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FLASH GAS CONTROL FOR REFRIGERATING SYSTEMS

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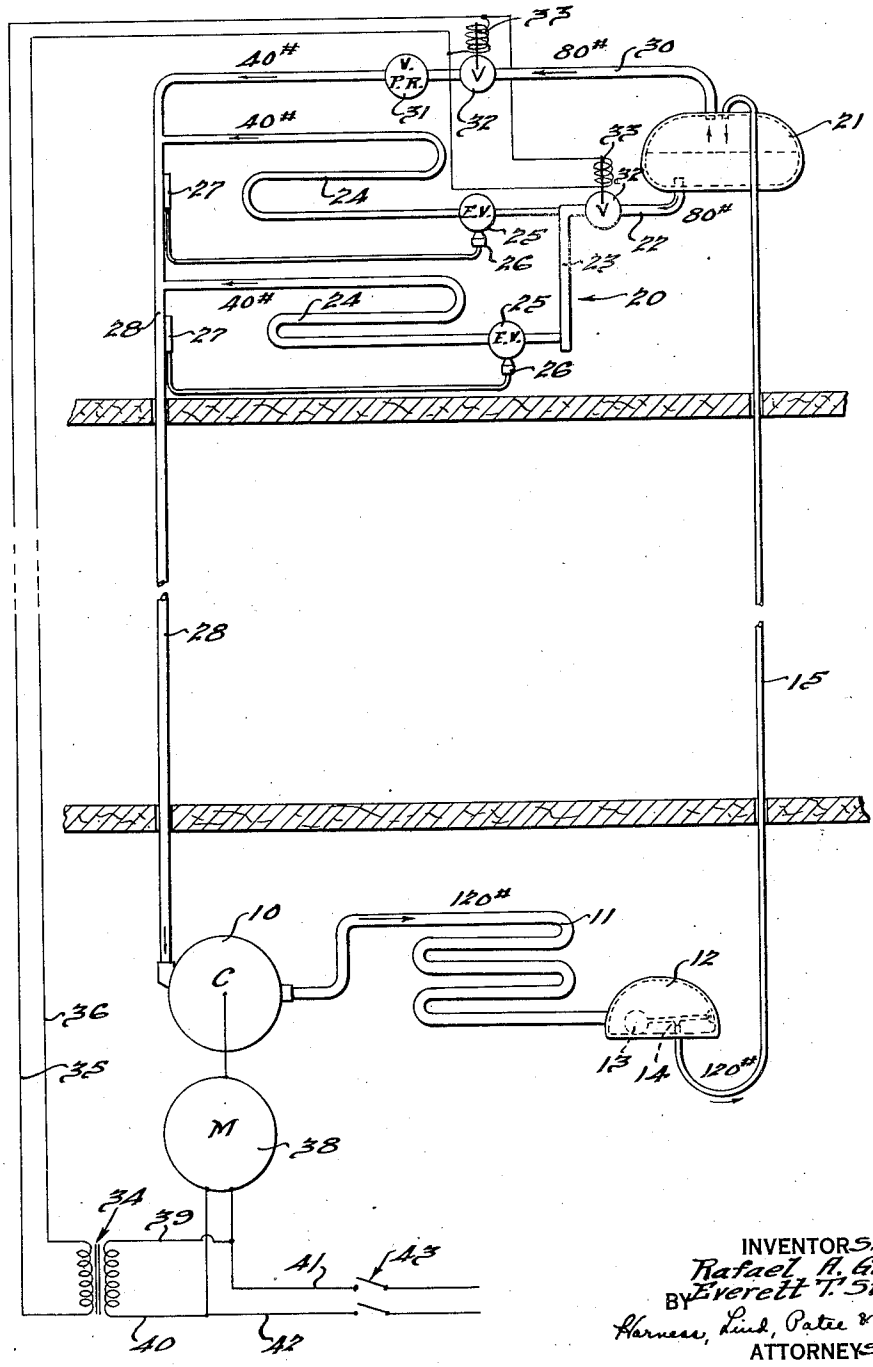

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FLASH GAS CONTROL FOR REFRIGERATING SYSTEMS

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11 Claims. (Cl. 62—115)

Our invention relates to the arts of refrigeration and air conditioning. The particular object of the present invention is to provide a means and method for improving the efficiency of cooling systems of the compressor-condenser-expander type.

It is a principal object of the present invention to eliminate the choking of expanders by flash gas formed in the liquid line leading to the expander. This improvement is of particular utility in applications where the compressor and condenser are to be located remotely from the expander, as in those buildings where the compressor and condenser are to be located in a basement and the expander in a portion of the building several stories above the street level. In such installations it has been common practice to prevent the formation of flash gas by sub-cooling the liquid refrigerant at the condensing unit so that the liquid will not be warmed to the temperature at which flash gas forms in quantities by the time it reaches the expander. As a result of this practice it has been necessary to insulate the liquid line heavily, not only to preserve the sub-cooled temperature of the liquid, but also to prevent the condensation of moisture on the liquid line with the resulting damage to walls, floors, and furnishings of the building. Such sub-cooling apparatus and insulation of heavy character are expensive and troublesome to install. An advantage of our system is that the sub-cooling apparatus and heavy insulation may be eliminated. Another practice has been to operate the system at a high head pressure, which is very expensive due to the increased power consumption and increased flow of condenser cooling water.

In particular, our invention comprises a cooling system of the compressor-condenser-expander type comprising a liquid escape valve at the outlet of the condenser, a closed vessel having sufficient volume to separate the liquid from the gas which may have formed or other gas separating means at the inlet to the expander, with the inlet to the expander so arranged as to receive the liquid separated from the gas, a by-pass for the gas separated from the liquid arranged around the expander with connection to the outlet of the expander, and a pressure reducing device in the gas by-pass for maintaining a high pressure in the gas separator in order that liquid may be expanded into the expander while permitting the escape of gas from the gas separator at the pressure of the suction side of the system.

For example, in one installation where the expander is located approximately 40 ft. above the compressor and condenser, it was found that liquid refrigerant would flash into gas into the liquid line leading up through the floors at such an extent that about 23% by weight would be expanded before the evaporators were reached, resulting in about eleven times the normal volume of combined gas and liquid refrigerant for which the expansion valves and expander were designed. This would reduce the efficiency of the evaporators tremendously since the expansion valves would be passing gas most of the time instead of liquid refrigerant, and it is the absorption of the heat of expansion which does most of the work of cooling. The installation of the present invention reduces the quantity of gas carried with the liquid refrigerant to an absolute minimum and thus permits the expanders to operate at full efficiency and under perfect control.

A further object of our invention is to provide means in the foregoing type of refrigerating system to lock the liquid in the high side of the system when the compressor is not in operation. This portion of our apparatus is of particular utility in installations having the compressor and condenser remotely located from the expander and necessitating a great length of suction pipe of large diameter into which liquid from the condenser or gas separator would be condensed during shut-down periods of the compressor. Condensation in the suction pipe permits slugs of liquid to pass into the compressor which might damage the valves of the compressor. Our invention comprises means for automatically locking the liquid in the high side of the system when the compressor stops and for opening the system to circulation when the compressor starts.

The objects and advantages of our present invention may be more fully understood by reference to the following specification and accompanying drawing wherein the present invention is illustrated in such form as to be readily understood by those skilled in the art.

The cooling system comprises a compressor 10 discharging hot, compressed, gaseous refrigerant into a condenser 11 from which the cooled, liquid refrigerant is passed into a liquid escape device 12 which permits the passage of liquid only. The liquid escape device preferably comprises a float 13 for opening a valve 14 when liquid is present in the escape device 12 in sufficient quantity, but which will prevent back flow

of liquid from the liquid line 15. The back flow may be prevented by the selection of a float 13 and its connected valve-operating lever of sufficient weight and lever effect to close the valve against the weight of liquid in the liquid line 15. The liquid line 15 may extend through several walls or floors of a building to a point in a remote portion of the building where the expander 20 is located and terminates in the top of a gas separator 21 preferably comprising a closed vessel of sufficient volume to maintain a fairly quiescent pool of liquid in the bottom thereof and to permit the collection of flash gas in the top portion thereof. The inlet 22 of the expander extends from the bottom of the gas separator 21 into a header 23 from which the several passes 24 of the expander extend. Liquid is permitted to flow into the expander 20, in order to perform the work of expansion therein, under control of expansion valves 25 regulated by valve motors 26 and superheat bulbs 27 on the suction pipe 28, as is the usual practice in cooling by the use of a volatile refrigerant. The flash gas which is separated in the gas separator 21 passes through a gas by-pass 30 having its inlet extending from the top of the closed vessel, and its outlet communicating with the suction pipe 28 at the outlet of the expander. As the compressor 10 operates it will draw the expanded refrigerant away from the expander at the suction pressure for which the system is designed, and the pressure at the outlet of the gas by-pass must be maintained at that suction pressure while the pressure in the inlet of the gas by-pass must be maintained at the condensing pressure minus the static head and friction loss of the liquid line 15 in order that refrigerant may be expanded in the expander. A pressure reducing valve 31 is placed in the gas by-pass for this purpose.

By way of example, the refrigerant may be compressed at 120 lbs., and will escape from the liquid escape valve at 120 lbs. The liquid receiver or gas separator 21 may be so high in the building that the static head and friction loss will require 40 lbs. pressure, leaving an expander inlet pressure of 80 lbs. If the system is designed to operate at a suction pressure of 40 lbs., the pressure reducing valve 31 will be set to permit the escape of gas at 80 lbs. into a suction pipe maintained at 40 lbs.

In order to maintain the system in immediate readiness for cooling operation and to prevent the condensation of a quantity of liquid at the inlet to the compressor, means are provided for locking the liquid refrigerant in the high pressure side of the system. The escape valve 12 is so arranged as to prevent return of the liquid into the condenser 11 as a part of the locking means. In order to trap the liquid in the gas separator 21, there are preferably provided a plurality of valves 32, one between the gas separator and the expander inlet header 23, and the other between the gas separator and the outlet of the expander 20. These valves are preferably operated by solenoids 33 arranged in parallel with each other and connected to the secondary of a transformer 34 by means of wires 35 and 36. The primary of transformer 34 is arranged in parallel with the compressor-operating motor 38 by means of wires 39 and 40 extending from the motor leads 41 and 42, respectively, on the loaded side of the motor controller 43 which may be operated in any of the numerous manners known to the arts.

The operation of the foregoing system is as follows: When the motor controller 43 is closed, the motor 38 drives the compressor 10 to compress gaseous refrigerant. Simultaneously, valves 32 are opened by solenoids 33. The gaseous refrigerant is cooled and liquefied in the condenser 11, and the liquid is permitted to escape through the escape valve 12 into the gas separator 21. Flash gas which may have formed in the liquid line 15 by-passes the expander through the pressure reducing valve 31, and liquid from the gas separator 21 is permitted to pass into the expander in the usual manner. The gases passing the pressure reducing valve 31 and the portion of the gas formed by the expansion of the liquid in the expander 20 are united and recycled through the system by the action of the compressor 10. When the compressor is stopped by opening the motor controller 43, the valves 32 simultaneously close to trap liquid in the liquid line 15 and gas separator 21.

Having described the preferred form of our invention it should be apparent to those skilled in the art that the same permits of modifications in arrangement and details thereof. All such modifications as come within the scope of the following claims are considered to be a part of our invention.

We claim:

1. A cooling system of the compressor-condenser-expander type, the system including an expansion device between the condenser and expander thereof for dividing the system into a high-pressure side including the condenser and a low-pressure side including the expander, and the system having particular utility in applications where the compressor and condenser are to be located remotely from the expander, comprising a liquid escape valve in the high-pressure side and located at the outlet of the condenser, a liquid receiver in the high-pressure side and located at the inlet to the expansion device with the inlet to the expansion device extending from the bottom of said liquid receiver, a gas by-pass extending from the top of said liquid receiver to the outlet of the expander, and a pressure reducing device in said gas by-pass for maintaining a high pressure in said liquid receiver while permitting gas to escape from said liquid receiver to the low-pressure side of the refrigerating system without going through the expander.

2. A cooling system of the compressor-condenser-expander type and having particular utility in applications where the compressor and condenser are to be located remotely from the expander, comprising a liquid escape valve at the outlet of the condenser, a liquid receiver at the inlet to the expander with the inlet to the expander extending from the bottom of said liquid receiver, a gas by-pass extending from the top of said liquid receiver to the outlet of the expander, a pressure reducing device in said gas by-pass for maintaining a high pressure in said liquid receiver while permitting gas to escape from said liquid receiver to the suction side of the refrigerating system without going through the expander, and valve means automatically closing said gas by-pass upon cessation of operation of the compressor and opening said gas by-pass when the compressor operates.

3. A cooling system of the compressor-condenser-expander type and having particular utility in applications where the compressor and

condenser are to be located remotely from the expander, comprising a liquid escape valve at the outlet of the condenser, a liquid receiver at the inlet to the expander with the inlet to the expander extending from the bottom of said liquid receiver, a gas by-pass extending from the top of said liquid receiver to the outlet of the expander, a pressure reducing device in said gas by-pass for maintaining a high pressure in said liquid receiver while permitting gas to escape from said liquid receiver to the suction side of the refrigerating system without going through the expander, and a plurality of valve means automatically closing said gas by-pass and the inlet to the expander upon cessation of operation of the compressor and opening said gas by-pass and the inlet to the expander when the compressor operates.

4. A cooling system of the compressor-condenser-expander type and having particular utility in applications where the compressor and condenser are to be located remotely from the expander, comprising a liquid escape valve at the outlet of the condenser, a liquid receiver at the inlet to the expander with the inlet to the expander extending from the bottom of said liquid receiver, a gas by-pass extending from the top of said liquid receiver to the outlet of the expander, a pressure reducing device in said gas by-pass for maintaining a high pressure in said liquid reeciver while permitting gas to escape from said liquid receiver to the suction side of the refrigerating system without going through the expander, electrically operated valve means in said gas by-pass movable from fully opened to fully closed position, and a control circuit for said valve means adapted to be energized to open said valve means when the compressor is placed in operation whereby said gas by-pass is open only when refrigerant is being compressed.

5. A cooling system of the compressor-condenser-expander type and having particular utility in applications where the compressor and condenser are to be located remotely from the expander, comprising a liquid escape valve at the outlet of the condenser, a liquid receiver at the inlet to the expander with the inlet to the expander extending from the bottom of said liquid receiver, a gas by-pass extending from the top of said liquid receiver to the outlet of the expander, a pressure reducing device in said gas by-pass for maintaining a high pressure in said liquid receiver while permitting gas to escape from said liquid receiver to the suction side of the refrigerating system without going through the expander, electrically operated valve means in said gas by-pass movable from fully opened to fully closed position, a second electrically operated valve means in the inlet to the expander movable from fully opened to fully closed position, and a control circuit for said valve means adapted to be energized to open both said valve means when the compressor is placed in operation whereby said gas by-pass and inlet are open only when refrigerant is being compressed.

6. A cooling system of the compressor-condenser-expander type, the system including an expansion device between the condenser and expander thereof for dividing the system into a high-pressure side including the condenser and a low-pressure side including the expander, and the system having particular utility in applications where the compressor and condenser are to be located remotely from the expander, comprising a liquid escape valve in the high-pressure side and located at the outlet of the condenser, a liquid line extending from the condenser to a point near the inlet side of the expansion device and in which, due to its length, considerable flash gas may form, a gas separator in the high-pressure side and located at the inlet to the expansion device and into which said liquid line extends, a gas by-pass extending from said gas separator to the outlet of the expander, and a pressure reducing device in said gas by-pass for maintaining a high pressure in said gas separator while permitting gas to escape from said gas separator to the low-pressure side of the refrigerating system without going through the expander.

7. A cooling system of the compressor-condenser-expander type and having particular utility in applications where the compressor and condenser are to be located remotely from the expander, comprising a liquid escape valve at the outlet of the condenser, a liquid line extending from the condenser to a point near the inlet side of the expander and in which, due to its length, considerable flash gas may form, a gas separator at the inlet to the expander and into which said liquid line extends, a gas by-pass extending from said gas separator to the outlet of the expander, a pressure reducing device in said gas by-pass for maintaining a high pressure in said gas separator while permitting gas to escape from said separator to the suction side of the refrigerating system without going through the expander, and valve means automatically closing said gas by-pass upon cessation of operation of the compressor and opening said gas by-pass when the compressor operates.

8. A cooling system of the compressor-condenser-expander type and having particular utility in applications where the compressor and condenser are to be located remotely from the expander, comprising a liquid escape valve at the outlet of the condenser, a liquid line extending from the condenser to a point near the inlet side of the expander and in which, due to its length, considerable flash gas may form, a gas separator at the inlet to the expander and into which said liquid line extends, a gas by-pass extending from said gas separator to the outlet of the expander, a pressure reducing device in said gas by-pass for maintaining a high pressure in said gas separator while permitting gas to escape from said gas separator to the suction side of the refrigerating system without going through the expander, and a plurality of valve means automatically closing said gas by-pass and the inlet to the expander upon cessation of operation of the compressor and opening said gas by-pass and the inlet to the expander when the compressor operates.

9. A cooling system of the compressor-condenser-expander type and having particular utility in applications where the compressor and condenser are to be located remotely from the expander, comprising a liquid escape valve at the outlet of the condenser, a liquid line extending from the condenser to a point near the inlet side of the expander and in which, due to its length, considerable flash gas may form, a gas separator at the inlet to the expander and into which said liquid line extends, a gas by-pass extending from said gas separator to the outlet of the expander, a pressure reducing device in said gas by-pass for maintaining a high pressure in said gas separator while permitting gas to escape

from said gas separator to the suction side of the refrigerating system without going through the expander, electrically operated valve means in said gas by-pass movable from fully opened to fully closed position, and a control circuit for said valve means adapted to be energized to open said valve means when the compressor is placed in operation whereby said gas by-pass is open only when refrigerant is being compressed.

10. A cooling system of the compressor-condenser-expander type and having particular utility in applications where the compressor and condenser are to be located remotely from the expander, comprising a liquid escape valve at the outlet of the condenser, a liquid line extending from the condenser to a point near the inlet side of the expander and in which, due to its length, considerable flash gas may form, a gas separator at the inlet to the expander and into which said liquid line extends, a gas by-pass extending from said gas separator to the outlet of the expander, a pressure reducing device in said gas by-pass for maintaining a high pressure in said gas separator while permitting gas to escape from said gas separator to the suction side of the refrigerating system without going through the expander, electrically operated valve means in said gas by-pass movable from fully opened to fully closed position, a second electrically operated valve means in the inlet to the expander movable from fully opened to fully closed position, and a control circuit for said valve means adapted to be energized to open both said valve means when the compressor is placed in operation whereby said gas by-pass and inlet are open only when refrigerant is being compressed.

11. The method of cooling comprising compressing a volatile refrigerant, condensing the compressed refrigerant at normal high-pressure side condensing pressures, passing the condensed refrigerant at normal high-pressure side pressures to a point near the place where cooling is to be accomplished, separating any flash gas which may have formed from the liquid refrigerant at such point and at normal high-pressure side pressures, expanding the remaining liquid refrigerant to a gaseous condition at normal low-pressure side pressures to do the actual work of cooling, reducing the pressure of the flash gas separated from the liquid refrigerant to that of the expanded refrigerant which has performed the actual work of cooling, commingling the flash gas at its reduced pressure with the expanded work-performing refrigerant, and recycling the mixed refrigerant through the steps recited above.

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CERTIFICATE OF CORRECTION.

Patent No. 2,295,992. September 15, 1942.

RAFAEL A. GONZALEZ, ET AL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, second column, line 4, for the words "into the" read --in the--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 17th day of November, A. D. 1942.

Henry Van Arsdale,
Acting Commissioner of Patents.

(Seal)