Aug. 24, 1937. J. H. O'BRIEN 2,090,875

AIR CONDITIONING APPARATUS

Filed July 7, 1933 3 Sheets-Sheet 1

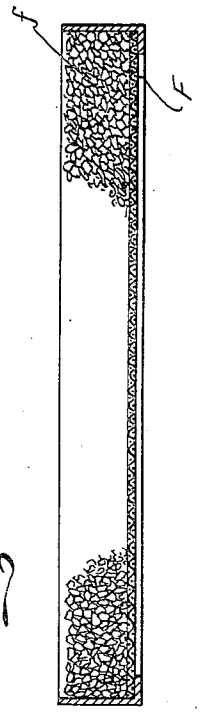

Fig. 3.

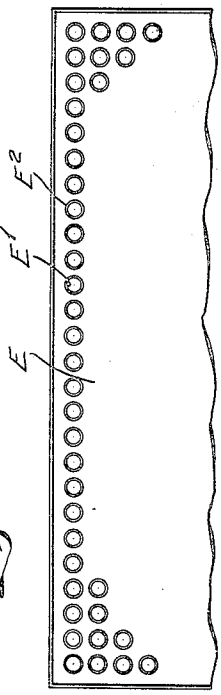

Fig. 4.

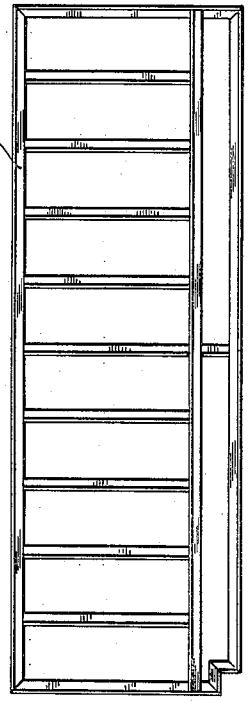

Fig. 5.

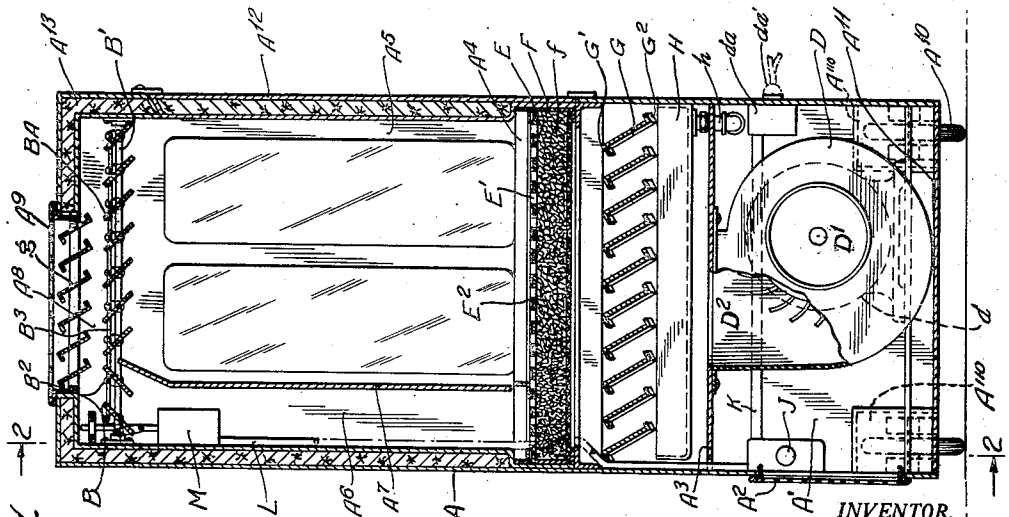

Fig. 1.

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AIR CONDITIONING APPARATUS

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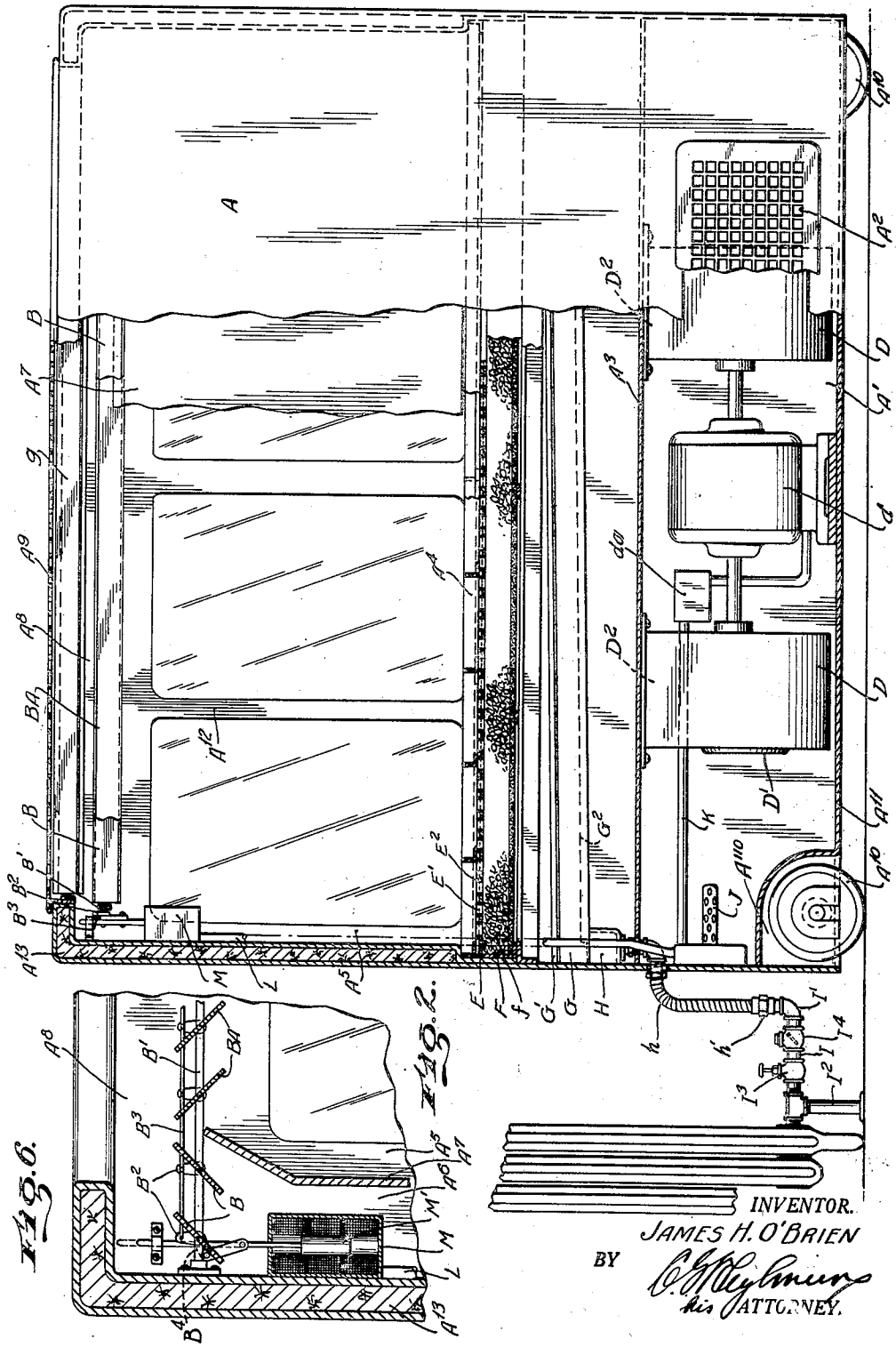

FIG. 2.

FIG. 6.

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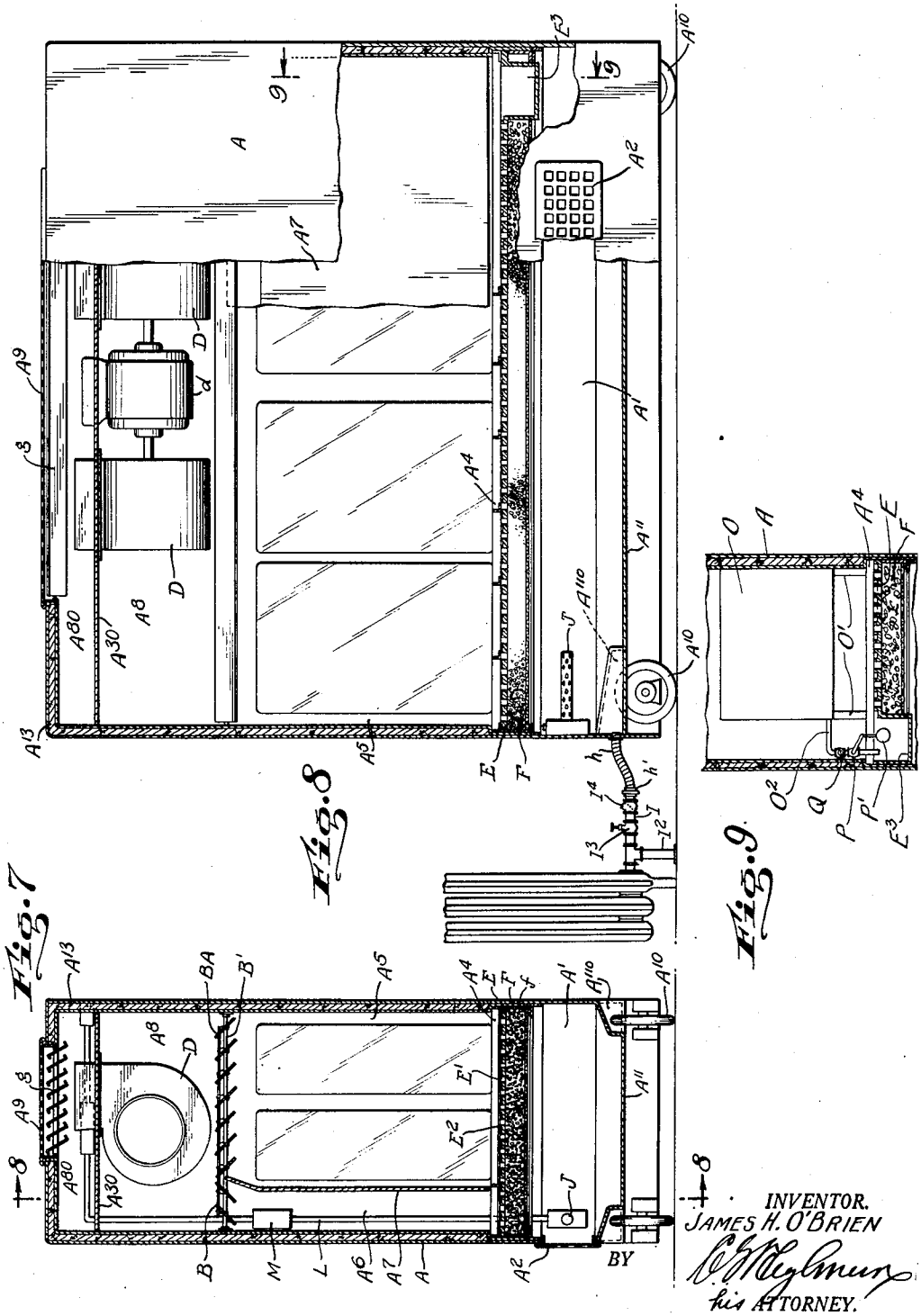

Patented Aug. 24, 1937

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UNITED STATES PATENT OFFICE

2,090,875

AIR CONDITIONING APPARATUS

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Application July 7, 1933, Serial No. 679,294

10 Claims. (Cl. 62—133)

The general object of the present invention is to provide improved apparatus for conditioning air, and in its preferred form my improved apparatus comprises an air cooling unit primarily devised and especially adapted for use in cooling the air in the room of a dwelling house or apartment by causing a circulation of the room atmosphere through a refrigerant compartment especially devised and adapted to receive a refrigerant in the form of blocks of ice. While the general features of the invention are adapted for use in air cooling units or structures permanently arranged in fixed position, a specific object of the invention is to provide a simple and effective portable air cooling unit which is adapted for use first in one and then in another of the rooms of a dwelling house or apartment as conditions make desirable, and which may readily be moved back and forth between the place or places of use and a convenient place for charging the unit with ice.

More specific objects of the present invention are to provide apparatus of the character described by its mechanical simplicity and by its comparatively small required bulk for a given cooling effect with exposure of the air to the ice surface ample in extent to cool the air below the dew point, and for the reheating of the air before delivery from the apparatus to a temperature above the dew point. Further specific objects of the invention having to do with the operation of the apparatus are the avoidance of operating noise and the avoidance of any necessity for a cold-water tank and water circulating pump commonly provided in previously proposed air cooling apparatus; provision of simple and effective means for regulating the temperature at which the air is delivered with a corresponding saving in ice at times when less than the maximum cooling effect is required; provisions for effectively utilizing the heat absorbing capacity of the water formed from the melting ice in precooling the air passing into direct contact with the ice; provisions for cleansing the air as an incident of the air cooling operation and for the continuous drainage from the apparatus of the water formed from the melting ice along with condensate formed from the air conditioned and the dirt or foreign matter eliminated from the air in passing through the apparatus whereby the latter is kept clean and free from odors; and provisions for preventing external condensation on and drip from the apparatus. A further object of the invention is to provide a unit especially adapted for cooling air but also adapted with no change except for the incorporation in its ice space of humidifying means, for use during the heating season in humidifying the air in a dwelling house or apartment.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming part of this specification. For a better understanding of the invention, however, and specific objects and advantages attained with it, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described preferred embodiments of the invention.

Of the drawings:

Fig. 1 is an end elevation of an air conditioning unit with its front end wall removed to show its interior construction;

Fig. 2 is a side elevation in section on the broken line 2—2 of Fig. 1;

Fig. 3 is a sectional elevation of an air scrubbing and cooling unit, the section being taken on the line 3—3 of Fig. 2;

Fig. 4 is a partial plan showing a portion of a water distributing element;

Fig. 5 is a plan view of the ice supporting frame;

Fig. 6 is a partial elevation taken similarly to Fig. 1, but on a larger scale, illustrating details of the damper adjusting means included in the apparatus of Figs. 1 and 2;

Figs. 7 and 8 are views similar to Figs. 1 and 2, respectively illustrating a modified form of air conditioning unit; and

Fig. 9 is a partial section on line 9—9 of Fig. 8 illustrating humidifying means which may be used under some conditions with either form of air conditioning unit illustrated.

The air conditioning unit in the form shown in Figs. 1–6 of the drawings, comprises a housing A of generally rectangular outline. The whole lower portion of the housing interior forms an air inlet chamber A' receiving room air to be conditioned through an inlet opening shown as formed in the lower front wall of the housing and across which a suitable screen or grill A^2 extends. From the inlet chamber A' the air to be conditioned is passed upward as hereinafter described, through the portion of the housing between the partition A^3 forming the top wall of the chamber A' and a superposed ice supporting frame A^4 located some distance above the partition A^3. The frame A^4 is in the form of a grid and is located at the bottom of the ice receiving chamber A^5 and an air passage A^6 which

forms a by-pass about the ice chamber A^5 and is separated from the latter by a vertically disposed partition A^7. Above the chambers A^5 and A^6 is an air mixing chamber A^8 from which the conditioned air passes out of the apparatus through an outlet in the top wall of the latter across which extends a grill A^9. The relative amounts of air passing through the chambers A^5 and A^6 and mixing in the chamber A^6 are determined by the adjustment of a damper mechanism hereinafter described and shown as including louvre damper blades B and BA.

As shown the housing A is made portable by providing it with supporting wheels A^{10}. The bottom wall A^{11} of the chamber A' is located somewhat above the floor level and prevents the passage of flow of dust into the chamber A', and, as shown, is recessed at A^{110} to provide clearance for the wheels A^{10}. At the side of the ice chamber A^5 opposite the partition A^7, the housing A is provided with a section A^{12} readily removable to permit the insertion of ice. Preferably the removable section A^{12} extends downward far enough to permit the ready removal and reinsertion of the hereinafter described scrubbing tray F.

The housing wall may be made in various ways and of various materials and the general details of its construction form no part of the present invention. It is noted, however, that ordinarily I contemplate the formation of the housing with a metallic framework and walls of suitable strength and rigidity. While heat radiation losses from the housing wall are of relatively small direct importance, I regard it as practically important to provide the upper portion of the housing with a heat insulating jacket or cover A^{13} effective to prevent water from condensing out of the surrounding atmosphere onto the housing with a resultant risk of injurious or annoying water drip from the housing.

The size and air conditioning capacity of the apparatus enclosed by the housing A obviously may vary in accordance with the conditions of use. In general, I consider it desirable to proportion the ice receiving chamber A with reference to a standard size of artificial ice cakes which may be split up to form the ice blocks of a size and form permitting them to be so spaced in the chamber A^5 as to provide suitable passage for upflow of air in contact with all four vertical sides of each block. Ordinarily artificial ice cakes are initially 11 inches thick, 22 inches wide and either 44 or 54 inches long. While as before indicated, the housing dimensions may vary widely with conditions of use, I note, for purposes of illustration, and not by way of limitation, that aparatus of the particular form shown in the drawings and intended for use in conditioning the air in ordinary dwelling rooms, may well have an ice chamber relatively proportioned generally as shown and having its longer horizontal dimension either four feet and two inches or five feet, depending on whether intended for use with ice cakes of the larger or of the smaller standard size mentioned above.

To move the air to be conditioned in suitable volume through the housing, I employ one or more circulating fans D. In the particular form of construction shown in Figs. 1 and 2 of the drawings, there are two fans D each having its rotor directly connected to the armature shaft of a driving motor *d*, and all located within the inlet chamber A'. The casing of each fan is formed with a central inlet opening D' at one or preferably at both of its sides. The outlet D^2 of each casing, which is shown as of the usual involute form, extends upward and opens to the space above the partition A^3 through a corresponding aperture in the latter. As shown a motor starter box *da* is attached to the rear wall of the housing, and is provided with a socket part *da'* for the attachment of cord conductors, not shown, which may be employed to energize the apparatus from any available outlet.

As shown a water distributor E, a scrubber F and a water eliminator G are located in the space between the partition A^3 and the ice supporting frame A^4, the scrubber F being above the eliminator G and below the distributor E. The distributor E is advantageously in the form of a horizontal metal plate formed with a multiplicity of apertures E' surrounded each by a horizontal uprising flange E^2 so that water dripping down from the ice chamber and not falling directly through the apertures E', will collect on the upper side of the distributor and flow in film form over flanges E^2 and thence downwardly through the apertures E' over the entire surface in a direction counter to the upflow of air through said apertures.

The scrubber F is shown as comprising a shallow tray or box open at its top and having a perforated or screen bottom and filled with suitable water distributing material *f*. The material *f* may advantageously be iron oxide, aluminum oxide, quartz or other material insoluble in water and presenting a rough surface when broken up into suitable small pieces, and preferably having a fine porous structure. The material may advantageously be broken up so that most of the particles are just small enough to pass through a screen of one-quarter inch mesh. The scrubber F forms a porous screen in passing through which the ascending air and the descending water are brought into intimate contact so that the water will give up practically all of its available heat to the air passing through the scrubber which thus serves as an efficient pre-cooler for the air.

The water eliminator G serves to collect all of the water dripping down through the perforated bottom of the scrubber F. As shown the eliminator G is formed by a series of inclined bars or plates extending from one end to the other of the housing and inclined to the horizontal so that adjacent water deflecting bars overlap. As shown, each bar or plate is formed with a downturned flange G' at its upper edge and with an upturned flange G^2 at its lower edge. Each flange G^2 with the body of the plate from which it projects, forms a gutter leading to a water collecting trough H at one end of the housing. To insure the proper flow through said gutters, the individual bars of the eliminator G are all longitudinally inclined to the horizontal and have their lower ends above the trough H, the flanges G^2 being cut away above the trough H to facilitate the discharge of water into the latter. A drainage pipe *h* leads downward from the trough H to some suitable receptacle or conduit receiving the drainage.

Advantageously, and as shown, the conduit *h*, which may well be a piece of hose or other form of flexible conduit, is provided at its lower end with a union fitting *h'* for attachment to an elbow fitting I' at the end of a branch I from the drain or return pipe I^2 of the steam or hot water heating radiator in the room in which the conditioning apparatus is located. The branch pipe

is shown as provided with a cut-off valve I^3, which may be closed during the heating season, and with a non-return valve I^4.

Immediately below and extending across the upper air outlet at which the grill A^9 is located, I advantageously place a water eliminator *g* which may be exactly similar in construction to the previously described eliminator G, except that the bars of the eliminator *g* need not be longitudinally inclined to the horizontal and may discharge any water collecting in their lower trough portions at the ends of the latter directly into the end portions of the ice chamber A^5.

The previously mentioned louvre damper comprising the damper members B and BA, extends horizontally across the housing at the bottom of the air mixing chamber A^8, and serves as a means for varying the relative amounts of air passing into the chamber A^8 from the ice chamber A^5 and from the by-pass channel A^6, respectively. As shown the damper members B and BA are in the form of flat vanes provided with trunnion extensions at each end which are journalled in a support B' secured to the housing for the purpose. Advantageously, the different vanes are connected for similar turning movements about their trunnion axes. To this end, as shown, each of the vanes is provided at one end with a crank arm portion B^2 pivotally connected to a floating bar B^3. When the damper as a whole is in its neutral position, the vanes B which are above the channel A^6 are inclined in one direction to the horizontal, and the vanes BA above the ice chamber A^5 are inclined in the opposite direction to the horizontal. In consequence when the floating bar B^3 is moved to the left, as seen in Figs. 1 and 6, the damper bars B approach the vertical and reduce their throttling effect on the passage A^6, while the bars BA are then moved into a more horizontal position and exert an increased throttling effect on the upflow of air to the ice chamber. Conversely, when the floating bar B^3 is moved to the right from the position shown in Figs. 1 and 6, the throttling effect of the vanes B is increased, and the throttling effect of the vanes BA is increased.

While the damper vanes B and BA may be manually adjusted, I advantageously provide means for automatically adjusting them to thereby vary the cooling effect on the air conditioned in automatic response to the need for the air cooling effect. To this end, in the form diagrammatically illustrated, the adjustment of the damper vanes is controlled by a thermostat J located in the inlet chamber A' and responsive to the temperature of the room air entering and passing through that chamber. As those skilled in the art will understand, various forms of thermostatic control devices and mechanism through which the control device proper effects the adjustment of the damper are known and may be made use of for the purposes of the present invention. As diagrammatically illustrated, the thermostat J is employed to control the passage of energizing current from the motor starting box *da* through conductors in a conduit K and thence through conductors in a conduit L running from the device J to an electromagnetic relay motor M for operating the damper. As shown the relay device M is in the form of an electromagnet comprising a sectionally wound winding and a solenoid armature M' adjusted to different vertical positions according to the manner in which the winding is energized through the action of the thermostat J. The armature M' has its stem connected by a pin and slot connection to an arm B^4 carried by the adjacent damper bar B. In consequence, as the core M' is raised from the neutral position shown in Fig. 6, it gives a closing adjustment to the damper members B and an opening adjustment to the damper members BA, reverse adjustments of the two sets of damper bars being affected when the core M' is lowered.

In operation the room air entering the inlet chamber A' and passed from the latter by the fans D, flows upwardly through the space between the bars of the water eliminator G, thence through the scrubber F and the apertures E' in the water distributor plate E, and thence upwardly normally in part through the channel A^6 and in part through the ice chamber A^5, the relative amounts of air passing through the channel A^6 and ice chamber A^5 depending on the adjustment of the damper blades B and BA.

As the air passes upward through the ice chamber A^5 it is substantially reduced in temperature and is given a correspondingly low dew point and when it leaves the chamber A^5 at the top, it can have admixed with it only the relatively small amount of vapor corresponding to the dew point of the air at its low temperature.

In consequence if all of the air conditioned were passed from the chamber A^5 directly out into the room, the relatively low absolute humidity of the air leaving the conditioning apparatus would lower the relative humidity in the room, unless that humidity were less than it normally is at the times at which the greatest need for air cooling or the air cooling action is experienced. Under normal conditions of operation, a portion only of the air passing through the conditioning apparatus will pass through the ice chamber A^5 into the mixing chamber A^8. The remainder of the air then entering the mixing chamber through the by-pass channel A^6 will enter the mixing chamber at a higher temperature and normally with a higher absolute humidity. The air mixture formed in the chamber A^8 will then have a temperature intermediate the temperature at which the air enters the chamber from the chamber A^5 and from the by-pass A^6 and the relative humidity of the mixture will be less than the maximum for the mixture temperature, even though it be assumed that the relative humidity of each portion of the air entering the mixing chamber is at a maximum.

In the passage of the air upward from the inlet chamber A' into the bottom of the ice chamber A^5 and by-pass channel A^6, the air is subjected to an efficient cooling action utilizing substantially all of the available heat absorbing capacity of the ice water formed in the ice chamber and distributed by the distributor E and scrubber F. The tendency of the air to become saturated in passing through the scrubber is minimized to some extent by the moisture absorbing capacity of the scrubber material *f* when the latter is formed of materials such as those specified above containing capillary pullers. This moisture absorbing capacity of the material *f* depends upon the dryness of the air within the capillary pores or lower vapor pressure of the latter and is vitiated as by the accumulation of moisture in such pores. The moisture absorbing capacity of the material *f* can be regenerated from time to time, however, by exposing the material to contact with suitably dry air, and more rapidly by a moderate heating action due to the

action of the sun's rays or advantageously, in some instances, by heating the material over a kitchen stove. The drying and heating of the material *f* from time to time also has the advantage of sterilizing and effectually eliminating any tendency of the scrubber material to give objectionable odors to the air passing through it.

The portable character of the conditioning unit obviously facilitates its effective use. For example, in an ordinary dwelling house or housekeeping apartment, the unit may be located in the dining room when meals are being served and at other times may be located in the living room or other room which it is especially desirable to cool. Furthermore, the portability of the unit makes it readily possible to move the unit onto a porch or into a kitchen or pantry whenever it becomes necessary to recharge the unit with ice.

In Figs. 7 and 8 of the drawings, I have illustrated an air conditioning unit generally similar in character to that previously described, but desirably simpler in some respects. In large part, the unit shown in Figs. 7 and 8 consists of parts similar to corresponding parts in the construction first described and designated by the same reference letters which thereby require no further description.

The principal difference between the construction shown in Figs. 7 and 8 and that previously described, consists in and results from the transfer of the fans D and motor *d* from their lower location illustrated in Figs. 1 and 2, into the mixing chamber A^8 of Figs. 7 and 8. To receive the fans D and motor, the mixing chamber A^8 of Figs. 7 and 8 is enlarged in the vertical direction. This does not require any increase in height of a unit of different capacity, however, as with the construction shown in Figs. 7 and 8, the height of the portion of the unit below the scrubber F may well be reduced as much as or more than the height of the chamber A^8 is increased. The reduction in height of the portion of the apparatus below the scrubber F in the construction shown in Figs. 7 and 8 is made possible not only by the transfer of the fans D and motor *d* to their upper location, but also because there is no need in the unit of Figs. 7 and 8 for the eliminator G or partition A^3 of the construction shown in Figs. 1 and 2.

In Figs. 7 and 8 the water dripping from the scrubber F collects in the lower portion of the air inlet chamber A', which extends uninterruptedly upward to the scrubber F, the latter forming a pervious roof for the chamber A'. In Figs. 7 and 8 the fans D and motor *d* are suspended from a plate A^{30} generally similar to the plate A^3 of Figs. 1 and 2, and which, as shown, is spaced to provide a small air outlet chamber A^{80} above the mixing chamber A^8, and between it and the discharge outlet opening over which the grill A^9 extends. In Figs. 7 and 8, no provisions are shown for the discharge of any water dripping onto the partition plate A^{30} from the water eliminator *g*, as the water which will so drip on the plate A^{30} at any time is relatively small and insignificant in amount, and will eventually be evaporated and passed out of the apparatus with the air discharged through the openings in the grill A^9.

Notwithstanding its simpler construction, the general operation of the air conditioning unit shown in Figs. 7 and 8 is like that of the unit first described, and is characterized by the same general advantages.

Either form of conditioning unit illustrated is adapted for use as a room humidifier during the heating season without any change whatever in the apparatus other than the substitution for the ice in the refrigerant compartment, of means for supplying water for humidifying purposes to the water distributor E. The humidifying water supply means may be of any suitable form, such for example as that illustrated in detail in Fig. 9, which is adapted for mounting on the ice supporting frame A^4.

The water supply means may be of any suitable form, but I regard the arrangement illustrated in Fig. 9 as especially desirable for the purpose. That arrangement comprises a supply tank O which is located in the ice compartment of the apparatus and supported on the frame A^4 when humidification is desired and may be removed from said compartment when the latter contains ice as at such times no need exists for a special air humidification effect. The tank O is provided with supporting legs O' and an outlet pipe O^2 which, as shown, supplies water to a float tank E^3. The latter, conveniently and as shown, is in the form of a depression in an unperforated distributor plate E. When the tank E^3 is filled with water to the proper level, the water overflows from the tank onto the plate E. A float E' resting on the water in the tank E^3 is connected to and serves to close a cut-off valve P in the discharge pipe O^2 when necessary to prevent the water level from rising above the tops of the flanges E^2 so as to create an objectionable flow of water through the perforations or openings O' in the plate E. The normal rate of discharge of water into the float tank E^3 from the supply tank O may advantageously be regulated by a solenoid valve Q controlled by a humidostat (not shown) which may be of any usual or suitable type adapted to open and close the valve Q as room humidity falls below or increases above the desired amount. The described humidifying means is thus effective, when humidification of the room atmosphere is desirable, to maintain a thin layer of water on the plate E which is of such considerable horizontal extent that the air moved through the apparatus may evaporate sufficient water to insure the desired humidification effect.

While in accordance with the provisions of the statutes, I have illustrated and described the best form of embodiment of my invention now known to me, it will be apparent to those skilled in the art that changes may be made in the form of the apparatus disclosed without departing from the spirit of my invention as set forth in the appended claims and that in some cases certain features of my invention may be used to advantage without a corresponding use of other features.

Having now described my invention what I claim as new and desire to secure by Letters Patent, is:

1. Apparatus adapted for use within a dwelling room to condition the air therein comprising a housing enclosing a compartment, a by-pass about said compartment, a mixing chamber receiving air from said compartment and said by-pass and an outlet from said chamber, means for effecting contact of the air passing to said by-pass and to said compartment with ice water drip from the latter, and means extending across said outlet for arresting and retaining entrained water in the air passing from said chamber through said outlet.

2. Apparatus for conditioning air comprising a

housing having an upper outlet chamber, an ice containing chamber beneath the first mentioned chamber, a by-pass for air about said ice containing chamber communicating at its upper end with said outlet chamber, a scrubber beneath said by-pass and ice containing chamber, means for distributing the ice water drip from said ice containing chamber onto said scrubber, and means for moving the air to be conditioned upward through the scrubber and thence upward partly through the containing chamber and partly through the by-pass into said outlet chamber.

3. Apparatus for conditioning air comprising a housing having an upper outlet chamber, an ice containing chamber beneath the first mentioned chamber, a by-pass for air about said ice containing chamber communicating at its upper end with said outlet chamber, a scrubber beneath said by-pass and ice containing chamber, means for distributing the ice water drip from said ice containing chamber onto said scrubber, means for moving the air to be conditioned upward through the scrubber and thence upward partly through the containing chamber and partly through the by-pass into said outlet chamber, and means below said scrubber for collecting water passing through said scrubber.

4. A portable air conditioning unit comprising a housing enclosing an ice receiving compartment, means for drawing air into said housing and passing it through the said compartment and thence out of the housing, and means for collecting the ice water drip from compartment and discharging it from said housing, said last mentioned means including a radiator return pipe having a valved inlet part, a flexible discharge pipe having its inlet end connected to said housing and having means at its discharge end for attachment to said inlet part.

5. A portable air conditioning unit comprising a housing enclosing an ice receiving compartment, and a scrubber beneath said compartment receiving the ice water drip from the latter, said scrubber comprising a tray with a pervious bottom and a pervious layer of material supported on said bottom and said housing having a portion of one side wall removable to permit the insertion and removal of said tray and for the charging of said compartment with ice.

6. In combination, a housing enclosing an air conditioning compartment, means for moving air into said housing and through said compartment and thence out of the housing, means for effecting contact of the air passing to said compartment with water including a perforated element extending across the path of air flow beneath said compartment, and means for maintaining water on said element.

7. In combination, a housing enclosing an air conditioning compartment, means for moving air into said housing and through said compartment and thence out of the housing, means for effecting contact of the air passing to said compartment with water including an element extending across the path of air flow beneath said compartment and formed with distributed apertures and uprising flanges surrounding said apertures, and means for maintaining a shallow body of water on said element.

8. In combination, a housing enclosing an air conditioning compartment, means for moving air into said housing and through said compartment and thence out of the housing, means for effecting contact of the air passing to said compartment with water including an element extending across the path of air flow beneath said compartment and formed with distributed apertures and with a depression adapted to serve as a float tank, and means for passing water onto said element, said means comprising a water container adapted to be inserted in and removed from said compartment, a valve controlling the discharge of water from said container into said tank and a float in said tank opening and closing said valve as the water level in said tank falls and rises.

9. Air conditioning apparatus comprising in combination a casing formed with an inlet chamber, an outlet chamber, an ice containing chamber providing a path for the flow of air from said inlet chamber to said outlet chamber in which the air passing to the outlet chamber along said path is substantially saturated with water vapor, and a by-pass about said ice containing chamber for the passage of air from said inlet chamber to said outlet chamber, and means for regulating the relative amounts of air passing from the inlet chamber to the outlet chamber through said ice containing chamber and by-pass, respectively, in automatic response to the temperature of the air passing through said inlet chamber.

10. Apparatus adapted for use within a dwelling room, to condition the air therein, comprising a housing having an air inlet and an air outlet and enclosing an outlet chamber communicating with said outlet, a compartment adapted to receive ice and providing a flow path to said outlet chamber from said inlet in which air passing along said path is saturated with water vapor at the temperature to which the air is cooled by contact with ice in said compartment, and enclosing a by-pass about said compartment for air flow from said inlet to said outlet chamber, means for passing air in regulable proportions from said inlet to said outlet chamber through said by-pass and compartment, respectively, and means extending across said outlet for arresting and retaining water entrained in the air passing from said outlet chamber through said outlet.

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