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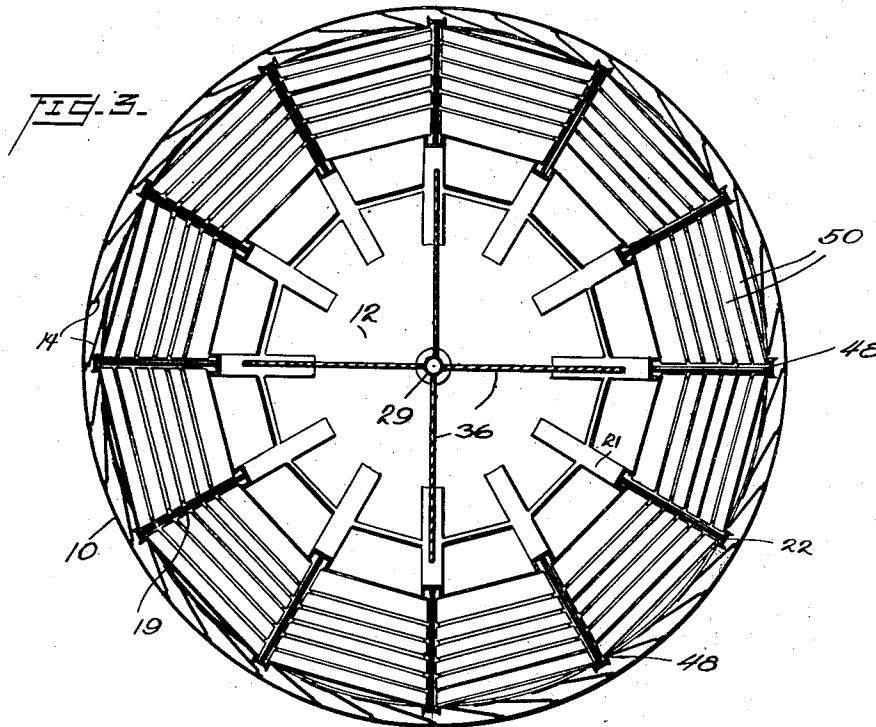
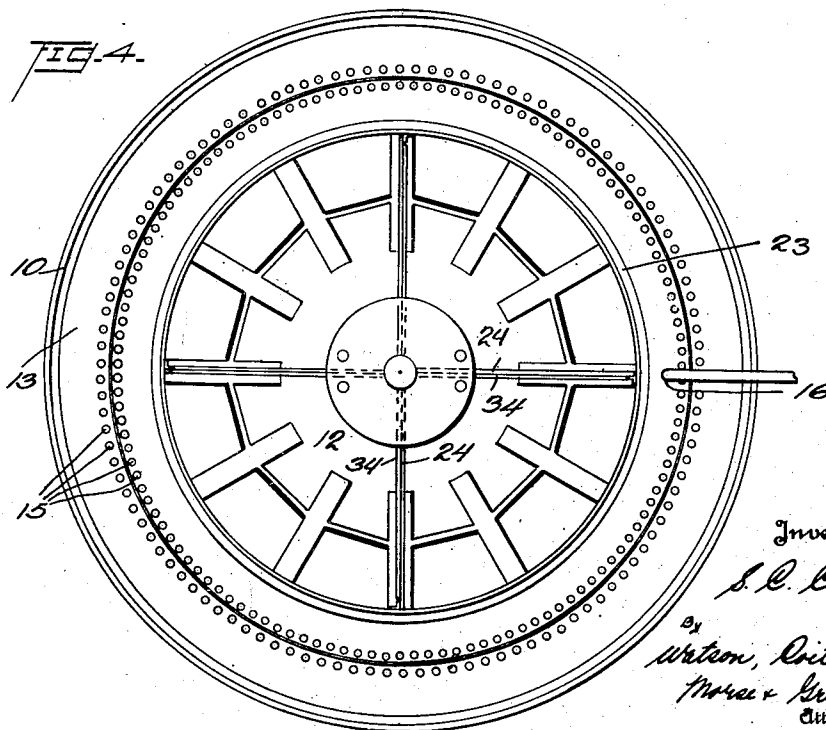
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COOLING TOWER

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COOLING TOWER

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16 Claims. (Cl. 261—79)

This invention relates to apparatus for cooling liquid and, more particularly, to that type of cooling apparatus wherein liquid is cooled by contact with a current of air.

It is the principal object of the present invention to provide a liquid cooling apparatus in which the size of the apparatus and consequently the space required for installation is relatively small as compared with the quantity of heat extracted from the water in a given time. The desired result is obtained in the present instance by the adoption of the cyclonic principle of operation, that is to say, by imparting a circular motion of high velocity to the air in contact with the liquid to be cooled and withdrawing the moist and heated air along the axis of the circular path followed by the air.

Difficulty has been experienced in this type of apparatus as the result of the high velocity developed adjacent the center of the whirling body of air in the path of air discharge. For instance, it has been found that certain cooling apparatus employing the cyclonic principle in which the velocity of motion of the air at the periphery of the circular path is ten feet per second, the air develops a velocity of forty or fifty feet per second adjacent the axis about which the air is caused to rotate or whirl. This high central velocity in the path of air discharge results in the production of a water spout or geyser of water, the water being withdrawn from the cooling zone or from a collecting trough beneath the cooling zone and discharged with terrific force along the axis of circular motion. This difficulty can be overcome by reducing the velocity of the air, but it will be appreciated that any reduction of the speed of motion of the air will reduce the capacity of the apparatus. It is therefore a further object of the present invention to provide cooling apparatus of the type specified in which the amount of water discharged with the vented air is reduced to a minimum whereas the velocity of the air is limited only by the mechanical strength of the cooling apparatus.

It is a further object of the present invention to so control the fall or showering of liquid within the chamber that the minimum of resistance will be offered to the rapid circulation of the air contacting therewith, the current of air following substantially the same path and remaining in intimate contact with the particles of liquid regardless of the amount of liquid in circulation.

More specifically stated, it is an object of the invention to impart motion in a substantially circular path to air within a cooling chamber, and to shower liquid through the moving air in such manner that any sheets of falling liquid formed will be substantially aligned with the direction of flow of air.

The word "sheet" as used herein is not intended to restrict the description to the projection of a continuous unbroken film of liquid, but to define the liquid discharge as one in which a series of adjacent particles of liquid, even though separate and distinct, extend in a given direction and form what may be referred to as an "envelop". For instance, a sheet of liquid may be formed by passing liquid through a series of spaced apertures in a tray. If the apertures are arranged in a straight line, the falling particles from a sheet or envelop defining a plane, whereas if the apertures are circularly arranged, the resulting sheet defines a cylinder.

A further object of the invention is the provision of means for preventing the introduction of the circulating liquid into the path of the discharging air and for preventing loss of liquid from any point in the chamber by the action of forces tending to deflect the liquid from the normal prescribed path followed thereby or by reason of the introduction of an excess supply of liquid into the chamber.

A further object of the invention is the construction of an apparatus of the type described in such manner as to provide the maximum of contact at a high velocity between the air and liquid with a minimum expenditure of power.

A further object of the invention is the provision of apparatus suitable for use in a continuous cooling system for efficiently reducing the temperature of water circulated in the system and particularly applicable in connection with the cooling of theaters, auditoria, restaurants, and for the cooling of the water of Diesel engines and the condensers of steam power plants. When applied to these and similar purposes the water may be cooled in advance of use and then discharged as waste, but preferably the water is recirculated and additional water is introduced into the system sufficient only to replace such water as is lost by evaporation, leakage and other small losses.

Further objects and features of the invention will be apparent from the following description taken in connection with the accompanying drawings, in which:

Figure 1 is an elevational view of one form of apparatus illustrating the principles of the present invention;

Figure 2 is a vertical sectional view of the apparatus shown in Figure 1;

Figure 3 is a section on the line 3—3 of Fig. 2; and

Figure 4 is a plan view of the apparatus.

It will be seen that the apparatus takes the form of a cylindrical chamber into which the water or other liquid and air are introduced, it being understood that the shape and dimensions of this chamber are not material, although it has

been found in general that the cylindrical form of chamber or tower is best adapted to the production and maintenance of a circularly moving air stream. The water or other liquid to be

5 cooled is preferably introduced at the top of the chamber adjacent the periphery, is showered down through the chamber, and after the temperature has been sufficiently reduced, is drawn off at the lower end of the chamber. The air
10 enters the chamber peripherally thereof, preferably in a tangential direction, and follows a circular path through the falling water, being eventually discharged along the axis of the chamber and preferably in an upward direction.
15 In the drawings, the chamber is indicated generally by the reference numeral 10 and comprises a base 12 in the form of a basin for receiving the cooled water or other liquid, an annular trough 13 at the upper end of the chamber
20 for the reception of water to be cooled, and vanes 14 extending between the base and the receiving trough 13 and constituting the peripheral wall of the chamber, these vanes being preferably arranged as shown in Figure 3 to form
25 louvers through which air may be admitted in a direction substantially tangentially of the chamber 10. An inlet pipe 16 for the heated water discharges into the trough 13 at the upper end of the chamber and the base 12 of the chamber is
30 provided with a discharge outlet 17 through which the cooled water may be withdrawn. A valve controlled pipe 18 is preferably connected with the discharge outlet 17 for the purpose of introducing liquid into the system, and when a
35 closed circulating system is used, liquid is introduced through the pipe 18 only in an amount sufficient to replace such liquid as is lost by evaporation and leakage. It will be understood that in the application of the apparatus to a
40 closed cooling system the liquid from the discharge outlet 17 is conveyed to the place of use and is returned at a substantially higher temperature and delivered through the inlet pipe
45 16 into the trough 13. A series of annular trays 19, described more in detail hereinafter, are disposed within the chamber and about the periphery thereof. Apertures 15 are provided in the
50 base of the trough 13 and in each of the superimposed trays, so that water introduced into the trough is showered down through the successive trays and is finally discharged through the outlet 17 in the base of the chamber.

A fan casing 23 disposed centrally of the chamber and preferably at the upper end thereof
55 encloses a fan 24 which serves to draw air through the vanes 14 about the periphery of the chamber, across the trays in intimate contact with the falling liquid, and upwardly through the central portion of the chamber, the air being
60 exhausted through the casing 23. The fan 24 is preferably driven by a motor 25 located beneath the chamber, a shaft 27 on which the fan is mounted serving to connect the motor and fan, although it will be understood that the motor
65 may be located above the chamber and adjacent the fan, if desired. A tubular housing 29 extends upwardly along the axis of the chamber and serves to encase the fan shaft 27, a suitable bearing 30 for the fan shaft being provided at
70 the upper end of the housing. Adjacent its upper end, the fan shaft housing 29 is supported by horizontally extending stays 32 disposed between the housing and the fan casing 23. Supporting stays 34 may also be provided between
75 the stays 32 and the fan shaft bearing 30 to en-

sure accurate alignment of the fan shaft with the chamber axis.

As pointed out hereinbefore, circular motion of the air is induced by the fan and the tangential arrangement of the louvers 14 to cause the air
80 to pass rapidly over the trays 19 and in intimate contact with the falling water. The velocity of this circular motion increases toward the central axis of the chamber so that there is a tendency to draw water from the base 12 upwardly through the chamber and discharge the
85 same, together with the vented air, in the form of a water spout or geyser. Furthermore, the tremendous velocity of the air frequently effects withdrawal of the falling water and discharge
90 thereof in the form of spray.

To avoid these difficulties I provide a plurality of baffles 36, extending radially of the chamber, and secured to the tubular housing 29, these
95 baffles being preferably strengthened by attachment to the stays 32 adjacent the upper end of the chamber. It has been found that this arrangement effectively reduces or prevents circular motion of the air adjacent the axis of the chamber and thereby prevents the withdrawal
100 of water or spray with the discharged air.

The trays or baffles 19 may consist of perforated annular or sector shaped baffle plates or may assume any other conventional form calculated to retard the downward movement of the
105 liquid, provided the fall of water is controlled in the manner described hereinbefore so that the resistance which the falling water offers to the flow of air is reduced by suitable disposition of the apertures or openings in the trays with respect to the path of the moving air within the
110 chamber. A preferred arrangement of these trays or baffles is illustrated in the drawings in which each tray is represented as comprising substantially an annulus consisting of a plurality of separate plates 50 extending between
115 and having the ends thereof resting on or secured to a number of radially disposed supporting elements 48. The elements 48 may conveniently consist of inverted T-shaped bars and
120 are supported at the inner and outer ends thereof on channel members 21 and 22 respectively, to which they are secured in any desired manner. These channel members extend between and may be suitably secured to the base 12 and the trough
125 13, the members 21 being inclined so that the lower trays will be of larger area whereby more effective heat transfer may be obtained between the partially cooled water and the incoming air and the movement of different volumes of air
130 through different portions of the chamber may be facilitated, as hereinafter more fully explained.

It will be noted from Figure 3 of the accompanying drawings that the plates 19 intermediate each pair of adjacent elements 48 are spaced
135 radially of the cooling chamber to permit liquid to fall therebetween, and by reason of this chordal arrangement of the plates the liquid discharging from each tray will fall in a series of thin, substantially continuous sheets each approximating a cylindrical form about the chamber. It will thus be observed that these liquid
140 sheets are substantially aligned with the general direction of movement of air within the outer portion of the chamber and no appreciable resistance will be offered to the circular flow of air by the falling liquid. The spacing of the plates
145 19 in successive trays is preferably staggered to ensure that the falling liquid will strike each

tray, and be retarded thereby, this being conveniently effected by providing outermost plates of different width in the successive trays without altering the spacing between the plates.

5 It will also be noted that the innermost and outermost plates in each tray are inclined from the horizontal to prevent possible discharge of liquid over the inner and outer circumferences of the trays. This feature is of particular importance in preventing discharge of liquid from the trays into the central portion of the chamber through which the air is being discharged since such liquid is carried out of the chamber in the form of spray which is highly objectionable aside from the loss of water which it entails. It will be appreciated that the incoming air is moving not only in a circular path, but is constantly crowded in toward the center of the chamber, this action being produced by the draft from the fan. This constant inward movement of the air tends to move such water as falls on the trays 19 inwardly of the chamber and spilling of the water from the trays into the central portion of the chamber is prevented by the arrangement just described.

10 If desired, the plates 19 may be curved so that each tray will assume the precise form of an annulus, but the chordal arrangement shown herein is cheaper and easier to construct and has been found extremely efficient in practice in facilitating the circular movement of air through the chamber, so that regardless of the quantity of liquid handled, the air is not deflected materially from the prescribed path of movement and highly uniform cooling is obtained.

15 If the trays or baffles consist of continuous annuli, or are constructed otherwise than as herein described so that the liquid must be discharged through perforations in the trays, a similar effect may be obtained by arranging the perforations in each tray to form a series of concentric circles about the central portion of the chamber.

20 The movement of the air in the direction of discharge is assisted materially by the action of centrifugal force resulting from the circular motion imparted to the incoming air. The air which has become warm and humid by passage through the liquid is lighter than the cooler dry air introduced through the louvers, and the heavier air tends to remain near the periphery of the chamber so that a natural draft is formed which assists the fan materially in effecting introduction and discharge of the air. When these factors are taken into consideration, it is found that the best results are obtained when the interior diameter of the lowest tray is substantially one half the diameter of the fan, there being obviously a greater volume of air passing in the direction of discharge through the upper portion of the chamber than through the lower portion. It will furthermore be noted that the trays 19 should be spaced further apart toward the lower end of the chamber and the louvers are also preferably arranged so as to admit the air more freely at the lower end of the chamber than at the upper end. The proper spacing of the louvers can best be obtained by constructing the louvers of greater width at the top than at the bottom so that adjacent louvers overlap to a greater extent at the upper end of the chamber. In this manner the resistance offered to the passage of air entering near the lower end of the chamber by reason of the greater length of the path followed is materially reduced and ap-

proximately the same volume of air may be caused to pass between each pair of adjacent trays whereby a more uniform and intimate mixing of the air and liquid is obtained.

Specific reference is made in the foregoing description to the use of the apparatus for contacting water and air for the purpose of reducing the water temperature, but it will be understood that the structure described herein is useful in carrying out various processes involving intimate association of liquid and gaseous matter aside from heat transfer processes, for instance, in effecting chemical combinations of liquids and gases, washing and scrubbing gases, or humidifying air.

While the invention has been described with reference to the specific embodiments shown in the drawings, it will be appreciated that various alterations may be made as to form and shape of the component parts of the apparatus and that all such changes are contemplated as fall within the spirit and scope of the appended claims.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. In a cooling tower for liquid, of the type wherein the liquid passing through the tower is contacted by a current of air flowing into and out of the tower, the combination with means for producing a whirling motion of the air within the tower about a central axis and for venting the air adjacent and in a direction parallel to the central axis, of means for causing the liquid to fall through the whirling air in such manner as to form a series of lanes for the passage of air extending in the general direction of whirling movement of the latter.

2. In a cooling tower for liquid, of the type wherein the liquid passing through the tower is contacted by a current of air flowing into and out of the tower, the combination with means for causing air to enter the tower laterally, follow a substantially circular path about the longitudinal axis of the tower and be discharged upwardly adjacent the said longitudinal axis, of means for showering the liquid in a sheet extending generally in the direction of circular movement of the air.

3. In a heat exchange apparatus, the combination with a substantially cylindrical chamber, of means for causing air to enter the periphery of the chamber and to be discharged axially thereof, a series of superimposed annular trays having openings therein for the passage of liquid disposed adjacent the chamber periphery, said openings being arranged in the general direction of the movement of the air adjacent the chamber periphery, and means for introducing liquid on the uppermost tray of the series.

4. In a heat exchange apparatus, the combination with a substantially cylindrical vertically disposed chamber, of means for causing air to enter the periphery of the chamber and be discharged along the chamber axis, a plurality of superimposed annular trays disposed adjacent the chamber periphery, said trays having openings therein to permit passage of liquid, the openings in each tray being arranged in a plurality of series, the openings in each series extending generally in the direction of movement of the air in the vicinity of the trays.

5. A cooling tower comprising a chamber having an inlet and an outlet for liquid to be cooled, said chamber being constructed to permit pas-

sage of the liquid therethrough adjacent the periphery of the chamber, means for causing air to enter the chamber, to follow a substantially circular path about the periphery of the chamber while contacting with the liquid passing therethrough, and to be discharged adjacent the central portion of the chamber in a direction substantially parallel to the axis of the circular path, means for confining the passage of liquid through the chamber to form a series of lanes therein extending generally in the direction of the circular path followed by the air, and means for reducing the velocity of circular motion of the air adjacent the central portion of the chamber.

6. In apparatus for cooling liquid, the combination with a substantially cylindrical, vertically disposed chamber arranged to permit passage of liquid therethrough in a downward direction and adjacent the periphery of the chamber, of means for causing a current of air to enter the chamber tangentially thereof, to pursue a substantially circular path adjacent the periphery of the chamber and in contact with the liquid, and to pass upwardly through the central portion of the chamber, means for confining the passage of liquid through the chamber to form a series of lanes therein extending generally in the direction of the circular path followed by the air, and means for obstructing the motion of the air in a circular path in the central portion of the chamber.

7. In a heat exchange apparatus, the combination with a vertically disposed chamber, of a series of superimposed trays having openings therein to permit passage of liquid, said trays being supported within said chamber and about the periphery thereof, means for introducing liquid on the uppermost tray of the series, means extending slightly above each tray and about the inner edge thereof to retain liquid thereon, said tray openings being substantially arcuately arranged with reference to the central portion of the chamber, and means for causing air to pass through and over the liquid.

8. A method of cooling liquid, which comprises causing air to flow in a substantially circular path, and showering liquid through and transversely of the moving air in sheets extending in the general direction of the flow of air with the sheets of liquid spaced radially of the center of the circular air path.

9. A method of cooling liquid, which comprises causing air to flow in a spiral path, and showering liquid transversely of the said spiral path so as to form a series of substantially circular, liquid envelopes generally concentric with the said spiral path.

10. In a heat exchange apparatus, the combination with a chamber, of means for causing air to move in a substantially horizontal direction within said chamber, and a plurality of superimposed substantially horizontal baffles within said chamber, each baffle comprising a series of baffle plates spaced transversely of the direction of movement of the air to permit liquid to pass therebetween, and means for introducing liquid on the uppermost of said baffles.

11. In a heat exchange apparatus, the combination with a chamber, of means for causing air to move in a substantially horizontal direction in

a substantially circular path within said chamber, and a plurality of superimposed substantially horizontal baffles within said chamber, each baffle comprising a series of baffle plates spaced transversely of the direction of movement of the air to permit liquid to pass therebetween, and means for introducing liquid on the uppermost of said baffles.

12. In a heat exchange apparatus, the combination with a chamber, of means for causing air to move in a substantially horizontal direction in a substantially circular path within said chamber, and a plurality of superimposed substantially horizontal baffles within said chamber, each baffle comprising a plurality of series of baffle plates, the plates in each series being spaced radially of the center of the circular path followed by the air to form chordal openings, so that the entire series of plates in each baffle provide substantially circular passages for the liquid, and means for introducing liquid on the uppermost of said baffles.

13. In a heat exchange apparatus, the combination with a chamber, of means for causing air to move in a substantially horizontal direction in a substantially circular path within said chamber, and a plurality of superimposed substantially horizontal baffles within said chamber, each baffle comprising a plurality of supports radiating from the central portion of the chamber, and baffle plates carried between adjacent supports in substantially chordal arrangement, the adjacent plates being spaced radially to permit passage of liquid therebetween whereby liquid envelopes extending generally in the direction of the moving air may be formed.

14. In a heat exchange apparatus, the combination with a chamber, of means for causing air to move in a substantially horizontal direction within said chamber, and a plurality of superimposed substantially horizontal baffles within said chamber, each baffle comprising a series of baffle plates spaced transversely of the direction of movement of the air to permit liquid to pass therebetween, the openings formed by the spacing of the baffle plates in the successive baffles being staggered, and means for introducing liquid on the uppermost of said baffles.

15. In a heat exchange apparatus, the combination with a substantially cylindrical chamber, of means for causing air to enter the periphery thereof, a series of superimposed annular trays having openings therein for the passage of liquid disposed adjacent the chamber periphery, each tray consisting of a plurality of chordally arranged baffle plates, the innermost series of plates being canted to prevent accidental discharge of liquid radially inward.

16. In a heat exchange apparatus, the combination with a substantially cylindrical chamber, of means for causing air to enter the periphery of the chamber and to be discharged axially thereof, a series of superimposed annular trays having openings therein for the passage of liquid disposed adjacent the chamber periphery, each tray consisting of a plurality of chordally arranged baffle plates, the innermost and outermost series of plates being canted to prevent accidental discharge of liquid radially inward or outward of the trays.

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