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L. G. HUGGINS

2,353,240

AIR CONDITIONING APPARATUS

Filed Aug. 3, 1940

2 Sheets-Sheet 1

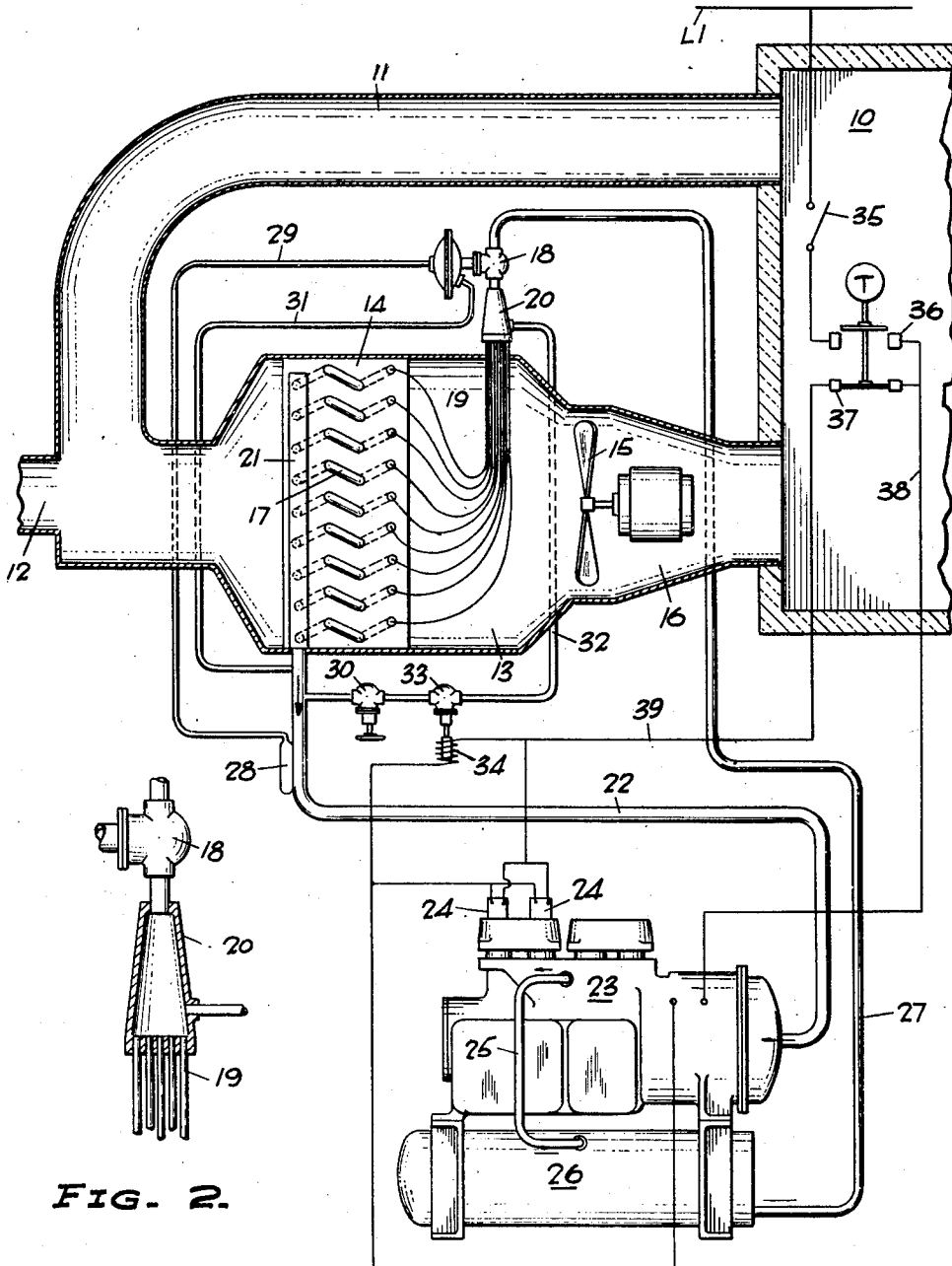


FIG. 2.

FIG. 1.

WITNESSES:
R. J. Winger
Andrew J. Cook

INVENTOR
LEROY G. HUGGINS
BY *W. A. Steigler*
ATTORNEY

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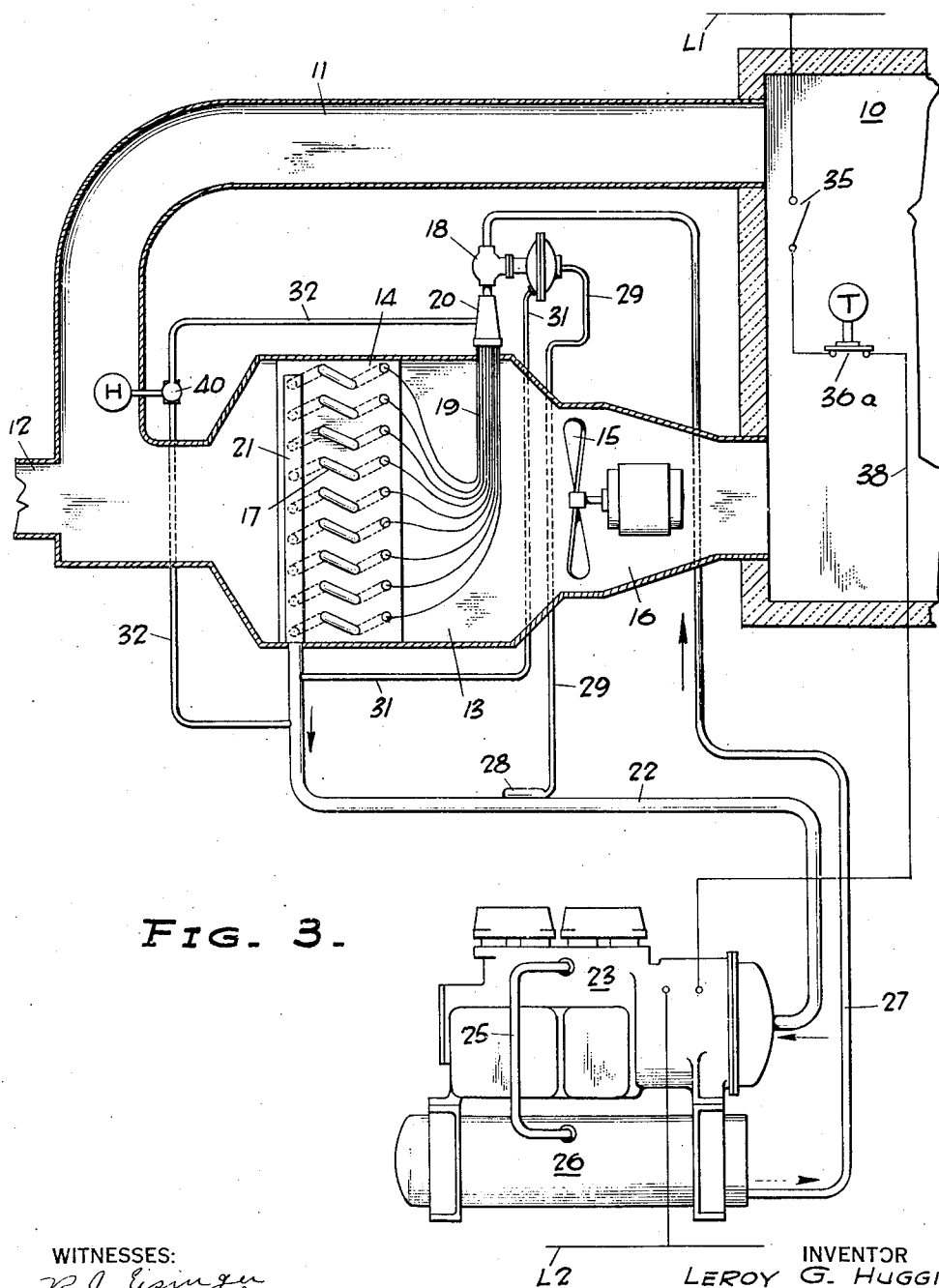


FIG. 3.

WITNESSES:

R. J. Lisinger
Andrew J. Cook

L2

INVENTOR
LEROY G. HUGGINS

BY *Walter G. Huggins*
ATTORNEY

UNITED STATES PATENT OFFICE

2,353,240

AIR CONDITIONING APPARATUS

Leroy Gale Huggins, Springfield, Mass., assignor to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

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11 Claims. (Cl. 62—8)

The present invention is an improvement upon the invention of Charles M. Sanders, Jr., described and claimed in his Patent No. 2,280,425 issued April 21, 1942, and is covered by the broad claims thereof.

My invention relates to air conditioning apparatus, more particularly to a refrigerant evaporator for cooling and dehumidifying air and means for controlling the flow of refrigerant in such evaporator.

It is an object of my invention to provide improved apparatus of the character set forth.

Another object is to provide improved means for varying the capacity or cooling effect of the evaporator.

Another object is to provide improved means for reducing the effective portion of the evaporator for partial load operation while at the same time maintaining the effective portion at a sufficiently low temperature to maintain a desired degree of dehumidification.

A more particular object is to provide improved means for controlling the admission of refrigerant to the evaporator in such manner as to reduce the effective portion of the evaporator, that is, the portion containing liquid refrigerant, in order to provide either reduced capacity for partial load operation or to provide increased degree of dehumidification.

A preferred embodiment of my invention includes a conventional evaporator of the so-called "dry" type, including, for example, a plurality of refrigerant passages or coils through which refrigerant flows in parallel and over which the air may flow either in series or in parallel, more commonly in parallel. Liquid refrigerant is distributed to the several coils in any known manner, preferably through orifices or restricted passageways which effect a portion of the expansion or pressure reduction of the refrigerant, and the admission of the refrigerant from a common supply is controlled by a thermostatic expansion valve which includes a temperature-responsive element subjected to the temperature of the vaporized refrigerant discharged from the several coils of the evaporator, the temperature-responsive element being usually strapped to the suction conduit. Such a valve controls the admission of refrigerant so as to maintain a substantially constant degree of super-heat of such vaporized refrigerant and, accordingly, provides the admission of such quantity of liquid refrigerant as can be fully vaporized in the evaporator. In accordance with the present invention, I provide means for selectively extracting or bleeding a small amount

of liquid refrigerant from a portion of the refrigerant circuit containing liquid refrigerant at a pressure higher than that existing in the evaporator; for example, between said thermostatic expansion valve and said orifices or restricted passageways. The extracted refrigerant is conveyed to the suction conduit at a point ahead of the temperature-responsive element, so that the latter is thereby subjected to a lower temperature. Accordingly, the expansion valve restricts the admission of liquid refrigerant to all of the coils, so that vaporization of the refrigerant is completed at a point nearer the inlet end, thereby reducing the portion of the evaporator containing liquid refrigerant.

These and other objects are effected by my invention as will be apparent from the following description and claims taken in accordance with the accompanying drawings, forming a part of this application, in which:

Fig. 1 is a diagrammatic view of air conditioning apparatus in which my invention is employed for the purpose of providing partial load operation;

Fig. 2 is a detail sectional view showing the refrigerant distributor head from which refrigerant is extracted; and,

Fig. 3 is a diagrammatic view of air conditioning apparatus in which my invention is employed for the purpose of providing increased degree of dehumidification.

Figure 1

Referring first to Fig. 1, in which my invention is employed for partial load operation, I show an enclosure 10 which is to be supplied with cooled and dehumidified air. A portion of the air to be conditioned and delivered to the enclosure is withdrawn from the enclosure 10 through a duct 11 and another portion is drawn from outdoors through a duct 12. These two portions are mixed and enter an air conditioning chamber 13 containing an evaporator 14. A motor-driven fan 15 draws the air through the chamber 13 and over the evaporator 14 and discharges the same through a duct 16 to the enclosure 10.

The evaporator 14 is of conventional construction, comprising a plurality of serpentine refrigerant coils 17, the coils shown having four tubes. Liquid refrigerant is supplied under control of an expansion valve 18 and is distributed to the inlet ends of the coils by a group of restricted passageways, such as the distributor tubes 19, which are also sometimes referred to as capillary

tubes. These tubes are of restricted bore and impose a pressure drop on the refrigerant flowing therethrough. The tubes 19 are connected to the valve 18 through a distributor head or fitting 20, shown in Fig. 2. The outlet ends of the several evaporator coils are connected to a discharge or suction header 21 which is in turn connected to a suction conduit 22. The latter conveys the vaporized refrigerant to a motor-compressor unit 23, which is shown as comprising four cylinders. Two of the cylinders are provided with solenoid-operated unloader mechanisms 24 adapted to unload the associated cylinders when the solenoids are energized. The compressed refrigerant is conveyed through a conduit 25 to a condenser 26, from which the condensed refrigerant is conveyed through a supply conduit 27 to the valve 18.

The valve 18 is of the type commonly known as a thermostatic expansion valve, regulating the admission of liquid refrigerant to the evaporator so as to maintain a predetermined desired degree of superheat of the vaporized refrigerant discharged from the evaporator into the suction conduit 22. It is provided with a thermostatic bulb 28 arranged in contact with the suction conduit 22. The bulb 28 preferably contains fluid similar to that used as refrigerant and provides a pressure varying as a function of the temperature of the vaporized refrigerant. This pressure is communicated to the valve through a tube 29 and is imposed thereon in valve-opening direction. The pressure of the vaporized refrigerant in the conduit 22 is also communicated through a tube 31 and imposed on the valve in valve-closing direction. The resultant of the two pressures is, therefore, a measure of the superheat of the vaporized refrigerant, so that the valve regulates the refrigerant admission so as to maintain said degree of superheat substantially constant. The valve 18 is preferably adjusted for 10° F. superheat.

A by-pass tube or conduit 32 is provided to convey a restricted flow of liquid refrigerant to the suction conduit to be mixed with the vaporized refrigerant leaving the evaporator. The purpose of this is to reduce the temperature imposed on the thermostatic bulb 28, thereby causing the valve 18 to reduce the admission of refrigerant to the evaporator. The inlet end of the tube 32 is connected to a portion of the refrigerant circuit containing liquid refrigerant at a pressure substantially higher than the refrigerant pressure within the evaporator 14. Preferably, it is connected between the valve 18 and the distributor tubes 19, in which region the pressure is higher than evaporator pressure because of the pressure drop imposed by the distributor tubes 19. In the illustrated embodiment, the tube 32 is connected to the distributor head 20. The outlet end of the tube 32 is connected to the suction conduit 22 at a point in advance of the thermostatic bulb 28. Alternatively, it may be connected to one of the evaporator coils 17 at a point adjacent the outlet end thereof. A valve 33 is connected in the tube 32 for controlling the flow therethrough and is operated by a solenoid 34, the valve being open when the solenoid is energized and closed when the solenoid is deenergized. A throttling valve 30 is also interposed in the tube 32 to vary the flow of refrigerant through the tube. In this embodiment, the valve 30 is manually adjustable. The tube 32 may be of restricted bore to impose restriction on the flow of refrigerant therethrough.

The control for the apparatus includes line

conductors L₁ and L₂ which supply electric current, a master or entrance switch 35 and a two-step thermostat T provided with contacts 36 and 37. The thermostat T is arranged to close the contacts 36 as the temperature in the enclosure 10 exceeds a predetermined value, such as 80° F., and to open the contacts 37 as the temperature exceeds a slightly higher predetermined value, such as 81° F. The contacts 36 control a circuit 38 which controls the motor-compressor unit 23. The solenoids of the unloader mechanisms 24 and the solenoid 34 are connected in parallel, the circuit 39 therefor extending through the contacts 36 and 37 in series. It is to be understood that the illustration of the control is diagrammatic, and that suitable conventional relays and other known expedients and instrumentalities commonly used in the art may readily be applied by anyone skilled in the art.

Fig. 1—Operation

Consider first that the temperature is above 81°, calling for full load operation. This means that the contacts 36 are closed to effect operation of the motor-compressor unit. The contacts 37 are open to deenergize the solenoid 34 and close the valve 33 and to deenergize the solenoids of the unloader mechanisms 24, so that all the cylinders of the motor-compressor unit are loaded. The apparatus now operates in a conventional manner. Refrigerant is compressed by the compressor, condensed in the condenser and admitted to the evaporator under the control of the thermostatic expansion valve 18. The refrigerant is distributed to the several coils 17 and evaporated in the coils by the heat extracted from the air flowing over the evaporator. The vaporized refrigerant returns to the motor-compressor unit through the suction conduit 22. Inasmuch as the valve 18 controls the refrigerant in such a manner as to maintain a constant degree of superheat of the discharged refrigerant vapor, preferably about 10° F., it will be apparent that a relatively small and substantially constant portion of each coil adjacent the outlet end will contain refrigerant which has been fully vaporized and is being superheated. The remainder of each coil contains liquid refrigerant and is at sufficiently low temperature to cool and dehumidify the air flowing over the evaporator.

The apparatus is designed, by proportioning compressor capacity to evaporator surface and capacity, so that the air is cooled to a sufficiently low temperature to effect the desired degree of dehumidification of the air.

When the temperature drops to a value between 80° and 81° indicating a reduced cooling demand, partial load operation is provided. At such a temperature, the contacts 37 are closed thereby energizing the several solenoids. The unloader mechanisms 24 unload two of the compressor cylinders, so that the compressor capacity is reduced to one-half. The solenoid 34 opens the valve 33 to by-pass a small portion of the refrigerant flowing through the distributor head 20. The admission of this refrigerant to the suction conduit reduces the temperature of the vaporized refrigerant and of the suction conduit, so that the pressure within the thermostatic bulb 28 is reduced and the expansion valve operates to reduce the admission of liquid refrigerant to the several coils. In the present embodiment, the valve 30 is preferably so adjusted that approximately one-half as much of each coil contains

liquid refrigerant and becomes fully effective as when operating at full load.

In the operation just described, the reduced compressor capacity is balanced by a corresponding reduction in the liquid-containing or fully effective portion of the evaporator, so that the suction pressure in the evaporator is maintained at a sufficiently low value to enable said liquid-containing portion to operate at a sufficiently low temperature to dehumidify the air flowing over the evaporator. There is thus provided suitable means for operating at partial load while at the same time maintaining the temperature of the effective portion of the evaporator at a sufficiently low temperature for dehumidification.

Figure 3

In Fig. 3 I show an air conditioning system incorporating substantially the same means for varying the capacity or liquid containing portion of the evaporator, but in which the same is used to vary the degree of dehumidification effected by the evaporator. The parts which are similar to those of Fig. 1 are designated by similar reference numerals, so that it is not necessary to repeat the description thereof. The compressor 23 in this case, is not provided with unloader mechanism but is of constant capacity. It is started and stopped by the thermostat T.

In this embodiment, a regulating valve 40 is interposed in the conduit 32 and is operated by a humidostat H, which is responsive to a humidity condition of the air in the enclosure 10, for example, the relative humidity thereof. The humidostat H may, for convenience, be disposed within the return conduit 11, containing air withdrawn from the enclosure.

Fig. 3—Operation

When the temperature of the air in the enclosure 10 exceeds a predetermined value, such as 80°, the thermostat T closes the contacts 35a and thereby initiates operation of the motor-compressor unit 23. When the temperature of the air in the enclosure 10 decreases substantially below the predetermined value, the thermostat T opens the contacts 35a to terminate operation of the motor-compressor unit.

During the operation of the motor-compressor unit, the valve 40 regulates the restricted flow of refrigerant through the by-pass tube 32. The humidostat H moves the valve 40 in opening direction to increase the flow of refrigerant through the tube 32 upon increase in the relative humidity of the air. The increased flow of refrigerant reduces the temperature of the refrigerant in the suction conduit 22 and causes the thermostatic bulb 28 to move the valve 18 in closing direction. The admission of refrigerant to the evaporator is reduced, thereby reducing the portion of the evaporator containing liquid refrigerant. Since the compressor capacity remains constant, this action results in reduced temperature of the refrigerant in the evaporator. The reduced temperature cools the air to a lower temperature and thereby effects a greater degree of dehumidification thereof.

Upon decrease in humidity of the air, the humidostat H moves the valve 40 in closing direction to decrease the flow of refrigerant through the tube 32. The temperature of the refrigerant flowing through the suction conduit 22 is increased so that the valve 18 increases the flow of refrigerant to the evaporator. Liquid refrigerant extends throughout a greater portion of

the evaporator and it operates at higher temperature, effecting a lesser degree of dehumidification but effecting a greater removal of sensible heat.

The novelty of the present invention resides particularly in connecting the inlet end of the tube 32 to a part of the refrigerant circuit wherein the pressure is substantially greater than the evaporator pressure, in order to obtain effective flow of refrigerant through the tube 32.

While I have shown my invention in several forms, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various other changes and modifications without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereupon as are specifically set forth in the appended claims.

What I claim is:

1. In a refrigerating system, the combination of an evaporator, a thermostatic expansion valve operating to regulate the flow of refrigerant to said evaporator in response to the superheat of the vaporized refrigerant leaving the same and including an element responsive to the temperature of said leaving refrigerant, means providing restricted flow of liquid refrigerant from a portion of the refrigerant circuit containing liquid refrigerant at a pressure substantially higher than the refrigerant pressure within the evaporator and utilizing said restricted flow of liquid refrigerant to reduce the temperature to which said element is subjected, whereby said valve restricts the flow of refrigerant to said evaporator and the portion of the evaporator containing liquid refrigerant is reduced, and means for controlling said restricted flow.

2. A refrigerating system as set forth in claim 1 wherein said restricted flow is controlled in response to the temperature of the air in the enclosure.

3. A refrigerating system as set forth in claim 1 wherein said restricted flow is controlled in response to humidity of air.

4. An air conditioning system as set forth in claim 1 and including means for simultaneously controlling said restricted flow and the capacity of said compressor means in response to the temperature of the air in said enclosure.

5. Air conditioning apparatus as set forth in claim 1 and further including means for controlling said restricted flow in response to the humidity of the air in said enclosure and for controlling said compressor in response to the temperature of the air in said enclosure.

6. In a refrigerating system, the combination of an evaporator comprising a plurality of refrigerant passages, expansion mechanism including a thermostatic expansion valve common to said passages and a plurality of restricted passageways for distributing refrigerant to the several passages, the parts being connected for flow of refrigerant through the valve, the restricted passageways and the evaporator in the order stated, said thermostatic expansion valve operating to regulate the flow of refrigerant to the evaporator in response to the superheat of the vaporized refrigerant leaving said evaporator and including an element responsive to the temperature of said leaving refrigerant, means providing a restricted flow of refrigerant from the refrigerant flowing between said valve and said restricted passageways, and utilizing said restricted flow to reduce the temperature to which said element is subjected, whereby said thermostatic expansion valve reduces the flow of refrigerant to the sev-

eral evaporator passages and the portion of each passage containing liquid refrigerant is reduced, and means for controlling said restricted flow.

7. In refrigerating apparatus, the combination of a refrigerating system including an evaporator, expansion mechanism including a thermostatic expansion valve and a restricted passageway, the parts being connected for flow of refrigerant through the valve, the restricted passageway and the evaporator in the order stated, said thermostatic expansion valve operating to regulate the flow of refrigerant to the evaporator in response to the superheat to maintain the same substantially constant and including an element responsive to the temperature of the refrigerant leaving said evaporator, means providing a restricted flow of refrigerant from the refrigerant flowing between said valve and said restricted passageway, to the vaporized refrigerant leaving said evaporator at a point ahead of said temperature-responsive element for reducing the temperature to which said element is subjected, and means responsive to increase and decrease in humidity of air for initiating and terminating said flow.

8. In a refrigerating system, the combination of an evaporator, a valve for controlling flow of liquid refrigerant to the evaporator, means for controlling said valve, said last mentioned means including an element responsive to the temperature of the vaporized refrigerant discharged from said evaporator, means for withdrawing a restricted flow of liquid refrigerant from a portion of the refrigerating system containing liquid refrigerant at a pressure higher than the refrigerant pressure existing in said evaporator and utilizing the same to reduce the temperature to which said temperature-responsive element responds, and means for controlling said restricted flow of liquid refrigerant.

9. In a refrigerating system, the combination of an evaporator having a plurality of conduits each having an inlet and an outlet, a refrigerant distributor connected to the inlet of each conduit, a single expansion valve for controlling flow of liquid refrigerant to the distributor, said single expansion valve including an element responsive to the temperature of the vaporized refrigerant discharged from the evaporator, means for withdrawing a restricted flow of liquid refrigerant from a portion of the refrigerating system containing liquid refrigerant at a pressure interme-

diating that of the supply and the refrigerant pressure existing in the evaporator, said portion being between said valve and the inlets of said conduits, and supplying said withdrawn refrigerant at a point ahead of said temperature responsive element whereby its temperature is reduced, valve means controlling the flow through said withdrawing means, and means responsive to a condition brought about by evaporation of refrigerant in said evaporator controlling said last mentioned valve means.

10. In a refrigerating system, the combination of an evaporator, a thermostatic expansion valve operating to regulate the flow of refrigerant to said evaporator in response to the superheat of the vaporized refrigerant leaving the same and including an element responsive to the temperature of said leaving refrigerant, means providing restricted flow of liquid refrigerant from a portion of the refrigerant circuit containing liquid refrigerant at a pressure substantially higher than the refrigerant pressure within the evaporator and utilizing said restricted flow of liquid refrigerant to reduce the temperature to which said element is subjected below the temperature of the vaporized refrigerant leaving the evaporator, whereby said valve restricts the flow of refrigerant to said evaporator and the portion of the evaporator containing liquid refrigerant is reduced, and means for controlling said restricted flow.

11. In a refrigerating system, the combination of an evaporator, a thermostatic expansion valve operating to regulate the flow of refrigerant to said evaporator in response to the superheat of the vaporized refrigerant leaving the same and including an element responsive to the temperature of said leaving refrigerant, means providing restricted flow of liquid refrigerant from a portion of the refrigerant circuit containing liquid refrigerant at a pressure substantially higher than the refrigerant pressure within the evaporator and reducing the temperature to which said element is subjected by mixing said restricted flow of liquid refrigerant with the refrigerant that has been fully vaporized in the evaporator, whereby said valve restricts the flow of refrigerant to said evaporator and the portion of the evaporator containing liquid refrigerant is reduced, and means for controlling said restricted flow.

LEROY GALE HUGGINS.