May 13, 1941. T. I. POTTER 2,241,931

THERMOSENSITIVE EXPANSION VALVE

Filed March 13, 1936 2 Sheets-Sheet 1

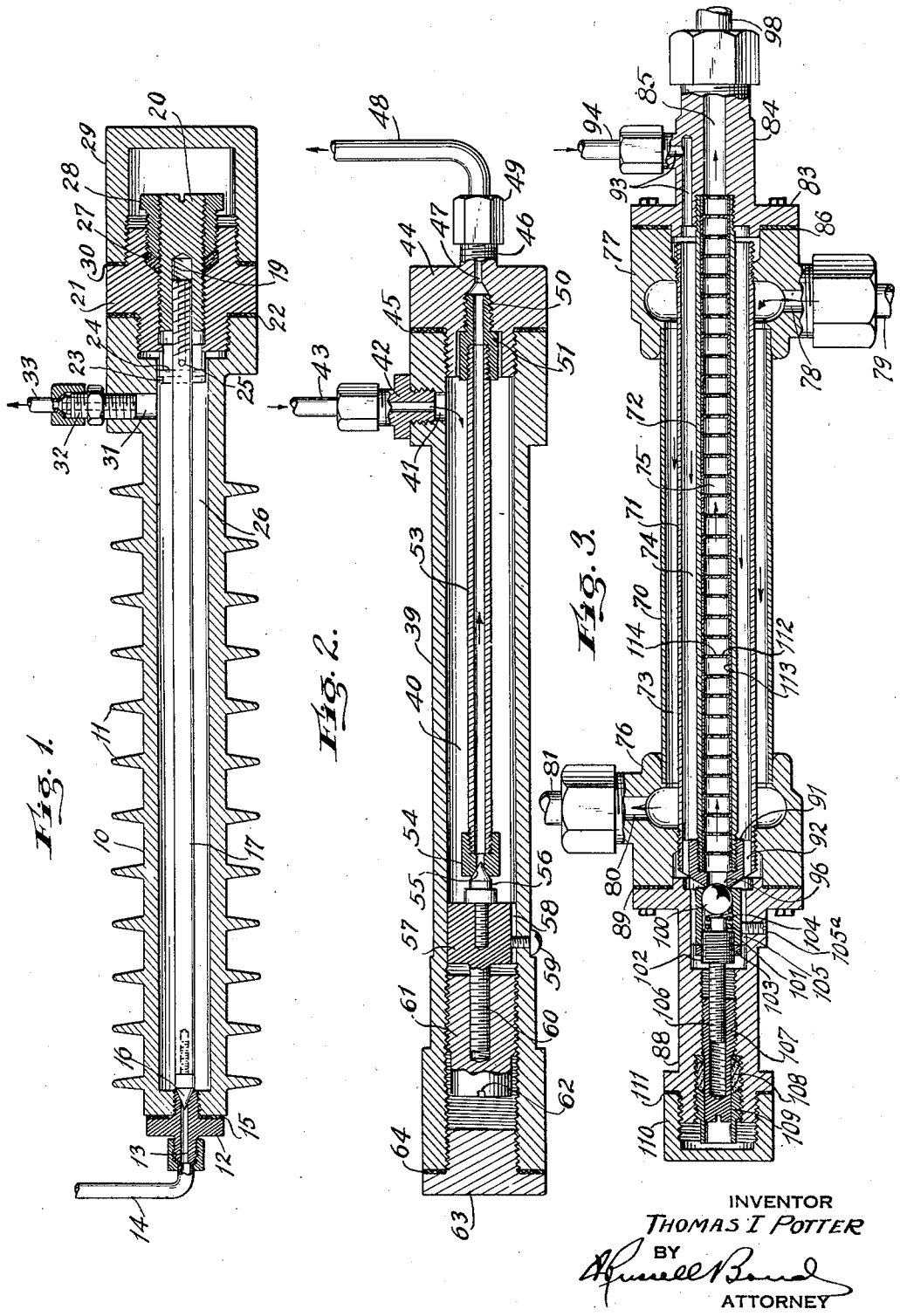


Fig. 1.

Fig. 2.

Fig. 3.

INVENTOR
THOMAS I POTTER
BY
ATTORNEY

May 13, 1941. T. I. POTTER 2,241,931

THERMOSENSITIVE EXPANSION VALVE

Filed March 13, 1936 2 Sheets-Sheet 2

Fig. 4.

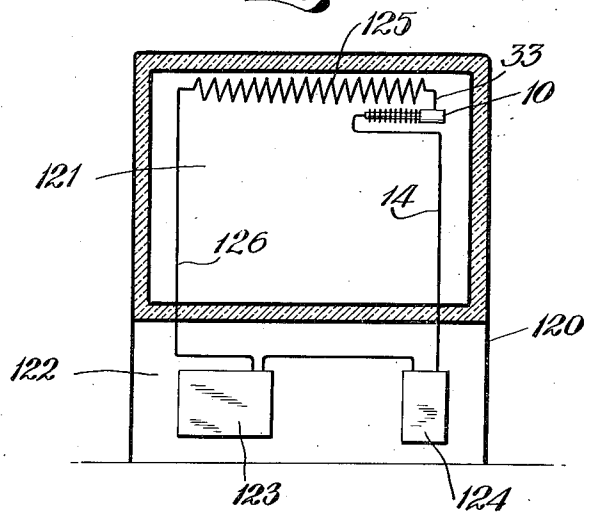
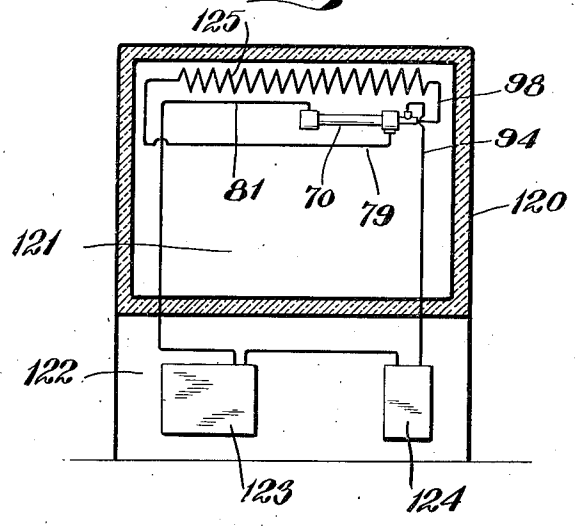


Fig. 5.



INVENTOR
THOMAS I. POTTER.
BY
Frederick S. Duncan, ATTORNEY

Patented May 13, 1941 2,241,931

UNITED STATES PATENT OFFICE

2,241,931

THERMOSENSITIVE EXPANSION VALVE

Thomas I. Potter, Buffalo, N. Y., assignor to Refrigeration Patents Corporation, Buffalo, N. Y., a corporation of New York

Application March 13, 1936, Serial No. 68,770

24 Claims. (Cl. 62—8)

The present invention relates to expansion valves for refrigerating or cooling systems and has for an object to provide an expansion valve which includes thermosensitive means for controlling the passage of refrigerant fluids therethrough.

An object of the invention is to provide an expansion valve having an orifice which will automatically expand and contract to take care of variations in the heat load on the refrigerating system. An advantage of this arrangement is that in a compressor-condenser-expander system the compressor may run continuously instead of intermittently, as has been heretofore the practice, and the control of the cooling or refrigerating effect may be maintained within predetermined limits by automatic adjustment of the expansion valve.

Another object of my invention is to provide an expansion valve which will completely cut off the flow of the refrigerant when for any reason the compressor is stopped, thus preventing flooding of the system with liquid refrigerant.

Still another object of my invention is to provide means for trapping some of the liquid refrigerant in the expansion valve on the low pressure side of the valve so as to prime the valve when starting up the compressor after it has been stopped. In other words, when the valve has been warmed sufficiently to completely close the orifice and the compressor is then started the evaporation of the trapped liquid will serve to cool the expansion valve sufficiently to open the orifice.

Other objects and advantages of my invention will appear in the following description of certain embodiments thereof and thereafter the novelty and scope of the invention will be pointed out in the claims.

In the accompanying drawings;

Figure 1 is a view in longitudinal section of one form of my invention comprising an expansion valve that is sensitive to temperature conditions immediately surrounding the same;

Fig. 2 is a view in longitudinal section of another embodiment of my invention in which the liquid refrigerant jackets one of the expansion elements of the valve;

Fig. 3 is a view in longitudinal section of a jacketed type of expansion valve in which fluid from the discharge end of an evaporator or cooling coil may be passed through the jacket to control the extent of opening of the expansion orifice of the valve;

Fig. 4 is a diagrammatic view of a household refrigerating system, in which the expansion valve shown in Fig. 1 may be incorporated; and Fig. 5 is a diagrammatic view of a similar system in which the valve shown in Fig. 3 may be incorporated.

The expansion valve shown in Fig. 1 comprises a tubular casing 10 formed exteriorly with annular flanges 11 to increase its heat-absorbing area. One end of the tubular casing is closed by a plug 12 having a bore 13 therethrough. A high-pressure refrigerant line 14 is coupled to this plug. A gasket 15 serves to seal the joint between the plug and the casing. At the inner end of the plug there is a conical valve seat for a needle valve 16 carried on the end of a rod 17. This rod extends axially through the casing 10 and at its opposite end is threaded into a bore 19 formed in an adjusting head 20. This adjusting head is, in turn, threaded into a tubular plug 21 closing the adjacent end of the tubular casing 10. A gasket 22 serves to provide a tight seal between the plug and the casing. The plug 21 is formed with a reduced inwardly directed extension 23, which is longitudinally slotted to receive a pin 24 transversely mounted in the rod 17.

The parts are so arranged that, as the head 20 is turned in one direction or the other, it will advance the needle valve 16 toward or withdraw it from its seat, the needle valve being prevented from turning by the pin 24 engaging the slotted extension 23. The pitch of the threads on the rod 17 has a differential relation to the pitch of the threads on the exterior of the plug 20, whereby a fine micrometer adjustment of the needle valve 16 may be obtained. Because the rod is adjustable in the bore 19 of the head 20, means are provided for venting the inner end of said bore. To this end the rod 17 has an axial bore open to the bore 19, communicating through a lateral port 25 with the expansion chamber or annular space 26 between the rod 17 and the casing 10.

In order to prevent leakage along the threaded surface of the adjusting head 20, a packing box is provided. In other words, the bore of plug 21 is enlarged to receive packing material 27 which is compressed about the adjusting head 20 by a gland 28 threaded thereon. A cap 29 is fitted over the gland 28 and is screwed upon a threaded extension of the plug 21. A gasket 30 serves to seal the joint between the cap and the plug.

The chamber 10 has an outlet port 31 adjacent the plug 21. A nipple 32 is threaded into this port and coupled to this nipple is a low pressure or expansion line 33.

The casing 10 of the expansion valve is preferably formed of steel while the rod 17 which car-

ries the needle valve, is preferably formed of brass so that there will be a differential expansion and contraction of these two elements under varying temperature conditions. Obviously, other materials of relatively different coefficients of expansion could be employed for the casing and rod. The parts are so adjusted that except when the refrigerating system is in operation and the expansion valve is cooled below a predetermined temperature, the valve 16 will be in closed position. In order to start operations, there must be a certain amount of liquid refrigerant in the expansion space 26. Initially the expansion valve may be primed by operating the adjusting head 20 to crack open the valve, but under service conditions if the compressor should be stopped, enough refrigerant will accumulate in the expansion line, before the expansion valve is warmed sufficiently to close, to insure the trapping of a small amount of liquid in the expansion chamber.

In Fig. 4 is disclosed a household refrigerating system in which the valve shown in Fig. 1 may be incorporated. Any suitable form of cabinet 120 provided with a cooling chamber 121 and a machinery compartment or space 122 may be employed. The system includes any form of compressor 123, any suitable form of condensor and liquid reservoir 124 and any suitable form of evaporator 125. The reservoir is connected by the high pressure line 14 to the inlet of the expansion valve indicated at 10, the outlet of the expansion valve being connected by the line 33 to one end of the evaporator 125, the other end of which is connected by the line 126 to the low side of the compressor 123.

In use the expansion valve is located in the room or chamber that is being cooled, so as to control temperature conditions therein. Let us assume that the compressor of the refrigerating system controlled by the expansion valve is being started up after a shut-down of sufficient duration to close the expansion orifice of the expansion valve, but that a small amount of liquid refrigerant has been trapped in the expansion chamber. The suction produced by the compressor lowers the boiling point in the expansion line sufficiently to evaporate the trapped liquid, thereby abstracting heat from the casing 10 and rod 17. But the latter is immediately chilled while the casing is kept relatively warm by its greater heat capacity and by the ambient heat flowing in through the flanges. As a result the rod 17 contracts to a much greater degree than does the casing 10, withdrawing valve 16 from its seat and starting the flow of refrigerant through the expansion valve. This differential contraction is further accentuated by the greater coefficient of contraction of the brass rod than of the steel casing. The parts are so proportioned that the expansion orifice will open wide enough to admit a predetermined maximum of refrigerant. However, as the temperature of the cooling chamber is gradually lowered, the casing will contract correspondingly and gradually reduce the expansion orifice. This contraction will continue until the quantity of refrigerant admitted is just sufficient to take care of the heat load on the expansion line, when a balance will be struck. Thereafter, any variation in the heat load will result in a corresponding change in the expansion orifice. For instance, if the expansion valve is located in the food chamber of a household refrigerator, every time the door of the chamber is opened or every time relatively warm food is introduced into the chamber, there will be a rise of temperature in the chamber which will expand the casing 10 and correspondingly expand the orifice to admit a larger stream of refrigerant and increase the refrigerating effect until the extra heat has been carried off, when the casing will again contract to establish the normal working balance.

Under running conditions the length of the valve stem 17 remains substantially constant although there will be some fluctuation, and variation of the expansion orifice will result in variation of pressure in the expansion line with attendant variation of boiling point of the refrigerant. However, after the expansion orifice has been opened by cooling of rod 17 substantially to the temperature of the expanding refrigerant further adjustment of the orifice, as long as the compressor is operating, will be controlled mainly by contraction and expansion of the casing 10 which directly reflects ambient temperature conditions. One of the reasons for making the valve stem 17 of a metal having a higher coefficient of expansion than that of the valve casing, is to prevent the orifice from being throttled too much or entirely closing as the ambient temperature approaches the temperature of the expanding refrigerant. Manifestly, if the casing and the valve stem had the same coefficient of expansion the orifice would be closed whenever the casing and stem were of the same temperature no matter what that temperature was, and if the casing cooled down to the temperature of the refrigerant in chamber 26 the valve orifice would entirely close. This, however, cannot occur where the stem has a higher coefficient of contraction than the casing. The orifice must remain open while the compressor is running. When the compressor is stopped and the expansion valve is allowed to warm up, both the casing and the valve stem will expand, but the latter because of its higher coefficient of expansion will overtake the casing and close the expansion orifice at a predetermined temperature, not, however, before enough refrigerant has been admitted to the expansion line to build up a pressure therein sufficient to trap and maintain some of the refrigerant in liquid form in chamber 26. The expansion valve is the coldest point in the expansion line and the liquid refrigerant in chamber 26 will be the last to vaporize. Preferably the expansion valve is located at a low point in the expansion line and this line leads out of the upper side of chamber 26, as shown in Fig. 1, so that there will be no danger of draining out the liquid trapped in said chamber. It is the compressor which, by lowering the boiling point in the expansion line, causes the expansion orifice to open and keep open. Hence, when the compressor is shut down the orifice will close, preventing flooding of the expansion line, so that on restarting the compressor there will be no slugs of liquid drawn therein which might cause the compressor damage.

The expansion valve shown in Fig. 2 differs from that shown in Fig. 1, in that the incoming liquid refrigerant jackets the expansion chamber, being interposed between the latter and the outside casing of the valve. The valve proper or closure member is carried by said casing while the seat for the closure member is carried by a tube in which the expansion chamber is formed. The differential expansion and contraction of the tube and casing control the size of the expansion orifice.

The outer shell or casing 39 of the valve encloses an intake chamber 40. Opening through the wall of the casing into this chamber near

one end thereof is an inlet port 41. Screwed into this port is a nipple 42 to which is coupled the high pressure refrigerant supply line 43. The chamber 40 is closed at the end adjacent the inlet port by a plug 44 screwed into the casing. The plug has an enlarged head portion which overlaps the end of the casing, and between said end and said head a gasket 45 is introduced to provide a gas-tight seal. The plug has a reduced outer extension 46 which is externally threaded, and an axial bore 47 extends through the plug and said extension. An outlet pipe 48 may be connected by a coupling 49 to the extension 46 and in communication with said bore.

The bore of the plug is enlarged at its inner end and has a threaded portion into which is screwed the stem 50 of a tubular holder 51. Tightly screwed into this holder is an inner tube 53 which is disposed axially in the chamber 40. The opposite end of the tube 53 is provided with a tubular enlargement 54 having a conical orifice 55. This orifice forms a seat for a conical valve or closure member 56 carried by a valve-head 57. The valve-head is fitted to slide within the casing 39. To prevent the valve-head from turning it is formed with a keyway 58 which is engaged by the end of a screw 59 threaded through the side wall of the tubular casing 39.

The valve head 57 is formed with a stem 60 which is threaded into an adjusting plug 61 and said plug in turn has threaded engagement with the casing 39. The pitch of the threads on the outer surface of the plug 61 has a differential relation to that of the threads on the stem 60 such that upon turning the plug 61 a micrometer adjustment of the needle valve 56 will be obtained. The adjusting plug may be formed with a transverse slot 62 to receive a screw-driver for effecting the desired adjustment of the valve 55. A screw plug 63 closes the adjacent end of the tubular casing 39, and is formed with a headed portion overlapping the end of the casing, so that a gasket 64 may be introduced between the head and the casing to provide a gas tight seal. The operation of this expansion valve is similar to that shown in Fig. 1 and may be connected in a refrigerating system in the same manner as the valve shown in Fig. 1 as illustrated in Fig. 4. Starting from the closed position shown in Fig. 2, with some liquid refrigerant trapped in the tube 53, when the compressor is operated and lowers the pressure in tube 53, the liquid therein boils, chilling and contracting the tube and withdrawing the valve seat member 54 from the closure member 56, thereby opening the expansion orifice 55. The casing 39 is protected from the chilling effect of the expanding refrigerant by the intervening jacket of liquid refrigerant filling chamber 40. The inlet pipe 43 is of copper or other metal of high thermal conductivity so that the liquid refrigerant is chilled as it is being led through the chamber that is being cooled. Thus, the liquid refrigerant in chamber 40 is at approximately the same temperature as that of the air surrounding the expansion valve. Because of the far greater heat absorbing area of the outer casing 39 than of the inner tube 53 the liquid refrigerant in chamber 40 will directly reflect ambient temperature conditions and will be only slightly affected by temperature variations within tube 53. The casing 39 is thus to a large extent insulated from tube 53.

As the ambient temperature is reduced by the evaporator (not shown) served by the expansion valve, the casing 39 contracts, gradually closing the expansion orifice and reducing the refrigerating effect until a balance is reached. The expansion valve seeks to maintain the balance, automatically opening to increase the refrigerating effect or closing to reduce the refrigerating effect. However, because of the intervening liquid in chamber 40 the casing 39 would never, under normal working conditions, contract enough to close the orifice completely. The casing 39 and tube 53 could therefore be made of the same metal. However, I find it preferable to use a metal of higher coefficient of expansion and contraction for the inner tube 53 so as to increase the relative movement of the tube and casing under varying temperature conditions. It will be understood that the parts are so designed and the expansion valve is so located in the refrigerant system that when the compressor is stopped, before the expansion orifice is completely closed a certain amount of liquid will be trapped in tube 53, so that the orifice may be automatically reopened when the compressor is started up again.

The preferred form of my invention is illustrated in Fig. 3. This form of expansion valve when used in a household refrigerating system may be connected in the system as disclosed in Fig. 5, the corresponding parts in Figs. 3 and 5 bearing the same reference characters. In this device there is an outer tube 70, an intermediate tube 71 and an inner tube 72 all annularly spaced and preferably concentrically mounted so that a chamber 73 is provided between tubes 70 and 71 and an intermediate chamber 74 is provided between tubes 71 and 72. Within the tube 72 there is the expansion chamber 75. Mounted on opposite ends of the outer tube 70 are collars 76 and 77 respectively, in which the intermediate tube 71 is threaded, thus closing opposite ends of the outer chamber 73. A port 78 in the collar 77 communicates with one end of the outer chamber 73 and is provided with means for coupling an inlet tube 79 thereto. In the collar 76 there is an outlet port 80 for the outer chamber 73 provided with means for coupling an outlet tube 81 thereto. The intermediate chamber 74 is closed at one end by a flange plate 83 secured to the outer face of the collar 77. This flange plate is formed with a tubular projection 84 in the bore 85 of which is threaded the adjacent end of the tube 72. A gasket 86 between the flange plate 83 and the collar 77 serves to provide a gas-tight seal. The opposite end of the chamber 74 is closed by a flanged tubular fitting 88 suitably secured to the outer face of the collar 76 with a gasket 89 therebetween to provide a gas-tight seal.

The free end of the tube 72, that is the left hand end, as viewed in Fig. 3, is provided with a collar 91 which has a sliding fit in the tube 71. The purpose of this is to give support to the free end of the tube 72. However, to prevent the collar from plugging the tube 71 it is fluted to form passages 92. In this way free communication is provided between the body of the chamber 74 and the extremity thereof beyond the collar 91. Refrigerant is introduced into the intermediate chamber 74 through a port 93 at the right hand end of the device, as shown in Fig. 3, said port being suitably coupled to a refrigerant supply pipe 94. This refrigerant goes to the opposite end of the chamber 74 through the passages 92 and thence through an expansion orifice 96 formed in the collar 91 and into the expansion chamber 75. The fluid then flows out through

the bore 85 into an expansion line 98 suitably coupled to the extension 84.

The admission of fluid from chamber 74 through the expansion orifice 96 is controlled by a ball valve 100. The ball is mounted in a sleeve 101 which is threaded upon a plug 102 and secured thereon at desired adjustment by a lock nut 103. The sleeve 101 is peened at its exposed end so that the ball 100 may project slightly from the end of the tube but cannot pass out of the tube. A spring 104 between the plug 102 and the ball normally presses the ball outwardly or toward the adjacent end of the tube 72. However, the ball may be depressed to a limited extent for a purpose which will be explained hereinafter. The plug 102 is provided with a lug which limits the extent to which the ball may be depressed.

The sleeve 101 is longitudinally grooved, as indicated at 105, so that liquid refrigerant may freely pass to the inner end thereof, that is the left hand end, as viewed in Fig. 3. One of these slots is engaged by a set screw 105*a*, which prevents the sleeve from turning with respect to the fitting 88. However, as will now be explained, means are provided for feeding the tube 101 toward and from the collar 91 to adjust the expansion orifice 96.

The plug 102 has a stem 106 which is threaded into the bore of a tubular screw 107, and the latter in turn is threaded into the bore of the tubular fitting 88. The outer threads of the tubular screw are of slightly different pitch from that of the inner threads, so that when the screw is turned the plug and with it the sleeve 101, will be moved with a micrometer adjustment.

To prevent leakage along the screw 107 it is surrounded near its outer end with packing material 108 suitably compressed by a gland 109. A cap 110 is screwed upon the outer end of the fitting 88 and a gas-tight seal for the cap is provided by a gasket 111.

The expansion chamber 75 is sub-divided into a plurality of chambers which are in communication with one another along the central axis of the tube 72. These sub-divisions are formed by inserting into the tube a series of washers 112 each formed with a peripheral flange 113 to space the washer from the next adjacent washer and each washer is formed with a central aperture 104. The operation of this expansion valve is similar to that of Fig. 2 except that contraction and expansion of the outer casing is controlled by temperature of the expanded refrigerant returning from the evaporator. In other words, the length of that portion which carries the ball 100 is controlled by the heat being absorbed by the evaporator. The greater this heat load the wider will the expansion orifice open, and vice versa. As in the valve shown in Fig. 2, the casing, which in this case comprises walls 70 and 71, is substantially insulated from the inner tube 72 by the intervening layer of relatively warm liquid refrigerant filling chamber 74. For this reason it is not necessary to use metals of different coefficients of expansion, because when the system is operating the inner tube will always be materially cooler than the casing. This is accentuated by the fins 112 within the tube 72 which radiate heat to the expanding refrigerant faster than it can flow into the tube from the relatively warm liquid refrigerant in chamber 74. The use of a ball valve 100 on a relatively large seat permits of a large opening with a comparatively slight differential expansion of the parts.

When for any reason the apparatus is closed down and the refrigerant is allowed to grow warm the inner tube will expand sufficiently to close the orifice 96. The relative expansion of the tube 72 with respect to the casing 70—71 will cause the collar 91 to press against the ball 100, completely closing the orifice 96. If the parts are still farther expanded after complete closure takes place, spring 105 will yield and prevent damage to any of the parts.

The cup-shaped washers 112 in the expansion chambers 75 serve not only as heat radiating fins but are also useful to retain a certain amount of liquid refrigerant in this chamber, so that after the apparatus has been closed down and the orifice 96 has been completely closed sufficient refrigerant will be trapped in chamber 75 to permit of restarting the automatic control without priming.

While I have described a preferred embodiment of my invention and certain modifications thereof it will be understood that these are to be taken as illustrative and not limitative of the invention and that I reserve the right to make various changes in form, construction and arrangements of parts without departing from the spirit and scope of my invention as pointed out in the following claims.

I claim:

1. An expansion valve for controlling the expansion of compressed refrigerant in a compressor-condenser-expander system, said valve comprising two rigid elongated members subject to thermal expansion and contraction, one of the members enclosing the other and shielding the same from ambient temperatures, one of the members forming an expansion chamber and having a port at one end of said chamber constituting the sole inlet for admission of said refrigerant to the chamber, and a closure for said port carried by the other member at the adjacent end thereof, the two members being secured to each other at the other end of said chamber, said chamber being defined at least in part by the inner member whereby said inner member will be chilled by expansion of the refrigerant in said chamber and the port will be variably opened by contraction and closed by expansion of the inner member with respect to the outer member.

2. An expansion valve for controlling the expansion of compressed refrigerant in a compressor-condenser-expander system, said valve comprising two rigid elongated members subject to thermal expansion and contraction, one of the members enclosing the other and shielding the same from ambient temperatures, one of the members forming an expansion chamber and having a port constituting the sole inlet for admission of said refrigerant to the chamber, and a closure for said port carried by the other member at the adjacent end thereof, the two members being secured to each other at their other ends, said chamber being defined at least in part by the inner member whereby said inner member will be chilled by expansion of the refrigerant in said chamber and the port will be variably opened and closed by differential contraction and expansion of the two members, said members being so related that when both are at a predetermined normal temperature the port will be completely closed.

3. An expansion valve for controlling the expansion of compressed refrigerant in a compressor-condenser-expander system, said valve com-

prising two rigid elongated members disposed one within the other and the inner member having a higher coefficient of expansion than the outer member, one of the members forming an expansion chamber and having a port constituting the sole inlet for admission of said refrigerant to the chamber, and a closure for said port carried by the other member at the adjacent end thereof, the two members being secured to each other at their other ends, said chamber being defined at least in part by the inner member whereby said inner member will be chilled by expansion of the refrigerant in said chamber and the port will be variably opened and closed by differential contraction and expansion of the two members.

4. An expansion valve for controlling the expansion of compressed refrigerant in a compressor-condenser-expander system, said valve comprising two rigid elongated members disposed one within the other and the inner member having a higher coefficient of expansion than the outer member, one of the members forming an expansion chamber and having a port constituting the sole inlet for admission of said refrigerant to the chamber, and a closure for said port carried by the other member at the adjacent end thereof, the two members being secured to each other at their other ends, said chamber being defined at least in part by the inner member whereby said inner member will be chilled by expansion of the refrigerant in said chamber and the port will be variably opened and closed by differential contraction and expansion of the two members, said members being so related that when both are at a predetermined normal temperature the port will be completely closed.

5. An expansion valve for controlling the expansion of compressed refrigerant in a compressor-condenser-expander system, said valve comprising two rigid elongated members disposed one within the other and the inner member having a higher coefficient of expansion than the outer member, one of the members forming an expansion chamber and having a port for admission of said refrigerant to the chamber, and a closure for said port carried by the other member at the adjacent end thereof, the two members being secured to each other at their other ends, said chamber being defined at least in part by the inner member whereby said inner member will be chilled by expansion of the refrigerant in said chamber and the port will be variably opened and closed by differential contraction and expansion of the two members, the inner member being formed with heat radiating fins projecting into the expansion chamber.

6. An expansion valve for controlling the expansion of compressed refrigerant in a compressor-condenser-expander system, said valve comprising two rigid thermo-expansive members disposed one within the other and providing an expansion chamber therebetween, a port at one end of the outer member constituting the sole inlet for admission of refrigerant to the chamber, and a closure for said port carried by the inner member at the adjacent end thereof, the two members being secured to each other at their other ends whereby the port will be variably opened and closed by differential contraction and expansion of the two members.

7. An expansion valve for controlling the expansion of compressed refrigerant in a compressor-condenser-expander system, said valve comprising two rigid thermo-expansive members disposed one within the other and providing an expansion chamber therebetween, a port at one end of the outer member constituting the sole inlet for admission of refrigerant to the chamber, and a closure for said port carried by the inner member at the adjacent end thereof, the two members being secured to each other at their other ends whereby the port will be variably opened and closed by differential contraction and expansion of the two members, one of the members being formed with flanges to increase the heat transfer area thereof.

8. An expansion valve for controlling the expansion of compressed refrigerant in a compressor-condenser-expander system, said valve comprising two rigid thermo-expansive members disposed one within the other and providing an expansion chamber therebetween, a port at one end of the outer member constituting the sole inlet for admission of refrigerant to the chamber, and a closure for said port carried by the inner member at the adjacent end thereof, the two members being secured to each other at their other ends whereby the port will be variably opened and closed by differential contraction and expansion of the two members, the outer member being formed exteriorly with flanges to increase the heat absorbing area thereof.

9. An expansion valve for controlling the expansion of compressed refrigerant in a compressor-condenser-expander system, said valve comprising two rigid members disposed one within the other and providing an expansion chamber therebetween, the inner member having a higher coefficient of expansion than that of the outer member, a port at one end of the outer member constituting the sole inlet for admission of refrigerant to said chamber, and a closure for said port carried by the inner member at the adjacent end thereof, the two members being secured to each other at their other ends whereby the port will be variably opened by differential contraction and closed by differential expansion of the two members.

10. An expansion valve for controlling the expansion of compressed refrigerant in a compressor-condenser-expander system, said valve comprising two rigid members disposed one within the other and providing an expansion chamber therebetween, the inner member having a higher coefficient of expansion than that of the outer member, a port at one end of the outer member constituting the sole inlet for admission of refrigerant to said chamber, and a closure for said port carried by the inner member at the adjacent end thereof, the two members being secured to each other at their other ends whereby the port will be variably opened by differential contraction and closed by differential expansion of the two members, the members being so related that when both are at a predetermined normal temperature the port will be completely closed.

11. An expansion valve for controlling the expansion of compressed refrigerant in a compressor-condenser-expander system, said valve comprising a tubular casing member providing an expansion chamber and having an inlet port at one end and an outlet port at the other end thereof, a valve controlling the inlet port, and a rigid stem member for the valve within the chamber and secured to the casing adjacent the outlet port, the stem member having a higher coefficient of expansion than that of the casing member, one of the members being formed with

flanges to increase the heat transfer surface thereof.

12. An expansion valve for controlling expansion of compressed refrigerant in a compressor-condenser-expander system, said valve comprising a tubular casing providing an expansion chamber and having an inlet port at one end and an outlet port at the other, a valve controlling the inlet port, a rigid stem for the valve within the chamber and secured to the casing adjacent the outlet port, said stem having a higher coefficient of expansion than that of the casing, and flanges exteriorly disposed on the casing to increase the heat transfer area thereof.

13. An expansion valve for controlling the expansion of compressed refrigerant in a compressor-condenser-expander system, said valve comprising two thermoexpansive tubular members disposed one within the other and secured together at one end, the inner member forming an expansion chamber and having a port at its free end for admission of said refrigerant to said chamber, and a closure carried by the outer member for controlling admission of refrigerant through said port, the members being so related that the port will be variably opened by contraction and closed by expansion of the inner member with respect to the outer member.

14. An expansion valve for controlling the expansion of compressed refrigerant in a compressor-condenser-expander system, said valve comprising two thermoexpansive tubular members disposed one within the other and secured together at one end, the inner member forming an expansion chamber and having a port at its free end for admission of said refrigerant to said chamber, and a closure carried by the outer member for controlling admission of refrigerant through said port, the members being so related that the port will be variably opened by contraction and closed by expansion of the inner member with respect to the outer member but will be completely closed when both members are at a predetermined normal temperature.

15. An expansion valve for controlling the expansion of compressed refrigerant in a compressor-condenser-expander system, said valve comprising two thermoexpansive tubular members disposed one within the other and secured together at one end, the inner member forming an expansion chamber and having a port at its free end for admission of said refrigerant to said chamber, a closure adapted to control admission of refrigerant through said port, a resilient mounting for the closure carried by the outer member, the members being so related that the port will be variably opened by contraction and closed by expansion of the inner member with respect to the outer member but will be completely closed when both members are at a predetermined normal temperature.

16. An expansion valve for controlling the expansion of compressed refrigerant in a compressor-condenser-expander system, said valve comprising two thermoexpansive tubular members disposed one within the other in annular spaced relation and secured together at one end, means for supplying compressed refrigerant to the space between the members, the inner member being formed with an expansion chamber and having a port at its free end for admission of refrigerant to said chamber, a closure carried by the outer member for controlling admission of refrigerant into said port, the member being so related that the port will be variably opened by contraction and closed by expansion of the inner member with respect to the outer member.

17. An expansion valve for controlling the expansion of compressed refrigerant in a compressor-condenser-expander system, said valve comprising two thermoexpansive tubular members disposed one within the other in annular spaced relation and secured together at one end, means for admitting compressed refrigerant to the space between the members, the inner member forming an expansion chamber and having a port at its free end for admission of the refrigerant from said space to said chamber, and a closure carried by the outer member and adapted to control said port, the members being so related that the port will be variably opened by contraction and closed by expansion of the inner member with respect to the outer member but will be completely closed when both members are at a predetermined normal temperature.

18. An expansion valve for controlling the expansion of compressed refrigerant in a compressor-condenser-expander system, said valve comprising two thermoexpansive tubular members disposed one within the other in annular spaced relation and secured together at one end, means for admitting compressed refrigerant to the space between the members, the inner member forming the expansion chamber and having a port at its free end for admission of the refrigerant from said space to said chamber, and a closure carried by the outer member and adapted to control said port, the members being so related that the port will be variably opened by contraction and closed by expansion of the inner member with respect to the outer member, but will be completely closed when both members are at a predetermined normal temperature, and fins on the inner surface of the inner member to increase the heat transfer area thereof.

19. An expansion valve for controlling the expansion of compressed refrigerant in a compressor-condenser-expander system, said valve comprising two thermoexpansive tubular members disposed one within the other in annular spaced relation and secured together at one end, means for admitting compressed refrigerant to the space between the members, the inner member forming the expansion chamber and having a port at its free end for admission of the refrigerant from said space to said chamber, a closure carried by the outer member and adapted to control said port, the members being so related that the port will be variably opened by contraction and closed by expansion of the inner member with respect to the outer member but will be completely closed when both members are at a predetermined normal temperature, the inner member being formed interiorly with annular flanges.

20. An expansion valve for controlling expansion of compressed refrigerant in a compressor-condenser-expander system, said valve comprising three thermoexpansive tubular members disposed one within another to form an outer annular chamber, an intermediate annular chamber and an inner expansion chamber, the outer and intermediate tubular members being secured to each other at each end to form a double wall casing and to isolate the outer chamber from the intermediate chamber, the inner tubular member being fixed to said casing at one end and having a port at the other end for providing communication between the intermediate and expansion chambers, an inlet

port at the end of the intermediate chamber at which the inner tubular member is fixed to said casing for admitting compressed refrigerant from the condenser of said system to the intermediate chamber, an outlet port at the fixed end of the expansion chamber adapted to be connected to the expander of said system, provided at one end with an inlet port adapted to be connected to the low side of the expander of said system and provided at the other end with an outlet port adapted to be connected to the low side of the compressor of said system, and a closure for said port carried by the casing, the members being so related that the port will be variably opened by contraction and closed by expansion of the inner member with respect to the casing but will be completely closed when both members are at a predetermined normal temperature.

21. An expansion valve for controlling expansion of compressed refrigerant in a compressor-condenser-expander system, said valve comprising three thermoexpansive tubular members disposed one within another to form an outer annular chamber, an intermediate annular chamber and an inner expansion chamber, the outer and intermediate tubular members being secured to each other at each end to form a double wall casing and to isolate the outer chamber from the intermediate chamber, the inner tubular member being fixed to said casing at one end and having a port at the other end for providing communication between the intermediate and expansion chambers, an inlet port at the end of the intermediate chamber at which the inner tubular member is fixed to said casing for admitting compressed refrigerant from the condenser of said system to the intermediate chamber, an outlet port at the fixed end of the expansion chamber adapted to be connected to the expander of said system, provided at one end with an inlet port adapted to be connected to the low side of the expander of said system and provided at the other end with an outlet port adapted to be connected to the low side of the compressor of said system, and a closure for said port carried by the casing, the members being so related that the port will be variably opened by contraction and closed by expansion of the inner member with respect to the casing but will be completely closed when both members are at a predetermined normal temperature, the inner member being formed interiorly with annular flanges.

22. An expansion valve for controlling expansion of compressed refrigerant in a compressor-condenser-expander system, said valve comprising three thermoexpansive tubular members disposed one within another to form an outer annular chamber, an intermediate annular chamber and an inner expansion chamber, the outer and intermediate tubular members being secured to each other at each end to form a double wall casing and to isolate the outer chamber from the intermediate chamber, the inner tubular member being fixed to said casing at one end and having a port at the other end for providing communication between the intermediate and expansion chambers, an inlet port at the end of the intermediate chamber at which the inner tubular member is fixed to said casing for admitting compressed refrigerant from the condenser of said system to the intermediate chamber, an outlet port at the fixed end of the expansion chamber adapted to be connected to the expander of said system, said outer chamber being provided at one end with an inlet port adapted to be connected to the low side of the expander of said system and at the other end with an outlet port adapted to be connected to the low side of the compressor of said system, a closure for said port carried by the casing, the members being so related that the port will be variably opened by contraction and closed by expansion of the inner member with respect to the casing but will be completely closed when both members are at a predetermined normal temperature, the inner member being formed interiorly with heat radiating fins.

23. An expansion valve for controlling expansion of compressed refrigerant in a compressor-condenser-expander system, said valve comprising three thermoexpansive tubular members disposed one within another to form an outer annular chamber, an intermediate annular chamber and an inner expansion chamber, the outer and intermediate tubular members being secured to each other at each end to form a double wall casing and to isolate the outer chamber from the intermediate chamber, the inner tubular member being fixed to said casing at one end and having a port at the other end for providing communication between the intermediate and expansion chambers, an inlet port at the end of the intermediate chamber at which the inner tubular member is fixed to said casing for admitting compressed refrigerant from the condenser of said system to the intermediate chamber, an outlet port at the fixed end of the expansion chamber adapted to be connected to the expander of said system, said outer chamber being provided at one end with an inlet port adapted to be connected to the low side of the expander of said system and at the other end with an outlet port adapted to be connected to the low side of the compressor of said system, a closure for said port, and a mounting for the closure secured to the casing and including a spring backing for said closure, the members being so related that the port will be variably opened by contraction and closed by expansion of the inner member with respect to the casing but will be completely closed when both members are at a predetermined normal temperature.

24. An expansion valve for controlling expansion of compressed refrigerant in a compressor-condenser-expander system, said valve comprising three thermoexpansive tubular members disposed one within another to form an outer annular chamber, an intermediate annular chamber and an inner expansion chamber, the outer and intermediate tubular members being secured to each other at each end to form a double wall casing and to isolate the outer chamber from the intermediate chamber, the inner tubular member being fixed to said casing at one end and having a port at the other end for providing communication between the intermediate and expansion chambers, an inlet port at the end of the intermediate chamber at which the inner tubular member is fixed to said casing for admitting compressed refrigerant from the condenser of said system to the intermediate chamber, an outlet port at the fixed end of the expansion chamber adapted to be connected to the expander of said system, said outer chamber being provided at one end with an inlet port adapted to be connected to the low side of the expander of said system and at the other end with an outlet port adapted to be connected to

the low side of the compressor of said system, a closure for said port, and a mounting for the closure secured to the casing and including a spring backing for said closure, the members being so related that the port will be variably opened by contraction and closed by expansion of the inner member with respect to the casing but will be completely closed when both members are at a predetermined normal temperature, the inner member being formed interiorly with annular flanges.

THOMAS I. POTTER.