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REFRIGERANT FLOW CONTROL

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FIG. 1.

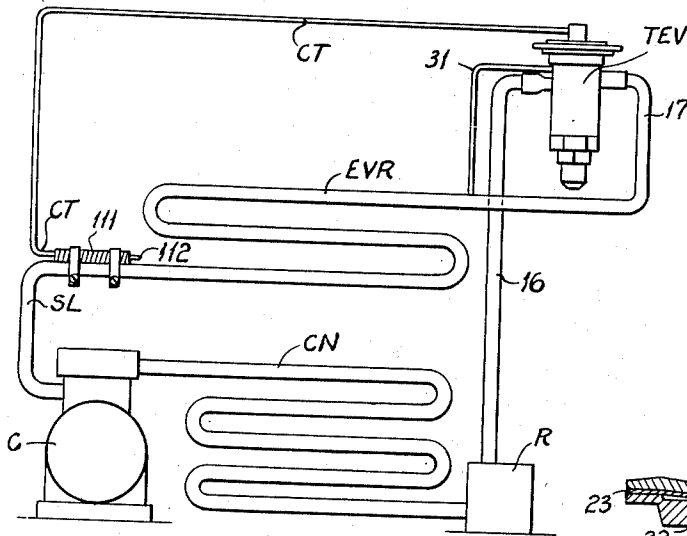


FIG. 2.

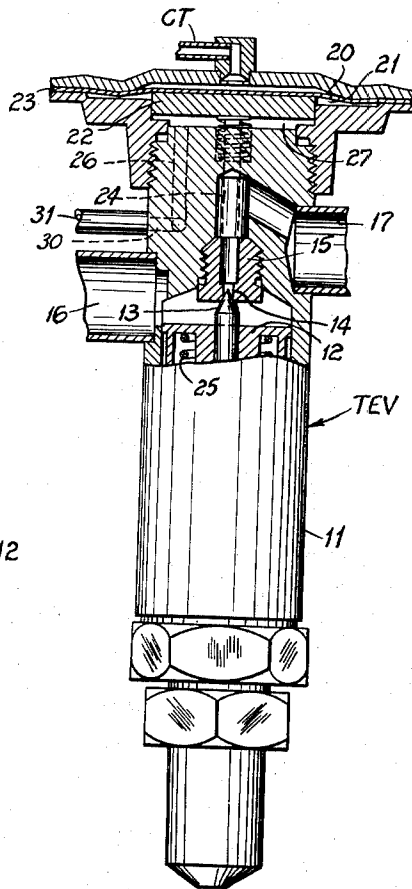
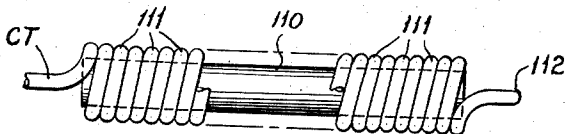


FIG. 3.



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UNITED STATES PATENT OFFICE

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REFRIGERANT FLOW CONTROL

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poration of Missouri

Original application October 9, 1947, Serial No.
778,814, now Patent No. 2,573,151, dated Octo-
ber 30, 1951. Divided and this application Au-
gust 20, 1951, Serial No. 242,657

3 Claims. (Cl. 62-8)

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This invention relates to improvements in re-
frigerant flow control, and more particularly to
improved means for the regulation of refrigerant
expansion valves as employed in systems of com-
pressor-condenser-evaporator type.

In the operation of refrigeration systems there
has been accepted as inevitable, certain undesir-
able irregularities in the operation of the expan-
sion valve or equivalent control agencies, specifi-
cally the effect known as hunting or cycling. Just a few of the factors contributing to this op-
erational difficulty are the many characteristics
of valve design, the extent of the refrigerant cir-
cuit, the lag through the evaporator and usual
nature of response of a thermo-sensitive element
such as a control bulb. This hunting effect tends
to cause unstable evaporator conditions, which
adversely affect the compressor performance due
to resulting wide variation and frequency of
fluctuations in suction pressures. The difficulty
may be overcome to a considerable degree if the
response of the valve to sudden thermal changes
be delayed, or if the valve be permitted to move
only at a reduced rate under certain conditions.

Among the few successful structural proposals
which have been presented for the correction of
this condition is the arrangement covered by a
copending application of this applicant bearing
Serial No. 778,814, filed October 9, 1947, now Pat-
ent No. 2,573,151, granted October 30, 1951, and
entitled "Refrigerant Expansion Valve," of which
the instant application is a division. The ele-
ments therein disclosed and claimed offer an ef-
fective arrangement to overcome the noted dif-
ficulties, obtaining optimum results without the
addition of moving parts, and at a virtually negli-
gible increase in cost over certain prevailing sys-
tems. Accordingly, the present invention has as
a principal object to overcome, at least substan-
tially, the hunting and cycling effects in a sys-
tem of the type noted, and to realize this result
by a structure which does not increase to any
important extent the cost of prevalent systems
and apparatus.

Another important object is attained through
the inclusion of an improved thermal sensing ele-
ment, which is so constructed as to maintain a
desirable character of response throughout nor-
mal operating conditions of a compressor-con-
denser-evaporator system, and yet afford
markedly differential rates of valve opening and
closing response under abnormal operating con-
ditions.

The foregoing and numerous other objects will
more clearly appear from the following detailed

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description of a preferred embodiment, particu-
larly when considered in connection with the
accompanying drawing, in which:

Fig. 1 is a schematic diagram of a refrigeration
system embodying the novel thermal sensing ele-
ment;

Fig. 2 is an enlarged side elevation, partly in
section, showing a refrigerant expansion valve
suitable for use with the present improvements;
and

Fig. 3 is a side elevation, with portions broken
away for clearness, of the novel thermal respon-
sive element.

Referring now by characters of reference to
the drawing, a typical compressor-condenser-
evaporator system is shown diagrammatically by
Fig. 1, principally for completeness of disclosure,
and includes a compressor C serving to discharge
the compressed refrigerant to the condenser CN,
the latter in turn delivering into a receiver R,
from which the liquid is transferred to a thermo-
static expansion valve TEV controlling the flow
of refrigerant to an evaporator generally indi-
cated at EVR, the evaporator being connected
through the suction line SL back to the intake
side of the compressor C, completing the closed
system. A thermal responsive element 111 is em-
ployed to control the expansion valve, and is op-
eratively connected as through capillary tubing
CT to a diaphragm chamber in the valve assem-
bly proper, as will later appear.

The thermostatic expansion valve is or may be
of itself of a known commercially successful type,
and includes a housing or casing 11, enclosing
a reciprocally movable valve guide 12, a valve
member 13 carried axially by the guide and op-
erable to open and close a valve seat 14, the seat
being formed on a replaceable threaded element
15 provided with a bore or flow passage there-
through. It is apparent that throttling move-
ments of the valve control the flow of liquid
through the inlet tubing and a connection 17, to
an outlet fitting 16 connected to the evaporator
EVR. (See Fig. 2.)

As is usual in thermostatic expansion valve
assemblies, there is provided an expansible ele-
ment such as a diaphragm 20, capable of flexing
action in or adjacent a diaphragm chamber 21,
under the influence of volume changes occurring
by reason of thermal effects imparted to the sen-
sing element 111 in response to changes in super-
heat in the suction line SL. A follower plate 22
underlies the diaphragm 20 as viewed in Fig. 2,
the diaphragm being peripherally positioned in
fluid tight relation as by a suitable metal seal 23

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between the companion parts of the diaphragm enclosure. Motion of the diaphragm and follower is imparted to the guide 12, and hence to valve member 13, through a plurality of push rods, only one of which is shown, being indicated at 24 in dotted lines. Fluid pressure transmitted through the capillary tubing CT to the chamber 21 acts to urge the diaphragm and follower inwardly with a valve opening action, such action being opposed by the valve spring 25.

The foregoing description of the expansion valve is included principally for completeness, the structure as shown and described being substantially that of a unit of this type sold as the type "L" valve assembly of Sporlan Valve Company of St. Louis, Missouri. The valve structure further includes a portion of a so-called equalizer passage, although in certain installations this may be omitted without affecting the operation of the valve. When employed, the equalizer passage includes a bore 26 extended into a chamber 27 below the follower 22, the latter having plenary marginal clearance to assure that the diaphragm is affected by suction pressure. The equalizer passage is continued outwardly of the body of the valve by a short horizontal bore 30, through the tubing 31 communicating with the inlet end of the evaporator. It is now apparent that the chamber 27 below the follower and diaphragm is subject at all times to pressure conditions existing at the evaporation inlet, which pressure, acting in conjunction with the spring 25, tends to bias valve 13 toward closed position against its seat 14, and in opposition to pressure above the diaphragm.

Referring now more particularly to the structure exemplifying the invention currently claimed, there is shown by Fig. 3 a thermal sensing element consisting of a number of adjacent spiral turns of capillary tubing wound upon and contiguous to an elongated core or mass, preferably formed of a material having a greater heat capacity than that of the material of the surrounding tubing, and indicated at 110. The several turns of tubing form, in effect, a bulb or cell, being indicated at 111. One end of the capillary tubing is indicated at 112, and may be utilized as a charging connection and sealed off after the fill of the chamber formed by the several turns 111, the opposite end of the tubing being connected to, or forming a continuation of the line CT. It is apparent that there is virtually only a line contact between the several turns of tubing 111 and the core 110, highly restricting the thermal path between the suction line to which the sensing element is attached, and the core 110.

The charge, particularly the fluid content of the turns of tubing 111, consists preferably of a fluid having characteristics approaching or identical with those of the refrigerant employed in the system, and will usually consist of Freon 12, methyl chloride or any other of the refrigerants selected for the system according to preference and field of usage. It is assumed that the fluid charge of the coiled tubular element 111 and the tubing CT will, throughout the temperature range of the system, exist in greater part as vapor, and in lesser part of liquid.

The present improvement takes advantage of the fact that the liquid will condense and that the vapor pressure within the sensing element-diaphragm system will correspond to that of the coldest part of this fluid motor assembly. With the foregoing structure and principles in mind,

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it is now apparent that when the temperature of the coiled tubing 111 of the thermal sensing element, is rapidly reduced, as at the time of starting up the system or during a sudden reduction in load, the chamber thereof having a thin highly conductive wall, becomes rapidly cooled, effecting a condensation on the inside of the wall since its temperature is currently the lowest in the motor system, which correspondingly and quickly reduces the pressure.

The system is protected against sudden pressure increases by reason of the comparatively large mass or core 110 which has a greater heat capacity than the material of the sensing tubing 111. Consequently, this mass 110 will for some time remain the coldest part of the system, causing the liquid to condense on the adjacent tubular wall surface, and will thus produce a distinct lag in the attainment of maximum vaporization with the motor system. The low pressure during this period of lag or damping effect, will result in a reduced pressure upon diaphragm 20, providing a distinctly delayed and minimized action of the valve incident to any unusual or rapid increase in suction line temperature or superheat. From the foregoing operative description it is clear that there are produced differential rates of action of the valve under opposite conditions.

During periods of normal or steady operation of the system, the mass 110 will attain a substantially steady temperature slightly lower than the temperature of the coiled tubular wall 111, inasmuch as the latter is influenced not only by the suction line temperature in response to superheat, but also by ambient air temperature. From this it follows that the mass 110, being substantially enclosed or embraced by the tubular sensing element 111, will after some lag, be influenced by the suction line temperature, but will not be directly affected by the ambient air. If it be assumed as is preferred, that the ballast mass 110 have the lowest temperature of the various parts of the motor system during normal running conditions, the pressure in the sensing element-diaphragm system will correspond to the temperature of the ballast mass 110, and will thus assure a steady or stable operation of the system.

From the foregoing it will be seen that this element permits the pressure of the vapor in the motor system to decrease rapidly when the coiled tubular element 111 becomes cooler than the thermal stabilizing mass 110 encompassed thereby, but the vapor pressure will be precluded from increasing rapidly when the coiled element 111 is appreciably warmer than the mass 110. It will now be seen that the provision of the mass 110 as a part of the motor system, serves also to raise the minimum point of the cycle by reducing at desired times the rate of refrigerant feed, and thereby overcomes the former tendency of a thermal responsive element to overregulate, resulting in feeding some of the liquid refrigerant over into the suction line.

Although the invention has been described by particularizing the elements and principles of a preferred embodiment, the detail of description is not in any sense to be understood as restricting, numerous variants being possible within the scope of the claims hereunto appended.

I claim as my invention:

1. The combination in a compressor-condenser-evaporator refrigeration system, of a thermostatic expansion valve arranged to control the

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flow of refrigerant to the evaporator, and comprising thermal responsive means arranged to act in accordance with suction line temperature for operating the expansion valve, said means including a thermal-sensitive container consisting of a coil of a thin-wall tubing, the coil being located and arranged to be heated and cooled from the suction line, said coil being charged with a volatile and expansive fluid, and a mass constituting a core within the coil and having restricted thermal communication with the coil tubing, the material of said mass possessing a greater heat capacity than the material of the coil, the mass being of such nature and so related to the coil as to effect markedly differential rates of valve opening and closing action in response, respectively, to increases and decreases of suction line temperatures.

2. The combination in a refrigeration system having an evaporator, of an expansion valve arranged to control the flow of refrigerant to the evaporator, a hollow, highly conductive thermal sensing element mounted to respond to variations in evaporator outlet line temperature, tubing connecting the expansion valve and the sensing element, a fluid charge in said tubing and said element under a pressure such that at a temperature within the range of operating temperature of the evaporator some of the charge is in a liquid state, and a mass of solid material spaced from said evaporator outlet line in contact with the external surface of said element and bearing a thermal relation to the element such as to delay temperature equalization between said mass and said element upon changes in evaporator outlet temperature for producing a lag in the pressure

increase of said charge in response to evaporator outlet temperature increases while permitting rapid pressure decrease of the charge in response to evaporator outlet temperature reductions.

3. The combination in a refrigeration system having an evaporator, of an expansion valve arranged to control the flow of refrigerant to the evaporator, a hollow, highly conductive thermal sensing element in the form of a coil mounted to respond to variations in evaporator outlet line temperature, tubing connecting the expansion valve and the sensing element, a fluid charge in said tubing and said element under a pressure such that at a temperature within the range of operating temperature of the evaporator some of the charge is in a liquid state, and a rod within said coil, spaced from said evaporator outlet line, and bearing a thermal relation to the element such as to delay temperature equalization between said mass and said element upon changes in evaporator outlet temperature for producing a lag in the pressure increase of said charge in response to evaporator outlet temperature increases while permitting rapid pressure decrease of the charge in response to evaporator outlet temperature reductions.

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