Nov. 19, 1940. L. A. PHILIPP 2,222,236

AIR CONDITIONING SYSTEM

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Fig. 1.

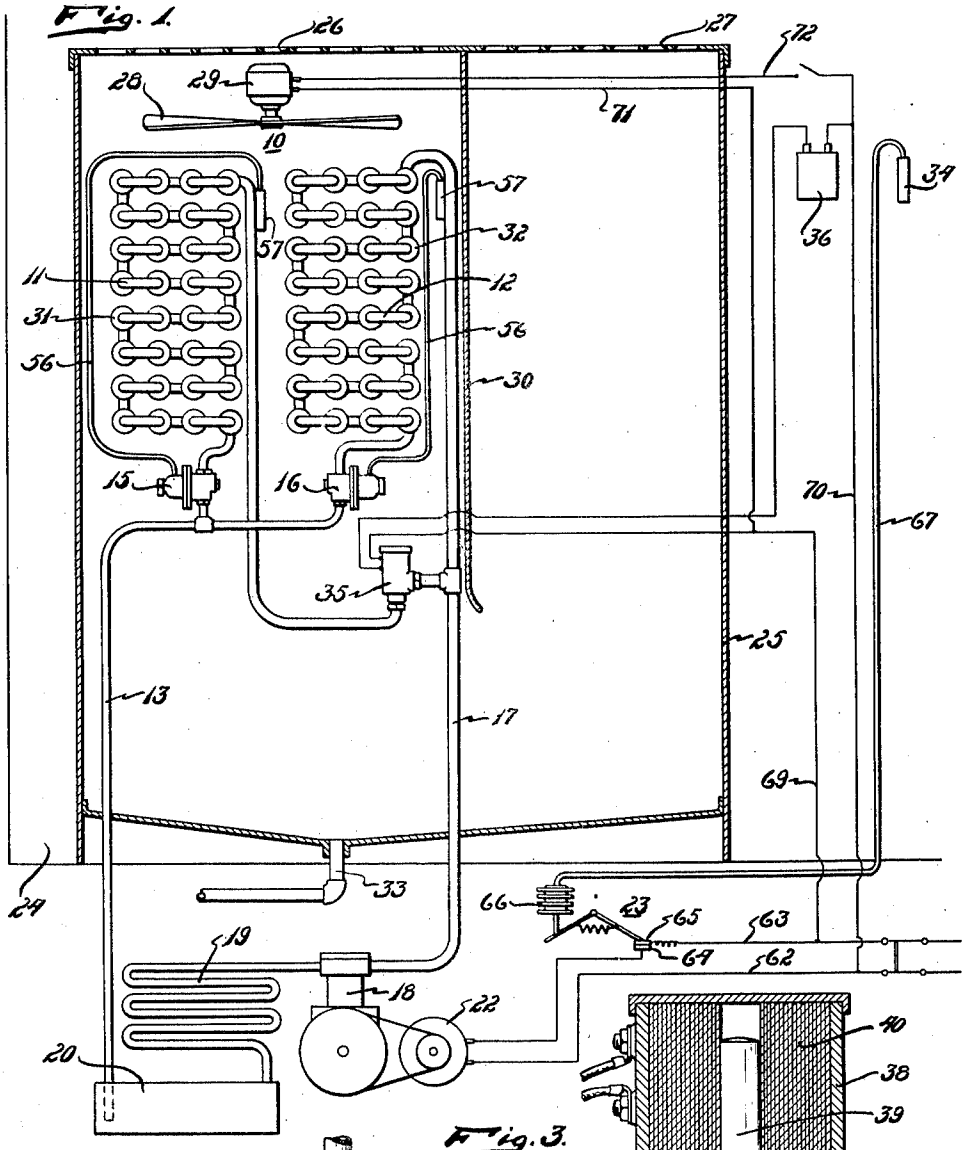


Fig. 2.

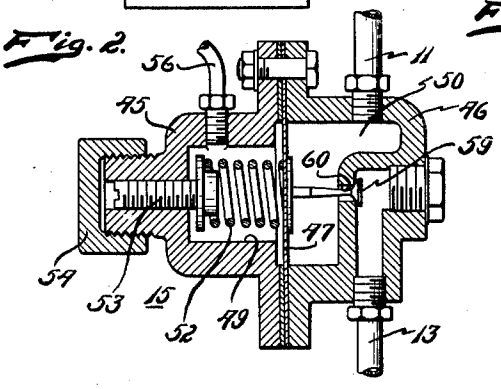


Fig. 3.

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AIR CONDITIONING SYSTEM

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The present invention relates to the art of conditioning air and more particularly to the method of and apparatus for cooling and dehumidifying air.

One of the objects of the present invention is to provide an improved method of and apparatus for conditioning air, utilizing a heat absorber about which air to be conditioned is circulated and varying the quantity of heat removed from the circulating air by different portions of the heat absorber in accordance with the relative humidity of the air to be conditioned; to cause one portion of the heat absorber to increase and another portion thereof to decrease in temperature in accordance with the relative humidity of the air to be conditioned; to control the temperature of the heat absorber in accordance with the temperature of the air to be conditioned and controlling the amount of heat absorbed by different portions of the heat absorber in accordance with the changes in the relative humidity of the air to be conditioned.

Other and further objects and advantages will be apparent from the following disclosure, reference being had to the accompanying drawing wherein a preferred form of embodiment of the present invention is clearly shown.

In the drawing:

Fig. 1 illustrates diagrammatically my improved air conditioning system as applied for cooling a room; Fig. 2 is a cross sectional view of an expansion valve, and Fig. 3 is a cross sectional view of another control valve used in the system.

My invention contemplates the use of a heat absorber of any suitable type about which a part of the air to be conditioned is circulated over one portion of the heat absorber for the purpose of removing principally sensible heat from the air. Part of the air to be conditioned is circulated over another portion of the heat absorber, which latter portion is utilized, particularly when the air to be conditioned is high in relative humidity, for cooling the air to below its dew point in order to cause precipitation and thereby removal of a large part of the moisture from the air.

In the present embodiment an evaporator 10 of a mechanical refrigerator is employed as a heat absorber and the two heat absorbing surfaces of the heat absorber are provided by dividing the evaporator into two sections or portions 11 and 12. The flow of refrigerant from a feed pipe 13 to sections 11 and 12 is controlled by expansion valves 15 and 16 respectively and gaseous refrigerant is withdrawn from these sections through a low pressure or suction pipe 17. The heat dissipator is herein shown as comprising a reciprocating type compressor 18, a condenser 19 and a receiver for liquid refrigerant 20. Gaseous refrigerant withdrawn from the sections 11 and 12 passes through the suction pipe 17 into the low pressure side of the compressor 18 wherein it is compressed and flows into the condenser where it is liquefied by being cooled and from the condenser the liquefied refrigerant flows into the receiver 20 and then conducted to the expansion valves 15 and 16 through liquid refrigerant feed pipe 13. The compressor is driven by a motor 22 which is controlled by a switch 23. It is to be understood that the capacity of the machine is such as to provide sufficient refrigeration under abnormal high temperature and humidity conditions or both of the air to be conditioned and that the refrigerating effect is varied in accordance with the conditions of the air to be conditioned.

The air conditioner herein illustrated is the type for cooling a room 24 such as an office or a living room in the home and the evaporator 10 is disposed in a cabinet 25 having an air inlet 26 and an air outlet 27. The air is forced through the cabinet and about the evaporator 10 by a fan 28 driven by an electric motor 29. A partition 30 extends downwardly from the top of the cabinet 25 and from the front to the back for directing air. The sections 11 and 12 of the evaporator are arranged side by side and approximately one-half of the air circulated passes about section 11 and the other half about section 12. Section 12 has approximately as much heat absorbing surface as section 11. In order to increase the heat absorbing surfaces of sections 11 and 12, fins 31 and 32 are attached to these sections. Water collected on the evaporators drips to the floor of the cabinet 25 and is conducted out of the cabinet through a drain pipe 33. Preferably the heat dissipator is disposed outside of the room to be conditioned but in case it is desirable to have this machine in the room, the condenser and compressor are cooled by water so that the heat is carried out of the room in the water.

The primary or principal purpose of section 11 is to remove sensible heat from all of the air passing thereover and although section 12 will remove sensible heat from the air passing thereover, its function at times, particularly when the relative humidity of the air to be conditioned is high, is to remove latent heat from the air by lowering the temperature of such air to considerably below its dew point. It will be appre-

ciated that the air in the room is subjected to different conditions due to changes in the temperature and humidity of the air outside the room and due to the direct addition of heat and moisture to the air within the room.

In order to maintain the air in the room between predetermined high and low temperature limits, a thermostat **34** is provided for controlling the operation of the heat dissipator. This thermostat is preferably disposed so as to respond to the mean temperature of the air in the room and controls the motor switch **23** by opening the same when the temperature of the air in the room attains a predetermined low value and closes the same when the temperature of the air attains a predetermined high value. Thus the temperature of the air in the room is maintained between certain limits by controlling the operation of the heat dissipator.

Not only is it desirable to control the temperature of the air in the room but, it is also desirable to control the relative humidity of the air. This is accomplished by lowering the temperature of part of the air, as it passes through the cabinet **25**, to below its dew point to cause precipitation or increased precipitation of the moisture out of the air. The section **12** of the evaporator **10** is used for this purpose, it being designed and controlled to main at times a temperature much lower than that of the section **11**. Since the relative humidity varies independently of variations in temperature, it is necessary to remove varying proportions of moisture from the air while maintaining the temperature of the air between the predetermined fixed high and low temperature limits. In other words it is necessary at times to provide a low temperature to remove sufficient moisture and it is also necessary that the temperature should not be lowered below a predetermined limit. To provide these proper refrigerating conditions, I vary the amount of heat absorbed by different portions of the evaporator **10** by increasing the temperature of one portion and decreasing the temperature of another portion of the evaporator. These portions in the present disclosure are sections **11** and **12**. When the relative humidity of the air to be conditioned is relatively high, the section **12** is arranged to operate at a low temperature and the section **11** is either ineffective or operates at a relatively high temperature. The temperature of the section **12** at this time will be low enough to cool a portion of the air to considerably below its dew point and the amount of heat units removed by the evaporator is sufficient only to maintain the temperature of the air in the room between its predetermined fixed high and low temperature limits.

The differential in temperature between the sections **11** and **12** or the relative amounts of heat absorbed by said sections can be controlled by preventing circulation or restricting the circulation through one of the sections. For this purpose, I provide a valve **35** which is controlled by a humidostat **36**. Valve **35** comprises a casing **38** which is fluid tight and incloses a solenoid including a core **39** and a magnet coil **40**. Core **39** is arranged to open and close a port **41** to control the flow of gaseous refrigerant from evaporator section **11**. If desirable, a by-pass **42** for the port **41** may be provided which by-pass permits a restricted flow of refrigerant from the section **11** to the interior of the casing **38** when the core is on its seat. When the magnet coil **40** is de-energized, the core rests upon its seat and, if the by-pass is provided, the refrigerant can flow from the section **11** only through by-pass **42**, however, when the magnet coil **40** is energized, the core is lifted from its seat permitting an unrestricted flow of refrigerant from section **11** to the interior of the casing. The magnet coil **40** is controlled by the humidostat **36**. When the percentage of relative humidity is proper, the humidostat causes current to flow through coil **40** so that the flow of refrigerant from section **11** to compressor **18** is unrestricted but when the percentage of relative humidity is too high, the circuit to the coil **40** is interrupted by the humidostat whereby refrigerant flow from section **11** to the compressor **18** is interrupted, or, if by-pass **42** is provided, the flow from section **11** is restricted to that which can pass through by-pass **42**.

The expansion valves **15** and **16** are identical in construction and valve **15** is shown in detail in Fig. 2. Each valve comprises a casing **45** and a casing **46** with a diaphragm **47** sealed therebetween to form chambers **49** and **50**. A spring **52** is disposed within chamber **49** and is adjustably set by a screw **53**. The threaded opening for this screw is closed by a cap **54**. A tube **56** connects the interior of chamber **49** with a thermostat **57** which thermostat is in intimate metallic contact with the outlet of evaporator section **11** and contains a volatile fluid. A valve **59** is attached to the diaphragm **47** and the stem thereof extends through a port **60** in a wall of casing **46**. This valve **59** controls the flow of refrigerant from the liquid pipe **13** to the chamber **50** and the inlet of evaporator section **11** is fed from this chamber.

The movement of diaphragm **47** and likewise the opening and closing of valve **59** of expansion valve **15** is governed by the differential in pressures on opposite sides of the diaphragm. The pressure of the volatile fluid in chamber **49** is governed by the temperature at the outlet of the evaporator section **11**. When the temperature at the outlet of section **11** is high, the pressure in chamber **49** is high, and vice versa. The pressure in chamber **50** is governed by the pressure of the refrigerant in section **11**. When the pressure of the refrigerant in section **11** is high, the pressure in chamber **50** is high, and vice versa.

When the effect of the pressure on the chamber **50** side of diaphragm **47** overbalances that of the opposite side of the diaphragm, valve **59** will be closed but when gaseous refrigerant is withdrawn from section **11** to reduce the pressure in section **11**, the valve will open. Now when only a limited amount of refrigerant is withdrawn from the section **11** only a corresponding amount of refrigerant will be admitted to the section **11** through valve **59** and therefore the temperature of the section will be relatively high. However, if the flow of refrigerant is not so restricted, the pressure within the section **11** will be lowered permitting a larger quantity of refrigerant to enter the section through valve **59** and consequently, the section will operate at a relatively lower temperature. The lower temperature operation of the section **11** is also governed by the thermostat **57** in such manner that after the temperature at the outlet of the section is lowered to a predetermined minimum, the pressure of the volatile fluid in chamber **49** is reduced to such value whereby the pressure in chamber **50** overbalances that in chamber **49** and causes the diaphragm to close valve **59** or to

so retard the flow of liquid refrigerant therethrough as to maintain the temperature of the evaporator section at its predetermined low value. The thermostat 57 is preferably placed in intimate metallic contact with the outlet of the evaporator and when refrigerant vaporizes at this point, at which time the evaporator section is operating at full capacity, this vaporization causes a material lowering of the temperature at the outlet of the evaporator and of the volatile fluid in thermostat 57 and a consequent material lowering of the pressure in the thermostat and in chamber 49 to affect the movement of the valve 59 as above described.

Expansion valve 16, which controls the flow of refrigerant to evaporator section 12, operates in the same manner as expansion valve 15 namely, it depends on the pressure of the refrigerant in section 12 which pressure is governed by the quantity of gaseous refrigerant withdrawn therefrom. If the back pressure of the compressor is low, a relatively large quantity of liquid refrigerant will be admitted to the section and the thermostat 57 at the outlet thereof will prevent flooding of the section. When the back pressure is higher, less refrigerant will enter the section and it will operate at a warmer temperature.

If the flow of gaseous refrigerant from the section 11 is restricted as by the solenoid valve 39, the pressure within the section 11 will be higher than when there is no restriction to the withdrawal of gaseous refrigerant as when the solenoid valve 39 is open. Therefore section 11 will operate at a warmer temperature when valve 39 is closed than when said valve is open. It will be observed that at this time, the suction of the compressor is substantially concentrated on reducing the pressure in section 12 since gaseous refrigerant can freely flow therefrom and only a limited amount of gaseous refrigerant escapes through the valve 35 and therefore the temperature of section 12 is reduced to a relatively low temperature. The adjustment or setting of the expansion valves 15 are such that when solenoid valve 39 is closed, the temperature of section 12 is low enough so that such air passing thereover, is cooled to considerably below its dew point whereby to remove the necessary moisture so that the air is maintained at the proper relative humidity. The combined cooling effect of sections 11 and 12, governed by the length of operation of the compressor 18 as controlled by thermostat 34, will adequately cool the air to the desired temperature and the section 12 will cool the air sufficiently to remove the required amount of moisture for proper humidity conditions.

If the relative humidity is low, the humidostat will cause current to flow through magnet coil 40 to open the port 41. Gas can then readily flow from the section 11 to the compressor and the suction of the compressor will no longer be concentrated primarily on the section 12. By increasing the flow of gaseous refrigerant from section 11, its temperature will be reduced to a lower value. Since the suction action of the compressor is no longer concentrated primarily on section 12, the pressure in both sections 11 and 12 will be substantially the same, section 11 decreasing in temperature and section 12 increasing in temperature and both sections will then operate at a temperature to remove principally sensible heat from the air.

Current for the motor 22 is conducted through wires 62 and 63, the current passing through contact 64 and movable contact 65 of the snap acting switch 23. The contact 65 of this switch is actuated by a fluid tight bellows 66 which is connected with the volatile fluid containing thermostat 34 by a pipe 67. The humidostat 36 is connected in parallel with the compressor motor 22 by wires 69 and 70 and fan motor 29 by wires 71 and 72.

From the foregoing, it will be apparent that I have provided an air conditioning system in which the temperature of the air will be maintained between predetermined high and low temperature limits. The room thermostat 34 controls the starting and stopping of the compressor 18 to provide the proper temperature of the air and this is accomplished regardless whether the evaporator sections are functioning to remove both latent and sensible heat or functioning to remove primarily sensible heat. By providing for varying the temperature differential between sections 11 and 12 so that one section is reduced to a temperature low enough to remove latent heat while the other section is increased in temperature, I have provided a system in which even temperature and desired humidity for a room is insured.

It will be observed that the cabinet is so constructed that the air which is not cooled or cooled slightly only, as the case may be, by section 11, commingles, in the lower part of the cabinet and while passing upwardly, with the relatively cold air which passed about section 12.

Under certain conditions, it will be desirable to cause some precipitation of moisture at the sections 11 and 12 when the valve 39 is open, and it is to be understood that when said section or portion 11 is referred to as functioning to remove principally sensible heat, such terms are used merely to define the main functional purpose of the section as distinguished from the main functional purpose of section or portion 12 at the time valve 39 is closed.

While the form of embodiment of the present invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What I claim is as follows:

1. The process of conditioning air which comprises causing the air which is to be conditioned to circulate in heat exchange relation with a cooling surface and causing a portion only of the cooling surface to decrease to a lower temperature than another portion of said cooling surface in accordance with an increase of relative humidity of the air to be conditioned and causing said first portion only to increase in temperature in accordance with a decrease of relative humidity of the air to be conditioned.

2. The process of conditioning air which comprises causing the air which is to be conditioned to circulate in heat exchange relation with a cooling surface and causing a portion of the cooling surface to increase in temperature and another portion of the cooling surface to decrease in temperature in accordance with the relative humidity of the air to be conditioned.

3. The process of cooling and dehumidifying air which comprises causing the air which is to be conditioned to circulate in heat exchange relation with a surface cooled by a refrigerating medium, controlling the heat exchange between the medium and said surface in accordance with the temperature of the air to be conditioned,

and causing a portion only of the cooling surface to decrease to a lower temperature than another portion of said cooling surface in accordance with an increase of relative humidity of the air to be conditioned and causing said first portion only to increase in temperature in accordance with a decrease of relative humidity of the air to be conditioned.

4. An air conditioning system comprising in combination, means providing a cooling surface for cooling circulating air, control means for causing a portion of the cooling surface to increase in temperature and for causing another portion of the cooling surface to decrease in temperature, and means responsive to the relative humidity of the air to be conditioned for actuating said control means.

5. The process of cooling and dehumidifying air which comprises causing the air which is to be conditioned to circulate in heat exchange relation with a portion of an evaporator of a mechanical refrigerator, the principal function of which portion is to remove sensible heat from the air, and in heat exchange relation with another portion of the evaporator, the function of which latter portion is to cool the air to below the dew point thereof, controlling the flow of refrigerating medium through the first mentioned portion of the evaporator in accordance with the changes in temperature of the air to be conditioned, and controlling the flow of refrigerating medium through the second mentioned portion of the evaporator in accordance with the changes in the relative humidity of the air to be conditioned.

6. The process of cooling and dehumidifying air which comprises causing the air which is to be conditioned to circulate in heat exchange relation with a portion of an evaporator of a mechanical refrigerator, the main function of which portion is to remove principally sensible heat from the air, and in heat exchange relation with another portion of the evaporator, the function of which latter portion is to cool the air to below the dew point thereof, controlling the amount of heat absorbed by the first mentioned and second mentioned portions of the evaporator in accordance with the changes in temperature and changes in the relative humidity, respectively, of the air to be conditioned.

7. The process of controlling the temperature and the humidity of air which comprises causing air, which is to be conditioned, to circulate in heat exchange relation with a heat interchanger and causing a portion of the heat interchanger to decrease in temperature and another portion to increase in temperature simultaneously in accordance with the condition of the air to be conditioned.

8. An air conditioning system comprising in combination, means providing a cooling surface over which air to be conditioned is circulated, and means responsive to an increase of relative humidity of the air to be conditioned for causing a portion only of said surface to decrease to a lower temperature than another portion of the cooling surface and responsive to a decrease of relative humidity of the air for causing said first portion to increase in temperature.

9. An air conditioning system comprising in combination, means providing a cooling surface over which air to be conditioned is circulated, means for maintaining said surface operative during changes in relative humidity of the air being conditioned and for varying the temperature differential between different portions of said surface during such changes in relative humidity.

10. The method of controlling the humidity and temperature conditions of air by a mechanical refrigerating system employing evaporating means comprising a plurality of evaporators connected with a compressor and condenser and in which the evaporators are connected in parallel circuit relation, which method comprises causing air to circulate over the evaporators; and while the compressor is in operation, varying the refrigerating effect of the evaporating means by controlling the flow of refrigerant from one of the evaporators in accordance with changes in one of the said conditions of air.

11. The method of controlling the humidity and temperature conditions of air by a mechanical refrigerating system employing evaporating means comprising a plurality of evaporators connected with a compressor and condenser and in which the evaporators are connected in parallel circuit relation, which method comprises causing air to circulate over the evaporators; and while the compressor is in operation, varying the refrigerating effect of the evaporating means by controlling the flow of refrigerant to one of the evaporators in accordance with changes in one of the said conditions of the air.

12. The method of controlling the humidity and temperature conditions of air by a mechanical refrigerating system employing evaporating means comprising a plurality of evaporators connected with a compressor and condenser and in which the evaporators are connected in parallel circuit relation, which method comprises causing air to circulate over the evaporators; causing the compressor to operate in response to one of the said conditions of the air; and while the compressor is in operation, varying the refrigerating effect of the evaporating means by controlling the flow of refrigerant to one of the evaporators in accordance with changes in the other condition of the air.

13. The process of controlling the humidity and temperature conditions of air by a mechanical refrigerating system employing an evaporator connected with a compressor and a condenser, which process comprises causing air to circulate over the evaporator; and while the compressor is in operation, varying the refrigerating effect of the evaporator by decreasing and increasing the flow of refrigerant to the evaporator in accordance with changes in one of the said conditions of the air.

14. The process of controlling the humidity and temperature conditions of air by a mechanical refrigerating system employing an evaporator connected with a compressor and a condenser, which process comprises causing air to circulate over the evaporator; causing the compressor to operate in response to one of the said conditions of the air; and while the compressor is in operation, varying the effect of the evaporator by increasing and decreasing the flow of refrigerant to the evaporator in accordance with changes in the other said condition of the air.

15. The method of controlling the humidity and temperature conditions of air by a mechanical refrigerating system employing evaporating means comprising a plurality of evaporators connected with a compressor and condenser and in which the evaporators are connected in par-

allel circuit relation, which method comprises causing air to circulate over the evaporators; and while the compressor is in operation, varying the refrigerating effect of the evaporating means by controlling the flow of refrigerant through one of the evaporators in accordance with changes in one of the said conditions of air.

16. The process of controlling the humidity and temperature conditions of air by a mechanical refrigerating system employing an evaporator connected with a compressor and a condenser, which process comprises causing air to circulate over the evaporator, causing the compressor to operate in response to changes in the temperature condition of the air, and while the compressor is in operation, varying the effect of the evaporator by increasing and decreasing the flow of refrigerant through the evaporator in accordance with changes in the relative humidity of the air.

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