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AIR CONDITIONING APPARATUS

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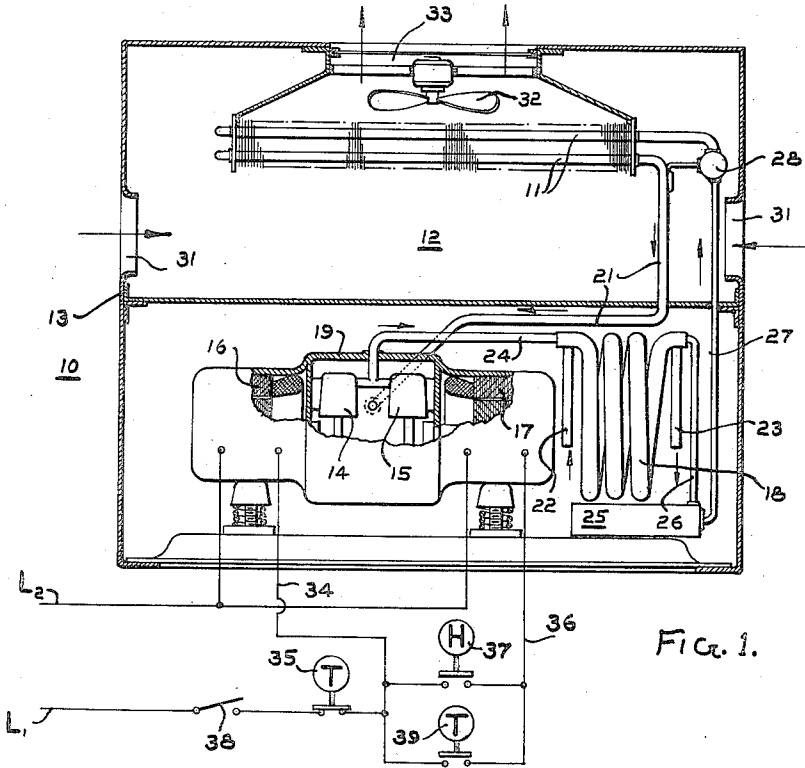


FIG. 1.

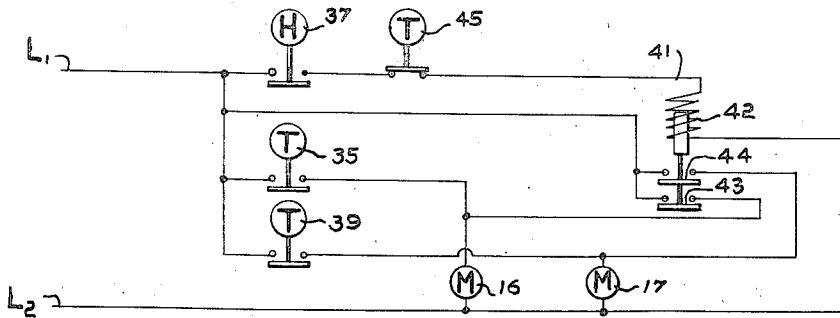


FIG. 2.

WITNESSES:

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AIR CONDITIONING APPARATUS

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8 Claims. (Cl. 62-4)

My invention relates to air conditioning apparatus and it has for an object to provide improved apparatus of this kind.

Another object of the invention is to provide apparatus of relatively simple form whereby the humidity of the air in the enclosure being air treated as well as the temperature thereof, may be maintained within desired limits.

In accordance with my invention, I employ a refrigerant evaporator with means for circulating the air to be conditioned in heat exchanging relation therewith. First and second refrigerant compressors are provided for circulating refrigerant through the evaporator. A thermostat is adapted to effect operation of one compressor in response to a high temperature of the air in the enclosure, and a humidostat is adapted to effect operation of both compressors in response to a high humidity condition of the air.

When only one compressor is operating, it is unable to effect as low a pressure of the refrigerant in the evaporator as when both compressors are operating. Accordingly, the evaporator operates at higher temperature and the air passing over it is cooled approximately only to its dew point. Most of the heat removed from the air, therefore, is sensible heat.

When both compressors are operating, they are able to effect a lower pressure and temperature of the refrigerant in the evaporator. In this case, the air is cooled to a much lower temperature, materially below the dew point of the entering air, so that a substantial amount of latent heat as well as sensible heat is also removed from the air, and both cooling and dehumidification are effected.

The invention is particularly applicable to unit type air conditioners or coolers having a pair of compressors such as is disclosed in the copending application No. 702,376, filed December 14, 1933 and assigned to the assignee of the present application. It is to be understood, however, that the invention is not limited to self-contained air conditioners but is equally applicable to other forms of air conditioning apparatus.

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

Fig. 1 is a diagrammatic view of an air conditioner arranged in accordance with my invention; and

Fig. 2 is a modified diagram of the control apparatus for the apparatus shown in Fig. 1.

Referring now to Fig. 1 of the drawing, I show my invention embodied in an air conditioning unit, generally shown at 10, and including an evaporator or air cooling unit 11 disposed within a chamber 12 that is defined by a casing structure 13. A pair of compressors 14 and 15, driven by motors 16 and 17, respectively, and connected to a condenser 18, operate to circulate refrigerant through the evaporator 11. The compressors 14 and 15 and their respective motors may be enclosed in a hermetic housing 19, as shown. The interior of the housing 19 may be connected to the evaporator 11 by means of a conduit 21 and may form a part of the low side of the refrigerating system. The condenser 18 may be cooled in any suitable manner such as, for example, by water which enters the condenser 18 by the conduit 22 and is discharged therefrom through conduit 23.

The refrigerating system disclosed, operates on the well known compressor-condenser-expander cycle wherein the compressors 14 and 15 withdraw vaporized refrigerant from the evaporator 11 through the conduit 21 and the interior of the housing 19 and compress it to a relatively high pressure. The compressed refrigerant is delivered through a conduit 24 to the condenser 18, wherein it is cooled by the water and is condensed. Liquefied refrigerant passes from the condenser 18 to a reservoir 25 through a conduit 26 and thence to the evaporator 11 by means of a conduit 27.

A suitable expansion device 28 is arranged in the conduit 27 for controlling the flow of the condensed refrigerant to the evaporator 11 and for reducing the pressure thereof. The device 28 may be of any suitable type but it is preferably a thermostatic expansion valve wherein the flow of refrigerant to the evaporator 11 is controlled in response to the refrigerant pressure prevailing in the evaporator and to the temperature of the refrigerant leaving the same. These two controlling influences cooperate to regulate the admission of refrigerant to the evaporator 11 so that a substantially constant amount of superheat is present in the refrigerant vapor leaving the evaporator 11. As the operation of expansion devices of this type are well known in the art, no further description of their construction or operation is deemed necessary.

Air to be conditioned is translated from the enclosure through inlet openings 31 by a fan 32 and is returned to the enclosure through an opening 33, after traversing the air cooling evaporator 11. Suitable filters, not shown, may be

provided in the openings 31 or 33 for cleansing the air passed therethrough.

In accordance with my invention, the motors 14 and 15 are energized from a suitable source of power indicated by the conductors L₁—L₂. One side of each of the motors 16 and 17 may be directly connected to the conductor L₂ as shown. The motor 16 includes a conductor 34 that is connected to the conductor L₁ through a thermostat 35, preferably responsive to the temperature of the air in the enclosure or space being air conditioned. The motor 17 includes a conductor 36 controlled by a humidity-responsive instrument 37 and, preferably, leading to the conductor 34. The thermostat 35 may be of any well known type responding to the dry bulb temperature of the air and operates to open and close the conductor 34 in response to relatively low and high temperature values, respectively. The humidity-responsive instrument 37 may be responsive to the relative humidity of the air or to the wet bulb temperature thereof. In the present description, it will be assumed that this instrument 37 reflects the relative humidity of the air and opens and closes the conductor 36 in response to relatively low and high values of the humidity, respectively.

A disconnecting switch 38 may be provided in the conductor L₁ for rendering the apparatus active or inactive, as desired.

Assume the apparatus is rendered active by the closure of switch 38 and that the temperature of the air in the enclosure has risen to a value of say 75°. The thermostat 35 closes the circuit to the motor 16 which circuit includes the conductor L₁, switch 38, thermostat 35, conductor 34, winding of motor 16 and conductor L₂. Accordingly, operation of the compressor 14 is initiated for circulating refrigerant through the refrigerant circuit including the evaporator 11. Circulation of water for cooling the condenser 18 may be effected in any well known manner.

The fan 32 may be controlled in any suitable manner and operated continuously for ventilation during periods when the evaporator 11 is inactive. As refrigerant is evaporated in the evaporator 11, the air circulated by the fan 32 is cooled and the temperature of the air in the enclosure is depressed to a value of say 72°, at which time operation of the compressor 14 ceases. It has been assumed that the air being treated is relatively dry so that the humidostat 37 has remained open. The heat removed from the air has been principally sensible heat as the evaporator 11 has operated with but one compressor and, therefore, at relatively high suction pressure and temperature.

Assume now that the temperature of the air being treated rises above 75° and that the compressor 14 is operated. If the relative humidity increases above a predetermined value, due to the addition of water vapor to the air or to the cooling thereof by the operation of the first compressor 14, the humidostat 37 closes the conductor 36 and the second compressor 15 operates in parallel with the compressor 14 for circulating refrigerant through the evaporator 11. Accordingly, a lower pressure and temperature prevail in the evaporator 11 so that the air is cooled to a greater degree and a substantial portion of the cooling effect is effective for the removal of latent heat.

From the foregoing, it will be apparent that, when the air being cooled is relatively dry, only a single compressor is operated to depress the temperature thereof and, when the vapor con-

tent of the air is relatively high, both of the compressors operate. In the first case, the evaporator is operated at a relatively high temperature for the abstraction of principally sensible heat from the air and in the second case, it is operated at a lower temperature for the removal of latent heat.

There may be occasions when the operation of a single compressor is insufficient to reduce the sensible heat present in the air and that the operation of the second compressor is necessary. Accordingly, the humidity-responsive instrument 37 may be paralleled by a second thermometer 39, that is set for effecting circuit closing operation at a higher temperature than the thermostat 35. With this arrangement, both motors 16 and 17 may be energized for operating their respective compressors when the temperature of the air in the enclosure has risen to a predetermined value, independently of the humidity-responsive instrument 37.

In the foregoing, the humidostat 37 is effective to control the second compressor 15 only during periods when the thermostat 35 is closed in response to a high temperature of the air being treated. I have shown in Fig. 2, an embodiment of my control wherein the humidostat may effect operation of the compressors during periods when the thermostats 35 and 39 are satisfied. In this embodiment, the thermostats 35 and 39 are connected in parallel for controlling the operation of their respective motors 16 and 17; the latter being started sequentially as thermostats 35 and 39 successively close.

The humidostat 37 is operative to initiate operation of both motors 16 and 17 and their respective compressors 14 and 15, independently of the thermostats 35 and 39, when the relative humidity of the air attains a predetermined value. The humidostat 37 controls a circuit 41 that includes a relay 42 having main switches 43 and 44 connected in parallel with the thermostats 35 and 39, respectively. Accordingly, when the relative humidity of the air increases to a predetermined value, the relay 42 is energized by the closure of the humidostat 37 and both motors 16 and 17 are energized by the closure of switches 43 and 44. Both compressors 14 and 15 are effective for the circulation of refrigerant and the pressure and temperature of the evaporator 11 is such that latent heat is removed from the air. During this operation, the thermostats 35 and 39 may be open and the cooling of the air is effected because of the high moisture content thereof.

In order that the temperature of the air in the enclosure be not depressed to an uncomfortable degree during the operation of the apparatus by the action of the humidostat, a limiting thermostat 45 may be connected in the conductor 41 in series with the humidostat 37 for controlling the energization of the relay 42 and the motors 16 and 17. The thermostat 45 is normally closed and opens when the temperature of the air in the enclosure has been depressed to a predetermined low value of, 70°, for example. Opening of the thermostat 45 deenergizes the relay 42 and motors 16 and 17 and discontinues the humidostat's control over these elements until such time as the temperature of the air has risen above the closing temperature of the thermostat 45.

From the foregoing, it will be apparent that I have provided an improved control for air conditioning apparatus in which variable quantities

of refrigerant are circulated and the temperature of the evaporator is varied in response to predetermined temperature and humidity conditions, whereby substantially all of the heat removed from the air at one time is sensible heat and, at another time, sensible and latent heat are removed.

While I have shown my invention in two 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 apparatus for conditioning air, the combination of air cooling means including first and second elements for circulating refrigerant in heat exchanging relation with the air to be conditioned, means responsive to a predetermined temperature of the air for effecting operation of one of said elements, whereby limited cooling of the air is effected, and means responsive to a predetermined condition of the humidity of the air for effecting operation of both of said elements, whereby maximum cooling of the air is effected.

2. In apparatus for conditioning air, the combination of air cooling means including first and second compressor elements for circulating refrigerant in heat exchanging relation with the air to be conditioned, means responsive to a predetermined temperature of the air for effecting operation of one of said compressor elements, whereby the air to be conditioned is principally cooled above its dew point, and means responsive to a predetermined condition of humidity of the air for effecting operation of both of said compressor elements, whereby the air to be conditioned is cooled below its dew point.

3. In apparatus for conditioning air, the combination of air cooling means including first and second compressor elements for circulating refrigerant in heat exchanging relation with the air to be conditioned, a thermostat responsive to the temperature of the air, and an instrument responsive to a condition of humidity of the air, said first and second compressor elements being controlled, respectively, by said thermostat and said humidity responsive instrument.

4. In apparatus for conditioning the air in an enclosure, the combination of means for translating air to the enclosure, an evaporator for cooling the air prior to its admission to the enclosure, first and second compressor elements for circulating refrigerant through the evaporator, means responsive to a predetermined temperature of the air in the enclosure for effecting operation of the first compressor element, and means

responsive to a predetermined value of the humidity of the air in the enclosure for effecting operation of the second compressor element during periods when the first compressor element is operated by the temperature responsive means.

5. In apparatus for conditioning air, the combination of an air cooler, first and second compressor elements for circulating refrigerant through the cooler, means for translating the air to be conditioned in heat exchanging relation with the air cooler, a thermostat responsive to the temperature of the air, an instrument responsive to a humidity condition of the air, and electrical means controlled by the thermostat and said instrument and operative to effect operation of the first compressor element when the thermostat calls for cooling and to effect operation of both compressor elements when the humidity responsive instrument calls for a reduction in the vapor content of the air.

6. In air conditioning apparatus for conditioning the air in an enclosure, the combination of an evaporator, a fan for withdrawing air from the enclosure and for translating it in heat exchanging relation with said evaporator, means for delivering the air cooled by the evaporator to the enclosure, first and second compressors for circulating refrigerant through the evaporator, means responsive to the temperature of the air within the enclosure for controlling the operation of said first compressor, and means responsive to the humidity of the air in the enclosure for controlling the operation of the second compressor, said temperature-responsive and humidity-responsive means being so arranged that operation of the second machine is always accompanied by operation of the first machine.

7. In air conditioning apparatus, the combination of an evaporator, means for conveying air over said evaporator, a plurality of compressors for withdrawing vapor from said evaporator to effect vaporization of refrigerant therein, means responsive to a predetermined maximum temperature for effecting operation of one compressor, and means responsive to a predetermined maximum temperature and a predetermined maximum value of humidity for effecting operation of two compressors.

8. In air conditioning apparatus, the combination of an evaporator, means for conveying air over said evaporator, a plurality of compressors for withdrawing vapor from said evaporator to effect vaporization of refrigerant therein, means responsive to a predetermined maximum temperature for effecting operation of one compressor, and means controlling the operation of at least one other compressor and effective to increase the number of compressors in operation to two in response to a predetermined high humidity condition.

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