

[54] **LOW PRESSURE REFRIGERATION SYSTEM**

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[58] Field of Search .... **62/149, 174, 512**

[56] **References Cited**

**UNITED STATES PATENTS**

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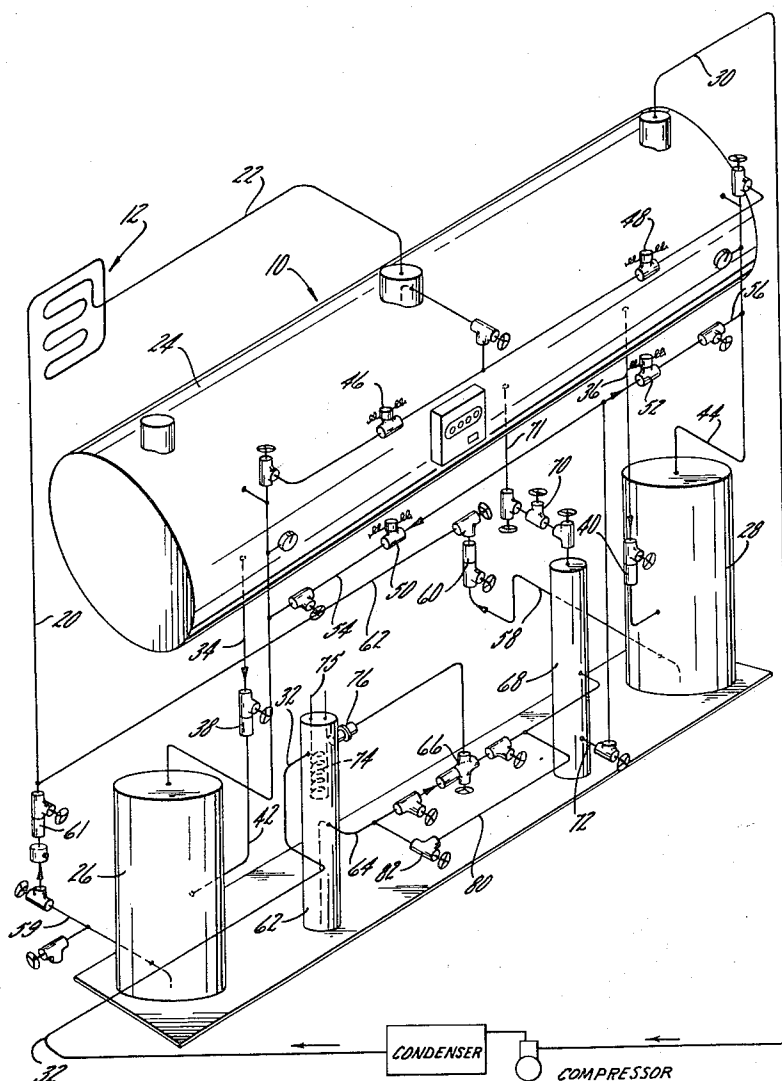
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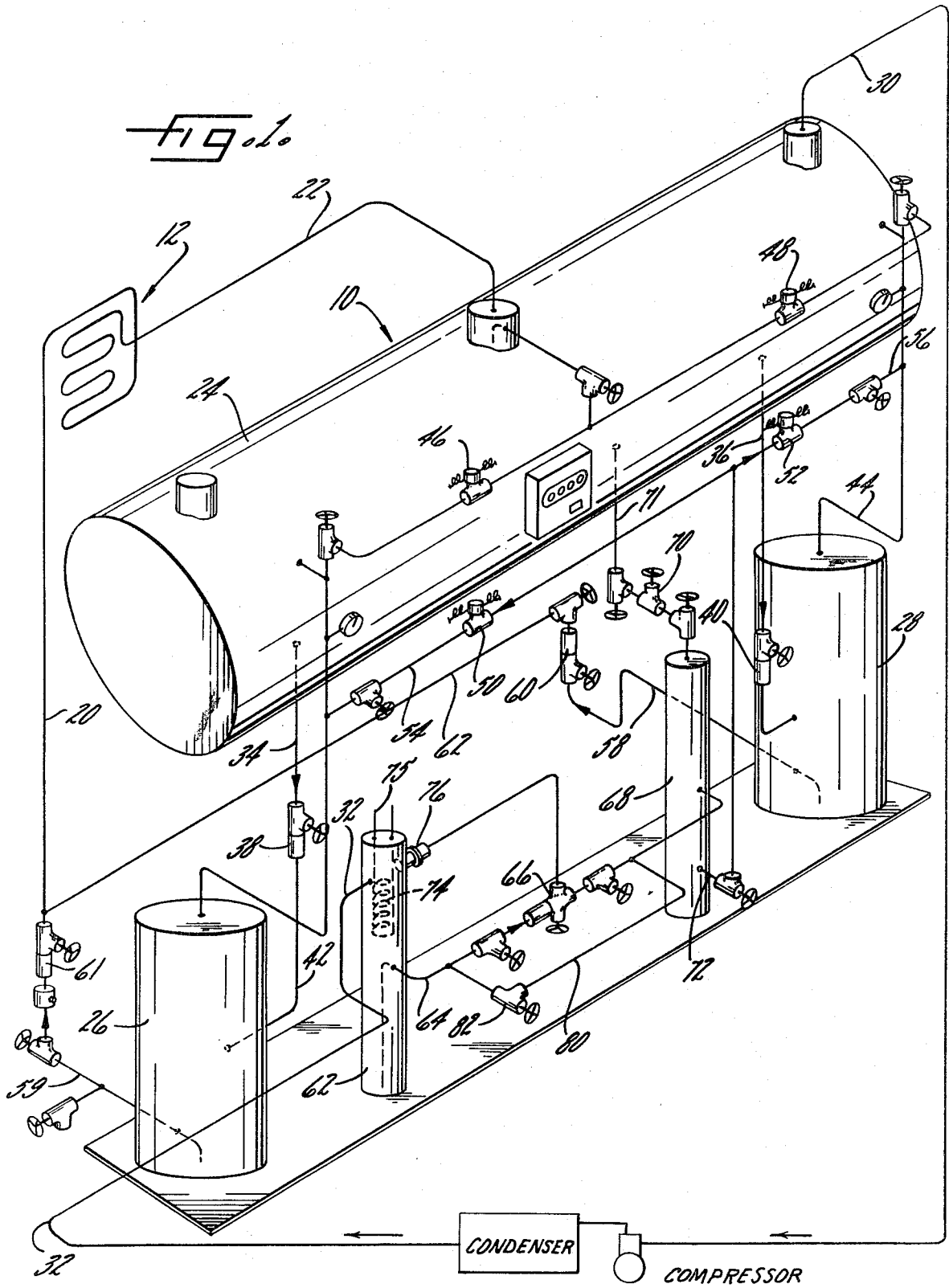
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[57] **ABSTRACT**

A liquid refrigerated recirculation system is disclosed in which overfeed liquid from the evaporators is collected in an accumulator, alternately drained to one or the other of two pumper drums, and recirculated to the evaporators with all make-up liquid which is supplied to the pumper drums and provides the recirculation pressure.

**3 Claims, 1 Drawing Figure**





## LOW PRESSURE REFRIGERATION SYSTEM

The invention relates to refrigeration systems generally, and more particularly to large capacity refrigeration systems suitable for commercial installations such as cold storage rooms, ice skating rinks, and other like refrigeration applications.

This invention is an improvement on gas pumping recirculation systems as disclosed in my prior U.S. Pat. Nos. 2,590,741; 2,931,191 and 2,952,137. The advantages of gas pumping recirculation systems are now well known in the art. Such systems are reliable and require little maintenance over long periods of time since mechanical pumps for circulating liquid refrigerant are dispensed with. Such systems when constructed and operated in accordance with the teachings of my patents provide operating economies because of reduced power consumption since condensing pressures are allowed to rise and fall with the ambient temperature of the cooling medium, while liquid refrigerant is fed under pressure to the evaporators thus taking advantage of lower condensing temperatures and pressures in the cooler periods of the year and "following the weather."

In the low pressure refrigeration system of said U.S. Pat. No. 2,952,137, the feed liquid refrigerant is subcooled and completely freed of flash gas, and with such subcooled liquid being furnished to the evaporator coils, the coils operate at higher efficiency. By providing for the recirculation of an amount of liquid refrigerant which is in excess of the evaporating capacity of the evaporators, at a steady and easily set liquid pressure below the condensing pressure, the system may be operated to allow condensing pressures to rise and fall according to the ambient condensing medium, thus reducing compressor power requirements to a minimum and reducing the cost of operation at the system.

The principal object of this invention is to provide improvements in the refrigeration system of U.S. Pat. No. 2,952,137 which will afford the advantages and features of that system with less costly equipment components, thus providing an improved system at less initial cost.

Another object is to provide a gas pumping recirculating system in which the evaporators are operated in a flooded condition, and wherein the liquid overfeed is recirculated via a pair of alternatively cycled pressurized pumper drums while the liquid from the condenser (corresponding to the refrigerant boiled off primarily in the system evaporators) is fed to the evaporators under a predetermined intermediate feed pressure without first being dropped to suction pressure. A related object is to reduce thermodynamic losses due to gas loss in a recirculating system of the general type of my prior U.S. Pat. No. 2,952,137 which is characterized by a pair of pumper drums for liquid overfeed recirculation, and to reduce other losses by providing a more compact arrangement of pumper drums and associated tanks and liquid lines.

A further object is to provide a system of this general type requiring less refrigerant charge and thus less costly to start-up.

Another object is to provide a system which is capable of furnishing a stream of subcooled liquid refrigerant to the evaporators made up of recirculated liquid combined with a steady stream of primary liquid from the condenser.

Turning now to the drawing, it illustrates a refrigeration system incorporating the invention.

Referring to the drawing, there is diagrammatically illustrated a central unit 10 for supplying liquid refrigerant, such as one of the Freons or Ammonia, to evaporator coils 12. The evaporator coils may be in the floor of an ice skating rink, in a cold storage room, or in other like refrigeration applications. In this system, the evaporators 12 are preferably operated in flooded condition, receiving preferably on the order of twice the liquid refrigerant evaporated in the coils, and the liquid overfeed is recirculated to the evaporators while the refrigerant gas is returned from the evaporators through a suction or return line 22 and carried to the compressors. Typically, the supply and return lines 20, 22 terminate in a plant power room where the central refrigerant unit 10 shown in the drawing is located adjacent the compressors (not shown). In some installations a plurality of central refrigeration units may be located throughout the plant and served by a common set of compressors and condenser but for illustration it may be assumed that the central refrigerant unit illustrated is located in a power room close to the compressors, while the condenser is located outside the plant connected by lines to the compressors and the central refrigeration unit.

As shown in the drawing, the central refrigeration unit 10 comprises an accumulator tank 24 and a pair of pumper drums 26, 28. These are assembled in a compact unit in practice, but are shown in their general physical relationship in the drawing. The accumulator tank 24 is interposed in the suction line 22 and receives liquid refrigerant overfeed from the evaporators 12, while spent refrigerant gas is carried from the accumulator tank to the compressors through the inlet line 30. Pressurized refrigerant gas discharged from the compressors is delivered by way of a hot gas outlet line (not shown) to the condenser (not shown) wherein the refrigerant is cooled and liquified. The liquid refrigerant then passes either to a receiver (not shown) in which the refrigerant is temporarily stored, and then through a connecting line 32 to the central unit, or directly from the condenser to the unit through said line 32 where the accumulator tank is made large enough to function as the plant receiver.

For recirculation of the liquid refrigerant overfeed which collects in the accumulator tank 24, this liquid drains continuously by gravity flow to one or the other of the two pumper drums 26, 28, the accumulator being connected through separate drain lines 34, 36, illustratively, to each of the pumper drums for this purpose. Check valves 38, 40 are interposed in these drain lines 34, 36, permitting flow of liquid from the accumulator to the tank but preventing reverse flow. Both pumper drums 26, 28 are connected to the suction side of the system by vent lines 42, 44 leading from the pumper drums to the accumulator and having vent solenoid valves 46, 48 in these lines. The vent solenoid valves 46, 48 are alternately operable to vent one pumper drum or the other to suction so as to allow filling the pumper drum by gravity with liquid refrigerant from the accumulator tank. Liquid refrigerant will drain from the accumulator to either pumper drum, depending on which vent solenoid valve is open to equalize the pressures in the accumulator and the pumper drum being filled.

Provision is made for introducing pressurized refrigerant into the pumper drums alternately to force the liquid refrigerant in the drums through the supply line to the evaporators and thereby recirculate the liquid refrigerant overfeed. Control means are provided so that the pumper drums are alternately filled and emptied. The control means herein shown includes solenoid operated valves 50, 52 located in branch lines 54, 56, which carry pressurized refrigerant through the lower sections of the vent lines 42, 44 to the pumper drums. The control wiring is such that one vent solenoid valve (46 or 48) and one pressure control solenoid valve (50, 52) are wired in parallel while the other pair of solenoid valves are similarly wired in parallel. The two sets of solenoid valves may be operated by a timer or by liquid level switches located in the pumper drums. The latter type of control system and wiring is illustrated in my prior U.S. Pat. No. 2,952,137 and hence not repeated here. The operation is such that when the vent solenoid valve 46 for pumper drum 26 is open, the pressure solenoid valve 50 therefor is closed allowing liquid to drain into the drum 20 from the accumulator 24 through the drain line 34. During the filling cycle for the pumper drum 26, the pumper drum 28 is on the feed cycle with its associated vent solenoid valve 48 closed and the pressure solenoid valve 52 open bringing over pressurized refrigerant to force the liquid out of the pumper drum 28 through its discharge line 58 and a check valve 60 into a feed line 62 connecting with the supply line 20 for the plant evaporators 12.

According to the present invention, the stream of liquid refrigerant recirculated to the evaporators 12 from the accumulator 24 via the pumper drums 26, 28 is augmented by combining therewith and feeding to the evaporators a stream of primary liquid received from the condenser. As herein shown this is achieved by feeding primary liquid refrigerant from the condenser and combining the primary liquid in the pumper drum 26, 28 during each pumping cycle of the drum with the liquid refrigerant therein. In carrying out the invention in its preferred form, make-up liquid refrigerant supplied from the condenser at a rate substantially equivalent to the actual evaporator load is fed to the evaporators at a controlled intermediate pressure, which is greater than suction pressure by an amount sufficient to overcome the liquid line losses and provide an adequate feed rate for the evaporators, and is less than condensing pressure. The refrigerant overfeed is recirculated via the pumper drums and pumped at the same intermediate pressure.

In the system disclosed in my prior patent 2,952,137, the primary liquid refrigerant from the condenser (or separate receiver if there is one) is carried through a liquid feed line to the accumulator, the liquid line having an orifice to flash down the liquid to suction pressure and thereby provide liquid in the accumulator at suction pressure. The primary liquid and the liquid overfeed from the evaporators is combined in the accumulator, and then drained alternately to one or the other of a pair of pumper drums which are pressurized alternately from the high side of the system to provide pumping pressure to force the liquid refrigerant alternately from the pumper drums through the supply lines to evaporators. According to the present invention, primary liquid refrigerant from the condenser (or receiver if there is one) is fed not to the accumulator but preferably to the pumper drums alternately at a reduced pres-

sure (compared to condenser pressure) providing the pressurization for the pumper drums.

The present invention provides an initial equipment cost savings because with smaller and less costly pumper drums and associated drain connections and valves, the system affords substantially the same operating advantages provided by the system of my prior art U.S. Pat. No. 2,952,137. Furthermore, thermodynamic losses are less with the present system since the primary liquid from the condenser is flashed down to an intermediate pressure greater than suction pressure resulting in less gas loss.

For augmenting during each pumping cycle the liquid feed from a pumper (26 or 28) drum with direct liquid feed from the condenser, which simultaneously supplies the pumping pressure for feeding the collected liquid from the pumper drum, the liquid line 32 from the condenser (or receiver if there is one) is connected to dump the liquid into an oil still 62, and a line 64 carries the primary liquid from the oil still 62 through a valve 66 into a separator tank 68. From the top of the separator tank 68 a connection is made through a regulator valve 70 to the suction side of the system by a connection 71 to the accumulator tank 24. In the separator tank 68, the flash gas resulting from the pressure drop at the orifice of the valve 66 is released in part through the regulator valve 70 into the accumulator tank 24 which is maintained at suction pressure. By means of the regulator valve 70 a predetermined pressure is maintained in the separator tank 68 which is the feed pressure for the system. This predetermined pressure may be either a fixed pressure, if the regulator valve 70 is of the conventional spring biased type to hold a fixed back pressure, or a predetermined differential pressure above suction pressure if the regulator valve 70 is a conventional differential pressure valve with a connection to sense suction pressure. The pressure in the separator tank is determined by the pressure regulator valve 70 and this pressure is the liquid pumping pressure for the system, since the liquid (or mixed phase fluid) in the separator tank is carried from the separator tank 68 through a discharge line 72 to one of the pumper drums 26 or 28 via one of the branch lines (54 or 56) and one of the vent lines (42 or 44) depending on which pressure solenoid valve (50 or 52) is open. By adjustment of the regulator valve 70, the system affords wide regulation of pumping pressure and thus liquid supply pressure to the house evaporator over the range between suction and compressor discharge pressure. In this improved system, the pressurizing of the pumper drums alternately is achieved by supplying a primary stream of pressurized refrigerant from the condenser which has been reduced to an intermediate pumping pressure by means of the pressure reduction across the orifice of the valve 66 and the control afforded by the pressure regulating valve 70, and this primary stream of pressurized refrigerant from the condenser is used to augment the recirculation of liquid overfeed collected in the pumper drums.

A further feature of this arrangement is the provision for oil separation from the liquid refrigerant, particularly important in the case where the freons are used as the refrigerant. For oil separation, interposed in the line 32 from the condenser is the oil still 62 to which the warm primary liquid from the condenser is supplied. The liquid from the condenser drains into the oil still 62 and discharges from the bottom of the oil still

through the discharge line 72. Within the oil still is a coil 74 (shown in dashed lines) draining oil to an oil receiver (not shown) and supplied with oil rich liquid refrigerant from the pumper drums and the accumulator through an oil line 75. The warm liquid refrigerant from the condenser as it passes over the coil in the oil still, vaporizes the refrigerant in the coil which is then released to the suction side of the system. The distilled oil is drained to the oil receiver and recirculated to the crankcases of the compressors.

A liquid level sensing device 76 in the wall of the oil still 62 senses the presence of liquid refrigerant received therein through the line 32 from the condenser, and controls the operation of the valve 66 so as to close down that valve when the device 76 senses a lowering of the liquid in the still. A bypass 80 around the valve 66 may be provided with a valve 82 to control flow through the bypass.

The pressurized refrigerant after expansion through the valve 66 and at the reduced pressure predetermined by the setting of the pressure control valve 70 is then carried alternately to the pumper drums 26 or 28 and is a stream of primary make-up pressurized refrigerant. That stream is combined in the pumper drums with the recirculated liquid refrigerant collected therein and discharged on the feed cycle through either the discharge line 58 for the pumper drum 28 or the discharge line 59 and check valve 61 for the pumper drum 26 to the feed line 20. It will thus be seen that the pumper drums, accumulator and associated lines and controls forms a recirculating system for liquid refrigerant overfeed passing through the evaporator, while all make-up pressurized refrigerant is supplied from the compressor and condenser, and combined with the liquid refrigerant recirculated via the recirculation system and fed to the evaporator.

I claim as my invention:

1. In a refrigeration system having an evaporator and operative to overfeed the evaporator with liquid refrigerant in excess of that evaporated, a compressor, a suction line connecting the return side of said evaporator with the suction inlet of said compressor, an accumulator tank interposed in said suction line operative to collect liquid refrigerant overfeed passing through the evaporator while permitting gaseous refrigerant to return to the compressor, a condenser connected to the outlet of said compressor operative to cool and liquify compressed refrigerant gas received from the compressor, and a system connected to the accumulator and the evaporator for recirculating the liquid refrigerant overfeed collected in the accumulator including a pair of pumper drums connected to said accumulator tank for alternately receiving liquid refrigerant therefrom by gravity, and means supplied from the outlet of the compressor for alternately pressurizing said pumper drums

for pumping the liquid refrigerant therein to the evaporator, the improvement comprising:

means including a pressure reducing connection and a pressure control valve connected to receive and operative to reduce the pressure of all of said refrigerant from the condenser to a predetermined pressure to provide a stream of primary make-up pressurized refrigerant, and further including means for carrying all of said stream of primary make-up pressurized refrigerant to said pumper drums, combining said stream with overfeed liquid refrigerant in said pumper drums and utilizing said stream for alternately pressurizing said pumper drums for feeding refrigerant to said evaporator.

2. In a refrigeration system, the improvement according to claim 1 wherein said means for carrying the stream of primary make-up pressurized refrigerant includes connections for feeding primary pressurized refrigerant alternately to said pumper drums and said stream of primary pressurized refrigerant simultaneously pressurizes said pumper drums and is combined with the overfeed liquid refrigerant collected therein.

3. In a refrigeration system having an evaporator and operative to overfeed the evaporator with liquid refrigerant in excess of that evaporated, a compressor, a suction line connecting the discharge side of said evaporator with the suction inlet of said compressor, and a condenser connected to the outlet of said compressor operative to cool and liquify compressed refrigerant gas received from the compressor, the combination comprising:

a recirculating system connected to the evaporator for recirculating the liquid refrigerant overfeed passing through the evaporator including an accumulator tank interposed in said suction line operative to collect liquid refrigerant overfeed passing through the evaporator while permitting gaseous refrigerant to return to the compressor, a pair of pumper drums connected to said accumulator tank for alternately receiving liquid refrigerant therefrom by gravity,

means including a pressure reducing connection and a pressure control valve connected to receive and operative to reduce the pressure of all make-up liquid refrigerant from the condenser to a predetermined pressure to provide a stream of primary make-up pressurized refrigerant; and

means for carrying all of said stream of primary make-up pressurized refrigerant to said pumper drums and alternately pressurizing said drums with said stream for pumping the liquid refrigerant therein to the evaporators.

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