March 29, 1966 M. W. BAKER ETAL 3,242,687

REFRIGERATION SYSTEM USING POLYPHASE EXPANSION VALVE ASSEMBLY

Filed Nov. 8, 1963 2 Sheets-Sheet 1

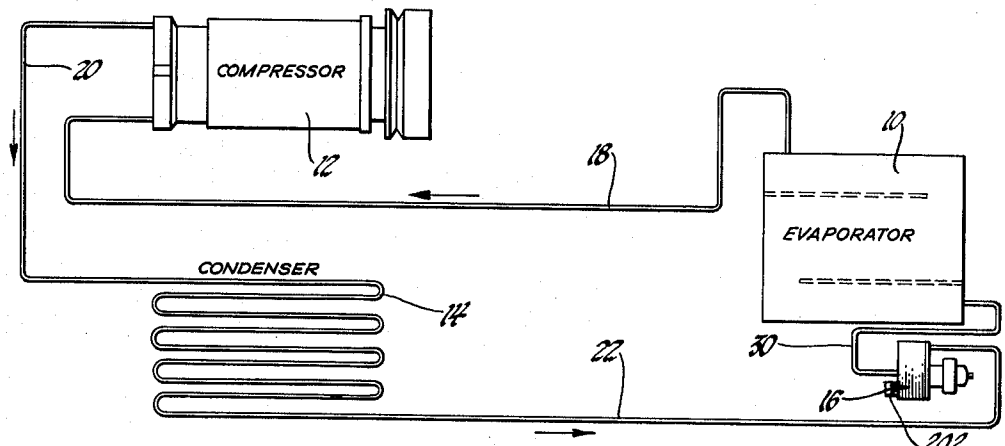


Fig. 1

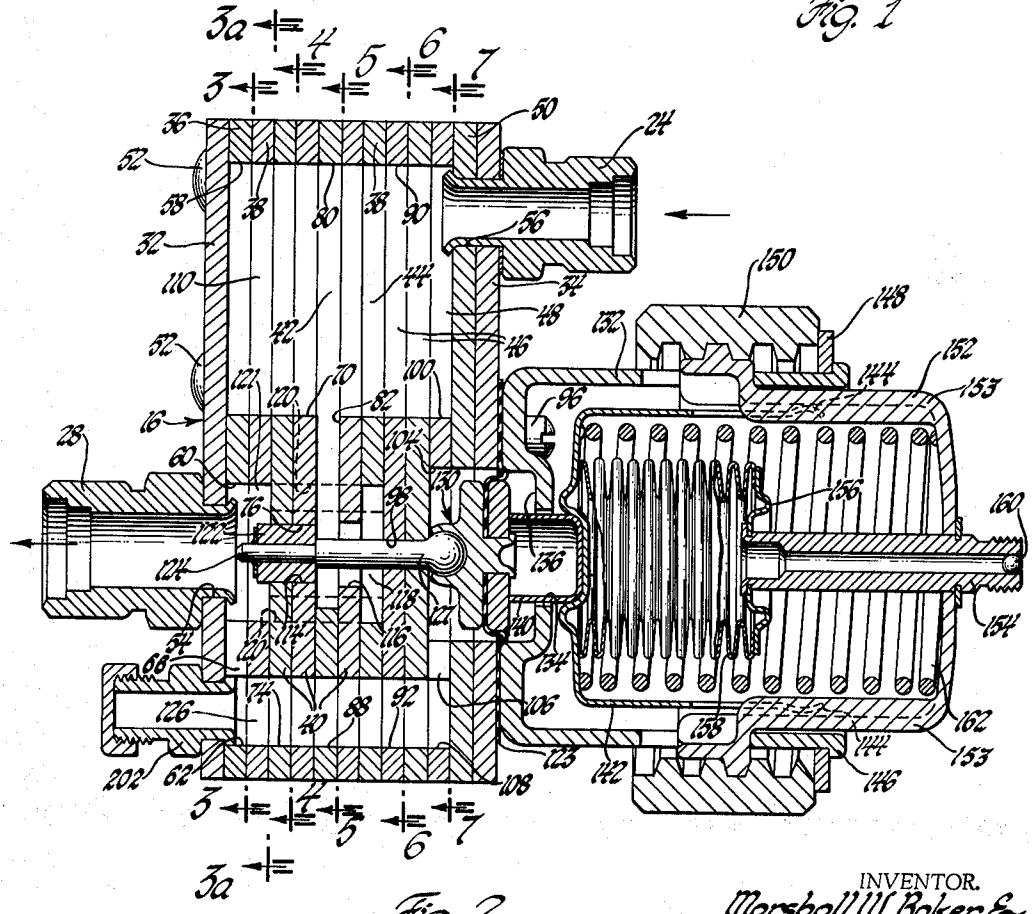


Fig. 2

INVENTOR.
Marshall W. Baker &
BY Paul K. Beatenbough
George E. Johnson
ATTORNEY

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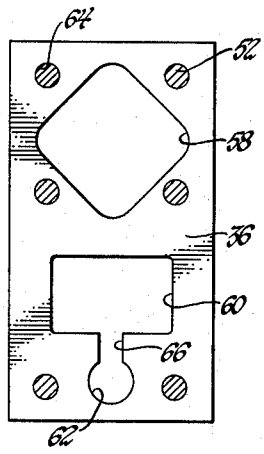


Fig. 3

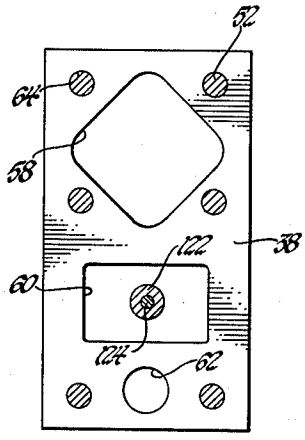


Fig. 3a

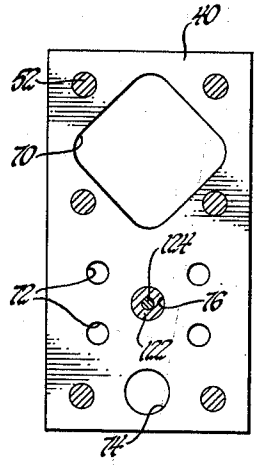


Fig. 4

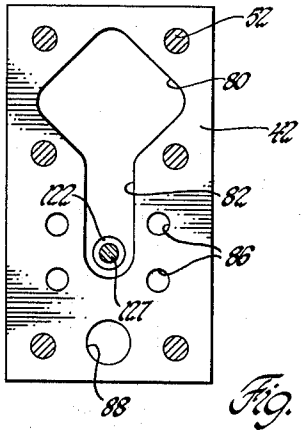


Fig. 5

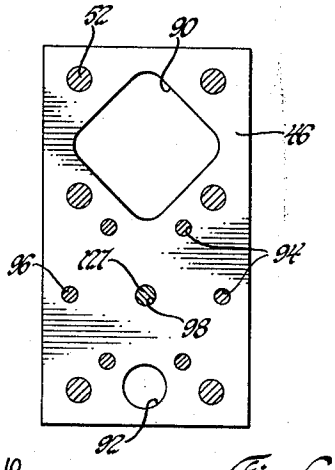


Fig. 6

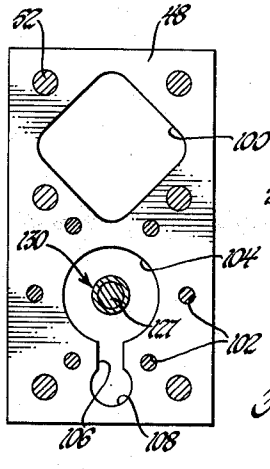


Fig. 7

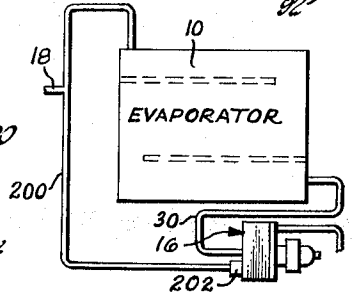


Fig. 8

INVENTOR.
Marshall W. Baker &
BY Paul K. Beatenbough
George E. Johnson
ATTORNEY

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3,242,687

REFRIGERATION SYSTEM USING POLYPHASE EXPANSION VALVE ASSEMBLY

Marshall W. Baker, Lockport, and Paul K. Beatenbough, Medina, N.Y., assignors to General Motors Corporation, Detroit, Mich., a corporation of Delaware

Filed Nov. 8, 1963, Ser. No. 322,468
7 Claims. (Cl. 62—214)

This invention pertains to a refrigeration system and more particularly to a system especially adapted for air conditioning an automotive vehicle and a refrigeration throttling or expansion valve assembly in combination with altitude or ambient pressure compensation means for use in such a system.

Automotive air conditioning systems must contend with sharply varying and difficult conditions. They must have adequate cooling capacity to maintain comfortable in-car temperature in city traffic and at low road speeds. Satisfying this requirement, they must be such as automatically to control the cooling capacity at intermediate and high road speeds while simultaneously protecting the system components insofar as the effects of variations in temperature and system pressure are concerned while retaining essential lubrication of the compressor. There are advantages in maintaining constant evaporator absolute pressure and these obtain particularly in automobile usage wherein changes in elevation are customary and usually frequent. The condensing and freezing of moisture from the atmosphere on the core of the evaporator must be prevented. Calibration of the system to suit personal preferences must also be possible and without undue complications and the system should be simple in construction and operation as well as low in cost.

An object of the present invention is to provide an improved refrigeration system in which the above-mentioned desired results are realized. Another object is to provide an improved refrigerant throttling or expansion valve assembly in combination with change in altitude or ambient pressure compensation means whereby a constant evaporator pressure may be attained.

A feature of the present invention is a refrigeration system using a high velocity refrigerant circuit through a compressor, evaporator and a condenser, the latter two components being connected by an altitude-compensated throttling or expansion valve assembly capable of handling not only all liquid refrigerant, but mixtures of vapor and liquid refrigerant, and possibly all vapor refrigerant. Another feature is an altitude-compensated expansion valve assembly capable of serving as a single control valve in a refrigerant circuit and combined with a pressure-actuated device and spring arrangement by means of which a desired evaporator pressure may be automatically maintained under all operating conditions and conveniently adjusted. One other feature is a laminated valve structure, the necessary passages in the structure being formed in flat plates constituting the laminations the final assembly of which is brazed into an integral unit.

These and other important features of the invention will now be described in detail in the specification and then pointed out more particularly in the appended claims.

In the drawings:

FIGURE 1 is a diagrammatic view of a refrigeration system in which the present invention is embodied;

FIGURE 2 is a sectional view of a polyphase expansion valve assembly employed in the system of FIGURE 1;

FIGURE 3 is a sectional view drawn to a reduced scale and taken along the line 3—3 of FIGURE 2;

FIGURE 3*a* is a similar sectional view but taken along the line 3*a*—3*a* of FIGURE 2;

FIGURE 4 is taken along the line 4—4 of FIGURE 2;

FIGURE 5 is taken along the line 5—5 of FIGURE 2;

FIGURE 6 is taken along the line 6—6 of FIGURE 2;

FIGURE 7 is taken along the line 7—7 of FIGURE 2; and

FIGURE 8 is a diagrammatic view of a portion of the system of FIGURE 1 as modified.

In FIGURE 1 the system is shown as comprising a three-pass evaporator **10**, a compressor **12**, a condenser **14**, and a special expansion valve **16**. A line **18** connects the evaporator **10** to the intake of the compressor and line **20** connects the discharge side of the compressor to the condenser **14**. The latter is connected by a line **22** to an inlet nipple **24** of the valve **16**. An outlet nipple **28** of the latter is connected by means of a line **30** to the evaporator **10**. The compressor **12** is preferably of a type having a high tolerance for a high percentage of refrigerant liquid entrainment in the vapor (mixture) being compressed. There are many ways heretofore used in refrigeration systems for achieving an elevated degree of tolerance for liquid refrigerant in compressors. An example of a suitable compressor is disclosed in the United States Patent No. 3,057,545, granted April 11, 1960, in the names of G. P. Ransom, W. K. Steinhagen and D. C. Unger.

The main body of the valve **16** comprises two end plates **32** and **34** between which are retained discharge port plate **36**, **38**, three valve guide plates **40**, one inlet port plate **42**, one outlet port plate **44**, two rod guide plates **46**, one equalizer plate **48** and one diaphragm chamber plate **50**. These plates are all held at least initially together by bolts **52** to insure proper and fluid tight bonding in brazing the plates together. The plates making up the valve may conveniently be made of aluminum, steel or copper.

The end plate **32** is apertured as at **54** tightly to receive the outlet nipple **28**. The end plate **34** and its adjacent plate **50** are apertured as at **56** tightly to receive the inlet nipple **24**. The plate **36** (FIGURE 3) has two relatively large apertures **58** and **60** and a smaller aperture **62**. It also bears six holes **64** for receiving the bolts **52**. The apertures **60** and **62** communicate by means of a slot **66**. Each of the two plates **38** is similar to plate **36** except that the aperture **60** and **62** do not communicate (FIGURE 3*a*). The three valve guide plates **40** are each as depicted in FIGURE 4 and are made to accommodate the bolts **52**. Each plate **40** bears a large aperture **70** conforming with the aperture **58**. Each plate **40** also is provided with four holes **72**, a hole **74** conforming with the aperture **62** of the plate **36** and also a hole **76** placed between the hole **74** and the large opening **70**.

The inlet port plate **42** is made to accommodate the bolts **52** and also bears a large aperture **80** which conforms with the apertures **58** and **70** except that it extends downwardly in the form of a slot **82**. This slot terminates in a zone located in the area between four holes **86** and the latter are made to register with the holes **72** in the assembly. The plate **42** also has a hole **88** adapted to register with the holes **62** and **74**.

Each of the rod guide plates **46** is depicted as shown in FIGURE 6 and is provided wtih a large aperture **90** and a smaller hole **92**, these being adapted to register with the large aperture **70** and the small hole **74** respectively. Each plate **46** also includes six holes **94** for receiving bolts such as the bolt **96** (FIGURE 2). These holes **94** are not threaded until after assembly and brazing of the valve. Between the large opening **90** and the small opening **92** is a central opening **98**.

The equalizer plate **48** has a large aperture **100**, six holes **102** surrounding a relatively large opening **104** and connected with the latter by means of a slot **106** is a small opening **108**.

With the plates joined together as shown in FIGURE 2 they form a laminated valve body and the apertures in the plates are in registry to form an inlet chamber at **110**, an inlet or supply port at **82**, and two valve bores at **114** and **116** formed by the aligned holes **76**. In the assembly, one of the two plates **38** defines a flat chamber **118**. There are four passages **120** for the free flow of refrigerant from the chamber **118** to a chamber **121** connected with the outlet nipple **28**. The plates also form an extra and lowest chamber **126** which communicates with the chamber **121** by means of the slot **66** and with a chamber at one side of a diaphragm **123** by means of the slot **106**.

A cylindrical valve member **122** is slidably retained and closely fitted within the valve bore **114** and retained on a reduced diameter portion **124** of a rod **127**. The latter extends through the hole **76** of each of the plates **40** and is slidable and also is attached by a ball and socket joint arrangement **130** to the central portion of the diaphragm **123**. The valve member **122** serves as a seal member between refrigerant at high pressure in the passage **82** and refrigerant at a lower pressure in chamber **121**. A cup member **132** is fixed to the end plate **34** by means of the screws **96** and with the margin of the diphragm **123** interposed. The central portion of the bottom of the cup **132** is apertured as at **134** and formed with a recess **136**. This recess is made with a diameter to coincide with that of the aperture **104** in the plate **48**. A small cup **140** is retained to bear on the ball and socket arrangement **130** and is slidable within the aperture **134**. Retained within the cup **132** is an inner cup **142** having fingers such as at **144** for retaining the cup **142** in axial alignment with respect to the cup **132**. The lip of the cup **132** bears an annular flange **146** which is adapted to restrain a washer **148** and abutting the latter is an internally threaded knurled ring **150**. This ring is in threaded engagement with a movable cup **152** which is adapted to move toward and away from the cup **132** and on the axis of the latter.

A hollow shaft **154** is fixed to the cup **152** and extends axially therein and is fixed to a disk **156** which serves as the sealed cover of a bellows indicated at **158**. The other end of the bellows is fastened to the closed end of the inner cup **142**. The bellows **158** may be evacuated by using the hollow shaft **154** sealed as at **160**. A coil spring **162** is retained within the cups **152** and **142** and its surrounds the bellows **158**. Ribs **153** on the cup **152** serve as centering guides for the spring **162**.

In operation of the system, liquid refrigerant such as Freon and some entrained lubricating oil for the compressor **12** leaves the condenser **14** through the line **22** and passes through the valve **16** to the evaporator **10**. The valve **16** so operates that a constant pressure will be maintained in the evaporator inlet despite changes in ambient temperatures, speed of the compressor or in ambient pressure. As the Freon evaporates in the evaporator it attracts heat from the air which is forced through the conventional core of the evaporator and refrigerant discharged from the evaporator **10** passes through the line **18** to the compressor. The single valve **16** permits system operation without a reserved supply of refrigerant in the line. The flow, whether it be in a liquid or vapor state, or a mixture of liquid or vapor, is at a constant rate through the line **18** and is sufficient at all times to fulfill the demands of the compressor while maintaining the refrigerant pressure at the valve outlet within predetermined limits.

In operation of the valve **16** the refrigerant, whether it be all liquid, or all vapor, will pass through the chamber **110** and to the valve bore **116** by way of the supply port **82**. This refrigerant will then flow into flat chamber **118** and by way of the four passages **120** in the chamber **121**. From this zone, the refrigerant passes through the nipple **28** to the evaporator. The chamber **121** is also in communication with the chamber at one side of the diaphragm **123** because of the chamber **126** and the passage

slot **106**. The opening **134** in the base of the cup **132** is of such size that atmospheric air may enter around the knurled nut **150** and engage one side of the diaphragm **123**. The diaphragm **123**, the bellows **158** and the spring **162** are so designed as to cooperate to control the valve member **122** whereby a desired pressure is maintained in the valve outlet **28**. The valve member **122** is subjected to outlet pressure at both ends because throttling action takes place between the valve member and one of the plates **40**. It is, therefore, a balanced valve member. The diaphragm **123** is acted upon by valve outlet pressure at one side and by atmospheric pressure on the other. The areas of the bellows and diaphragm exposed to the atmosphere are made equivalent. Expansion of the vacuumized bellows **158** is resisted by atmospheric pressure and the design is such that when atmospheric pressure reduces as when the system is operated at a high elevation the bellows **158** is relieved and thereby expands to permit the spring **162** to tend to move the diaphragm **123** and the valve member **122** to the left to positions as viewed in FIGURE 2. In other words, the bellows **158** opposes expansion of the spring **162** at sea level but its opposition decreases as the elevation increases. The valve **116** maintains refrigerant flow at constant refrigerant pressure at the evaporator inlet at all times during normal operation when the compressor capacity equals or exceeds the capacity of the evaporator **10**. The valve also provides additional flow of refrigerant liquid, liquid-vapor mixture, or vapor (hence "polyphase") to satisfy extra compressor capacity. When the compressor capacity is less than the evaporator capacity, calibrated leakage in the valve provides sufficient refrigerant flow to allow the evaporator pressure to maintain nearly optimum cooling effect with the reduced compressor capacity. It will be noted that an oil bleed line around the evaporator is rendered unnecessary for the valve **16** permits high velocity refrigerant flow in the evaporator and a good oil return to the compressor is assured. It will also be noted that a dehydrator is not essential.

With the present arrangement, however, the valve **16** operates well above the freeze point and cannot freeze and the moisture level is kept so low in the present system that there is little evidence of refrigerant decomposition or corrosion of the parts. The receiver or desiccant holder as customarily used in previous systems served as a container for reserve refrigerant but the tolerance of the present valve **16** in combination with the other components of the system for operating with refrigerant in the vapor as well as the liquid state, give satisfactory system performance and reliability without a receiver i.e.—line **20** includes no receiver so that line is characterized by having a constant velocity flow along its length. A temporarily installed service dehydrator can be used to dry out systems involving the present invention if the admission of moisture is encountered inadvertently or otherwise. Further processing of the system by flushing and evacuation should be easier and more effective with equal or better results when compared to a system using a dehydrator.

Heretofore, an external pressure sensing line has been used to override the expansion valve into opening under low compressor inlet pressure so as to flood liquid refrigerant through the evaporator into the compressor suction line. This has been necessary to prevent too low a pressure at the compressor inlet when the compressor capacity exceeds evaporator load. Such an external equalizer line is not necessary in the present system since the valve **16** maintains the evaporator inlet pressure at a predetermined amount.

It has been customary heretofore to use a sight glass in refrigeration systems to detect the presence of gas in the liquid line as an aid in diagnosing system malfunctions. Since gassing is expected under many operative conditions, the sight glass has been omitted from the present system.

It will be appreciated that if an evaporator pressure

higher than anticipated is desired, the loading of the spring **162** may be changed by rotating the knurled nut **150**. The system results in a constant evaporator pressure determined by the adjustment of the nut **150** but the specific type of control of air temperature in the passenger compartment of a car in which the present system is installed is not involved. This control may be effected by various expedients such as reheating—i.e.—heating the air after cooling and drying it. The valve **16** is characterized by high sensitivity to give a constant outlet pressure under normal conditions. This outlet pressure is departed from only under conditions where the compressor is of low capacity with a high heat input to the evaporator. The valve member **122**, being balanced, adds to the sensitivity.

The above description pertains to a valve and system using an internal equalizing connection—i.e.—a system in which the valve outlet is closely coupled to the evaporator inlet. If the evaporator outlet pressure becomes more critical or more important than the evaporator inlet pressure under given conditions in the control of refrigerant, then the slot **66** could be closed off and an exterior equalizing connection such as the line **200** and the fitting **202** of FIGURE 8 could be added. With this arrangement, the valve **16** may be said to be externally equalized as it responds to pressures at a location external to the valve. It is obvious that several places on the evaporator **10** could serve as a suitable location for connection to the equalizer line leading to the valve side of the diaphragm **123**.

From the above description, it will be noted that the system is characterized by at least four important aspects: (1) the high rate of refrigerant flow through the special valve **16** to the multi-pass evaporator is accompanied by a gradual reduction of refrigerant pressure and not a sudden reduction. This combination of the multi-pass evaporator and a control valve in the system therefore permits elimination of an excess refrigerant receiver and promotes over-all simplicity and reduces cost; (2) the system operates independent of barometric pressure changes by virtue of the special valve construction; (3) the valve **16** operates well above the freeze point of residual moisture in the system and cannot freeze; and (4) no suction throttling valve is needed in the line **18**.

We claim:

1. A refrigeration system including an evaporator, a compressor, a condenser and a polyphase expansion valve assembly connected in that order in a closed circuit, said valve assembly having a body with a supply port connected to said condenser and an outlet port connected to said evaporator, two aligned valve bores in said body each

connecting said ports, a valve member slidable in one of said bores, a rod fixed to said valve member and slidable in said body, a diaphragm fixed to said rod with one side exposed to pressure in said outlet port and the other side to ambient pressure, and resilient means including a spring and bellows arrangement mounted to act on said diaphragm to compensate for ambient pressure fluctuation.

2. A refrigeration system such as set forth in claim **1**, said resilient means being adjustable to vary the evaporator pressure.

3. A refrigeration system as set forth in claim **1**, said resilient means including a cup arangement enclosing said bellows and spring and said valve assembly having a laminated body.

4. A refrigeration system as set forth in claim **1**, one end of said bellows and one end of said spring being fixed in position with relation to said valve assembly body, and the other ends of said bellows and spring being movable with said valve.

5. A refrigeration system as set forth in claim **4**, and said fixed ends of said bellows and spring being adjustable in their positions with relation to said valve assembly body.

6. A polyphase expansion valve assembly having a body with a supply port and an outlet port, two aligned valve bores in said body, an open passage leading from said supply port and terminating at said bores, a valve member slidable in one of said bores, a rod having one end fixed to said valve member and an intermediate portion extending through the other of said bores, another portion of said rod being journaled in said body, a diaphragm fixed to the other end of said rod with one side exposed to pressure in said outlet port and the other side to ambient pressure, and resilient means including a spring and bellows arrangement mounted to act on said diaphragm to compensate for ambient pressure fluctuation.

7. A polyphase expansion valve assembly such as set forth in claim **6**, a bellows of said spring and bellows arrangement being vacuumized and a spring of the latter cooperating with said bellows in affecting the position of said valve member with respect to said other valve bore.

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MEYER PERLIN, *Primary Examiner.*