April 17, 1951 O. HOHEISEL 2,549,466

METHOD FOR MAKING HEAT EXCHANGERS

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FIG. 1

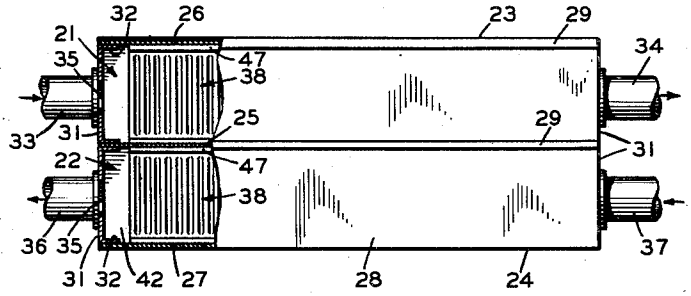

FIG. 2

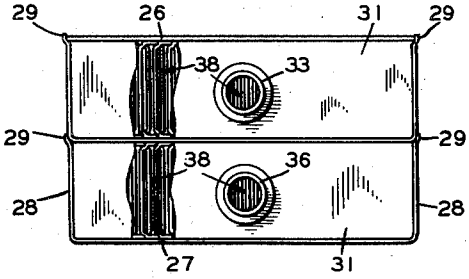

FIG. 3

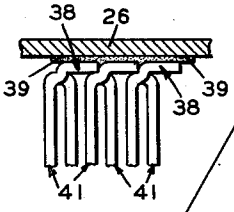

FIG. 4

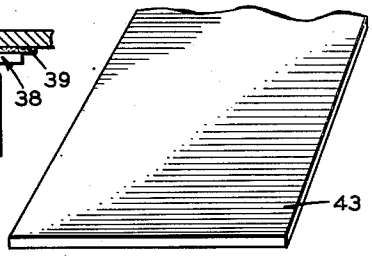

FIG. 5

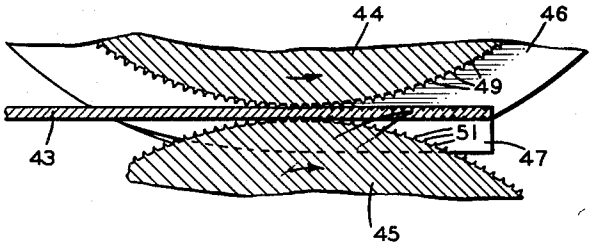

FIG. 6

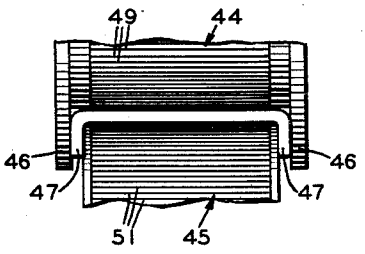

FIG. 7

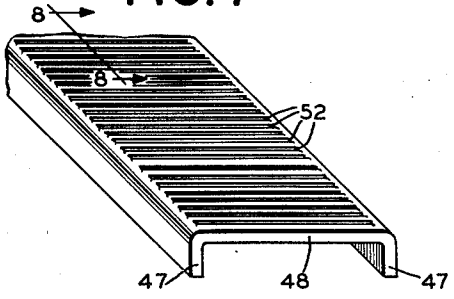

FIG. 8

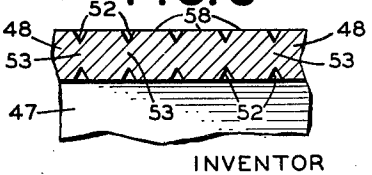

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FIG. 9

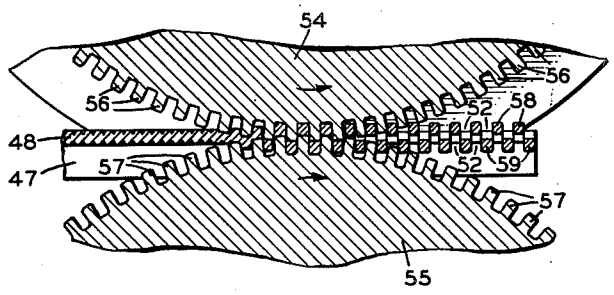


FIG. 10

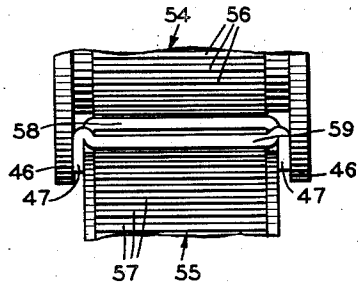


FIG. 11

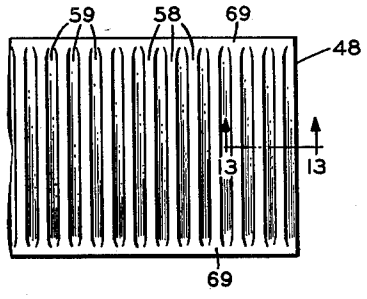


FIG. 12

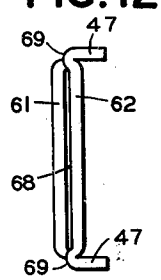


FIG. 13

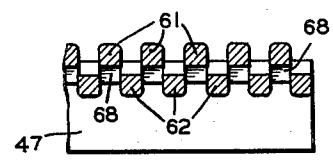


FIG. 14

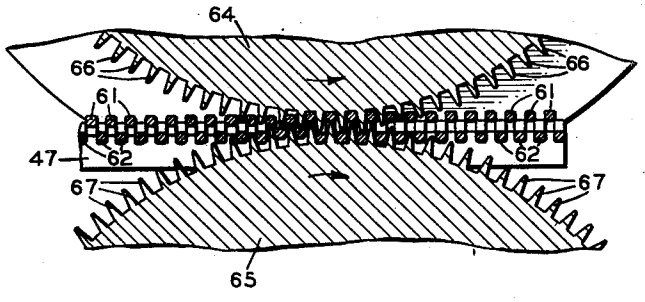


FIG. 15

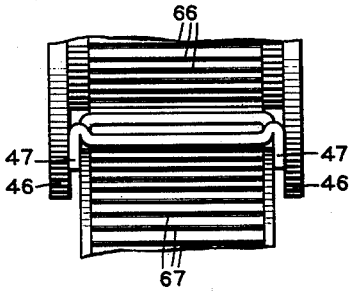


FIG. 16

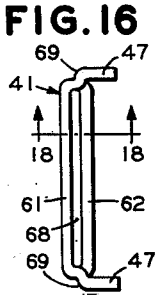


FIG. 17

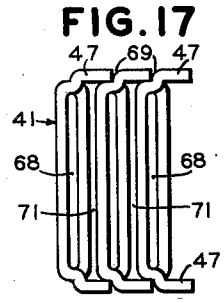
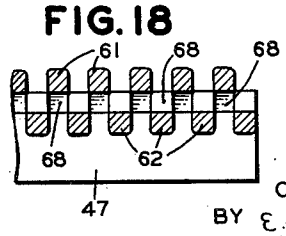


FIG. 18



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UNITED STATES PATENT OFFICE

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METHOD FOR MAKING HEAT EXCHANGERS

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Application April 23, 1947, Serial No. 743,314

2 Claims. (Cl. 29—157.3)

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This invention relates to heat exchange devices, and particularly to the secondary or extended surface portion of an extended surface heat exchanger in which the primary heat exchange portion is provided by one or more wall surfaces. More particularly, the invention relates to improvements in a method of making the secondary heat exchange portion of an extended surface heat exchanger.

In the heat exchanger art it is common practice to assemble a plurality of tray-like sections one above the other to form a plurality of adjacent fluid paths alternately connected at each end by suitable header arrangements to form a heat exchange device for the indirect interchange of heat between various heat exchange media. In order to promote increased thermal efficiency, various expedients have been employed for extending one or more chamber wall surfaces to provide increased contacting surface for the fluid heat exchange medium. To this end various types of fins, bars, rods and pins, bonded in suitable mechanical and thermal connection to one or both of the inner opposite walls of the chamber, have been employed. For maximum heat exchange efficiency it has been found that an extended surface comprising a considerable number of closely spaced thin pin-type members is most suitable. Preferably the pin members are integrally bonded in good heat exchange connection to opposite chamber walls. While various attempts have been made to construct a suitable heat exchanger along these general lines, it has been found that serious difficulties are encountered in forming suitable pin-type extended surface members and in assembling the various parts so that uniform spacing and bonding of the pin members is assured. The extended surface portions of such heat exchangers usually comprise separate elements which may be assembled in the form of a mat or matrix in contact with a primary heat exchange surface, such as the bottom surface of a tray, and bonded thereto with a suitable heat conductive material, such as solder. The bonding may be effected by previously preparing the surface of the tray or the surface of the mat, or both, with a coating of bonding material, assembling the mat in contact with the primary heat exchange surface, applying pressure to hold the secondary heat exchange portion or mat firmly in contact with the primary heat exchange portion, heating the entire unit to a temperature sufficient to fuse the bonding material, and then permitting the unit to cool so that the parts firmly adhere.

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In fabricating extended surface heat exchangers, serious difficulties have been encountered in providing secondary heat exchange portions, such as fins or mats of fin members, which may easily be assembled, will have a maximum of heat exchange contact surface, and may readily be bonded to the opposite chamber walls in good thermal connection.

A principal object of my invention is to provide an improved method of making an extended surface heat exchanger.

Another object is to provide an improved method of making the secondary or extended surface portion of an extended surface heat exchanger.

A further object is to provide an improved heat exchanger fin or secondary portion of an extended surface heat exchanger and a method for fabricating the same.

These and other objects are effected by my invention, as will be apparent from the following description and claims taken in connection with the accompanying drawings forming a part of this application, in which:

Fig. 1 is a view in elevation of a multiple chamber heat exchanger constructed in accordance with my invention, a portion of the chamber wall being broken away to show the inner mat or extended surface portion of the heat exchanger;

Fig. 2 is an end view of Fig. 1, with a portion of the end wall of the chamber broken away to show the inner construction;

Fig. 3 is an enlarged fragmentary view showing the bond between the mat and the heat exchange wall of a chamber;

Fig. 4 is an isometric view of the metal strip used as the feed stock in fabricating the pin-type fin used in forming the mat, or extended surface portion, of the novel heat exchanger;

Fig. 5 shows the strip of Fig. 4 being subjected to the first metal-working stage of my method;

Fig. 6 is an end view of Fig. 5;

Fig. 7 is an isometric view showing the deformation of the strip of Fig. 4 after passing through the first metal-working stage of my method;

Fig. 8 is an enlarged section taken along the line 8—8 of Fig. 7;

Fig. 9 shows the strip of Fig. 7 being subjected to the second metal-working stage of my method;

Fig. 10 is an end view of Fig. 9;

Fig. 11 is a plan view of the strip of Fig. 7 after passing through the second metal-working stage of my improved method;

Fig. 12 is an end view of Fig. 11;

Fig. 13 is an enlarged section taken along the line 13—13 of Fig. 11;

Fig. 14 is a view showing the strip of Fig. 11 being subjected to the third metal-working stage of my method;

Fig. 15 is an end view of Fig. 14;

Fig. 16 is an enlarged end view of the strip of Fig. 11 after passing through the third metal-working stage of my improved method;

Fig. 17 is an enlarged end view of a plurality of fins, as shown in Fig. 16 arranged in nested relation to form a mat; and

Fig. 18 is a section taken along the line 18—18 of Fig. 16.

Referring to the drawings, Figs. 1 and 2 are elevation and end views, respectively, of a multiple chamber heat exchanger constructed in accordance with my invention. Aside from the packing of fin members and the bonding thereof to the wall surfaces, the design of the unit is conventional and is included only for the purpose of illustration.

Although any desired number of chambers may be provided, the heat exchanger unit illustrated, for the sake of simplicity, comprises two chambers 21 and 22, formed by superimposing two open tray sections 23 and 24 in nested relationship so that the bottom 25 of the upper tray 23 forms a common heat transfer wall between the upper and lower chambers 21 and 22, respectively. A cover plate 26 closes the uppermost chamber 21 of the tray 23 to form the top side of the heat exchanger unit, while the bottom wall 27 of tray section 24 forms the under side.

Tray sections 23 and 24 may be formed in any suitable manner, as by turning up the ends of a wide sheet metal strip to form a bottom wall and two side walls, such as the bottom wall 27 and the side walls 28 of the tray 24. The upper edges of side walls 28 are slightly flared or off-set outwardly, as at 29, so that one tray may be nested slightly within the other to provide a sturdy structure. End closures 31 form the opposite end walls of each chamber 21 and 22, flanges 32 being provided on the end closures for fluid-tight attachment to the inner walls of the chamber.

Flanged connectors 33 and 34 are attached to each end closure 31 of chamber 21 in registry with openings 35 to permit the passage of a fluid heat exchange medium through the chamber 21. Similarly, flanged connectors 36 and 37 are provided for the passage through chamber 22 of a second fluid heat exchange medium. Although the fluid streams passing through chambers 21 and 22 may flow in the same direction, countercurrent flow, as indicated by the arrows, is preferred.

Within each of the fluid chambers 21 and 22 is placed a mat, generally indicated by the numeral 38, constructed, in a manner hereinafter to be fully described, of heat conducting material and intimately bonded in good thermal connection along its top and bottom surfaces to the upper and lower chamber walls. The bonding material 39 connecting the mat to the chamber wall is clearly shown in the enlarged fragmentary view of Fig. 3. Bonding material 39 may be any one of the many materials in common use for such purposes, dependent upon the materials from which the mats and trays are formed, the heat exchange fluids to be handled, and the severity of temperature and pressure conditions within the chambers. It is desirable that bonding material be such as to provide a strong, permanent bond, impervious to corrosive or other deleterious action by the heat exchange fluid in contact therewith, and free, of itself, from contaminating effect upon the heat exchange fluid. The bonding material may be applied as a coating to the chamber wall or to the surface of the mat, or to both. Or it may be placed as a thin foil between the chamber wall and the mat. In either case, a subsequent heat treatment while pressure is applied to the chamber walls to squeeze the bonding material between the wall and the mat so that the bonding material is fused to the mat and to the wall, is effective to provide the desired thermal connection.

Since the tray sections are made of comparatively thin sheet material, and the top and bottom chamber walls are of relatively broad area, the bonding of the walls to the mat provides a sturdy inner reenforcement, so that comparatively high pressures may be employed within the chambers without causing the walls to bulge or warp, or to separate from the adjoining walls.

The mat 38 comprises a series of channel-shaped fin members 41, as shown in Figs. 16, 17 and 18, disposed adjacent and parallel to each other in nested relationship. The channel or fin members extend longitudinally across the chambers 21 and 22, terminating short of the end closures 31 so as to provide a space 42 between each closure and the mat 38 to serve as a distributing zone for heat exchange fluid entering the chambers.

Within the distributing zones 42 means may be provided, if necessary, to deflect or disperse the incoming fluid stream in order to more effectively distribute the fluid to the far corners of the zone for uniform introduction to the passages through the mat.

The mats 38 extending between and integrally bonded to the walls 25 and 26, and 26 and 27, provide extended heat transfer surfaces therebetween. The connecting wall or walls, such as wall 25, of a multiple chamber unit, are known as the primary heat transfer surfaces, and the fin members extending between the walls are known as secondary heat transfer surfaces, or extended surfaces.

The configuration of the channel or fin members 41 will best be described in connection with the steps of fabrication. Figs. 5, 6, 9, 10, 14 and 15 show in schematic arrangement a preferred mode of shaping metal ribbon or strip stock, as shown in Fig. 4, to form the fin member 41, as shown in Fig. 16; and Figs. 7, 8, 11, 12 and 13 show the fin member in its various intermediate stages of fabrication.

In passing from the strip form of Fig. 4 to the pin-type channel of Fig. 16, the strip passes through three metal-working stages. In the first stage, illustrated in Figs. 5 and 6, the flat metal strip 43 is passed between pressure rollers 44 and 45. The upper roller 44 has flanges 46 at either side axially spaced a distance substantially less than the width of metal strip 43. The lower roller 45 extends between the flanges 46 of the upper roller, the side faces of the lower roller being spaced from the inner faces of the flanges a distance substantially equal to the thickness of strip 43, as shown in Fig. 6, so that in passing between the rollers, the edges of the strip are turned down to transform the flat strip into a channel member having side portions 47 and a base portion 48, as shown in Fig. 7. The rollers 44 and 45 have identical milled or knurled surfaces 49 and 51, respectively, adapted by reason of the close spacing of the rollers to transversely indent or score the inner and outer surfaces of the base portion 43. The teeth of indenting, milling or scoring rollers 44 and 45 are in registry, so that the indentations 52 in the outer and inner faces of base

portion 48 will be oppositely disposed. In this manner, evenly spaced transverse zones of reduced cross-section, as at 53, are provided in the base portion 48 along the entire length of the channel. The longitudinal spacing of adjacent indentations is preferably substantially equal to the thickness of the metal, as illustrated in the drawings. Care must necessarily be exercised in this stage to so construct and mount rollers 44 and 45 and synchronize their rotation that the scoring teeth of opposite rollers will be in accurate registry at all times during contact with the strip. If the opposite teeth are not so aligned, unsatisfactory positioning of the zones of reduced cross-section will be obtained.

The channel member of Fig. 7 resulting from the first metal-working stage, that is, the channel-forming and indenting stage, is then passed to the second or shearing stage.

In the second stage, illustrated in Figs. 9 and 10, the scored channel is suitably guided and passed between rollers 54 and 55 shaped in general like spur gears and having teeth 56 and 57, respectively, which are partially enmeshed. It is not necessary that teeth 56 and 57 be constructed as conventional gear teeth, since driving engagement therebetween is not required. The rollers 54 and 55, however, are rotated in precise synchronism by conventional means, not shown. Teeth 56 and 57 are circumferentially spaced so that in contacting the channel strip each tooth of a roller engages alternate strip portions between the indentations 52. Since teeth 56 and 57 are enmeshed, one of adjacent strip portions is contacted from one side by a tooth from one roller, while the adjacent strip is contacted on the opposite side by a tooth from the other roller.

The simultaneous application of forces in opposite directions on opposite sides of adjacent areas of unreduced thickness causes shearing of the metal in the zones 53 of reduced thickness. Since the spacing of the indentations 52 is substantially equal to the thickness of the metal strip, the shearing action at each zone of reduced thickness produces a series of parallel pin-like members 61 and 62 alternately displaced outwardly and inwardly from the original plane of base 48. The configuration of the channel after passing between rollers 54 and 55 is clearly shown in Figs. 11, 12 and 13. The base 48 of the channel is thus transformed into two parallel rows of pins. The pins 61 are in a row off-set or displaced outwardly from the original plane of base 48, and the pins 62 are in a row off-set or displaced inwardly therefrom.

It is obvious from an inspection of Fig. 8 that the series of pin members 61 and 62 produced by shearing the base 48 along the transverse zones 53 will be substantially octagonal in cross-section and that the sides may comprise more or less irregular surfaces. While it is preferred that the distance between shearing zones 53 be substantially equal to the thickness of base 48, in order that the pin members may have a fairly regular cross-section, slight variations in the cross-sectional configuration may be made without materially affecting the heat conducting characteristics of the pins. It is contemplated, for example, that the pins may be substantially round, square, or octagonal in cross-section, or may be of any other desired cross-section. The shape of the pins will depend to a certain extent upon the configuration of the toothed portion of the indenting rollers 44 and 45, the possible deformation caused by teeth 56 and 57 during the shearing operation, and the irregularities in the sheared surfaces. Since exact uniformity of the pins, while desirable, has not been deemed necessary for the present embodiment, a sacrifice of consistency between the separate views of the drawings for the sake of clarity in illustration has been made. For example, the cross-sectional representation in Figs. 9, 13, 14, and 18 is not meant to illustrate to any high degree of accuracy the shape produced by shearing the indented strip of Fig. 8.

The pin-type channel member resulting from the second metal-working stage, that is, the shearing stage, is then passed to the third or final shaping stage.

In the third stage, illustrated in Figs. 14 and 15, the channel is passed between another set of tooth or gear-like rollers 64 and 65 functioning in a manner similar to the rollers 54 and 55 of the second stage, but having their teeth 66 and 67, respectively, enmeshed to a greater degree. Sufficient clearance is, of course, provided between the outer end of the teeth on one roller and the base of the grooves on the other roller to receive the pin members 61 and 62. The grooves of each roller may be so formed, especially in the base portion, that when the pin members are pressed therein by the teeth of the opposite roller, at least a partial deformation of the pin surface is attained. For example, the base of the grooves may be rounded so that the leading edges of a pin entering a groove may be deformed to a corresponding shape. Preferably, however, the non-sheared portions of the pins are shaped by the teeth of the indenting rollers 44 and 45 of Fig. 5. The grooves of rollers 44 and 45 may be shaped to provide curved sides in the indentions instead of the straight sides illustrated by the indentations 52 of Fig. 8. The teeth 66 and 67 of rollers 64 and 65 are necessarily formed with a degree of precision not required for the teeth 56 and 57 of rollers 54 and 55. Great care must be exercised in forming teeth 66 and 67 so that they may readily engage and disengage each other without catching or binding, and may pass into and out of the spaces between the pin members without rupturing or otherwise injuring the same, and without distorting them out of the desired shape. The configuration of the channel after passing between rollers 64 and 65 is clearly shown in Figs. 16, 17 and 18. The pin members 61 and 62 which were formed and slightly displaced in the second stage are further displaced in the third stage, as shown in Fig. 16. The parallel rows of pins 61 and 62 are now separated sufficiently to provide an unobstructed path 68 extending the length of the pin-type channel.

Since the off-set sheared portions of the channel do not extend across the entire width of the base 48, but terminate at points near the inner faces of the sides 47, shoulder portions 69 are formed by the undisplaced areas of the original outer surface of the base portion 48. These areas form the narrow shoulders which extend the length of the channel. The shoulders 69 are slightly evident after the second stage operation, as may be seen from an inspection of Fig. 12.

In forming the mat 38, a series of the pin-type channels or fins of Fig. 16 are placed side by side, as shown in Fig. 17. The fins may be assembled into a mat separate from the heat exchanger trays 23 and 24, or they may be assembled within the tray. In the latter case, the heat exchange surface of the tray is first provided with the necessary bonding material.

When assembled, the fins are disposed in nested relationship, with the outwardly displaced row of pins 61 extending laterally partially within the channel of the adjacent fin and with the edges of the sides 47 contacting the shoulders 69, as shown in Fig. 17. The shoulders 69 provide a suitable contacting surface for the edges of the adjacent channel, and their width is such that the curved ends of the outer row of pin members 61 fit snugly between the sides 47 of the adjacent channel member. The nesting arrangement made possible by this construction provides rigidity and strength in the assembled mat structure. Preferably, the sides 47 are of a width suitable to provide a space 71 between the row of pins 61 of one fin and the row of pins 62 of the adjacent fin equal in width to the space 68 between the rows 61 and 62 of a single fin.

It is evident from the foregoing description that the method of this invention provides a simple, sturdy, and highly efficient fin member suitable for group arrangement to form a mat to be used for an extended surface or secondary heat exchange portion of a heat exchanger. Pursuant to this method, a flat ribbon of heat conductive material having a continuous plane surface may readily be transformed into a connected series of parallel, spaced pin-like members of substantially equal width and thickness without removing any of the material, so that the total cross-section area of the strip in a plane cutting transversely through the pin members is substantially identical with the cross-section area in a parallel plane cutting through the continuous surface of the connected portions of the strip. Thus, a considerable increase in contact surface is obtained without any diminution in total cross-section area. Furthermore, the transformation is effected without the removal of material, so that, in fabricating, economies are effected by the elimination of waste.

The stages herein described may be carried out as separate steps or as a continuous process. In the latter case, it is contemplated that the necessary guide and feed control means for passing the partially formed strip from stage to stage without injury to the pins may be provided.

While a preferred mode of fabricating the fin portion of the exchanger has been shown, it is obvious that means other than the rollers shown in the three metal-working stages may be used without departing from the spirit of the invention. It is contemplated, for example, that the scored channel of the first stage might be die-pressed as a single operation or in successive increments. Or it may be stamped, drawn, or shaped in any other conventional metal-working operation. The second and third metal-working stages are also susceptible of modification. The shearing and displacing steps may be carried out by a pressing operation with suitable dies.

It is, therefore, desired that only such limitations be placed upon the invention as are specifically set forth in the appended claims.

I claim:

1. In the manufacture of a heat exchanger having fluid passages confined between parallel walls of adjacent fluid chambers, the common walls between adjacent fluid passages forming primary heat exchange surfaces, and having extended surface elements within said fluid passages in thermal connection with said primary heat exchange surfaces for the rapid transfer of heat from the fluid within said passages to said primary heat exchange surfaces, the improvement which comprises the steps of forming a plurality of elongated fins having continuous longitudinal side portions and a discontinuous intermediate portion composed of a series of parallel pin members alternately offset from the normal plane of said fin at points closely adjacent said continuous portions to form parallel rows of pin members, assembling said fins in side-by-side relationship within fluid passages in contact with said primary heat exchange surfaces, spaced so that the distance between adjacent pin rows of adjacent fins is substantially equal to the distance between the pin rows of a single fin, and providing a good thermal bond between the continuous side portions of said fins and said primary heat exchange surfaces.

2. In the manufacture of a heat exchanger having fluid passages confined between parallel walls of adjacent fluid chambers, the common walls between adjacent fluid passages forming primary heat exchange surfaces, and having extended surface elements within said fluid passages in thermal connection with said primary heat exchange surfaces for the rapid transfer of heat from the fluid within said passages to said primary heat exchange surfaces, the improvement which comprises the steps of forming a plurality of elongated fins having continuous longitudinal side portions and a discontinuous intermediate portion composed of a series of parallel pin members alternately offset from the normal plane of said fin at points closely adjacent said continuous portions to form parallel rows of pin members, said longitudinal side portions being turned inwardly from said normal plane to form narrow foot portions along the edges of said strip having their inner face portions spaced a distance equal to the length of said offset pin members whereby the foot portions of one fin may embrace in interlocking engagement the outwardly offset row of pin members of an adjacent fin, said foot portions being of a length substantially equal to twice the spacing between the rows of pin members of a fin, assembling said fins in nested side-by-side relationship within said fluid passages with said foot portions in contact with said primary heat exchange surfaces, and providing a good thermal bond between said foot portions and said primary heat exchange surfaces.

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