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REFRIGERATION SYSTEM FOR WIDELY VARYING AMBIENT CONDITIONS

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3 Sheets-Sheet 1

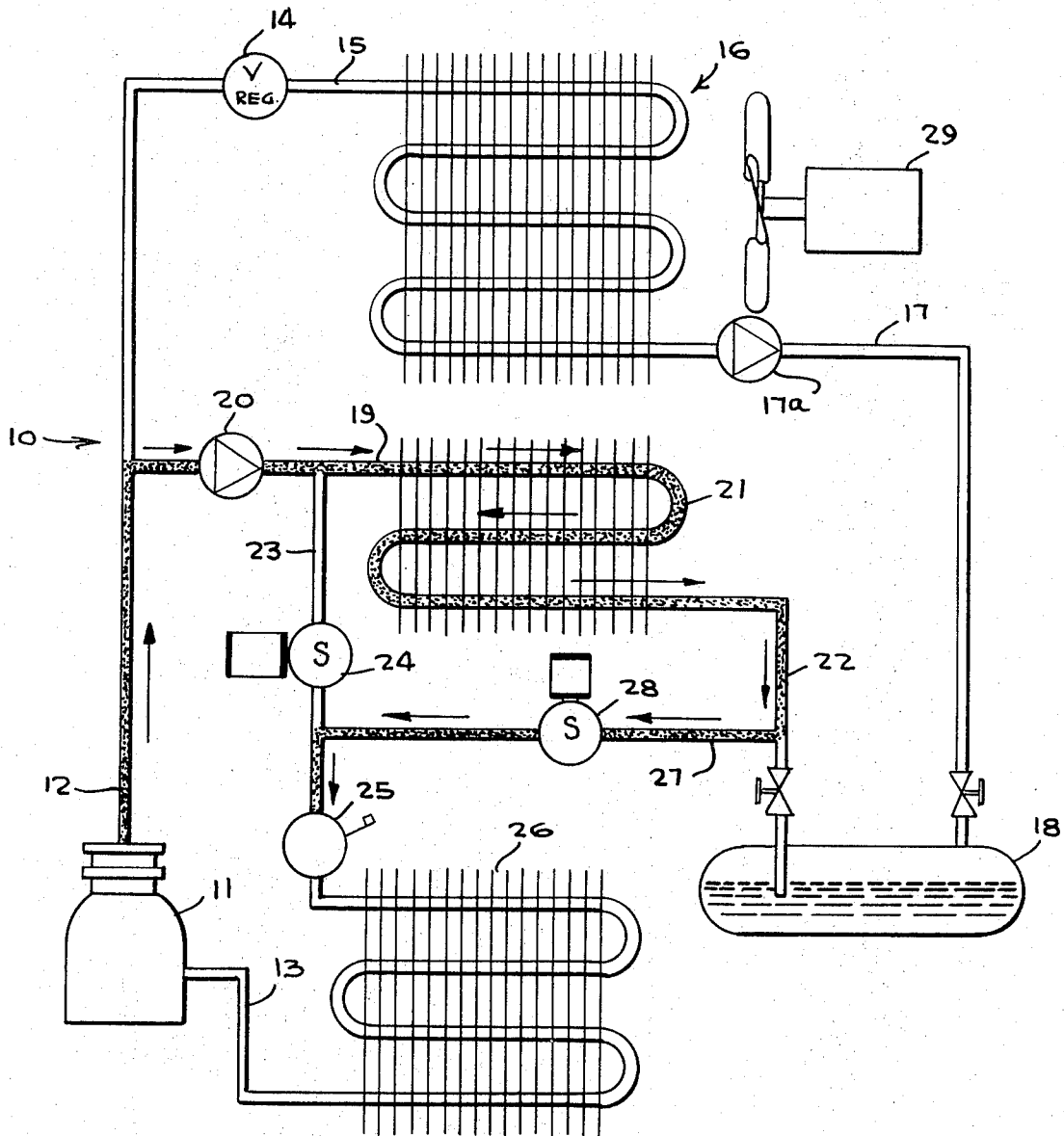


Fig-1

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3 Sheets-Sheet 2

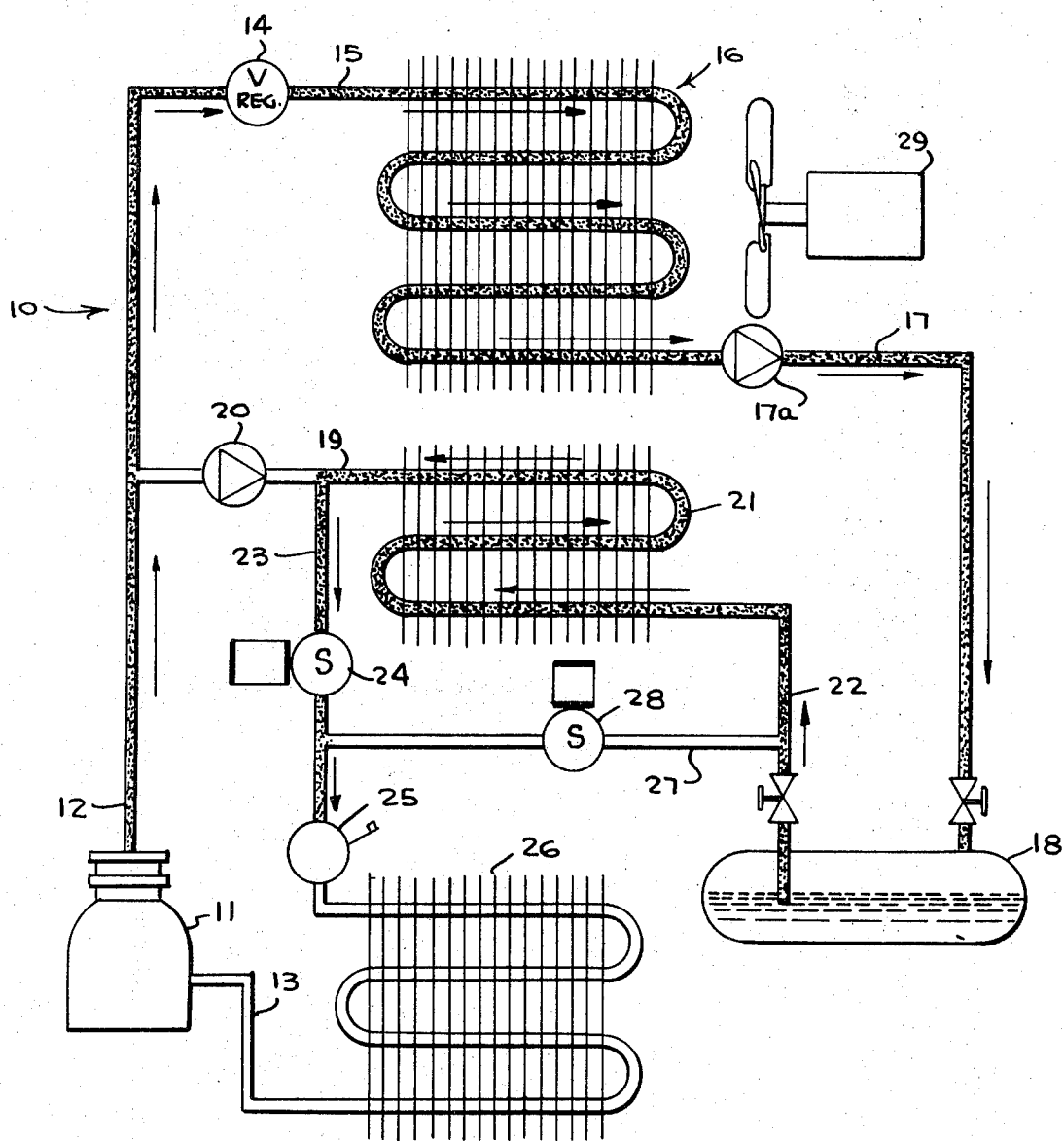


Fig-2

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3 Sheets-Sheet 3

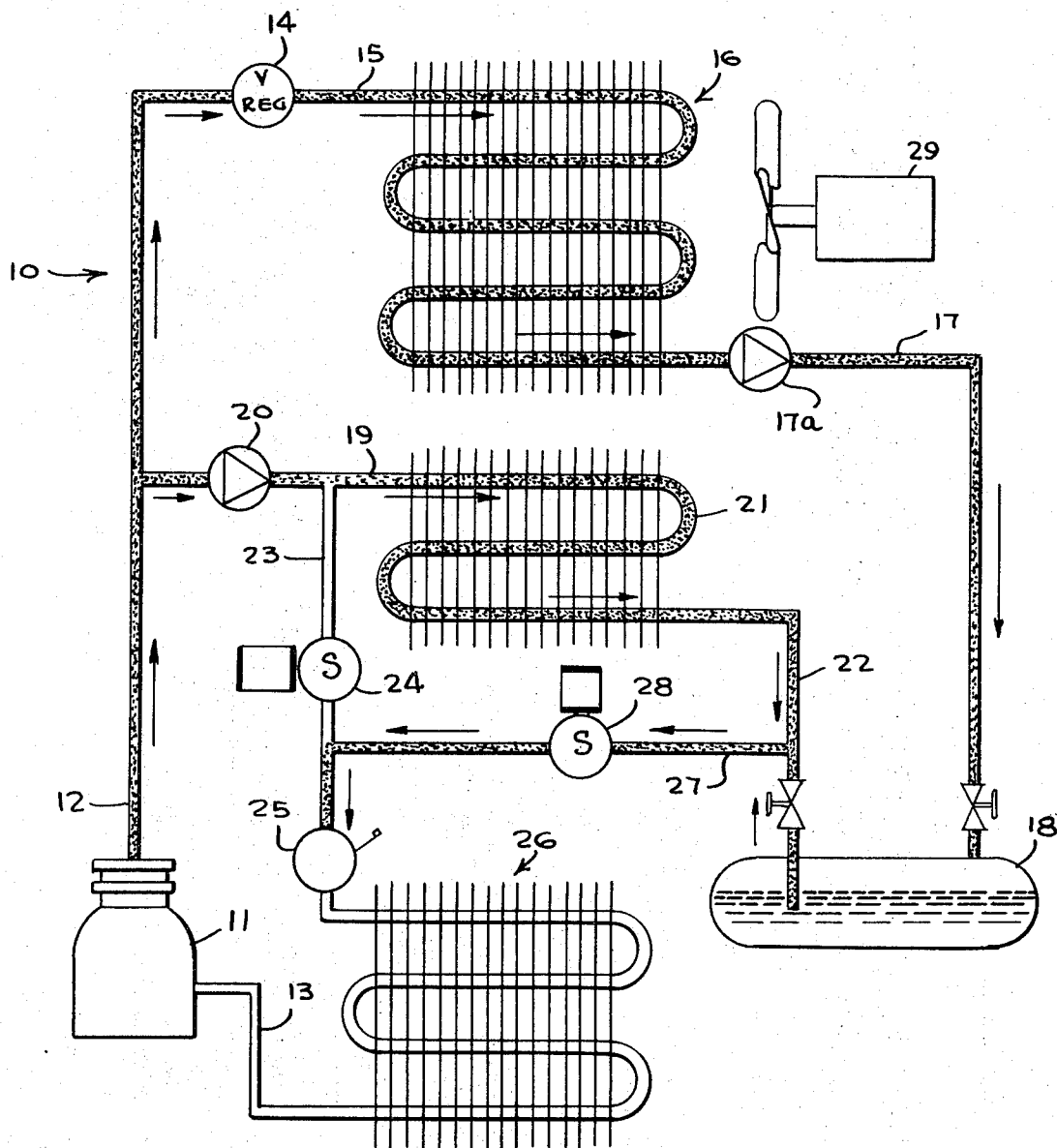


Fig-3

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1

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**REFRIGERATION SYSTEM FOR WIDELY  
VARYING AMBIENT CONDITIONS**

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8 Claims

## ABSTRACT OF THE DISCLOSURE

A refrigeration system having an air-cooled condenser and a sub-cooler and means for interconnecting them with the compressor and evaporator to course refrigerant through both the condenser and through the sub-cooler in a first direction during high ambient temperature conditions and for by-passing the condenser and coursing the refrigerant through the sub-cooler in an opposite direction during low ambient temperatures.

## BACKGROUND AND OBJECTS OF THE INVENTION

Numerous refrigeration systems have heretofore been developed for maintaining efficient operation of refrigeration systems having air cooled condensers over a wide range of ambient temperatures. It will be appreciated that air cooled condensers sized to provide proper condensing capacity for certain ambient temperature ranges, for example those encountered during the summer season, provide excessive condensing capacity when the ambient air is in the lower winter temperature ranges. Efforts to maintain efficient refrigeration system operation with air cooled condensers over wide ranges of ambient temperature have taken the form of complex controls for varying the flow of air over the condenser coils by special fan controls or shutter systems designed to regulate condenser air flow, or by by-pass conduits and control valves responsive to temperature variations or to refrigerant pressure variations to deliver gaseous refrigerant from the compressor directly to the receiver in by-passing relation to the condenser coils when the ambient air temperatures are in selected low regions.

The present invention seeks to achieve improved performance of refrigeration systems having air cooled condensers over a wide range of ambient temperature conditions by providing a subcooler coil assembly, in addition to the usual condenser coil assembly, which is so related to the system as to provide the sole source of condensing of refrigerant during low ambient or winter conditions, which is disposed in a branch refrigerant circuit in parallel with the condenser circuit in intermediate ambient conditions, and which is in the refrigerant flow path from the receiver to the evaporator in high ambient or summer conditions to thereby obtain improved regulation of condensing function in the system with variations in ambient temperature.

An object of the present invention, therefore, is the provision of a novel refrigeration system of the type having an air cooled condenser, which achieves improved variation of condensing function in the high pressure section of the system with variation in ambient temperature.

Another object of the present invention is the provision of a novel refrigeration system of the type having an air cooled condenser, wherein a subcooler coil system is incorporated in different selected relationships to the usual condenser, receiver and evaporator of the system for different ambient temperature ranges for improved system operation.

Yet another object of the present invention is the pro-

2

vision of a novel refrigeration system including an air cooled condenser, wherein a subcooler coil assembly is provided to effect subcooling of refrigerant outflow from the receiver during high ambient conditions, to serve as the sole condenser for the system in low ambient conditions, to provide an alternate condensing path for refrigerant flow paralleling the flow path through the condenser in intermediate ambient conditions.

Other objects, advantages and capabilities of the present invention will become apparent from the following detailed description taken in conjunction with the accompanying drawings illustrating a preferred embodiment of the invention.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic view of a refrigeration system embodying the present invention, illustrating the flow path of refrigerant in the high pressure section thereof for low ambient condition encountered in the winter season;

FIG. 2 is a diagrammatic view similar to FIG. 1, illustrating the flow path of refrigerant in the high pressure section of the system for high ambient or summer season conditions, and

FIG. 3 is a diagrammatic view similar to the preceding figures, illustrating the flow path of refrigerant in the high pressure leg thereof for intermediate ambient conditions.

## DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

Referring to the drawings wherein like reference characters designate corresponding parts throughout the several figures, the refrigeration system of the present invention, indicated generally by the reference character 10, comprises a conventional compressor 11 having a discharge conduit 12 connected to the discharge or high pressure side of the compressor, and a suction conduit 13 connected to the suction side of the compressor. The discharge conduit 12 is connected to the inlet of a pressure regulating valve 14 controlling conduit 15 to the inlet of a conventional air cooled condenser coil assembly 16, the outlet of which is connected through check valve 17a and liquid line 17 to a receiver 18. The discharge conduit 12 is also connected through a branch conduit 19 having a check valve 20 therein to a subcooler coil assembly 21, the outlet of which is connected through liquid line 22 to the receiver 18. A conduit section 23 having a solenoid valve 24 therein is connected to the branch conduit 19 at a location between the check valve 20 and the subcooler coil assembly 21 and to the thermostatic expansion valve 25 at the inlet of an evaporator valve 25 at the inlet of an evaporator 26 whose outlet is connected to the suction line 13 for return of refrigerant to the compressor 11. Another conduit section 27 having a solenoid control valve 28 therein extends between the conduit 22 intermediate the subcooler 21 and receiver 18, and the conduit section 23 downstream from the solenoid control valve 24. A conventional motor driven fan 29 moves ambient air through the condenser coil and subcooler coil, both of which are disposed adjacent each other.

The pressure regulating valve 14 is a pressure sensitive valve operative to close on a selected drop in pressure at its inlet or its outlet. The check valve 20 is an ordinary spring-loaded check valve or other device which will impose a fixed restriction in the line from the compressor discharge to the subcooler coil 21, which restriction is sufficient to prevent any flow through the valve 20 when the regulator valve 14 is wide open. The check valve 20 is designed to open at any selected outlet pressure so long as the valve 14 is closed or sufficiently throttled.

The solenoid valves 24 and 28 in the liquid lines 23 and 27 are controlled by a thermostat (not shown) sensitive to ambient temperature. Typically, they may be set so that the valve 24 is maintained in closed condition and the valve 28 is open for all ambient temperature below 70° F., and to open valve 24 and close valve 28 at ambient temperatures above 70° F.

In operation, at extremely low ambient temperatures, flow is as illustrated in FIG. 1, where regulating valve 14 is closed because the pressure at its inlet or outlet is below its control setting, preventing any flow through the condenser coil assembly 16, valves 20 and 28 are open, and valve 24 is closed. All refrigerant from the compressor 11 is forced through the check valve 20, branch conduit 19, sub-cooler coil assembly 21 and liquid line 22 to its juncture with the conduit section 27, and thence through conduit section 27 and open solenoid valve 28 to the expansion valve 25 and evaporator 26. In this condition, the sub-cooling coil 21 performs the entire condensing function for the system, and liquid refrigerant is delivered from it to the evaporator by way of the solenoid valve 28 without passing through the receiver. When no refrigeration is required, both solenoid valves 24 and 28 will be closed by the operating thermostat, so that the evaporator 26 is evacuated and the compressor 11 is stopped by its low pressure control.

In high ambient temperature conditions, as during the summer season, when maximum loading occurs, as for example with the ambient temperature in excess of 70° F., regulating valve 14 is wide open, because the pressure at the discharge of the compressor 11 is higher than the control setting of valve 14, the check valve 20 is closed, because the pressure difference between its inlet and outlet is not sufficient to counteract the closing force of its spring, solenoid valve 24 is open and solenoid valve 28 is closed. Thus the refrigerant from the compressor 11 courses through the condenser coils 15 and liquid line 17 to the receiver, and thence up the liquid line 22 through the sub-cooler coils 21, and the conduit section 23 and open solenoid valve 24 to the expansion valve 25 and evaporator 26. Therefore, the condenser coils 15 operate at full capacity and the liquid flow from the condenser courses through the receiver 18 and the sub-cooler 21 to the evaporator. In this condition, the flow through the sub-cooler coils 21 is in a direction opposite that of the previous case, and is illustrated in FIG. 2. The use of the sub-cooler 21 in the system in this manner when high ambients occur takes advantage of the presence of this component of the system and the condenser by further enhancing refrigeration capacity when it is most needed, as sub-cooling of condensed refrigerant produces about a 5% capacity increase for every 10° of sub-cooling at unchanged power consumption.

In intermediate weather, when the ambient temperatures are between these two extremes, flow will be as illustrated in FIG. 3, and since both valves 14 and 20 are open, some refrigerant discharge from the compressor 11 will flow in a first circuit through the condenser coil assembly 15 to the receiver 18 and some will flow in a second circuit through the open check valve 20 to the sub-cooler coil assembly 21 and down the conduit section 22. Thus both the condenser coil system 15 and the sub-cooler coil system 21 are operating in parallel in this condition. The sub-cooler coil 21 will condense at its full capacity while the rate of condensation in the condenser coil 15 is regulated by the valve 14 responsive to the pressure at the compressor discharge 12. If the liquid quantity required by the evaporator 26 exceeds that supplied by the sub-cooler 21, it will be augmented by reserve liquid in the receiver 18, rising through the line 22 to its juncture with the conduit section 27 and then merging with the liquid flowing from the sub-cooler through the conduit section 27 and solenoid valve 28 to the evaporator 26.

By this arrangement, the sub-cooler coil 21, which has

in the past been used to perform the sole function of sub-cooling, is utilized to provide a more versatile system by making it also a means of condenser capacity control, as it serves both as a sub-cooler at times of high ambient and, during the cold season, when the compressor has ample capacity, the main condensing coil capacity is modulated while the sub-cooler coil supplies the basic condensing capacity required at those times.

While but one specific embodiment of the invention has been particularly shown and described, it is apparent that various modifications may be made therein within the spirit and scope of the invention, and it is desired, therefore, that only such limitations be placed thereon as are imposed by the prior art and set forth in the appended claims.

What is claimed is:

1. In a refrigeration system adapted for use under a wide variety of ambient temperatures, including a compressor having discharge and suction sides, an air cooled condenser, a sub-cooler, a receiver and an evaporator, the improvement comprising the provision of:

valve regulated conduit means interconnecting the refrigeration system components in a plurality of selected refrigerant flow circuits including means for establishing a first refrigerant flow circuit for coursing refrigerant from said compressor discharge side through said condenser and receiver and thence through said sub-cooler to said evaporator during selected high ambient temperatures and means for establishing a second refrigerant flow circuit for coursing refrigerant from said compressor discharge side through said sub-cooler to said evaporator in by-passing relation to said condenser, and

valve means associated with said first and second refrigerant flow circuits for selectively diverting all refrigerant flow from said compressor discharge side to said second refrigerant flow circuit in response to ambient temperatures below a selected value whereby the sub-cooler serves as the sole condensing component during low ambient temperature conditions.

2. A refrigeration system as defined in claim 1, wherein said valve regulated conduit means includes means establishing a pair of refrigerant flow paths between said compressor and evaporator during selected intermediate ambient temperatures above said selected value including a first flow path coursing refrigerant through said condenser and receiver to said evaporator and a second flow path coursing refrigerant through said sub-cooler to said evaporator, said first and second flow paths intersecting downstream of each of said condenser and sub-cooler to commingle the refrigerant in said flow paths prior to its entering said evaporator.

3. A refrigeration system as defined in claim 2, wherein said sub-cooler has first and second ends, said valve regulated conduit means include first and second valved conduit sections connected between a common junction point and the first and second ends of said sub-cooler respectively, a third conduit connecting said common junction point to said evaporator, and a fourth conduit connecting the sub-cooler outlet to said receiver, the refrigerant coursing through said sub-cooler in a first direction from said fourth conduit and said receiver and through said first valved conduit section and third conduit section to said evaporator during said high ambient temperatures and coursing through said sub-cooler in a second direction from said compressor discharge side and through a portion of said fourth conduit and said second valved conduit section and third conduit section to said evaporator during said low ambient temperatures.

4. A refrigeration system as defined in claim 3, wherein said first valved conduit includes a temperature regulated valve which is open responsive to ambient temperatures above a selected value and closed for all lower temperatures and said second valved conduit includes a temperature regulated valve which is open responsive to

5

ambient temperatures below said value and is closed at all temperatures above said value.

5. A refrigeration system as defined in claim 3, wherein the inlet of said condenser is connected through a pressure responsive valve to said compressor discharge side and said first end of said sub-cooler is connected through a spring actuated, normally closed, check valve to said compressor discharge side, said check valve being opened responsive to a selected pressure differential between its inlet and outlet established when said pressure responsive valve has interposed selected restriction to refrigerant flow to said condenser to permit refrigerant flow from said compressor directly to said sub-cooler.

6. A refrigeration system as defined in claim 1, wherein said sub-cooler has first and second ends, said valve regulated conduit means including first and second valved conduit sections connected between a common junction point and the first and second ends of said sub-cooler respectively, a third conduit connecting said common junction point to said evaporator, and a fourth conduit connecting the sub-cooler outlet to said receiver, the refrigerant coursing through said sub-cooler in a first direction from said fourth conduit and said receiver and through said first valved conduit section and third conduit section to said evaporator during said high ambient temperatures and coursing through said sub-cooler in a second direction from said compressor discharge side and through a portion of said fourth conduit and said second valved conduit section and third conduit section to said evaporator during said low ambient temperatures.

6

7. A refrigeration system as defined in claim 6, wherein said first valved conduit includes a temperature regulated valve which is open responsive to ambient temperatures above a selected value and closed for all lower temperatures and said second valved conduit includes a temperature regulated valve which is open responsive to ambient temperatures below said value and is closed at all temperatures above said value.

8. A refrigeration system as defined in claim 6, wherein the inlet of said condenser is connected through a pressure responsive valve to said compressor discharge side and said first end of said sub-cooler is connected through a spring actuated, normally closed check valve to said compressor discharge side, said check valve being opened responsive to a selected pressure differential between its inlet and outlet established when said pressure responsive valve has interposed selected restriction to refrigerant flow to said condenser to permit refrigerant flow from said compressor directly to said sub-cooler.

#### References Cited

#### UNITED STATES PATENTS

|           |        |           |              |
|-----------|--------|-----------|--------------|
| 3,134,241 | 5/1964 | Johnson.  |              |
| 3,370,438 | 2/1968 | Hopkinson | ----- 62—196 |

MEYER PERLIN, Primary Examiner

U.S. Cl. X.R.

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