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A. L. KOHL ETAL

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CORRUGATED PACKING FOR COUNTERFLOW COOLING TOWERS

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Fig. 1

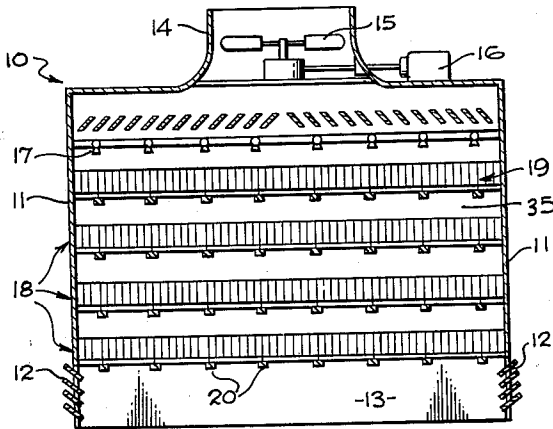


Fig. 3

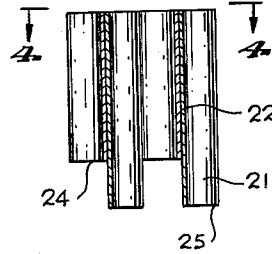


Fig. 4

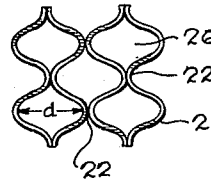


Fig. 5

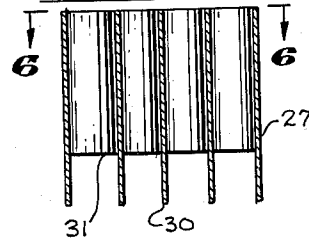


Fig. 6

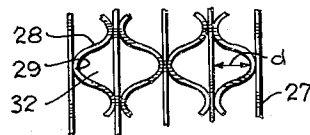


Fig. 2

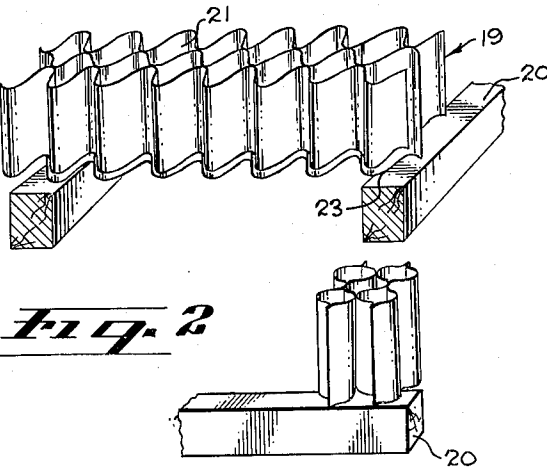
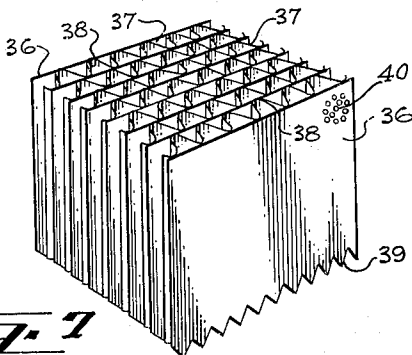


Fig. 7



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1

3,084,918 CORRUGATED PACKING FOR COUNTERFLOW COOLING TOWERS

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1 Claim. (Cl. 261-112)

This invention relates generally to improvements in packing for cooling towers, and more specifically has to do with the provision of novel packing units to be assembled in vertically spaced decks within cooling tower chambers, the units embodying corrugated grid sheets forming vertically open cells through which air may flow upwardly in cooling relation with water being filmed and with minimum air pressure drop.

One of the problems overcome by the present invention consists in the existence of an undesirably high pressure drop sustained by air flowing upwardly through conventional packing, the purpose of which is to film liquid for cooling by the air stream. Thus, packing conventionally fills the bulk of the cooling tower chamber with uninterrupted vertical extent, and vertical openings through the packing are very small in order to maximize the water film extent to promote cooling. However, it is found that when the vertical openings have maximum dimensions less than about $\frac{1}{2}$ inch and particularly less than $\frac{1}{4}$ inch, the water bridges many of the openings by surface tension action, thereby blocking the upward air flow through the openings and materially increasing the pressure drop sustained by that flow.

Accordingly, efforts have been made in the past to increase the rate of air flow upwardly through the packing to prevent such surface tension bridging of the packing cell openings, however, it has been found that an undesirably high pressure drop is sustained by the flow so that on an over all basis the performance of the tower is limited.

According to the present invention, the pressure drop sustained by the air flowing upwardly through the packing is diminished substantially without diminishing the amount of cooling of water flowing downwardly in counterflow relation to the air, all as compared with a conventionally packed tower as described above, through the provision of vertically spaced and horizontally extending decks of packing units in block form, each of these units having novel configuration to achieve the results desired. Each unit includes grid sheets extending in a face to face series of vertical planes for filming liquid to drain down the vertical sides of the sheets, at least some of the latter being corrugated, with face to face sheets being bonded together. Furthermore, the sheets form vertically open cells through which air circulates upwardly, the cell openings being of sufficient size to prevent surface tension bridging of liquid completely across the cell openings.

In one form of the invention face to face adjacent sheets are corrugated as will be described, whereas in another form certain of the sheets are flat and are interposed between the corrugated sheets. Water drainage from the cell openings is promoted by terminating the lower edges of adjacent sheets at different elevations, it having been found that if the bottom edges of the cell forming sheets are all at the same level, water collects at these common level edges to reduce the free area available for upward air flow, with concomitant increased pressure drop.

As mentioned above, the packing units extend in vertically spaced decks, which are to be distinguished from a vertically continuously packed zone of equivalent size. In this connection it is believed that a major portion of

2

the cooling performance increases results from air turbulence in the open zone and where air and water enter and leave the packing grids. Best performance is realized when the vertical spacing between the grid decks is at the same order of size as the vertical dimension of each deck or packing unit, as will be further discussed.

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

FIG. 1 is a vertical elevation taken through a cooling tower chamber showing the vertically spaced decks of packing units;

FIG. 2 shows in perspective view the arrangement of vertically successive packing units;

FIG. 3 is a side elevation illustrating the difference in height of adjacent packing sheet lower edges;

FIG. 4 is a plan view of the FIG. 3 packing;

FIG. 5 is an elevation similar to FIG. 3 showing the manner in which corrugated and flat sheets are bonded together to have terminal lower edges at different heights;

FIG. 6 is a plan view of the FIG. 5 packing; and

FIG. 7 is a perspective view of a packing unit of somewhat different configuration.

Referring first to FIG. 1, the cooling tower chamber 10 has side walls 11 including louvers 12 through which air flows into the chamber lower interior space 13. The top of the chamber includes a venturi shaped stack 14 in which a fan 15 is driven by motor 16 so as to draw air upwardly from space 13 to discharge from the stack, the air flowing in counterflow relation to water moving downwardly within the tower chamber. The water may be conventionally distributed as by means indicated at 17 including a header, laterals and nozzles distributing the water in particles across the upper interior of the chamber.

Arranged in vertically spaced decks 18 within the tower are packing units 19 each supported on cross-members 20 which may comprise the wooden beams as better illustrated in FIG. 2. The latter are transversely spaced apart so as to support the edge portions of the packing units 19, whereby the members 20 offer minimal obstruction of upward air flow from the tower. The block form packing units 19 are furthermore arranged in laterally continuous decks 18 so that all the air flowing upwardly and all the water flowing downwardly through the chamber must pass through the decks 18.

Referring now to FIGS. 2, 3 and 4, typical packing units 19 comprise grid sheets 21 extending in a face to face series of vertical planes for filming water to drain down the vertical sides of the sheets, the latter being bonded together preferably at the locations shown at 22 in FIG. 4. Accordingly, the bonds extend vertically throughout the extents of the corrugated sheets thereby providing a rigid block form structure having great strength and capable of being fully supported only at the edges of the unit as indicated at 23 in FIG. 2.

In FIGS. 2 through 4, all of the grid sheets are corrugated as shown, the bonds 22 being located at adjacent corrugations. Also, face to face adjacent corrugations have their lower terminal edges 24 and 25 at different elevations so as to prevent water collection at the lower terminal edges before dropping from the grid. If these bottom edges are all at the same level, water collects at the common lower edge and around the periphery of each cell 26 to reduce the free area available for air flow upwardly into the cell 26, thereby increasing the pressure drop. By disrupting the bottom edge of the effective size of the cell for air entry is kept as open as possible to minimize pressure drop. For best results, the difference in elevation between edges 24 and 25 should be con-

siderably less than the over all height of the packing unit 19, and also, such over all height is desirably considerably less than the horizontal dimensions of the rectangular unit. In a typical example, a square unit measuring 36 inches horizontally along each side has an over all height of 6 inches and the differences in elevation between the lower edges 24 and 25 is between $\frac{1}{8}$ inch and $\frac{3}{4}$ inch.

In FIGS. 5 and 6, flat sheets 27 are interposed between pairs of corrugated sheets 28, the bonds 29 being located at the points where the corrugations meet the flat sheets so that these bonds again extend vertically. Here again the differences in elevations between the lower edges 30 and 31 of the longer flat sheets and interior corrugated sheets are of the same size order in relation to the over all size of the packing unit, as previously discussed in connection with FIGS. 3 and 4. Alternatively, in connection with FIGS. 5 and 6, the corrugated sheets 31 can be longer than the flat sheets 30 with the same desired results of preventing water from collecting at the lower terminal edges.

An important feature of the invention consists in providing cell openings 26 in FIG. 4 and 32 in FIG. 6, of sufficient size to prevent surface tension bridging of liquid completely across these openings. It has been found that the nominal diameter d of the openings as shown in FIGS. 4 and 6 should be between about $\frac{1}{2}$ inch and 1 inch, these nominal diameters comprising the maximum cross-dimensions of the cell openings which generally are non-circular, as for example the heights of the corrugations. Furthermore, these dimensions d are measured in the direction of series horizontal stacking of the sheets, as is clearly indicated. If the dimension d is less than $\frac{1}{2}$ inch, water begins to bridge the cell openings to increasing extent as the cell dimension d decreases. On the other hand, if the dimension d is greater than 1 inch a serious loss in film surface area is sustained which reduces the cooling performance. In addition, it has been found that blocking of the cell openings with scale or dirt does not occur in a cooling tower if the dimensions d are greater than $\frac{1}{2}$ inch.

Another important feature of the invention is to limit the vertical spacing between the decks 18 in FIG. 1, to the same order dimension as the vertical height of each deck. Thus, the vertical spacing between the decks should be at least 3 inches, to promote effective turbulence of air in the open zones 35 between the decks, such turbulence increasing heat exchange or cooling of the water by air flowing through the decks. On the other hand, vertical spacing greater than about 1 foot or 12 inches is of little use in improving cooling performance through promotion of turbulence and otherwise needlessly extends the column height.

Reference to FIG. 7 shows a somewhat modified square packing unit consisting of flat sheets 36 interposed between corrugated sheets 37 with bonds being provided at the locations 38 where single corrugations meet the flat sheets. This is distinguished from FIG. 6 wherein corrugations of sheets at opposite sides of a flat sheet meet the latter at the general location of the bond 29. Also, in FIG. 7 the bottom terminal edges of the flat sheets are notched as at 39 to minimize water collection at these lower terminal edges. Here again the corrugated sheets 37 can be notched in combination with or

separately from the flat sheets to give the desired effect of minimizing water collection at the lower terminal edges.

The sheets themselves may comprise asbestos paper specially refined and suitably treated to withstand hot water flooded service, resin impregnated asbestos paper, or resin bonded glass or polymeric fiber cloth, these materials being preferred. Furthermore, the sheets may contain very small perforations as indicated at 40 in FIG. 7, permitting water to migrate from one cell to another that is horizontally within a packing unit. Such perforations may for example be provided by incompletely impregnating glass fiber cloth with polyester resin. Generally speaking, the perforations will be sufficiently small that water will bridge them by surface tension action, thereby promoting filming of water within the packing.

We claim:

In combination with a cooling tower for liquids comprising an upright tower chamber having inlet and outlet openings for circulating air upwardly through said chamber in heat exchange relation with liquid moving downwardly therein, the improvement which comprises vertically spaced horizontally extending multiple decks of like packing units, the units each having horizontally rectangular block form and being closely packed horizontally across each deck, the spacing between vertically successive decks being about 6 inches and approximately equal to the vertical dimension of each of said successive decks, each of said units including grid sheets extending in a face to face series of vertical planes for filming liquid to drain down the vertical sides of said sheets, as least some of said sheets being corrugated and face to face sheets being bonded together, said sheets forming vertically straight and open cells through which air circulates upwardly, the cell openings having maximum cross dimensions between $\frac{1}{2}$ and 1 inch, the sheet lower edges in each unit terminating at different vertical elevations the maximum dimensional difference of which is substantially less than the overall height of the said unit, and means supporting said decks in vertically spaced relation, said means including cross members extending horizontally under each deck and across the chamber interior, said members under each deck having horizontal spacing to support a large number of sheet lower terminal edges in each unit, the cross member vertical dimensions being substantially less than the vertical spacing between successive decks and the cross member width dimensions being substantially less than the horizontal overall dimensions of each packing unit.

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