HEAT EXCHANGER OR COOLING TOWER

Filed April 12, 1946 2 Sheets-Sheet 1

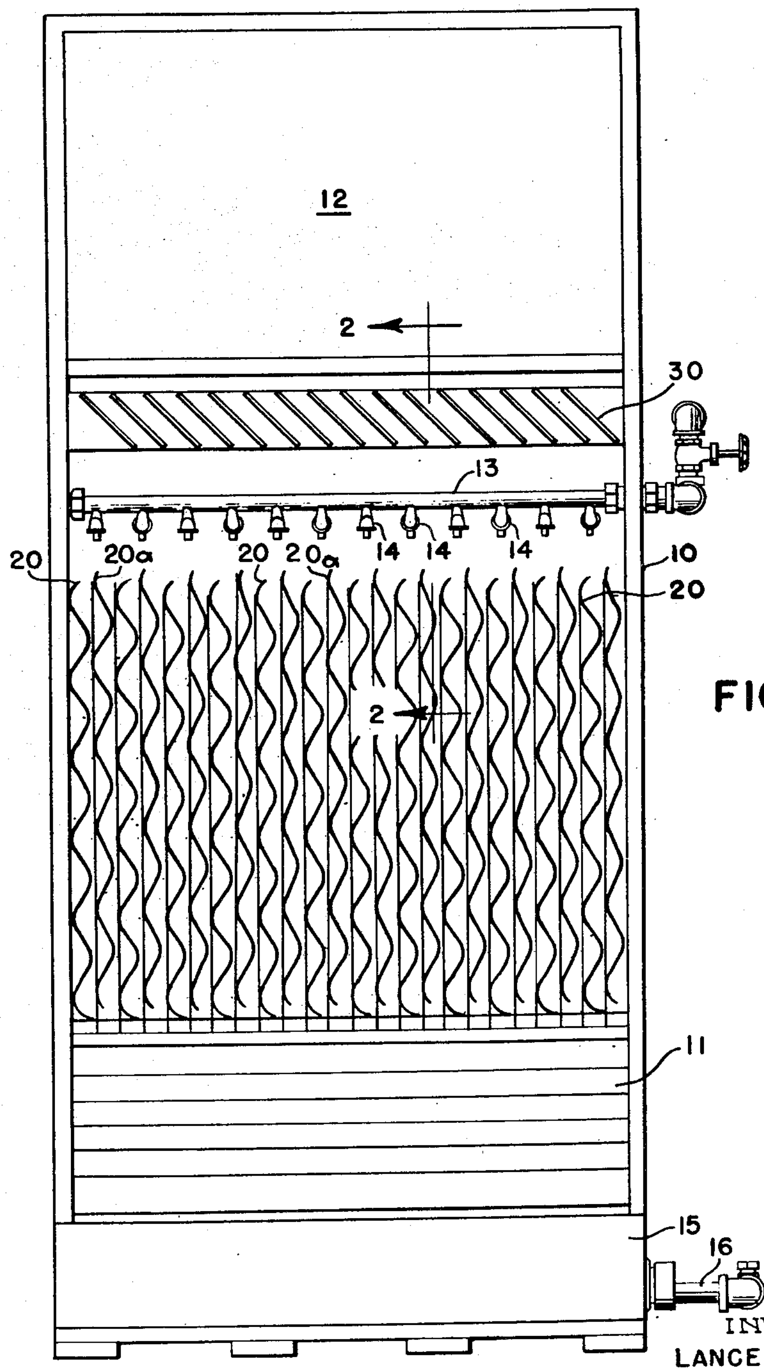


FIG. 1

INVENTOR
LANCE L. SIMMONS
BY
Toulmin & Toulmin
ATTORNEYS

Oct. 25, 1949. L. L. SIMMONS 2,485,849

HEAT EXCHANGER OR COOLING TOWER

Filed April 12, 1946 2 Sheets-Sheet 2

FIG. 2

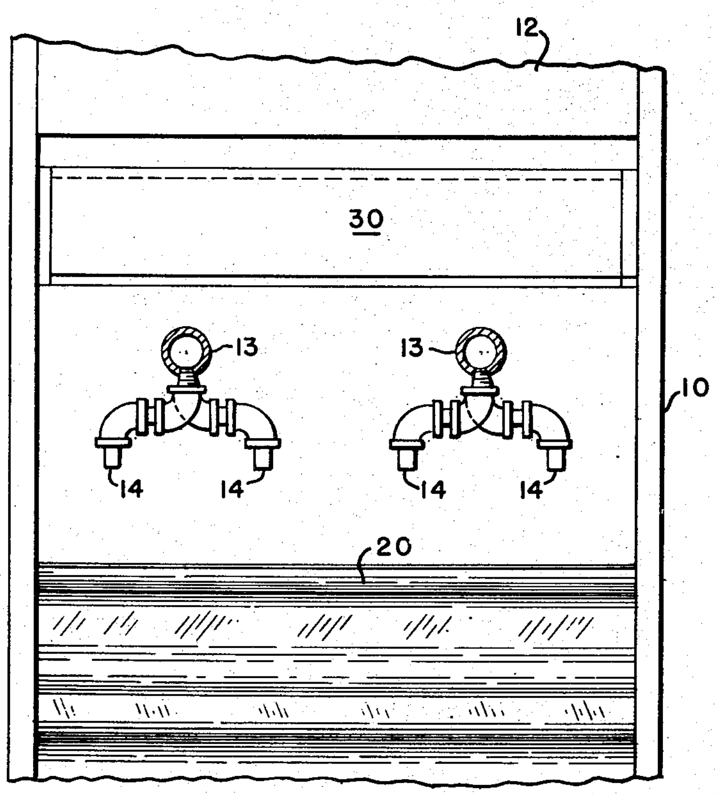
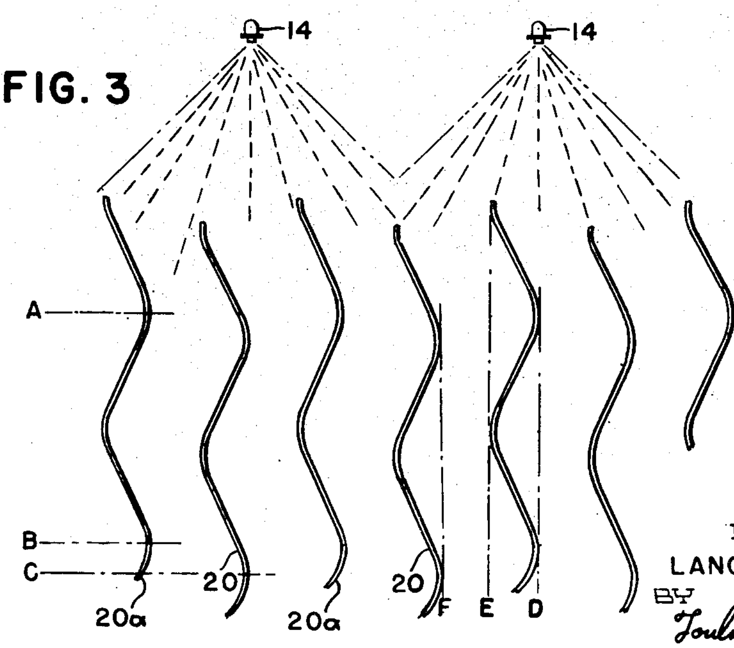


FIG. 3



INVENTOR
LANCE L. SIMMONS
BY
Toulmin & Toulmin
ATTORNEYS

Patented Oct. 25, 1949

2,485,849

UNITED STATES PATENT OFFICE

2,485,849

HEAT EXCHANGER OR COOLING TOWER

Lance L. Simmons, Detroit, Mich., assignor to American Blower Corporation, Detroit, Mich., a corporation of Delaware

Application April 12, 1946, Serial No. 661,481

5 Claims. (Cl. 261—112)

1

This invention relates to heat exchangers, and particularly to heat exchangers of the type having a plurality of plates therein over which liquid flows and a forced draft of air or other gas is directed between the plates for cooling the liquid.

An object of the invention is to provide a heat exchanger wherein the plates are formed and so arranged to increase the efficiency of operation of the heat exchanger.

Still another object of the invention is to provide a heat exchanger of the type referred to wherein the efficiency of the heat exchanger is increased without causing any increase in the resistance to the movement of gas under forced draft through the heat exchanger, and in fact reduce the horsepower consumed over known types of heat exchangers or cooling towers.

Another object of the invention is to provide a heat exchanger, or cooling tower, wherein a plurality of sinuous plates are positioned that alternate restricted and unrestricted vertical spatial volumes are provided by the spacing of the plates and alternate plates are offset in a horizontal plane so that the undulations form alternate horizontal chambers of increasing and decreasing area, to disturb or prevent any straight line flow of gas through the heat exchanger.

Further objects and advantages will become apparent from the drawings and the following description.

In the drawings:

Figure 1 is an end elevational view of a heat exchanger or cooling tower constructed in accordance with this invention, having an end wall plate removed to show the interior construction.

Figure 2 is a cross-sectional view taken substantially along line 2—2 of Figure 1.

Figure 3 is a fragmentary view illustrating the contour and spacing arrangement of the sinuous sheets used in the heat exchanger.

The heat exchanger or cooling tower of this invention is adapted to secure a high ratio of contact between liquid and gas moving in counterflow direction to obtain a high efficiency of heat transfer between the liquid and the gas. The cooling tower, or the heat exchanger, is adapted to secure this high ratio of contact while holding the resistance to flow of gas through the tower to a minimum amount, and reducing this resistance over that obtained in current practice. It is

2

therefore possible to increase the efficiency of the cooling tower because the horsepower required to move the air through the tower is reduced, the amount of liquid cooled through a predetermined differential remaining the same as can be obtained in current practice, or if the horsepower used is increased, the amount of liquid cooled can be increased over that obtained in current practice.

This is accomplished by providing a large number of closely spaced corrugated sheets over which the liquid to be cooled flows in thin films in counter-flow direction to the movement of a draft of cooling air or gas between the sheets. The corrugated sheets are provided with horizontally disposed undulations therein that form substantially identical reversely curved surfaces on opposite sides of a plane extending through the sheet substantially midway between the ridges formed by the undulations. The spaces between the sinuous sheets cause the gas flowing therethrough to flow in a sinuous path following the contour of the undulations and also allow a free flow of gas between the same to reduce the resistance to flow of the gas. Also, each alternate sheet is displaced vertically relative to the other sheets so that the ridges formed by the undulations in the alternate sheets are out of registry in a horizontal plane with the other sheets, but the ridges of all of the alternate sheets are in common planar relationship as are the ridges of the other sheets.

The arrangement of the sinuous sheets having uniformly undulated surfaces therefore provides chambers between the sheets that alternately increase and decrease in area to produce a turbulence in the gas flowing between the sheets without increasing the resistance to flow of the gas and for intimately contacting the liquid film on the surface of the sheets and thereby increase the efficiency of operation of the heat exchanger.

Also, the turbulence or movement of the air between the sheets is sufficient to maintain free-falling drops of moisture between the sheets for further surface contact with the moisture and increasing the efficiency of operation of the heat exchanger.

The heat exchanger or cooling tower illustrated in the drawings consists of a tower or enclosure **10** having an air inlet **11** and an air outlet **12**.

The air is moved through the tower 10 under forced draft by any suitable circulating means such as a fan or blower, not shown. The liquid to be cooled is delivered into the tower 10 through a plurality of distributing pipes 13 each having a plurality of spray heads 14 connected thereto. A sump 15 is provided in the bottom of the tower 10 for receiving the liquid passing downwardly through the tower, and the liquid is withdrawn through the pipe 16.

A plurality of sinuous sheets 20 are suspended within the tower 10 beneath the spray heads 14, and may be supported therein in any suitable manner. The sheets 20 are in the form of continuous reverse curves, which are best shown in Figure 3. Each of the sheets 20 is formed with a plurality of undulations that are of substantially identical curvature, and somewhat take the form of a sine wave. The undulations in each sheet are arranged in parallel relationship and are adapted to extend horizontally when the sheets 20 are placed within the tower 10. The pitch A—B of the undulations is substantially the same for all of the sheets and the curvature of the undulation is substantially uniform and regular within the pitch of each undulation so that ridges of like curvature are positioned alternately on opposite sides of a plane through the center of the sheet between opposite faces thereof.

The sinuous sheets 20 are spaced relative to one another that the space occupied between opposite faces of the sheets as produced by the undulations therein is substantially equal to the space unoccupied thereby. Thus, a sinuous path is provided between adjacent sheets that breaks up any tendency toward a straight line flow of gas between the sheets, forcing the gas to flow in the sinuous path.

Also, each alternate sheet 20*a* of the series of sheets 20 within the tower 10 is displaced vertically with respect to a plane extending through the ridges of the sheets 20, thus placing the ridges of the sheets 20*a* out of horizontal planar alignment with the ridges of the sheets 20. The amount of displacement is illustrated in the drawings by the distance C—B. This displacement of the sheets produces alternate horizontal chambers of increasing and decreasing volume, causing the gas flowing between the sheets to constantly vary its speed of flow alternately in opposite directions causing turbulence and a scrubbing action on the surface of the sheets 20 and 20*a*.

It has been found through carefully conducted tests that the resistance to flow of gas under forced draft between a series of sheets arranged in the manner referred to herein is less than through a series of sheets arranged with all of the ridges in planar alignment, and that the reduction in resistance to flow of gas will vary from 10% to as much as 50%, depending to some extent upon the shape of the curves provided by the undulations in the sheets. The smooth-flowing curves, such as illustrated in this invention, produce the minimum resistance to flow of air under forced draft passing between the sheets. Therefore, the horsepower consumed in driving a fan for moving the air between the plates under forced draft is reduced over that required by other arrangements of the sheets of the heat exchanger.

As for example, I have found that the most beneficial arrangement of the sheets 20 and 20*a* is one wherein the sheets 20*a* are displaced in a horizontal plane relative to the sheets 20 by approximately 10% to 20% of the pitch A—B of the undulations. In a specific example, the pitch of the undulations A—B is approximately 2¾″ and the sheets 20*a* are offset relative to the sheets 20 approximately ¼″ to ⅜″. The height of the undulations from the apex of one ridge to the apex of an adjacent ridge is ½″, the spacing of the sheets being 1⅛″ thereby establishing a vertical spatial volume D—E occupied by the sinuous sheets offering resistance to flow of gas between the sheets that is approximately equal to the unrestricted spatial volume E—F between adjacent sheets, which arrangement is effective in reducing the total resistance to flow of gas between the sheets while maintaining a sinuous movement of the body of gas flowing therethrough. The offset arrangement of the sheets is to create alternate chambers of small and large volume to cause the air to move at different rates alternately in alternate portions of the path of travel between the sheets, thus causing sufficient turbulence to the flow of gas to obtain a positive scrubbing of the surface of the sheets by the gas in contact with the liquid film passing over the same. This effect is obtained without increasing the resistance to the flow of gas between the sheets. Also, I have found that the scrubbing action of the gas on the liquid film on the sheets is sufficient to maintain free drops of liquid between the sheets which fall by gravity, and these free drops of liquid add to the liquid surface contacted by the air moving between the sheets. Both foregoing factors have a direct relationship upon the efficiency of operation of the heat exchanger.

In the invention as illustrated, the liquid is delivered to the upper edges of the sheets 20 and 20*a* by means of the spray heads 14, thereby causing liquid to be delivered simultaneously to both sides of each of the sheets so that both surfaces of the sheets are at work in conducting liquid through the cooling tower. An eliminator 30 is provided above the spray heads 14 to avoid any carry-over of liquid from the heat exchanger or cooling tower.

In a cooling tower constructed in accordance with the invention wherein the sinuous sheets are approximately 48″ in height, with the sheets spaced approximately 1⅛″ from center to center, I have determined that four gallons of water per minute per square foot of face area can be cooled from 100° F. to 85° F. using air having a 78° F. wet bulb temperature with .0164 air horsepower per square foot of face area of the tower. This a greater efficiency than I have been able to obtain for other arrangements of sinuous sheets.

While the apparatus disclosed herein constitutes a preferred form of the invention, yet it will be understood that the device is capable of alteration without departing from the spirit of the invention, and that all modifications that fall within the scope of the appended claims are intended to be included herein.

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

1. In a heat exchanger, a series of sinuous sheets each having each of the undulations thereof of like curvature producing regularly spaced ridges positioned alternately on opposite sides of a plane through the center of the sheet between the faces thereof and positioned with the spaces between the sheets of sufficient width to obtain an appreciable vertical unre-

stricted spatial volume therebetween, means for delivering liquid to the surface of each sheet near the upper edge thereof, and means for inducing a forced draft of gas upwardly between the sheets, each alternate sheet of said series of sheets being displaced vertically relative to the other sheets to position the ridges of said alternate sheets out of horizontal planar alignment with the ridges of the said other sheets, the displacement between each ridge of one sheet and the ridge of the next adjacnt sheet being a distance which is less than that necessary to bring the said ridges opposite to each other to provide a path of alternately enlarged and constricted sections.

2. In a heat exchanger, a series of sinuous sheets each having each of the undulations thereof of like curvature producing regularly spaced ridges positioned alternately on opposite sides of a plane through the center of the sheet between the faces thereof and positioned with the spaces between the sheets of sufficient width to obtain an appreciable vertical unrestricted spatial volume therebetween, means for delivering liquid to the surface of each sheet near the upper edge thereof, and means for inducing a forced draft of gas upwardly between the sheets, each alternate sheet of said series of sheets being displaced vertically relative to the other sheets to position the ridges of said alternate sheets out of horizontal planar alignment with the ridges of the said other sheets, the displacement between each ridge of one sheet and the ridge of the next adjacent sheet being approximately 10% to 20% of the pitch of said ridges to provide a path of alternately enlarged and constricted sections.

3. In a heat exchanger, a series of sinuous sheets each having each of the undulations thereof of like curvature producing regularly spaced ridges positioned alternately on opposite sides of a plane through the center of the sheet between the faces thereof and positioned with the spaces between the sheets of sufficient width to obtain an appreciable vertical unrestricted spatial volume therebetween, means for delivering liquid to the surface of each sheet near the upper edge thereof, and means for inducing a forced draft of gas upwardly between the sheets, each alternate sheet of said series of sheets being displaced vertically relative to the other sheets to position the ridges of said alternate sheets out of horizontal planar alignment with the ridges of the said other sheets, the displacement between each ridge of one sheet and the ridge of the next adjacent sheet being approximately 10% to 20% of the pitch of said ridges to provide a path of alternately enlarged and constricted sections.

4. In a heat exchanger, a series of sinuous sheets having uniformly formed undulations therein substantially in the form of a sinewave forming regularly spaced ridges of substantially like curvature positioned alternately on opposite sides of a plane through the center of the sheet between the faces thereof and positioned with the spaces between the sheets of sufficient width to obtain an appreciable vertical unrestricted spatial volume therebetween, means for delivering liquid to the surface of each sheet near the upper edge thereof, and means for inducing a forced draft of gas upwardly between the sheets, each alternate sheet of said series of sheets being displaced vertically relative to the other sheets to position the ridges of said alternate sheets out of horizontal planar alignment with the ridges of the said other sheets, the displacement between each ridge of one sheet and the ridge of the next adjacent sheet being a distance which is less than that necessary to bring the said ridges opposite to each other to provide a path of alternately enlarged and constricted sections.

5. In a heat exchanger, a series of sinuous sheets each having each of the undulations thereof of like curvature producing regularly spaced ridges positioned alternately on opposite sides of a plane through the center of the sheet between the faces thereof and positioned with the spaces between the sheets of sufficient width to obtain an appreciable vertical unrestricted spatial volume therebetween substantially equal to the vertical restricted spatial volume occupied by a sinuous sheet, means for delivering liquid to the surface of each sheet near the upper edge thereof, and means for inducing a forced draft of gas upwardly between the sheets, each alternate sheet of said series of sheets being displaced vertically relative to the other sheets to position the ridges of said alternate sheets out of horizontal planar alignment with the ridges of the said other sheets, the displacement between each ridge of one sheet and the ridge of the next adjacent sheet being a distance which is less than that necessary to bring the said ridges opposite to each other to provide a path of alternately enlarged and constricted sections, and an eliminator located above said means for delivering liquid whereby to avoid carry-over of liquid from said sheets.

LANCE L. SIMMONS.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,117,309	Bentz	Nov. 17, 1914
1,549,068	Dickey	Aug. 11, 1925
2,231,088	Richardson	Feb. 11, 1941
2,356,530	Pflock	Aug. 22, 1944

FOREIGN PATENTS

Number	Country	Date
4,570	Great Britain	Feb. 24, 1909