

July 10, 1962

E. F. CHANDLER

3,043,573

THERMO-TRANSPARATION PORTABLE AIR CONDITIONER UNIT

Filed Feb. 16, 1956

2 Sheets-Sheet 1



Fig. 1

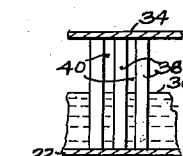


Fig. 3

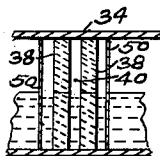


Fig. 4

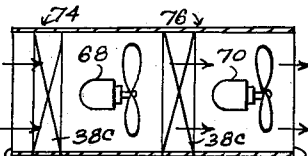


Fig. 9

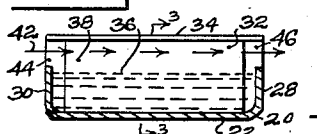


Fig. 2

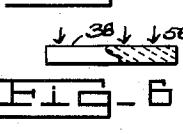


Fig. 6

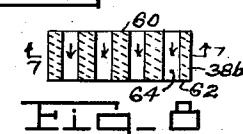


Fig. 8

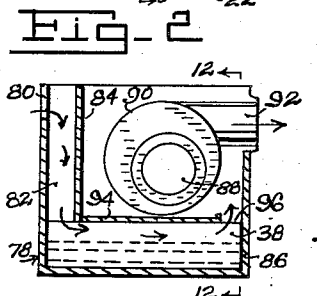


Fig. 11



Fig. 5

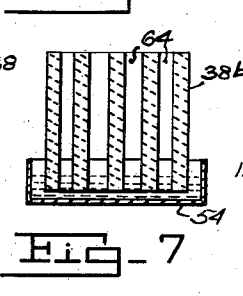


Fig. 7

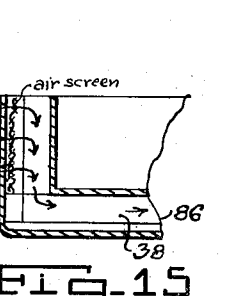


Fig. 15

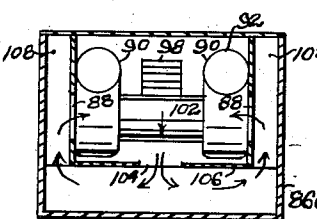


Fig. 14

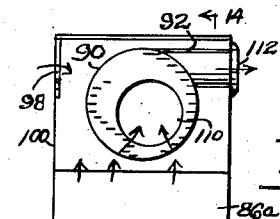


Fig. 13

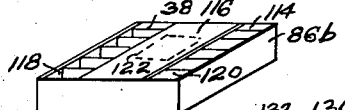


Fig. 10

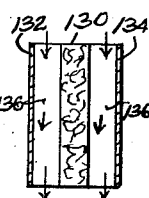


Fig. 16

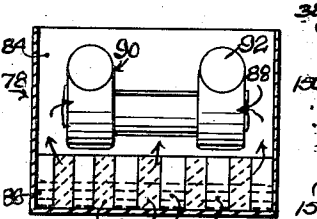


Fig. 12

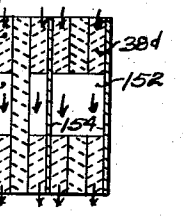


Fig. 18

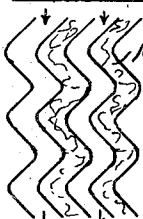


Fig. 19

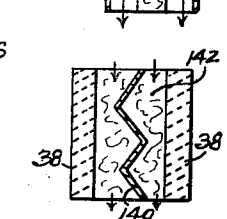


Fig. 17

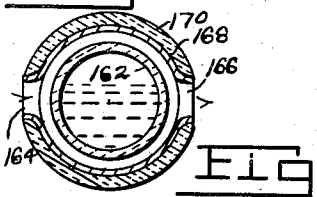


Fig. 21

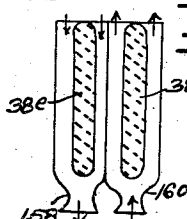


Fig. 20

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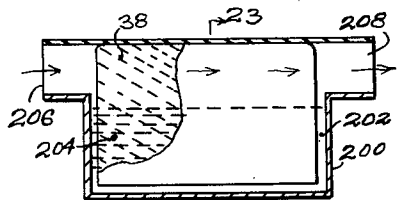


Fig. 22

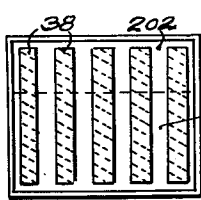


Fig. 23

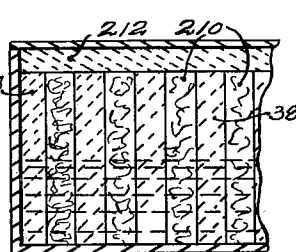


Fig. 24

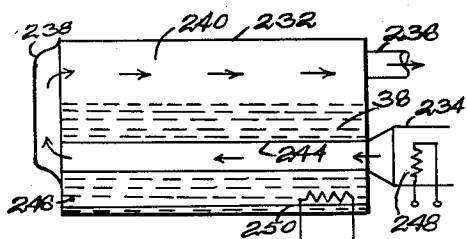


Fig. 27

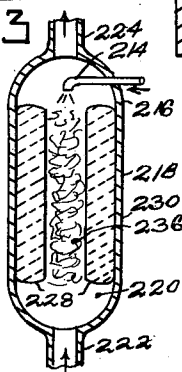


Fig. 26

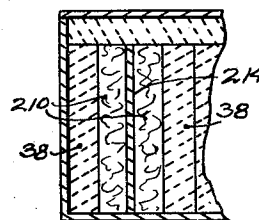


Fig. 25

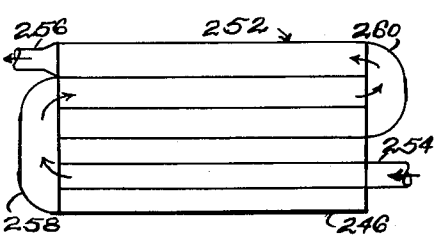


Fig. 28

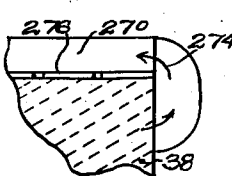


Fig. 30

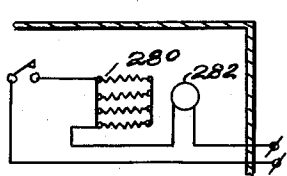


Fig. 29

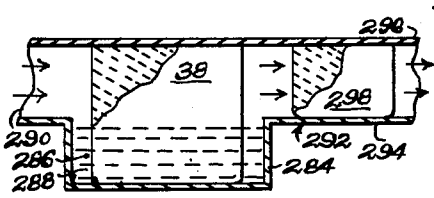


Fig. 31

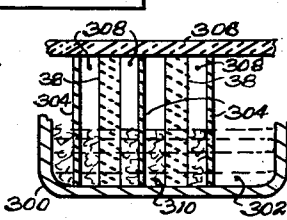


Fig. 33

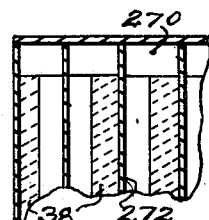


Fig. 32

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THERMO-TRANSPARATION PORTABLE AIR CONDITIONER UNIT

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2 Claims. (Cl. 261—24)

This invention relates to improvements in air conditioning devices.

An object of the invention is to provide a novel and improved device in compact portable form, for heating, cooling, and tempering air for conditioning purposes.

Another object of the invention is to provide a novel and improved device for heating, cooling and tempering air by thermo-transpiration means.

A further object of the invention is to provide a novel and improved air conditioning device in small compact, and readily portable form, to afford bodily comfort locally as needed, reducing or increasing the temperature of the air brought into contact with the body of the user, and otherwise altering the humidity thereof.

Still another object of the invention is to provide a novel and improved air conditioning device in which air is caused to move into contact with a large surface wetted by a fluid such as water, within a small chamber, so that the air is readily and efficiently humidified as desired.

Another object of the invention is to provide a novel and improved air conditioning device in which a high degree of efficiency is achieved without need for large air impelling fans or the like, so that the unit is readily compacted to a large extent for easy portability.

A further object of the invention is to provide a novel heat exchange and air conditioning device in which the air to be conditioned is caused to move along in contact with porous bodies immersed at least partially in water, to provide humidifying contact with the moving air stream, with novel outer coating of the porous bodies to prevent droplet formation thereon which might otherwise hinder humidification with efficiency.

Another object of the invention is to provide a novel and improved device of the character described, which is simple in design, uses few parts, is effective in use for its intended purposes, and highly rugged and long lived.

These and other objects and advantages of the invention will become apparent from the following description of a preferred embodiment thereof, as illustrated in the accompanying drawings, forming a part hereof, and in which:

FIGURE 1 is a top plan view of a device according to the invention.

FIGURE 2 is a sectional elevational view taken substantially on plane 2—2 of FIGURE 1.

FIGURE 3 is a schematic end figure view of a portion of the element shown in FIGURES 1 and 2.

FIGURE 4 is a schematic end view similar to that of FIGURE 3, but showing a modified form of the invention.

FIGURE 5 is a sectional elevational view of a device in which air to be cooled is caused to pass through a sheet of moisture absorbing material.

FIGURE 6 is a top plan detail view of the element of FIGURE 5.

FIGURE 7 is an end elevational view of the device shown in FIGURE 5, according to a modified form, with increased thickness providing increased surface area effectiveness.

FIGURE 8 is a top plan view of the element shown in FIGURE 7.

FIGURE 9 is a schematic elevational view showing a two phase cooling system and device, with successive steps of cooling sequences.

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FIGURE 10 is a perspective view showing a complete cooling and/or conditioning element as a removable and replaceable unit for use in the devices shown.

FIGURE 11 is a sectional elevational schematic view showing a modified form of unit with blower and evaporators in a housing.

FIGURE 12 is a transverse sectional elevational view taken substantially on plane 12—12 of FIGURE 11.

FIGURE 13 is a sectional elevational schematic view showing another modified form of housing with blower and evaporator unit therein.

FIGURE 14 is a transverse sectional elevational view taken substantially on plane 14—14 of FIGURE 13.

FIGURE 15 is a fragmentary sectional elevational view similar to that of FIGURE 11, but showing a modified form with filtering screen in the air path.

FIGURE 16 is a fragmentary sectional elevational view showing a modified form of construction for use in the device.

FIGURE 17 is a fragmentary sectional elevational view showing another modified form of construction.

FIGURE 18 is a fragmentary sectional elevational view showing a further modified form of construction of element.

FIGURE 19 is a fragmentary sectional elevational view showing still another modified form, with undulational arrangement for increased contact effectiveness.

FIGURE 20 is a fragmentary sectional elevational view of means for increasing the velocity of the air stream and controlling same before and after passing the evaporator elements.

FIGURE 21 is a sectional elevational view showing a closed vessel of ceramic material with cooling paths.

FIGURE 22 is a schematic side elevational view of a complete air treating unit indicating the air path, the view being partly broken out.

FIGURE 23 is a transverse sectional elevational view taken substantially on plane 23 of FIGURE 22.

FIGURE 24 is a sectional elevational view similar to FIGURE 22, but with further modified structure.

FIGURE 25 is a sectional elevational view showing another modified structure.

FIGURE 26 is a sectional elevational view showing another form of air treating unit and casing.

FIGURE 27 is a schematic sectional view showing another type of air conditioning unit, including heating element.

FIGURE 28 is a schematic view showing still another form of conditioning unit.

FIGURE 29 is a schematic sectional elevational view of a corner of a housing, with electric heating means therein.

FIGURE 30 is a fragmentary sectional elevational view showing a corner of a modified form of structure according to the invention.

FIGURE 31 is a schematic sectional elevational view showing a dual stage wet and dry air conditioning unit with air paths indicated.

FIGURE 32 is a schematic sectional elevational view showing another modification of the device.

FIGURE 33 is a sectional fragmentary elevational view showing a further modified form of the device.

This application is a continuation in-part of my co-pending patent application, Serial Number 436,834, filed June 15, 1954, for Air Conditioning Unit, pending at the time of filing of this application, and now abandoned.

In order to understand clearly the nature of the invention, and the best means for carrying it out, reference may now be had to the drawings, in which like numerals denote similar parts throughout the several views.

In FIGURES 1 and 2, it is seen that there is a closed chamber or housing 20, with a floor 22, and upstanding

side and end walls 24, 26, 28 and 30, defining the chamber 32, a cover 34 being shown in position in FIGURE 2, but removed in FIGURE 1. Inside the chamber, there is a liquid fluid, such as water 36, partially filling the chamber, and a number of elements 38 are disposed in spaced upright positions within the chamber, so as to define elongated narrow passageways 40 between adjacent evaporator and conditioning elements 38, for the passage of air in the direction of the arrows 42. Openings 44 and 46 are formed in the end walls 28 and 30, to allow entry and outlet of the air as indicated, for treatment in the chamber. The elements 38 are relatively narrow, closely spaced, composed of suitable moisture absorbing surface evaporator elements, such as unglazed porcelain or tile or clay, or other types of materials adverted to and further explained hereinbelow as the specification proceeds. As seen, the air is divided into a plurality of ribbons as it passes between each two active evaporator surfaces 38, on its way from the inlet opening 44 to the outlet 46 of the chamber. In this way, the air is caused to contact an extended surface area of the elements 38 under ideal heat-exchange conditions. The effectiveness of the element may be further improved by positioning a suitable spacer between the evaporator members, such as glasswool, for example, which does not seriously impede the passage of air, but does tend to increase the scrubbing action, and also causing free moisture to be removed from the air and returned to the fluid supply 36 in which the elements 38 are partially immersed. FIGURE 3 shows in section how the elements stand in the liquid.

FIGURE 4 shows a modified form of the device, in which there are a pair of similar elements 38 positioned between two preferably thin plates or walls 50 and spaced therefrom, the plates 50 being for example of metal or other material and adapted to be positioned as shown, and, when cooled by the evaporative action, to accumulate thereon surplus moisture extracted from the air stream.

FIGURES 5 and 6 show a common arrangement of the elements, apart from the outer container or housing for clarity, there being a pan 54 for the reception of fluid like 36, with a number of or one such element 38 standing upright in the pan and partly immersed in the liquid. As indicated in FIGURE 6, the air is caused to pass through the element 38 in the direction of the arrows 56, the element 38 being a sheet of moisture-absorbing material which allows the air to pass therethrough readily, cooling the air. As seen in FIGURES 7 and 8, by modifying the element as at 38b, increasing the spacing between its walls surfaces 60 and 62, in the manner of FIGURE 8, and then forming thin passages 64 therethrough, the air passing through in the direction of the arrows in FIGURE 8, is much more effectively treated, more surface area being present, and the air being in contact much longer in passage, with the element.

FIGURE 9 shows schematically how my system is applied to a two phase cooling operation, whereby it is possible to reduce the temperature of relatively hot air, in a plurality of steps, to a desired lower temperature. As shown in the view, there is a housing 66, with a suitable blower or suction fan as at 68 and 70 for each stage, the cooling and treating elements being indicated at 38 in any one of the suitable forms shown herein, so that the fans draw the air through in at 69 the direction of the arrows for cooling as desired and then discharge it at the right side outlet 72. Also a single fan means may be employed to cause the air to pass through a series of such staged, temperature reduction steps. For example, by this means, air at 150 degrees F., may be reduced about 50 degrees in the first stage 74, and from about 100 degrees to a desired lower temperature in the next stage 76 or succeeding stages.

FIGURES 11 and 12 show one possible form of air circulating unit with housing 78, in which warm air is drawn in at 80, passes through vertical riser 82 behind wall 84 in the direction of the arrows downwardly,

through the spaced evaporator elements 38 immersed in the liquid 36 in the pan portion 86, and then upwardly being drawn into the opening 88 in the fans 90, and ultimately discharged by the centrifugal blowers 90 out of outlet ducts 92. A wall 94 has an opening 96 to allow air flow.

In FIGURES 13 and 14 another modified form is shown, with a change in the direction of air flow. In this form, the air enters as at 98 which is the air inlet opening in wall 100, and then flows in the direction of arrows 102 vertically downwards through opening 104 in the floor 106, then through the spaces 106 between the cooling elements 38 in the pan portion 86a, the air dividing and going right and left as seen in FIGURE 14, and up through the hollow passages 108, and being suctioned in through fan intakes 110 and discharged at 112.

FIGURE 10 shows a removable construction of a pan 86b, which may be inserted in the units shown, and removed as needed, this unit containing a chamber 114 in which are disposed the spaced elements 38, with a top partial wall 116 forming air inlet and outlet openings 118 and 120, to permit the air to flow into and between the elements 38, and then out again, the pan having a bottom and four side walls to enclose the same. For use as the unit of FIGURE 14, the top wall 116 may have an opening as at 122 formed therein also with removable cover.

FIGURE 15 shows a modified form of the housings of the various views, such as FIGURES 11 and 14, with an air screen or filter wall 124 to screen and filter the incoming air. Preferably the said filter 124 may be of water repellent material rather than absorptive material, and adapted to return to the pan 86, any trapped moisture from the air.

FIGURE 16 shows a wick or other suitable absorbing agent 130 disposed between thin metallic plates 132 and 134 so that the air passing through the interspaces 136 is in contact with the two metallic surfaces 132 and 134 for precipitating contained moisture from the air while also in contact with 130.

In FIGURE 17, the thin plate 140 which may be of metal is shown formed to cause the air to follow other than a straight path between the evaporator elements 38 in moving in the direction of the arrows shown. This action can be further increased by placing within the space between the evaporators 38, a suitable filler, such as glass wool, or the like, as at 142.

In FIGURE 18 is shown two cases in which air being drawn in through the element shown, in the direction of the arrows enters a free space, as at 150 or 152, where it may expand before passing through the next portion of the evaporator element 38d, a set of metal wall dividers shown at 154.

FIGURE 19 shows an undulating formation of the air passages between the evaporator wicks 156 to increase the surface contact and enhance efficiency.

In FIGURE 20 is shown means for increasing the velocity of the air after it has passed over the evaporator agents 38e with the nozzle 158 at the outlet of the passage, and using the nozzle 160 to increase the air velocity before passing the evaporator agents at the right.

FIGURE 21 shows a closed vessel 162 of ceramic material, for example adapted to contain water to be evaporated on its outer surface. To cause the air to pass in contact with the said outer surface from inlet 164 to outlet 166, a shield 168 is formed with such inlet and outlets for the air stream. Preferably the shield 168 is of a material to be readily cooled by the evaporative action as the air moves at high velocity over the said surface, and it may be of ceramic material or of metal, possibly also aluminum. A suitable insulating material 170 may be used to reduce absorption of external heat from outside. A closed ceramic chamber is shown in my original patent application mentioned above. This means is effective as a cooling element and, being closed, tends to con-

serve the water stored therein, same being out of direct contact with the atmosphere, etc.

An interesting feature of this invention is its highly efficient functioning, being as it is a non-mechanical means. Heretofore, to accomplish a reasonable amount of cooling, relatively large equipment has been required, including pumping means for spraying or otherwise distributing water over the absorptive surfaces. With my thermo-transpiration element, there is nothing to get out of order. It is self contained and if, after extended usage, it should be necessary to replace same, it is easily removed and a new element substituted. By my method, the air passing through the element is not only reduced in temperature, but also there is a degree of humidity control whereby the usual objection, of excessive moisture, is overcome.

FIGURES 22 and 23 show another form of the invention, with a housing 200 defining a chamber 202 inside which the porous elements 38 are disposed and partially immersed in water 204 as explained already. There are inlet and outlet openings 206 and 208 to allow air to enter and leave, flowing between the spaced elements 38 as shown. Here there is a plurality of closely spaced porous elements 38 so positioned as to cause a stream of air to be laminated as it passes therebetween for the purpose of causing said air to contact an extended, active surface area exposed by the elements 38. The elements 38 have a wick-like character in that they are adapted to absorb a fluid, water, for example, with which they are in partial contact, and present a moist exterior surface from which said moisture evaporates. These elements 38 may be constructed of any material suitable for the purpose, as for example, a ceramic material, cotton or other fabric, formed as a wick, a porous metallic substance, just so long as the element serves to provide a relatively uniform evaporative film upon the surfaces over which the relatively thin air lamina passes. In FIGURE 22 is shown the complete air treating unit in side elevation, the air passing through the upper section and above the surface of the liquid 204 into which the lower portion of the elements 38 is shown submerged, as one means of supplying fluid thereto, as by wick action.

In FIGURE 24 the construction is similar to that of FIGURES 22 and 23, except that between the evaporator elements 38, to increase molecular diffusion within these transitional zones, means are provided for setting up eddy or mixing currents within the moving air laminae. For this purpose any suitable means or material may be employed which, while accomplishing the desired end, does not seriously impede the air flow. For example, metallic wool, fiber glass wool, a specially formed thin metallic baffle member, etc., may be employed, as at 210. In this view, the air channels are shown as closed at the top by a plate 212 which may be of the same material as that of the evaporator elements 38, the same serving to increase somewhat the effective surface area exposed to the air and hence the overall effectiveness of the device.

In FIGURE 25, for example, a thin metallic separator wall 214, of aluminum for example, is so positioned as to cause each air laminae to pass in two thin streams through each evaporator zone, the cooling effect of the evaporative action tending to reduce the temperature of the metallic separator. The reduction in temperature causes some of the moisture in the air to condense upon the metallic surface and be retained within the air treating unit.

FIGURE 26 shows schematically an air treating unit wherein the fluid to be evaporated is fed contra-flow by means of nozzle 214 extending through the wall 216 of the housing 218, which has a chamber 220 extending therethrough. The air stream enters through the lower inlet 222 and leaves through the outlet 224, the housing being shown in this form to be generally cylindrical although other shapes may be used for special purposes. Here the fluid to be evaporated is fed contra-flow to the air stream to a diffusing mass or core 226 of fibre-glass,

glass wool, or other similar characteristic material not impeding air flow, and positioned between the two evaporator or wick elements 228 which may be similar to the elements 38 shown in other views herein, which absorb moisture which in turn is evaporated from their surfaces, said evaporation being accelerated by the air current. In this unit, not only is the temperature of the air reduced but the outer wall of the unit, as at 230 is cooled. This view may also represent the section of a well of a cylindrical chambered vessel the interior of which is to be cooled, in which case the evaporating means shown would surround the interior chamber 220. That is to say, would line the chamber 220, giving it a double wall.

In FIGURE 27 there is shown a housing 232 with air inlet at 234 and discharge outlet at 236, a connecting duct being shown at 238. In this construction, the air stream passes through the evaporator element 38 as already explained, as in FIGURE 22, and then through duct 238, and returns to the right through second channel 240 as indicated and flows out outlet 236. This second channel 240 may contain means for further treating the air and may have thus a further cooling means, as in FIGURES 25, 30 or 32, for example. It should be noted that the entering air from inlet 234 passes through a tube positioned as at 244 in the fluid supply chamber or pan 246, whereby the temperature of the fluid may be increased by the entering warm air. To increase this effect, where desired, or required, the air may be preheated by any suitable means, as by the electric heater element 248 in the air stream. Or on the other hand, the fluid may be heated by the electric heater element 250 immersed in the pan 246.

In FIGURE 28, another modification is shown, this being a housing 252 with air inlet at 254 and outlet at 256, with end conduits 258 and 260 connecting the sequential passages as shown by the arrows. The operating description for FIGURE 27 also applies to FIGURE 28. The operation of the FIGURE 28 construction is merely that the warmed air passes through the evaporator element, as shown, the added warmth of the air accelerating the evaporative effect in a well known manner.

FIGURE 32 is a schematic end view of a cooling chamber means 270 above the evaporator system already described, with evaporator elements 38 and walls 272 located as shown. In this case, the metal separating plates 272 projecting upwardly provide a plurality of elongated channels, cooled by the transmitted evaporative effect, through which the air must pass, the degree of cooling affected and other conditions, ambient humidity, etc., causing condensation within these channels and thereby modifying the character of the delivered air as desired.

In FIGURE 30, which is oriented on FIGURE 32, there is shown the air after passing through the evaporative zone past the elements 38 in the direction of the arrows 274, entering the cooling chamber 270, where some moisture may be condensed and returned, through suitable perforations in wall 276, and to the fluid source.

FIGURE 29 shows a portion of the housing of any of units described, indicated by the walls shown, whereby, through the resistance heating elements 280 and the wires to the power supply, a thermostatic switch 282 may be in the circuit, so that excessive or dangerous overheating may be avoided by shutting off the circuit automatically on reaching a predetermined temperature.

In these devices as described, it is seen that the principle is employed wherein the air is caused to flow in a plurality of thin streams between a plurality of spaces between evaporative elements, thereby doubling the effective area to which the laminated streams of air are exposed.

FIGURE 31 shows another modified form of the device, in which there is a housing with a pan at 284 containing a chamber 286 with water or the like 288 therein, and one or more elements 38 immersed partially therein

with their upper portions in the path of the air stream shown by the arrows in the view, from inlet 290. At the same time, there is a raised portion 292 of the housing, to the right of the pan 284, which has no pan per se, the floor 294 thereof being elevated above that of the pan, and thus there is liquid in the pan 284, but no fluid in the raised portion 292. By disposing the major evaporating elements 38 in the pan section 284, with their lower portions immersed in the water, the air first is cooled by passing between the elements 38 and then passes on to the right toward the outlet end 296, and there are a number of similar air laminating elements 298 disposed in the housing 292 and resting on the dry floor 294. The elements 288 are similar to those at 38, but are shorter and remain dry for lack of immersion in the liquid. If the entering air has a high moisture content, the evaporative cooling effect at 38 is lowered and slightly cooled air leaving 38 will be moist. An object of the means shown at 298 is to reduce the moisture content of the air finally leaving 298 while at the same time increasing the cooling effect so as to show a marked temperature reduction between the entering air at 290 and that leaving at 296. In theory, moisture carried by the air leaving the elements 38 will be partially absorbed by the dry elements 298, thereby first reducing the moisture content thereof and secondly, setting up a secondary evaporative cooling effect as the moving air stream causes the absorbed moisture to be evaporated from the adjacent surfaces of the elements 298. Thus it not only partially de-humidifies the original moist entering air, but also reduces the temperature thereof beyond that which may be expected when said air is treated as usual by passing same only through a conventional evaporative air cooling step. Any excess moisture accumulating at 298 may drain into the pan 284 by sloping the bottom wall 294 thereto.

FIGURE 33 shows another modified form of the invention in which there is a pan 300 containing water 302, and having a number of spaced elements 38 standing partially therein. At the same time, there are a number of metal plates or thin walls 304 also standing in the water and up to the roof member 306 which roof may be of the same material as members 38. The plates are of metal, aluminum sheet, and are spaced from the elements 38 to define air passageways 308 between them and the elements 38 for the air to be cooled to flow through at right angles to the plane of the drawing, for the cooling effect mentioned. The plates 304 may also be made of porous metals or alloys made by a process such as powder metallurgy, sintering, pressing, and the like well known in the art of metal making, giving wick action and high evaporative rate.

Although I have described my invention in specific terms, it will be understood that various changes may be made in size, shape, materials and arrangement without departing from the spirit and scope of the invention as claimed.

In a relatively small portable unit, the blower capacity may range from about 150 to about 250 cubic feet per minute. It is important that with as little resistance as possible to the passage of the air through the cooling element, said air make contact with maximum evaporative surface during said passage. An important feature of my device resides in the method whereby an air stream is laminated by being caused to pass between a plurality of relatively parallel evaporative-active surfaces, the evaporator elements preferably being so spaced as to accommodate the volume of air in transit. For example, it has been found that porous ceramic plates of approximately $\frac{1}{8}$ inch in thickness, spaced about $\frac{1}{8}$ inch apart, assembled so as to afford a plurality of air passages there-

between to accommodate the volume of air produces a reduction in the ambient air temperature, as for example, of about five degrees F. more or less, in a room air temperature of 75 degrees Fahrenheit, to provide a cooling effect not obtainable by an electric fan which only re-circulates the ambient air.

Elements of ceramic, clay and such materials as well as cellulose sponge, cotton wicking, glass wool, and the like, capable of absorbing water to be evaporated from a surface film, have been found useful. The material may be relatively rigid and self supporting or same may be mounted to maintain its form and rigidity as for example by stapling or otherwise securing same to an aluminum wire screening fabric or by other suitable means. Relatively fine porosity at the evaporative surface is desirable so long as the wick-action is sufficient to maintain the desired surface moisture characteristics. By laminating the air stream, I provide a large surface within a confined space, keep the air in contact therewith longer, and offer less resistance to air flow, for a given optimum end result. Use may also be made of ram-air action, as when in a moving vehicle, as mentioned for FIGURE 20 and other views.

I claim:

1. In an evaporative type air cooler: a housing defining a closed chamber and having an air inlet opening and an air outlet opening; means for drawing air into the housing through the inlet opening and discharging the air through the outlet opening; a plurality of closely spaced moisture absorbent plate elements fixedly positioned within the chamber, the plate elements defining passages for the body of air moving from the inlet opening to the outlet opening; a supply of water within the chamber; capillary action means for delivering water from said supply to the plate element surfaces; and means positioned in the spaces between the moisture absorbent plate elements for absorbing and dissipating heat, said means including thin metal plates of high thermal conductivity.

2. An air cooling device comprising a housing defining a closed chamber and having an air inlet opening and an air outlet opening; a plurality of spaced moisture absorbing members fixedly positioned within said chamber between the inlet and outlet opening; a thin metallic plate element positioned between each two spaced moisture absorbing members thereby forming a plurality of restricted channels between the absorbing members and the metallic elements; means supplying moisture by capillary action to the moisture absorbing members to be evaporated from the surfaces thereof, said means comprising a supply of water which is in contact with the lower portion of said moisture absorbing members and said metallic plate elements; and means for directing air into the inlet opening to pass through said channels and from the chamber through the outlet opening.

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