July 3, 1962 N. A. PENNINGTON 3,042,383

UNIVERSAL AIR CONDITIONER

Filed July 10, 1958 4 Sheets-Sheet 1

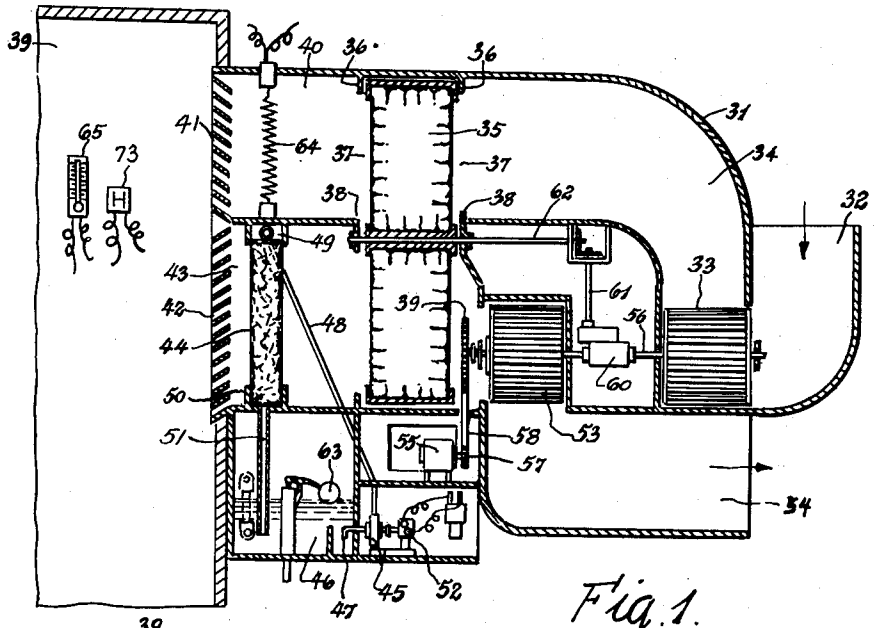


Fig. 1.

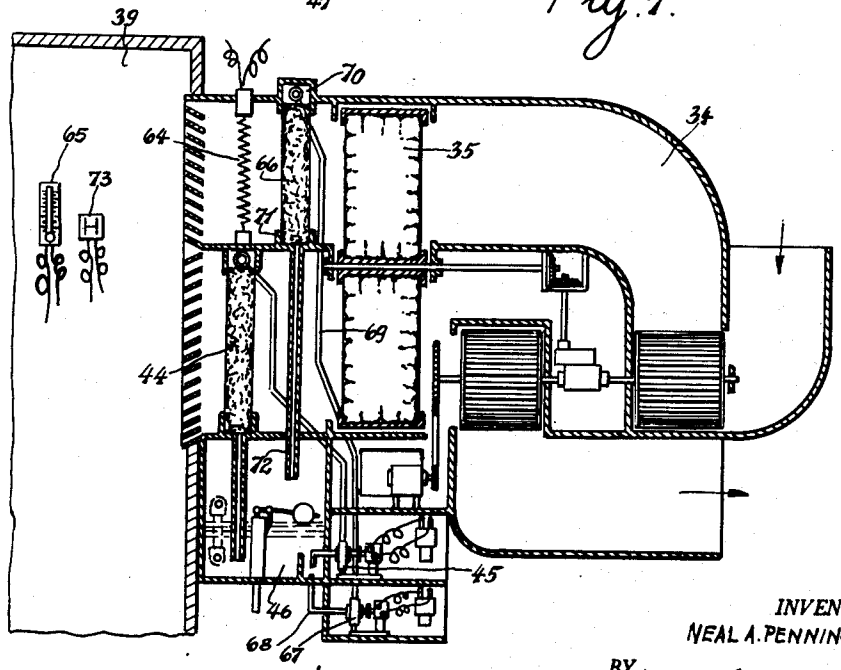


Fig. 2.

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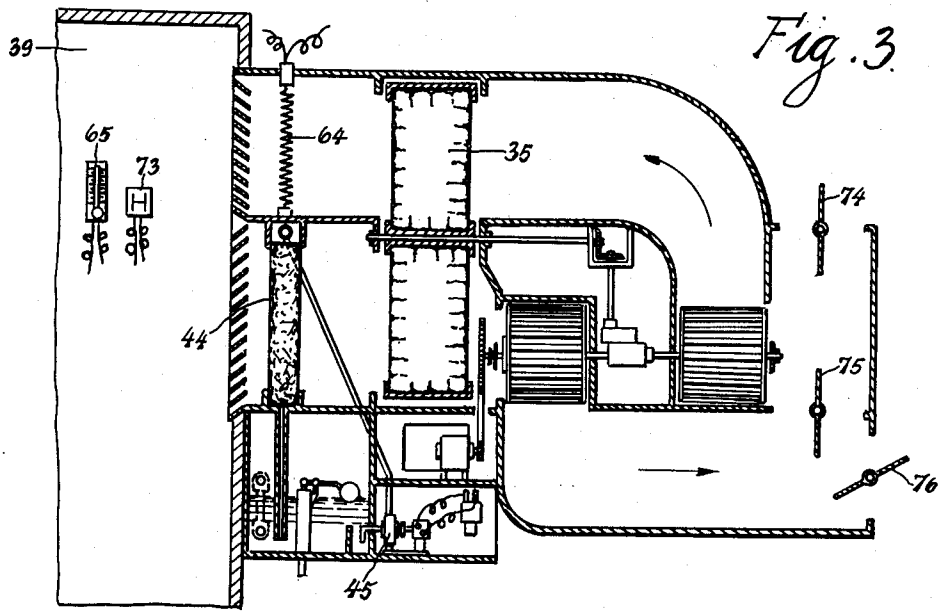


Fig. 3.

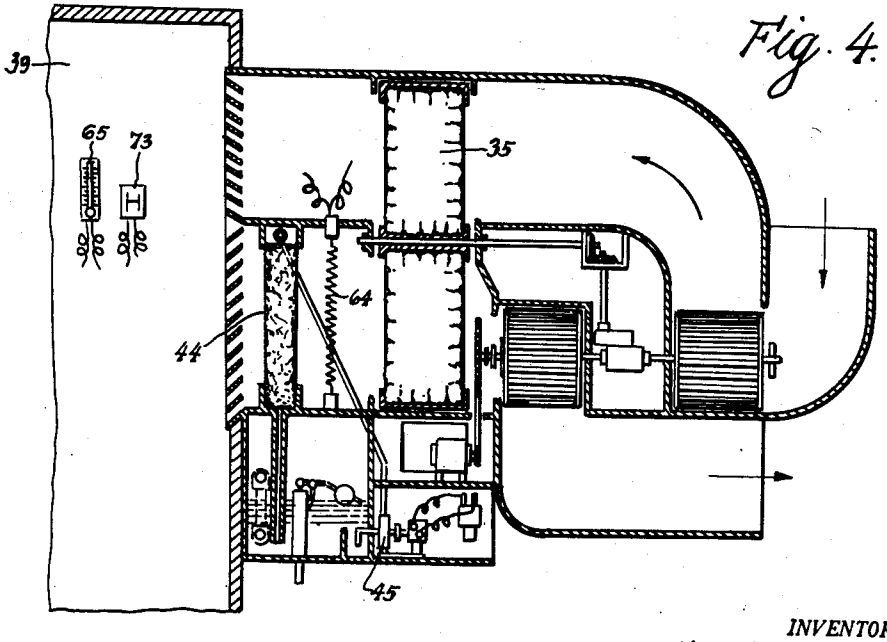


Fig. 4.

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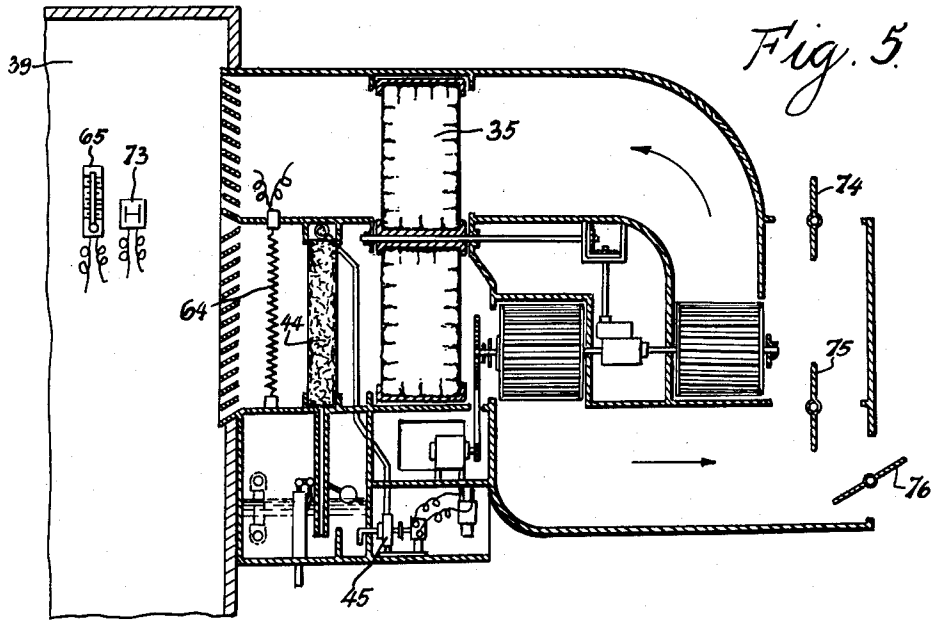


Fig. 5.

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Fig. 6.

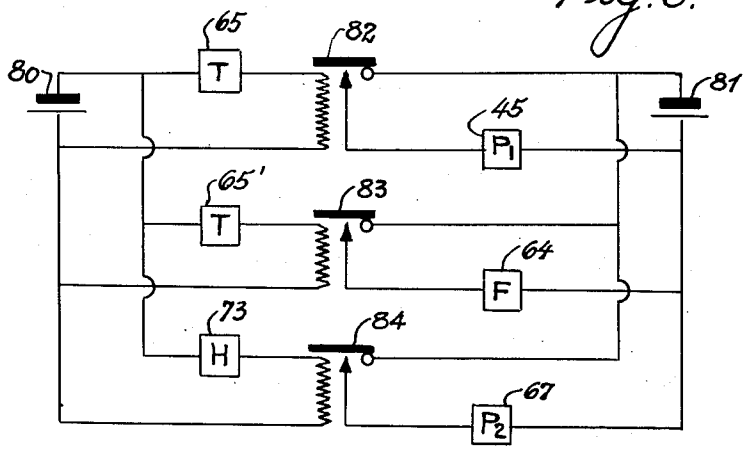
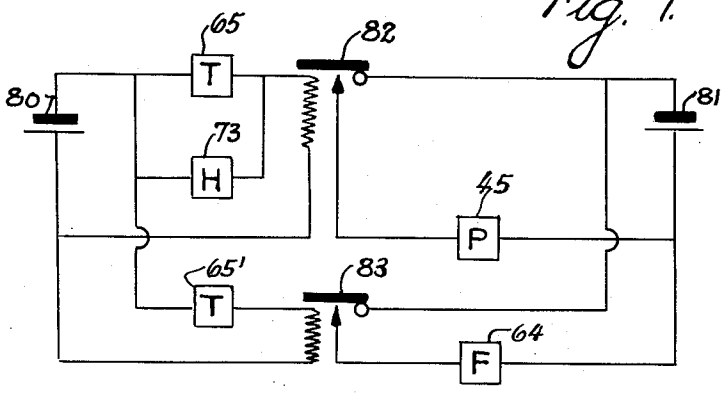


Fig. 7.



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United States Patent Office 3,042,383 Patented July 3, 1962

3,042,383

UNIVERSAL AIR CONDITIONER

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Filed July 10, 1958, Ser. No. 748,562
4 Claims. (Cl. 257—281)

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. The present application is a continuation-in-part, as to all common subject matter of my copending application No. 122,322, filed October 19, 1949, now abandoned.

In my Patent No. 2,464,766, issued March 15, 1949, I disclosed the basic idea of all my systems, namely evaporatively cooling a stream of outgoing air, and then transferring to that stream the heat from a stream of incoming air. Also therein I disclosed and claimed a marked improvement on that general idea, namely the utilization, for the above-mentioned heat-transfer, of a flat cylindrical pad of metal-wool, divided into sectors, and rotating in the two streams. This heat-transfer means, which involves practically perfect counter-flow, is claimed per se in that patent; and the heat-transfer pad per se is claimed in a copending divisional (Serial No. 55,594, filed October 20, 1948, now Patent No. 2,563,415) of that patent. This system underlies all subsequent pending applications of mine.

A second variant disclosed and claimed in the first mentioned patent, and several further variants disclosed and claimed in copending applications of mine, are designed to increase the efficiency and reduce the pad-thickness of my basic apparatus.

My copending Patent No. 2,499,411, issued March 7, 1950, discloses and claims a novel thermostatic control, devised primarily for said apparatus, but adapted to use in other air-conditioning systems.

Ever since the demonstration of the practicality, efficiency, and commercial success of my basic apparatus, one of my objectives has been to devise a universal air-conditioner, utilizing insofar as possible the basic ideas and elements of that apparatus, with as little as possible change from and/or addition to that apparatus.

My copending application, Serial No. 765,554, filed August 1, 1947 (now abandoned without prejudice to two continuations-in-part: Serial No. 234,301, filed June 29, 1951, and Serial No. 234,800, filed July 2, 1951, now Patents Nos. 2,700,537 and 2,723,837), represents a successful solution of that problem; but the main object of the invention described and claimed in this present application is to attain a simpler and more efficient solution.

In addition to devising a universal air-conditioner based upon the basic apparatus of my Patent No. 2,464,766, my further objects are to humidify the incoming air in winter, and to recirculate in winter none or very little of the air, while conserving practically all of the heat of the discarded stale air.

I shall take as the summer air-conditioner which I shall use as an exemplification of the device which my present invention is intended to convert into a universal air-conditioner for winter as well as summer, the particular form of my basic apparatus which is shown in my copending Patent No. 2,499,411, already referred to. Accordingly it will be among the objectives of this present invention: to utilize for winter air-conditioning the thermostatic controls of that application, without any alteration of their original summer setting, and without the rerouting of any of the air-streams; to utilize for winter air-conditioning the same heat-transfer means as in summer, without alteration or rerouting of air; and to utilize for humidifying the incoming winter air, the same elements used to evaporatively cool the outgoing air in summer, still without alteration or rerouting. Furthermore I aim that such elements and controls as I may add for winter use shall remain connected in summer, with no alterations in setting.

Thus I shall have produced a universal air-conditioning apparatus which will operate all the year round, without any switch-over, disconnection, or change of setting.

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.

My invention consists in the novel parts and in the combination and arrangement thereof, which are defined in the appended claims, and of which several embodiments are 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 vertical longitudinal section of a first variant of my present invention.

FIGURE 2 is a vertical longitudinal section of a second variant.

FIGURE 3 is a vertical longitudinal section of a third variant.

FIGURE 4 is a vertical longitudinal section of a fourth variant.

FIGURE 5 is a vertical longitudinal section of a fifth variant.

FIGURE 6 is a wiring diagram of one way of controlling my second variant.

FIGURE 7 is a wiring diagram of one way of controlling my first, third, fourth and fifth variants.

Let us now consider the first variant of my present invention, which first variant is exemplified by FIGURE 1.

Referring to FIGURE 1, we see that **31** is the main container of my invention, in which **32** is an air-inlet from outdoors, **33** is a centrifugal fan, which impels incoming air into passages **34**, and thence through the upper portion of rotating heat-transfer pad **35**. This pad **35** is similar to the corresponding pad of my Patent No. 2,464,766, and is more particularly described in my copending application, Serial No. 55,594, filed October 20, 1948, now Patent No. 2,563,415, and contains a packing of highly heat-absorbent material as there described, and rotates at a speed of about 30 r.p.m.

This pad **35**, like the corresponding pad of my said patent, rotates in a casing **36**, each face of which has two sectorial orifices **37**, separated from each other by a bridge **38**.

The incoming air, after having been thus anhydrously cooled by heat-exchange by this heat-transfer pad **35**, passes into the enclosure **39**, through passage **40** and louvers **41**.

Outgoing air passes from enclosure **39** through louvers **42** into passage **43**, where it encounters evaporative pad **44**, which serves exactly the same purpose as the corresponding pad of my said Patent No. 2,464,766. This pad **44** is kept moistened by pump **45** drawing water from tank **46** through pipe **47**, and delivering this water through pipe **48** to trough **49**, whence the water seeps down through pad **44**. So much of this water as does not evaporate into the outgoing air during the water's downward seeping through pad **44**, is collected in trough **50**, and thence passes through pipe **51** back into tank **46** again. Pump **45** can be driven by an electric motor **52**, or otherwise.

Evaporative pad **44** could be of any other convenient type, such for example as the rotating evaporative pad of my said Patent No. 2,464,766; or any other convenient

evaporation cooling means could be employed at this stage of my apparatus.

The outgoing air, having been evaporatively cooled in evaporative pad **44**, cools heat-transfer pad **35**, and then is sucked by centrifugal fan **53** into air-outlet **54** through which it is discharged outdoors or into the attic.

As already stated, the thus-cooled heat-transfer pad **35** serves to anhydrously cool the incoming air.

Motor **55** drives shaft **56** through pulley **57**, belt **58**, and pulley **39**. Shaft **56** drives the two fans **33** and **53** at a high rate of speed. Also, through gear-reduction **60**, shaft **56** drives shaft **61**, and thereby shaft **62**, at about 30 r.p.m., thus driving heat-transfer pad **35** (keyed to shaft **62**) at that same rate.

Tank **46** is kept filled, from any convenient source (not shown) by means of ball-cock **63**.

Thermostat **65**, as in my already-mentioned copending Patent No. 2,499,411, is so connected to pump-motor **52**, as to turn pump **45** on when the room temperature rises to a predetermined high, and to turn the pump off again when the room temperature drops to a predetermined low.

Thus far I have been describing merely the basic apparatus of my prior inventions.

To convert this summer-time apparatus into a year-round apparatus, I have added an air-heating device of any conventional or other type, together with appropriate thermostatic and humidistat controls for turning this device on and off. I shall call the air-heating device the "heater."

As shown in FIGURE 1, the heater takes the form of an electric grid **64**, located across the incoming air-stream in passage **40**. Thermostat **65**, shown located in enclosure **39** (but could be located between heater **64** and louvers **41**, or between louvers **42** and evaporative pad **44**) in addition to continuing to perform in winter without change its summertime function of turning pump **45** on and off, is also so connected to heater **64** as to turn that heater on when the room-temperature drops to another or the same predetermined low; and to turn heater **64** off again when the room-temperature rises to another or the same predetermined high. When in the claims as to any of my five variants I recite a thermostat performing these two functions, it is to be understood that I intend to cover generically a single thermostat with multiple contacts, or a compound thermostat, i.e. two thermostats.

Humidistat **73** (appropriately located like thermostat **65**) and thermostat **65**, both control the water supply to pump **45**, either alone being sufficient to turn it on, whereas both are required to turn it off. Thus the evaporative cooling pad **44** of summer use, is employed in winter to do the humidifying, and without any rerouting of the air-circuits when changing from summer to winter.

FIGURE 7 shows the wiring diagram of this first variant.

For simplicity the thermostat is shown as two thermostats, **65** and **65'**. The reference character **80** indicates a source of low-potential electricity, suitable for control-purposes; and **81** a source of high-potential electricity, suitable for actuating an electric motor. The motor of pump **45** is indicated by the same reference character and **64** represents the heater. **82** and **83** are relays of any convenient sort, such as magnetic switches. The two thermostats, each acting through its relay, respectively turn on and off pump **45** and heater **64**, as already explained. Humidistat **73** is in parallel with thermostat **65**, in the line of control of pump **45**. This parallel hook-up turns on pump **45** if either the thermostat or the humidistat is closed, but requires both to be open to turn off the pump. If desired, each could have its own relay, the switches of the two relays being in parallel.

FIGURE 7 is equally applicable to the third to fifth variants, as to first variant.

The operation of my apparatus when the heater is off, and the pump is on, can be readily understood from Patent No. 2,464,766.

The operation of my apparatus when the heater is off and the pump is intermittently on and off, can be readily understood from my copending Patent No. 2,499,411.

There will now be explained the winter operation of this third variant, when heater **64** is on steadily or intermittently, and pump **45** is not kept on by thermostat **65**, but instead is kept on intermittently by humidistat **73** just enough to supply the requisite humidification.

First, however, let us see why heat-exchange pad **35** which is anhydrous when used to cool the hot incoming air in summer, nevertheless serves to humidify as well as heat the cold incoming air in winter. Inasmuch as each particle of heat-exchange pad **35** is warmed up in its passage across the outgoing air, and is cooled down in its passage across the incoming air, it stands to reason that each particle must be cooler than the outgoing air when in contact therewith, and warmer than the incoming air when in contact therewith.

If the incoming air is cold enough, and the outgoing air, when it reaches heat-transfer pad **35**, is humid enough, due to its natural moisture content when leaving the room plus whatever moisture is added to it by evaporative pad **44** under the influence of the humidistat, this outgoing air in passing through heat-transfer pad **35** will eventually reach a lamina where it has cooled down sufficiently to be saturated: i.e., its temperature has reached its dew-point. Further cooling is impossible without reduction of dewpoint also. Accordingly, as the outgoing air is cooled to a progressively lower temperature while passing through this pad, it will give up moisture to the remaining laminae of the pad. Each particle of these laminae, being cooler than the dewpoint temperature of this air, will hold the moisture, until that particle passes into the incoming air-stream and meets the incoming air, which being unsaturated and a lower vapor-pressure than the water on the lamina, quickly absorbs that water. Thus it will be seen that up to a certain lamina this pad, which is an anhydrous heat-transferer in summer, transfers sensible heat anhydrously in winter too, and beyond that lamina transfers both sensible heat and moisture. This same explanation holds for the moisture-exchange part of the cycle of each of the variants to be discussed hereinafter.

The discussion of the operation of each of the variants is, of course, predicated on the assumption that the capacity of its elements is sufficient.

The winter operation is as follows. Cold dry outside air enters the apparatus, and first has its temperature raised considerably by heat-exchange pad **35**, and may also have its moisture content raised thereby to the extent that moisture has been extracted by a part of this pad from the outgoing air, as already explained earlier herein. The temperature of the air is then further raised, by heater **64**, to a temperature controlled by thermostat **65'**. The air then enters the room **39**, where it is mixed with air already in the room. The mixture can be expected to lose temperature by the escape of heat to the cold outdoors, and to gain a little moisture. Air leaves the room. In evaporative pad **44** (now acting as a humidifier, if this pad is operating under the influence of humidistat **73**) the outgoing air adiabatically loses sensible heat, and gains moisture to the extent necessary to cause the incoming air to satisfy the humidistat. This air then passes through heat-transfer pad **35**, giving up thereby to the incoming air, considerable sensible heat and enough moisture to satisfy the demands of the humidistat.

If, as usually is the case, the constant use of pad **44** to thus indirectly humidify the incoming air, would otherwise produce more than enough humidity to satisfy the humidistat, the humidistat will operate intermittently to turn pump **45** on and off, thus reducing the supply of water to pad **44**.

Let us now consider the second variant of my present

invention, which second variant is exemplified by FIGURES 2 and 6.

Referring to these two figures, we see that they are identical to the variant of FIGURES 1 and 7, except for the following changes. In the upper air-passage, that is to say the incoming air-passage 34, between heat-transfer pad 35 and heater 64, there has been added a second evaporative pad 66. This pad 66 is kept moistened by pump 67 drawing water from tank 46 through pipe 68, and delivering its water through pipe 69 to trough 70, whence the water seeps down through pad 66. So much of this water as does not evaporate into incoming air durinng the water's downward seeping through pad 66, is collected in trough 71, and thence passes through pipe 72 back into tank 46 again.

Evaporative pad 66, like evaporative pad 44, could be of any other convenient type; or any other convenient evaporative humidifying means could be employed at this stage of my apparatus.

Humidistat 73 now controls (see FIG. 6) second pump 67, through relay 84; and thermostat 65, through relay 82, now alone controls first pump 45.

The summer operation of this second variant is the same as the first variant.

The winer operation varies, as follows. Evaporative pad 44 will not function. But if the incoming air is cold enough, and the outgoing air is humid enough, the outgoing air will cool down sufficiently, part way through heat transfer pad 35 to become saturated, and thus (as in the first variant) will impart some moisture (via this pad) to the incoming air. If this moisture is not sufficient to produce the humidity for which the humidistat is set, the humidistat will start pump 67 supplying water to evaporative pad 66, which will adiabatically humidify and cool the incoming air. Heater 64 will supply the heat necessary to compensate this additional coolness. If steady operation of pump 67 produces too much humidification, this pump will operate intermittently as did pump 45 in the discussion of the first variant.

Let us now consider the third variant of my present invention, as exemplified by FIGURES 3 and 7.

Turning to FIGURE 3, we see that it is identical to FIGURE 1, except for the fact that this third variant of mine adds the possibility of recirculation. Dampers 74, 75, and 76, when properly set, provide this recirculation. Thus, when damper 75 is shut, and the other two dampers are wide open, we have no recirculation at all, and the variant now under discussion acts exactly like the first variant. But, when damper 75 is wide open, and the other two dampers are shut, we have 100% recirculation. Normally the present variant will operate with the three dampers so adjusted as to attain some intermediate percentage of recirculation, with make-up air being admitted from outdoors through damper 74, and waste air being discharged through damper 76.

When recirculation is employed, this of course results, depending upon the percentage of recirculation, in more or less preheating and prehumidifying the incoming air, even to the extent of sometimes rendering unnecessary the humidifying of the incoming air by means of humidistate 73, evaporative pad 44 and heat-transferrer 35, as explained under variant 1. A small amount of recirculation can result in greatly reducing the heat and moisture load on the heat-transfer wheel.

Let us now consider the fourth variant of my present invention, as exemplified by FIGURES 4 and 7.

Turning now to FIGURE 4, we see it is identical to FIGURE 1, except that in this present variant heater 64 is located in the outgoing air-stream between evaporative pad 44 and heat-transfer pad 35, instead of being (as in the first and third variants) in the incoming stream between heat-transfer pad 35 and room 39.

The winter operation differs from that of variant 1 as follows: In variant 1, the warm humid air leaving the room is further humidified adiabatically (although still

warmer than the outdoors' air) by evaporative pad 44, under control of humidistat 73; and then a considerable amount of this moisture and heat is transferred to the incoming air by transferrer 35; the balance of the heat required by thermostat 65' being then imparted by heater 64 directly to the incoming stream. Whereas in variant 4, after the outgoing air has been humidified adiabatically by pad 44, under control of humidistat 73, it is then heated under control of thermostat 65', and then transmits the required moisture and heat, via transferrer 35, to the incoming air.

Let us now consider the fifth and final variant of my present invention, which fifth variant is exemplified by FIGURES 5 and 7.

Turning now to FIGURE 5, we see that it is identical to FIGURE 4, except that in this present variant, heater 64, although still in the outgoing rather than the incoming stream, is now located between room 39 and evaporative pad 44, instead of being (as in the fourth variant) between this pad and heat-exchange pad 35; also recirculation is provided.

This location of heater 64 is very useful, as it enables this present variant to share with variants 1 to 3 the advantage that a conventional heating unit can be combined with the thermostat-controlled summer anhydrous cooler of my copending Patent No. 2,499,411 (even placing the two at some distance from each other), by the mere addition of appropriate ducts connecting the two units, and a humidistat, and appropriate controls, either with or without a set of three dampers to permit and control recirculation of some of the exhaust air.

Moreover this present fifth variant has the following further advantage over even variants 1 to 3, namely that the heater can be located in a "heat-closet" on the main floor of a house, the bottom panel of which closet is a set of louvers through which passes all the return air from the house. Many houses are being so constructed nowadays and have their heating unit already located in such a closet, and therefore could easily be converted to my fifth variant.

Consider now this fifth variant with zero recirculation. Its winter operation differs from that of variant 4; merely that the outgoing air is heated before, rather than after, being humidified. Under the same setting of humidistat and thermostat, transferrer 35 should transfer the same amount of moisture and sensible heat in either of these two variants, within their respective capacities. But it should be noted that the fifth variant, by heating the outgoing air before rather than after its passing through evaporative pad 44, enables the outgoing air to pick up, and hence have available for transfer by transferrer 35, more moisture than in the other variants. Thus variant 5 is especially adapted to uses in which a high humidity needs to be maintained in the room.

The discussion of recirculation under the third variant applies equally to this fifth variant.

Many subvariants of the above described five variants are possible without departing from the spirit of my invention.

Having now described the operation of each of variants 2 to 5, largely by pointing out differences between each of my five variants and each other, let us now consider their similarities.

It should by now be evident that I have not merely aggregated a heater for winter use with a cooling device for summer use. For, in the first place, I have inserted a heater in a very special class of summer coolers. And, in the second place, even in that very special class of summer coolers there are only three alternative locations which I consider wholly feasible to place the heater.

As a result, my heat-transfer means which operates with such a high degree of efficiency in summer to transfer heat anhydrously away from the incoming air into the waste air, operates in winter with the same degree of efficiency and without change, and without rerouting of

the air-streams, to transfer heat in the reverse direction, namely from the waste air into the incoming air, and (in all of the variants under certain conditions) to transfer moisture as well. For an anhydrous summer heat-exchanger to become a moisture-exchanger in winter, is quite an invention per se.

Then too, the same thermostat which in summer automatically regulates the cooling of the waste air, and thereby the temperature of the incoming fresh air, and thereby the temperature of the room, in winter automatically regulates the heating of the incoming air, directly in some variants, and in other variants indirectly by heating the waste air, and then transferring this heat to the incoming air.

Furthermore the same summer thermostatic control of the evaporative cooling (but now, in all but one variant, counter-controlled by a humidistat) controls in winter the same evaporative cooling device but, without change, now serving to humidify rather than to cool. This counter-controlling of thermostat by humidistat is another important invention per se.

The net result of all this carefully thought out interaction of an unchanged summer cooler with the minimum of added winter elements, is that my universal air-conditioner operates winter and summer without rerouting of air or other change-over; and especially that it makes possible a nearly 100% recirculation of the heat of the waste air, with little or no recirculation of the waste air itself.

This recirculation of heat without recirculation of air is the meat of my present invention. It renders my invention particularly useful in crowded spaces, such as theaters, restaurants, hospitals, etc., where it provides easy and inexpensive elimination of the problems of odors and germs, which problems arise from too much recirculation of air.

All five of the herein disclosed variants are inherently capable of transferring moisture by means of the heat-transferrer, when necessary to humidify the incoming air.

Having now described five variants of my invention, I wish it to be understood that my invention is not to be limited to the specific forms or arrangements of parts herein described and shown.

What is claimed is:

1. In combination with a device for anhydrously cooling an enclosure, which device includes a first air-passage, for admitting outdoors air to the enclosure, and a distinct second air-passage, for conveying exclusively air exhausted from the enclosure and for discharging the same, and means for impelling air through these two passages respectively, and means for evaporatively cooling the outgoing air in the second passage, and means to supply water to said evaporative means, and mean for anhydrous heat-exchange between the air in the two passages outdoorward of the evaporative means, said heat-change means comprising sectors of air-permeable non-hygroscopic highly heat-absorbent material and means to bring each sector successively into heat-exchange contact with each of the two air-streams; the combination therewith of means for rendering the device universal, so that the device may be used to heat as well as cool the entering air, such means comprising: a heater in one of the two passages indoorward of the heat-exchange means; a thermostat responsive to dry-bulb temperature of air treated by the device; means controlled by said thermostat to turn the heater on in response to air at the thermostat attaining a predetermined minimum dry-bulb temperature, and to turn the heater off in response to said air attaining a predetermined maximum dry-bulb temperature; and means controlled by the thermostat to reduce the supplying of water to the evaporative cooling means in response to the air at the thermostat attaining a predetermined minimum dry-bulb temperature, and to restore the full supplying of water in response to said air attaining a predetermined maximum dry-bulb temperature, the two predetermined minima not necessarily being the same, and the two predetermined maxima not necessarily being the same, means for recirculating a portion of the outgoing air from the outlet passage into the inlet passage, a humidistat responsive to the moisture content of air treated by the device, and means controlled thereby, to increase the supplying of water to the evaporative means in response to the air at the humidistat attaining a predetermined minimum dew-point, and to reduce the supplying of water to the evaporative cooling means in response to said air attaining a predetermined maximum dew-point; and interlocking control means between the thermostat, the humidistat, and the water supply means, for independently increasing the supplying of water in response to high temperature or low humidity, and dependently decreasing the supplying of water in response to low temperature and high humidity.

2. In combination with a device for anhydrously cooling an enclosure, which device includes a first air-passage, for admitting outdoors air to the enclosure, and a distinct second air-passage, for conveying exclusively air exhausted from the enclosure and for discharging the same, and means for impelling air through these two passages respectively, and means for evaporatively cooling the outgoing air in the second passage, and means to supply water to said evaporative means, and means for anhydrous heat-exchange between the air in the two passages outdoorward of the evaporative means, said heat-exchange means comprising sectors of air-permeable non-hygroscopic highly heat-absorbent material and means to bring each sector successively into heat-exchange contact with each of the two air-streams; the combination therewith of means for rendering the device universal, so that the device may be used to heat as well as cool the entering air, such means comprising: a heater in one of the two passages indoorward of the heat-exchange means; a thermostat responsive to dry-bulb temperature of air treated by the device; means controlled by said thermostat to turn the heater on in response to air at the thermostat attaining a predetermined minimum dry-bulb temperature, and to turn the heater off in response to said air attaining a predetermined maximum dry-bulb temperature; and means controlled by the thermostat to reduce the supplying of water to the evaporative cooling means in response to the air at the thermostat attaining a predetermined minimum dry-bulb temperature, and to restore the fully supplying of water in response to said air attaining a predetermined maximum dry-bulb temperature, the two predetermined minima not necessarily being the same, and the two predetermined maxima not necessarily being the same, means to render inoperative the control of the water supply to the evaporative-cooling means by the thermostat, said means comprising a humidistat responsive to the moisture content of air treated by the device, and means controlled thereby, to increase the supplying of water to the evaporative cooling means in response to the air at the humidistat attaining a predetermined minimum dew-point, and to reduce the supplying of water to the evaporative cooling means in response to said air attaining a predetermined maximum dew-point; and interlocking control means between the thermostat, the humidistat, and the water supply means, for independently increasing the supplying of water in response to high temperature or low humidity, and dependently decreasing the supplying of water in response to low temperature and high humidity; and further characterized by the fact that there is means for recirculating a portion of the outgoing air from the outlet passage into the first passage.

3. An air-conditioning device according to claim 2, further characterized by the fact that the heater is in the second passage.

4. An air-conditioning device according to claim 3, further characterized by the fact that the heater is in the

second passage, upstream from the evaporative cooling means.

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