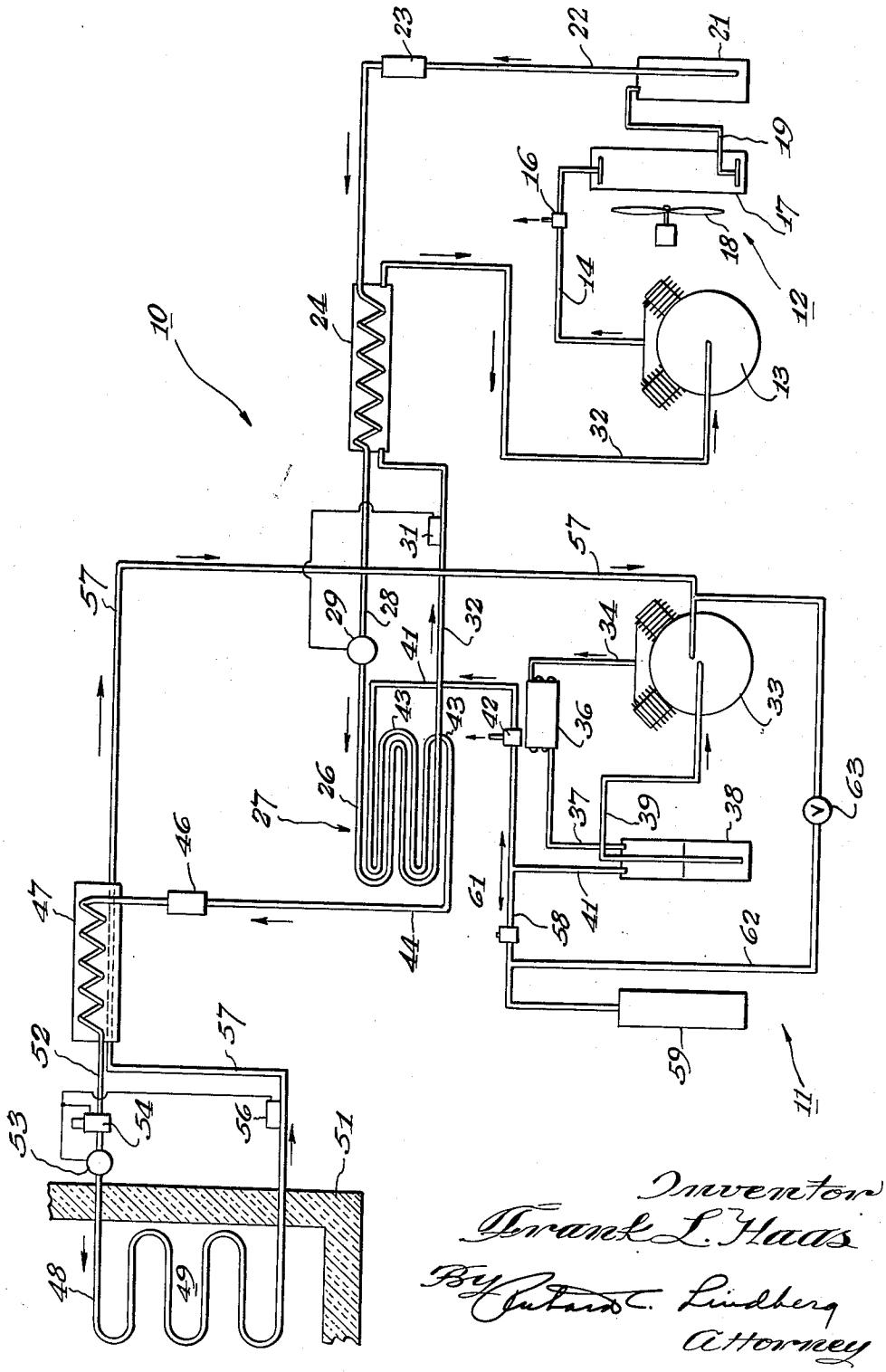
June 15, 1954 F. L. HAAS 2,680,956

PLURAL STAGE REFRIGERATION SYSTEM

Filed Dec. 19, 1951



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Patented June 15, 1954

2,680,956

UNITED STATES PATENT OFFICE

2,680,956

PLURAL STAGE REFRIGERATION SYSTEM

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Application December 19, 1951, Serial No. 262,439

9 Claims. (Cl. 62—3)

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This invention relates generally to cascade stage refrigeration systems, and particularly to a cascade system wherein a rise in temperature of the refrigerant in one of the stages to that of the ambient, as might be occasioned by power failure, will not affect restarting of the system.

In certain types of extremely low temperature installations as, by way of example, those employed for cold hardening of special steels, cascade stage refrigeration systems are employed to provide the extremely low temperatures necessary. In the last stage of such system certain halogenated hydrocarbons, which are efficient in temperature ranges of the order of −75° to −130° F., may be used, "Freon 13" being an example of such a refrigerant. However, such refrigerants, when in a closed system, develop very high pressures at ambients of around 80° F., pressures of the order of 520 p. s. i. g. being possible. It is important in such low temperature installations to maintain the desired temperature for a definite period, but power failure or unintended opening of circuits to prime movers of such installations may cause the closed system to reach the temperature of the ambient with the resulting high pressures. Safety codes require the use of relief devices, and power failure for even a brief period may cause operation of the relief means. The system may not be restarted, however, until it is recharged with refrigerant which has been lost by operation of the relief means, a vexatious, costly and lengthy operation, which in some cases nullifies the results sought.

In carrying out the present invention a charging and discharging reservoir is employed to receive the refrigerant as it increases in pressure by a rise in temperature approaching the ambient, as might be occasioned by a failure of the prime mover for the system, the reservoir being so connected as to discharge back to the compressor with the refrigerant properly valved so as to be at the same pressure as that returning to the compressor by way of the conventional return line.

With the foregoing considerations in mind it is a principal object of this invention to provide an extremely low temperature refrigeration system, which will be available for restarting after a power failure or the like without the necessity for recharging the system with refrigerant.

Another object is to afford a low temperature cascade type refrigeration system wherein the operation of the first stage will not be affected by a rise in temperature of the refrigerant

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thereof to the ambient, the first stage being so arranged that high pressures resulting from rise in temperature to the ambient are avoided.

Other objects and important features of the invention will become apparent from a study of the following specification taken with the drawing which together illustrate a preferred embodiment of the invention and what is now considered to be the best mode of practicing the principles thereof. Other embodiments of the invention may be suggested to those having the benefit of the teachings herein, and it is therefore intended that the scope of the invention not be limited by the precise embodiment shown, which is capable of modification, nor otherwise than by the scope of the appended claims.

Referring now to the drawing, there is shown a cascade type refrigeration system referred to generally by the reference numeral 10, which includes a first closed refrigeration circuit 11 and a second closed refrigeration circuit 12. The two circuits are so arranged that the refrigeration circuit 12 provides sub-cooling for the refrigerant of circuit 11.

Closed refrigeration circuit 12 consists of a compressor 13 which pumps compressed refrigerant by way of a line 14 past a relief valve 16 and into a condenser 17. A fan 18 reduces the temperature of the compressed refrigerant to that of the ambient. The cooled and compressed refrigerant passes by way of a line 19 to a receiver 21 and moves therefrom by a line 22 and past a dehydrator 23 to a heat exchanger 24. An evaporator coil 26 of a cascade condenser and subcooler 27 is connected by a line 28 to the heat exchanger 24. A thermostatically operated expansion valve 29 controls the admission of refrigerant to the evaporator coil 26, and is controlled by thermal control element 31 sensitive to the temperature of a return line 32 from the evaporator coil 26.

The heat exchanger 24 is connected in the return line 32 and is so arranged that the temperature of the compressed refrigerant entering the heat exchanger 24 is lowered by heat exchange with expanded refrigerant of the return line 32, the heat exchanger 24, by way of example, being able to reduce the heat of the compressed refrigerant approximately twenty degrees.

Closed refrigeration circuit 11 consists of a compressor 33 which pumps compressed refrigerant by way of a line 34 into an auxiliary condenser 36 which removes the heat of compression of the refrigerant, as by means of a fan,

not shown, similar to the fan 18 shown with condenser 17 of the refrigeration circuit 12. The cooled and compressed refrigerant passes by a line 37 to an oil separator 38, the oil separated therein being conducted by a line 39 back to the input side of the compressor 33 for lubrication thereof.

The refrigerant, which has been thus separated from the lubricating oil in the separator 38 moves by way of line 41 past a relief valve 42 to a condenser coil 43 of the subcooler 27 where the refrigerant is in heat exchange relationship with the evaporator coil 26 thereof which, it will be remembered, is circulating the refrigerant of the closed refrigeration circuit 12. The sub-cooled refrigerant leaves the condenser coil 43 by way of a line 44 and moves past a dehydrator 46 and to a heat exchanger 47.

An evaporator coil 48 is located within a refrigerated space 49 defined by insulated walls 51 and is connected by a line 52 to the intercooler 47. A thermostatically operated expansion valve 53 and a solenoid operated shut-off valve 54 control the admission of refrigerant to the evaporator coil 48, and are controlled in their operation by a thermal control element 56 sensitive to the temperature condition of a return line 57 from the evaporator coil 48.

The heat exchanger 47 is connected in the return line and is so arranged that the temperature of the compressed and sub-cooled refrigerant entering the heat exchanger 47 is lowered by heat exchange with the expanded refrigerant in the return line 57, the heat exchanger 47 being able thus to lower the temperature of the compressed and sub-cooled refrigerant from the subcooler 27 an additional amount.

By the provision of the subcooler 27 and the heat exchangers 24 and 27 the refrigerant entering the evaporator coil 48 is at the lowest possible operating temperature so that the refrigeration effect within the space 49 is greatly increased.

The compressed refrigerant from the compressor 33 which has been relieved of the heat of compression in the auxiliary condenser 36 is maintained below a pressure which would operate the relief valve 42 which may be set at a value of the order of 270 p. s. i. g. A branching line 58 from the refrigerant line 41 is connected to a charging and discharging reservoir 59, and a pressure relief valve 61 is located between the line 41 and the reservoir 59. Pressure relief valve 61 is set at a value of the order of 210 p. s. i. g.

A reservoir return line 62 is connected between the pressure relief valve 61 and the charging and discharging reservoir 59, and leads back to the intake side of the compressor 33, joining to the main return line 57, an expansion valve 63 being connected in the reservoir return line 62. The expansion valve 63 is so arranged as to reduce the pressure of the refrigerant in the reservoir return line 62 to the same pressure as that obtaining by the expansion valve 53 at the evaporator coil 48.

The closed system 11 employs a commercial refrigerant providing cooling for the space 49 of the order of —75° F. to —130° F., but such a system upon power failure or opening of the circuit supplying the prime mover therefor will cause the refrigerant to approach the temperature of the ambient. Such temperatures in the case of some of the halogenated hydrocarbon

types of refrigerants will cause the pressure in a closed system as closed system 11 to reach pressures of the order of 520 p. s. i. g., a value higher than that permitted by the usual safety codes, operating limits of standard commercial units. Ordinarily, such pressures would be relieved by the pressure relief valve 42, but the provision of the valve 61 in the branching line 58 to the reservoir 59 provides for release of the excess pressure to the charging and discharging reservoir 59. Sufficient volume is available in the reservoir 59 to maintain the pressure of the closed system 11 at a value well below that causing relief thereof through the pressure relief valve 42.

The reservoir 59 which is charged thusly by the rise in temperature of the refrigerant is capable of discharging back to the system when the compressor 33 is again started, the expansion valve 63 releasing the refrigerant back to the compressor 33 at the same pressure as that afforded by the expansion valve 53.

By the provision of the charging and discharging reservoir 59 the system may be started without first recharging the system with additional refrigerant which ordinarily would be lost. Either brief or extended periods of power failure or open circuits to the prime mover for the refrigeration system of the present invention, therefore, do not in any way affect the condition of the system for a resumption of use, it being possible to resume operation without recharging or otherwise adjusting the system prior to restarting.

While the invention has been disclosed in terms of an embodiment which has been found acceptable in practice, it is not intended that the scope of the invention be limited by the embodiment shown herein nor otherwise than by the breadth and spirit of the claims here appended.

I claim:

1. In a cascade refrigeration system; a first closed refrigeration circuit including a compressor, a condenser and an evaporator; a heat exchanger in said system for reducing the temperature of the compressed and condensed refrigerant by heat exchange with refrigerant returning from said evaporator; a second closed refrigeration circuit including a compressor, a condenser and an evaporator; a heat exchanger in said second circuit for reducing the temperature of the compressed and condensed refrigerant by heat exchange with refrigerant returning from said second named evaporator; said first named condenser and said second named evaporator being in heat exchange relationship for sub-cooling of the compressed refrigerant of said first closed refrigerant circuit; an auxiliary condenser connected between said first named compressor and said first named condenser for precooling the refrigerant from said first named compressor; and means for receiving refrigerant when the pressure thereof increases beyond a predetermined value in approaching ambient temperature in said first refrigerant circuit comprising a charging and discharging reservoir connected in parallel with said first named compressor, a valve connected between said reservoir and the output side of said first named compressor and operable to pass refrigerant to said reservoir upon increase in pressure of said refrigerant beyond said predetermined value, an expansion valve connected between said reservoir and the input side of said compressor for enabling said reservoir to pass

refrigerant to said first named compressor at a pressure corresponding to the pressure of the refrigerant returning from said first named evaporator.

2. In a cascade refrigeration system; a first closed refrigeration circuit including a compressor, a condenser and an evaporator; a heat exchanger in said system for reducing the temperature of the compressed and condensed refrigerant by heat exchange with refrigerant returning from said evaporator; a second closed refrigeration circuit including a compressor, a condenser and an evaporator; a heat exchanger in said second circuit for reducing the temperature of the compressed and condensed refrigerant by heat exchange with refrigerant returning from said second named evaporator; said first named condenser and said second named evaporator being in heat exchange relationship for subcooling of the compressed refrigerant of said first closed refrigerant circuit; and means for receiving refrigerant when the pressure thereof increases beyond a predetermined value in approaching ambient temperature in said first refrigerant circuit comprising a charging and discharging reservoir connected in parallel with said first named compressor, a valve connected between said reservoir and the output side of said first named compressor and operable to pass refrigerant to said reservoir upon increase in pressure of said refrigerant beyond said predetermined value, and valve means connected between said reservoir and the input side of said compressor for enabling said reservoir to pass refrigerant to said first named compressor at a pressure corresponding to the pressure of the refrigerant returning from said first named evaporator.

3. In a cascade refrigeration system; a first closed refrigeration circuit including a compressor, a condenser and an evaporator; a heat exchanger in said system for reducing the temperature of the compressed and condensed refrigerant by heat exchange with refrigerant returning from said evaporator; a second closed refrigeration circuit including a compressor, a condenser and an evaporator; a heat exchanger in said second circuit for reducing the temperature of the compressed and condensed refrigerant by heat exchange with refrigerant returning from said second named evaporator; said first named condenser and said second named evaporator being in heat exchange relationship for subcooling of the compressed refrigerant of said first closed refrigerant circuit; an auxiliary condenser connected between said first named compressor and said first named condenser for precooling the refrigerant from said first named compressor; a reservoir circuit including a charging and discharging reservoir therein connected in parallel with said first named compressor for receiving refrigerant when the pressure thereof increases beyond a predetermined value in approaching ambient temperature, a valve connected in said parallel circuit between the output side of said first named compressor and said charging and discharging reservoir and operable to pass refrigerant to said reservoir upon increase in pressure of said refrigerant beyond said predetermined value, and an expansion valve connected in said parallel circuit between said reservoir and the input side of said first named compressor for enabling said reservoir to pass refrigerant to said first named compressor at a pressure corresponding to the pressure of the refrigerant returning from said first named evaporator.

4. In a cascade refrigeration system; a first closed refrigeration circuit including a compressor, a condenser and an evaporator; a heat exchanger in said system for reducing the temperature of the compressed and condensed refrigerant by heat exchange with refrigerant returning from said evaporator; a second closed refrigeration circuit including a compressor, a condenser and an evaporator; a heat exchanger in said second circuit for reducing the temperature of the compressed and condensed refrigerant by heat exchange with refrigerant returning from said second named evaporator; said first named condenser and said second named evaporator being in heat exchange relationship for subcooling of the compressed refrigerant of said first closed refrigerant circuit; a reservoir circuit including a charging and discharging reservoir therein connected in parallel with said first named compressor for receiving refrigerant when the pressure thereof increases beyond a predetermined value in approaching ambient temperature, a valve connected in said parallel circuit between the output side of said first named compressor and said charging and discharging reservoir and operable to pass refrigerant to said reservoir upon increase in pressure of said refrigerant beyond said predetermined value, and an expansion valve connected in said parallel circuit between said reservoir and the input side of said first named compressor for enabling said reservoir to pass refrigerant to said first named compressor at a pressure corresponding to the pressure of the refrigerant returning from said first named evaporator.

5. In a cascade refrigeration system, a first closed refrigeration circuit, a second closed refrigeration circuit, a subcooler for said first refrigeration circuit including an evaporator connected in said second circuit and a condenser connected in said first circuit in heat exchange relationship with respect to each other, a compressor and an evaporator in said first named refrigeration circuit, an auxiliary condenser connected between said compressor and said first named condenser for precooling the refrigerant from said compressor, a reservoir circuit including a charging and discharging reservoir therein connected in parallel with said first refrigeration circuit for receiving refrigerant when the pressure thereof increases beyond a predetermined value in approaching ambient temperature, a valve connected in said parallel circuit between the output of said compressor and said reservoir and operable to pass refrigerant to said reservoir upon increase in pressure beyond said predetermined value, and an expansion valve connected in said parallel circuit between said reservoir and the input side of said compressor for enabling said reservoir to pass refrigerant to said compressor at the input side thereof at a pressure corresponding to that from said evaporator.

6. In a cascade refrigeration system, a first closed refrigeration circuit, a second closed refrigeration circuit, a subcooler for said first refrigeration circuit including an evaporator connected in said second circuit and a condenser connected in said first circuit in heat exchange relationship with respect to each other, a compressor and an evaporator in said first named refrigeration circuit, a reservoir circuit including a charging and discharging reservoir therein connected in parallel with said first refrigeration circuit for receiving refrigerant when the pressure thereof increases beyond a predetermined

value in approaching ambient temperature, a valve connected in said parallel circuit between the output of said compressor and said reservoir and operable to pass refrigerant to said reservoir upon increase in pressure beyond said predetermined value, and an expansion valve connected in said parallel circuit between said reservoir and the input side of said compressor for enabling said reservoir to pass refrigerant to said compressor at the input side thereof at a pressure corresponding to that from said evaporator.

7. In a cascade refrigeration system, a first closed refrigeration circuit, a second closed refrigeration circuit, a subcooler for said first refrigeration circuit including an evaporator connected in said second circuit and a condenser connected in said first circuit in heat exchange relationship with respect to each other, a compressor and an evaporator in said first refrigeration circuit, an auxiliary condenser connected between said compressor and said first named condenser for precooling the refrigerant from said compressor, and means for receiving refrigerant when the pressure thereof increases beyond a predetermined value in approaching ambient temperature in said first refrigeration circuit comprising a charging and discharging reservoir connected in parallel with said compressor, a valve connected between said reservoir and the output side of said compressor and operable to pass refrigerant to said reservoir upon increase in pressure beyond said predetermined value, an expansion valve connected between said reservoir and the input side of said compressor for enabling said reservoir to pass refrigerant to said compressor at a pressure corresponding to that from said evaporator.

8. In a cascade refrigeration system, a first closed refrigeration circuit, a second closed refrigeration circuit, a subcooler for said first refrigeration circuit including an evaporator connected in said second circuit and a condenser connected in said first circuit in heat exchange relationship with respect to each other, a compressor and an evaporator in said first refrigeration circuit, and means for receiving refrigerant when the pressure thereof increases beyond a predetermined value in approaching ambient temperature in said first refrigeration circuit comprising a charging and discharging reservoir connected in parallel with said compressor, a valve connected between said reservoir and the output side of said compressor and operable to pass refrigerant to said reservoir upon increase in pressure beyond said predetermined value, and valve means connected between said reservoir and the input side of said compressor for enabling said reservoir to pass refrigerant to said compressor at a pressure corresponding to that from said evaporator.

9. In a refrigeration system, a closed refrigeration circuit comprising a compressor, a condenser and an evaporator, means for receiving refrigerant when the pressure thereof increases beyond a predetermined value in approaching ambient temperature in said refrigeration circuit comprising a charging and discharging reservoir connected with the downstream end of said condenser and the input side of said compressor, a valve connected between said reservoir and the downstream end of said condenser and operable to pass refrigerant to said reservoir upon increase in pressure beyond said predetermined value, and valve means connected between said reservoir and the input side of said compressor for enabling said reservoir to pass refrigerant to said compressor at a pressure corresponding to that from said evaporator.

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