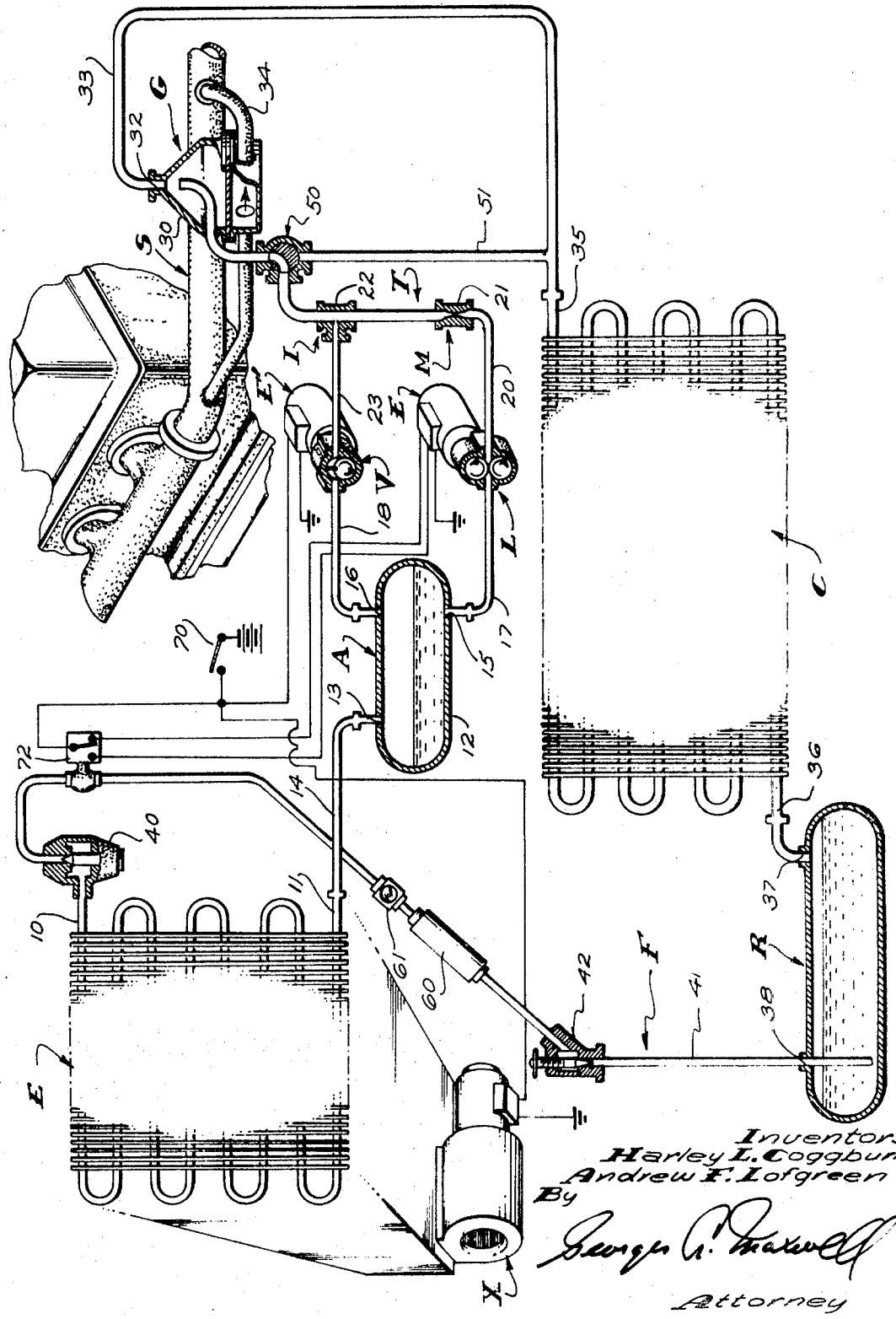
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REFRIGERATION SYSTEM

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REFRIGERATION SYSTEM

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ABSTRACT OF THE DISCLOSURE

A refrigeration system including, an elongate evaporator with inlet and outlet ends, a liquid vapor phase separator connected with the evaporator, a liquid pump connected with and draining liquid from the separator, a delivery line from the liquid pump to a generator, a venturi in the delivery line to accelerate the rate of flow of refrigerant therethrough, 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, an elongate condenser with inlet and outlet ends, a flow line from the generator to the inlet end of the condenser, a receiver connected with the outlet end of the 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.

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, compression 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 where the system is subject to being moved about and its 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 a large, heavy and inefficient compressor must be provided.

In the case of the ordinary automotive air conditioning unit, utilizing the compression system, a compressor is driven by the automobile engine. Such compressors normally require from ten to fifteen horsepower, from the engine, to effect operation of the refrigeration system.

It is an object of our invention to provide a refrigeration system of the character referred to suitable for use in automotive air conditioning units and the like, which utilizes heat from the automobile engine exhaust system to operate a heat absorption phase of the system and which includes a fractional horsepower liquid pump and a fractional horsepower vapor pump to operate a compressor phase of the system, 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.

It is an object of our invention to provide a system of the character referred to including a boiler or generator related to the exhaust system of an internal combustion

engine which serves to increase the temperature and thus the pressure of the refrigerant (Freon #12) and to assist in maintaining the refrigerant in motion.

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 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 pump moves and discharges liquid refrigerant from the low pressure to the high pressure side of the system and through the generator. Accordingly, it is an object of this invention to provide a system wherein the movement of liquid refrigerant is employed to move and ciruulate 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 discharged by the liquid pump, downstream of the generator, 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 into and through the generator.

Yet another object of our invention is to provide a system of the character referred to including a flow metering means at the discharge side of the liquid pump and downstream of the connection with the discharge of the vapor pump which means 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 expends 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 and the line pressure is sufficient to assure injection of the discharge of the vacuum pump into the line.

It is to be noted that the pumps and the generator of our invention do not perform the full corresponding functions of pumps and generators in true compression and absorption type systems, but serve, primarily, to establish and maintain a high pressure, high velocity flow of refrigerant at the downstream end 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 and will become apparent 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 apparatus and 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 of the high pressure side of the system and into which liquid refrigerant is introduced, to flow therethrough, expand partially or totally into vapor and/or gas, and to thereby absorb heat from the ambient atmosphere. The evaporator E has an outlet or discharge end **11** which is connected with the accumulator A.

The accumulator A is a liquid vapor phase type accumulator and consists of a closed tank or vessel **12** with an inlet opening or fitting **13** with which the outlet **11** of the evaporator is connected, as by a line **14**, a liquid outlet opening or fitting **15** at its lowermost or bottom side and a vapor-gas opening or fitting **16** 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 termed a pumping means. The means T may also and properly be defined as a flow augmenting means, the function of 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 pump L, a vapor pump V, flow accelerating means M related to the liquid pump L, vapor injecting means I and a generator (boiler) G.

The liquid pump L can be of any type or design of pump suitable for moving liquids and is preferably a positive displacement gear type pump. The pump L can be driven by any suitable prime mover and, in practice, is driven by an electiric motor E.

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

Connected with the discharge side of the liquid pump L and extending to and connected with the genarator G 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 pressure drop 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** upstream of the venturi, which head inhibits premature vaporization of the refrigerant in the line.

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

The vapor injecting means I involves a lateral tap-fitting **22**, such as a T-fitting, in the line **20** downstream of the means M and connected with a vapor line **23** extending from and connected with the discharge side of the vapor pump V.

The temperature and resulting or corresponding pressure of the vapor delivered by the pump and flowing through the vapor line **23** is greater than the temperature and pressure of the refrigerant in the line **20** downstream of the venturi. 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 and pressure 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 T-fitting of the means M has been determined by observation of the system when in operation and while believed to be substantially correct, may be technically inaccurate in certain respects.

The generator G can be any suitable generator or boiler construction and can be related to any suitable heat source. In the case illustrated, and in the preferred carrying out of the invention, the generator is that form of generator shown in Patent No. 2,659,214, issued to Harley L. Coggburn on Nov. 17, 1953, and is adapted to be related to the exhaust system S of an automobile engine.

The generator G illustrated includes a boiler portion **30** having inlet and outlet openings **31** and **32** and a fire box or heater portion **33** which, in the instant case, is provided with gas inlet and outlet openings and is arranged in an exhaust gas bypass pipe **34** related to the system S.

The generator G is essentially a heat exchanger and is provided to heat and vaporize the refrigerant by means of heat from the engine exhaust gases flowing through the system S.

The inlet opening **31** of the generator G is connected with the downstream end of the line **20** and the outlet opening **32** is connected with the condenser C by a conductor line **33**.

The rapidly moving refrigerant flowing through the line **20** is delivered into the generator and is heated and further vaporized therein and is discharged therefrom through the line **33** at high velocity, high temperature and resulting high pressure, but in a rare state (minimal mass) wherein its heat carrying capacity, by volume, is minimal.

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 **33** connects with the inlet fitting **35** and the outlet fitting **36** is connected with the receiver R.

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 of the condenser and an outlet opening **38**.

The rare, heated refrigerant, at high pressure flowing into the condenser, is rapidly cooled and condenses therein and is discharged therefrom and into the receiver R in a liquid state 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 from 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 of the evaporator E and a liquid line **41** extending from the expansion valve **40** to the receiver R. The line **41** extends through the opening **38** in the receiver R and opens within the receiver R at the bottom thereof and within the liquid.

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-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 the event the pressure side of the system increases and becomes excessive, a bypass valve **50** is provided in the flow line **20** ahead of the generator G and is connected, as by a line **51**, to the line **33** downstream from the generator, thereby effectively bypassing the generator.

It has been found that the generator G is essential to start or initiate operation of the system. Under certain operating conditions and particularly where the temperature of the ambient air is low and the demand of the evaporator is low, the generator G can, subsequent to putting the system in operation, be cut out or bypassed without adverse effects.

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' and to the motor of a blower X related to the evaporator.

The motor E is preferably a two-speed motor and such that it will normally run at full speed and is such that it can be shunted to operate at half speed, thereby reducing the rate of flow of refrigerant issuing from the pump L and flowing through the system, when the system reaches operating temperature and so the system will not shunt.

The motor E is under control of a two-way pressure responsive switch **72** engaged in the line **41** and suitably connected with the master switch **70**.

Since the details of the control means can vary widely without departing from or effecting 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. In a refrigeration system, including an evaporator, an accumulator receiving refrigerant from the evaporator, refrigerant transporting means to remove refrigerant from the accumulator 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 accumulator being a liquid vapor phase separator having an inlet connected with the evaporator, a liquid outlet opening and a vapor outlet opening, said refrigerant transporting means including a liquid pump connected with the liquid outlet opening, a vapor pump connected with the vapor outlet opening and a generator receiving liquid and vapor refrigerant from the pumps and discharging said refrigerant into the condenser.

2. A structure as set forth in claim **1** wherein a delivery line extends from the liquid pump to the generator and vapor line extends from the vapor pump to said delivery line, said system further including means in the delivery line between the liquid pump and the vapor line 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 means.

3. A structure as set forth in claim **1** wherein a delivery line extends from the liquid pump to the generator and vapor line extends from the vapor pump to said delivery line, said system further including means in the delivery line between the liquid pump and the vapor line 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 means, said means including a flow restriction in the flow line.

4. A structure as set forth in claim **1** wherein a delivery line extends from the liquid pump to the generator and vapor line extends from the vapor pump to said delivery line, said system further including means in the delivery line between the liquid pump and the vapor line 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 means, said means including a venturi in the flow line.

5. A structure as set forth in claim **1** wherein said generator includes a boiler portion with inlet and outlet openings, said inlet opening connected with the delivery line, said outlet opening connected with a flow line connected with the condenser, and a heater portion with inlet and outlet portions and into and out of which hot gas from a heat source are conducted.

6. A structure as set forth in claim **1** wherein a delivery line extends from the liquid pump to the generator and vapor line extends from the vapor pump to said delivery line, said system further including means in the delivery line between the liquid pump and the vapor line to increase the rate of flow of liquid refrigerant delivered by the liquid pump and create pressure drop in the delivery line downstream from said means, each of said pumps being driven by an electric motor, the motor driving the liquid pump being a two-speed motor and under control of a pressure responsive switch responsive to refrigerant pressure in the flow control and expansion means whereby the speed and output of the liquid pump is responsive to the pressures in the system.

7. A structure as set forth in claim **1** wherein a delivery line extends from the liquid pump to the generator and vapor line extends from the vapor pump to said delivery line, said system further including means in the delivery line between the liquid pump and the vapor line to increase the rate of flow of liquid refrigerant delivered by the liquid pump and create pressure drop in the delivery line downstream from said means, each of said pumps being driven by electric motors, the motor driving the liquid pump being a two-speed motor and under control of a pressure responsive switch responsive to refrigerant pressure in the flow control and expansion means whereby the speed and output of the liquid pump is responsive to the pressures in the system, said flow control and expansion means including an expansion valve at the inlet end of the evaporator, a liquid line from the receiver to the expansion valve and flow metering means in the liquid line to control the volume of refrigerant flowing through the liquid line.

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