

May 5, 1953

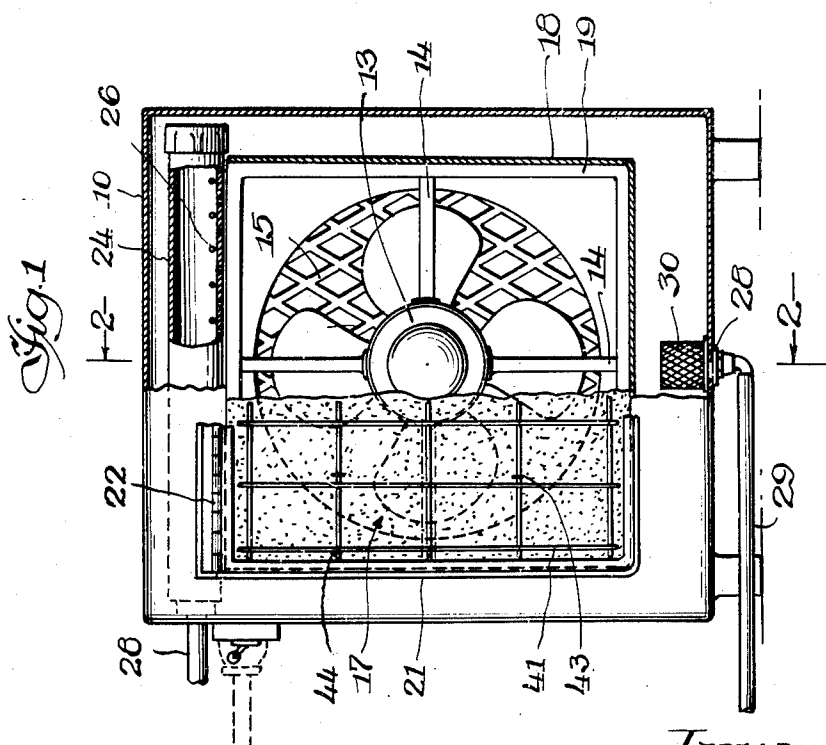
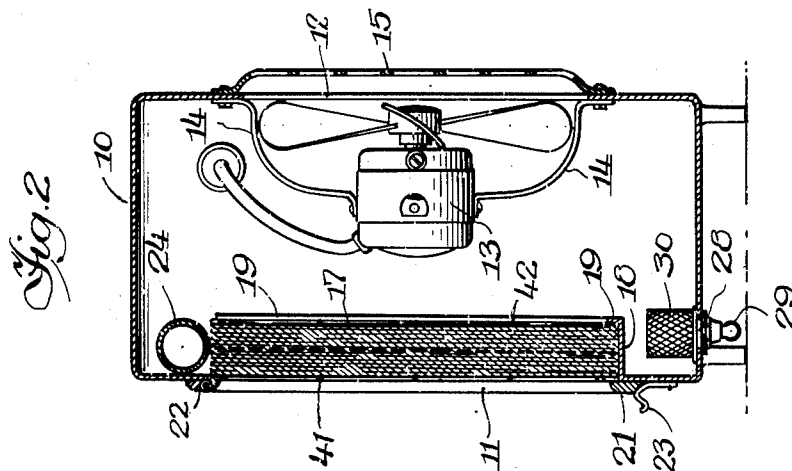
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GAS-LIQUID CONTACT APPARATUS

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2 SHEETS—SHEET 1



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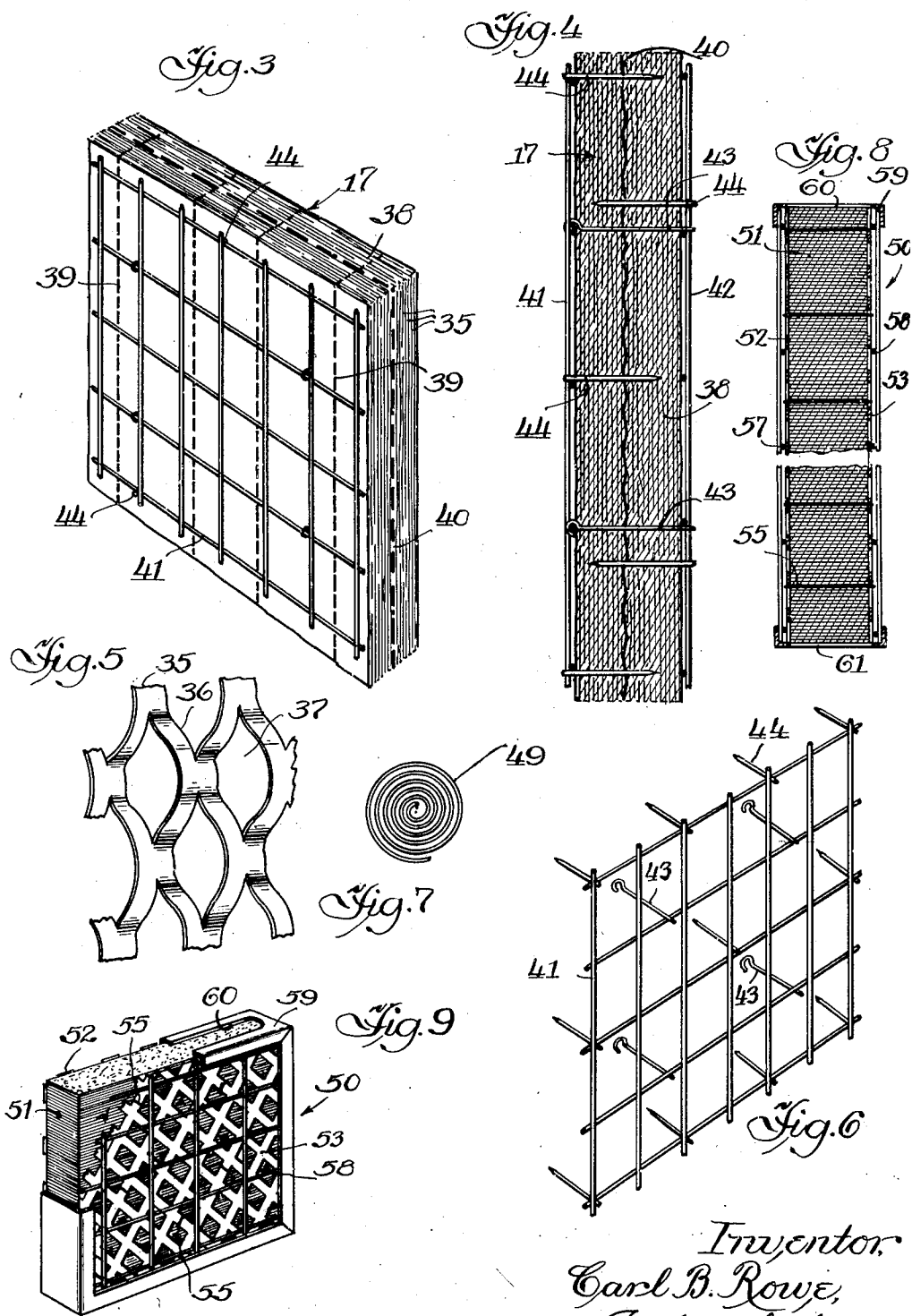
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2 SHEETS—SHEET 2



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## UNITED STATES PATENT OFFICE

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## GAS-LIQUID CONTACT APPARATUS

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9 Claims. (Cl. 261-94)

1

This invention relates to apparatus for altering the vapor content and temperature of gases and more particularly to improved apparatus for cooling, humidifying and dehumidifying air by bringing it in contact with water. Apparatus of the character described is especially adapted for use in coolers in hot arid climates and in humidifiers in warm air heating systems and also in unit humidifiers and dehumidifiers.

An object of the invention is to provide an improved apparatus for causing the flow of air and bringing water into contact with the flowing air and causing an effective evaporation operation for the cooling and humidifying of the air or an effective chilling operation for the cooling and/or dehumidifying of the air, as may be desired.

Another object of the invention is to provide a contact unit of the character described which presents to the flowing air a succession of short flat wet surfaces disposed at an oblique angle to the direction of air flow.

Another object of the invention is to provide a contact unit of the character described which while it is highly effective in bringing the water into thorough contact with the air, offers resistance to air flow which is relatively low, is uniform over the area of the unit, and is readily controlled.

Another object of the invention is to provide an improved contact unit of the character described which is simple and inexpensive and has a long operating life.

More specifically, it is the object of the invention to provide a contact unit of the character described which comprises a plurality of superposed expanded sheets of water-absorbent character. The sheets may be arranged so that their planes are at an angle to the direction of flow of the air or parallel thereto.

Other objects and advantages will become apparent as the following description progresses. In the accompanying drawings,

Fig. 1 is an elevation view of an apparatus in accordance with the invention, with portions thereof broken away to show internal structure;

Fig. 2 is a sectional view taken along line 2-2 of Fig. 1;

Fig. 3 is a perspective view of an embodiment of a contact unit in accordance with the present invention;

Fig. 4 is a transverse sectional view of the contact unit of Fig. 3;

Fig. 5 is a fragmental view of an expanded sheet such as is employed in the contact unit of Figs. 3 and 4;

2

Fig. 6 is a perspective view of a facing and supporting grid such as is employed in the mentioned contact unit;

Fig. 7 is a side view of a rolled up length of blanket composed of superposed expanded sheets of contact material;

Fig. 8 is a transverse sectional view of the contact unit of Fig. 9, and

Fig. 9 is a perspective view of a different embodiment of a contact unit.

Referring to Figs. 1 and 2, the apparatus includes a casing designated generally by the numeral 10, which may be so shaped that it is adapted to fit into a window or other opening in a wall of the space to be cooled, humidified or dehumidified. The casing 10 has an inlet opening 11 in one wall thereof and an outlet opening 12 in the opposite wall thereof. Means for moving a stream of air through the apparatus is provided comprising a fan 13 which is mounted inside the outlet opening 12 upon bracket members 14 which are supported by the casing 10. A protective grill 15 is mounted over the outlet opening 12 and fan 13. The fan 13 is adapted to draw a stream of air through the inlet opening 11 and forwardly through the casing 10 and out through the outlet opening 12.

A contact unit designated generally by the numeral 17 is mounted within the casing and across the inlet opening 11. The contact unit is supported upon a frame 18 which is mounted upon the rear wall of the casing 10 and borders the inlet opening upon the bottom and the two sides thereof. The frame has a flange 19 at the inner end thereof and the side and bottom marginal portions of the contact unit 17 fit into the frame with the edges resting against the main portion of the frame and the margins of the inner or outlet face resting against the flange 19. An exterior frame-shaped holding member 21 is hingedly supported at 22 upon the exterior of casing 10 and is adapted to rest in contact with the margin of the outer or inlet face of the contact unit 17. A spring latch 23 mounted on casing 10 cooperates with the portion of holding member 21 remote from hinge 22 to releasably hold said member in the closed position. The contact unit 17 is removable and insertable into the frame 18 by swinging open the holding member 21 against the spring pressure of latch 23.

Means are provided for supplying water to the top edge of the contact member 17 comprising an elongated distributor 24 which is mounted within casing 10 immediately above the contact unit and extends lengthwise of the upper edge of said unit and is substantially coextensive with said edge.

3

The distributor 24 is in the form of a pipe and the lower portion of the wall thereof is provided with openings 26 through which water is fed from the distributor 24 upon the contact unit 17. A conduit 28 serves to supply water to the distributor 24, said conduit passing through openings in the walls of casing 10 and distributor 24 as shown and being connected to a source of water supply which is not shown. The openings 26 are distributed along the length of the distributor 24 and are of such size and number as to feed a controlled quantity of water down upon the top edge of the contact unit 17 which water is distributed more or less uniformly over the area of said edge. The water spreads downwardly throughout the body of contact member 17, as will be described in detail hereinafter. Means are provided in the bottom of the casing 10 for removing any water which may drip from the unit 17 into the bottom of the casing. Such means comprises an opening 28 in the bottom wall of the casing to which is connected a conduit 29 which may be connected to waste or to a recirculating pump (not shown) adapted to return the water to the distributor 24. The inlet to opening 28 may be protected by a cylindrical screen 30 if desired to prevent foreign matter from entering the pipe 29 and clogging the same.

The contact unit 17 is illustrated separately in Figs. 3 and 4. For convenience of illustration, the thickness of the unit is exaggerated in Figs. 2, 3 and 4. In accordance with the present invention, the unit comprises a plurality of superposed expanded sheets 35 of water-absorbent character. A fragment of an expanded sheet 35 is shown in Fig. 5 and is formed in a known manner by cutting parallel lines of spaced-apart slits in a sheet, the slits of each line being in staggered relationship to those of the adjacent line, and expanding the sheet transversely of the slits to convert the slits into openings. The expanded sheet is a network of thin, flat webs or baffles 36 separated by the openings 37, the broad surfaces of the webs being disposed at an oblique angle to the general plane of the sheet.

The sheets are of water-absorbent character and may be composed of any water-absorbent material which does not rupture or disintegrate when soaked with water. Sheets of felted, woven or knitted vegetable, animal or synthetic fibers may be used, such as water-absorbent paper, cloth, wool felt or the like, having sufficient strength to resist rupture when wet. The saturating papers may be used, that is, the porous papers which absorb and become saturated with water or other liquid when the liquid is brought in contact therewith. In making the expanded sheets from such paper, they may be set in the expanded condition by moistening with water vapor and then drying. A preferred material for the expanded sheet is water-absorbent kraft paper and it may be impregnated with a small amount of a water resistant substance to improve its strength when wet. As an example, impregnation with from 1% to 2% of polymerized melamine-formaldehyde resin, based on the dry weight of the paper, produces a satisfactory water-absorbent sheet which resists disintegration by water soaking for a long period of time. Other impregnating substances may be used, such as phenol-formaldehyde resin and urea-formaldehyde resin. The substance may be introduced by incorporating it in powdered form with the pulp in the wet machine prior to the felting operation.

A plurality of the expanded sheets 35 are ar-

4

ranged in superposed relation to form a blanket in which the planes of the sheets are parallel to the broad surfaces of the blanket. The sheets are preferably arranged in such manner that the openings 37 of one sheet do not coincide with those of the next sheet. The sheets may all be oriented similarly or they may be oriented differently so that the long dimensions of the openings 37 extend in different directions in the different sheets. By way of example and not of limitation, a unit such as is shown in Figs. 3 and 4 may contain 15 superposed expanded sheets forming a pad adapted to fit into frame 18 as described heretofore.

The superposed sheets 35 may be united into a pad 38 by stitching 39 which may be applied in lines as shown in Fig. 3 by sewing a heavy thread through the thickness of the pad. Such uniting of the sheets resists the tendency of the latter to sag while soaked with water and holds the layers in close contact with each other whereby the water travels from one sheet to another by a wicking action. Figs. 3 and 4 illustrate the specific construction in which the expanded sheets 35 are composed of paper and a separate expanded sheet 40 composed of a non-absorbent material, preferably flexible expanded metal such as metal foil, is provided in substantially the middle of the unit as a reinforcement to resist sagging when the unit is soaked with water. The reinforcing sheet 40 may be located elsewhere than in the middle of the unit and more than one such reinforcing sheet may be employed. The stitching 39 extends through the expanded sheet 40, through the openings thereof or through the material of the thin expanded foil. The stitching attaches the absorbent sheets 35 to the reinforcing sheet at locations throughout the area of the pad to provide the desired support.

The pad with the flexible reinforcing sheet 40 may be initially made in the form of an elongated blanket and rolled up spirally into the form of a roll 49 as shown in Fig. 7 for storage purposes. The pads 38 may be cut from the blanket by a suitable instrument when desired.

The pad of superposed sheets is faced on both of its broad surfaces with open-mesh, stiff, supporting grids 41 and 42 which are composed of an intersecting pattern of spaced apart wires or other stiff, thin, elongated non-absorbent members. The grids 41 and 42 are held in position by suitable means, such as the wire hooks 43. The hooks are fastened at one end, as by welding or soldering, to one of the grids and pass through the body of the pad and at the other end are looped about the members of the other grid. The hooks 43 are of a length such that the grids are held firmly against the faces of the pad 38 without compressing the pad sufficiently to cause undesired compacting of the sheets 35. The hooks 43 also serve to space the grids apart and protect the pad from being crushed during storage and shipment. As illustrated in Figs. 3 and 4, the length and width of the grids 41 and 42 are somewhat less than the corresponding dimensions of the pad. This is the preferred construction although the invention is not limited thereto and the grid may be larger than shown. In the preferred construction, the margins of the pad project beyond the grids and provide resilient compressible edge surfaces for fitting within the frame 18.

Additional means for resisting the sagging of the expanded sheets 35 when soaked with water are shown in Figs. 3, 4 and 6. The grids 41 and

5

42 have pins or spikes 44 attached thereto and projecting inwardly into the body of the pad 38. The said spikes may be composed of metal and attached to the grids by welding or any other suitable method. As shown in Fig. 6, they are attached at any desired locations on the cross members of the grid. The spikes 44 project inwardly from the grid to which they are attached through the major portion of the thickness of the pad. As an alternative, one of the facing grids only may be provided with spikes which penetrate through substantially the entire thickness of the pad, instead of the spikes being provided upon both grids. The pad 38 with the supporting grids 41 and 42 make up the contact unit 17.

The contact unit 17 is highly effective for the purpose of bringing the water into thorough contact with the air and producing rapid cooling of the air. It is quite pervious and offers but little resistance to the flow of air through it. In effect, it is an air-pervious body composed of an interstitial network of the thin, flat, narrow webs 33 which have their broad flat surfaces disposed at an oblique angle to the direction of flow of air through the unit. In operation, these webs are soaked and carry water internally and on their surfaces and each of them represents a small baffle which deflects the flowing stream of air. As the air passes in contact with each baffle it picks up water in an effective manner, and such water supply is replenished by travel from other portions of the unit upon the surfaces of the network and by a wick action within the elements of the network. The expanded pattern provides a uniform porosity throughout the area of the unit and the air is brought into a thorough and uniform contact with the water across the entire stream. The sheets 35, being of water-absorbent character, are uniformly wetted throughout the volume of the pad 38, and the uniform wetness is maintained during the continued operation of the device. In addition, the material can be fabricated to close specifications and can be fabricated into pads having accurately controlled uniformity throughout their volume. As a result, the effectiveness of air and water contact and the resistance to air flow at any particular part of the face area of the unit is equal to that at any other particular part. Also, the construction readily lends itself to the production of the stock rolls 49 from which pads 38 of any desired size can be readily cut by an instrument as simple as a pair of shears.

Tests show that the loss of performance caused by the accumulation of salt deposits is not as great as with other forms of material, such as massed fibers or filaments. Also, the open and uniform porosity of the unit results in it maintaining its advantageous effectiveness and low resistance for a long period of use. It has been found, furthermore, that a contact unit constructed as described herein resists rupture and disintegration and has a long useful life. In addition, it is relatively simple in structure and the apparatus is inexpensive to build and operate.

The foregoing description has emphasized the use of the apparatus and contact unit 17 as a cooler which functions by evaporation of water. In this use it serves also to humidify the air. It is also adapted for cooling and dehumidifying the air. For this application cold water is used, that is, water which is at a temperature of 50° F. or lower. The cold water is fed to the upper edge of the contact unit 17 in the same manner as has been described heretofore and it spreads through-

6

out the volume of the unit and chills the air passing through it. The cooling is accomplished by this chilling effect and may be accompanied by a dehumidification. If the chilling causes the temperature of the air to be reduced below its dew point, a condensation of some of the contained vapor will take place and the resulting water is deposited on the baffles 36 and drains downwardly and away from the unit 17 with the cooling water. In this application, recirculation of the water may be accomplished by means of a pump which is not shown, as has been described heretofore, and the incoming water or the recirculated water, or both, may be cooled by a suitable cooling apparatus which is not shown. In this service, the quantity of water fed to the unit 17 and passing downwardly through it will probably be greater than that employed in the cooling and humidifying type of apparatus, but the operation is otherwise the same.

As a modification of the structure which has been described, the contact unit may be constructed with the expanded sheets of absorbent material disposed with their planes parallel to the direction of air flow instead of perpendicular thereto as has been heretofore described. Such an embodiment of the contact unit is illustrated in Figs. 8 and 9 and may be employed in the same manner as is the unit 17 illustrated in Figs. 3 and 4. In said embodiment, the unit 50 is composed of expanded sheets 51 having a length equal to the length of the unit and a width substantially equal to the thickness of the unit. The sheets are built up in superposed relationship to a height equal to the width of the unit. The result is an interstitial body in which the planes of the sheets 51 are perpendicular to the broad surfaces of the body. Upon the broad surfaces or faces of the body are arranged the expanded sheets 52 and 53 of non-absorbent material, preferably thin metal, which may be of foil thickness. The width of the webs of sheets 52 and 53 is exaggerated in Figs. 8 and 9. The surface sheets 52 and 53 are united to the body by suitable means such as tufting 55 to form a pad. Any usual form of tufting may be used as for example, the stitches 55 which pass through the body of sheets 51 and are looped at their ends over portions of the expanded sheets 52 and 53. The expanded sheets 52 and 53 serve as supporting members and the tufting 55 is employed at sufficiently close intervals over the area of the body of sheets 51 so that there is no objectionable sagging when the body is soaked with water. The pad is faced by open mesh stiff grids 57 and 58 similar to the grids 41 and 42 shown in Fig. 4. The grids 57 and 58 may have means (not shown) for holding them together and resisting sagging of the body of expanded sheets 51, similar to the hooks 43 and spikes 44 described heretofore in connection with unit 17. The edges of the pad and the grids are fitted into a channel shaped frame 59 which encloses all four edges of the unit and may be composed of sheet metal, synthetic resin or the like. The frame 59 has elongated openings 60 and 61 at the top and bottom thereof for the introduction and drainage of water.

The contact unit 50 is adapted to be arranged in the casing 10 in the same manner as is unit 17 described heretofore. With contact unit 50, the flat surfaces of the webs of the expanded sheets 51 are disposed at an oblique angle to the direction of flow of the air and the operation and performance are substantially the same as

has been described in connection with the unit 17 illustrated in Figs. 3 and 4.

Various additional modifications may be made from the structures which have been described. For example, the facing girds 41, 42, 57 and 58 may be composed of any open mesh structure, such as expanded metal, screening, or the like. Also, while the non-absorbent reinforcing sheets 40, 52 and 53 are described as preferably being flexible, they may be stiff and may be composed of a non-absorbent material other than metal, such as thermoplastic resin. The advantage of the flexible sheets is that the pad of contact material may be made initially in the form of an elongated blanket which can be rolled up and stored and then cut into pads as needed. The reinforcing sheets 40, 52 and 53 may also be composed of wire screen if desired. Also, while stitching is described in connection with unit 17 and tufting with unit 50, either stitching or tufting or other suitable means for securing the sheets together may be used in either unit as desired. Also, if the grids 41 and 42 or one of them are of relatively small mesh the stitching 39 may be fastened thereto and they may serve as reinforcement for the pad 38 and the sheet 40 may be omitted.

By way of definition, when the term "expanded" is used herein in the specification and claims, it means the slitted and expanded condition such as has been described in connection with the sheet illustrated in Fig. 5. Also, by the term "air" it is intended to include other gases which it may be desirable to cool, humidify or dehumidify.

While but a single embodiment of the overall apparatus and a few embodiments of the contact unit have been described, the invention is not limited thereto but is commensurate with the scope of the appended claims.

What is claimed is:

1. A gas-pervious water and gas contact unit comprising a plurality of superposed sheets of high wet strength water-absorbent fibrous material, said sheets each comprising an open mesh network of thin flat webs having their broad surfaces disposed at an angle to the general plane of the sheet.

2. A gas-pervious water and gas contact unit comprising a plurality of superposed expanded sheets of high wet strength water-absorbent fibrous material.

3. A gas-pervious water and gas contact unit comprising a plurality of superposed expanded sheets of water-absorbent paper impregnated with particles of a water-resistant binder.

4. A gas-pervious water and gas contact unit comprising a plurality of superposed expanded sheets of high wet strength water-absorbent paper.

5. A gas-pervious water and gas contact unit

comprising a plurality of superposed expanded sheets of high wet strength water-absorbent fibrous material, and means for securing said expanded sheets together.

6. A gas-pervious water and gas contact unit comprising a body composed of a plurality of superposed open mesh sheets, at least one of said sheets being composed of non-absorbent material, the remainder of said sheets being composed of high wet strength water-absorbent expanded fibrous sheet material, and means for securing said water-absorbent sheets to said non-absorbent sheet at intervals over the area of said sheets.

7. A water and gas contact unit comprising a gas-pervious pad having generally parallel broad faces for the ingress and egress of gas, said pad comprising a plurality of superposed expanded sheets of high wet strength water-absorbent fibrous material, the planes of said expanded sheets being generally parallel to said broad faces.

8. A water and gas contact unit comprising a gas-pervious pad having generally parallel broad faces for the ingress and egress of gas, said pad comprising a plurality of superposed expanded sheets of high wet strength water-absorbent fibrous material, the planes of said expanded sheets being generally perpendicular to said broad faces.

9. As a new article of manufacture, a spiral roll composed of a rolled up elongated flexible blanket comprising a plurality of superposed expanded sheets, and means for securing said sheets together at intervals over the area of said sheets, at least one of the sheets of said blanket being composed of flexible non-absorbent material and the remainder of the sheets being composed of high wet strength water-absorbent fibrous material.

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