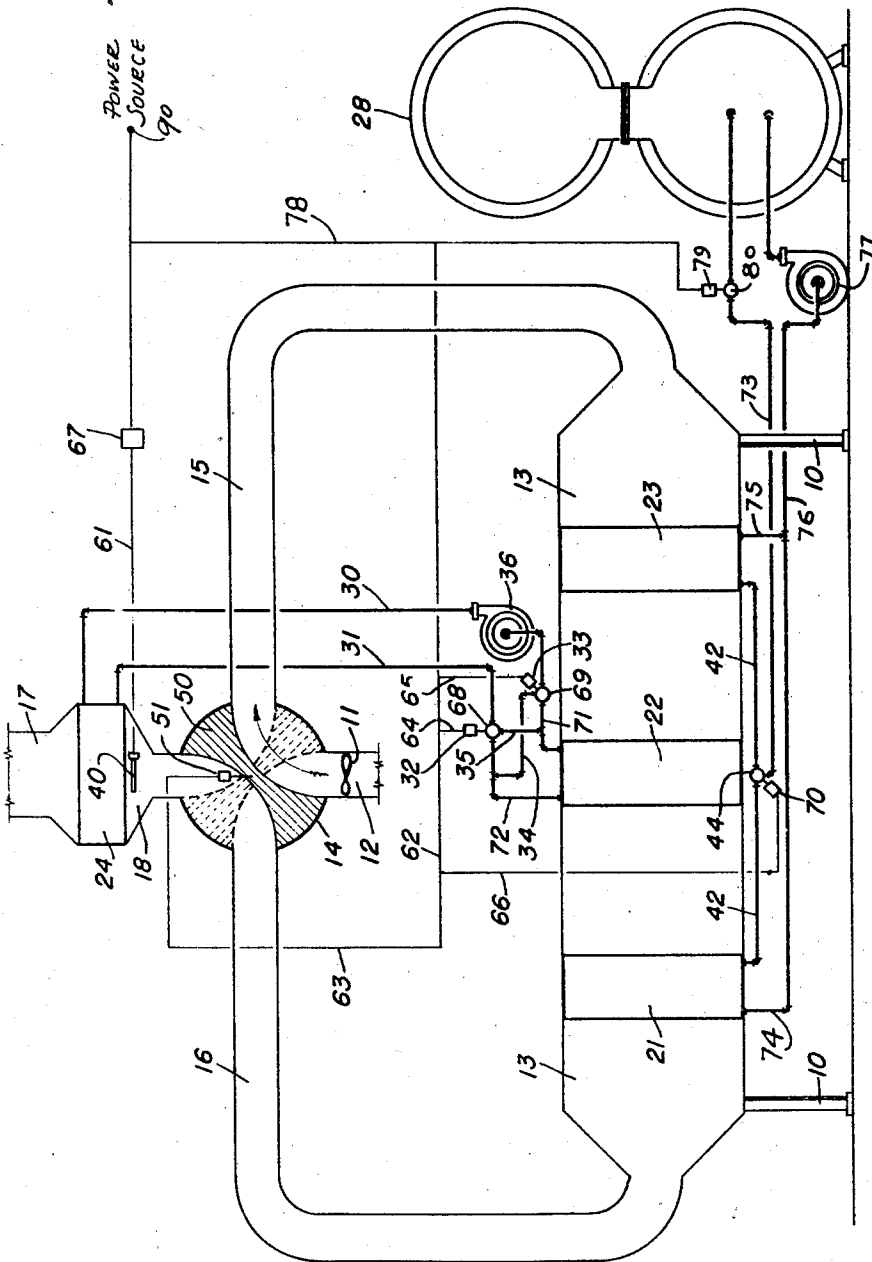


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AIR CONDITIONING APPARATUS

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AIR CONDITIONING APPARATUS

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1

The object of our invention is to provide an apparatus for conditioning air or gas, particularly when this air or gas must be conditioned to a temperature at or below the frost point.

Another object of our invention is to provide a sequence of cooling and reheating stages for conditioning air or gas whereby the air or gas may be economically dehumidified and reheated in a comparatively small space.

Another object of our invention is to provide an apparatus which will condition air or gas by dehumidifying it and subsequently reheating it so that the air or gas conditioned will have a continuously uniform moisture content and dry bulb temperature.

Another object of our invention is to provide a means of control whereby the conditioned air or gas will be uniform as to moisture content and dry bulb temperature.

Another object of our invention is to provide an apparatus which will allow air or gas conditioned below the frost point to deliver this air or gas on a continual basis without the necessity of using more than one system of apparatus for the purpose.

Another object of our invention is to provide an apparatus which will allow air or gas conditioned below the frost point to be delivered on a continual basis without the necessity of shutting down the apparatus for defrosting.

Another object of our invention is to provide an apparatus to deliver a continual flow of air or gas at a constant condition and at the same time require the use of less refrigeration capacity than normally required.

It is well known that in the use of air or gas where this air or gas must be dehumidified to a condition at or below the frost point that a duplexing of equipment is required so that the air or gas can be delivered constantly without shutting down for removal of ice or frost accumulations. At the same time the total amount of refrigeration available is applied towards the conditioning of this air or gas. With our invention, a considerable saving in refrigeration is possible and at the same time the necessity of duplexing certain of the apparatus is eliminated.

The foregoing and many other specific features of our invention are set forth in the following specification, where we describe what we consider the preferred embodiments of our invention. They are illustrated in the accompanying drawing, wherein the figure shows the invention diagrammatically.

The flow of gas or air through our apparatus differs from that previously used or invented mainly in the following feature:

Coils 21 and 23 are identical. Coil 21 is used as the final cooler when gas or air is routed through duct 15. During this cycle coil 23 is be-

2

ing defrosted. Coil 23 is used as final cooler when gas or air is routed through duct 16. During this cycle coil 21 is being defrosted.

Our invention is not limited to this one feature—but stress is placed on it to clarify the typical example which is given below:

The figure shows diagrammatically the means of accomplishing our invention. Referring to the figure, 12 represents an inlet duct or pipe wherefrom air or gas is moved by fan 11 through either conduits 15 or 16, then through casing 13, then through either conduits 15 or 16 to outlet duct 17. The casing 13 which may be in either a horizontal or vertical position, and is shown in the figure to be raised from the ground by supports 10.

As a typical illustration, assume the following conditions:

Gas at 70° F. saturated is to be conditioned to 25° F. saturated when leaving coil 21 into the duct 16 or leaving coil 23 into duct 15.

This 70° gas enters apparatus through duct 12, into duct 15, through transfer valve 14, then into casing 13.

Gas then passes over coil 23, defrosting that coil provided a previous cycle has occurred.

The gas then passes over coil 22, and is reduced to 57.5° F. saturated. Gas then flows over coil 21 and is reduced to 25° F. saturated.

Gas then leaves casing 13, travels through duct 16, through transfer valve 14, and through duct 18.

In this problem, the sole purpose of reducing the gas temperature to 25° F. saturated is the elimination of moisture. Any sensible heat pick-up, after that accomplishment, is a gain. Therefore, gas now travels through heating coil 24 which is interposed in duct 18. This coil (24) is connected by pipe circuits 30 and 31 to cooling coil 22, to form a heat reclamation cycle. A pump 36 is interposed in the pipe circuit (30 and 31) to circulate the heat exchange medium from cooling coil 22 to heating coil 24, and back again.

Heating coil 24 restores to the gas as sensible heat both the latent and sensible heat which cooling coil 22 abstracted. Thus the gas has been dehumidified to the equivalent of 25° F. saturated, but leaves apparatus with part of the sensible heat restored which had to be removed for dehumidification.

Conversely, this heat reclamation causes the heat exchange medium to be reduced in temperature by the passage of 25° F. gas over heating coil 24. The heat exchange medium, thus reduced in temperature, is returned to coil 22 at a lower temperature than that at which it left this same coil, thus causing a direct saving in the amount of refrigeration required to reduce the gas temperature to 25° F.

Coils 24 and 22 need only be used when de-

3

sired to raise the outlet temperature of air emitting either from coils 21 or 23.

In this problem the gas now leaves apparatus through duct 17 at a dew point temperature of 25° F. but a dry bulb temperature of 60° F.

As in all refrigeration dehumidifying apparatus where it is necessary to use a cooling medium at or below the frost point, ice or frost will form on the coil or other apparatus used for heat transfer purposes. In this problem ice has gradually accumulated on coil 21 until its effectiveness as a transfer medium is about to be impaired. The defrosting of coil 21 and the simultaneous transfer of the function of dehumidifying and cooling from coil 21 to coil 23, occurs as follows:

The cooling coils 21 and 23 are supplied with a cold heat exchange medium, preferably brine from the refrigeration unit 28, through a pipe circuit 42, the flow being controlled by valve 44. The brine circuit is formed by the supply pipe 73 from the refrigeration unit 28 to the valve 44 which selectively allows the flow of cooling medium to coil 21 and shuts off the flow of cooling medium to coil 23, and when actuated by the motor 70 will shut off the flow of cooling medium to coil 21 and allow the flow of cooling medium to coil 23.

The cooling medium is returned from coil 21 to conduit 76 through conduit 74 and the cooling medium is returned from coil 23 to conduit 76 through return conduit 75. A pump 77 is interposed in the return conduit 76 to pull the cooling medium from the coils back to the refrigerating unit 28. Interposed in the line 73 is a valve 80, operated by a motor 79, actuated by the power line 78, responsive to the thermostat 40 to regulate the amount of flow of the brine. In the sequence of operation described, the cold heat exchange medium is only supplied to coil 21, the flow of this medium being shut off to coil 23 by valve 44. As accumulations of ice and frost on coil 21 develop and a reversal of the flow of the gas is made through the actuation of transfer valve 14, causing the air or gas entering casing 13 to pass through inlet 16 instead of inlet 15. At the same time valve 44 is actuated to shift the flow of the cold brine from coil 21 to coil 23. At the same time valves 68 and 69 in pipe circuit 30 and 31 operate to divert the flow of the heat exchange medium in pipe circuit 30 and 31 through pipe 34 and pipe 35 so that a reversal of flow of this heat exchange medium takes place in cooling coil 22. The operation of the valves mentioned above may be accomplished either through an air supply source and air conduits such as 61, 62, 63, 64, 65, 66, 78, etc., as shown, or may be accomplished by other well known means such as, for example, an electrical circuit (not shown). It is advantageous in heat exchange, from a heat exchange medium to air using a multirow coil, that the coolest portion of heat exchange medium be in contact with the leaving air, and thus when the direction of the flow of air through the coil (a multirow coil) is changed, the direction of the flow of the heat exchange medium through the coil should be changed, so that the warmest portion of the heat exchange medium be in contact with the entering air, and the coolest portion of the heating medium be in contact with the leaving air.

When the flow of air through the coil 22 is reversed it is also desirable to reverse the flow of heat exchange fluid medium through coil 22, without reversing the flow of heat exchange medium through coil 24. This is accomplished by

4

the said two way valves 68 and 69, whereby when the air enters through conduit 15, the valve 68 would allow a flow of heat exchange fluid from conduit 31 through conduit 72, through a multirow coil 22, out through conduit 71 through pump 36 and conduit 30. In this position valve 68 prevents any flow through conduit 35, and valve 68 prevents any flow through conduit 34.

When the air enters through conduit 16, the flow of heating exchange medium through coil 22 is reversed by valves 68 and 69, whereby the valve 68 allows a flow of heat exchange medium from conduit 31 through conduit 35 and a portion of conduit 71, then through the multirow coil 22 and out through 72, then through conduit 34 and through the valve 69, pump 36 and conduit 30. In the last operation the position of the valves 68 and 69 are both changed from the first operation and shuts off the flow of heat exchange medium from conduit 31 to conduit 72 and allows the flow of heat exchange medium from conduit 31 through conduit 35 while the position of valve 69 shuts off the flow of heat exchange medium from that portion of conduit 71 between the valve 69 and coil 22.

The direction of flow through the valve 68 is always from conduit 31 through the valve either to the conduit 72 or the conduit 35, depending upon the position of the two-way valve 68, and the direction of the flow through the valve 69 is always toward the pump 36, with the inlet open to allow flow either from conduit 34 or from that portion of conduit 72 between the valve 69 and the coil 22.

Thus, when the direction of air through the coil 22 is reversed by operation of damper 14, it is desirable at the same time to change the flow of heat exchange medium through coil 22 by operation of valves 68 and 69. The same electrical circuit 63 operates the motor 51, controlling damper 14, and motor 33, operating valve 69, and motor 32 operating valve 68, so that valves 68 and 69 are actuated simultaneously with the operation of damper 14.

From duct or pipe 12, the gas passes through transfer valve 14, through pipe or duct 16, into casing 13. As this gas stream passes over coil 21, the accumulated ice and frost is melted off and drained out of casing 13. The gas stream then flows over coil 22 where its temperature is reduced from 70° F. saturated to 57.5° F. saturated. This gas then flows over coil 23 where its temperature is further reduced to 25° F. saturated. The stream of air or gas then flows through duct or pipe 15 from casing 13 through transfer valve 14, and then over reheating coil 24, where the latent and sensible heat that is removed by coil 22 is added to the air or gas as sensible heat.

As ice and frost begin to accumulate on coil 23 in the described sequence of operation, transfer valve is again actuated and the flow of air or gas is again reversed through apparatus casing 13. At the same time valve 44 in pipe circuit 42 is actuated to stop the flow of brine through coil 23 and allow the flow of brine to go through coil 21. Valve 68 and valve 69 in pipe circuit 30 and 31 are also actuated so that the flow of the heat exchange medium through coil 22 is reversed. It is apparent from the above description that through the method of operation herein used that our invention gives a continual operating apparatus for the delivery of air or gas at dew points as low as the frost point or lower without the necessity of shutting down the apparatus for de-

icing or defrosting or for the necessity of duplexing the apparatus.

In order to show further advantages of the apparatus which we describe herein, we refer to a typical problem of cooling 10,000 C. F. M. of free air or gas which on entering our apparatus at 70° F. saturated leaves at a final condition of 60° F. dry bulb and 25° F. dew point. The conditioning of the air or gas as set forth in the above example could be obtained by means of a single cooling coil such as coil 21 or 23 with a refrigeration requirement of 90 tons being necessary. However, by means of our method of dehumidifying and reheating we are able to reduce the refrigeration load from 90 tons to 56 tons and at the same time deliver this gas or air at the same dew point.

A thermostat 40 responsive to the temperature of the air in conduit 18 controls the operation of the valve 44 so as to selectively direct the flow of brine either to coil 23 or coil 21, and also controls the operation of transfer valve or damper 14, so as to selectively direct the flow of air to be conditioned either through duct 15 or duct 16, and also controls operation of the valves 68 and 69, so as to selectively direct the flow of heat exchange medium to coil 24 either through pipe 31 or pipe 30. Assuming that the coil 23 becomes frosted as to impair the operation of the coil, the result in most cases would be to reduce the quantity of air being able to pass the coil with a resultant lower dry bulb temperature. Assuming the thermostat 40 to be set so that a reduction in the dry bulb temperature of the air in conduit 18 will cause the thermostat to activate the motors controlling valve 14, valve 44 and valves 68 and 69 through the lines 61, 62, 63, 64, 65 and 66. The motors are of the commercially reversible type and a time relay 67 (also commercially known) is interposed in the line 61, so as to preclude any further operation of the motors until sufficient time has elapsed to allow the new cycle to take effect and raise the temperature of the air surrounding thermostat 40, and then when the thermostat 40 again activates line 61 to cause the motors controlling the operation of valves 14, 68, 69 and 44 to reverse their operation. The motor controlling the valve 14 is designated as 51. The motor 32 controls the valve 68, the motor 33 controls the valve 69 and the motor 70 controls the valve 44.

The valve or damper 14 is shown by the curved blade 50, which allows flow of air from conduit 12 to conduit 15 and from conduit 16 to conduit 18. A 90° revolution of the blade 50, as is shown by the dotted lines, will cause the air from conduit 12 to flow through conduit 16 and the air from conduit 15 to flow through conduit 18.

The valve 44 is a two way valve, which in one position supplies refrigerant to coil 23 and shuts off the flow to coil 21 and when revolved by the motor 70 will cut off the supply to coil 23 and supply refrigerant to coil 21.

The valve 69 is a two way valve in one position to supply heat exchange fluid to coil 22 through pipe 71 and in the second position to cut off the supply of heat exchange fluid to pipe 71 and to supply said fluid to coil 22 through pipe 34.

Valve 68 is a similar two way valve, which in one position allows a flow of fluid from coil 22 through lines 71, 35 and 31 to coil 24, and in another position allows a flow of fluid from coil 22 through lines 72 and 31 to coil 24.

The damper 14 is circular operatively connected with conduits 12, 15, 16 and 18, so that the posi-

tion of the blade or damper 50 will selectively direct the air from conduit 12 to either conduit 15 or 16.

If it is desired to control the operation of the said rotors and valves responsive to an interval of time, then a device designed to operate a motor upon the lapse of a predetermined interval of time may be substituted for thermostat 40, or an instrument responsive to the accumulation of frost on cooling coils 21 or 23 may be substituted for the thermostat 40.

We claim:

1. An air conditioning apparatus comprising a casing with air inlet and outlet, means to move air therethrough, two cooling coils interposed in said casing in the path of said air, and means to reverse the flow of air through said casing, and means to alternately supply refrigerant to one and then the other of said cooling coils, a third cooling coil interposed in said casing between said first mentioned cooling coils and operatively connected by conduits containing heat exchange medium with a reheating coil positioned in the path of the air emitting from said outlet.
2. An air conditioning apparatus comprising a casing with air inlet and outlet, means to move air therethrough, two cooling coils interposed in said casing in the path of said air, and means to reverse the flow of air through said casing, and means to alternately supply refrigerant to one and then the other of said cooling coils, a third cooling coil interposed in said casing between said first mentioned cooling coils and operatively connected by conduits containing heat exchange medium with a reheating coil positioned in the path of the air emitting from said outlet means to change the direction of flow of heat exchange medium through said third cooling coil responsive to the temperature of the air emitting from said outlet.
3. In an air conditioning apparatus comprising a casing with air inlet and outlet, means to move air through said casing and through a first coil and then through a second coil, said coils being spaced in said casing, means to reverse the direction of the flow of air through said casing and the first and second coil, and means to selectively supply refrigerant to either one of said coils and on reversal of flow of air to cut off the refrigerant to the coil supplied and supply refrigerant to the other of said coils.
4. In an air conditioning apparatus comprising a casing with air inlet and outlet, means to move air through said casing and through a first coil and then through a second coil, said coils being spaced in said casing, means to reverse the direction of the flow of air through said casing and the first and second coil, means to supply refrigerant to whichever of said coils is last in the path of said air and to cut off the supply of refrigerant to the coil first in the path of said air.
5. In an air conditioning apparatus comprising a casing with an air inlet and outlet and two spaced coils therein and means to move air through said casing and first through one coil and then through the other, means to reverse the flow of air and means to supply refrigerant to one of said coils and on reversal of flow of air to cut off the supply of refrigerant to the last named coil and supply refrigerant to the other coil.
6. In an air conditioning apparatus comprising a casing with an air inlet and outlet two spaced cooling coils in said casing, means to move air through said casing and successively through said coils and means to reverse the flow of said air, means to alternately supply refrigerant to

first one and then the other of said cooling coils, both of said last two means being responsive to conditions indicating that one of said coils has become frosted.

7. In an air conditioning apparatus comprising a casing with an air inlet and outlet, and two spaced cooling means therein, means to move air through said casing and first through one cooling means and then through the other, means to reverse the flow of air, and means to supply cooling medium to one of said cooling means and on reversal of the flow of air to cut off the supply of cooling medium to the last mentioned cooling means and supply cooling medium to the other said cooling means.

8. In an air conditioning apparatus comprising a casing with an air inlet and outlet, two spaced coils therein, and means to move air through said casing and first through one of said coils and then through the other of said coils, means to selectively reverse the flow of air and means to supply refrigerant to one of said coils and on reversal of flow of air to cut off the supply of refrigerant to the last named coil and supply refrigerant to the other coil.

9. In an air conditioning apparatus comprising a casing with air inlet and outlet, means to move air through said casing and through a first coil and then through a second coil, said coils being spaced in said casing, means to reverse the direction of the flow of air through said casing and the first and second coil, means to supply refrigerant to whichever of said coils is last in the path of said air and to cut off the supply of refrigerant to the coil first in the path of said air, both of said last two means being responsive to conditions indicating that one of said coils has become frosted.

10. In an air conditioning apparatus comprising a casing with air inlet and outlet, means to move air through said casing and through a first coil and then through a second coil, said coils being spaced in said casing, means to reverse the direction of the flow of air through said casing and the first and second coil, and means to selectively supply refrigerant to either one of said coils and on reversal of flow of air to cut off the refrigerant to the coil supplied and supply refrigerant to the other of said coils, both of said last two means being responsive to conditions indicating that one of said coils has become frosted.

11. In an air conditioning apparatus comprising a casing with an air inlet and outlet and two spaced coils therein and means to move air through said casing and first through one coil and then through the other, means to reverse the flow of air and means to supply refrigerant to one of said coils and on reversal of flow of air to cut off the supply of refrigerant to the last named coil and supply refrigerant to the other coil, and a reheating coil positioned in the outlet of said casing to reheat the outgoing air after it has left the last of said cooling coils.

12. In an air conditioning apparatus comprising a casing with an air inlet and outlet and two spaced coils therein and means to move air through said casing and first through one coil and then through the other, means to reverse the flow of air and means to supply refrigerant to one of said coils and on reversal of flow of air to cut off the supply of refrigerant to the last named coil and supply refrigerant to the other coil, a third cooling coil interposed in said casing

between said first mentioned cooling coils and operatively connected by conduits containing heat exchange medium with a reheating coil positioned in the path of air emitting from said outlet.

13. In an air conditioning apparatus comprising a casing with an air inlet and outlet and two spaced coils therein and means to move air through said casing and first through one coil and then through the other, means to reverse the flow of air and means to supply refrigerant to one of said coils and on reversal of flow of air to cut off the supply of refrigerant to the last named coil and supply refrigerant to the other coil, a third cooling coil interposed in said casing between said first mentioned cooling coils and operatively connected by conduits containing heat exchange medium with a reheating coil positioned in the path of the air emitting from said outlet and means to change the direction of flow of heat exchange medium through said third cooling coil responsive to the temperature of the air emitting from said outlet.

14. An air conditioning apparatus comprising a casing with an air inlet and outlet, means to move air therethrough, two heat exchangers in said casing in the path of said air, means to reverse the flow of air through said casing, means to alternately supply refrigerant to one and then the other of said heat exchangers, a third heat exchanger interposed in said casing between said first mentioned heat exchangers, a reheat exchanger at the outlet of said casing in the path of air flowing through said outlet, conduits connecting said reheat exchanger and said third heat exchanger for circulation of heat exchange fluid therethrough.

15. An air conditioning apparatus comprising an elongated duct, two heat exchangers in said duct, an air valve having four openings therein, a first conduit connecting the first of said openings to one end of said duct, a second conduit connecting the second of said openings to the other end of said duct, the third of said openings serving as an air supply opening, a third conduit connected to the fourth of said openings, said valve having movable means which in one position connects the first and third openings and the second and fourth openings for passage of air and in another position connects the first and fourth openings and the second and third openings for passage of air, means to move air inwardly through said third opening and through said duct and conduits, a third heat exchanger in said duct interposed between said two heat exchangers, and a fourth heat exchanger in said third conduit, means for circulating a heat exchange fluid between said third and fourth heat exchanger, and means for selectively supplying heat exchange medium to one of said first mentioned two heat exchangers.

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