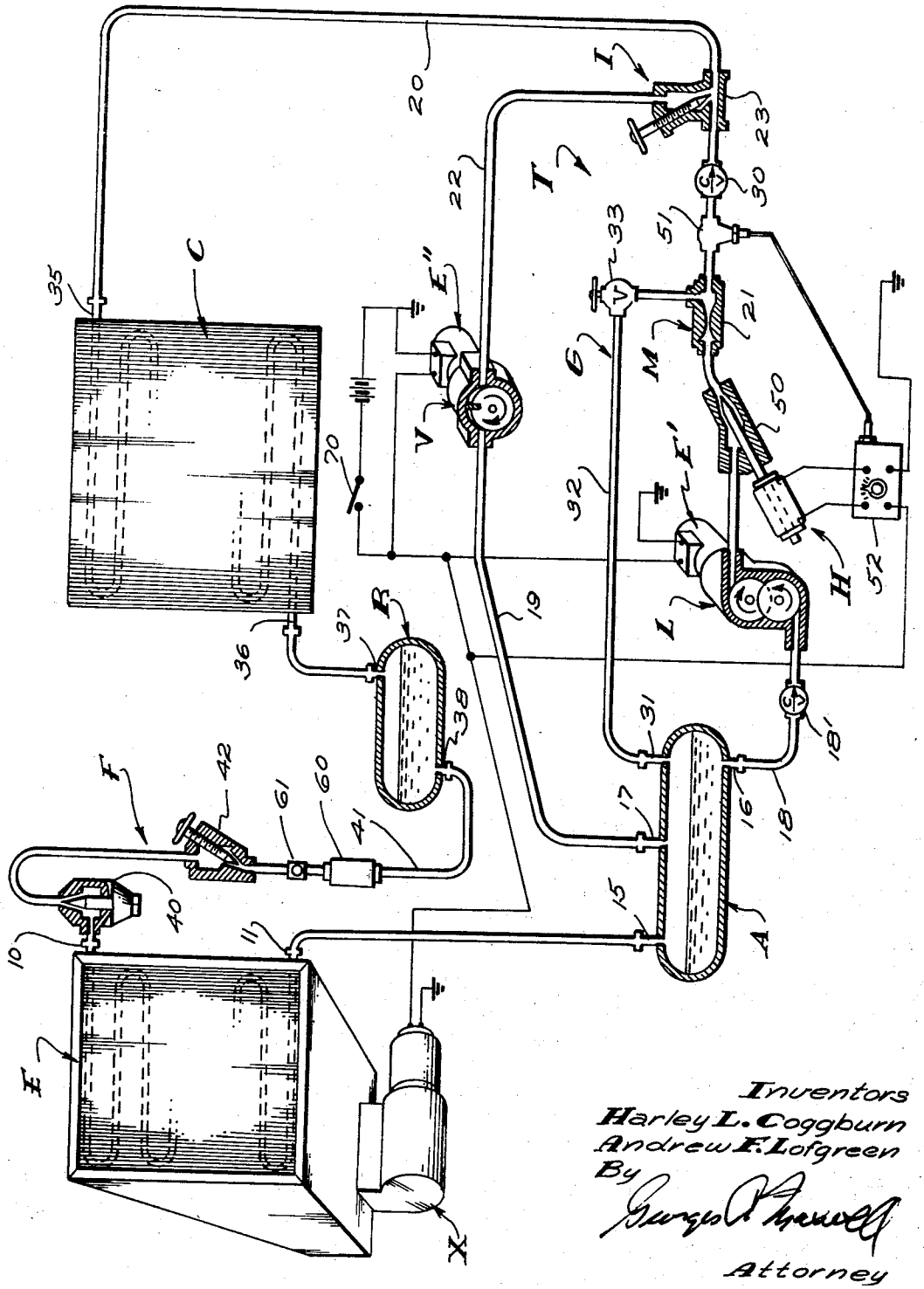
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REFRIGERATION SYSTEM WITH LIQUID AND VAPOR PUMPS

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REFRIGERATION SYSTEM WITH LIQUID AND VAPOR PUMPS

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ABSTRACT OF THE DISCLOSURE

A refrigeration system including, an elongate evaporator with inlet and outlet ends, an elongate low pressure condenser with inlet and outlet ends and means connecting the inlet end of said condenser with the outlet end of the evaporator, a liquid vapor phase separator connected with the outlet end of the low pressure condenser, a positive displacement heat pump connected with and draining liquid from the separator, an elongate high pressure condenser with inlet and outlet ends, a delivery line from the heat pump to the inlet end of the high pressure condenser, an electro magnetically controlled metering valve in the delivery line, a venturi in the delivery line downstream of the metering valve to accelerate the rate of flow of refrigerant therethrough, a temperature sensing bulb in the line downstream of the venturi connected with the metering valve, a vapor pump connected with and extracting vapor from the separator and connected with the delivery line downstream of the venturi and injecting vapor into said line, a receiver connected with the outlet end of the high pressure condenser and flow control and expansion means between the receiver and the inlet end of the evaporator to control the rate of flow of high pressure liquid refrigerant from the receiver and into the evaporator.

This invention relates to a novel, improved refrigerating system and is more particularly concerned with a system wherein the refrigerant is pumped when in a liquid state, to effect the necessary flow of refrigerant and to that extent is distinguishable from conventional systems employing absorption or compression principles.

In general, thermally operated or absorption type refrigeration systems have been less than moderately successful because of an inherently relatively low coefficient of performance. A major shortcoming of absorption type systems resides in the large quantities of rejected heat and the requirements of bulky accessory equipment, such as condensers, cooling towers and the like.

Further, absorption type refrigeration systems are normally such that they must be carefully and accurately installed and set, to the end that they are, in addition to being inefficient, unsuitable for use in automobiles or other like installations where minimal space is available and/or where the systems are subject to being moved about and their position varied.

In general, compression type refrigeration systems are more versatile than absorption type systems and are such that they can be made small and compact and are unaffected by movement or change in position. Accordingly, this type of system is suitable for and finds wide use in automotive air conditioning systems or units. The principal shortcoming in compression type systems resides in the fact that large, heavy and inefficient compressors capable of handling large volumes of gaseous refrigerants, must be provided.

To illustrate the efficiency of the ordinary compression type refrigeration system, the ordinary automotive air conditioning unit includes a compressor driven by the automobile engine, which compressor draws from ten to

fifteen horsepower of work energy from the engine to effect operation of the system.

It is well known and recognized that liquids can be efficiently moved by pumps, while moving gases by means of pumps or compressors, is, by comparison, very inefficient.

A refrigerant, such as Freon #12, when in a liquid state, is aout $\frac{1}{277}$ the volume of a like mass of that refrigerant when in a gaseous state; accordingly, it will be apparent that a given mass of liquid Freon #12 can be pumped and moved much more efficiently and with the expenditure of a small fraction of the power that would be required to move a like mass of gaseous Freon #12.

In an ordinary compression type refrigeration system, the work energy employed to effect its operation is introduced into the refrigerant when it is in a gaseous state by means of a mechanical compressor, with the result that the refrigerant is being worked upon when it is in that state where it is least capable of absorbing the desired work energy.

An object of our invention is to provide a refrigeration system wherein the refrigerant is worked upon and work energy is imparted into, when in a liquid state and by means of a pump.

It is an object of our invention to provide a refrigeration system which includes a fractional horsepower liquid moving and heat generating pump and a fractional horsepower vapor pump, the aggregate power of the pumps being less than one horsepower and the output of the system being equal to the output of compression type systems requiring from ten to fifteen horsepower to operate.

It is another object of our invention to provide a liquid vapor phase separator type accumulator at the discharge end of an evaporator, a positive displacement liquid moving and heat generating pump to draw liquid refrigerant from said accumulator and a vapor pump to draw gaseous refrigerant and refrigerant vapor from said accumulator whereby the volume of refrigerant contained in said accumulator is maintained sufficiently low to receive the flow of refrigerant from the evaporator at all times.

It is yet another object of our invention to provide a system of the character referred to wherein the liquid moving and heat generating pump moves and discharges liquid refrigerant from the low pressure to the high pressure side of the system. Accordingly, it is an object of this invention to provide a system wherein the movement of liquid refrigerant is employed to move and circulate gaseous refrigerant through the system.

Another object of the present invention is to provide a system of the character referred to wherein gaseous or vaporous refrigerant discharged by the vapor pump is combined with the refrigerant issuing from the liquid pump, whereby the gaseous and vaporous refrigerant, being at a higher temperature and resulting higher pressure, induces vaporization and expansion of the liquid refrigerant and resulting increased velocity or rate of flow of the pumped refrigerant flowing through the high pressure side of the system.

Yet another object of our invention is to provide a system of the character referred to including a venturi at the discharge side of the liquid pump, upstream of the connection with the discharge of the vapor pump, which venturi maintains sufficient head pressure at the discharge side of the liquid pump to maintain the refrigerant in a liquid state and which creates a pressure drop at its downstream side whereby the liquid refrigerant expands sufficiently to accelerate its rate of flow and cools sufficiently to create a temperature and resulting pressure drop so that the necessary pressure differential between the discharge of the vacuum pump

ınd the line pressure is sufficient to assure injection of he discharge of the vacuum pump into the line.

It is a further object and feature of our invention to ɔrovide a metering means between the liquid pump and he venturi to regulate the rate of flow of refrigerant nto and through the venturi and to provide means, re- ıponsive to the temperature of the refrigerant down- ıtream of the venturi and operating the metering means.

Still further, it is an object and feature of the present nvention to provide a liquid pump which is a positive lisplacement, heat generating pump and serves to heat he liquid refrigerant whereby it is readily vaporized ınd transformed to a gaseous state when flowing through he venturi and mixing with the discharge of the vapor ɔump and whereby the gaseous refrigerant entering the ıigh pressure condenser is at a high temperature.

It is to be noted that the pumps and the several means lirectly related to them, at the high pressure side of the ɜystem, do not perform the full corresponding function ɔf compressors in true compression type systems, but ɜerve, primarily, to establish and maintain a high pres- ɜure, high velocity flow of refrigerant at the downstream ɜnd of the high pressure side of the system, which high pressure, high velocity flow creates the necessary and desired operating pressure and temperature differential below the high and low pressure sides of the system.

The foregoing and other objects and features of our invention will be fully understood from the following detailed description of a typical preferred form and application of our invention, throughout which description reference is made to the accompanying diagrammatic drawing of our system.

The system that we provide includes a plurality of interconnected and related refrigerant handling and conducting components, parts and means, and defines a circuit having high and low pressure sides.

The high pressure side of the circuit includes, generally, refrigerant transporting means T, a condenser C, a receiver R, and flow control means F.

The lower pressure side of the circuit includes an evaporator E and an accumulator A.

The evaporator E is shown as a direct expansion type evaporator coil having an inlet end **10** connected with the flow control means F of the high pressure side of the system and into which liquid refrigerant is introduced. The refrigerant introduced into the evaporator E flows therethrough, expands partially or totally into vapor and/or gas, absorbing heat from the ambient atmosphere. The evaporator E has an outlet or discharge end **11** which is connected with the low pressure condenser K, or directly with the accumulator A.

The accumulator A is a liquid vapor phase type accumulator and consists of a closed tank or vessel **14** with an inlet opening or fitting **15** with which the outlet **11** of the evaporator is connected, a liquid outlet opening or fitting **16** at its lowermost or bottom side and a vapor-gas opening or fitting **17** at its uppermost or top side. The accumulator A is adapted to receive the refrigerant discharged from the evaporator.

The refrigerant transporting means T of the high pressure side of the system is intended to perform the function of a compressor in a compression type refrigeration system or a generator (boiler) in a heat absorption refrigeration system and to that extent may be considered as a transporting means. The means T may also and properly be defined as a flow augmenting means, the function to which is to accelerate the flow of refrigerant in the high pressure side of the system to effect an operative pressure differential between the high and low pressure sides of the system.

The means T includes a liquid moving and heat generating pump L, a vapor pump V, flow accelerating means M related to the pump L and vapor injection means I.

The pump L is preferably a two-stage type positive displacement pump, such as a positive displacement pump

provided with a restricted outlet or a flow bean at its outlet to create a back pressure which increases the internal pressures in the pump and so that a predetermined portion of the work energy imparted into the pump is transformed into heat energy and heat the refrigerant being worked upon by the pump.

The gas or vapor pump V can be of any type or design of pump suitable for moving gases and vapors, such as a vane type or diaphram type of pump. The pump V can be driven by any suitable prime mover, and, in practice, is driven by an electric motor E'.

The inlet side of the pump L is connected with the liquid outlet fitting **16** of the accumulator A by a suction line **18** and the inlet side of the pump V is connected with the gas outlet fitting **17** of the accumulator of a suction line **19**.

The suction line **18** is shown provided with a check valve **18'** to prevent a reverse flow or surge of refrigerant in the line **18** and from the pump L into the accumulator A.

Connected with the discharge side of the liquid pump L and extending to and connected with the condenser C is a delivery line **20**.

The flow accelerating means M is engaged in the line **20** and is adapted to accelerate the rate of flow of refrigerant in the line and issuing from the pump L.

The means M is shown as a simple venturi **21** arranged in the line **20**.

The function of the means M or venturi is to accelerate the rate of flow of liquid refrigerant in the line **20** and at the same time create a presure drop at or adjacent the discharge end of the venturi which causes a portion of the accelerated liquid to vaporize whereby the accelerated rate of flow does not diminish or diminish rapidly or noticeably downstream of the venturi.

It is to be noted that the means M or venturi **21** creates a back pressure or head in the line **20** between the pump L and the venturi, which head inhibits premature vaporization of the refrigerant in the line between the pump and the venturi.

Further, the noted limited expansion of the accelerated refrigerant downstream of the venturi effectively cools the refrigerant and lowers its corresponding pressure.

The vapor injecting means I can include a lateral tap-fitting, such as a T-fitting, in the line **20** downstream of the means M and conected with a vapor line **22** extending from and connected with the discharge side of the vapor pump V, or can, as ilustrated, be an adjustable metering valve **23** with a straight through primary passage aligned and communicating with the line **20**, a lateral passage connected with the line **22**, a lateral port communicating with the two passages, and a valve member shiftably arranged in the port.

The temperature and resulting or corresponding pressure of the vapor delivered by the pump V and flowing through the vapor line **22** is greater than the temperature and pressure of the refrigerant in the line **20** downstream of the venturi **21**. Accordingly, the vapor is injected into the accelerated and rapidly moving flow of refrigerant in the line **20**. The injected vapor adds to or increases the volume of refrigerant flowing through the line **20** and increases the temperature, pressure and velocity of the refrigerant, inducing further vaporization of liquid refrigerant. This results in further acceleration of the refrigerant in the line **20**.

The foregoing explanation of the function and effect of the means M and I has been determined by observation of the system when in operation and while believed to be substantially correct, may be inaccurate in certain respects.

If desired, a check valve **30** can be engaged in the line **20** upstream of the means I to prevent the possibility of high pressure vapors in the line flowing back into the venturi.

In the case illustrated, the system is shown provided with a scavenging means G, which means includes a

secondary gas-vapor outlet **31** in the accumulator A, and a vacuum line **32** extending between and connected with the outlet **31** and the low pressure side of the venturi **21** of the means **23**.

The means G supplements the operation or function of the vapor pump V and injecting means I and can greatly reduce the work load of the pump V or reduce the size and power requirements for the pump V.

In practice, a valve **33** can be arranged in the line **32** to put the means G into and out of operation as circumstances require or as desired.

The condenser C is a conventional coil type heat exchanger and has inlet and outlet fittings or openings **35** and **36** at the opposite ends of the coil. The line **20** connects with the inlet fitting **35**.

The receiver R is a simple tank or vessel to receive and collect liquid refrigerant flowing from the condenser and has an inlet opening **37** suitably connected with the outlet end **36** of the condenser and an outlet opening **38**.

The rare, heated refrigerant, at high pressure flowing through the line **20** into the condenser, is rapidly cooled and is condensed therein and is discharged therefrom and conducted into the receiver R in a liquid state at a low temperature and at high pressure.

The flow control means F is that means provided to conduct the cool, high pressure liquid refrigerant collected by the receiver R to the evaporator E. The means F can vary widely in form without departing from the spirit of this invention.

In the case illustrated, the means F includes an expansion valve **40** connected with the inlet end **10** of the evaporator E and a liquid line **41** extending from the expansion valve **40** to the outlet **38** of the receiver R. The opening **38** in the receiver R is at the bottom thereof and below the liquid level therein.

In addition to the foregoing, the means F is shown as including a flow control or flow metering device, such as a flow bean or, as illustrated, a metering valve **42** in the line **41** to limit and/or control the volume of refrigerant flowing from the receiver R through the line **41** and into, through and thence from the expansion valve **40** and into the evaporator E.

In practice, the expansion valve **40**, line **41** and valve **42** could be replaced with a capillary tube without departing from the spirit of this invention, since such a substitution would constitute the use of a well-known mechanical equivalent.

The refrigerant issuing from the expansion valve **40** flows into and through the low pressure side of our system to complete the refrigeration cycle.

In practice, and in a system as provided by this invention, for use in an automobile air conditioning unit and using Freon #12 as the refrigerant, the electric motors operating the pumps L and V are one-half and one-quarter horsepower motors. The operating pressure at the lower pressure side of the system is 25 p.s.i. and the high pressure side is 125 p.s.i., creating an operating pressure differential of 100 p.s.i.

In addition to the foregoing, we provide means H to control the volume of refrigerant flowing into and through the venturi **21**. The means H includes an electro-magnetically actuated metering or demand valve **50** in the line **20** between the pump L and venturi **21**, a temperature bulb **51** in the line **20** between the venturi **21** and valve **23** of the means I, and an amplifier **51** operatively connecting the bulb **51** and the valve **50**.

In the event the temperature in the high pressure side of the system increases or drops excessively, the metering or demand valve **50** opens or closes upon demand of the system, downstream of the venturi **21**, and as sensed by the bulb **51**.

It will be apparent that with the means H set forth above, the operating temperature of the system can be advantageously set and maintained uniform.

In addition to metering and controlling the rate of flow of refrigerant into and through the venturi, the valve **50** also creates a flow restriction and back pressure on the pump L and causes the pump to churn and heat the refrigerant and enhance the heating action of the pump. Accordingly, in practice, the valve **50** can serve in place of a flow bean or restricted outlet in the pump L to make it a heat generating pump and in which case the pump L is a simple, unaltered positive displacement pump.

It has been found that the heat generating capacity of the pump L is essential in starting or putting the system into operation and becomes less critical once the system is in operation, though slight heating of the refrigerant at all times appears to be necessary or desirable.

In operation, the pump L increases the temperature of the refrigerant about sixty-five degrees.

In accordance with common practice, the system can be provided with a drier **60** and sight glass **61**. In the case illustrated, the drier and sight glass are arranged in the liner **41**.

In practice, the system can be provided with any suitable control means. In the case illustrated, the system is under control of a master switch **70**, which switch controls the flow of current to the motors E and E', to the amplifier **52** and to the motor of a blower X related to the evaporator.

Since the details of the control means can vary widely without departing from or affecting the spirit of this invention, we will not burden this disclosure with further details of the control means shown or of other alternative and more complicated control means that have proven satisfactory.

Having described only a typical preferred form and application of our invention, we do not wish to be limited or restricted to the specific details herein set forth, but wish to reserve to ourselves any modifications and/or variations that may appear to those skilled in the art.

Having described our invention, we claim:

1. A refrigeration system including an evaporator, a liquid vapor phase separator receiving refrigerant from the evaporator, refrigerant transporting means to remove refrigerant from the liquid vapor phase separator and to discharge it at increased pressure, a condenser to condense the refrigerant discharged by the transporting means, a receiver collecting condensed refrigerant from the condenser and flow control and expansion means between the receiver and the evaporator to control the rate of flow of liquid refrigerant from the receiver and into the evaporator, said liquid vapor phase separator including a tank having an inlet connected with the evaporator, a liquid outlet opening and a vapor outlet opening, said refrigerant transporting means including a heat generating liquid pump connected with the liquid outlet opening, and a delivery line extending from the liquid pump to the condenser, a vapor pump connected with the vapor outlet opening, a vapor line extending from the vapor pump and vapor injecting means in the delivery line and connected with the vapor line and introducing vapor from the vapor pump into the delivery line.

2. A system as set forth in claim **1** and further including means in the delivery line between the liquid moving and heat generating pump and the injecting means to increase the rate of flow of liquid refrigerant delivered by the liquid moving pump and create a pressure drop in the delivery line downstream from said liquid pump.

3. A system as set forth in claim **1**, said system further including means in the delivery line between the liquid pump and the vapor injecting means to increase the rate of flow of liquid refrigerant delivered by the liquid pump and create a pressure drop in the delivery line downstream from said liquid pump, said means including a venturi in the flow line.

4. A system as set forth in claim **1** further including means in the delivery line between the liquid pump and the vapor injecting means to increase the rate of flow of liquid refrigerant delivered by the liquid pump and

reate a pressure drop in the delivery line downstream rom said liquid pump, said means including a venturi in he flow line, and a metering valve in said flow line ıpstream of the venturi and controlling the volume of efrigerant flowing through the venturi.

5. A system as set forth in claim 1 further including neans in the delivery line between the liquid pump and he vapor injecting means to increase the rate of flow of iquid refrigerant delivered by the liquid pump and create ı pressure drop in the delivery line downstream from aid liquid pump, said means including a venturi in the low line, and a metering valve in said flow line upstream ›f the venturi and controlling the volume of refrigerant lowing through the venturi, said metering valve having

electro-magnetic operating means and temperature sensitive control means connected with said operating means and responsive to the temperature of refrigerant in the delivery line downstream of the venturi.

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