CAPACITY CONTROL FOR COMPRESSION EXPANSION REFRIGERATION SYSTEMS

Inventors: John W. Barlass, Excelsior; Lowell B. Naley, St. Louis Park, both of Minn.

Assignee: Thermo King Corporation, Minneapolis, Minn.

Filed: Jan. 18, 1971

Appl. No.: 107,246

U.S. Cl.................................62/196, 62/217, 62/278
Int. Cl.................................F25b 41/00
Field of Search........................62/196, 217, 278

References Cited

UNITED STATES PATENTS
2,632,303 3/1953 Smith..........................62/196
3,303,664 2/1967 Hansen........................62/217

Primary Examiner—Meyer Perl
Attorney—F. H. Henson and F. E. Blake

ABSTRACT

A compression expansion refrigeration system is provided with a hot gas line to connect hot gas from the compressor directly to the expansion coil for reducing its capacity and a servo operated suction pressure modulation valve is provided in the intake line to the compressor to vary the capacity of the system to obtain a controlled load temperature. Thermostatic control means disables the servo operated modulation valve in the open position and maintains closed a valve in the hot gas line to provide maximum capacity so long as the controlled temperature is above a predetermined amount above the desired controlled temperature and when the controlled temperature falls below the predetermined amount the valve in the hot gas line is opened to provide a direct step reduction in capacity and the suction modulation valve is activated to vary the lowered capacity to obtain the desired controlled load temperature.

5 Claims, 2 Drawing Figures
CAPACITY CONTROL FOR COMPRESSION EXPANSION REFRIGERATION SYSTEMS

CROSS REFERENCES TO RELATED PATENT APPLICATIONS

So far as is known, this application is not related to any copending patent applications.

BACKGROUND OF THE INVENTION

There are many known arrangements for varying the capacity of a compression expansion refrigeration system. For example, it is known that the capacity of the system may be reduced by injecting hot refrigerant gas directly from the compressor into the expansion coil. Also, it is known that a throttle valve may be interposed in the suction line to the compressor to be variably closed or modulated to vary the suction pressure and the capacity of the system to thereby obtain a desired controlled refrigerated temperature. The known arrangements for capacity control such as just described have well known limitations and problems which prevent their being effective to give a very wide range of capacity control down to as low as three to five percent of total capacity. Therefore, a system using only the known capacity control cannot have an excess of capacity or large capacity relative to the normal load because of the limited range of operation of such capacity controls. Transportable refrigeration systems for trucks, railroad cars and the like can be more effectively used if the refrigeration system can be provided with a large or excess capacity for rapidly cooling a new load and can then have the capacity controllably reduced over a large range to as low as three percent of the maximum capacity while operating continuously to maintain the load at the desired controlled refrigerated temperature.

PRIOR ART

The U.S. Pat. to Long No. 3,088,291 issued May 7, 1963 may be of interest in disclosing a compression expansion refrigeration system having both hot gas injection and suction line pressure modulation for capacity control but the control arrangements for the hot gas injection and suction line pressure modulation are not such as to provide the large range of capacity control in the manner provided by the present invention.

SUMMARY

In accordance with the invention, a compression refrigeration system is provided with a hot gas line between the discharge of the compressor and the evaporator coil to bypass the condenser and feed a predetermined amount of hot gas directly into the expansion coil to reduce the capacity of the system. A normally closed hot gas valve is provided in the hot gas line to enable the system to function with maximum capacity when the valve is closed. A servo operated suction line pressure modulating throttle valve is provided in the suction line of the system to be controllably closed when it is desired to vary the capacity of the system to maintain a desired refrigerated load temperature. The servo operated suction valve is arranged to be normally open when its servo mechanism is inactivated or disabled. Thermostatic control means is provided to maintain the hot gas valve closed and to inactivate the servo mechanism of the suction pressure modulation valve in the valve open position when the load temperature is above a predetermined amount above the desired controlled refrigerated temperature and the maximum refrigeration capacity is therefore required. The thermostatic control means is effective to open the hot gas valve to provide a direct and immediate step reduction in capacity when the load temperature drops below the predetermined amount above the desired controlled load temperature. The thermostatic control is also arranged to activate the servo mechanism for the suction pressure modulation valve after the hot gas valve has been opened when the load temperature falls below a predetermined amount above the desired load temperature so that the lowered capacity may be further reduced to as low as three percent of the total capacity in order to maintain the desired load temperature. The hot gas injection as described above is effective to provide a step reduction in capacity that enables the system capacity to be further lowered to about three percent of the maximum capacity by the operation of the suction pressure modulation valve without fully closing the valve to such an extent as would cause a vacuum into the compressor or would starve the compressor of cooling gas to be compressed. This also assures a sufficient gas flow to provide return of lubricating oil to the compressor.

Further features and advantages of the invention will be apparent with reference to the following specification and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of the refrigeration system embodying the capacity control of the invention; and

FIG. 2 is a graphical showing of the operation of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1 of the drawings, a refrigerant gas compressor 10 is shown to have its outlet connected to the hot gas line 11 and to the condensing coil 12. The condensed liquid refrigerant from the condensing coil 12 is connected by the liquid line 13 to the expansion device 14 and the expansion coil 15. Expanded refrigerant gas from the expansion coil 15 is connected by the suction line 16 to the inlet of the refrigerant gas compressor 10 thus completing the refrigerant circuit.

A hot gas bypass line 20 is connected from the hot gas discharge line 11 to the outlet side of the expansion device 14 and thus to the expansion coil 15. When the solenoid operated hot gas valve 21 is opened, the bypass line 20 functions to continuously connect a quantity of hot refrigerant gas directly from the compressor 10 into the expansion coil 15 thus providing a step reduction in refrigeration capacity for the system. The hot gas line valve 21 is a form of normally closed solenoid operated valve well known in the art which may be opened when the solenoid coil of the valve is energized upon the closing of the thermostatic switch contacts 22 as will be further described in some detail.

A suction pressure modulating or throttle valve 30 is interposed in the suction line 16 and such valve is of the servo operated type that will be normally opened when its servo mechanism 31 is inactivated as is well known in the art. The servo mechanism 31 is arranged to be operated by the pressure of liquid refrigerant in the line 33. A solenoid valve 34 is connected in the liquid refrigerant line 33 to be normally closed except when its solenoid coil is energized upon the closing of the thermostatic switch 35. When the valve 34 is closed, the servo mechanism 31 for the suction pressure modulating valve 30 is inactivated with the valve in the full open position. On the other hand, when the solenoid valve 34 is open, the liquid refrigerant under pressure in line 33 is connected to the servo mechanism 31 which functions responsive to the temperature sensing coil 32 to variably close the suction pressure modulating valve 30 and vary the suction pressure in the line 16 to the compressor 10 to obtain a desired controlled load temperature from the evaporator coil 15.

Referring now to both FIGS. 1 and 2 of the drawing, the preferred operation of the capacity control system of the invention will be described. It should first be remembered that the refrigeration system of the invention is provided with a very high or excess of capacity to thereby obtain a rapid cooling of a load such as might be desired in a refrigerated truck or railroad car compartment. When the system is first operated, both the hot gas bypass solenoid valve 21 and the liquid line solenoid valve 34 are closed so that no hot gas is injected directly into the expansion coil and the suction pressure modulation valve is full open thus assuring the operation of
the system at maximum capacity as indicated by the point CX on FIG. 2 of the drawing. Thus the system operates at maximum capacity to rapidly cool a new load until the temperature of the load drops as shown by FIG. 2 of the drawing to the temperature T1 which is a predetermined temperature above the desired load temperature T2. When the temperature T1 is reached, both thermostatic switches 22 and 35 may be closed. The closure of thermostatic switch 22 causes the energization of the solenoid valve 21 in the hot gas bypass line 20 to thus open the valve 21 and cause a predetermined quantity of hot refrigerant gas to be continuously injected directly into the expansion coil 15. This immediately produces a stepped reduction of capacity of the refrigeration system as indicated from the point C to the point C1 in the curve of FIG. 2. At the same time, with the thermostatic switch 35 closed to energize and open the solenoid valve 34, the servo mechanism 31 for the hot gas suction line valve 30 is activated. Servo mechanism 31, functioning in connection with the temperature sensing coil 32, thus causes the suction valve 30 to variably close until the desired controlled temperature T2, at a very low capacity C3 of the refrigeration system, is reached. Thereafter the suction modulation valve 30 will operate in a known manner to maintain the desired low temperature T2 by varying the capacity of the refrigeration system as required about the low capacity point C3.

Although the invention has been described as employing two thermostatic switches 22 and 35, it should be obvious to those skilled in the art that a single thermostatic switch may be used in place of the two switches and the electric current connected by the single thermostatic switch would be connected in parallel to both of the solenoid valves 21 and 34. Such an arrangement, of course, would require that both valves 21 and 34 open at the same time. It may be desirable to open valve 21 and inject hot gas directly into the evaporator coil 15 before the servo mechanism 31 for the suction pressure modulation valve 30 is activated. In such case, the separate thermostatic switch 35 could be differently adjusted from the thermostatic switch 22 so that the solenoid valve 34 would be opened at a different time from the opening of the solenoid valve 21. Depending upon the desired operating parameters of the system, either valve 21 or 34 may be opened before the other, it being understood, however, that when the valve 21 is opened, an immediate step reduction in capacity of the refrigeration system will be obtained and that when the valve 34 is opened, the graduated or modulated change in capacity of the system would be obtained as the servo operating suction pressure modulation valve 30 is variably closed or opened.

Various modifications will occur to those skilled in the art.

We claim as our invention:

1. A capacity control for a compression refrigeration system having a compressor connected in a refrigerant circuit with a condensing coil to an expansion device and an evaporator coil comprising, a suction modulation valve in the suction line between said evaporator coil and said compressor, servo means to be activated to variably close said modulation valve to change the capacity of the system, a hot gas injection line connected between said compressor and said evaporator to bypass said condenser and inject hot refrigerant gas directly from said compressor into said evaporator to reduce the capacity of the system, a normally closed hot gas valve in said hot gas line to be opened when the capacity of the system is to be reduced from maximum capacity, and thermostatic control means to inactivate the servo control of said modulation valve in the open position and to cause said hot gas valve to be in the closed position when maximum capacity is desired and the controlled refrigerated load temperature is above a predetermined amount above the desired controlled load temperature, said thermostatic control means being responsive to open said hot gas valve and activate the servo means for said modulation valve when the temperature falls below the predetermined amount above the desired load temperature whereby the capacity of the refrigeration system is directly reduced a predetermined amount by the opening of the hot gas valve and is gradually reduced beyond the predetermined amount by the operation of said modulation valve to obtain the desired load temperature.

2. The invention of claim 1 in which said servo operated suction valve is normally open and is provided with a servo mechanism powered by compressed refrigerant liquid supplied from the refrigerant circuit to variably close the valve for capacity control, and said thermostatic control means to inactivate said suction valve in the open position is comprised of a normally closed valve in the supply of liquid refrigerant to the suction valve servo mechanism that is operated to be opened when the controlled temperature drops below the predetermined amount above the desired controlled temperature.

3. The invention of claim 1 in which said thermostatic control means is effective to open said hot gas valve when the controlled temperature is below one predetermined amount above the desired temperature and is effective to activate the servo controlled suction valve when the controlled temperature is below another predetermined amount above the desired temperature.

4. The invention of claim 2 in which said thermostatic control means is effective to open said hot gas valve when the controlled temperature is below one predetermined amount above the desired temperature and is effective to activate the servo controlled suction valve when the controlled temperature is below another predetermined amount above the desired temperature.

5. The invention of claim 4 in which said normally closed valve in the supply of liquid refrigerant to the suction valve servo mechanism and the normally closed hot gas valve in said hot gas line are solenoid operated valves, said thermostatic control means including respective thermostatic switches connected to energize the respective solenoid valves when they are required to be opened for controlling the capacity of the system.

* * * * *