

June 9, 1931.

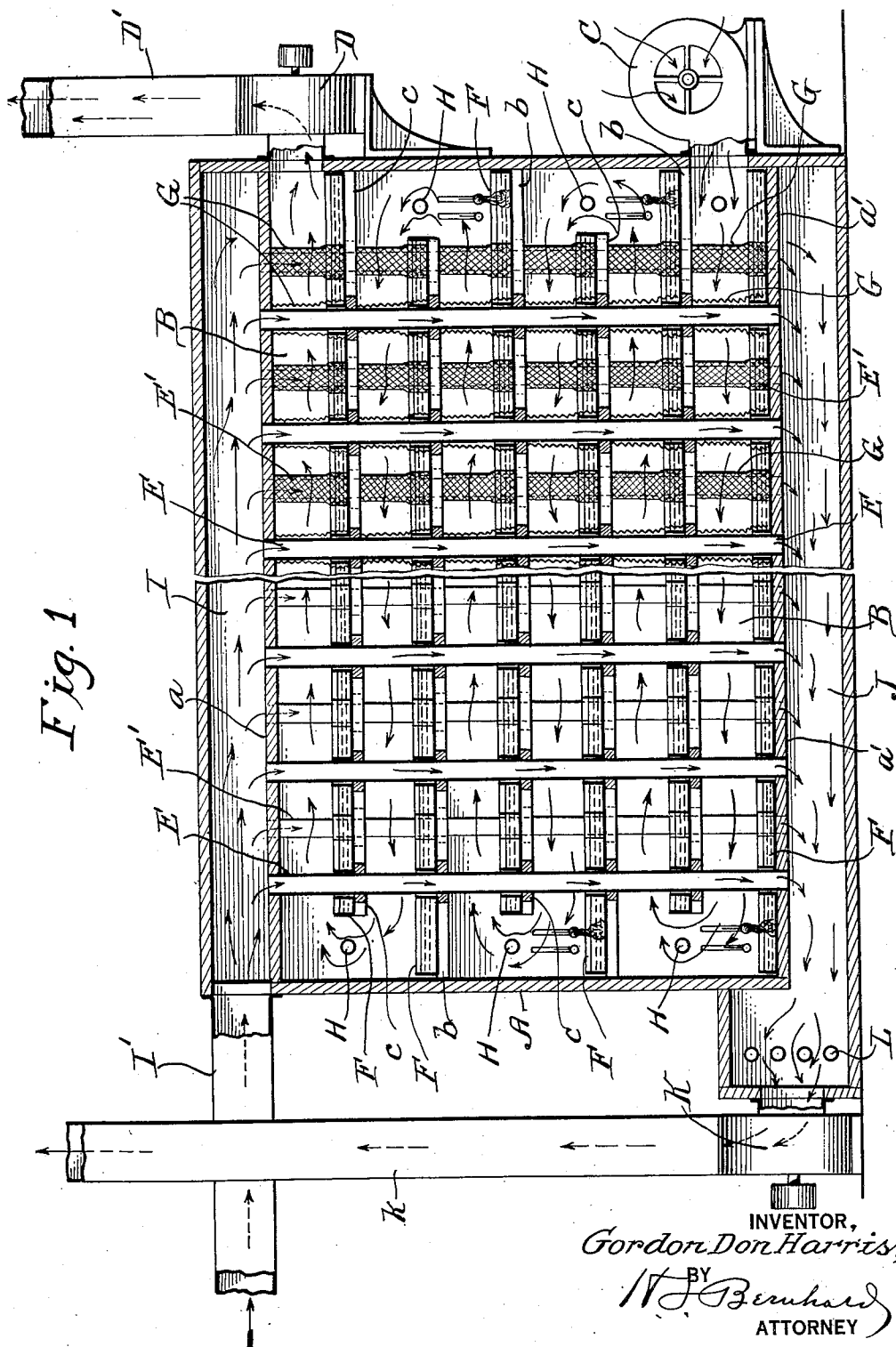
G. D. HARRIS

1,808,982

AIR CONDITIONER

Filed April 14, 1926

2 Sheets-Sheet 1



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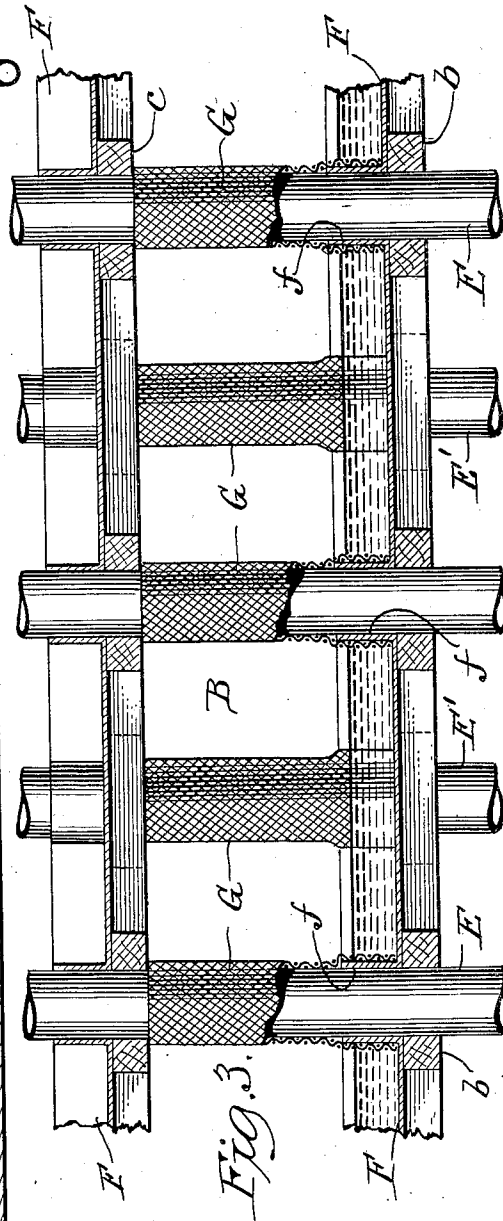
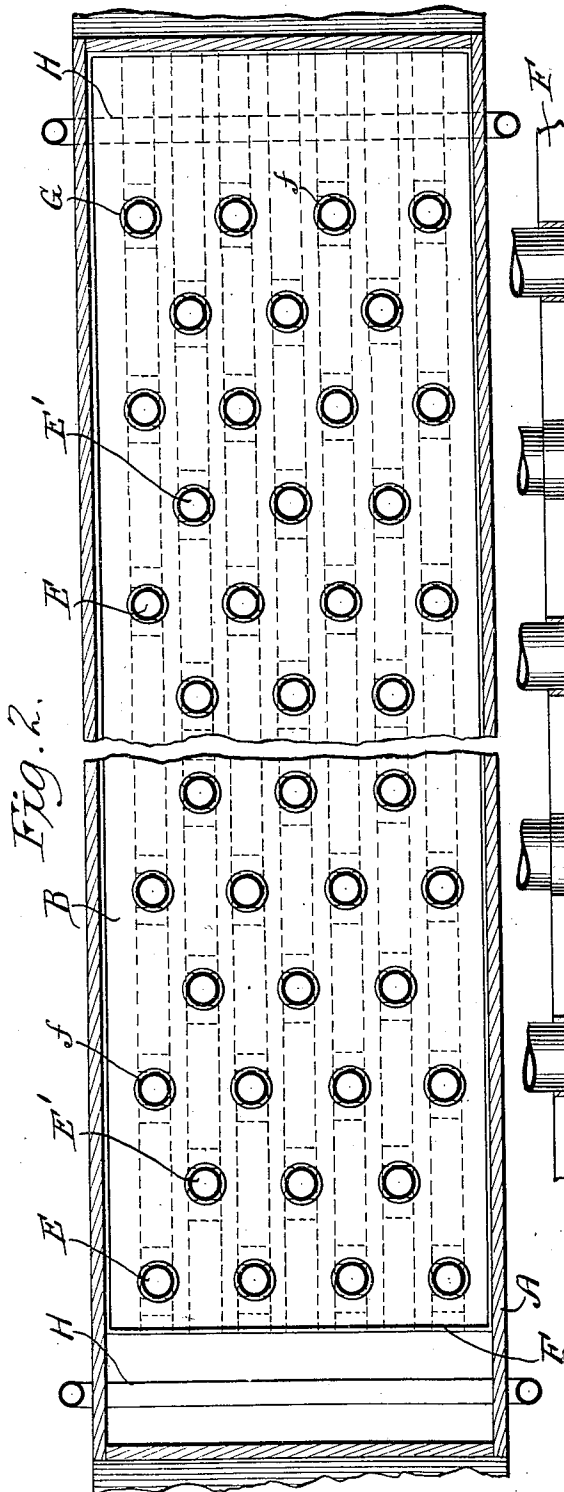
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2 Sheets-Sheet 2



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AIR CONDITIONER

Application filed April 14, 1928. Serial No. 101,870.

This invention is an apparatus for conditioning air by humidifying and warming the air, or by dehumidifying and cooling the air, or by dehumidifying and warming the air.

5 The object in view is to condition the air for rendering the same available for use in factories or plants of one kind or another, as well as for supplying the conditioned air to buildings, apartments, and to other places, structures or apparatus, generally.

10 In some industrial establishments, it is desirable to supply humid air (with or without warming the same) to work rooms, and other places, in order that the air thus supplied will aid or assist in conditioning the materials to be handled or operated upon, as for example, in paper making or in shoe making, and in various other operative relations, wherein the material to be fabricated is required to be in a more or less moist condition.

20 Again, in other places or other establishments, the air is required to be in a warm condition or in a cool condition, more or less free from moisture, i. e., relatively dry and warm or dry and cold.

25 According to my invention, provision is made for conditioning air to meet requirements of a factory, an apparatus or machine for utilizing such air, or a building or in any other place or in other relations generally.

30 My invention provides for the supply of humid air, either warm or cool, and it provides, also, for the supply of dehumidified air, either warm or cool. To condition the air by imparting a desired moisture content thereto, the air is charged with moisture in such a manner that a true humidity is imparted thereto.

35 Other functions and advantages of the invention will appear from the following description taken in connection with the drawings, wherein—

40 Figure 1 is a vertical longitudinal sectional view through an air conditioning apparatus embodying my invention.

45 Figure 2 is a horizontal sectional view thereof, illustrating the staggered relation of the air cooling tubes and the saturable wickings thereon.

50 Figure 3 is an enlarged detail view partly

in elevation and partly in vertical section showing a preferred construction of liquid tanks and the wickings with respect to the moisture condensing and air cooling tubes.

55 In the invention of this application, provision is made in one and the same apparatus for conditioning air so as to dehumidify the air and for warming or cooling the air, and provision is made, also, for humidifying the air in a manner to give a true humidity thereto, such humidified air being either warmed or cooled as desired.

60 A is a suitable housing the interior of which is divided by horizontal partitions *b, c*, to produce a flow channel, B, for the air undergoing humidification. As shown, the partitions *b* have one end joined to the wall of the housing, whereas partitions *c* are joined at one end to the opposite wall of the housing. Said partitions are parallel, or substantially so, and they are arranged within said housing in a manner to leave openings or spaces by which a continuous tortuous path or channel is provided for the flow of air.

65 At the intake to the flow channel, air is supplied by the action of a blower C. At the delivery end of the flow channel, the humid air is drawn out by an exhaustor D, whence the air is delivered by a flue D' to a suitable place in which the humid air is utilized.

70 E, E', are rows of vertical tubes extending crosswise of the housing and across the flow channel B therein, the upper ends of said tubes passing through the top *a* of the housing, whereas their lower ends extend through the floor *a'* of the housing, see Figure 1. The tubes are composed of metal, and are suitably joined to the top and to the floor of the housing, said tubes passing through the partitions *b, c*, and crossing the several branches of the flow channel B. As shown in Figure 2, there are a desired number of tubes in each row E, E'; by way of example, four are shown in each row E, and three tubes in each row E', although the number may be increased or decreased according to the desired capacity of the apparatus. It is preferred to stagger the tubes of one row relatively to the tubes of adjacent rows, and thus the tubes of

row E' are disalined to the tubes of row E, so that all the tubes of one row are opposite to the spaces intervening the tubes of an adjacent row or rows, as shown clearly in Figure 2 and indicated in Figures 1 and 3. This arrangement or spacing of the tubes in dis-alined or staggered order is advantageous in that all the tubes are exposed for contact with the air flowing within the flow channels.

F are liquid tanks positioned within the several branches or runs of the flow channel. These tanks are relatively shallow vessels which are shown as resting upon the horizontal partitions b, c. Said tanks are open at their upper ends for exposure of the liquid to the air flowing within channel B. Each tank has a series of openings bounded or surrounded by upstanding collars f, thus making provision for the passage through the tanks and the collars of the rows of air pipes E, E'. The tanks are supplied with water, or other liquid, which fills the tanks up to a desired level, the liquid level being below the upper ends of the collars f, see Figures 1 and 3.

Each tube is provided with an absorbent element, or rather with a series of absorbent elements, adapted to be saturated with liquid, and to be exposed for contact with the air in a manner to give off moisture which is taken up by the flowing air, whereby true humidity is given to the air in its flow into contact with a multiplicity of absorbent elements for the reason that the air becomes impregnated with moisture to a desired percentage of saturation. The absorbing element on each tube is shown as a wicking G, composed of appropriate fibrous material in the form of a sleeve or tube. The tubular wicking envelops a determined length of the metal tube E or E', and at its lower end, the tubular wicking encases the collar f which stands upwardly from the bottom of the tank. Each tubular wicking G is disposed for its lower part to be immersed in the liquid within the tank, said wicking extending upwardly from the tank along and in contact with the metal tube practically to the partition b or c, see Figures 1 and 3. The tubular wicking, with its lower part immersed or dipping into the liquid, absorbs such liquid by capillarity, and this liquid diffuses or spreads throughout the entire length and width of the wicking, the effect of which is to expose for contact with the air practically the entire saturated surface of the wicking. As there are a large number of tubular wickings on the rows of tubes exposed within the flow channels, it follows that there is in the aggregate a large moist area against which the air flows or with which it contacts, and thus the air takes up the moisture given off by the saturated wickings, with the result that the air in its flow becomes impregnated with moisture to the

desired point of saturation, the percentage of which, however, may vary according to conditions.

By reference to Figure 1, it will be noted that there are a number of tubular wicks G on each tube E, E'. As there are a multiplicity of these tubes, with the tubes of one row staggered relatively to the tubes of adjacent rows, it follows that a large number of wickings is provided within the several branches or runs of the flow channel. Such multiplicity of saturated wicks is desirable for humidifying the air to the desired saturation and for giving a true humidity to such air, because the air is blown in large volume and at a determined velocity within the flow channel by the fan C.

Means are provided for supplying heat units to the air at or during the humidifying operation, and to this end, radiators H are provided at suitable places within the flow channel, see Figure 1. Obviously, suitable instruments, such as thermometers, wet and dry bulb indicators, or the like, may be, or should be, provided for showing the humid condition or temperature of the air undergoing treatment. Means such as radiators H are provided, also, for supplying heat units in ratio to evaporation of the water in the wicks G. Heats units from radiators H when evaporating water from wickings E, become latent, but as this latent heat (which travels down the wickings to the water in the tank will gradually become apparent), then it would be necessary to drain the warm water from the tanks, and to add new water. As the humidified air passing out through duct D is carrying a large amount of water, new water added to compensate for that taken out in vapor by the air will be sufficient to offset the latent heat which, as stated, is continually being taken up by the water in the tank in ratio to the water evaporated from the wicking.

The rapid evaporation of moisture from the tubular wicks (which are in intimate contact with the metal tubes) due to the flow of air in large volume and at speed into contact with said saturated wicks, tends to lower the temperature of the metal tubes and to keep them in a cool condition. This cooling of the tubes is utilized in my apparatus for condensing the moisture present in atmospheric air, thus depriving such air of its moisture content, and dehumidifies the air, whereby the cooled and dehumidified air may be utilized in any place desired. To these ends I provide an air feeding flue or chamber I, and an air eduction chamber or flue J. The feeding or flue chamber I is on the roof of the housing A, and it communicates with the upper ends of the thermostatic metal tubes E, E', whereas the eduction flue of chamber J is below the floor of said housing

and it communicates with the lower ends of said thermostatic tubes E, E', all as shown in Figure 1. Atmospheric air is supplied to flue or chamber I by a duct, I', and the flow of air in the required volume and at the velocity desired is effected by an exhaustor K, the latter being connected with the eduction flue or chamber J. From this exhaustor leads a duct k, by which cool air in a more or less dehumidified condition is conveyed to any place at or in which the air may be utilized.

Provision is made for supplying heat units to the dehumidified air, if required or desired, and in Figure 1 the exhaust duct or chamber J is shown as containing a radiator L, the same being positioned at any suitable point, such as at or adjacent the opening through which the air flows from chamber J into flue K.

The operation will be understood from the foregoing description taken in connection with the drawings. The air is charged with moisture by circulating it into contact with the saturated wicks G of the multiple tubular humidifier, and if desired heat units are supplied to such moist air by radiators H during the flow of air within the apparatus. Air is circulated by either the blower C or the exhaustor D. The flow of air results in the rapid evaporation of moisture from the wicks G which are in close or intimate contact with the metal tubes, the effect of which evaporation is to cool such metal tubes, i. e., to lower the temperature thereof. Such cold tubes are used for the condensation of moisture from atmospheric air, which flows through duct I', chamber I, the tubes E, E', and chamber J, such air flow being induced by the action of exhaustor K which blows the dehumidified air through duct k. Obviously, the air circulated by exhaustor K and cooled by contact with the thermostatic tubes may be warmed to a desired temperature by heat given off by the radiator L.

My apparatus enables air to be humidified to a desired moisture content, and to be cooled or warmed as required. The same apparatus makes provision for dehumidifying air to eliminate moisture, and for warming or cooling such dehumidified air. The operations are carried on simultaneously, and such operations of humidifying one current of air and of dehumidifying a separate current of air, utilize certain elements of the one apparatus, i. e., the metal tubes and the saturated tubular wickings. It will be understood, however, that the operation of humidifying the air may be conducted to the exclusion of the operation of dehumidifying the air. In other words, the exhaustor K may remain at rest, and chambers I, J, be idle, when the humidifier is in service by the action of blower C or exhaustor D acting jointly or separately to circulate air within the flow

channel and into contact with the saturated tubular wicks G.

In the operation of humidifying air in accordance with my invention, the air makes a succession of passes, into contact with saturated wickings at each pass, and the moisture content (humidity) of the air is progressively increased at such successive passes until the air attains a desired saturation of moisture. Initially, air at atmospheric temperature and in the required volume, is supplied to the flow channel by the action of the blower or of the exhaustor (or jointly as desired), and the air flow successively within the several passes, is attended by a drop in temperature of such air at each pass, due to the exchange of heat for moisture. To compensate for this drop in temperature, means such as radiators H are provided for heating the air as it flows from one pass to the next pass of the series, and thus the air is conditioned as it flows from one pass to the next in the order of succession, whereby the air picks up moisture from the saturated wickings within each pass, there being a succession of stages for heating and expanding the air and a succession of stages for picking up moisture, to the end that the moisture content is increased progressively, with the final result that the air attains a 100% saturation, or saturation to a determined percentage.

By my procedure of heating and humidifying air alternately, and of performing such humidification at successive stages by flowing air into the presence of water vapors given off by the saturated elements, I am able to progressively increase the moisture content of the air and to impart a true humidity thereto, with the ultimate result that the air is, or may be, given a 100% saturation.

Having thus fully described the invention, what I claim as new and desire to secure by Letters Patent is:

1. In an apparatus of the class described, the combination of a flow channel including a plurality of passes, means for circulating air within the flow channel and through the successive passes thereof, means for artificially heating the air at the stages of its flow within the successive passes of said flow channel, a series of tubular members extending across the passes of said flow channel, absorbent material supported by said tubular members and exposed within the passes of said flow channel for the contact of air therewith, means for charging said absorbent material with liquid, and means for circulating air within said tubular members independently of the air flow within said flow channel.

2. In an apparatus of the class described, the combination of a flow channel including a plurality of passes, means for circulating air within the flow channel and through the

successive passes thereof, means for artificially heating the air at the stages of its flow within the successive passes of said flow channel, a series of tubular members exposed
 5 within the passes of said flow channel, humidifying means co-operating with said tubular members for cooling the same, and means for circulating air within the tubular members to the exclusion of air circulating
 10 within the flow of channel.

3. In an apparatus of the class described, a flow channel including a plurality of passes, means for circulating air within the flow channel and through the successive passes
 15 thereof, means for artificially heating the air in the periods of its flow within the successive passes, tubes arranged in rows crosswise of the passes of said flow channel, with the tubes of one row in dis-alined relation to
 20 the tubes of adjacent rows, tubular wicks enveloping said tubes of the rows, and a series of trays within the passes of the flow channel for charging said tubular wicks with moisture.

25 4. In an apparatus of the class described, a flow channel including a plurality of passes connected in series, means for circulating air within the flow channel and successively through the passes thereof, means for arti-
 30 ficially heating the air in the periods of its flow within the successive passes, tubes crossing said passes of the flow channel, liquid tanks within said passes of the flow channel, and tubular wicks contacting with the
 35 tubes and dipping into liquid present in the tanks, whereby the wicks are charged by capillary action with liquid supplied from said tanks.

5. In an apparatus of the class described,
 40 a flow channel including a plurality of passes connected in series, tubes crossing said passes of the flow channel, liquid tanks provided with collars extending upwardly from the tank and said collars fitting around the tubes,
 45 said tanks being within said passes of the flow channel, tubular absorbent wicks enveloping the tubes and the collars and dipping into liquid present within the tanks, there being a plurality of said wicks on
 50 each tube, means for circulating air within the flow channel and successively through the passes thereof for contact with moist surfaces of said tubular wicks, and means for artificially heating the air during the stages
 55 of its flow within the several passes.

6. An apparatus for conditioning air embodying a flow channel, tubular members positioned crosswise of said flow channel, absorbent material in contact with said tu-
 60 bular members, said absorbent material being saturable with moisture and exposed within the flow channel, means for heating air, and means for circulating heated air into contact with said absorbent material for the heat
 65 present in the air to expedite the evaporation

of moisture from the surface of said tubular members.

7. An apparatus for conditioning air embodying a flow channel, a series of tubular members crosswise of said flow channel, 70 moisture diffusing members in contact with said series of tubular members, said moisture diffusing members being composed of material saturable with moisture, means for arti-
 75 ficially heating air, and means for circulating heated air into contact with the moisture diffusing members for the heat present in the air to expedite the evaporation of moisture from the saturable material of said moisture-
 80 diffusing members, whereby water vapor is generated by the evaporation of moisture and the heated air is charged with the resultant water vapors.

8. In an apparatus for conditioning air, in combination, a flow channel, a series of tubu- 85 lar members crosswise of said flow channel, humidifying means contacting with the surfaces of said tubular members, said humidifying means being operable by the evaporation of moisture for cooling said tubular
 90 members, means for artificially heating air, means for circulating air into contact with said humidifying means for the heat present in the air to expedite the evaporation of moisture for said humidifying means, and
 95 means for circulating air into contact with surfaces of the tubular members free from said humidifying means, the air circulated by the last mentioned means flowing into contact with cooled surfaces of said tubular
 100 members.

9. In an apparatus for conditioning air, in combination, a flow channel, tubular mem- 105 bers therein, humidifying means including saturable material in contact with the exterior surfaces of said tubular members, means for artificially heating air by radiation of heat into the air, means for circulating heated
 110 air into contact with the humidifying means and operable for the heat to facilitate the evaporation of moisture from the saturable material, and separate means for circulating air within the tubular members and into contact with the cooled surfaces thereof.

10. In an air conditioner, in combination, 115 a flow channel, tubular members crosswise of said channel, absorbent material contacting with surfaces of said tubular members, means for radiating heat into air, means for circulating heated air for the radiated heat to contact with said absorbent material and expedite the evaporation of moisture there-
 120 from, means for circulating air into contact with the cooled tubular members whereby the air so circulated is dehumidified, and means for artificially heating the dehumidified air.

11. In an air conditioner, in combination, a series of tubular members provided with absorbent material in contact with surfaces 130

of said tubular members, means for artificially heating air, means for circulating air for the heat therein to contact with said absorbent material and expedite the evaporation of moisture therefrom, separate means for circulating air into contact with the cooled surfaces of said tubular members, whereby the air last circulated is dehumidified, and separate ducts for the independent outflow of humidified air and of dehumidified air.

12. In an air conditioner, in combination, a series of tubular members having absorbent material in contact with the exterior surfaces thereof, means for supplying moisture to said absorbent material, means for artificially heating air, means for circulating heated air for the heat therein to expedite the evaporation of moisture from said absorbent material, whereby the air is humidified by the diffusion of resultant water vapor, and means for flowing air within the tubular members and into contact with the cooled surfaces thereof, whereby the air circulated interiorly of the tubular member is dehumidified.

13. In an air conditioner, in combination, tubular members provided exteriorly thereof with absorbent material, means for supplying moisture to said absorbent material, means for artificially heating air, means for circulating heated air therein to expedite the evaporation of moisture from the absorbent material, whereby the air is humidified by the diffusion therein of the resultant water vapor, means for the outflow of humidified air, means for circulating air interiorly of the tubular members for contact with cooled surfaces thereof, and separate means for the independent outflow of dehumidified air.

14. In an air conditioner, in combination, tubular members provided exteriorly thereof with absorbent material, means for supplying moisture to said absorbent material, means for artificially heating air, means for circulating heated air for the heat therein to expedite the evaporation of moisture from the absorbent material, whereby the air is humidified by the diffusion therein of the resultant water vapor, means for circulating air interiorly of said tubular members for contact with the cool surfaces thereof, whereby the air is dehumidified, means for conducting the outflowing dehumidified air in a separate path from the outflowing humidified air, and means for heating the outflowing dehumidified air.

15. In an air conditioner, in combination, tubular members provided with absorbent material, means for supplying moisture to said material, means for heating air, means for circulating heated air for the heat therein to expedite the evaporation of moisture from said absorbent material, means for circulating air into contact with the cooled surfaces of said tubes whereby air so circulated is de-

humidified, and means for heating the outflowing dehumidified air.

16. In the art of conditioning air, the process which consists in encasing metal tubes with moisture saturable material, heating air and circulating such heated air around the tubes, vaporizing the moisture from said saturable material by the heat present in the circulated air and cooling the metal tubes, and flowing air into contact with the surfaces of said metal tubes, thereby dehumidifying the air.

17. In the art of conditioning air, the process which consists in providing metal tubes with moisture saturable material, supplying moisture to the saturable material, heating air, circulating the heated air into contact with the moisture saturable material, thereby expediting the evaporation of moisture, and circulating a separate body of air into contact with the cooled surfaces of said metal tubes, whereby the air last circulated is dehumidified.

18. In the art of conditioning air, the process which consists in providing metal tubes with moisture saturable material, supplying moisture to the saturable material, heating air, circulating the heated air into contact with the moisture saturable material, thereby expediting the evaporation of moisture, circulating a separate body of air into contact with the cooled surfaces of said metal tubes, whereby the air last circulated is dehumidified, and radiating heat into the outflowing dehumidified air.

19. In an air conditioner, in combination, a cooling member, saturable means in contact with said cooling member, means for artificially heating air and flowing such heated air into contact with the saturable means to expedite the evaporation of moisture therefrom, and means for flowing air into contact with that surface of the cooling member which is free from said saturable means.

20. In the art of conditioning air, the steps of causing air to flow serially and transversely against successive portions of a plurality of longitudinally arranged elements from which moisture is evaporated to cool said elements, and passing a separate current of air substantially parallel to the longitudinally disposed elements and into contact therewith to dehumidify said second current of air.

21. In an apparatus for conditioning air, a plurality of cooling elements, means to moisten a portion of the surface of said elements, means to direct a body of air against said moist surface to cool the elements, said means comprising a plurality of contiguous channels through which the elements extend, said channels being connected in series, and means for directing a current of air separate from the body of air against the elements to cool and dehumidify said second current of air.

22. A process of treating gases comprising passing one gas through a circuitous channel containing a plurality of moisture impregnated bodies, evaporating moisture from the bodies, passing a second gas through a plurality of channels in heat exchange relations with said bodies but out of contact therewith in a direction cross-current to the flow of the first gas.

23. A method of treating gases comprising alternately heating a gas and passing it in contact with moisture impregnated bodies to humidify the gas, passing a second gas in heat exchange relation with said bodies but out of communication therewith to cool the second gas.

24. A method of treating gases to humidify and dehumidify gases comprising passing one gas through a plurality of zones containing moisture impregnated bodies to humidify said gas, passing a second gas serially through said zones and out of communication with the first gas to cool the second gas.

25. A method of treating gases to humidify and dehumidify gases comprising passing one gas through a plurality of zones containing moisture impregnated bodies, heating the gas intermediate of said zones to effect humidification of the gas, passing a second gas serially through said zones and out of contact with the first gas to cool the second gas.

In testimony whereof I have hereto signed my name this 10th day of April, 1926.

GORDON D. HARRIS.