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C. M. SANDERS, JR
AIR CONDITIONING APPARATUS

2,280,425

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FIG. 1.

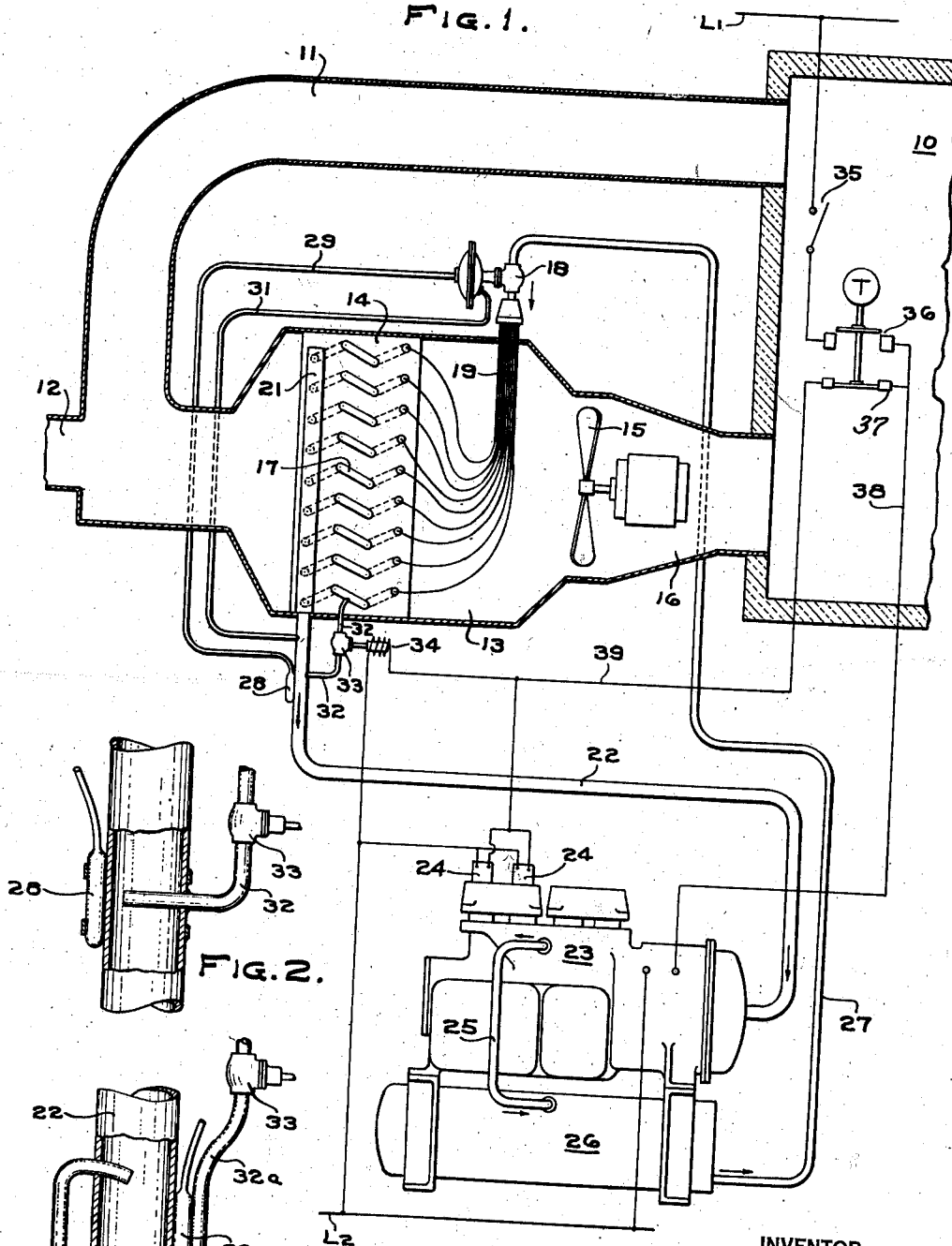


FIG. 2.

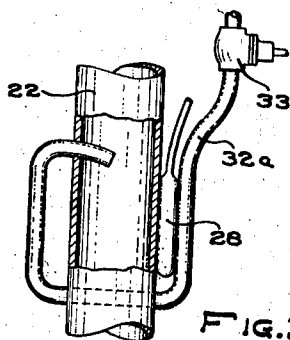


FIG. 3.

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2,280,425

AIR CONDITIONING APPARATUS

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Application June 2, 1938, Serial No. 211,310

13 Claims. (Cl. 62-6)

My invention relates to air conditioning apparatus, more particularly to a refrigerant evaporator for cooling and dehumidifying air, and it has for an object to provide improved apparatus.

A further object is to provide improved means for varying the capacity or cooling effect of the evaporator for partial load operation.

A more particular object is to reduce 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 further object is to reduce the portion of the evaporator containing liquid refrigerant.

Apparatus incorporating my invention includes a conventional evaporator of the so-called "dry" type, including a plurality of 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 and the admission thereof 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 element being usually strapped to the suction conduit. In accordance with my invention, I provide means for selectively extracting or bleeding a small portion of refrigerant from one of the coils at an intermediate point of the refrigerant path and I convey this extracted refrigerant to the suction conduit at a point such that the temperature responsive element is affected by the temperature thereof. Accordingly, the expansion valve restricts the admission of liquid refrigerant, to all of the coils, so that vaporization of refrigerant is completed at a point adjacent the extraction point. Thus, the portion of the evaporator containing liquid refrigerant is reduced.

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

Fig. 1 is a diagrammatic view of air conditioning apparatus incorporating my invention; and

Figs. 2 and 3 are enlarged detail views of modifications thereof.

Referring to the drawing in detail, 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 distributor tubes 19 which are also sometimes referred to as capillary tubes. The outlet ends of the several 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 substan-

tially constant. The valve 18 is preferably adjusted for 10° F. superheat.

In accordance with my invention, I provide a by-pass tube or conduit 32, which is connected to one of the coils 17 at an intermediate point in the path of the refrigerant therethrough. In the embodiment illustrated in Fig. 1, one end of the tube 32 is connected to the U-bend between the second and third tubes of the coil and the other end is connected to the suction conduit 22 at a point in advance of the thermostatic bulb 28. A valve 33 is connected in the conduit 32 and is operated by a solenoid 34, the valve being opened when the solenoid is energized and closed when the solenoid is deenergized.

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.

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 lower-most coil 18 to the suction conduit 22. 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. The valve restricts the admission so that approximately one-half of each coil contains liquid refrigerant.

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 be effective 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.

The present invention resides in novel and improved means for varying the portion of the evaporator containing liquid refrigerant. It may be used in connection with any suitable control system, such as the one illustrated or the one disclosed and claimed in the application of L. G. Huggins, Serial No. 157,681, filed August 6, 1937.

In Fig. 2, I show a modification in which the by-pass conduit 32 projects into the interior of the suction conduit 22 and discharges directly against that part of the wall of the suction conduit which is in contact with the thermostatic bulb 28. The purpose of this arrangement is to subject the bulb 28 more nearly to the temperature of the refrigerant at the intermediate point of the coil to which the by-pass conduit 32 is connected and to reduce the extent to which it is influenced by the higher temperature of the vaporized refrigerant flowing through the header 21.

In the embodiment shown in Fig. 3, the by-pass conduit 32a extends first in direct contact with the thermostatic bulb 28 and then discharges into the interior of the suction conduit against the portion in contact with the thermostatic bulb 28. With this arrangement, the bulb 28 is subjected still more fully to the temperature of the refrigerant flowing through the by-pass conduit and affected to a lesser extent by the higher temperature of the refrigerant flowing from the header 21.

When the thermostatic bulb 28 is subjected fully to the temperature of the refrigerant at the point of extraction, the valve 28 will control the admission of refrigerant to the evaporator so that liquid refrigerant will be completely vaporized and the refrigerant vapor will be superheated 10 degrees F. at the point of extraction, just as if the refrigerant were returned to the suction conduit after passing through the first two rows of the coils. However, the vaporized refrigerant, other than the small portion by-passed, continues on through the third and fourth rows in which it is further superheated.

The liquid containing or effective portion of the evaporator, when the valve 33 is open, may be

varied as desired by correspondingly varying the extraction point at which the by-pass conduit 32 is connected to one of the coils. It may also be varied by varying the degree to which the bulb 28 is subjected to the temperature of the refrigerant at the point of extraction.

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 imposed by the prior art or as are specifically set forth in the appended claims.

What I claim is:

1. In refrigerating apparatus, the combination of an evaporator having a refrigerant passage, a valve for controlling admission of liquid refrigerant to said passage, a suction conduit connected to the outlet end of said passage for receiving vaporized refrigerant therefrom, means for controlling said valve in accordance with the superheat of the vaporized refrigerant discharged from said refrigerant passage to said conduit and including temperature responsive means subjected to the temperature of said vaporized refrigerant, and means for selectively by-passing refrigerant from said passage at an intermediate point thereof to said suction conduit and subjecting said temperature responsive means to the temperature of said by-passed refrigerant whereby said valve regulates the admission of liquid refrigerant to said passages so that a smaller portion of the passage contains liquid refrigerant.

2. In refrigerating apparatus, the combination of evaporator means comprising a plurality of refrigerant passages, a valve for controlling admission of liquid refrigerant to said passages, a suction conduit connected to the outlet ends of said passages for receiving vaporized refrigerant therefrom, means for controlling said valve in accordance with the superheat of the vaporized refrigerant discharged from said refrigerant passages to said conduit and including temperature responsive means subjected to the temperature of said vaporized refrigerant, and means for selectively by-passing refrigerant from one of said passages at an intermediate point thereof to said suction conduit and subjecting said temperature responsive means to the temperature of said by-passed refrigerant, whereby said valve regulates the admission of liquid refrigerant to said passages so that a smaller portion of each passage contains liquid refrigerant.

3. In air cooling apparatus, the combination of an evaporator of the dry type, means for supplying liquid refrigerant thereto, a suction conduit for removing vaporized refrigerant from the evaporator, a valve for controlling flow of liquid refrigerant to the evaporator, means responsive to pressure of the vaporized refrigerant and to the temperature of said suction conduit for controlling said valve, and means for by-passing refrigerant from the evaporator at an intermediate point of the refrigerant flow path therein to said suction conduit to modify the temperature imposed on said temperature responsive means and thereby to vary the portion of the evaporator containing liquid refrigerant.

4. In air cooling apparatus, the combination of an evaporator, a compressor, a condenser and an expansion valve connected in a refrigerant circuit, means including a temperature responsive element subject to the temperature of the re-

frigerant leaving said evaporator for controlling said valve in response to said temperature, and means for selectively reducing the average temperature imposed on said temperature responsive element below that of said leaving refrigerant.

5. In apparatus for cooling an enclosure, the combination of an evaporator, a compressor, a condenser, and an expansion valve connected in a refrigerant circuit, means for conveying air in heat transfer relation to said evaporator and into the enclosure, means including a temperature-responsive element subjected to the temperature of the vaporized refrigerant leaving said evaporator for controlling said valve to control the superheat of said vaporized refrigerant, and means operable in response to a condition of the air in the enclosure for withdrawing refrigerant from the circuit at a point containing liquid refrigerant and utilizing the withdrawn refrigerant to reduce the temperature imposed on said temperature responsive element and thereby causing said valve control means to maintain a higher degree of superheat of said vaporized refrigerant.

6. In apparatus for cooling an enclosure, the combination of a refrigerant circuit including a liquid refrigerant supply line, a valve, an evaporator, and a suction conduit connected in refrigerant flow relation in the order stated, means for conveying air in heat transfer relation to said evaporator and into the enclosure, means including a temperature-responsive element subjected to the temperature of the vaporized refrigerant in said suction conduit for controlling said valve to control the superheat of said vaporized refrigerant, and means operable in response to a condition of the air in the enclosure for withdrawing refrigerant from the refrigerant circuit at a point containing liquid refrigerant and admitting the withdrawn refrigerant to the suction conduit at a point as far upstream as said temperature-responsive element to reduce the temperature imposed on said temperature-responsive element and thereby causing said valve control means to maintain a higher degree of superheat of the vaporized refrigerant leaving the evaporator.

7. In combination with a refrigerating apparatus having a plurality of evaporators arranged in parallel for evaporating refrigerant, a distributor for distributing liquid refrigerant to the evaporators, a common outlet for the evaporators and means for circulating refrigerant through the evaporators, a thermostatic expansion valve including thermostatic means responsive to the temperature of superheated refrigerant adjacent the common outlet for the evaporators for regulating the flow of liquid refrigerant to the evaporators through the distributor to maintain a desired amount of liquid refrigerant in the evaporators, and means for diverting a portion of the liquid refrigerant which has passed through the expansion valve and supplying said diverted portion to said common outlet for cooling the thermostatic means.

8. In combination with a refrigerating apparatus having evaporator means in which refrigerant is evaporated for controlling the condition of a medium and means for circulating refrigerant through the evaporator means, a thermostatic expansion valve including thermostatic means responsive to the temperature of the superheated refrigerant adjacent the outlet of the evaporator means for regulating the flow of refrigerant to the evaporator means to maintain a desired amount of liquid refrigerant in the evaporator means, means for cooling the thermostatic means

of the thermostatic expansion valve to change the amount of liquid refrigerant maintained in the evaporator means, and means responsive to the condition of the medium being controlled by the evaporator means for controlling said last-mentioned means.

9. In combination with a refrigerating apparatus having evaporator means in which refrigerant is evaporated for controlling the condition of a medium and means for circulating refrigerant through the evaporator means, a thermostatic expansion valve including thermostatic means responsive to the temperature of the superheated refrigerant adjacent the outlet of the evaporator means for regulating the flow of refrigerant to the evaporator means to maintain a desired amount of liquid refrigerant in the evaporator means, conduit means for passing refrigerant in heat-exchange relationship with the thermostatic means of the thermostatic expansion valve for cooling the thermostatic means to change the amount of liquid refrigerant maintained in the evaporator means, valve means in said conduit means for controlling the flow of refrigerant therethrough, and means responsive to the condition of the medium being controlled by the evaporator means for controlling said valve means.

10. In combination with a refrigerating apparatus having evaporator means in which refrigerant is evaporated for controlling the condition of a medium and means for circulating refrigerant through the evaporator means, a thermostatic expansion valve including thermostatic means responsive to the temperature of the superheated refrigerant adjacent the outlet of the evaporator means for regulating the flow of refrigerant to the evaporator means to maintain a desired amount of liquid refrigerant in the evaporator means, means for cooling the thermostatic means of the thermostatic expansion valve by the evaporation of liquid refrigerant adjacent the thermostatic means to change the amount of liquid refrigerant maintained in the evaporator means, and means responsive to the condition of the medium being controlled by the evaporator means for controlling said last-mentioned means.

11. In combination with a refrigerating apparatus having evaporator means in which refrigerant is evaporated for controlling the condition of a medium and means for circulating refrigerant through the evaporator means, a thermostatic expansion valve including thermostatic means responsive to the temperature of the su-

perheated refrigerant adjacent the outlet of the evaporator means for regulating the flow of refrigerant to the evaporator means to maintain a desired amount of liquid refrigerant in the evaporator means, means for supplying liquid refrigerant to said superheated refrigerant at a point as far upstream as the thermostatic means of the thermostatic expansion valve for cooling the thermostatic means to change the amount of liquid refrigerant maintained in the evaporator means, and means responsive to the condition of the medium being controlled by the evaporator means for controlling said last-mentioned means.

12. 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, conduit means for withdrawing liquid refrigerant from a portion of the refrigerating system containing liquid refrigerant at a pressure sufficient to cause flow through the conduit means and supplying said withdrawn refrigerant to said discharged vaporized refrigerant at a point as far upstream as the temperature-responsive element, whereby the temperature of the latter is reduced, valve means controlling flow through said conduit means, and means responsive to a condition brought about by evaporation of refrigerant in said evaporator for controlling said last-mentioned valve means.

13. In combination with a refrigerating apparatus having a plurality of evaporators arranged in parallel for evaporating refrigerant, a distributor for distributing liquid refrigerant to the evaporators, a common outlet for the evaporators and means for circulating refrigerant through the evaporators, a thermostatic expansion valve including thermostatic means responsive to the temperature of the superheated refrigerant adjacent the common outlet for the evaporators for regulating the flow of liquid refrigerant to the evaporators through the distributor to maintain a desired amount of liquid refrigerant in the evaporators, and means for cooling the thermostatic means of the thermostatic expansion valve to change the amount of liquid refrigerant maintained in the evaporators.

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