

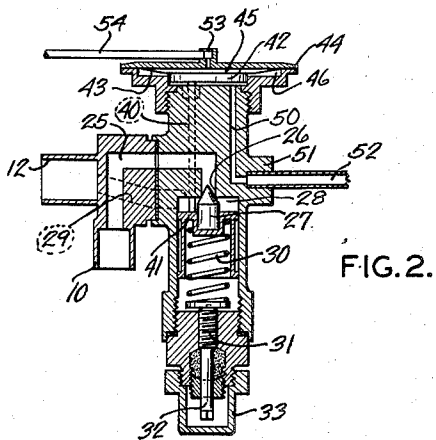
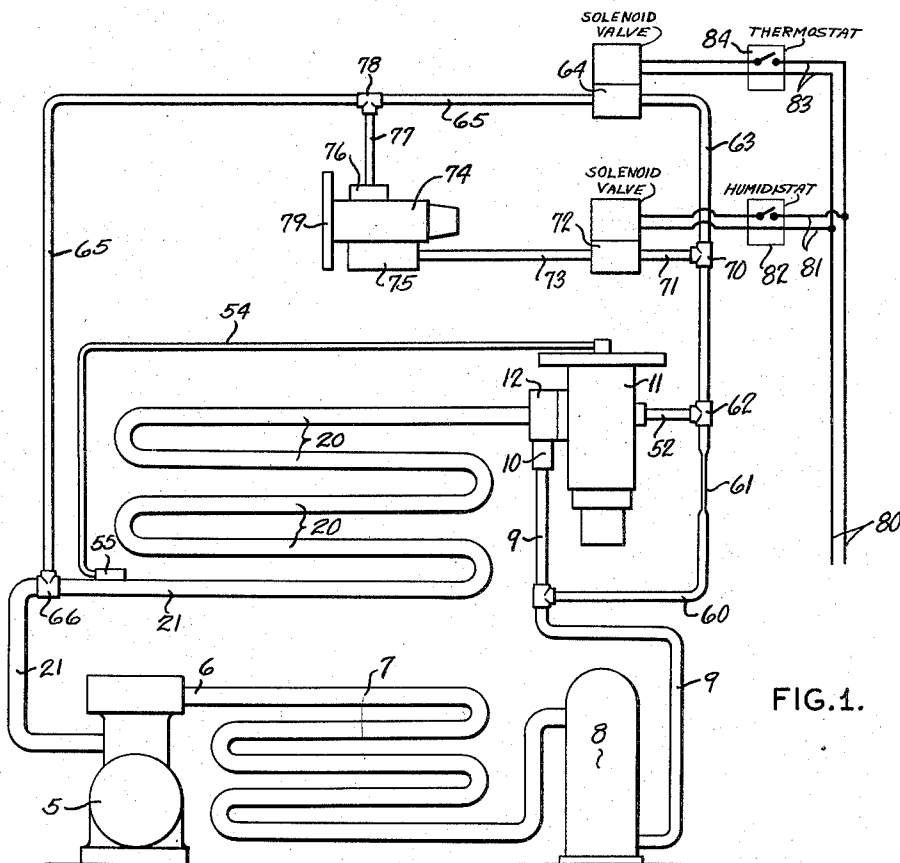
Oct. 7, 1941.

H. T. LANGE

2,258,458

CONTROL OF REFRIGERATING FLUIDS

Filed Dec. 12, 1938



INVENTOR.
HAROLD T. LANGE

BY

Robert B. Terry
ATTORNEY.

UNITED STATES PATENT OFFICE

2,258,458

CONTROL OF REFRIGERATING FLUIDS

Harold T. Lange, Webster Groves, Mo., assignor
to Spoehrer-Lange Company, St. Louis, Mo., a
corporation of Missouri

Application December 12, 1938, Serial No. 245,192

13 Claims. (Cl. 62-6)

This invention relates to improvements in control of refrigerating fluids, and more particularly to improved means for the regulation of refrigerant flow in refrigeration and air conditioning systems, as well as improved methods of control of such flow.

In air conditioning systems it is usually desirable to condition or control the state of the air under treatment, whether for the preservation of foodstuffs as in refrigeration installations for this purpose, or in installations for the conditioning of a space such as a room or vehicle occupied by persons, in such manner as to vary a plurality of the characteristics or conditions of the conditioned air, e. g., the temperature as well as the humidity of the air under treatment. Difficulties have often arisen in connection with existing and earlier installations involving refrigeration apparatus, in that the temperature of the air is reduced to the required value before such time that the humidity is low enough for an optimum condition of personal comfort. In utilizing prevailing systems of control, even though the temperature requirements were satisfied, the cooling plant would continue to operate at full cooling capacity until the humidity reached the proper point. The result would inevitably be that the conditioned space would attain a needlessly low temperature, for the sole purpose of satisfying the humidostat requirements. It is to the end of obviating this difficulty that the present invention has one of its major objectives.

Yet another object of the invention is attained in an improved combination of control agencies for a refrigeration or conditioning system such as to provide, without change in evaporator or evaporator connections, and without requiring any changes in air flow or control, what may be termed a multiple-range evaporator operation, whereby the evaporator elements may be operated under a plurality of distinct working conditions including full capacity as well as one or more additional distinct conditions under which the evaporator will operate at distinctly less than full working capacity.

Yet another object, generally expressed, is attained in the provision of certain modifying controls, in order better to satisfy the somewhat dissimilar requirements of optimum humidity and temperature regulation, the modifying controls being presently described as utilized in a system of compressor-condenser-evaporator type also employing a thermostatic expansion valve under the influence of the modifying controls.

The foregoing and numerous other objects of

the invention will more clearly appear from the following detailed description of a preferred embodiment of the invention, considered in connection with the accompanying drawing, in which:

Fig. 1 is a schematic or diagrammatic view of a refrigeration system to which the present improvements are applied, and Fig. 2 is a vertical sectional elevation of a thermostatic expansion valve of one type suitable for use in the system exemplified by Fig. 1.

Referring now by characters of reference to the drawing and particularly to Fig. 1, the system includes a compressor 5 driven by any suitable power source (not shown) and having its discharge line 6 connected into a condenser 7, the latter being in turn in communication with a liquid receiver 8, and the latter having its outlet in a liquid line 9. This line is connected to the inlet fitting 10 of a thermostatic expansion valve or the equivalent generally designated at 11, and provided with the usual liquid outlet port or fitting 12. Although the specific construction of thermostatic expansion valve is not material to the present invention, a suitable construction thereof is shown by Fig. 2, and will be hereinafter fully described in detail.

The outlet connection of the thermostatic valve 11 is connected to the inlet of the evaporator 20 which may be of fin-and-tube type or of any other suitable construction, and is provided with a low side or suction connection 21 returning to the suction side of compressor 5. It is preferred, for purposes of present description of an exemplary embodiment of the invention, that the evaporator 20 be of so-called direct-expansion type as distinguished from the flooded type of unit. The elements as thus far described including the compressor 5, condenser 7, receiver 8, thermostatic expansion valve 11 and the evaporator, together with fluid connections whereby these elements are related in a closed fluid circuit, are or may be of conventional form and arrangement.

The thermostatic expansion valve indicated at 11 is shown more in detail in a form suitable for the practice of the method presently to be described, in Fig. 2 and includes, in connection with the inlet 10, an inside passage 25 directed to the port 26 controlled by the valve element 27. This valve is subjected to a limited vertical movement in the relation shown by Fig. 2, so that it serves to govern the flow of liquid into the valve chamber 28, whence the liquid finds its exit via passage 29, thence into the outlet fitting 12. In the structure shown by Fig. 2, downward movement of the

valve 27 is opposed by a spring 30 adjustably loaded as through a screw 31 provided with an adjusting head 32 accessible upon removal of cap 33. Serving the purpose of controlling the movement of valve 27 are a pair of actuating rods 40, one of which is shown in dotted lines in Fig. 2. The rods 40 are packed or otherwise provided with agencies to prevent fluid communication therealong, and serve to constitute a rigid operative connection between the valve disc or block 41 and a plate 42 constituting a backing or reinforcing follower adjacent a flexible diaphragm 43, the diaphragm being securely peripherally sealed between the upper and lower mating portions of the structure 44 serving to form a diaphragm chamber, or more explicitly, two such chambers, one of which is indicated at 45, on one or the upper side of the diaphragm, and the other chamber designated as 46 and located on the opposite or lower side thereof. For purposes of the control to be described, fluid communication is established with the lower chamber 46 through an internal duct 50 leading into an outlet fitting 51 and a connecting tube 52. It may be noted that in many heretofore prevailing valves, a chamber such as 46 was utilized in fluid communication with the evaporator or low-pressure portion of the system.

A fluid connection for the usual thermostatic control purpose, is made to the upper chamber 45 through a fitting 53, and tubing 54 which leads to a thermostatic bulb 55 (Fig. 1). The expansion valve structure of itself, apart from the duct 50—51—52, is or may be of conventional construction and operation, except as influenced by items of apparatus later to be described. It may be briefly stated that the bulb 55, tubing 54 and chamber 45 constitute a sealed-in thermostatic control portion, the influence of which is, in cooperation with changes in evaporator pressure, to effect movement of the diaphragm 43 and hence of valve 27 in response to changes in superheat of the vapor in line 21 leading from the evaporator. The usual effect of this arrangement of parts is however subject to a modulated control attained by a novel arrangement of additional valves and connections to be described.

Incident to the present improvements there is provided a fluid by-pass connection from the high pressure side of the system to the low pressure side thereof, which by-pass is not necessarily but may be intermediately branched as shown, the two branches of this by-pass line shown in the present system, being selectively controlled by electric valves each functioning in accordance with a characteristic or condition of the air subjected to the cooling effect of the system, and the by-pass conduit being in communication with the chamber 46 of the thermostatic expansion valve.

In the arrangement presently disclosed there is provided a connection 60 into the line 9, the piping 60 being continued through means providing a constricted portion creating a small leak port or passage 61. The portion 61 of the by-pass conduit may consist, as shown, merely in a short pipe element of reduced internal passage area, or may be provided as by an adjustable needle valve (not shown), or other suitable flow limiting expedient, the passage therethrough being sufficiently restricted to assure that no substantial amount of liquid can be carried through the by-pass conduit into the low side of the system and hence into the compressor. Beyond the leak port or passage is a T connection 62 which serves to connect the line 60—61, through tube

52, with the chamber 46 of the expansion valve 11. Beyond the T 62 the by-pass connection continues through piping 63 thence through a solenoid valve 64 and a return line 65 into a T connection 66, the latter being located in any suitable portion of the evaporator or the low side of the system. It is preferred for convenience that the connection of tubing 65 be made to the outlet of the evaporator, although the exact location of this connection into the low side of the system is not material. For convenience of fitting and utilization of usually available materials, the line 60—61—62—65 and 66 may consist of copper tubing of small diameter.

Another branch of the by-pass line appears in the present example in a T fitting 70, a section of tubing 71 leading to the body of the solenoid valve 72, thence through tubing 73 into a valve 74. The inlet of valve 74 is shown at 75 communicating with tube 73, and the valve outlet connection is shown at 76 provided with a section of tubing 77 connected into a T fitting 78 in line 65 of the by-pass, particularly that portion thereof leading into the fitting 66 in the low pressure side of the system.

The valve 74 is in the nature of a pressure reducing valve adapted to be adjustably set to maintain a constant outlet pressure; it may be of any one of the well known constant pressure types and for this purpose, a small so-called automatic expansion valve may be employed. The valve is provided with a handle 79 through the manipulation of which the loading of the spring or equivalent internal resistance element in the valve, may be regulated.

Electric energization at desired times, of the magnet valves 64 and 72 is provided for by supply leads 80. A branch line 81 is under the control of a humidostat 82 and, subject to the opening and closing of the humidostat, selectively energizes valve 72. Similarly, branch 83, subject to the control of the thermostat indicated diagrammatically at 84, serves selectively to energize the valve 64. Both of the valves 72 and 64 are so arranged that when their coils are energized, the valves are held in open position, permitting fluid flow respectively through branch 62—65 in the case of valve 64, and through branch 71—72—77 connected into and out of valve 72.

As well understood in the air conditioning art, in case the system is employed for this purpose, the thermostat 84 and humidostat 82 are conveniently physically disposed so as to be responsive to the respective conditions of the room air. According to prevalent practice these may be located, say in the return air duct (not shown) of the system.

It is a preference that the system described be provided with a suction pressure switch (not shown) which may conveniently serve directly, in case the compressor is motor-driven, to start and stop the compressor in the event of attaining predetermined pressure values in the low pressure side of the system.

The method involved in the use of the apparatus heretofore described, and the control operations incident thereto will have been partly apparent from the foregoing description of parts and connections, but it may be noted for completeness that when the system is in full and normal operation, and requiring both cooling and de-humidification of the air subject to cooling, both of the valves 64 and 72 are open. Under these conditions the by-pass conduit will serve substantially to equalize the pressure in chamber

46 with the evaporator pressure, and the thermostatic expansion valve 11 will then function in its usual intended manner to deliver such a quantity of liquid refrigerant as to allow full use of the entire evaporator surface at a suction pressure and temperature determined by the balance between the capacity of the evaporator and the compressor. Let there be assumed as an example, the use of "Freon (F-12)" as the refrigerant in the system when used for air conditioning, and that the suction pressure will be approximately 40 pounds gauge; the resulting temperature will then be of the order of 43 degrees F. Under these conditions the system will continue to operate with the primary purpose and effect of reducing the temperature of the air to the predetermined point indicated by thermostat 84. Upon attaining the requisite reduction in temperature, the thermostat 84 will change its position to open this part of the circuit, resulting in a closure of the associated pilot valve 64. It may be noted that in most installations operating under normally prevailing conditions of temperature and humidity, the air temperature is reduced to the required value prior to the time when the moisture content of the air is brought down to the desired value as indicated by the setting of humidostat 82, and in many cases the plant continues to operate at full cooling capacity for some little time after satisfaction of the thermostat, and solely for the purpose of attaining a desired and predetermined reduction in moisture as indicated by the instrument 82. The result of such undesirable continued operation is that the conditioned space gets undesirably cold, and for the sole reason of satisfying humidity requirements. It may be noted that the temperature of the air passing the evaporator is primarily dependent upon the surface area of the evaporator which is contacted by the air, as well as the temperature of the cooling medium, whereas the removal of moisture from the air which is in contact with the cooling surfaces, is primarily dependent upon the temperature of the cooling medium.

Due to the foregoing fact, the present improvements serve to obviate the noted disadvantages in operation by subjecting the main expansion valve 11 to a modulating or dominating control which is attained in the present example through the effects of the valves 64 and 72 and the constant-pressure regulating valve 74. These valves realize their intended functions through the control of flow through the by-pass conduit heretofore described, in such manner as to permit normal operation of the system within a certain range of suction pressures, and to continue such operation under reduced working conditions of the evaporator and under corresponding temperature conditions such as better and more quickly to attain, at lower operating costs than heretofore, the satisfaction of the humidity requirements.

It will have appeared that the diaphragm 43 whose action controls, with spring 30, the opening and closing of the valve 27 of the thermostatic expansion valve 11, is subject to the resultant of pressures on its opposite sides, viz., that in chamber 45 which is directly responsive to the thermostatic effect of the fluid charge in bulb 55 acting through line 54, and on its lower side exposed to the pressure in chamber 46, a pressure component which is determined by and is the same as the pressure in the by-pass from

the high pressure side, as line 9 of the system, to the low pressure side, for example, line 21.

Assuming now that the temperature has been sufficiently reduced to satisfy the predetermined requirement of the thermostat 84 but that the humidostat 82 is not yet satisfied, the valve 64 now being closed, the chamber 46 of valve 11 is vented to the evaporator through the electrically operated valve 72 which yet remains open, and also through the constant pressure valve 74, it being assumed that this latter valve is set to maintain a predetermined outlet pressure, say of 20 lbs. gauge in the fitting 76 and line 77. The valve 74, in attempting to maintain its predetermined outlet pressure, will seek a position of opening which will strike a balance between the flow through the leak port or passage 61, and its own opening; it results from this fact that if the suction pressure in lines 21 and 65 drops below the predetermined value, say of 20 lbs., valve 74 will open farther with the effect of venting the chamber 46, reducing the pressure on that side of diaphragm 43 and permitting the thermostatic expansion valve element 27 to open more nearly in a normal manner. If however the suction pressure rises above that corresponding to the setting of valve 74, the reverse action will take place, with the effect of increasing the pressure in chamber 46, and throttling the thermostatic expansion valve.

The effect of the last said throttling action is to cause the superheat in line 21 to rise above that corresponding to the normal setting of valve 11 with the effect of reducing the actively effective surface of the evaporator, hence of decreasing the capacity of the plant as a result of the lowered suction pressure. This results in a drop in evaporator temperature to a value corresponding to the suction pressure say of 20 lbs., which in the case of Freon, will be a temperature of the order of 17° F. Conditions will thus be made much more favorable for a rapid reduction of humidity by reason of the colder evaporator temperature, and without a substantial additional reduction of temperature of the room air as a result of the reduction of plant capacity.

Assuming now that both the temperature and humidity requirements have been met in accordance with the setting of instruments 82 and 84, both of valves 72 and 54 will close, and a pressure will be set up in the chamber 46 against diaphragm 43, which is equal to the condenser pressure. Since the pressure to which the diaphragm is now subject from chamber 46, exceeds the normal pressure on the opposite side of the diaphragm in chamber 45, the thermostatic expansion valve will close, stopping the flow of refrigerant completely. Under this condition the suction pressure will immediately drop to a low value with the desired effect of opening the pressure switch hereinabove referred to, and stopping the compressor.

It is important to note the characteristic of the present control arrangement and method, that the thermostatic expansion valve 11 is always available and ready to function in the usual manner for the purpose of supplying liquid refrigerant to the evaporator in whatever amount is called for, even with the modifying or modulating control elements in effect, the valve 11 always serving to prevent the possibility of an excessive amount of refrigerant entering the evaporator 20.

Among the older expedients attempting to attain the objectives and results of the present method may be mentioned the practice of re-

stricting, augmenting or dividing the air flow, in the conditioning system, through the cooling coil; another expedient sometimes resorted to is the use of sectional evaporator coils and arrangements for refrigerant flow selectively to different numbers or groups of the sections. There may also be recounted as among the known practices proposing to effect a better regulation of temperature in relation to humidity of the conditioned air, that of utilizing a plurality of separate magnetic control valves directly or relay-controlled through thermostatic and humidostatic means, and wherein the flow is directed to one or more than one evaporator or evaporator sections. It will be apparent that the expedients mentioned and other prior attempts to attain the result, all require considerably more items of apparatus, together with an increase in piping and wiring requirements and hence of cost. The present invention may be and is preferably embodied in a low cost system involving the addition only of the constant pressure valve such as 74 and the solenoid valves such as 64 and 72, together with a small amount of piping and little additional wiring, thus conducing to marked simplification in comparison with former structural attempts at the same objectives, particularly since the items of added equipment in accordance with the present disclosure are not only inexpensive but are readily obtained as stock products.

It is understood that numerous modifications may be made in the elements described as well as in their arrangement and combinations, all without departure from the spirit and full intended scope of the invention as defined by the claims hereunto appended.

I claim as my invention:

1. The described method of regulating the flow of refrigerant in a cooling system for the air in a space to be conditioned, which consists in throttling the flow of refrigerant in accordance with a pressure effect which is the resultant of at least one fluid pressure component variable in response to changes in temperature in the low pressure side of the system, and another component pressure derived from both the high and low pressure sides of the system, and in differently varying the last said pressure component in accordance with different predetermined characteristics of air in the space conditioned by the evaporator of the system.

2. The described method of regulating the flow of liquid refrigerant in a cooling system including an evaporator exposed to the air in a space to be conditioned, which consists in throttling the flow of refrigerant in accordance with a variable pressure effect which is the resultant of at least one component fluid pressure variable responsively to changes in temperature adjacent the superheating region of the low pressure side of the system, and another component pressure derived from both the high and low pressure sides of the system and variable within the limits of such pressures, and in throttling one of said component pressures, in accordance with changes in different conditions of the air in a space conditioned by the evaporator.

3. The described method of regulating the flow of liquid refrigerant in a system for cooling the air in a space such as a room, which consists in throttling the flow of liquid refrigerant to be evaporated, in accordance with a variable fluid pressure effect which is the resultant of one component variable in response to variations in temperature in the low pressure side of the system,

in by-passing a reduced flow of refrigerant fluid from the high pressure side of the system to the low pressure side thereof, and deriving a second component fluid pressure from the pressure of said by-passed fluid flow, in effecting a throttling control of the by-pass fluid flow, in response to a satisfaction of one condition of the air being conditioned by the system, and further throttling the by-pass fluid flow in response to satisfaction of another condition of such air.

4. The method of operating an expansion valve in a refrigerating system for air in a space under conditioning treatment, which includes the actuation of said valve in response to changes in capacity of a variable-capacity pressure chamber; in by-passing a reduced auxiliary flow of refrigerant between the high-pressure and low-pressure portions of the system; in subjecting said chamber to the pressure of the by-pass fluid for influencing the control actuation of said valve, and in subjecting the flow of by-pass fluid to separate and different control effects responsive, respectively, to changes in different conditions obtaining in the air under conditioning treatment by the system.

5. The method of operating an expansion valve in a refrigerating system connected in cooling relation to the air in a conditioned space or room, the valve being of a type wherein said valve is movable responsively to changes in capacity of a variable-capacity pressure chamber, which consists in by-passing a reduced auxiliary flow of refrigerant between the high-pressure and low-pressure portions of the system, subjecting said pressure chamber to the pressure of the by-pass fluid for influencing the control actuation of said valve, and in limiting to a predetermined pressure, a portion of the by-passed fluid in response to a predetermined reduction in temperature of the air under treatment, while the humidity of such air exceeds a predetermined value.

6. The method of operating an expansion valve in a refrigerating system for air in a space under conditioning treatment, which includes the actuation of said valve in response to variation in capacity of a variable-capacity pressure chamber, and further consists in by-passing a reduced auxiliary flow of refrigerant between the high-pressure and low-pressure portions of the system, subjecting the variable-capacity chamber to the pressure of the by-pass fluid for influencing the control actuation of said valve, and predeterminedly limiting the pressure of the by-pass fluid responsively to satisfaction of temperature reduction of the air under treatment by the system without satisfaction of predetermined humidity values therein.

7. The method of operating an expansion valve in a refrigerating system which includes the actuation of said valve in response to variation in capacity of a variable-capacity pressure chamber, in varying the capacity of said pressure chamber, in part by by-passing a reduced auxiliary flow of refrigerant between the high-pressure and low-pressure portions of the system, introducing the by-pass fluid to said chamber for influencing the control actuation of said valve, and in further thermostatically influencing pressure conditions in said pressure chamber by a body of fluid confined externally of and adjacent to said chamber and subject to suction temperature in a superheating portion of the system.

8. In a cooling system of the general type described, including a thermostatic expansion valve unit provided with a movable valve-controlling

portion, a by-pass conduit between the high and low pressure parts of the system, and connected into the expansion unit so that the by-pass fluid is in influencing relation to the movable valve-controlling portion of the unit, a thermostat responsive to temperatures in the air under treatment by the system, and a valve in the by-pass conduit arranged to be opened and closed responsive to predetermined control by said thermostat.

9. In a cooling system of the general type described and including a thermostatic expansion valve unit provided with a movable valve-controlling portion, a by-pass conduit between the high and low pressure portions of the system and connected into the expansion valve unit so that the by-pass fluid is in influencing relation to the movable valve-controlling portion of said unit, an automatic pressure-regulating valve in the by-pass conduit, and means responsive to a condition of the air under treatment by the system, for selectively rendering the pressure-regulating valve effective and ineffective to control the flow in said by-pass conduit.

10. In a cooling system of the general type described and including a thermostatic expansion valve unit provided with a movable valve-controlling portion, a by-pass conduit connecting the high-pressure with the low-pressure portions of the system and connected into the expansion valve unit whereby the by-pass fluid is in influencing relation to the movable valve-controlling portion of said unit, a thermostat and a humidostat each arranged to be responsive to the air under treatment by the system, valve means in the by-pass conduit influenced by the thermostat and humidostat and arranged to effect a reduction of suction pressure in the low pressure side of the system upon satisfaction of the thermostat.

11. In a cooling system of the general type described and including a compressor, a condenser, a thermostatic expansion valve unit characterized by a movable valve-controlling member, and an evaporator, piping connected between the high-pressure and low-pressure portions of the system so as to constitute an auxiliary by-pass conduit, said piping being connected into the expansion valve unit so as to bring the by-pass fluid into influencing relation to the movable valve-controlling member of said unit, a plurality of pilot valves and a constant-pressure regulat-

ing valve in the piping forming the by-pass conduit, a thermostat and a humidostat each positioned to be subject to the air being treated by the system, and in influencing relation to said valves in the by-pass piping.

12. In a cooling system of compressor-condenser-evaporator type including a thermostatic expansion valve unit characterized by a movable valve-controlling member, a by-pass conduit between the high and low pressure portions of the system and connected into the expansion valve unit whereby the by-pass fluid is in influencing relation to the movable valve-controlling member of said unit, means forming a leak passage in the by-pass conduit, between its intake end and the point of connection into the expansion valve unit, a plurality of branches in said by-pass conduit between the expansion valve unit and the by-pass connection into the low pressure portion of the system, a thermostat and a humidostat arranged responsively to conditions of the air under treatment by the system, a magnetic pilot valve under control of the thermostat, and disposed in one of said by-pass branches, a second magnetic pilot valve and constant-pressure regulating valve in another of said branches, the pilot valves being electrically associated, respectively, with said thermostat and said humidostat.

13. The combination with a refrigerant circuit for cooling a fluid medium of means for controlling the flow of refrigerant therethrough; said circuit including an evaporator and means for supplying liquid refrigerant thereto; and said control means comprising an expansion valve located in said circuit between the evaporator and the means for supplying refrigerant thereto, a device responsive to two opposing pressures connected to the expansion valve for actuating the same, means for by-passing a portion of the refrigerant around said evaporator and including a constantly open leak passage and a valve arranged in series with the leak passage, means responsive to the temperature of the medium being cooled for actuating the second mentioned valve, means for subjecting the pressure responsive device to the pressure in the by-pass means between the leak passage and the second mentioned valve, and means for subjecting the pressure responsive device to a pressure corresponding to the temperature at the evaporator outlet.

HAROLD T. LANGE.