PLATE FIN TUBE HEAT EXCHANGER
Addison Y. Gunter, Houston, Tex., assignor to Hudson Engineering Corporation, Houston, Tex., a corporation of Texas
Filed Feb. 21, 1966, Ser. No. 528,996
1 Claim. (Cl. 165—152)

ABSTRACT OF THE DISCLOSURE

A tube module for use in heat exchangers in which the tubes are disposed "in line" with air flow theretop, and each fin comprises a plate having an interrupted surface within an area bounded by lines through the centers of tubes of adjacent laterally and longitudinally extending rows of tubes. Each such interrupted surface is spaced from the tubes and is discontinuous from each other interrupted area. In a preferred embodiment of the module, each interrupted area comprises one or more louver extending parallel to the lines through the centers of the longitudinally extending rows of tubes.

This invention relates to plate fins and plate fin tube modules adapted for use in forming tube bundles for installation in air coolers or the like. More particularly, it relates to improvements in fins and modules of this type in which the tubes are to be disposed "in line" with the air flow theretop.

As contemplated by this invention, a plate fin tube module comprises an assembly of laterally and longitudinally extending rows of side-by-side tubes about which closely spaced apart flat plates are tightly engaged. Thus, as well known in this art, each plate has holes through it corresponding in spacing and number to the tubes so as to form a fin common to all the tubes. Headers are connected to the fin-free ends of sections made up of one or more of the modules to form the tube bundles.

In modules of this type in which this invention pertains, the laterally and longitudinally extending rows of tubes, and thus the holes through the plate fins, are perpendicular to one another. In the resulting rectangular patterns of tubes, the laterally extending rows of tubes may be disposed "in line" with air flow past the leading edges to the plate fins. This arrangement of the tubes and plate fin holes is to be distinguished from a "staggered" arrangement in which the rows form patterns of triangular or parallelogram shape.

It is also well known in this art that interruptions of the flat surfaces of the plate fins will improve their heat transfer rate. These interruptions may comprise mere dimples or other indentations in one or both sides of the plate. On the other hand, they may comprise perforations in the plate, preferably in the form of louvered of desired shape. In any case, a proper design of such interruptions must take into account not only their improved heat exchange rate, but also the resulting pressure drop and loss of stiffness in the plate fins.

It is also important that there be a tight joint between each tube and the fin hole through which it is received. For this purpose, the fin may be soldered or brazed about each tube. However, it is difficult to solder aluminum fins which are, in many instances, preferable to fins of other materials. Consequently, the tubes are often expanded into tight engagement with the fin, as by a drawing process. Although this makes it possible to obtain a tight joint between the tube and fin, it nevertheless requires a fairly substantial area of solid or uninterrupted fin area about the tube in order to hold the contact pressure between the tube and fin. Obviously, this must be taken into account in the design of interruptions in a plate fin.

Plate fin tube modules in which the tubes are arranged in line are preferred in that they cause less pressure drop in the air flow theretop inasmuch as they provide less resistance to the flow. However, it has also been shown that, due to the arrangement of the tubes, these modules have more dead air space behind the tubes than modules in which the tubes are staggered.

The primary object of this invention is to provide a more efficient plate fin and plate fin tube module in which air is caused to flow into the otherwise dead spaces behind the tubes; and, more particularly, in which such air flow is directed into such spaces by means of an interrupted area of the surface of each plate fin.

A further object is to provide such fins and modules in which the interruptions are so designed and arranged as to maintain much of the stiffness in the plate as well as an uninterrupted area about each fin hole which is sufficiently strong to give contact pressure to the tube as it is expanded theretop.

In the drawings, wherein like reference characters are used throughout to designate like parts:

FIG. 1 is a perspective view of one end of a plate fin tube module constructed in accordance with the present invention;

FIG. 2 is a plan view, on an enlarged scale, of one of the plate fins of the module shown in FIG. 1;

FIG. 3 is a cross sectional view of the plate fin, as seen along broken line 3—3 of FIG. 2; and

FIG. 4 is another cross sectional view of the plate fin, as seen along broken line 4—4 of FIG. 2.

With reference now to the details of the above described drawings, the tube module shown in FIG. 1, and designated in its entirety by reference character 10, comprises laterally and longitudinally extending rows of side-by-side tubes 11a to 11f and 12a to 12f, and a plurality of closely spaced apart plate fins 13 tightly engaged about the tubes. Thus, as shown in FIG. 2, each plate fin 13 has tube-receiving holes 14a to 14f and 15a to 15f therethrough which correspond in spacing and number to the tubes so as to form a fin common to all the tubes. More particularly, hole 14a is tightly engaged about tube 11a, hole 14b is tightly engaged about tube 11b, etc.

As shown in the drawings, each such hole is formed through a hub 16 which is pressed from the plate. Although this is preferred inasmuch as the hub provides a wide surface over which the tube is engaged, the hole may in some cases be more perforation in the plate. Also, of course, the tubes and thus the fins holes may be oval-shaped, squares or of most any cross section other than round, as illustrated.

As can be seen from FIG. 1, the ends of the tubes of module 10 are free of plate fins 13 so that, when one or more of them is assembled in sections to make up a tube bundle, headers may be connected to such free ends prior to installation in an air cooler or the like. In the illustrated embodiment of the invention, it is contemplated that the bundles may be installed so that air flow is in a direction perpendicular to the long dimension of the plate fin 13. Thus, assuming that air flow is from left to right in FIGS. 1 and 2, the left-hand edge of each plate fin may be termed its leading edge while the right-hand edge thereof may be termed its trailing edge.

For purposes of description, the long rows of tubes and thus the plate fin holes for receiving them, are said to extend longitudinally, while the short rows of tubes and holes are said to extend laterally. Thus, in the illustrated embodiment of the invention, there are two longitudinally extending rows of tubes 11a to 11f and 12a to 12f, respectively, and six rows of laterally extending tubes 11a—12a, 11b—12b, 11c—12c, 11d—12d, 11e—12e, and 11f—12f, respectively. Obviously, there may be a greater
number of longitudinally extending rows and a greater or lesser number of laterally extending rows.

As is also apparent from the drawings, the longitudinally extending rows are parallel to one another, while the laterally extending rows are also parallel to one another. More particularly, the longitudinally extending rows are arranged perpendicularly to the laterally extending rows to form a rectangular pattern of tubes and plate fin holes, whereby such tubes will be disposed in "line" with air flowing in a direction perpendicular to the leading edge of the plate fins.

In accordance with the novel aspects of the present invention, air flow will be directed to the fin surface area at the back or trailing side of each fin hole, and thus each tube received therethrough, by means of interruptions in the areas of such surface intermediate adjacent laterally extending rows of holes, and thus between the two such rows illustrated, and on the back or trailing side of each longitudinally extending row. As can be seen from FIGS. 1 and 2, these interruptions preferably comprise a series of longitudinally extending louvers each arranged within a rectangular pattern formed by the laterally extending as well as the longitudinally extending rows of holes.

More particularly, each series of louvers includes relatively long and relatively short louvers 17 and 18, respectively, arranged symmetrically within each rectangular pattern. Each series includes three long louvers 17, with the center louver spaced equidistant the longitudinally extending rows and all of them centrally of the laterally extending rows. Each series also includes a single short louver 18 on the side of each outer long louver 17 closer to the longitudinally extending row, each such short louver being arranged centrally of the long louver of the series and thus centrally of the laterally extending rows. Since the louvers of each series are discontinuous with respect to the long louvers of another series, they leave an uninterrupted surfaces area of the plate fin intermediate adjacent holes of each laterally extending row of holes. Also, the opposite ends of the long and short louvers terminate sufficiently short of the holes so as to leave an annular area of uninterrupted or solid surface around each such hole.

As will be understood from the foregoing, air flowing in the region perpendicularly to the long edges of the plates will be directed by the louvers 17 and 18 behind each of the tubes of the leading longitudinal row of tubes as such air moves across the plate fin. Thus, the louvers not only increase the heat transfer rate of the plate fin, but also in effect baffle the air flow so as to direct at least some of it to the otherwise dead air spaces behind these tubes. From these dead air spaces, the air is free to then flow toward the trailing tube of the laterally extending row, and then about such tube to its back side, as described to follow. In order to obtain this effect over the entire length of the fin, it is preferred that the upper and lower ends thereof to provided with a series of what might be termed partial long and short louvers 17a and 18a, respectively.

In the illustrated embodiment of the invention, there is a partial series of long and short louvers on the outer side of each longitudinal row of holes as well as between such rows. As shown, each such partial series comprises a single short louver 18 inwardly of a single long louver 17. Obviously, the disposal of such a partial series at each side insures that regardless of which edge is employed as the leading edge, air flow will be directed behind the trailing side of each hole and tube of the trailing longitudinal row of tubes. Furthermore, when modules are assembled side-by-side, the partial series of adjacent modules forms nearly an entire series.

The unloivered or solid area of the surface of the plate fin behind each hole not only provides a path of least resistance to air flow, but also maintains the stiffness of the plate between the holes of the longitudinally extending rows of holes. For this purpose, and in the particular embodiment illustrated in the drawings, this uninterrupted area has a width of approximately 80% of the diameter of the holes, it is preferred that the alternate groups of long louvers be not less than 60% of the hole diameter. Thus, in any case, each louver 17 is preferably longer than the spacing between adjacent holes in each longitudinal row, so that, with the louvers arranged centrally of adjacent lateral rows of holes, the opposite ends of each louver extend into the area between adjacent holes in each lateral row. In a tube module in which the tubes are %" in outside diameter, it is also preferred that the uninterrupted or solid area of the plate about each hub be a minimum of approximately %" to %"

The short louvers 18 of adjacent series of louvers are spaced apart from one another a distance greater than the spacing between the adjacent louvers of each series. In the illustrated embodiment of the invention, this spacing is approximately 60% of the diameter of the holes in the plate fins. Preferably, it is not less than 37% of such diameter. This uninterrupted surface area between adjacent holes of each longitudinally extending row of holes serves to further stiffen the plate. It is made possible, in the arrangement of louvers according to this invention, by virtue of the fact that the heat transfer rate of the plate fin intermediate adjacent holes of each longitudinally extending row of holes in any case increased by virtue of the increased velocity of the air flow between the tubes received through the adjacent holes. Thus, the heat transfer rate at this particular location in the plate fin is increased to substantially the same extent that it is increased in other portions of the plate fins by virtue of the louvers 17 and 18, so that there would be nothing to be gained in further increasing the heat transfer rate between adjacent tubes in view of the fact that this would result in an increase in pressure drop across the plate fins and loss of stiffness in the plate.

As best illustrated in FIGS. 3 and 4, the louvers are pressed out from the same surface of the plate fin as are the hubs 16, thus facilitating the simultaneous pressing out of the hubs and louvers in the formation of the plate fin. In the illustrated embodiment, the hubs are taller than the louvers, so that normally they would determine the minimum spacing between adjacent plate fins.

The illustrated arrangement of tube holes and louvers provides a desired balance between pressure drop and heat transfer rate from still another standpoint. Thus, although a wider spacing of the tubes would increase the free frontal area of the module, it would also increase the height of the distance between the tubes, which would have to travel over a point on the fin surface to the tubes. Ideally, the free frontal area is kept within the range of 30%–60%, and the average fin height is about 0.7" in a module of the type above described in which the tubes have %" in diameter.

From the foregoing, it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the apparatus.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claim.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matters herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

The invention having been described, what is claimed is:

1. A plate fin tube module, comprising a plurality of closely spaced, parallel plate fins having holes therein, and a plurality of parallel tubes having a first medium adapted to flow therethrough and disposed in the holes of
said plate fins to define a rectangular array of longitudinally and laterally extending rows of tubes, said plate fins being fixed to said tubes and adapted to be contacted by a second medium flowing laterally across the leading edges thereof, each plate having a group of louvers extending longitudinally intermediate adjacent rows of laterally extending tubes for substantially the full distance between said adjacent rows, each group of louvers including at least one relatively long louver and a shorter louver spaced laterally from each side thereof, and each said plate fin having smooth surface areas between the groups of louvers and about the tubes to maintain the stiffness of the plate fins and direct the flow of the second medium to the trailing sides of the leading tubes in each laterally extending row of tubes.

References Cited

UNITED STATES PATENTS

2,977,918 4/1901 Kritzer 165-181 X
3,223,153 12/1965 Simpelaar 165-181 X
3,135,320 6/1964 Forgo 165-151

FOREIGN PATENTS

209,361 6/1960 Austria.

ROBERT A. O'LEYARY, Primary Examiner.
T. W. STREULE, Assistant Examiner.