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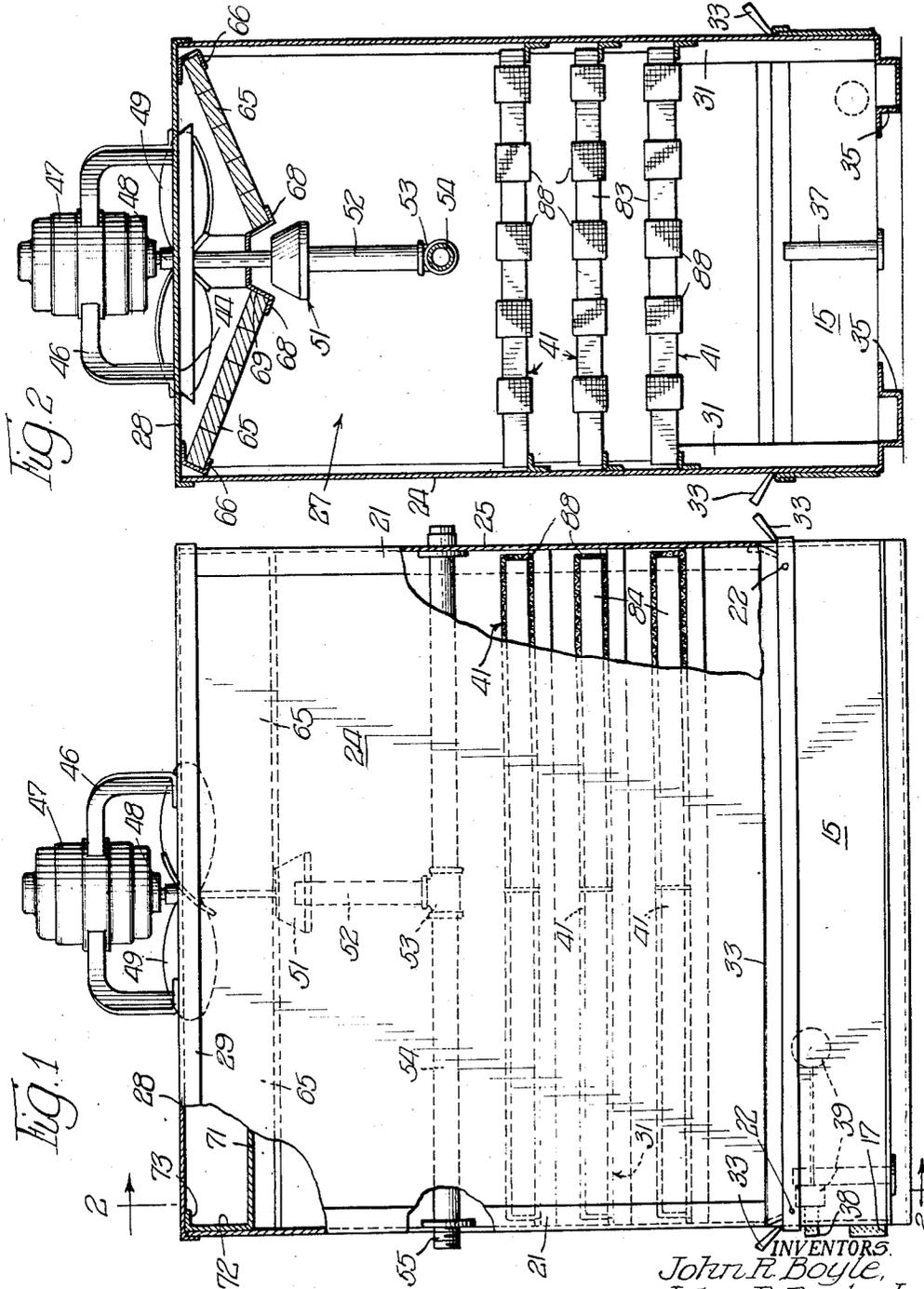
J. R. BOYLE ET AL

2,780,306

COOLING TOWER

Filed Aug. 31, 1953

2 Sheets-Sheet 1



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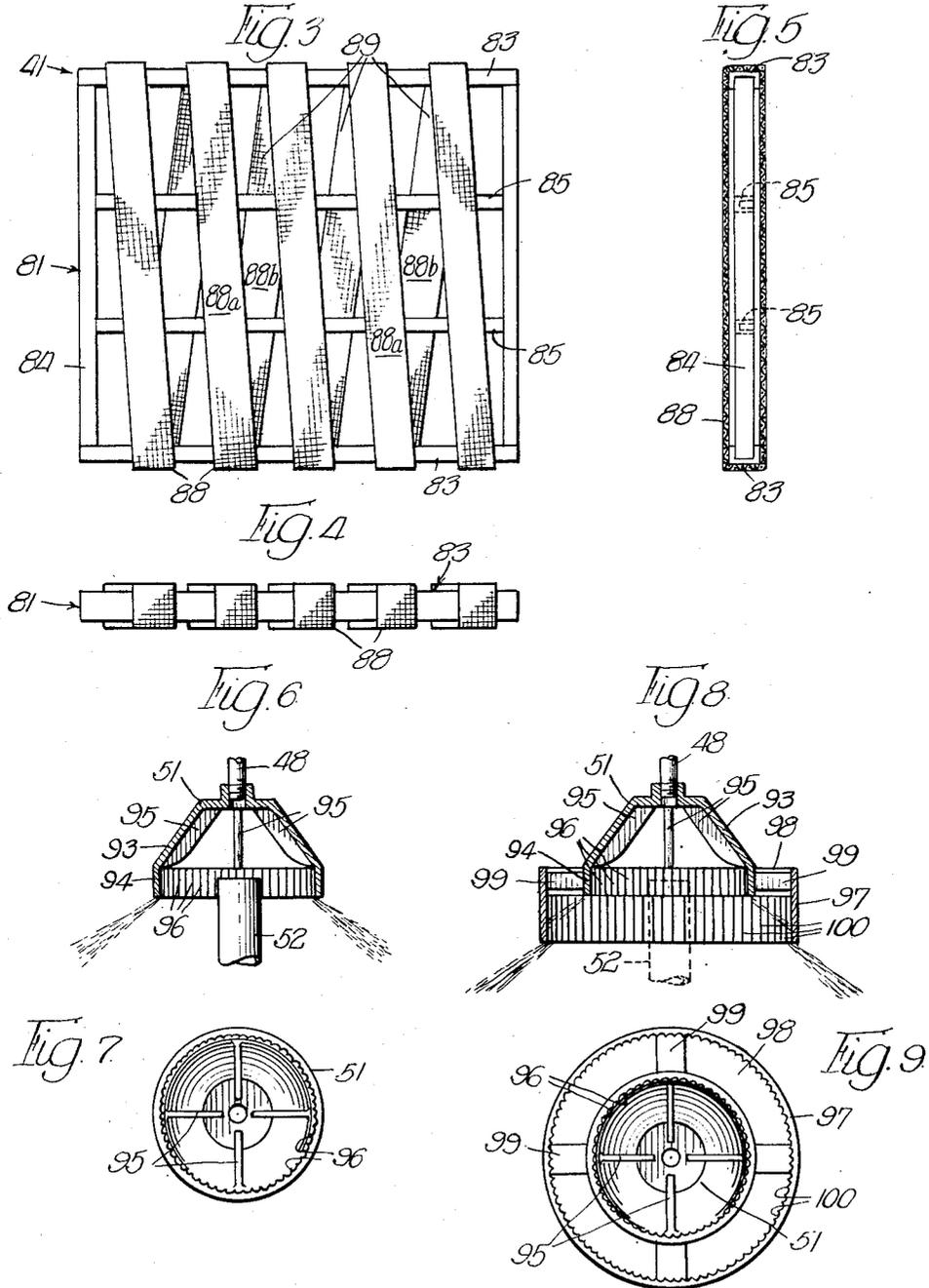
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COOLING TOWER

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12 Claims. (Cl. 183—14)

The present invention relates to cooling towers of the type used for lowering the temperature of water by evaporative cooling in contact with a forced draft flow of air through the cooling tower. These cooling towers are extensively used for cooling the recirculated water employed in the condensers of refrigerating systems, air conditioning systems, etc., but it will be understood that the invention is not necessarily limited thereto.

One well known construction of cooling tower which has been in widespread use in installations such as described above is the type which uses a "fill" made up of redwood slats; the water being sprayed down upon these redwood slats and the air being passed upwardly between the slats. This construction is subject to several objections, such as the relatively large weight of the redwood slat "fill," the deterioration thereof, etc.

The general objection of our invention is to provide a more efficient, more durable and lighter construction of cooling tower by using a unique form and arrangement of woven plastic or plastic mesh "fill" over which the water is sprayed and through which the flow of air passes.

In the preferred embodiment of our invention, this "fill" comprises a stack of superposed water suspension cells, each made up of an open frame over which is wrapped a long band of woven plastic fabric, composed, for example, of vinylidene chloride ("Velon"), polyethylene, or the like. These cells of woven plastic create an enormous amount of surface on which the water is momentarily suspended. This woven plastic surface also affords an enormous number of voids or interstices to permit the ready flow of air through the cell medium without objectionable resistance to the air flow.

This same woven plastic or plastic mesh construction is also used in forming the eliminators of our improved cooling tower. These eliminators are disposed above or beyond the point of spray discharge, and all air leaving the cooling tower is compelled to pass through the eliminators for extracting or eliminating the greater part of the moisture content in the air.

Another feature of our invention pertains to improvements in the construction of the frames of the air-water contact cells, and to an improved manner of spirally wrapping a tubular band of woven plastic around these frames.

Another feature of our invention pertains to improvements in the construction of the spray apparatus which is capable of breaking the water up into a fine or aerated spray, almost to a fogging condition, irrespective of the pressure at which the water is delivered to the spray. That is to say, the water can be delivered to the tower under a very slight head or pressure, and the very finely divided sprays obtained by a unique construction and arrangement of power driven spinner which projects the water downwardly over the plastic fill. Associated with this rotary spray head is the fan which impells the forced circulation of air upwardly through the cooling tower.

Other objects, features and advantages of our invention will be apparent from the following detail descrip-

tion of one embodiment thereof. In the accompanying drawings illustrating such embodiment:

Figure 1 is a side view of our improved cooling tower, partly in elevation and partly in section;

5 Figure 2 is a transverse sectional view through the tower, taken approximately on the plane of the line 2—2 of Figure 1;

10 Figure 3 is a detail plan view of one of the water suspension cells, showing one preferred woven plastic band around the cell frame;

Figure 4 is an end elevational view of the water suspension cell;

Figure 5 is a side elevational view of the cell;

15 Figure 6 is an axial sectional view through a modified form of rotary water distributing cone, characterized by radially extending internal vanes and a fluted lower edge for augmenting the action of breaking up the spray water;

Figure 7 is a bottom end view of such modified cone;

20 Figure 8 is an axial sectional view of another modified form of water distributing cone, similar to the embodiment shown in Figures 6 and 7, but provided with an additional water break-up ring, and also with our vanes for increasing the aerating action on the spray; and

25 Figure 9 is a bottom end view of the modified cone illustrated in Figure 8.

We preferably make our improved cooling tower of a knock-down kit type of construction so as to facilitate its shipment and also to facilitate its assembly on the roof of a building or other outdoor location. The main supporting base for the cooling tower comprises a bottom pan or tank 15, preferably of rectangular or square form, and having its top open for receiving the cooled water discharging down from the air-water contact cells. One or more outlets 17 conduct this cooled water from the pan. The upwardly extending frame structure comprises vertically extending corner angle bars 21 which are set in the corners of the pan 15 and which are secured to the upper rim of the pan by bolts 22, which permit the ready assembly of the frame on location. Sheet metal side panels 24 and sheet metal end panels 25 are secured to the corner angle bars 21 by bolts or by self-tapping screws, these panels defining an enclosed spray chamber 27 of substantially the dimensions of the open top of the pan 15. The top of this spray chamber is closed by a sheet metal cover 28 having a downwardly extending marginal flange 29 which fits over the corner angle bars and the side and end panels. The side and end panels 24 and 25 have their lower edges spaced substantially above the top edge of the pan 15, so as to form air inlet openings 31 around all four sides of the casing, directly above the pan 15. Secured to the upper edges of the pan are splash strips 33 which slope outwardly and upwardly from the upper edge of the pan on all four sides of the unit for the purpose of catching any spray or splash water which might tend to pass out through the air inlet openings 31. As shown in the end view of Figure 2, the bottom surface of the pan 15 is preferably supported above the roof, floor, or other supporting surface by two longitudinally extending channel bars 35 secured to the bottom of the pan along its side edges. The pan may be provided with an overflow pipe 37, and also with a water inlet connection 38 which is controlled by a float responsive valve indicated at 39, such governing the admission of make-up water.

The air-water contact cells comprising the woven plastic fill are indicated at 41, there being a plurality of these cells in superposed relation in the spray chamber 27, above the level of the air inlet openings 31. The detail construction of these air-water contact cells will be later described.

The discharge of air from the cooling tower occurs through a discharge opening 44 formed in the sheet metal cover 28. Secured to the cover above this discharge opening 44 is a supporting spider or bracket 46 in which is mounted a vertically disposed electric motor 47. Mounted on the motor shaft 46 is the air impelling fan 49 which rotates substantially directly within the outlet opening 44. Secured to the lower end of the motor shaft 48 below the fan 49 is a rotating spinner cone 51 which projects the spray discharge of water downwardly over the air-water contact cells 41, 41. Extending upwardly into the under side of this downwardly directed rotary cone 51 is a vertical pipe 52 functioning as a spray head for discharging water against the bottom and inner walls of the cone. This spray head 52 is supported by a coupling 53 in a supply header 54 supported in the end walls of the spray chamber, one end of this header being connected at 55 with the source of water which is to be cooled. It will be seen that this water to be cooled need enter the supply header 54 only under sufficient pressure to issue from the upper end of the spray head 52 for contact with the inner side of the rotary spinner cone 51. The spinner cone projects the water downwardly and outwardly in a conical pattern over substantially the entire upper surfaces of the upper air-water contact cells 41. The high speed of the spinner breaks the water up into a fine or aerated spray, almost to a fogging condition. Depending upon the degree of aeration required, we propose to use different diameters and shapes of spinner cones 51. We also contemplate modified constructions of rotary spinning cones wherein internal vanes are provided within the cone to impart velocity to the water and wherein the cone has a fluted lower edge to augment the action of breaking up the water. Small air-impelling blades, separate from the blades 49, may also be associated with this rotary conical spinner to augment the flow of air adjacent the cone for breaking up and aerating the water. In the illustrated embodiment and in these contemplated modified embodiments the action of the cone breaks up the water into exceedingly small particles and mist, gives it downward velocity and counterflow to the air, creates a uniform pattern, and aerates the water in its travel. Practically no entering water pressure is required in feeding water to the cone.

The eliminator cells are indicated at 65, 65 in Figure 2, these eliminator cells being disposed in the upper portion of the housing, between the spinner cone 51 and the air circulating fan 49. These cells are preferably set at the sloping angles shown to facilitate drainage, and have their upper edges set in brackets 66 secured to the under side of the removable cover 28. The lower edges of the eliminator cells 65 rest on step flanges 68 projecting outwardly from the lower edges of inclined side flanges 69 of a channel-shaped support 71. As shown in Figure 1, this channel-shaped support extends throughout the length of the chamber and has upwardly bent legs 72 at its ends provided with inwardly bent attaching flanges 73 which are secured by rivets or bolts to the under side of the removable cover 28. When it is desired to obtain access to the interior of the cooling tower, it is only necessary to lift the removable cover 28 upwardly off the top of the spray chamber, this cover carrying with it as a part of the removable assembly the electric motor 46, fan 49, spinner cone 51 and eliminator cells 65, 65. The latter can be slid into and out of place by endwise movement on the supporting flanges of the brackets 66 and on the step flanges 68.

Referring now to Figures 3, 4 and 5 illustrating the details of construction of one of the water suspension cells 41, it will be seen that each of these cells comprises an open rectangular frame 81 consisting of two side stringer members 83 joined at their ends by the transverse cross bars 84. Reinforcing struts 85 extend between the end cross bars 84 intermediate the sides of the frame. These

frame members 83—85 are constructed of formed aluminum, preferably of channel section, with their ends joined by welding, riveting or in any other desired manner. The finished frame is preferably given a baked plastic coating 86.

Wound spirally around each frame 81 is a length of woven plastic mesh or fabric 88, one end of this plastic band being fastened in any suitable manner to one end of the frame and the other end of the band to the other end of the frame. The successive convolutions or wrapped turns of this plastic band 88 are preferably spaced slightly from each other to provide the long narrow openings 89 between spans. The top spans 88a of this plastic webbing overlie substantial areas of these intervening openings 89 between the bottom spans 88b, and, in turn, these bottom spans 88b underlie substantial areas of the intervening openings 89 between the top spans 88a. In this manner, the major portion of the air passing through the water suspension cell 41 is compelled either to pass through the mesh of the plastic band, or to follow a slightly zig-zag or tortuous path, such as by entering the intervening openings 89 at one point on the lower side of the cell and discharging from the intervening openings 89 at a laterally displaced point on the upper side of the cell. In this lateral or zig-zag travel of the air through the water suspension cell 41, a substantial portion of the air will have wiping contact with the wet surfaces of the woven plastic spans 88a and 88b. The widths of the intervening openings 89 between adjacent turns or convolutions may be increased or decreased as desired in the winding of the plastic band about the frame, this feature enabling the amount of surface area and the internal air flow resistance of each cell to be proportioned as desired for different sizes of cooling towers, different operating conditions, different numbers of cells in the vertical stack, etc.

The plastic in stranded form may be woven into the form of a single thickness band or belt; but we find it preferable to have it woven into tubular form, something like a fabric cylinder or sock. In such embodiment, each span 88a and 88b is then of two thicknesses of woven plastic. We have obtained very good results using vinylidene chloride ("Velon") or using polyethylene, woven with a mesh in the approximate order of 8 to 10 strands or threads per inch, corresponding to voids or interstices in the mesh of approximately $\frac{1}{8}$ inch, but it will be understood that the invention is not limited to these specific materials or proportions. The successive cells 41 are shown as being removably mounted in vertically spaced relation on the inwardly extending flanges 91 of supporting angle bars 92 which have their ends secured to the vertical corner angle bars 21. As shown in dotted lines in Figure 1, there are preferably two water suspension cells 41 disposed substantially in end-to-end abutment in each horizontal layer of cells, the division of each horizontal layer into two cells facilitating the insertion and removal of the cells in the spray chamber. Convenient access for assembling the cells 41 within the spray chamber or removing them therefrom is afforded through the open top of the spray chamber; the removal of the cover 28 carrying with it the electric motor, fan, conical sprayer and eliminator cells, and the water suspension cells 41 being capable of insertion or removal to one side or the other of the spray head 52 and supply header 54.

The eliminator cells 65, 65 are of substantially the same construction described above of the water suspension cells 41, each eliminator cell comprising a tubular band of woven plastic mesh 88 lapped spirally around an aluminum frame of substantially the same construction as the frame 81. However, we find it desirable to wrap this tubular plastic band on the eliminator frames with the edges in abutment or overlapping to provide substantially two thicknesses of each convolution of the band so as to trap a large percentage of the entrained water particles and mist in the outward flow of the air through

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the eliminator cells. There are preferably two eliminator cells 65 disposed end-to-end in each inclined bank or layer of eliminator cells.

In Figures 6 and 7 we have shown a modified form of rotary water distributing cone characterized by a conical upper portion 93 and a substantially cylindrical lower skirt portion 94 at the bottom of the conical portion 93. A series of radially extending vanes 95 are formed within the conical portion 93, and a fluted inner surface or edge 96 is formed within the cylindrical lower skirt portion 94. The internal vanes 95 aid in imparting angular velocity to the water, so that the water picks up the angular velocity of the cone more quickly. The vanes further exert a break-up action on the entering water. The flutes 96 in the inner peripheral surface at the bottom of the cone also break the water up into a fine or aerated spray almost to a fogging condition. The substantially cylindrical lower skirt portion 94 imparts a sufficient downward component to the sprayed water to have it strike the central areas of the water suspension cells 41 directly below the spraying apparatus, as well as the marginal edge areas of the cells.

In Figures 8 and 9, we have shown still another modified embodiment of distributing cone which embodies the same features and general construction of Figures 6 and 7, but adds thereto an additional water break-up ring 97 of substantially cylindrical form which is spaced outwardly from the bottom edge of the cone 51 to provide the annular air passageway 98 therebetween. This outer ring 97 is preferably joined to the cone by a series of air impelling vanes or blades 99 which impel air through the annular air passageway 98. The inner peripheral surface of the outer ring 97 is also formed with flutes 100 to provide a second stage of water break-up action. The vanes 99 can be pitched downwardly or upwardly as desired, either direction of air flow through the annular air passageway 98 having an aerating and fogging action in passing through the spray being projected from the cone 51 to the outer ring 97, or to levels below this ring. The fluted lower edge of the cone 51 first throws the water out substantially radially. This outwardly travelling spray then encounters the second fluted surface 100 of the outer ring 97 which is moving more or less at right angles to the outwardly travelling spray from the cone. This second fluted surface 100 thus atomizes the water still further, so that it passes downwardly from the outer ring in the form of a finely atomized spray. This is of particular advantage when the device is used for water purification and aeration. The substantially cylindrical form of the skirt portions 94 and 97 imparts the desired downward component to the sprayed water as above described.

The main fan 49 still insures a main upward flow of air through the tower, irrespective of whether the small aerating vanes 99 are pitched upwardly or downwardly. Instead of this main air impelling device 49 being in the form of a fan, it might be in the form of a centrifugal blower laid horizontally on the cover 28, with its intake drawing air through the opening 44, and with the distributing cone 51 mounted on the lower end of the blower shaft.

While we have illustrated and described what we regard to be the preferred embodiments of our invention, nevertheless it will be understood that such is merely exemplary and that numerous modifications and rearrangements may be made therein without departing from the essence of the invention.

We claim:

1. In a cooling tower of the class described, the combination of a spray chamber, air impelling means for circulating air through said chamber, an electric motor for driving said air impelling means, a water supply header for supplying water to said chamber, a rotary conical spinner driven by said motor receiving the water from said header, and a water suspension cell in said chamber

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receiving the spray water from said rotary conical spinner and through which the impelled air is adapted to pass, said water suspension cell comprising an open frame, and a tubular band of woven plastic material wrapped spirally around said frame with the edges of adjacent convolutions spaced from each other.

2. In a cooling tower of the class described, the combination of a spray chamber having air inlet and air discharge openings, air impelling means for circulating air through said spray chamber between said openings, an electric motor for driving said air impelling means, a water supply header for supplying water to said spray chamber, a rotary conical spinner driven by said motor receiving the water from said header, a water suspension cell in said spray chamber receiving the spray water from said rotary conical spinner and through which the impelled air is adapted to pass, and an eliminator cell in said spray chamber adjacent to said air discharge opening adapted to eliminate entrained water particles and mist from the discharged air, said water suspension cell and said eliminator cell each comprising a frame and a band of woven plastic material wrapped around said frame.

3. In a cooling tower of the class described, the combination of a casing defining a spray chamber having an air inlet opening adjacent to its lower end and an air discharge opening adjacent to its upper end, air impelling means for circulating air through said spray chamber between said openings, a plurality of water suspension cells in said spray chamber stacked one above the other, each of said cells comprising an open frame and a tubular band of woven plastic material wrapped spirally around said frame with the edges of adjacent convolutions spaced from each other, a water supply header, a spinner driven by said air impelling means in the form of a downwardly directed cone adapted to receive the water from said supply header and project the water outwardly and downwardly over said water suspension cells, and eliminator cells in said chamber adjacent to said air discharge opening adapted to eliminate entrained water particles and mist from the discharged air, each of said eliminator cells comprising a frame and a band of woven plastic material wrapped around said frame.

4. In a cooling tower of the class described, the combination of a casing defining a spray chamber having an air inlet opening adjacent to its lower end and an air discharge opening adjacent to its upper end, a water suspension cell in said spray chamber, means for circulating air through said water suspension cell between said openings, spraying apparatus for spraying water down over said cell comprising an upwardly directed water supply header and a motor driven spinner of conical form directed downwardly over said supply header whereby the water issuing therefrom is projected outwardly and downwardly over said cell by said conical spinner, and an eliminator cell in said chamber adjacent to said air discharge opening adapted to eliminate entrained water particles and mist from the discharged air, said eliminator cell comprising a body of woven plastic mesh.

5. In a cooling tower of the class described, the combination of a casing defining a spray chamber, a water suspension cell in said spray chamber, means for circulating air through said water suspension cell, and spraying apparatus for spraying water down over said cell comprising an upwardly directed water supply pipe, a rotating slinger in the form of an inverted conical cup receiving water issuing from said supply pipe, internal vanes in said inverted conical cup to impart angular velocity to the water received from said supply pipe, and a fluted inner peripheral surface in said cup adjacent to its lower edge adapted to exert an atomizing action on the water after it leaves said internal vanes.

6. In a cooling tower of the class described, the combination of a casing defining a spray chamber, a water suspension cell in said spray chamber, means for circulat-

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ing air through said water suspension cell, and spraying apparatus for spraying water down over said cell comprising an upwardly directed water supply pipe, a motor driven slinger in the form of an inverted conical cup directed downwardly over said water supply pipe, internal vanes in said inverted conical cup adapted to impart angular velocity to the water received from said supply pipe, a fluted inner peripheral surface in said cup adapted to receive water from said vanes and to exert an atomizing action thereon, an outer ring spaced peripherally from said cup to define an annular air passageway therebetween, air impelling vanes in said passageway for impelling air therethrough, and a fluted inner peripheral surface in said outer ring adapted to receive the water discharged from said cup to exert an atomizing and aerating action thereon.

7. In spraying apparatus of the class described, the combination of an upwardly directed water supply pipe, a motor driven slinger in the form of an inverted conical cup directed downwardly over said water supply pipe, internal vanes in said inverted conical cup adapted to impart angular velocity to the water received from said supply pipe, a fluted inner peripheral surface in said cup adapted to receive water from said vanes and to exert an atomizing action thereon, an outer ring spaced peripherally from said cup to define an annular air passageway therebetween, air impelling vanes in said passageway for impelling air therethrough, and a fluted inner peripheral surface in said outer ring adapted to receive the water discharged from said cup to exert an atomizing and aerating action thereon.

8. In a cooling tower of the class described, the combination of a casing defining a spray chamber having an air inlet opening adjacent to its lower end and an air discharge opening adjacent to its upper end, a water suspension cell mounted in the lower portion of said casing above said air inlet opening, an eliminator cell mounted in the upper portion of said casing adjacent to said air discharge opening and adapted to eliminate entrained water particles from the discharged air, said eliminator cell being spaced substantially above said water suspension cell to define a spray zone therebetween, air impelling means for circulating air upwardly through said water suspension cell, said spray zone and said eliminator cell to said air discharge opening, an electric motor for driving said air impelling means, and water emitting means located in said spray zone for emitting water downwardly over said water suspension cell, said water suspension cell comprising an open frame and a tubular flexible band of non-hygroscopic woven plastic mesh wrapped spirally around said frame with the edges of adjacent convolutions spaced from each other.

9. In a cooling tower of the class described, the combination of a casing defining a spray chamber having an air inlet opening adjacent to its lower end and an air discharge opening adjacent to its upper end, a water suspension cell mounted in the lower portion of said casing above said air inlet opening, an eliminator cell mounted in the upper portion of said casing adjacent to said air discharge opening and adapted to eliminate entrained water particles from the discharged air, said eliminator cell being spaced substantially above said water suspension cell to define a spray zone therebetween, air impelling means for circulating air upwardly through said water suspension cell, said spray zone and said eliminator cell to said air discharge opening, an electric motor for driving said air impelling means, and water emitting means located in said spray zone for emitting water downwardly over said water suspension cell, said water suspension cell comprising an open frame, and a band of non-hygroscopic plastic mesh material wrapped spirally around said frame in the form of upper spans of plastic mesh material on the upper side of said frame and lower spans of plastic mesh material on the lower side of said frame, said upper and lower spans being vertically spaced

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from each other to provide horizontal spaces therebetween, said upper spans being laterally separated to provide upper openings between spans, and said lower spans also being laterally separated to provide lower openings between the lower spans, substantial portions of said upper and lower openings being in vertically offset or staggered relation so as to cause a substantial portion of the air which does not pass through the plastic mesh material to be deflected laterally through said horizontal spaces in wiping contact with said upper and lower spans.

10. In a cooling tower of the class described, the combination of a casing defining a spray chamber having an air inlet opening adjacent to its lower end and an air discharge opening adjacent to its upper end, a water suspension cell mounted in the lower portion of said casing above said air inlet opening, an eliminator cell mounted in the upper portion of said casing adjacent to said air discharge opening and adapted to eliminate entrained water particles from the discharged air, said eliminator cell being spaced substantially above said water suspension cell to define a spray zone therebetween, air impelling means for circulating air upwardly through said water suspension cell, said spray zone and said eliminator cell to said air discharge opening, an electric motor for driving said air impelling means, and water emitting means located in said spray zone for emitting water downwardly over said water suspension cell, said water suspension cell comprising an open frame, and a tubular band of non-hygroscopic plastic mesh material wrapped spirally around said frame in the form of upper spans of plastic mesh material on the upper side of said frame and lower spans of plastic mesh material on the lower side of said frame, said upper and lower spans being vertically spaced from each other to provide horizontal spaces therebetween, said upper spans being laterally separated to provide upper openings between spans, and said lower spans also being laterally separated to provide lower openings between the lower spans, substantial portions of said upper and lower openings being in vertically offset or staggered relation so as to cause a substantial portion of the air which does not pass through the plastic mesh material to be deflected laterally through said horizontal spaces in wiping contact with said upper and lower spans, said spans comprising non-hygroscopic plastic strands having a mesh of approximately eight strands to the inch corresponding to voids or interstices in the mesh of approximately one-eighth inch, whereby to provide a large amount of surface on which the spray water is momentarily suspended but without causing objectionable resistance to air flow through the mesh of said spans.

11. In a cooling tower of the class described, the combination of a casing defining a spray chamber, a water suspension cell in said spray chamber, means for circulating air through said water suspension cell, and spraying apparatus for spraying water down over said cell comprising an upwardly directed water supply pipe, a motor driven inverted conical cup receiving water issuing from said supply pipe, and a substantially cylindrical skirt portion rotating with said conical cup and having its lower edge extending down below the lower edge of said conical cup for projecting the water received from said cup, said skirt portion imparting a sufficient downward component to the sprayed water to have it strike the central area of the water suspension cell directly below said spraying apparatus as well as the edge areas of said water suspension cell.

12. In a cooling tower of the class described, the combination of a casing defining a spray chamber, a water suspension cell in said spray chamber, means for circulating air through said water suspension cell, and spraying apparatus for spraying water down over said cell comprising an upwardly directed water supply pipe, a motor driven inverted conical cup receiving water issuing from said supply pipe, a substantially cylindrical

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skirt portion rotating with said inverted conical cup and having its lower edge extending down below the lower edge of said conical cup for projecting the water received from said cup, said skirt portion imparting a sufficient downward component to the sprayed water to have it strike the central area of the water suspension cell directly below said spraying apparatus as well as the edge areas of said water suspension cell, and a fluted inner peripheral surface in said skirt portion adapted to exert an atomizing action on the water projected from said skirt portion.

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