Nov. 15, 1955 N. A. PENNINGTON 2,723,837

UNIVERSAL AIR-CONDITIONER

Filed July 2, 1951 2 Sheets-Sheet 1

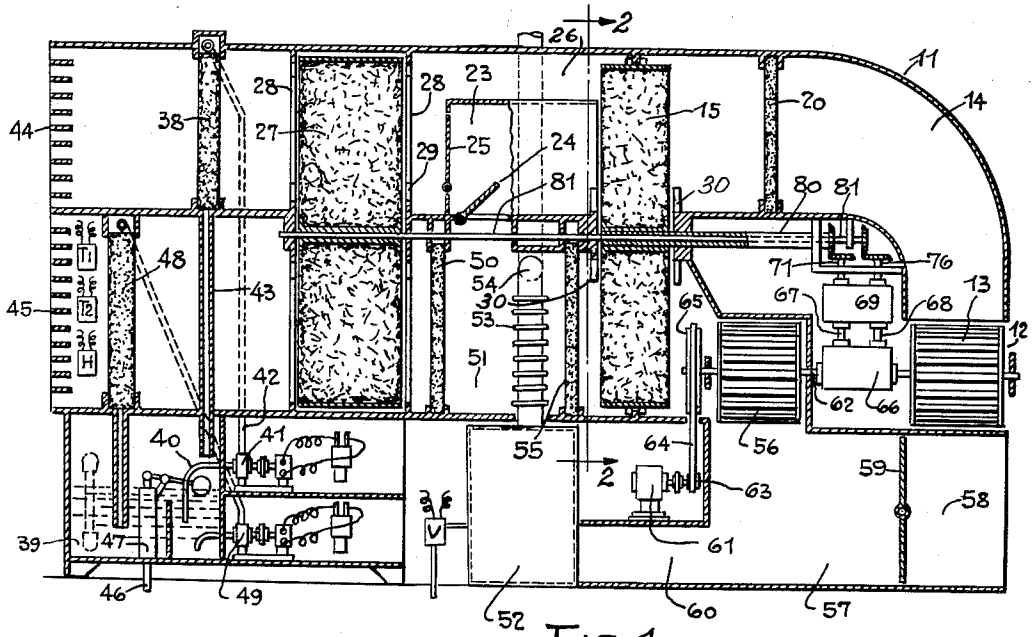


FIG. 1.

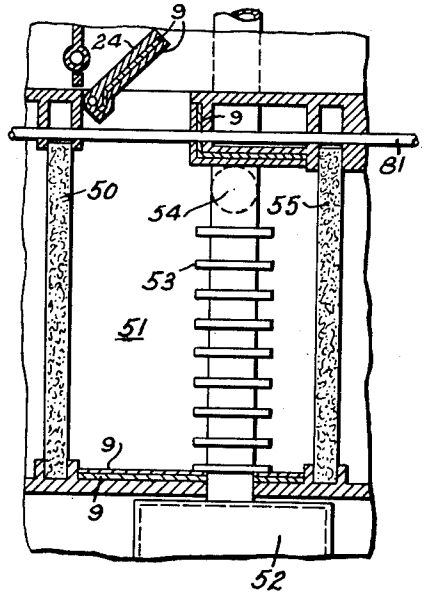


FIG. 3.

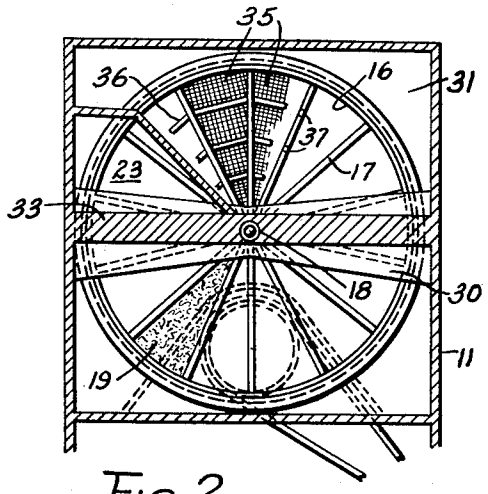


FIG. 2.

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Nov. 15, 1955 N. A. PENNINGTON 2,723,837

UNIVERSAL AIR-CONDITIONER

Filed July 2, 1951 2 Sheets-Sheet 2

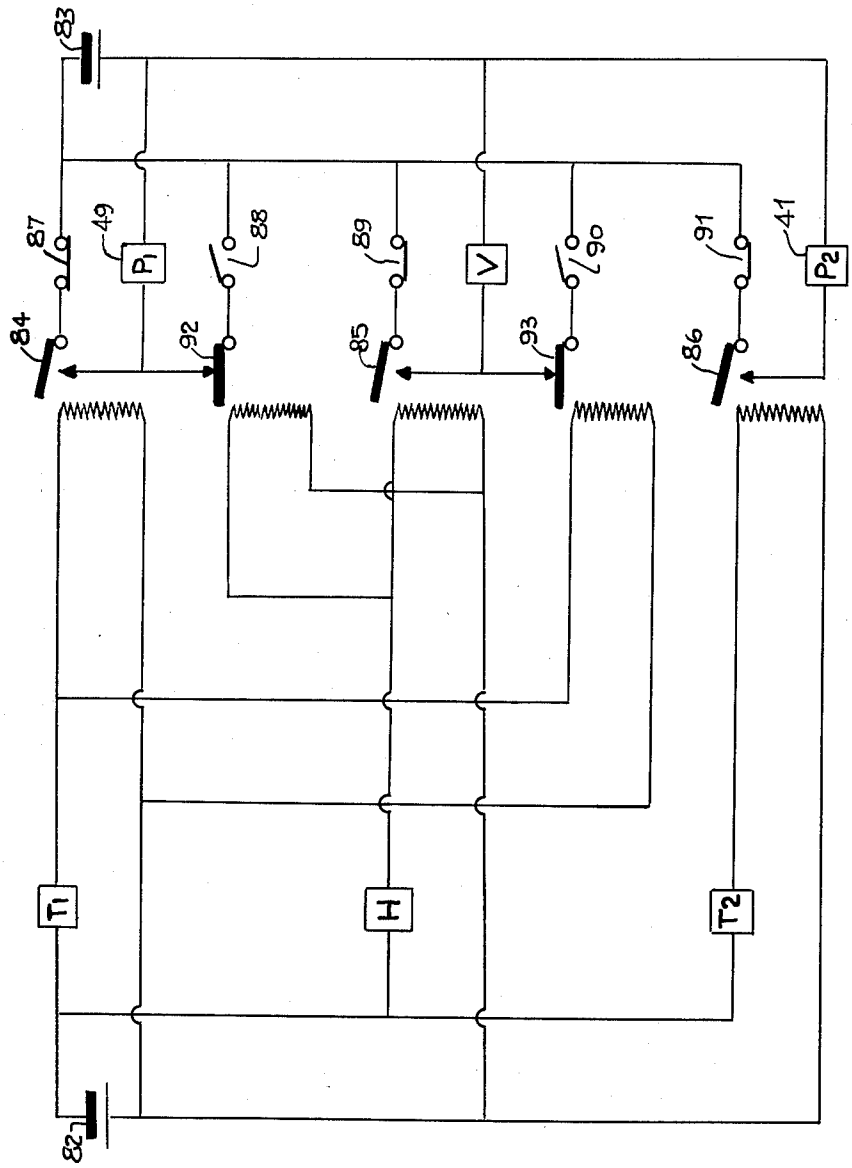


FIG. 4.

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United States Patent Office 2,723,837
Patented Nov. 15, 1955

2,723,837

UNIVERSAL AIR-CONDITIONER

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Application July 2, 1951, Serial No. 234,800

20 Claims. (Cl. 257—3)

My invention relates to new and useful improvements in air-conditioning apparatus, and more particularly to apparatus for "universal" (i. e., both summer and winter) air-conditioning.

This present application is a continuation, as to all common subject-matter, of my copending application for improvements in Universal Air-Conditioner, Serial No. 765,554, filed August 1, 1947, now abandoned without prejudice to this present application and one other continuation-in-part, Serial No. 234,301, filed June 29, 1951, now Patent No. 2,700,537, granted Jan. 25, 1955. It embraces the non-elected subject-matter of that parent case, plus certain subsequent improvements, and is being filed pursuant to the requirement of division in that parent case. This non-elected subject-matter is that part of the parent application which covers my complete apparatus.

In my Patent No. 2,464,766, issued March 15, 1949, which patent was copending with the parent of this present application, I disclosed and claimed evaporatively cooling a stream of outgoing air, and then utilizing that thus-cooled stream to cool a stream of incoming air, my heat-transfer means being a rotary heat-transferer divided into sectors of metal-wool, and rotating across the two air-streams. This heat-transferer involves practically perfect counterflow and one-to-one correspondence of heat-pickup and heat-discharge, all of which will be explained later herein. The principles of Patent No. 2,464,766 underlie practically all subsequent patent applications of mine.

Heavy room-load and high outdoor dew-point impose a severe burden on the apparatus of my above-mentioned patent; and so one of my primary objectives in improving the conception of that patent has been to increase the efficiency of my apparatus for meeting these conditions.

Accordingly, my above-mentioned patent discloses, as a second variant, the use of two evaporative coolers, alternating with two heat-transfer pads, the total thickness of which need be less than if only one had been used.

My Patents No. 2,576,140 and No. 2,527,569, both copending with the parent of this present application, disclose precooling the outgoing stream, respectively by heat-exchange with itself, and by feeding back a portion of the cooled incoming stream into the hot outgoing stream before the latter reaches the evaporative cooling means. Each of these expedients reduces the necessary total pad-thickness.

It is one of the objects of my present invention to devise a still different and better way of reducing the necessary total pad thickness of my apparatus, by reducing the load due to high dew-point, and thereby removing the limitations imposed on the scope of the apparatus by the high dew-points of some climates.

One of my main objects is to dehumidify the incoming air, for the attainment of greater comfort in summer.

Another main object is to devise a universal air conditioner, where the summer dehumidifying means can be used for heating and humidifying in winter, this change-over being effected without any complicated system of

ducts and dampers, nor the rerouting of either of my main air-streams, nor of any other fluids.

In addition to the objects above stated, I have worked out a number of novel and useful details, which will be readily evident as the description progresses.

Reference is hereby made to my copending application for improvements in humidity-changer for air-conditioning, Serial No. 234,301, filed June 29, 1951, and referred to earlier herein. That application embraces the elected subject-matter of the parent case, plus certain subsequent improvements, and is directed to the moisture-exchange portion of the present application which is directed to the complete machine. Said copending application should be consulted for details of the moisture-exchange portion and to the novel psychrometric principles involved therein.

My invention consists in the novel parts and in the combination and arrangement thereof, which are defined in the appended claims, and of which one embodiment is exemplified in the accompanying drawings, which are hereinafter particularly described and explained.

Throughout the description the same reference-number is applied to the same member or to similar members.

Figure 1 is a longitudinal vertical central section of my complete apparatus.

Figure 2 is a transverse vertical section of my apparatus, taken along the line 2—2 of Figure 1.

Figure 3 is an enlargement of a portion of Figure 1, to show the lining of chamber **51**.

Figure 4 is a wiring diagram of my interlocked thermostatic and humidistatic controls.

Referring now to Figure 1, we see that **11** is the main container of my invention, in which **12** is an air-inlet from outdoors. Centrifugal fan **13** impels this air into passage **14**, thence through filter-pad **20**, and thence through the upper portion of rotating wheel-like moisture-transferer **15**.

This moisture-transferer is preferably built in accordance with the description in my already-mentioned companion divisional application. Without going into details here, it may be stated that the rim **16**, ribs **17**, and hub **18** are of substantially of the same width in an axial direction, each of the sectors between successive ribs containing an air-pervious packing **19** impregnated with a suitable hygroscopic impregnant. This packing is preferably held in place by sectoral pieces of metal-screening **35**, which in turn is held in place by wires **36**, strung through transverse holes **37** in the ribs near the edges thereof. **33** is the partition between the two air-passages. **30** is one of the two bridges, which cooperates with partition **33**, to keep the air from leaking from one passage to the other. **31** is the shroud which keeps the air from by-passing the moisture-transferrer **15**. All of which is explained in more detail in the companion application mentioned above.

This moisture-transferer has the capability, which is very important to my complete apparatus, of being able to transfer moisture in either direction, by merely changing the R. P. M. thereof. This capability is fully explained in my companion application, Serial No. 234,301.

As more fully explained in the companion application, said sectoral portion of the incoming air first treated by this moisture-transferer (see Figure 2), passes therefrom into by-pass **23**, and thence into the outgoing air-stream. The explanation in my companion application is as follows. In summer when using my moisture-transferrer to dehumidify the incoming air, said first-treated sectoral portion of the incoming air will be found to be humidified and considerably heated, where what is wanted is dehumidification and no more heating than necessary. By discarding this sectoral portion, the rest of the incoming stream is just what is wanted; and an

important by-product is that we conserve the sensible heat of the air which goes through the by-pass so that this heat can be used over again in reconcentrating the hygroscopic impregnant of the moisture-transferrer.

If damper **24** be closed and damper **25** be opened, this air, instead of being thus discarded, will pass with the rest of the incoming stream. If there be no damper **25**, and damper **24** be closed, all the incoming air will by-pass the by-pass.

In any event, the main stream of incoming air continues on in passage **26**, until it encounters heat-transferer **27**, rotating at a speed of about 25 to 30 R. P. M.

This heat-transferer **27** is preferably of the sort of the "aluminum wool pad" of my Patent No. 2,464,766, already alluded to, or it might be packed with a foraminous carrier impregnated with some non-hygroscopic liquid, as explained in the companion application.

The alternative means for preventing leakage of air past my heat-transferer **27**, are explained in my companion application, Serial No. 234,301.

The incoming air, after having been cooled by heat-transferer **27**, is further cooled by passing through evaporative pad **38**, which I call my "secondary" pad. Water from tank **39** is sucked through pipe **40** by electric pump **41**, by which this water is impelled through feed pipe **42** to the top of pad **38**, whence it trickles down through this pad, so much of the water as is not evaporated therein, being returned to the tank through pipe **43**.

The tank is supplied with water from any convenient source through supply pipe **46** and ball-cock **47**.

The air then enters the room or other enclosure through louvres **44**.

Exhaust air leaves the room or other enclosure through louvers **45**, and is cooled by passing through evaporative pad **48**, which I call my "primary pad," and which is supplied with water from tank **39** by pump **49** in exactly the same manner as secondary pad **38**, already described.

In place of each of these two pads, I could use the pads and sprinkler of the copending application of McKinney and self, for improvements in Evaporative Air-Cooler, now Patent No. 2,681,217.

Adiabatically cooled by primary pad **48**, the outgoing air in turn cools heat-transferer **27**, being itself warmed in the process, and then passes through radiation-shield **50** into chamber **51**, where it is joined by the by-passed portion of incoming air entering the chamber through by-pass **23**.

In this chamber there is an air-heater, of one of the sorts described in my companion sole application. As shown it is a furnace (preferably gas) **52**, which heats the air by means of fins **53** on its flue **54**. This furnace, and its flue and fins, are represented here merely conventionally.

The outgoing air, greatly heated by the furnace, then passes through radiation-shield **55**.

Chamber **51** should be lined with some highly heat-reflecting material, backed by heat-insulating material.

Radiation-shield **50** may be of any convenient construction which will shield heat-transferer **27** from the direct rays emanating from air-heater **52**, while permitting the free passage of air. In other words, it should be substantially impervious to heat-radiations, and yet pervious to air. I prefer a stationary pad of much the same sort of aluminum-wool as employed as a filler for heat-transferer **27**. Radiation-shield **55** is similar, and similarly protects moisture-transferer **15** from the rays of air-heater **52**.

The outgoing air, having been raised in temperature by passing through heat-transferer **27** and through radiation-screens **50** and **55**, and by the addition of by-passed incoming air, and by air-heater **52**, then passes through moisture-transferer **15**, where it dries and heats the hygroscopic packing thereof.

Thence it is sucked through centrifugal fan **56** into passage **57**, whence it passes outdoors through exit opening **58**. In this opening is butterfly valve **59**.

From passage **57**, in the opposite direction there extends a draft-passage **60**, which connects with furnace **52** in such manner as to furnish draft-air thereto. The amount of this draft can be regulated by butterfly-valve **59**. The advantages of this expedient are explained in my companion application, Serial No. 234,301.

Motor **61** drives shaft **62** through pulley **63**, belt **64**, and pulley **65**. Fans **13** and **56** are keyed to, and driven by, this shaft **62**.

This shaft **62**, through gear-reduction **66**, drives shaft **67** at a very slow speed (about 3 R. P. M., or less), and drives shaft **68** at a relatively-faster speed (about 25 to 30 R. P. M.). On these speeds, see later herein. Shafts **67** and **68** enter speed-changer **69**, the details of which are shown and explained in my companion application, Serial No. 234,301.

The optimum rotation-speeds differ somewhat for various materials, but can easily be experimentally determined for each. The optimum fast speed for both exchangers is of the order of 25 to 30 R. P. M., but somewhat more would be permissible.

The optimum slow speed for a fully-impregnated moisture-exchanger is of the order of 3 R. P. M. or less. For example, for excelsior fully impregnated with triethylene glycol, it is 2 to 3 R. P. M. For excelsior fully impregnated with the best hygroscopic salts, it is ⅓ to ½ R. P. M.. For asbestocel fully impregnated with the best hygroscopic salts, it is of the order of ⅛ R. P. M. On the effect of underimpregnation, see later herein.

The object of the two speeds for the moisture-transferrer is briefly as follows. I have discovered that, at low rotation-speeds, moisture transfer takes place from the cooler air-stream to the hotter air-stream, regardless which stream has the higher vapor-pressure; whereas, at high rotation-speeds, moisture transfer takes place from the air-stream of greater vapor-pressure to the air-stream of less vapor-pressure, regardless which stream is the hotter. Of course, these principles presuppose that the controlling differential is substantial.

My explanation of this surprising phenomenon is given in my companion application, Serial No. 234,301, together with a full explanation of the psychrometry thereof.

Finally as to the controls, as to which see Figure 1 first.

T_1 and T_2 are two thermostats (but might as well represent two stages of one double-stage thermostat, which the mention of two thermostats in my claims will be intended to include). H is a humidistat. These three stats could be placed at any strategic location in the room or other enclosure which is being air-conditioned, or equivalently in the outgoing air-passage just inside the louvres **45**. These three stats control the turning on and off of pumps **41** and **49**, and of valve V which supplies fuel to furnace **52**, all in a manner which will now be described.

If, as suggested earlier herein, I employ in place of each of pads **38** and **48** the sprinkler and pads of the copending application of McKinney and self for improvements in Evaporative Air-Cooler, pumps **41** and **49** might be replaced in this connection by normally-closed electrically-operable water-valves.

Figure 4 represents a wiring-diagram of the controls. **82** is a source of low-potential electricity, suitable for control-purposes. **83** is a source of high-potential electricity, suitable for actuating electric motors, and the like. For mnemonic convenience, pump **49** is marked P_1, to indicate that it supplies water to my primary pad **48**, and pump **41** is marked P_2, to indicate that it supplies water to my secondary pad **38**.

84, **85**, and **86** are normally-open solenoid-switches, closable by energizing the solenoid. **92** and **93** are

normally-closed solenoid-switches, openable by energizing the solenoid.

87, 88, 89, 90 and **91** are switches, preferably simultaneously actuable in any convenient manner. **87, 89,** and **91** are shown with the movable contact above the fixed contact, to indicate that simultaneous setting of these switches in one direction opens **87, 89,** and **91,** and closes **88** and **90**; and that simultaneous setting in the other direction closes **87, 89** and **91,** and opens **88** and **90.**

Each thermostat closes at a higher temperature than it opens. Thermostat T_2 closes and opens at higher temperatures than does thermostat T_1. Humidistat H closes at a higher humidity than it opens.

In summer, switches **87, 89,** and **91** are closed, and switches **88** and **90** are open. Accordingly thermostat T_1 controls the primary pad, thermostat T_2 controls the secondary pad, and humidistat H controls fuel-valve V of the furnace. When the room-temperature rises sufficiently, thermostat T_1 trips, thus closing the solenoid-switch **84,** and thus operating pump **49** to supply water to primary pad **48.** If this does not produce sufficient cooling, the temperature continues to rise until thermostat T_2 trips, thus closing solenoid-switch **86,** and thus operating pump **41** to supply water to secondary pad **38.** Conversely a drop in temperature, by successively opening solenoid-switches **86** and **84,** successively stops the supply of water to the secondary pad and then the primary pad.

If the room air becomes too humid, humidistat H trips, thus closing solenoid-switch **85,** and thus causing the furnace to operate. This heats up the outgoing air, thus causing the moisture-transferrer to dehumidify the incoming air as explained earlier herein. Conversely a drop in room-humidity, by opening solenoid-switch **85,** turns off the furnace, causing the moisture-transferrer to humidify the incoming air.

In winter, switches **87, 89,** and **91** are open, and switches **88** and **90** are closed. Accordingly thermostat T_1 now controls fuel-valve V, humidistat H controls primary pad **48,** and secondary pad **38** is inoperative.

Normally-closed solenoid-switch **93** remains closed so long as thermostat T_1 is inactive; thus the furnace normally operates to keep the room warm. But when the room becomes too warm, thermostat T_1 closes, thus opening switch **93,** and thereby shutting off the furnace.

Similarly normally-closed solenoid-switch **93** remains closed so long as humidistat H is inactive; thus pump **49** normally operates to supply water to primary pad **48,** to keep the room air humidified. But when the room air becomes too humid, humidistat H closes, thus opening switch **92,** and thereby shutting off pump **49** and stopping the supplying of water to the primary pad.

It should be understood that the particular wiring-diagram shown and described herein is merely illustrative, the invention inhering in the relationship of my controls rather than in the particular electrical devices employed to achieve them.

An important subcombination of my complete apparatus, which subcombination is useful per se as a mere air-drier is the combination of the two air-passages, the fans, the moisture-transferrer, the air-heater, the by-pass, and the heat-transferrer. This subcombination is fully discussed and claimed in my companion case.

In conclusion, reverting to the complete combination, I wish to emphasize the fact that my universal air-conditioner, by conserving and reusing the room-heat in winter and the room-coolness in summer, is able to supply nearly 100% fresh air (without resorting to recirculation) all the year round, without any material increase in heating load or in cooling load over conventional types of machines which resort to considerable recirculation to reduce one or both of these loads.

I also wish to emphasize the ability of my moisture-transferrer to transfer total heat (i. e., sensible heat, plus latent heat in the form of moisture) in winter.

Having now described and illustrated one form of my invention, although with variant settings to meet various conditions, I wish it to be understood that my invention is not to be limited to the specific form or arrangement of parts herein described and shown.

I claim:

1. In an air-conditioner, the combination of: an outgoing-air passage; an incoming-air passage; means for impelling air through the two passages in counter-current relationship; a rotary wheel-like moisture-transferer, mounted for rotating across both passages; means for rotating the moisture-transferer; a rotary wheel-like heat-transferer, located indoorward of the moisture-transferer, and mounted for rotating across both passages; means for rotating the heat-transferer; an air-heater, located in the outgoing-air passage between the heat-transferer and the moisture-transferer, for heating the outgoing air; and an evaporative air-cooler, located in one of the passages, indoorward of the heat-transferer.

2. An air-conditioner according to claim 1, characterized by the fact that the evaporative air-cooler is in the outgoing-air passage.

3. An air-conditioner according to claim 2, further characterized by having, in the incoming-air passage, indoorward from the heat-transferer, a second evaporative air-cooler.

4. An air-conditioner according to claim 3, further characterized by the fact that the moisture-transferer comprises imperforate spokes substantially as thick as the moisture-transferer in an axial direction, and a packing of inert air-permeable absorbent material impregnated with a non-volatile hygroscopic substance, said packing substantially filling each sectoral space between successive spokes, and being held substantially immovable relative to said spokes.

5. An air-conditioner according to claim 4, characterized by the fact that the incoming-air passage is divided, at the inward face of the moisture-transferer, into two branches, across the entrance to one of which branches the successive sectors of the rotating moisture-exchanger first pass, and across the entrance to the other of which branches these sectors pass thereafter in their rotation, the first branch leading into the outgoing passage between the heat-exchanger and the moisture-exchanger, and the second branch constituting a continuation of the incoming air-passage, whereby that portion of the air in the incoming-air passage which is first encountered by successive sectors of the rotating moisture-transferer is by-passed into the outgoing-air stream.

6. An air-conditioner according to claim 5, further characterized by the fact that there is in the first branch a valve, which can be set at will to selectively open the first branch to the outgoing air passage, or to close it therefrom.

7. An air-conditioner according to claim 6, further characterized by the fact that there is in the first branch a second valve, which can be set at will to selectively close the first branch from the second branch, or to open it thereto.

8. An air-conditioner according to claim 1, characterized by the fact that the means for rotating the moisture-transferer includes a two-speed speed-changer, by which the moisture-transferer can at will be selectively rotated at a very slow speed or at a relatively fast speed.

9. An air-conditioner according to claim 8, further characterized by the fact that the incoming-air passage is divided, at the inward face of the moisture-transferer, into two branches, across the entrance to one of which successive sectors of the rotating moisture-exchanger first pass, and across the entrance to the other of which these sectors pass thereafter in their rotation, the first branch leading into the outgoing passage, and the second branch constituting a continuation of the incoming air-passage, whereby that portion of the air in the incoming-air passage which is first encountered by successive sectors of

the rotating moisture-transferer is by-passed into the outgoing-air stream; and by the fact that there is in the first branch a valve, which can be set to selectively close this branch from the outgoing air passage or to open it thereto.

10. An air-conditioner according to claim 9, further characterized by the fact that there is in the first branch a second valve, which can be set to selectively open this second valve to the second branch, or to close it therefrom.

11. In an air-conditioner according to claim 1, further characterized by having: a thermostat so located as to be responsive to changes in temperature in the enclosure to be conditioned; a humidistat so located as to be responsive to changes in humidity in the enclosure to be conditioned; and means to turn the evaporative air-cooler and the air-heater on and off; the combination therewith of: circuit means to connect the thermostat and the humidistat to the means for turning on and off the evaporative air-cooler and the air-heater in such manner that alternatively: (A) the response of the thermostat to high or low temperature in the enclosure will turn the air-heater respectively off and on, and the response of the humidistat to high or low humidity in the enclosure will turn the evaporative air-cooler respectively off and on; and (B) the response of the thermostat to high or low temperature in the enclosure will turn evaporative air-cooler respectively on and off, and the response of the humidistat to high or low humidity in the enclosure will turn the air-heater respectively on and off; said circuit means including master control means, whereby for winter operation the circuit means can be set to perform alternative A, and for summer operation the circuit means can be set to perform alternative B.

12. In an air-conditioner according to claim 1, further characterized by the fact that the evaporative air-cooler is in the outgoing air-passage, and by having: a first thermostat so located as to be responsive to changes in temperature in the enclosure to be conditioned; means to turn the first evaporative cooler on and off; a second evaporative air-cooler in the incoming air-passage indoorward from the heat-transferer; a second thermostat, so located as to be responsive to changes in temperature in the enclosure to be conditioned, and so adjusted as to have a temperature range higher than the temperature range of the first thermostat; and means to turn the second evaporative air-cooler on and off; the combination therewith of circuit means to connect the first thermostat to the means for turning on and off the first evaporative air-cooler in such manner that the response of the first thermostat to high or low temperature in the enclosure will turn the first evaporative air-cooler respectively on and off; and circuit means to connect the second thermostat to the means for turning on and off the second evaporative air-cooler in such manner that the response of the second thermostat to high or low temperature in the enclosure will turn the second evaporative air-cooler respectively on and off.

13. Apparatus for conditioning hot humid air for use in an enclosure, by thermodynamic exchanges with air extracted from the enclosure, which apparatus comprises: a first air-passage; a second air-passage; means for impelling a stream of outdoor air into and through the first passage; means for extracting air from the enclosure into and through the second passage; heat-and-moisture exchange means for dehumidifying and heating the first-passage air by thermodynamic exchange with the air in the second passage, the heating being to some extent accomplished by transfer of sensible heat to the first-passage air from the second-passage air, but principally by conversion of latent heat of the first-passage air into sensible heat by the condensation of moisture from the first-passage air onto the heat-and-moisture exchange means; means for then anhydrously cooling the first-passage air by heat-exchange with the second-passage air indoorward from the heat-and-moisture exchange means; means for then passing the thus dehumidified and cooled first-passage air into the enclosure; means for evaporatively cooling the second-passage air, indoorwards of the above-mentioned anhydrous heat-exchange means; and an air-heater located in the second passage, between said anhydrous heat-exchange means and the heat-and-moisture exchange means.

14. Apparatus according to claim 13, further characterized by having a by-pass extending, from the first passage between the heat-and-moisture exchange means and the anhydrous heat-exchange means, to the second passage between the anhydrous heat-exchange means and the air-heater, and so disposed that it will extract, from the first passage air immediately after said air has passed through the heat-and-moisture exchange means, so much of said air as has not been dehumidified by said means, and will then dump such extracted air into the second passage, just prior to the treatment of the second passage air by the air-heater therein.

15. Apparatus for conditioning dry hot air for use in an enclosure, by thermodynamic exchanges with air extracted from the enclosure, which apparatus comprises: a first air passage; a second air passage; means for impelling a stream of outdoor air into and through the first passage; means for extracting air from the enclosure into and through the second passage; heat-and-moisture exchange means for humidifying and cooling the first-passage air by thermodynamic exchange with the air in the second passage, this cooling being to some extent accomplished by transfer of sensible heat from the first-passage air to the second-passage air, but principally by evaporative cooling of the first-passage air by the transfer of moisture thereto from the second-passage air; means for then anhydrously further cooling the first-passage air by heat exchange with the second-passage air indoorward from the heat-and-moisture exchange means; means for then passing the thus humidified and cooled first-passage air into the enclosure; and means for evaporatively cooling the second-passage air, indoorwards of the above-mentioned anhydrous heat-exchange means.

16. Apparatus for conditioning cold air for use in an enclosure, by thermodynamic exchange with air extracted from the enclosure, which apparatus comprises: a first air-passage; a second air-passage; means for impelling a stream of outdoor air into and through the first passage; means for extracting air from the enclosure into and through the second passage; heat-and-moisture exchange means for humidifying and heating the first-passage air by transferring sensible heat and moisture to the first-passage air from the second-passage air; means for then passing the thus humidified and heated first-passage air into the enclosure; means for evaporatively humidifying the second-passage air; and an air-heater located in the second passage, between said evaporatively humidifying means and the heat-and-moisture exchange means.

17. In an air-conditioner the combination of: outgoing-air passage means; incoming-air passage means; means for impelling air through these two means in countercurrent relation; a moisture-transferer comprising a mass of air-permeable material, mounted to move cyclically across both passage means; means for so moving the moisture-transferer; a heat-transferer comprising a mass of air-permeable material located indoorward of the moisture-transferer and mounted to move cyclically across both passage means; means for so moving the heat-transferer; means for heating the outgoing-air for regenerating the moisture-transferer, said means located between said moisture-transferer and said heat-transferer; and an evaporative air-cooler located in one of the passage means, indoorward of the heat-transferer.

18. An air-conditioner, according to claim 17, characterized by having in the outgoing-air passage means between the heat-transferer and the heating means an air-pervious screen relatively impervious to heat radiations; and by the fact that the evaporative air-cooler is in the outgoing air-passage means.

19. An air-conditioner, according to claim 17, characterized by having in the outgoing-air passage means between the heating means and the moisture-transferer an air-pervious screen relatively impervious to heat radiations.

20. Apparatus according to claim 13, further characterized by having, between the means for anhydrously cooling the first-passage air, and the means for passing this air into the enclosure: means for evaporatively cooling this air.

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