United States Patent

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[54] **MECHANICALLY ASSISTED SPIRAL-DRAFT WATER-COOLING TOWER**
18 Claims, 8 Drawing Figs.

[52] **U.S. Cl.** .... **261/30,** 261/79 A, 261/111, 261/DIG. 11
[51] **Int. Cl.** **B01f 3/04**
[50] **Field of Search** .... 261/79 A, DIG. 11, 108–113, 24, 30

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ABSTRACT: A forced-draft cooling tower employs fans, passages to receive fan-displaced air or gas, and packing sections spaced about the tower axis so that positive swirling of the gas or air about that axis within the tower interior is produced as the flow passes through the passages and packing sections.

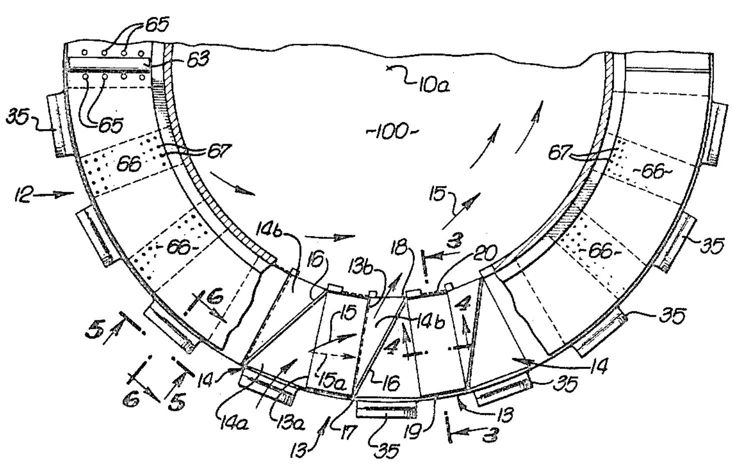

FIG. 1.

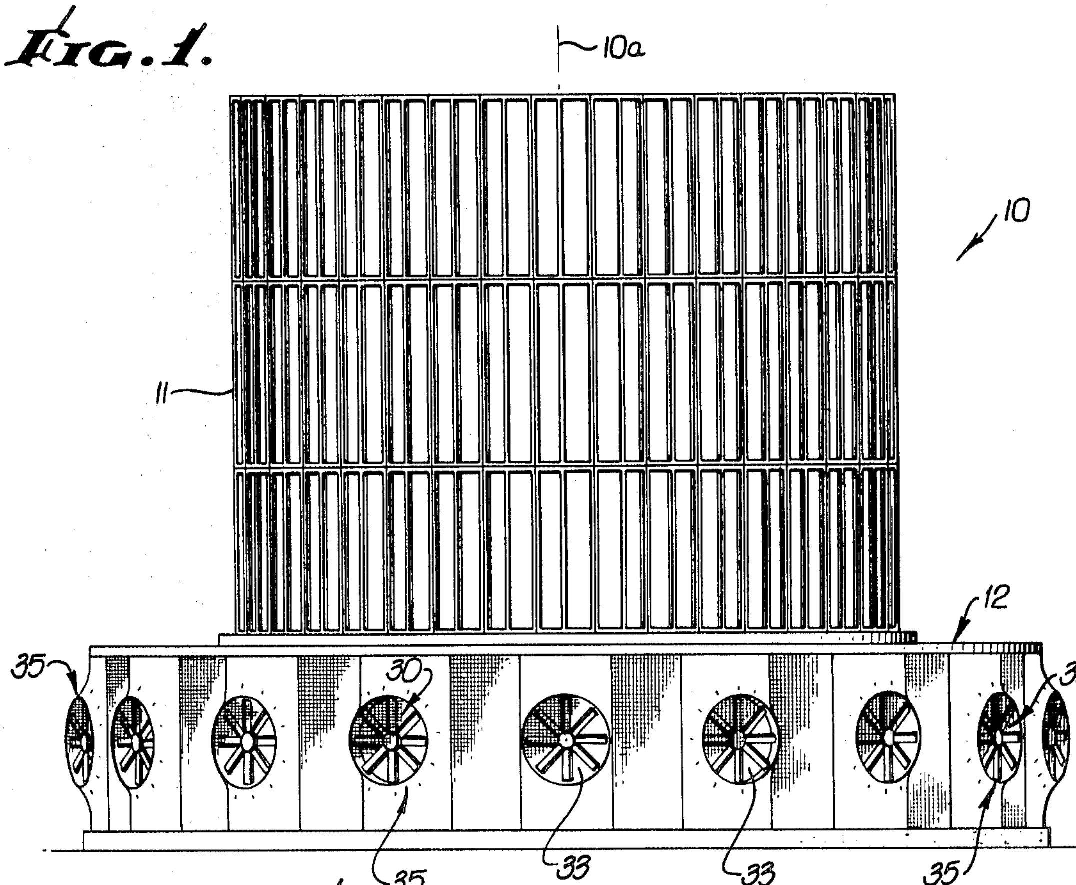

FIG. 2.

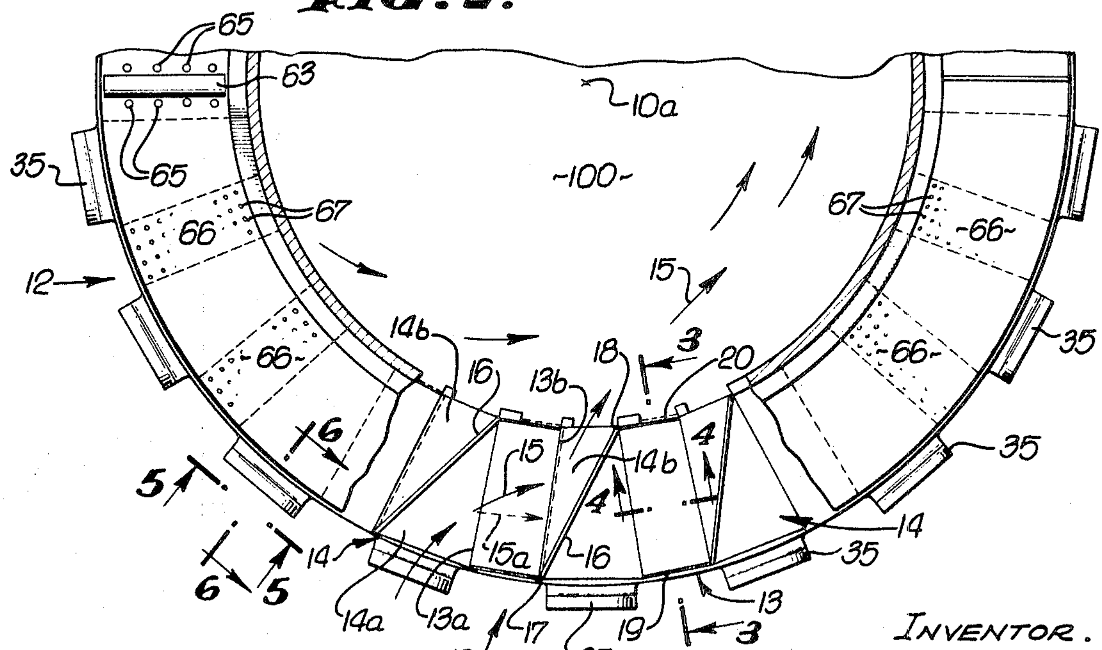

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FIG. 3.

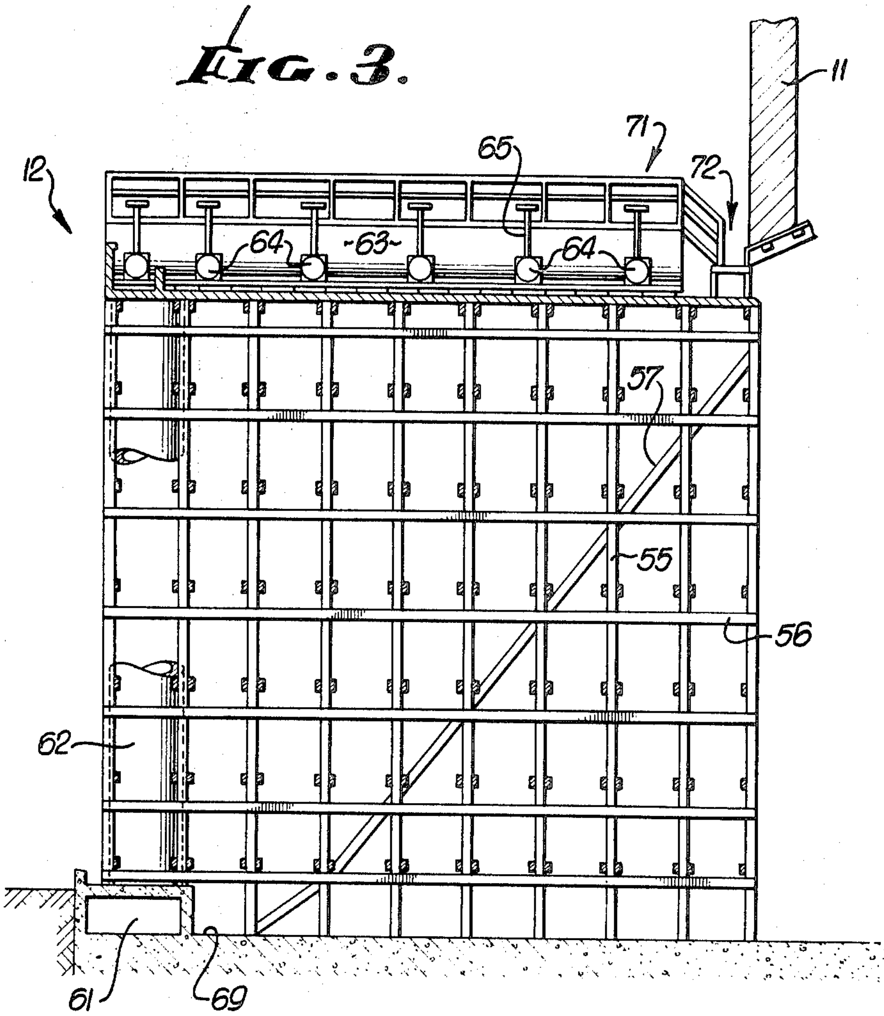
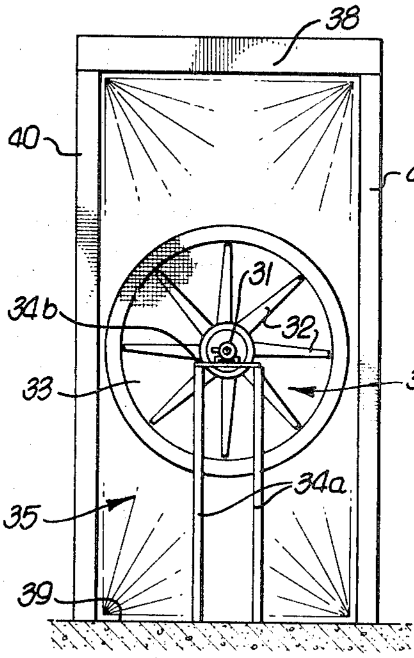


FIG. 5.



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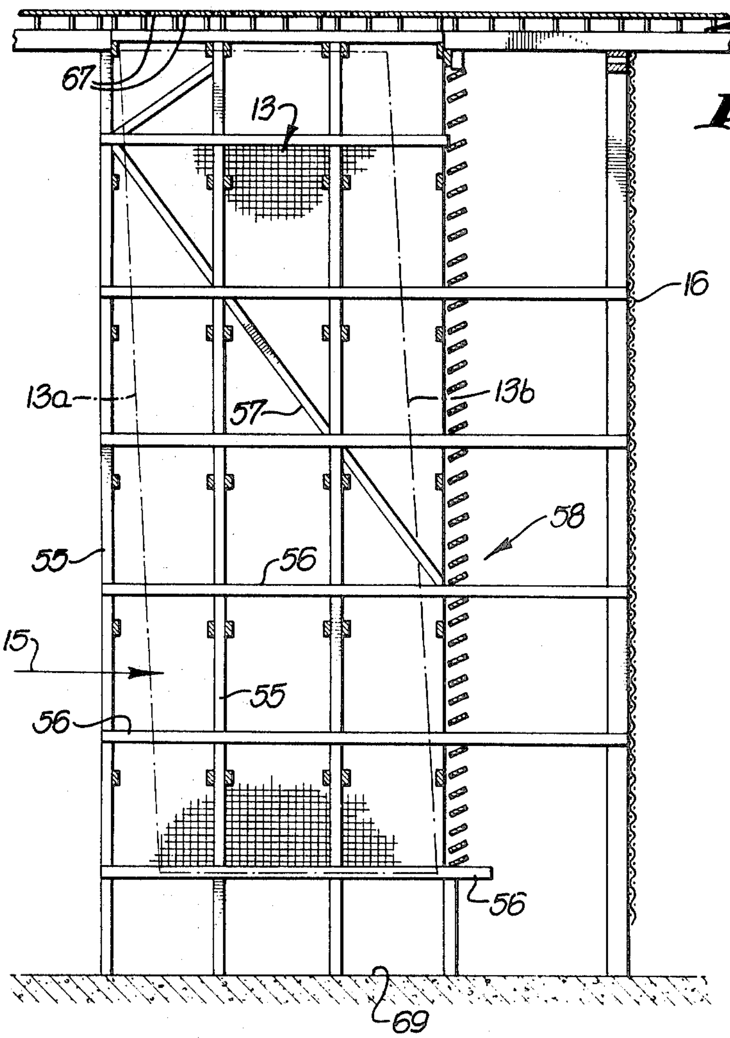
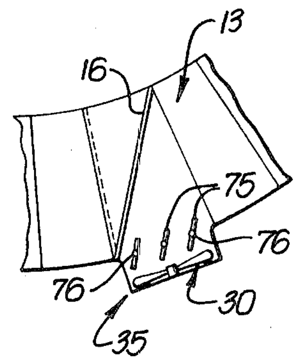


FIG. 4.

FIG. 8.



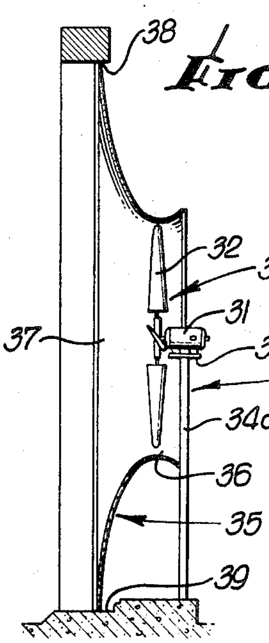
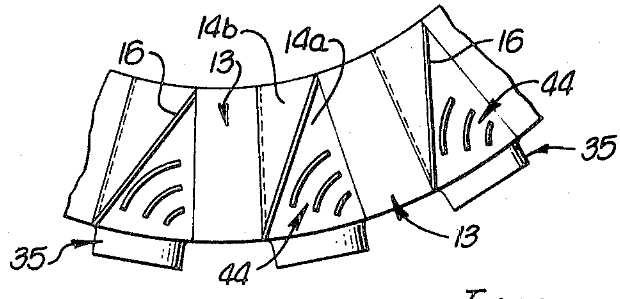


FIG. 6.

FIG. 7.



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MECHANICALLY ASSISTED SPIRAL-DRAFT WATER-COOLING TOWER

BACKGROUND OF THE INVENTION

This invention relates generally to mechanical and natural draft water-cooling towers, and more specifically concerns an unusually advantageous and economical tower construction with substantially increased water-cooling capacity.

Conventional mechanical and natural draft towers typically employ grid decking or packing for draining and splashing water in such dispersed condition as to be cooled by air streams passing generally horizontally through the packing. The packing decks normally extend continuously along the side or sides of such a tower in order to achieve direct inward flow through the packing of all air passing between the exterior and interior of the tower, this having been thought to be consistent with most economical tower construction and mode of operation. For example, it was thought that continuity of packing extent along the tower sides achieves maximum "surface" to "area" ratio, the surface referring to available wetted packing area presented to the entering air, and area referring to the ground area covered by the tower.

It has been found, however, that the construction and operation of conventional mechanical-draft towers present certain problems and lack of desired economies. For example, the length of packed sections is limited to the length of the tower side, limiting the water-cooling capacity of the tower below desired level; also, where fans were located outside the tower, the amount of packing was reduced by virtue of the location of individual packing sections adjacent the discharge sides of the fans, resulting in unequal airflow into the packing sections, a tendency to icing of the fans in cold weather due to water-droplet splash, and unused gaps between the packing sections as in U.S. Pat. No. 2,732,190 to Mart.

BRIEF SUMMARY OF THE INVENTION

It is a major object to provide a mechanical or natural draft tower construction such as will overcome the above-referred-to problems, as well as others, while at the same time providing unusual advantages contributing to reduction in space occupied by a tower of given capacity, production of spiral flow of air into the tower interior and a gain in tower-operating economy. Basically, the invention is embodied in a tower construction that includes a series of fans spaced about and outwardly of the tower upright axis; plenum passages spaced about that axis and in the path of gas displacement by the fans; multiple packing sections spaced about the axis and located in the spaces between the passages for inlet exposure to the passages and outlet exposure to the tower interior; partitions to direct the flow of gas into the packing sections after gas reception in the passages so that the resultant flow swirls about the tower axis, and means to supply water (or other liquid) for dispersal within the sections to be cooled by the gas flow therethrough. As a result, the passages act to equalize the fan-discharge flow to the packing sections, and also to isolate the fans from water splash near the packing, to prevent fan icing. Also, the structure enables housing of dampers, doors or similar devices for regulating airflow into the tower as required for cold-weather operation. The tower shell may be of right circular cylindrical, hyperboloid of revolution or other geometrically regular form.

Typically, the tower construction may include certain upright partitions extending within the spaces between the packing sections to confine the air to enter the sections at the inlet sides and to flow laterally within the sections, such partitions for example extending diagonally between the outer extents of the outlet sides of the sections and the inner extents of the inlet sides of the sections to effect the spiral flow. As will be seen, the fans are typically mounted at the tower periphery outwardly of the spaces between the packing sections to direct airflow toward the diagonal partitions. Further, the tower construction may include other partitions covering the outermost and innermost extents of the packed sections.

Additional objects and advantages of the invention include the provision of fan shrouds extending with gas-directing diffusing divergence from the fan peripheries toward adjacent packing sections; the provision of packing sections circularly arranged about a vertical central axis with section elongation generally radially; the provision of vanes in the passages or spaces between the packing sections and angled to guide the fan-displaced gas flow into the packing sections; the provision for inlet flow of air to the plenum passages in bypassing relation to the fans when the latter are shut down, to enable natural-draft mode of tower operation; the provision of water-supply means including a water basin overlying the section and spaces therebetween, the basin having dispersal openings located only over the sections; the provision of means including piping having water outlets directed to discharge water into the basin to flow therealong and over the sections and spaces therebetween; and the provision of a basin underlying such spaces to receive water splashing into the spaces from the packing sections. Conventional natural-draft cooling tower, usually of hyperboloidal shape depend largely upon the lesser density of the moisture laden interior air than ambient air to create the draft or air movement. During ambient atmospheric conditions unfavorable to the creation of sufficient draft for desired cooling performance; the present invention on the other hand provides auxiliary fans to create the needed air movement (quantity). In a similar manner, the addition of fans can reduce the design size of the cooling tower where available site area is limited.

These and other objects and advantages of the invention, as well as the details of illustrative embodiments, will be more fully understood from the following specification and drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevational showing of one form of mechanical-draft tower incorporating the invention;

FIG. 2 is a fragmentary plan view of a portion of the FIG. 1 tower, and partly broken away to show interior construction;

FIG. 3 is an enlarged elevation taken in section on line 3—3 of FIG. 2;

FIG. 4 is an enlarged elevation taken on line 4—4 of FIG. 2;

FIG. 5 is an enlarged elevation taken on line 5—5 of FIG. 2;

FIG. 6 is an enlarged elevation taken on line 6—6 of FIG. 2;

FIG. 7 is a schematic plan view of a modified form of the invention; and

FIG. 8 is another schematic plan view of a further modified form of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring first to FIGS. 1–6, the illustrated water-cooling tower **10** is of mechanical-draft type, wherein air is displaced horizontally into the lower interior of the tower and rises in the stack **11** of vertical cylindrical shape and defining a central axis **10***a*. The stack has modular panel construction, as shown, and is circular in horizontal planes as is the annular lower portion **12** of the tower. While airflow to cool dispersed water is described, it will be understood that gas flow to cool liquid is comprehended within the scope of the invention.

Included in the tower is a plurality of water-receiving packing sections having inlet and outlet sides laterally separated in a direction generally lengthwise or circumferentially of the tower horizontal periphery. As seen in FIG. 2, the sections **13** are typically rectangular in plan view with inlet and outlet sides **13***a* and **13***b* separated in the circumferential direction. Further, the sections **13** are circularly arranged about the vertical central axis **10***a* of the tower, with spacing therebetween indicated at **14** for reception of air between the sections. Air displaced into these spaces, or plenum passages **14***a* then turns to flow through the sections **13** between sides **13***a* and **13***b*, and is subsequently received in spaces **14***b* for exit flow to the tower interior **100**. Arrows **15** designate the general flow path. As is clear from FIG. 2, the flow through the sections **13** has a substantial component **15*a*** concentric with the (circumferential) direction of the tower horizontal periphery, and the resultant flow into the tower interior and about axis **10*a*** produces a swirl effect. The latter upward spiral course of the positive flow induces enhanced mixing of the moisture-laden air or gas, so as to decrease the density thereof in order to increase the tendency of the air to rise in the tower. The airflow may typically approach a turbulent-flow state, permitting increased air-water contact with consequent raising of the wet bulb temperature of the exit air, thereby improving the water-cooling performance.

Certain partitions or control baffles extend within the plenum passages **14** to direct the air to enter the sections **13** at their inlet sides, to flow laterally therein as described. For example, vertical partitions **16** may be provided to extend diagonally between the outer extents **17** of the outlet sides **13*b*** of the sections **13** and the inner extents **18** of the inlet sides **13*a*** of the sections. Further, other vertical partitions **19** and **20** are provided to cover the outermost and innermost extents of the sections **13**. Such partitions may extend throughout the vertical heights of the sections **13** to block airflow through those inner and outer extents or ends.

Typically, the like sections **13** are radially horizontally elongated and the overall radial dimension of the section multiplied by the number of such sections substantially exceeds the boundary dimension (as for example circumference of tower lower portion **12**) defined by the outer extents of the sections. Accordingly, a substantially higher than normal ratio of "surface" to "area" is achieved, these terms having been previously defined.

Extending the description to FIGS. **5** and **6** fans **30** are spaced in circular series about axis **10*a*** and radially outwardly therefrom, the fans also being spaced outwardly of the plenum passages **14*a*** and oriented to positively displace air into those spaces when the fans are rotated by motor **31**. Accordingly, the fans are kept well away from the sections **13** to prevent icing of the blades due to water splash in cold weather. Also, flow of air into the sections is equalized by the plenum passages. In this regard, the fans have blades **32** and may be housed in such relation to passages **14*a*** that air may freely flow past the fans and into those passages when the fans are shut down, providing an auxiliary natural-draft mode of tower operation as may be desirable or effective under certain weather condition. For example, the spaces **33** between the blades may pass such airflow, or alternatively the fan housing may provide for such bypass flow. The fan motors **31** may be supported on stands **34** having legs **34*a*** and a crosspiece **34*b*** as shown.

Housing of the fans **30** may be effected by means of shrouds **35** having venturi shape, forming throats **36** receiving the fans and diffuser sections **37** to expand the flow to the full vertical flow area of the plenum chambers. The shrouds may, for this purpose be vertically elongated as seen in FIG. **5**, and extend with divergence to tops and bottoms **38** and **39** of the passage opening, and to the vertical sides **40** and **41** thereof.

FIG. **7** illustrates the use of additional flow guides such as vanes **44** in passages **14*a***, and angled to direct the fan-discharge flow uniformly into the packing sections. Dampers may be used to regulate the inlet airflow, as during cold-weather operations. See, for example, dampers **75** movable in shroud **35** in FIG. **8**, as by pivoting at **76**.

Referring back to FIGS. **1–4**, means is provided to supply liquid, as for example water, for distribution within the sections in order to be cooled by airflow through the latter, the water typically falling in dispersed drops which splash and film on the decking surfaces or slats. Many different types of decking or fill may be used, FIG. **4** indicating a closely packed section **13** of such fill as inclined downwardly and in the direction **15** airflow through the fill, water particles tending to fall in the packing with corresponding angularity from vertical. Tower structure supporting the fill includes columns **55**, ties **56** and bracing **57**. An upright drift eliminator **58** is spaced close to the outlet side **13*b*** of the packing for eliminating drift particle form the exit air stream.

The water supply means illustrated in the drawings includes a hot water basin **60** overlying the packing sections **13** and the spaces **14*a*** and **14*b*** therebetween. As seen in FIG. **3**, hot water may be pumped from a concrete supply conduit **62** upwardly within a riser **62** to a flume or piping **63** extending transversely and and inwardly across the basin **60**. The latter has multiple outlets **64**, individually valve controlled at **65**, directed to discharge water into the basin for open-channel flow therealong in the length direction of the basin. The basin has intermittent groups **66** of distribution openings **67** located lengthwise thereof, for dispersing water into and onto the decking or packing sections **13**; also the basin over the spaces **14** between sections **13** is free of such holes so that water does not drain from the basin into the interiors of those air spaces. On the other hand, any water splashing from the packing into the spaces **14** falls into the collection basin **69** at the bottom of the tower, and no louvers are needed to intercept such splash since spaces **14** are within the tower.

To complete the description, an access walkway is shown at **71** over the piping **63**; walkway **72** extends along and at the inner side of the basin **60**.

I claim:

1. In a mechanical-draft-liquid cooling tower having an upright axis, the combination comprising

a. a series of fans spaced about and outwardly from said axis,
b. means defining a series of plenum passages spaced about said axis and in the direct path of gas displacement by the fans, toward the tower interior,
c. multiple packing sections spaced about said axis and located in the spaces between said passages, said sections having inlet exposure to the passages and outlets communicating with the tower interior,
d. said means including generally upright partitions to direct the fan-displaced gas into said packing sections after reception of the gas in said passages, and with directional flow components angled from said axis so that the gas upon exiting from said sections flows in an upward spiral course about said axis within the tower interior, said partitions extending within the plenum passages, and
e. means to supply liquid for dispersal within said sections to be cooled by the gas flow therethrough

2. In a mechanical-draft cooling tower having a generally circular horizontal cross section and a vertical axis, the combination comprising,

a. a plurality of upright generally annularly spaced packing sections having open inlet and outlet sides laterally separated in a direction generally lengthwise of the tower periphery, the sections being spaced in said direction and about said axis for reception of gas therebetween prior and subsequent to gas flow through the sections between said sides so that the flow through the sections has substantial components parallel to said direction, the sections also being radially outwardly spaced from said direction, the sections also being radially outwardly spaced from said axis,
b. certain upright partitions located in said spaces between the sections and extending generally diagonally between the outer extents of said outlet sides of the sections and the inner extents of the inlet sides of the sections, thereby to direct the gas to flow in a spiral course about said vertical axis as the gas passes through the sections and into the tower interior inwardly of said sections, there being other partitions located at the radially inner and outer ends of the sections to block airflow therethrough,
c. multiple fans mounted to discharge gas under pressure into said spaces at the inlet sides of the sections for forced-draft flow through the sections, and
d. means to supply liquid for dispersal within said sections to be cooled by the gas flow therethrough, said flow in a spiral course inducing enhanced mixing of the moisture-laden gas so as to decrease the density thereof thereby to increase the tendency of the gas to rise in the tower.

3. The combination of claim 2 wherein said fans are mounted at the tower periphery to direct said discharge gas toward the diagonal partitions.

4. The combination of claim 3 including fan shroud each extending with gas-diffusing divergence from the fan peripheries toward the adjacent packing section.

5. The combination of claim 4 wherein said shrouds are vertically elongated.

6. The combination of claim 4 wherein the fans are located directly outwardly of spaces.

7. The combination of claim 3 including vertically elongated vanes located in said spaces radially inwardly of the fans and angled to guide the gas flow into said sections.

8. The combination of claim 1 wherein the fans have blades and are housed in such relation to said passages that gas may flow past the fans into said passages when the fans are shut down.

9. The combination of claim 4 including damper means mounted for movement within at least one shroud for regulating inlet airflow.

10. In a natural-draft liquid-cooling tower having an upright axis, the combination comprising

a. a series of fans spaced about and outwardly from said axis,

b. means defining a series of plenum passages spaced about said axis and in the direct path of gas displacement by the fans, toward the tower interior,

c. multiple packing sections spaced about said axis and located in the spaces between said passages, said sections having inlet exposure to the passages and outlet communicating with the tower interior,

d. said means including generally upright partitions to direct the fan-displaced gas into said packing sections after reception of the gas in said passages, and with directional-flow components angled from said axis so that the gas upon exiting from said sections flows in an upward spiral course about said axis within the tower interior, said partitions extending within the plenum passages, and

e. means to supply liquid for dispersal within said sections to be cooled by the gas flow therethrough.

11. In a natural-draft cooling tower having a generally circular horizontal cross section and a vertical axis, the combination comprising,

a. a plurality of upright generally annularly spaced packing sections having open inlet and outlet sides laterally separated in a direction generally lengthwise of the tower periphery, the sections being spaced in said direction and about said axis for reception of gas therebetween prior and subsequent to gas flow though the sections between said sides to that the flow through the sections has substantial components parallel to said direction, the sections also being radially outwardly spaced from said axis,

b. certain upright partitions located in said spaces between the sections and extending generally diagonally between the outer extents of said outlet sides of the sections and the inner extents of the inlet sides of the sections, thereby to direct the gas to flow in a spiral course about said vertical axis as the gas passes through the sections and into the tower interior inwardly of said sections, there being other partitions located at the radially inner and outer ends of the sections to block airflow therethrough,

c. multiple fans mounted to discharge gas under pressure into said spaces at the inlet sides of the sections for forced-draft flow through the sections, and

d. means to supply liquid for dispersal within said sections to be cooled by the gas flow therethrough, said flow in a spiral course inducing enhanced mixing of the mositure-laden gas so as to decrease the density thereof thereby to increase the tendency of the gas to rise in the tower.

12. The combination of claim 11 wherein said fans are mounted at the tower periphery to direct said discharge gas toward the diagonal partitions.

13. The combination of claim 12 including fan shrouds each extending with gas-diffusing divergence from the fan peripheries toward the adjacent packing sections.

14. The combination of claim 13 wherein said shrouds are vertically elongated.

15. The combination of claim 13 wherein the fans are located directly outwardly of said spaces.

16. The combination of claim 12 including vertically elongated vanes located in said spaces radially inwardly of the fans and angled to guide the gas flow into said sections.

17. The combination of claim 10 wherein the fans have blades and are housed in such relation to said passages that gas may flow past the fans into said passages when the fans are shut down.

18. The combination of claim 13 including damper means mounted for movement within at least one shroud for regulating inlet airflow.