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 [73] Assignee **Modine Manufacturing Company**

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[54] **HEAT TRANSFER DEVICE AND METHOD OF MAKING**  
**16 Claims, 11 Drawing Figs.**

[52] U.S. Cl. .... 72/367,  
 29/157.3 A, 165/179  
 [51] Int. Cl. .... B21d 53/06  
 [50] Field of Search ..... 72/367,  
 369; 29/157.3; 113/118; 165/179

**ABSTRACT:** A heat transfer device and a method of making the same in which the device comprises a heat transfer tube having a longitudinal bore for flow of fluid therethrough, spaced heat transfer internal fins within the tube and distortions in the wall of the tube adjacent the fins that not only distorts the wall but also deflects the fins in the region of the distortions to increase internal fluid turbulence and thereby promote better heat transfer.

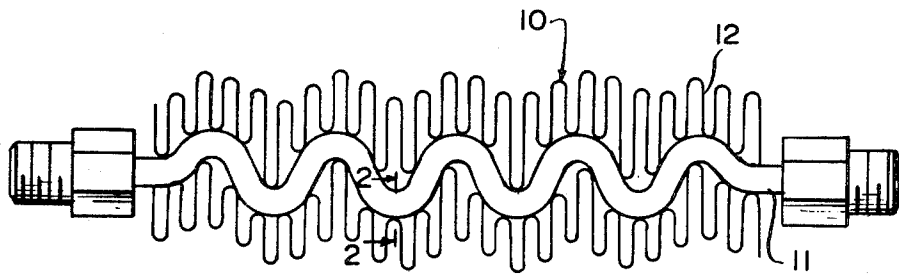
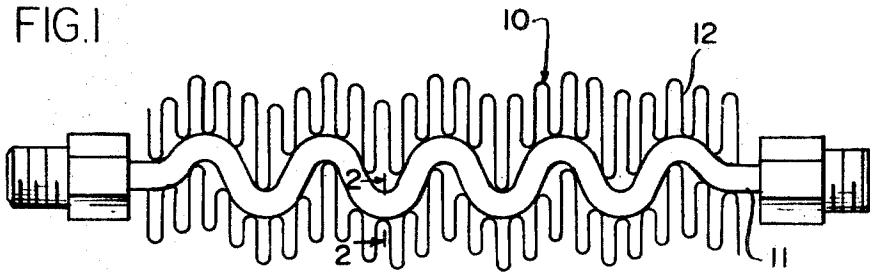


FIG. 1



→ 3

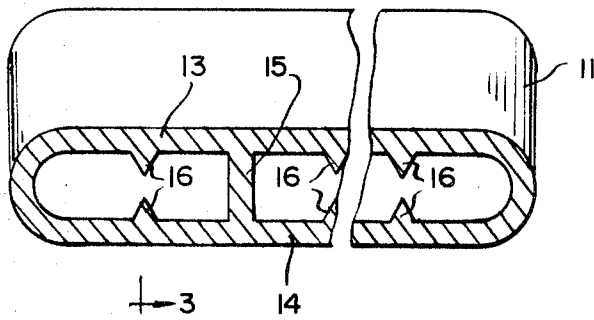


FIG. 2

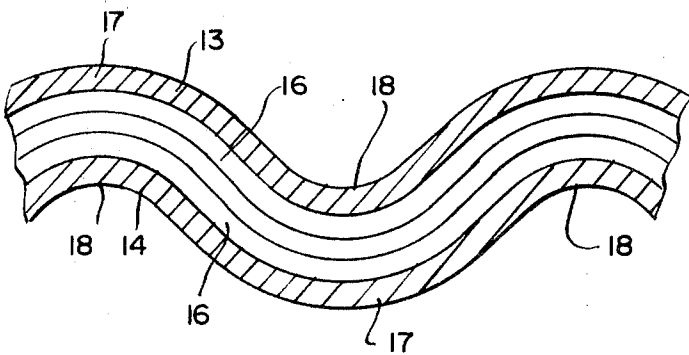
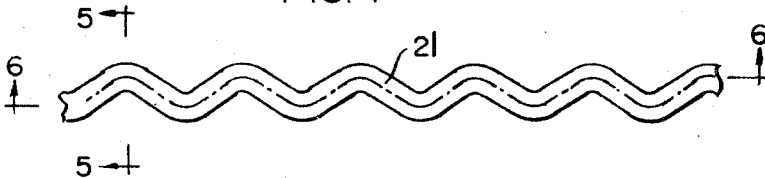


FIG. 3

FIG. 4



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FIG. 5

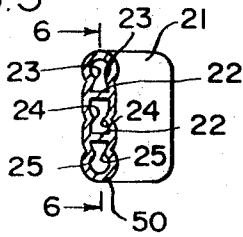


FIG. 6

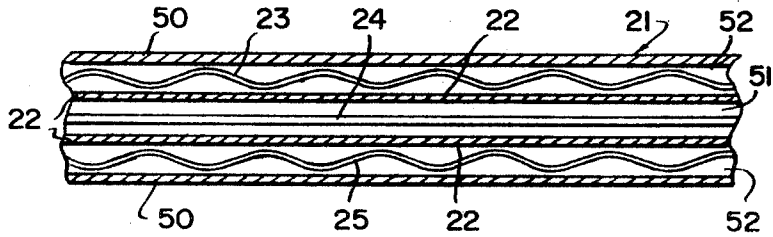


FIG. 7

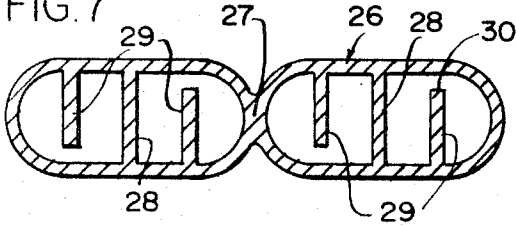


FIG. 8

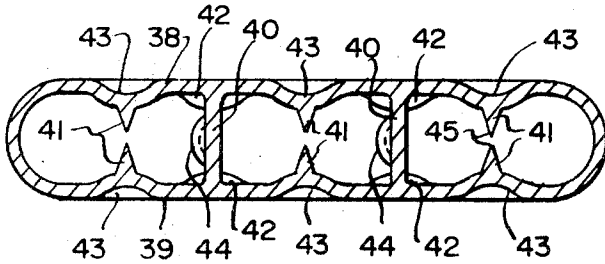
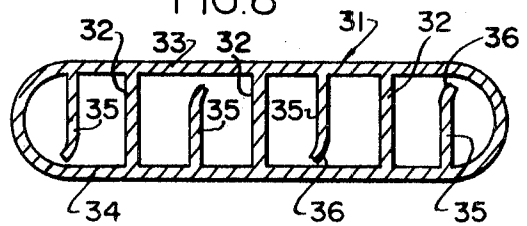


FIG. 10

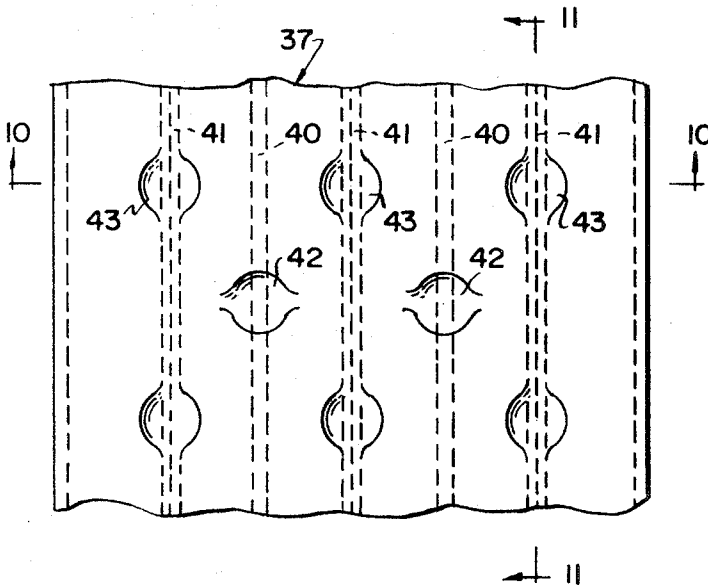
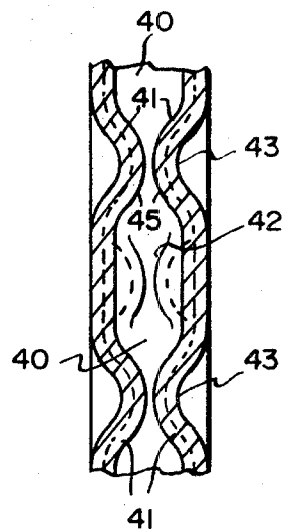


FIG. 9

FIG. 11



**HEAT TRANSFER DEVICE AND METHOD OF MAKING**

It is common practice to provide heat transfer tubes adapted to contain a heat transfer liquid with these tubes having internal fins over which the fluid flows for promoting the heat transfer. These tubes and their integral internal fins are customarily made by extruding, drawing and other methods in which the fins and other internal structural details such as webs, which are types of fins, are smooth and usually continuous and parallel. This smooth configuration when the heat transfer fluid is viscous such as an oil operates as extra drag surfaces that permit heavy buildup of the viscous boundary layer. In certain instances this buildup can become so severe with viscous fluids that substantially no benefit is experienced by the additional internal surface provided by the fins.

This invention corrects this condition by providing such an internally finned tube with external distortions in the regions of the fins to deflect them in the regions of the distortions and thereby increase internal turbulence with improved heat transfer.

The invention will be described as illustrated by the accompanying drawings which disclose several different embodiments of the invention. Of the drawings:

FIG. 1 is a side elevational view of an oil cooler tube that is contacted with a cooling medium for cooling the lubricating oil of an internal combustion engine.

FIG. 2 is an enlarged cross-sectional view of the tube of FIG. 1 taken substantially along line 2-2 of FIG. 1.

FIG. 3 is a fragmentary sectional view taken substantially along line 3-3 of FIG. 2.

FIG. 4 is a side elevational view of a heat transfer tube incorporating a second embodiment of the invention.

FIG. 5 is a sectional view taken substantially along line 5-5 of FIG. 4.

FIG. 6 is a sectional view taken substantially along line 6-6 of FIGS. 4 and 5.

FIG. 7 is an enlarged cross-sectional view through an undistorted tube that may be used in practicing the invention.

FIG. 8 is a view similar to FIG. 7 but showing a further embodiment of the invention.

FIG. 9 is a fragmentary plan view of a heat transfer tube embodying the invention.

FIG. 10 is a view taken substantially along line 10-10 of FIG. 9.

FIG. 11 is a view taken substantially along line 11-11 of FIG. 9.

The method of making the heat transfer device and the heat transfer device itself are illustrated by the embodiments shown in the accompanying drawings. Thus, in the first embodiment of FIGS. 1-3 the device 10 comprises a sinuous tube 11 carrying on its outer surface the usual fins 12. This tube 11 is of oval cross section with parallel opposite walls 13 and 14 connected on the interior by spaced fins in the form of webs 15 of which only one is shown here. Extending inwardly from each wall 13 and 14 are internal integral fins 16 of a different type. In manufacturing the tube 11 it is initially straight and can be formed by extruding and drawing. Then the tube 11 during the manufacturing operation is undulated to form in each wall 13 and 14 successive peaks 17 and valleys 18 with each peak 17 in one wall 13 having a corresponding opposite valley 18 in the other wall 14. These successive undulations form inward distortions which are the spaced valleys 18 in this embodiment.

In the second embodiment of the invention illustrated in FIGS. 4-6 the tube 21 contains a pair of spaced webs 22 and inwardly extending sets 23, 24 and 25 of integral inwardly extending fins with one pair 23 being located on one side of a web 22, the other pair 24 positioned between the spaced webs 22 and the other pair 25 spaced between the opposite edge of the tube and the adjacent web 22.

In undulating the tube 21 in the same manner as the tube 11 of the first embodiment the central pair of fins 24 remain straight while the edge fins 23 and 25 undulate at their peaks,

as indicated in FIG. 6, to promote internal turbulence and thus heat transfer of the fluid flowing past these fins 23 and 25. These undulations as shown in FIG. 6 for the outer pair of fins 23 and 25 also occur in the fins 16 of the first embodiment of FIGS. 1-3.

In both embodiments the further the fin is from the outer edges 50 of the tube, as shown in FIGS. 5 and 6, the less distortion there would be in the fins. In fact, in the embodiment of FIGS. 5 and 6, the central fins 24 as shown in FIG. 6 are substantially undistorted and remain straight instead of containing the undulations of the outer fins 23 and 25. The apparent reason for this is that the center channel or duct 51 is symmetrical as compared to the two outer channels 52. The two outer channels are not symmetrical because each is bounded on the sides by the planar web and the arcuate tube edge 50 while with the center channel 51 the sides are defined by the parallel webs 22. Then, when the tube is undulated as shown in FIG. 4 the rounded edges 50 tend to be drawn inwardly setting up stresses that cause the outer fins 23 and 25 to undulate. These stresses are not substantially transmitted to the central fins 24 so that there is substantially no undulation here.

Because a fin such as the fin 24 that is a part of a symmetrical channel does not distort and thus does not undulate the third and fourth embodiments of FIGS. 7 and 8 are provided to illustrate other forms of tubes where undulation is achieved.

The third embodiment of FIG. 7 employs a tube 26 which is undulated in the same manner as the tube 11 of the first embodiment and 21 of the second embodiment. However, the tube here is of different internal and external construction. In this embodiment of FIG. 7 the tube is in two parallel parts interconnected by a central integral wall 27 and prior to undulating the tube 26 each half of the tube on opposite sides of the wall 27 is provided with a central web 28 and a pair of fins 29.

In the fourth embodiment of FIG. 8 the tube 31 is provided with a plurality, here shown as three, of internal webs 32 that are spaced from each other and that extend between the opposite sidewalls 33 and 34 of the tube 31. Between each pair of webs 32 and between a sidewall and the side of the tube 31 there is provided a fin 35. The edge 36 of each fin 35 is curved over.

In the embodiments of FIGS. 7 and 8 the undulating of the tubes 26 and 31 will cause the free edges 30 and 36 of the fins to contact the opposite tube wall at the peaks and valleys of the undulations. It will also cause the fins in the nonsymmetrical tube passages or channels to undulate at 90° to the direction of the tube bend as is the case with the fins 23 and 25 of the embodiment illustrated at FIG. 6. Thus, in FIG. 7 all fins 29 will undulate while in FIG. 8 only the outer fins 35 will undulate because the more centrally located fins 35 are in symmetrical channels.

In the fifth embodiment of FIGS. 9-11 the tube 37 is also provided with opposite sides 38 and 39. These sides in this embodiment are connected by a pair of spaced internal webs 40 and between each pair of webs and between one web and the adjacent edge of the tube there is provided a pair of inwardly extending aligned fins 41 formed integrally with the tube.

In improving the heat transfer turbulence of fluid flowing through the tube of this embodiment each wall 38 and 39 is distorted inwardly by spaced dimples 42 and 43 with some 42 being opposite a web 40 and others 43 opposite a fin 41. The dimples 42 cause the corresponding web 40 to bulge laterally as indicated at 44 in FIG. 10. The dimples 43 that are in the region of and opposite the fins 41 cause the fin edges 45 to be moved closer together in the areas of the dimples 43 as is shown in FIG. 11 and to either touch, remain separated or overlap depending upon the dimple depth.

I claim:

1. The method of making a heat transfer device; comprising: providing a heat transfer tube having a longitudinal bore for flow of fluid therethrough and spaced heat transfer internal fins of preselected height with free peaks; and distorting said tube inwardly from exteriorly thereof in the region of said fins to distort the internal fins laterally, thereby increasing fluid

turbulence and promoting better heat transfer efficiency, said distorting being in a direction parallel to the fin height to distort the fins laterally at said peaks.

2. The method of making a heat transfer device, comprising: providing a heat transfer tube of oval cross section with opposing flat sides having a longitudinal bore for flow of fluid therethrough and spaced heat transfer internal fins located at said sides and substantially parallel to each other; and distorting said tube inwardly from exteriorly thereof in the region of said fins to distort the internal fins laterally, thereby increasing fluid turbulence and promoting better heat transfer efficiency, said distorting providing a series of undulations normal to said flat sides.

3. The method of making a heat transfer device, comprising: providing a heat transfer tube having a longitudinal bore for flow of fluid therethrough and spaced heat transfer internal fins; and distorting said tube inwardly from exteriorly thereof in the region of said fins to distort the internal fins by providing internally extending spaced dimples in the area of said fins of a depth insufficient to contact the opposite wall.

4. A heat transfer device, comprising: a heat transfer fluid flow tube having an internal bore defined by a wall; a heat transfer internal fin extending inwardly of said tube wall for contact by said fluid; and inwardly extending distortion means in the tube wall adjacent said fin that both distorts said wall and deflects said fin in the region of said distortion means, thereby improving the heat transfer between the flowing fluid, the fin and the tube wall.

5. The device of claim 4 wherein said tube is of oval cross section with opposite walls extending between opposite tube edges, and there are provided a plurality of said fins extending between said walls and extending from one wall but short of the opposite wall.

6. The device of claim 5 wherein said distortion means comprise a wave undulation at right angles to said opposite walls.

7. The device of claim 5 wherein said distortion means comprises inward dimples in said walls each coinciding with a fin.

8. The method of making a heat transfer device, comprising:

providing a heat transfer tube having a longitudinal bore for flow of fluid therethrough and spaced heat transfer internal fins; and distorting said tube laterally inwardly from exteriorly thereof in the region of said fins to provide a permanent inward set in said tube and thereby distort the internal fins laterally, thereby increasing fluid turbulence and promoting better heat transfer efficiency.

9. The method of claim 2 wherein said distorting is to the degree that the internal fin edges adjacent the internally concave portions of the undulations are puckered to provide turbulence undulations.

10. The method of claim 2 wherein certain of said internal fins extend from one of the sidewalls to the other and other fins extend from one wall but terminate in an edge short of the other wall.

11. The method of claim 3 wherein said tube is of oval cross section with opposing flat sides and said internal fins are located at said sides and are substantially parallel to each other.

12. The method of claim 11 wherein certain of said dimpled distorted fins extend between opposite sidewalls of the tube and others extend from one wall but terminate short of the opposite wall.

13. The device of claim 4 wherein there are a plurality of said fins that extend inwardly of a wall of the tube and comprise free peaks distorted laterally in undulations.

14. The device of claim 4 wherein said distortions comprise internally extending spaced dimples in the area of said fins of a depth insufficient to contact the opposite wall.

15. The device of claim 4 wherein said tube is of oval cross section with opposing flat sides and said internal fins are located at said sides and are substantially parallel to each other.

16. The device of claim 4 wherein certain of said dimple-distorted fins extend between opposite sidewalls of the tube and others extend from one wall but terminate short of the opposite wall.

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