Jan. 28, 1964 J. H. HEIDORN 3,119,559

THERMOSTATIC EXPANSION AND SUCTION LINE VALVE

Filed Aug. 20, 1962

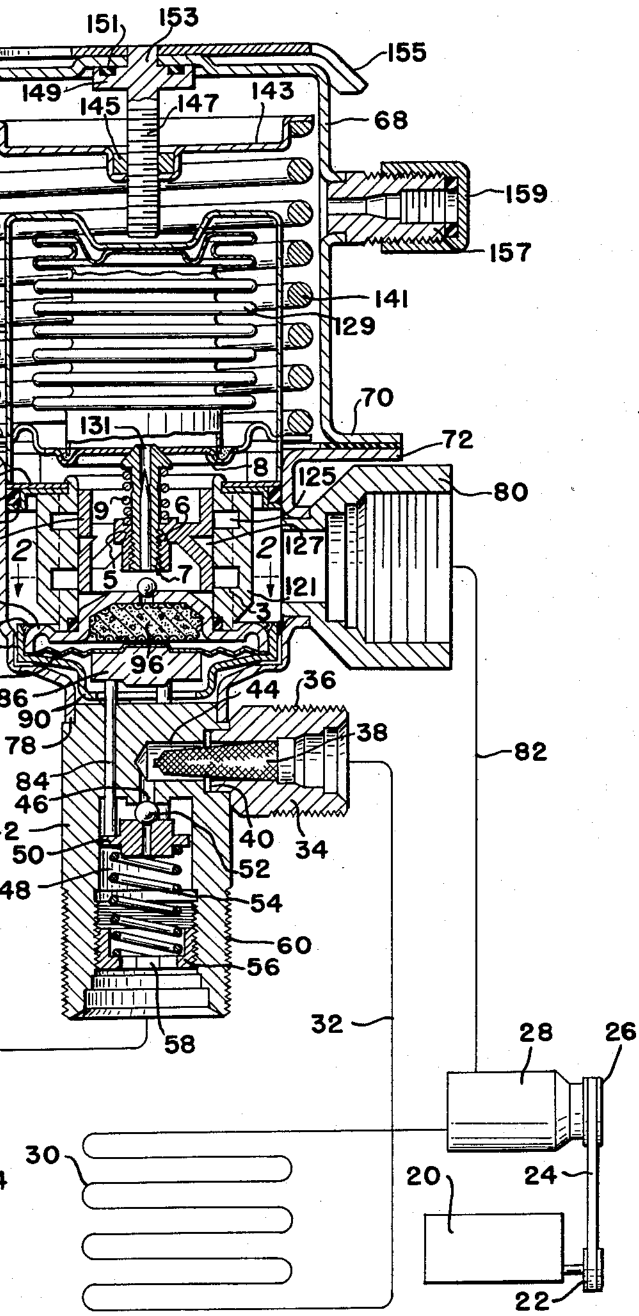

Fig. 1

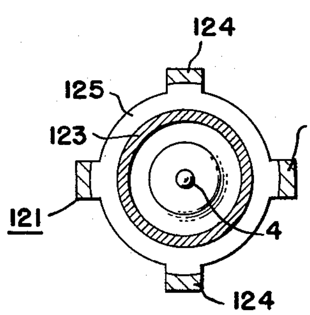

Fig. 2

INVENTOR.
John H. Heidorn

BY Carl A. Stickel

His Attorney

United States Patent Office

3,119,559
Patented Jan. 28, 1964

1

3,119,559
THERMOSTATIC EXPANSION AND SUCTION LINE VALVE

John H. Heidorn, Dayton, Ohio, assignor to General Motors Corporation, Detroit, Mich., a corporation of Delaware

Filed Aug. 20, 1962, Ser. No. 218,015
6 Claims. (Cl. 236—91)

This invention pertains to refrigerating apparatus and more particularly to the control of refrigerating systems of automotive air conditioning apparatus wherein it is desired to keep the evaporator at a constant low temperature and pressure at all times but just high enough to prevent frosting of the evaporator.

In automobile air conditioning systems, it is urgent to keep the evaporator at a minimum size in order to conserve space. To obtain maximum cooling effect from such a small evaporator, it is necessary to operate the evaporator as cold as possible but also to prevent the accumulation of frost thereon. Automobile air conditioning systems operate at varying speeds under all types of weather and altitude conditions. For example, the automobile may drive through the hot, low altitude, low humidity regions like Death Valley, California, or up to the top of Pike's Peak in Colorado, or from the warm humid climate of Florida to the cold of Alaska and Canada. Since the compressor is driven by the car engine at speeds varying with the car speed, this provides further difficulties in maintaining a constant evaporator temperature. By controlling the flow of refrigerant into and out of the evaporator, a relatively constant evaporator temperature has been attained. However, the controls for accomplishing this have been expensive.

It is an object of this invention to provide a less expensive, single, compact control for controlling the flow of liquid refrigerant into and evaporated refrigerant out of the evaporator to maintain the evaporator at a substantially constant low temperature.

It is another object of this invention to provide an inexpensive, efficient, effective, combined thermostatic expansion valve and a suction line valve.

It is another object of this invention to provide a valve in which the major portions of the housing are composed of sheet metal while cast or forged portions of greater thickness are bonded at appropriate locations to the sheet metal to support the working parts.

It is another object of this invention to provide an arrangement wherein the thermostatic fluid motor of a thermostatic expansion valve is located within a portion of a suction line valve.

These and other objects are attained in the form shown in the drawings in which a combined thermostatic expansion valve and suction line valve has its inlet fitting connected to the outlet of the condenser and extends into the side of a thick walled valve housing having a seat normally closed by a ball valve. This ball valve is brazed or welded to a follower which is pushed downwardly to the open position by three pins extending upwardly through the thick walled valve housing to a diaphragm follower. A closure spring presses upwardly upon the valve follower and is located within the open end of the thick walled valve housing. It is provided with an adjusting screw at the bottom.

Bonded to the valve housing is a sheet metal diaphragm casing which surrounds the diaphragm assembly. The diaphragm assembly includes an upper wall portion enclosing a capsule of activated charcoal and carbon dioxide. The lower wall portion is open at the bottom and encloses the diaphragm follower. The diaphragm itself is held between the upper and lower wall portions and rests upon the diaphragm follower. It is sealed at its edges to the

2

wall portions by solder. A closed chamber is provided between the diaphragm and the valve housing which is connected to the suction line connection. The bottom of the valve housing provides a threaded connection to the inlet of the evaporator. The outlet of the evaporator connects to a second upper inlet in a sheet metal spring housing which is bolted to the lower sheet metal diaphragm casing. In addition to the adjustable spring, the spring housing contains an evacuated bellows supported at its upper end upon a yoke. The lower end of the bellows is bonded to a notched disk which serves as a lower spring retainer. This disk or plate is bonded to a charging tube which also provides a spherical connection to a double piston-type valve which discharges outwardly into the diaphragm housing which also serves as a discharge chamber. The diaphragm housing has a flanged opening to which is bonded a threaded discharge fitting connecting with the suction line.

The upper diaphragm wall is responsive to the temperature of the evaporated refrigerant flowing through the piston-type valve at the outlet of the evaporator to provide suitable thermostatic action for the ball-type liquid refrigerant inlet valve below. Grooves in the diaphragm housing provide a passage between the second outlet connecting to the suction line and the chamber provided between the lower valve housing and the diaphragm. This causes the bottom of the diaphragm to be subject to the suction line pressure while the top of the diaphragm is responsive to the pressure of the carbon dioxide as maintained by the capsule of activated charcoal. The capsule of activated charcoal is charged with carbon dioxide through an opening closed by the ball which is welded in place after the charging. The charcoal makes the carbon dioxide responsive to temperature of the evaporated refrigerant flowing through the piston valve. Thus, the ball valve operates as a thermostatic expansion valve.

The bellows within the spring housing is responsive to the pressure in the evaporator. When the pressure within the evaporator is low, the piston valve will be held in the closed position by the large spring. However, when the evaporator pressure rises, the bellows will be contracted by the increase in external pressure thereby moving the piston valve toward the open position. The large spring is adjusted so that the increase in evaporator pressure upon the bellows will move the piston valve upwardly to open position. As the evaporator pressure increases, the piston valve will move upwardly to provide a wider opening with greater flow out of the evaporator sufficient to keep the evaporator at a minimum temperature of 35° F.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein a preferred embodiment of the present invention is clearly shown.

In the drawing:

FIGURE 1 is a vertical sectional view through a combined thermostatic expansion and suction valve together with a diagrammatic representation of the remainder of a refrigerating system; and

FIGURE 2 is a fragmentary horizontal sectional view taken along the line 2—2 of FIGURE 1.

Referring now to the drawing, there is indicated diagrammatically an automobile engine **20** primarily used for driving a passenger car, a truck or a bus. This engine operates at varying speeds to drive the car according to the intention of the driver and traffic conditions. Consequently its operation is not in accordance with the requirements of a refrigerating system which is used for cooling the interior of the passenger car, truck or bus. The engine **20** has a driving pulley **22** which, through a belt **24**, drives a pulley **26** upon a high speed automotive compressor 28. The outlet of the compressor 28 is connected to the inlet of the condenser 30 which may be placed in front of the automobile radiator or provided with some other form of air circulation by which it is cooled. The outlet of the condenser 30 connects through a liquid supply conduit 32 to the liquid inlet fitting 34.

This liquid inlet fitting 34 may be of brass and externally threaded as indicated by the reference character 36 upon an automatic screw machine. This inlet fitting 34 is also provided with a coaxial internal bore which receives the tapered inlet screen 38. This inlet fitting 34 is provided with an annular projection 40 fitting into the side of the valve housing 42 which may be made of bar stock on the screw machine. It has a lateral passage 44 receiving the inner portion of the screen 38 connecting with a downward centrally located coaxial passage leading to a valve seat 46. The valve seat 46 opens into the coaxial valve chamber 48 within which is slidably mounted the valve follower 50 at the top of which is welded a ball valve 52. Also in the valve chamber 48 beneath the follower 50 is a compression-type coil spring 54 supported at its lower end by the ring-shaped spring retainer 56. The spring retainer 56 is provided with a hexagonal aperture 58 through which it may be adjusted and through which the refrigerant flows to the inlet 61 of the evaporator 62. The valve housing 42 is provided with external threads 60 by which a connection may be made through a flare nut to the tubing of the evaporator 62.

The evaporator 62 has its outlet 64 connected to the threaded fitting 66 bonded to the edges of an opening in the inverted cap-shaped sheet metal housing member 68. The housing 68 has a lower outwardly turned flange 70 which is bolted by the bolt 74 to the upper outwardly turned flange 72 of the cup-shaped housing member 76. The bottom of the housing 76 is provided with an opening surrounded by a cylindrical rim 78 which is bonded to the reduced top of the lower valve housing 42. At one side the cup-shaped housing 76 is provided with a flanged opening connecting to the threaded fitting 80 which in turn connects to the suction line 82 connecting with the inlet of the compressor 28.

The liquid refrigerant valve 52 is operated by three symmetrically located vertical pins 84 extending from the valve follower 50 upwardly through three drilled passages to the diaphragm follower 86 located beneath the actuating diaphragm 88. The diaphragm 88 forms the part of the power element assembly which includes a lower retainer 90 provided with an inwardly turned flanged lower section for retaining the follower 86 and an upwardly turned rim. The assembly also includes a cap member 92 above the diaphragm provided with a downwardly turned rim nesting within the rim of the retainer 90. The upwardly turned rim of the diaphragm 88 extends between the rims of the elements 90 and 92 and is soldered therein as indicated by the solder 94 which seals the chamber above the diaphragm 88. The cap member 92 has a raised central portion containing activated charcoal 96 enclosed in a suitable screen. This activated charcoal 96 as well as the chamber formed between the diaphragm 88 and the cap member 92 is charged with carbon dioxide which is adsorbed and evolved in and from the activated charcoal 96 according to temperature conditions of the cap member 92 which is subjected to the temperature conditions within the cup-shaped members 76. The carbon dioxide is charged into this chamber through a central aperture in the cap member 92 which is closed by a metal ball which is welded in place. A second chamber is formed between the diaphragm 88 and the valve housing 42. This chamber is charged with refrigerant under suction line pressure through grooves 98 provided in the inner surface of the cup-shaped housing 76 around the rim of the retainer 90.

Seated on top of the cap member 92 and aligned by its central projecting portion is a sleeve valve cage 121 which is sealed to the cap member 92 by an O-ring seal. This sleeve valve cage 121 is provided with upper and lower annular ports 125 between which and on either side of which are lands 3 which slidably support the sleeve valve 123 and which are integrally connected by four vertical external posts 124, symmetrically located. The sleeve valve 123 has a central annular port 127 which is adapted to register with the upper annular port 125 while the lower skirt of the sleeve valve 123 normally covers the lower annular port 125 but upon upward movement gradually uncovers the lower port. The sleeve valve 123 is provided with a central aperture which includes a spherical seat 5 upon which is adapted to rest the nut 6 having a complementary spherical surface. The nut 6 is threaded onto the stem 7 extending upwardly through the aperture in the sleeve valve 123 and connecting at its upper end to the bellows follower 8. The stem 7 is surrounded by a spring 9 which tends to hold the sleeve valve 123 with its spherical seat 5 in engagement with the spherical surface of the nut 6. The bellows follower 8 is bonded to the bottom of a cylindrical metal bellows 129 which is evacuated through a passage 131 in the stem 7 prior to its sealing by a seal pin. The top of the bellows 129 is welded or otherwise bonded to an inverted U-shaped yoke 133 having its legs extending downwardly through opposite side notches in the bellows follower 8 and fastened to the plate 135. The ring-shaped plate 135 of sheet metal together with a ring 137 are riveted together and sealed to the top of the sleeve valve cage 121 by the spinning of the upper rim of the sleeve valve cage 121 over the plate 135 as shown. Between the plate 135 and the ring 137, there is provided an O-ring seal 139 which seals against the inner cylindrical face of the cup-shaped housing member 76 to prevent flow of refrigerant outside the cage 121. The provision of a double ported sleeve valve reduces the amplitude of movement of the bellows 129 thereby minimizing bellows failure.

The bellows follower 8 and the sleeve valve 123 are urged downwardly to the wide open position by a coil spring 141 which surrounds the bellows 129 and the yoke 133 and rests on the rim of the bellows follower 8. The upper end of the spring 141 is supported by the spring retainer 143. This spring retainer 143 has a centrally located recess receiving a nut 145 threaded onto the screw 147 which extends upwardly and has a shoulder 149 bearing against the inner surface of the top of the inverted cap-shaped housing member 68. It is sealed to the cap-shaped member 68 by the O-ring seal 151. The screw 147 has a projecting portion 153 extending through an aperture in the top of the inverted cap-shaped member 68 to which is attached an adjusting disk 155 provided with fingers at its periphery. The side of the inverted cap-shaped member 68 is provided with a fitting 157 which, by removal of the cap 159, may be connected to a gauge.

The adjusting screw and spring retainer 56 of the thermostatic expansion valve is set to provide a superheat of from 5° to 12° F. at the outlet 64 of evaporator 62. The adjusting disk 155 is adjusted to maintain an evaporator pressure corresponding to about 32° F. in the evaporator 62. For example, if difluorodichloromethane is used as the refrigerant, the disk 155 is set to maintain a pressure of about 30 pounds per square inch in the evaporator 62. This adjustment causes the evaporator 62 to normally operate at a temperature just about 32° F. This, therefore, maintains evaporator 62 at the lowest temperature substantially that it can operate without accumulating frost. Since the operating bellows 129 and the diaphragm 88 are completely enclosed in the valve housing without connection with the external air, changes in barometric pressure will not affect the setting of the valve. The valve is compact and of light weight. It is composed of some solid parts of bar stock which can be economically made on an automatic screw machine. The remainder of the parts may be stamped or pressed from sheet metal. The valve can be readily taken apart by removing the bolts **74**. The stamped and pressed sheet metal parts may be connected to the parts made on a screw machine by hydrogen brazing or welding.

The thermostatic expansion valve portion operates in the conventional manner. When gas with sufficient superheat flows through the diaphragm housing **76**, the activated charcoal **96** will evolve sufficient carbon dioxide to create a pressure on the diaphragm **88** which is greater than the pressure on the opposite side derived from the outlet chamber in the diaphragm housing **76**. This will cause a downward deflection of the diaphragm **88**, the follower **86**, the pins **84** and the valve follower **50** to open the valve **52** against the force of the return coil spring **54** to allow additional liquid to flow past the valve seat into the evaporator **62**.

As long as the pressure in the evaporator **62** is below thirty pounds per square inch, the spring **141** will hold the sleeve valve **123** in the closed position. When the pressure rises above thirty pounds, the bellows **129** will be collapsed sufficiently to raise the sleeve valve **123** efficiently to uncover the slots **125** to allow gas flow through the slots to the outlet **80**. The sleeve valve will remain in this position as long as the pressure within the evaporator **62** is above thirty pounds and will not close until the pressure in the evaporator falls below thirty pounds. When the evaporator pressure falls below thirty pounds, the spring **141** will move the sleeve valve **123** downwardly into closed position.

While the embodiment of the present invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted.

What is claimed is as follows:

1. A combined thermostatic expansion valve and suction line valve including a hollow valve body having an opening at one end, a liquid valve arrangement including a separate valve body fitted to said opening and provided with a liquid inlet and outlet and a liquid valve means between the liquid inlet and outlet, a first diaphragm means located within said hollow valve body provided with a thermostatic chamber and a pressure chamber within said hollow valve body, operating means operably connecting said diaphragm means and said liquid means, a suction line valve arrangement located in said hollow valve body having a gas valve means adjacent said first diaphragm means and having a second diaphragm means located on the opposite side of said gas valve means from said first diaphragm means, means operatively connecting said second diaphragm means and said gas valve means, said hollow valve body being provided with a gas inlet on one side of said gas valve means and a gas outlet an the opposite side of said gas valve means, said valve bodies and said valve means and said diaphragm means being coaxially arranged.

2. A combined thermostatic expansion valve and suction line valve including a hollow thin metal valve body having a coaxial aligned opening at one end, a liquid valve arrangement including a separate thick walled valve body aligned and coaxial with the hollow valve body and fitted to said opening and joined to said hollow valve body, said separate valve body having liquid inlet and outlet openings and a passage provided with a valve seat connecting said liquid inlet and outlet openings, a diaphragm power element means coaxial with and located within and bonded to said thin metal hollow valve body adjacent to but having portions spaced from said separate thick walled valve body having a stiff heavy wall portion and a thin flexible wall portion joined to enclose a sealed chamber containing a temperature responsive means, a liquid valve located in said separate valve body adjacent to and cooperating with said valve seat to control liquid flow, valve operating means extending from said flexible wall to said liquid valve, said hollow valve body having bonded to it heavy gas inlet and outlet fittings, said hollow valve body having passage means extending around said diaphragm means to the face of said flexible wall portion, a gas valve means located in said hollow valve body between said gas inlet and outlet fittings, and a sealed flexible walled evacuated casing located in said hollow valve body operably connected to said gas valve means for operating said gas valve means.

3. A combined thermostatic expansion valve and suction line valve including a hollow thin metal valve body having an opening at one end, a liquid valve arrangement including a separate thick walled valve body fitted to said opening and joined to said hollow valve body, said separate valve body having liquid inlet and outlet openings and a passage provided with a valve seat connecting said liquid inlet and outlet openings, a diaphragm power element means located within and bonded to said hollow valve body adjacent to but having portions spaced from said separate valve body having a stiff heavy wall portion and a thin flexible wall portion joined to enclose a sealed chamber containing a temperature responsive means, a liquid valve located in said separate valve body adjacent to and cooperating with said valve seat to control liquid flow, valve operating means extending from said flexible wall to said liquid valve, said hollow valve body having bonded to it heavy gas inlet and outlet fittings, said hollow valve body having passage means extending around said diaphragm means to the face of said flexible wall portion, a gas valve means located in said hollow valve body between said gas inlet and outlet fittings, a sealed flexible walled evacuated casing operably connected to said gas valve means for operating said gas valve means, said gas valve means including a stationary valve portion provided with an interfitting arrangement with said stiff heavy wall portion of said diaphragm means and a movable valve portion operably connected to said evacuated casing.

4. A combined thermostatic expansion valve and suction line valve including a hollow thin metal valve body having an opening at one end, a liquid valve arrangement including a separate thick walled valve body fitted to said opening and joined to said hollow valve body, said separate valve body having liquid inlet and outlet openings and a passage provided with a valve seat connecting said liquid inlet and outlet openings, a diaphragm power element means located within and bonded to said hollow valve body adjacent to but having portions spaced from said separate valve body having a stiff heavy wall portion and a thin flexible wall portion joined to enclose a sealed chamber containing a temperature responsive means, a liquid valve located in said separate valve body adjacent to and cooperating with said valve seat to control liquid flow, valve operating means extending from said flexible wall to said liquid valve, said hollow valve body having bonded to it heavy gas inlet and outlet fittings, said hollow valve body having passage means extending around said diaphragm means to the face of said flexible wall portion, a gas valve means located in said hollow valve body between said gas inlet and outlet fittings, a sealed flexible walled evacuated casing operably connected to said gas valve means for operating said gas valve means, said gas valve means including a stationary valve portion provided with an interfitting arrangement with said stiff heavy wall portion of said diaphragm means and a movable valve portion operably connected to said evacuated casing, means connecting one portion of said evacuated casing and said stationary portion, spring means surrounding said casing and having one portion connected to another portion of said evacuated casing, and adjustment means supported by said hollow body applied to another portion of said spring means to adjust said spring means.

5. A combined thermostatic expansion valve and suction line valve including a hollow thin metal valve body having an opening at one end, a liquid valve arrangement including a separate thick walled valve body fitted to said opening and joined to said hollow valve body, said sepa-

rate valve body having liquid inlet and outlet openings and a passage provided with a valve seat connecting said liquid inlet and outlet openings, a diaphragm power element means located within and bonded to said hollow valve body adjacent to but having portions spaced from said separate valve body having a stiff heavy wall portion and a thin flexible wall portion joined to enclose a sealed chamber containing a temperature responsive means, a liquid valve located in said separate valve body adjacent to and cooperating with said valve seat to control liquid flow, valve operating means extending from said flexible wall to said liquid valve, said hollow valve body having bonded to it heavy gas inlet and outlet fittings, said hollow valve body having passage means extending around said diaphragm means to the face of said flexible wall portion, a gas valve means located in said hollow valve body between said gas inlet and outlet fittings, a sealed flexible walled evacuated casing operably connected to said gas valve means for operating said gas valve means, said gas valve means including a normally stationary slotted sleeve valve cage portion provided at one end with an interfitting arrangement with said stiff heavy wall portion of said diaphragm means and provided at its opposite end with a sealing arrangement with the portion of said hollow body between said gas inlet and outlet fittings, said gas valve means also including a hollow sleeve valve portion slidably mounted within said sleeve valve cage portion and operably connected to said evacuated casing for covering and uncovering a slot in said slotted sleeve valve cage portion.

6. A combined thermostatic expansion valve and suction line valve including a hollow thin metal valve body

having an opening at one end, a liquid valve arrangement including a separate thick walled valve body fitted to said opening and joined to said hollow valve body, said separate valve body having liquid inlet and outlet openings and a passage provided with a valve seat connecting said liquid inlet and outlet openings, a diaphragm power element means located within and bonded to said hollow valve body adjacent to but having portions spaced from said separate valve body having a stiff heavy wall portion and a thin flexible wall portion joined to enclose a sealed chamber containing a temperature responsive means, a liquid valve located in said separate valve body adjacent to and cooperating with said valve seat to control liquid flow, valve operating means extending from said flexible wall to said liquid valve, said hollow valve body having bonded to it heavy gas inlet and outlet fittings, said hollow valve body having passage means extending around said diaphragm means to the face of said flexible wall portion, a gas valve means located in said hollow valve body between said gas inlet and outlet fittings, a sealed flexible walled evacuated casing operably connected to said gas valve means for operating said gas valve means, said diaphragm means having between said stiff heavy wall portion and said thin flexible wall portion a gas and an absorbent for said gas capable of adsorbing and evolving said gas upon changes in its temperature.

References Cited in the file of this patent

UNITED STATES PATENTS

2,116,801 Shivers ---------------- May 10, 1938