

Aug. 18, 1942.

A. B. NEWTON

2,293,557

AIR CONDITIONING SYSTEM

Filed June 12, 1939

2 Sheets-Sheet 1

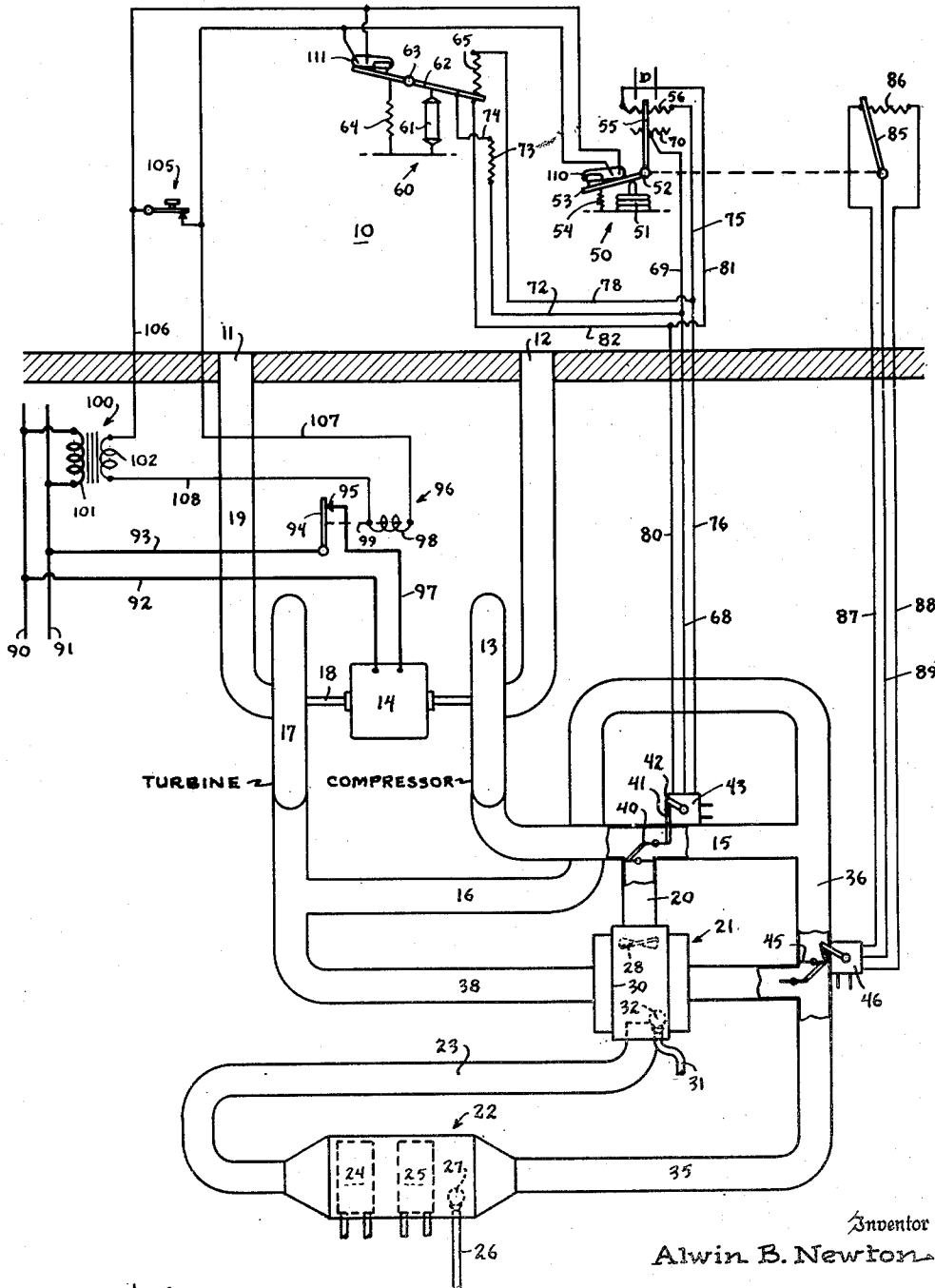


Fig. 1

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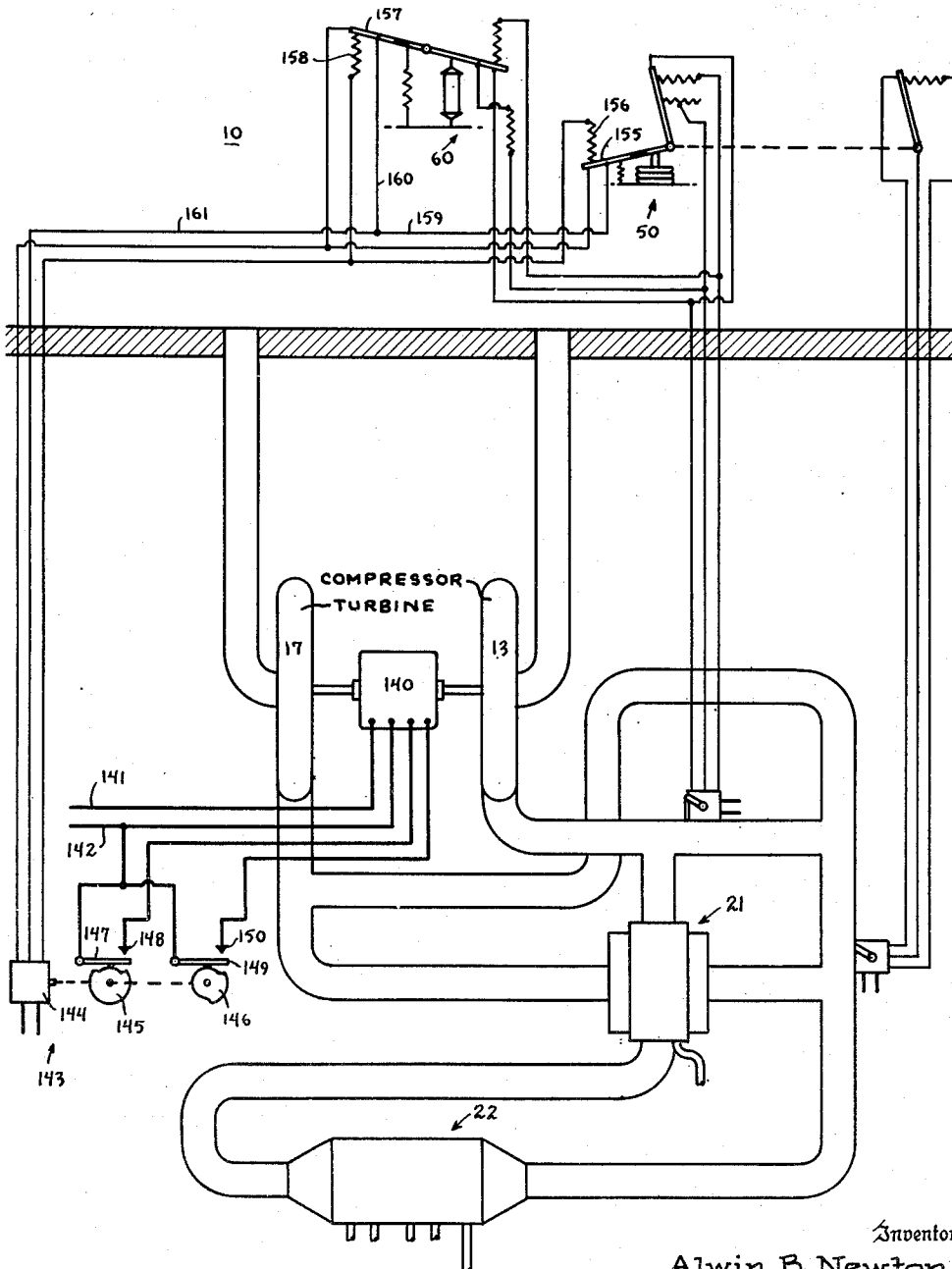


Fig. 2

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UNITED STATES PATENT OFFICE

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AIR CONDITIONING SYSTEM

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12 Claims. (Cl. 62—6)

This invention relates to an air conditioning system and is directed more particularly to a type of air conditioning system wherein air to be conditioned is compressed, the compressed air then being cooled whereby dehumidification of the air takes place, the cooled compressed air then being expanded through a turbine and delivered to the space to be conditioned. The air leaving the cooling means may be passed in heat exchange relationship with the relatively warm compressed air for reheating purposes, if desired, prior to passing to the turbine so that the air on being delivered to the space will not reduce the temperature thereof below a desired value. When no cooling or dehumidifying is desired the air may be passed directly from the compressor to the turbine in which case the system will act as a mere air circulating system. The invention contemplates the provision of suitable controls for controlling the flow of air through the cooler and the heat exchanger, and in one modification thereof, for controlling the compressor speed.

It is accordingly an object of this invention to provide an air conditioning system and controls therefor of the type described above.

Other objects and advantages will become apparent upon a study of the specification, claims and appended drawings wherein like reference characters represent like parts in the various views and wherein

Figure 1 is a schematic view of one form of air conditioning system embodying the principles of my invention, and

Figure 2 is a modification of the system shown in Figure 1.

Referring now to Figure 1, the reference character 10 represents a space to be conditioned, there being suitable air inlets and outlets 11 and 12 for providing for a circulation of air through the space 10. Air is withdrawn from the space through the outlet 12 by means of a compressor 13 driven by a motor 14, the air being compressed in the compressor, which action is accompanied by a rise in temperature of the air. The air leaving the compressor may pass through ducts 15 and 16 directly to a turbine 17 which is mounted on the shaft 18 of the motor 14, the air being expanded and thereby cooled in the turbine and passing therefrom through the duct 19 back to the space 10 by way of the inlet 11. The air in passing through the turbine 17 and expanding therein gives back a large portion of the energy required to compress the air and assists the motor 14 in driving the compressor 13 so that the motor 14 may be of relatively small capacity.

Connected to the duct 15 by way of a duct 20 is a heat exchanger 21 which may be of any suitable construction and as explained hereinafter is arranged to provide for reheating of the air after passing through the cooling chamber 22, this chamber being connected to the heat exchanger 21 by means of a duct 23. The cooler 22 may be provided with any suitable cooling means such as cooling coils 24 and 25 through which water from a city water supply, a domestic water heating system, or any suitable cooling fluid may pass whereby the heated compressed air is substantially cooled and the dew-point of the air will at the same time be decreased. For example, coil 24 may be connected to domestic water supply for supplying heat thereto, and coil 25 may be connected to a city water supply or other source of cooling fluid. The condensate that will form in the cooling chamber 22 by reason of the reduction in the dew-point of the air may flow therefrom by way of a drain 26 which may be controlled by a suitable float valve 27. Located at the inlet of the heat exchanger 21 may be arranged a suitable vane arrangement 28 for causing a whirling action of the air flowing through the heat exchanger to whereby a large amount of the moisture in the air will be deposited upon the walls 30 of the heat exchanger and this moisture may be withdrawn from the heat exchanger by way of the drain 31 controlled by the float valve 32. The valves 27 and 32 in control of the drains 26 and 31, respectively, are provided so that these drains will at no time be opened to the entrance of air which would tend to relieve the pressure within the system.

The air leaving the cooling chamber 22 passes through the duct 35 and may pass either directly to the turbine 17 by way of ducts 36 and 16 or may pass to the turbine by way of the heat exchanger 21 and duct 38.

For controlling the flow of air from the compressor 13 through the ducts 15 and 20, the dampers 40 are provided, these dampers being connected by a link 41 to an arm 42 of a motor 43 which may be a proportioning motor of the type shown in Patent 2,028,110 issued to D. G. Taylor, January 14, 1936. Thus the position of the arm 42 of the motor 43 will determine the relative amounts of air that flow from the compressor 13 directly to the turbine 17 by way of duct 16 and through the heat exchanger 21 by way of duct 20. Dampers 45, positioned by a motor 46 which may also be a proportioning motor similar to the motor 43, control the rela-

tive amounts of air that flow from the cooler 22 to the turbine by way of ducts 36 and 16 and by way of the heat exchanger 21 and the duct 38.

Located within the space 10 is a temperature responsive device 50 which may be of any suitable construction but is shown to comprise a bellows 51 provided with a suitable fill such as a volatile fill whereby the bellows will expand or contract in accordance with changes in the space temperature, the bellows controlling the position of the bell crank lever 52, the arm 53 of which is biased by means of a spring 54 into engagement with the bellows. The other arm 55 of this lever is arranged to move over a potentiometer resistance 56 in accordance with variations in temperature in the space, the arm moving towards the right as the temperature in the space rises.

Also located within the space 10 is a humidity responsive device 60 which may comprise a suitable hygroscopic element 61 controlling the position of a lever 62 pivoted at 63 and biased by means of a spring 64 in a direction to maintain the element 61 in tension. The right end of the arm 62 is arranged to pass over a potentiometer resistance 65 in response to variations in humidity in the space, the arrangement being such that upon a rise in humidity the arm 62 will move upwardly under the influence of the spring 64.

The center terminal of the damper motor 43 is connected to the arm 55 of the temperature responsive device 50 by means of conductors 68, 69 and the center tapped resistance 70. This same terminal of the motor is connected to the arm 62 of the humidity responsive device 60 by means of conductors 68, 72, the resistance 73 and conductor 74. The right end of the resistance 56 is connected by means of conductors 75 and 76 to the right terminal of the motor 43 which terminal is also connected by means of conductors 76 and 78 to the upper end of the resistance 65. The left terminal of the motor 43 is connected by means of conductors 80 and 81 with the left end of resistance 56 and by means of conductors 80 and 82 to the lower end of the resistance 65. Upon reference to the aforementioned Taylor patent it will be understood that as the arm 55 of the temperature controller 50 moves over the resistance 56, the arm 42 of the motor 43 will move a corresponding amount. Thus as the temperature in the space rises and the arm 55 moves towards the right over the resistance 56 the dampers 40 will be moved to admit air into the heat exchanger 21 from the compressor 13 at a rate which is proportional to the increase in the space temperature. The controller 55 is so arranged that the movement of this control arm through a distance such as represented by the reference character D will have the effect of moving the dampers 40 from the position wherein no air is admitted to exchanger 21 to a position wherein all of the air must pass through this heat exchanger by way of the duct 20. The circuit between the motor and the arm 62 of the humidity controller 60 is provided with a resistance 73 so that this controller has less effect on the position of the motor 43 for a given movement thereof than the control arm 55. In other words, movement of arm 55 through the distance D will cause the motor to move from one extreme position to the other, whereas the arm 62 must move through the entire range of resistance 65 to cause the same movement of the motor. The effect of this is that upon a rise in humidity in the space the control range D of the control arm 55 will

shift to the left so that the controller 50 will tend to maintain a somewhat lower space temperature. The center tapped resistance 70 insures that the control range D will always be the same length, regardless of its position as determined by the position of the arm 62. If desired the two controllers could merely be hooked up in parallel so that the motor 43 would move directly in accordance with variations either in temperature or humidity or any other suitable control arrangement for the motor 43 by means of the temperature and humidity responsive devices could be employed, the one shown being merely one suitable form of control system for the motor.

The temperature responsive device 50 also controls the position of a control arm 85 which forms a control arm for the potentiometer resistance 86 which resistance is connected to the outside terminals of the motor 46 by means of conductors 87 and 88. The arm 85 is connected to the center terminal of the motor by means of conductor 89. As the temperature in the space increases the arm 85 will move toward the right over the resistance 86 and will cause motor 46 to close the dampers 45 to the heat exchanger 21 and open the dampers to the duct 36 by an amount which is in proportion to the increase in the space temperature. The result of this is that less of the air leaving the cooler flows to the exchanger 21 so that a smaller portion of the air will be reheated thereby and a greater portion will pass directly to the turbine so that the air will be delivered at a lower temperature to the space as the space temperature rises. It is of course possible that the heat exchanger 21 may have the reverse effect on the temperature of the air, depending on how much cooling is effected by the cooler 22 and accordingly the amount of pre-cooling of the air taking place in the heat exchanger 21, in which case the dampers 45 should operate in the reverse manner from that described.

The motor 14 may be operated continuously or may operate in response to the temperature or humidity in the space. Line wires 90 and 91 are provided for supplying power to the motor, line wire 90 being connected directly to the motor by means of conductor 92 and line wire 91 being connected by means of conductor 93, switch arm 94 and contact 95 of a relay 96 and the conductor 97. The relay 96 also comprises a relay coil 98 and an armature 99, the arrangement being such that when the coil 98 is energized the arm 94 moves into engagement with the contact 95 and upon deenergization of the relay coil the arm 94 moves away from the contact 95 under the influence of gravity or any suitable biasing means (not shown). A step-down transformer 100 including a high tension primary 101 connected across the line wires 90 and 91 and a low tension secondary 102 is provided for supplying power to the relay 96. A manual switch 105 is provided in the circuit to the relay and when this switch is closed, as illustrated, the relay 96 will be continuously energized by way of conductors 106, switch 105, conductor 107, relay coil 98 and conductor 108. When this switch 105 is opened however the motor 14 will be under the control of the temperature responsive device 50 and the humidity responsive device 60.

Mercury switches 110 and 111 are carried by the arm 53 and the lever 62, respectively, and are arranged to be moved to closed position whenever

the temperature or the humidity in the space become sufficiently high so that conditioning of the air in the space is required. As will be apparent from the drawings, these switches are arranged to establish a connection between line wires 106 and 107 if either the temperature or humidity in the space become high but if the temperature and humidity are both low and the control devices are in the positions illustrated the circuit to the relay 96 will be interrupted unless the manual switch 105 is closed. Accordingly whenever the switch 105 is opened the relay 96 will be under the control of the temperature and humidity responsive devices 50 and 60 and the motor will therefore be in operation only when there is a call for cooling or dehumidification within the space 10.

To summarize briefly the operation of the system shown in Figure 1 it may be assumed the temperature and humidity in the space are both sufficiently low but that the manual switch 105 is closed so that the motor 14 is energized and the compressor 13 is operating to withdraw air from the space 10 and compress the same. The air leaving the compressor will pass directly to the turbine 17 since the passageway 20 is closed by the dampers 40 so that the compressor will operate merely to circulate air to the space for ventilating purposes. It should be understood that provision may be made for admitting fresh outside air to the compressor if desired. Should either the temperature or humidity in the space rise to an undesirable value the dampers 40 will be adjusted to admit air to the heat exchanger 21 and the cooler 22 in an amount which is in proportion to the rise in temperature or humidity.

If the temperature rises the motor 46 will also operate to adjust the dampers 45 to decrease the amount of air leaving the cooler 22 by way of the duct 35 flowing to the heat exchanger 21 so that a proportionately smaller amount of air will be reheated in the exchanger 21 and a correspondingly greater amount will flow directly from the cooler 22 to the turbine 17 and back to the space 10. Thus as the space temperature rises, less reheating of the air takes place and the air is delivered to the space at a lower temperature. As the temperature or humidity of the space increases, more air passes from the compressor through the cooler and less of the air passes from the compressor 13 directly to the turbine 17 so that more of the air is cooled and dehumidified. If the switch 105 is opened the compressor will be placed under the control of the temperature and humidity responsive devices and therefore will operate only when there is a call for cooling or dehumidification.

Referring now to Figure 2 the system disclosed in this figure is the same as that illustrated in Figure 1 with the exception of the means for controlling the driving motor for the compressor 13. The motor for driving the compressor which is herein represented by the reference character 140 is a variable speed motor, power to which is supplied by means of conductors 141 and 142 which are in turn connected to a suitable source of power (not shown). The speed of the motor 140 may be controlled by a step controller represented generally by the reference character 143 and it may include a proportioning motor 144 which controls the position of cams 145 and 146. The cam 145 controls the position of a switch arm 147 with respect to a contact 148 whereas the cam 146 controls the position of a switch arm 149 with respect to a contact 150. When both

the switches 147 and 149 are opened, as illustrated, the motor 40 operates on low speed. Closure of the switch 147 causes the motor to operate on a higher speed and closure of the switch 149 causes the motor 140 to rotate at a still higher speed. The particular means for varying the speed of the motor have not been illustrated as any conventional arrangement may be utilized.

The switch 110 of Figure 1 is replaced by a control arm 155 and a potentiometer resistance 156 whereas the switch 111 of Figure 1 is replaced by the control arm 157 and the potentiometer resistance 158. These control arms 155 and 157 are connected together by means of conductors 159 and 160 and are connected to the center terminal of the motor 144 by means of conductor 151. The resistances 156 and 158 are connected in parallel and are connected to the outer terminals of the motor 144 as is apparent from the drawings. Upon an increase either in the temperature or the humidity in the space 10, the movement of the control arm 155 or the control arm 157 over the respective potentiometer resistance causes operation of the motor 144 to rotate the cams 145 and 146 in a clockwise direction. If the temperature or humidity or the combined effects of both have risen sufficiently, cam 145 moves the arm 147 into engagement with the contact 148 and the speed of the motor 140 is increased. Upon sufficient further increase in temperature or humidity or both the cam 146 will have rotated sufficiently to move the arm 149 into engagement with the contact 150 so that the motor 140 will rotate at maximum speed. While the motor 140 has been described merely as a three-speed motor it will be obvious that the motor may be arranged to rotate at any desired different number of speeds in accordance with the teachings of this invention so that smaller increases in temperature or humidity will be effective to increase the speed of the compressor motor. For a fixed room temperature, the amount of air flowing through the heat exchanger 21 for precooling the air will vary with the relative humidity, so that a greater proportion of latent cooling of the air will take place as the relative humidity increases.

It will thus been seen that while the system of Figure 2 operates in the same manner as that of Figure 1 it has the additional feature of varying the speed of the compressor in accordance with the cooling load of the space. In a system of this type an increase in the compressor speed will not only change the rate of flow of air into the space being conditioned but it will at the same time increase the amount of conditioning imparted to the air and accordingly the condition of the space may be adjusted at a quicker rate than in systems of the type wherein the delivery of air to the space being conditioned is at a constant rate and the only change is in the amount of conditioning imparted to the air.

While I have illustrated and described some preferred forms of my invention it should be understood that many modifications may be made without departing from the spirit and scope of the invention, and it should therefore be understood that this invention is limited only by the scope of the appended claims.

I claim as my invention:

1. In an air conditioning system, means for compressing air to be conditioned, cooling means, means for conducting the compressed air to the cooling means, means for conducting the cooled compressed air in heat exchange relationship

with the uncooled compressed air, means for re-expanding the compressed air and delivering the same to a space to be conditioned, means responsive to the humidity of the air in said space for controlling the flow of air through said cooling means, and means responsive to the temperature of the air in the space for controlling the flow of air in heat exchange relationship with the uncooled compressed air.

2. In an air conditioning system, means for compressing air to be conditioned, cooling means, means for conducting the compressed air to the cooling means, means for conducting the cooled compressed air in heat exchange relationship with the uncooled compressed air, means for reexpanding the compressed air and delivering the same to a space to be conditioned, means responsive to the temperature and the humidity of the air in said space for controlling the flow of air through said cooling means, and means responsive to the temperature of the air in the space for controlling the flow of air in heat exchange relationship with the uncooled compressed air.

3. In an air conditioning system, means for compressing air to be conditioned, cooling means, means for conducting the compressed air to the cooling means, means for conducting the cooled compressed air in heat exchange relationship with the uncooled compressed air, means for re-expanding the compressed air and delivering the same to a space to be conditioned, means responsive to the temperature and the humidity of the air in said space for controlling the flow of air through said cooling means, means responsive to the temperature of the air in the space for controlling the flow of air in heat exchange relationship with the uncooled compressed air, and means for causing the air to pass directly from the compressing means to the expanding means when the temperature and humidity of the air in the space are sufficiently low.

4. In an air conditioning system, means for compressing air to be conditioned, cooling means, means for conducting the compressed air to the cooling means, means for conducting the cooled compressed air in heat exchange relationship with the uncooled compressed air, means for re-expanding the compressed air and delivering the same to a space to be conditioned, means responsive to the humidity of the air in said space for controlling the flow of air through said cooling means, means responsive to the temperature of the air in the space for controlling the flow of air in heat exchange relationship with the uncooled compressed air, and means for increasing the rate of compression and circulation of the air as the temperature of the space increases.

5. In an air conditioning system, means for compressing air to be conditioned, cooling means, means for conducting the compressed air to the cooling means, means for conducting the cooled compressed air in heat exchange relationship with the uncooled compressed air, means for reexpanding the compressed air and delivering the same to a space to be conditioned, means responsive to the humidity of the air in said space for controlling the flow of air through said cooling means, means responsive to the temperature of the air in the space for controlling the flow of air in heat exchange relationship with the uncooled compressed air, and means for increasing the rate of compression and circulation of the air as the humidity of the space increases.

6. In an air conditioning system, compressor means for compressing air to be conditioned, a

motor for driving said compressor means, a turbine for reducing the load on said motor, means for conducting air from said turbine to a space to be conditioned, cooling means, means for conducting the air leaving said compressor means directly to said turbine or to said turbine by way of said cooling means, means responsive to the humidity of said space controlling the amount of cooling of said air, means for warming the air cooled by said cooling means, and means responsive to the temperature in said space controlling the amount of warming of said air.

7. In an air conditioning system, compressor means for compressing air to be conditioned, a motor for driving said compressor means, a turbine for reducing the load on said motor, means for conducting air directly from said compressor to said turbine, means for conducting air from said turbine to a space to be conditioned, cooling means, means for conducting air from said compressor means to said turbine by way of said cooling means, means for warming the air cooled by said cooling means, means responsive to the temperature and humidity of the air in said space in control of the cooling and warming of the air.

8. In an air conditioning system, compressor means for compressing air to be conditioned, a motor for driving said compressor means, a turbine for reducing the load on said motor, means for conducting air directly from said compressor to said turbine, means for conducting air from said turbine to a space to be conditioned, cooling means, means for conducting air from said compressor means to said turbine by way of said cooling means, means responsive to the humidity of the air in said space in control of said last named means, a heat exchanger wherein the cooled compressed air may pass in heat exchange relationship with the uncooled compressed air, and means responsive to the temperature of the air in the space for controlling the flow of air from the cooling means to the turbine by way of said heat exchanger.

9. In an air conditioning system, a compressor for compressing air to be conditioned, control means for rendering said compressor operative or inoperative, cooling means for reducing the temperature of the compressed air so as to lower the dew-point thereof, means for passing the cooled compressed air in heat exchange relationship with the uncooled compressed air, means for reexpanding the compressed air whereby its temperature is reduced, means for delivering the air to a space to be conditioned, and means responsive to conditions of the air in said space controlling said cooling means and heat exchange means independently of said compressor.

10. In an air conditioning system, a compressor for compressing air to be conditioned, cooling means for reducing the temperature of the compressed air so as to lower the dew-point thereof, means for passing the cooled compressed air in heat exchange relationship with the uncooled compressed air, means for reexpanding the compressed air whereby its temperature is reduced, means for delivering the air to a space to be conditioned, and means responsive to the temperature and humidity of the air in the space for causing the air to pass directly from the compressor to the turbine when the temperature and humidity are both sufficiently low.

11. In an air conditioning system, a compressor for compressing air to be conditioned, cooling means for reducing the temperature of the compressed air so as to lower the dew-point thereof,

means for passing the cooled compressed air in heat exchange relationship with the uncooled compressed air, means for reexpanding the compressed air whereby its temperature is reduced, means for delivering the air to a space to be conditioned, and means responsive to the temperature and humidity of the air in the space for simultaneously controlling the speed of the compressor and the amount of cooling and reheating of the air.

12. In an air conditioning system, compressor means for compressing air to be conditioned, a

5 motor for driving said compressor means, a turbine for reducing the load on said motor, means for conducting air directly from said compressor to said turbine, means for conducting air from said turbine to a space to be conditioned, cooling means, means for conducting air from said compressor means to said turbine by way of said cooling means, and means for passing cooled air from said cooling means in heat exchange
10 relationship with uncooled air.

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