG. 4 show the direction of refrigerant flow during heating

operation. The compressor C supplies discharge gas through the tube **10**, the reversal valve RV, and the tube **23** into the indoor coil **22** operating as a condenser. Liquid flows from the coil **28** through the tube **19**, the capillary tube **51**, the check-valve **52**, and the tube **13** into the outdoor coil **12** operating as an evaporator. Gas flows from the coil **12** through the tube **11**, the reversal valve RV, and the tube **24** into the heat exchanger **25**, and from the latter through the tube **28** to the suction side of the compressor C.

When there is too much superheat in the suction gas flowing through the heat exchanger **25**, heat from the latter increases the vapor pressure of the refrigerant within the receiver **26**, forcing gas into the open top of the tube **30**, and through the tubes **30** and **31**, the check-valve **52**, and the tube **13** into the outdoor coil **12**, thereby decreasing the superheat in the suction gas leaving the latter. If there is insufficient superheat in the suction gas flowing through the heat exchanger **25**, the latter cools the refrigerant within the receiver **26**, reducing its vapor pressure so that refrigerant is sucked through the tubes **30** and **31** from the outlet of the capillary tube **51**, preventing that refrigerant from entering the outdoor coil **12**, and thereby increasing the superheat in the suction gas leaving the latter. The refrigerant which is not required during heating operation is stored within the receiver **26**.

The receivers of FIGS. 2 and 3 could be used in the heat pump of FIG. 4.

Disadvantages of the heat pump of FIG. 4, as compared to that of FIG. 1, are that the coil operating as a condenser is not as well drained; the condensed liquid is not always subcooled, and the heat pump cannot operate as effectively at low outdoor temperatures as the heat pump of FIG. 1.

The invention is not limited to heat pumps, but can be used in non-reversible cooling systems which would operate as described in the foregoing in connection with cooling operation, with the reversal and check-valves omitted, with the outdoor coil considered as a condenser, and with the indoor coil considered as an evaporator.

What is claimed, is:

1. A refrigeration system comprising a refrigerant compressor, a condenser, means including a discharge gas tube connecting said condenser to said compressor, refrigerant expansion means, means including a liquid tube connecting the inlet of said expansion means to said condenser, an evaporator, a third tube connected to the outlet of said expansion means, means connecting said third tube to said evaporator, a heat exchanger, means including a fourth tube connecting said heat exchanger to said evaporator, means including a suction gas tube connecting said heat exchanger to said compressor, a receiver, said heat exchanger being arranged to change the temperature of refrigerant within said receiver, and means connecting the interior of said receiver to said third tube.

2. A refrigeration system as claimed in claim **1** in which said expansion means is a subcooling control valve responsive to the temperature and the pressure of the liquid flowing through said liquid tube.

3. A refrigeration system as claimed in claim **2** in which said means connecting the interior of said receiver to said third tube includes a tube extending from the bottom of the interior of said receiver towards the top of said receiver, said last mentioned tube having an open top.

4. A refrigeration system as claimed in claim **1** in which said means connecting the interior of said receiver to said third tube includes a tube extending from the bottom of the interior of said receiver towards the top of said receiver, said last mentioned tube having an open top.

5. A heat pump comprising a refrigerant compressor, an outdoor heat exchanger, an indoor heat exchanger, refrigerant expansion means, a receiver heat exchanger, means when cooling is required for routing refrigerant from the discharge side of said compressor through said outdoor heat exchanger operating as a condenser, said expansion means, said indoor heat exchanger operating as an evaporator, and said receiver heat exchanger to the suction side of said compressor, and when heating is required for routing refrigerant from said discharge side of said compressor through said indoor heat exchanger operating as a condenser, said expansion means, said outdoor heat exchanger operating as an evaporator, and said receiver heat exchanger to said suction side of said compressor, a receiver, said receiver heat exchanger being arranged to change the temperature of refrigerant within said receiver, and means connecting the interior of said receiver to the refrigerant inlet of said indoor heat exchanger when the latter is operating as an evaporator, and to the refrigerant inlet of said outdoor heat exchanger when the latter is operating as an evaporator, said receiver heat exchanger being connected to said suction side of said compressor and to the refrigerant outlet of the one of said indoor or outdoor exchangers that is operating as an evaporator.

6. A heat pump as claimed in claim **5** in which said expansion means is a subcooling control valve responsive to the temperature and the pressure of the refrigerant flowing from the one of said outdoor or indoor heat exchangers which is operating as a condenser.

7. A heat pump as claimed in claim **6** in which said connecting means includes a tube within said receiver extending from the bottom of said receiver towards the top of said receiver, said tube having an open top.

8. A heat pump as claimed in claim **5** in which said connecting means includes a tube within said receiver extending from the bottom of said receiver towards the top of said receiver, said tube having an open top.

9. A heat pump comprising a refrigerant compressor, refrigerant reversal means, a discharge gas tube connecting said compressor to said reversal means, an outdoor heat exchanger, a second tube connecting one end of said outdoor heat exchanger to said reversal means, an indoor heat exchanger, a third tube connecting one end of said indoor heat exchanger to said reversal means, an expansion valve, a fourth tube connected to the inlet of said expansion valve, a fifth tube connected to the outlet of said expansion valve, a sixth tube connected to the other end of said outdoor heat exchanger, a seventh tube containing a first check-valve connecting said sixth tube to said fourth tube, an eighth tube connected to the other end of said indoor heat exchanger, a ninth tube containing a second check-valve connecting said eighth tube to said fourth tube, a tenth tube containing a third check-valve connecting said sixth tube to said fifth tube, an eleventh tube containing a fourth check-valve connecting said eighth tube to said fifth tube, a receiver, a heat exchanger arranged to change the temperature of refrigerant within said receiver, a twelfth tube connecting said reversal means to said last mentioned heat exchanger, a suction gas tube connecting said last mentioned heat exchanger to said compressor, and means connecting the interior of said receiver to said fifth tube.

10. A heat pump as claimed in claim **9** in which said expansion valve is a subcooling control valve responsive to the temperature and the pressure of the refrigerant flowing through said fourth tube.

11. A heat pump as claimed in claim **10** in which said connecting means includes a tube within said receiver extending from the bottom of said receiver towards the top of said receiver, and having an open top.

12. A heat pump as claimed in claim **9** in which said connecting means includes a tube within said receiver extending from the bottom of said receiver towards the top of said receiver, and having an open top.

13. A heat pump comprising a refrigerant compressor, refrigerant reversal means, a discharge gas tube con-

necting the discharge side of said compressor to said reversal means, an outdoor exchanger, a second tube connecting said outdoor heat exchanger to said reversal means, an indoor heat exchanger, a third tube connecting said indoor heat exchanger to said reversal means, a first capillary tube, a first check-valve, means including said capillary tube and said check-valve for flowing refrigerant from said outdoor exchanger when it is operating as a condenser into said indoor heat exchanger operating as an evaporator, a second capillary tube, a second check-valve, means including said second capillary tube and said second check-valve for flowing refrigerant from said indoor heat exchanger when it is operating as condenser into said outdoor heat exchanger operating as an evaporator, a receiver, a receiver heat exchanger arranged to change the temperature of refrigerant within said receiver, means for flowing refrigerant gas from the one of said indoor or outdoor exchangers that is operating as an evaporator through said receiver heat exchanger to

the suction side of said compressor, and means connecting the interior of said receiver to the outlets of said capillary tubes.

14. A heat pump as claimed in claim **13** in which said connecting means includes a tube within said receiver extending from the bottom of said receiver towards the top of said receiver, and having an open top.

References Cited

UNITED STATES PATENTS

2,510,881	1/1950	Gerteig	62—509
2,867,094	1/1959	Herrick	62—174
2,885,868	5/1959	Radcliffe	62—509
2,901,894	9/1959	Zearfoss	62—509
2,977,773	4/1961	De Kanter	62—324
3,163,998	1/1965	Wile	62—512
3,232,073	2/1966	Jobes	62—160

WILLIAM J. WYE, *Primary Examiner.*