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FLEXIBLE PLATE HEAT EXCHANGERS WITH VARIABLE SPACING

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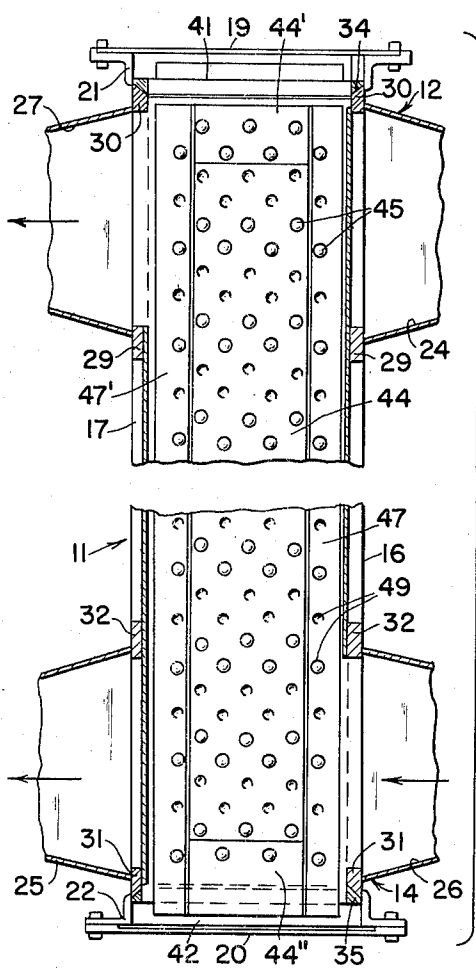


FIG. 1

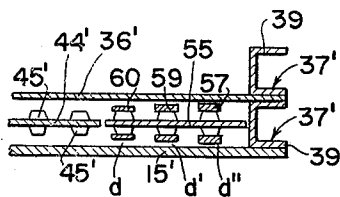


FIG. 4

FIG. 2

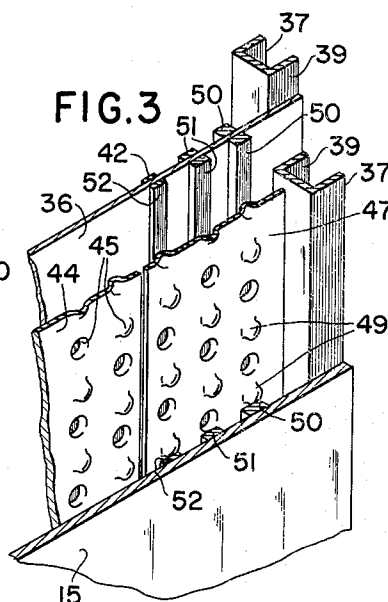
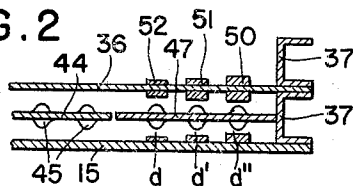
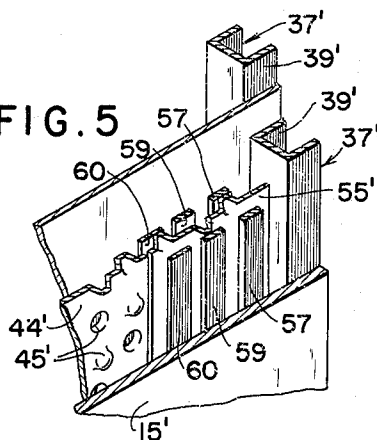


FIG. 5



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3,211,219 FLEXIBLE PLATE HEAT EXCHANGERS WITH VARIABLE SPACING

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13 Claims. (Cl. 165-166)

This application is a continuation-in-part of my application Serial No. 295,312, filed July 16, 1963, which is incorporated herein by reference in its entirety.

This invention relates to flexible plate heat exchangers and is particularly concerned with such heat exchangers which are equipped with spacer members between the flexible plates and wherein such spacer members limit the flexing of the plates to varying extent at different positions of the plates.

The present application is concerned with the provision of spacer plates which control the permissible spacing or flexing of the flexible wall plates adjacent the borders of the channels, so that localized plate flexing and consequent weakening of the plates and possible eventual failure thereof is kept to a minimum. In the parent application Serial No. 295,312, there were disclosed heat exchangers of the flexible plate type wherein flexing of the plates adjacent their borders was progressively limited in directions toward the respective borders by separator means at the borders of the channels formed by the heat exchanger plates. The separator means at such borders were there in the form of oppositely indented dimple plates having dimples of lateral extents or heights as measured from the general plane of such plates which varied, being of minimum height adjacent their inner edges and of maximum height adjacent their outer edges.

It has been found that the provision of dimpled spacer plates with dimples of progressively varying height presents significant difficulties and added expense, both as regards the making of such plates and their installation. Thus in forming such dimple plates of varying dimple heights, it is usually necessary to provide two sets of dies, one for the longer plates and one for the shorter plates, which are different from and additional to the dies employed in forming the main dimple plates, which are disposed in the central or intermediate portion of the channel. Such main dimple plates have the dimples thereon of uniform height throughout their extents, so that they may be formed from sheets shaped by either large platen presses or cooperating roller dies, the thus formed sheets being then sheared to the desired length and width. The dimple plates of varying dimple height, employed as the spacer means at the borders of the heat exchanger plates, cannot be formed in this manner. Instead, they must be formed by the use of other dies, which have lengths and widths which are dictated by the length and width of the heat exchanger plates of each heat exchanger or at most model of heat exchanger.

Further, the thus formed border spacers require great care in their installation, lest they be installed in a heat exchanger in the wrong manner. The varying height of the dimples on the plates may not be easy to see or feel, particularly in the installed location of the heat exchanger. Thus it is possible to install the border spacer plates, either initially or after they have been removed for cleaning, in such manner that the dimples of least height lie outwardly, adjacent the edges of the flexible heat exchanger plates, rather than inwardly thereof as they should, thereby defeating the purpose of such bordering spacer plates and leading to the injury of the heat exchanger plates.

The present invention overcomes the above outlined difficulties experienced in the manufacture and use of prior bordering spacer means of the dimple plate type. The plates proper of the bordering spacer means in ac-

cordance with the invention may be formed from dimple sheets shaped by a single set of dies additional to the dies employed in forming the intermediate or main spacer plates. The border spacer plate stock, after being shaped to provide dimples thereover of a uniform height, less than that of the main or intermediate spacer plates, may be sheared to any length and width, as required by the particular heat exchanger being built. This leads to great economies in manufacture, and greatly reduces the care necessary to keep the dimpled spacer sheet stocks for the intermediate and bordering portions from becoming confusingly intermingled.

The varied over-all height required of the bordering spacer plates at the locations of the dimples thereon is provided by strips of metal of varying thickness which are aligned with and overlie the rows of dimples on the bordering spacer plates. In a first disclosed embodiment of the invention, such strips are secured as by being welded to the faces of the flexible heat exchanger plates. In a second disclosed embodiment the strips are secured as by being welded to the dimples in the respective rows thereof on the bordering spacer plates. The first embodiment makes it impossible to install the bordering spacer plates in other than a correct manner. In the second embodiment, the strips of varying thickness are exposed at their edges and ends, so that the thicknesses of the various strips can be readily seen and felt, thereby facilitating the correct assembly of the bordering spacer plates in the heat exchanger.

It is, accordingly, the over-all object of the invention to improve upon provision of bordering spacer means for flexible plate heat exchangers.

Another object is to control in a novel manner the extent of flexing of the plates of flexible plate heat exchangers to different extents at different positions adjacent the borders thereof.

Another object is to effect the control of the flexing of the plates of flexible heat exchangers in varying degree adjacent the borders thereof by the use of spacer means including dimple plates having dimples of uniform height.

Still another object is to provide novel spacer means which are more economically made than those of the prior art.

A still further object is to provide for achieving the foregoing objects in simple and economical manner with regard to construction, operation, and maintenance.

Further and more detailed objects will in part be pointed out and in part be obvious as the description of the invention taken in conjunction with the accompanying drawing proceeds.

In that drawing:

FIG. 1 is a front elevation with the front cover plate removed of a heat exchanger in accordance with the invention, the removal enabling the spacer plate construction to be seen;

FIG. 2 is a fragmentary horizontal section on line 2-2 of FIG. 1 looking in the direction of the arrows and on a somewhat larger scale than that of FIG. 1;

FIG. 3 is a fragmentary view in perspective of the portion of the heat exchanger shown in FIG. 2;

FIG. 4 is a view similar to FIG. 2 showing a second embodiment of the construction of the spacer means in accordance with the present invention; and

FIG. 5 is a fragmentary view in perspective of the portion of the heat exchanger shown in FIG. 4.

Considering the construction of the heat exchanger of the invention in detail, the heat exchanger 10, as shown in FIG. 1, can be considered as being composed generally of an elongated intermediate portion 11, and upper and lower end portions 12 and 14. Considered from the standpoint of these separate portions, it is to be generally

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understood that the embodiment of the invention of FIGS. 1, 2, and 3, as well as the embodiment of FIGS. 4 and 5, comprehend that, save for the upper and lower portions, as shown here, and for the novel side strips to be described, the intermediate portion is characterized by the provision of spacer members throughout of uniform effective height or thickness. The end portions shown in FIG. 1, when considered vertically, provide spacer members increasing in height from the intermediate portion toward the top and bottom ends. This variable increase in height of the spacer members correspondingly reduces the extent to which the flexible wall plates of the heat exchanger can flex at their ends.

The housing of the heat exchanger is generally made up of a front plate 15 (FIGS. 2 and 3) and a comparable back plate (not shown). The right and left sides throughout the principal portion of the height of the heat exchanger, as indicated generally at 16 and 17, are merely made up of the vertically extending U bars between the sides of which the flexible plates of the heat exchanger are secured. The heat exchanger has top and bottom plates 19 and 20 which are removably secured by means of a series of bolts to the flanges of collars 21 and 22, respectively, which are sealingly secured about the upper and lower ends of the heat exchanger housing.

The heat exchanger shown is designed for countercurrent flow of the heat exchange media passed through the separate channels thereof. Thus one medium enters at the top and to the right through the inlet conduit 24 and passes out at the bottom left through its paired outlet conduit 25. The pair of conduits for the medium passed in heat exchange relationship therewith is made up of the inlet conduit 14 shown at the lower right hand side of FIG. 1 and its paired outlet conduit 27 shown at the left hand upper side thereof. At the upper end of the heat exchanger where the conduits 24 and 27 join up to the stack, filler pieces 29 and 30 are used for filling the exterior troughs provided by the U bars so that flow into and out of the respective channels can be effected without leakage. Similar sealing pieces are seen at 31 and 32, where the lower conduits 25 and 26 are joined to the stack. It is also to be noted that the upper filler pieces 30 are chamfered off in the line where their side and top U bars come together and have smaller filler pieces 34 secured thereto to fill the ends of the troughs of alternate ones of the U bars extending across the top. Similar filler pieces 35 are provided for a similar purposes at the bottom of the heat exchanger.

The flat flexible heat exchanger plates 36 extend throughout the full height of the heat exchanger. Such plates are secured together in spaced relationship throughout most of their vertical height by means of U bars 37 at their edges, the sides 39 of bars 37 being welded in tight leak-proof joints to the edge portions of the plates 36. In the areas where the respective conduits 24-27 join the stack of the heat exchanger, it will be appreciated that every other one of the U bars will be removed to allow the fluid to flow into the channels provided between the heat exchanger plates. Thus the sections removed for one set of channels at the inlet 24 will correspond with the sections removed from the same channels at the outlet 25, leaving the remainder closed. The other set of channels will be open for flow of fluid therein from the inlet 26 and upwardly and outwardly through the outlet 27.

Above the upper edges of heat exchanger plates 36, the housing is provided with a shallow upper chamber 41; a similar shallow lower chamber 42 is provided in the housing below the lower edges of the plates 31. Thus the fluid, besides flowing in-between plates 36, can also well up into the chamber 41 at the head of the stack. In the alternate channels, liquid or fluid entering through the inlet 26 will well down into the chamber 42 before flowing upwardly through its channels and out through the outlet 27. In this flow, the fluid entering at 26 will, of course, be isolated by the flexible heat exchanger walls

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36 from the channels in which the fluid introduced at 24 flows down and out through the outlet 25.

The flexible heat exchanger plates 36 are restrained from excessive flexing by means of dimple type spacer plates which are positioned in the channels or spaces between the plates 36. In the embodiment shown in FIG. 1, such spacer plates are made up of five pieces or elements: a main spacer plate 44, separate vertically short spacer plates 44' and 44'' at the top and bottom, respectively, of the main spacer plate 44, and vertically elongated side spacer plates 47 and 47' which extend along the respective sides of the central spacer plates 44 and 44' and 44''.

The main spacer plate 44 has a plurality of dimples or hollow projections 45 disposed thereof with uniform spacing, alternate ones of the dimples facing in opposite directions. For simplicity of illustration, the number of dimples shown on the various pieces making up the composite spacer plate means are greatly reduced in number in FIG. 1. Thus in actuality, as shown in FIGS. 2 and 3 in connection with the first embodiment and FIGS. 4 and 5 in connection with the second embodiment, each side spacer plate may have, for example, three vertically extending rows of dimples therein.

The dimples 45 of the main spacer plate 44 are of uniform height, being spaced from the confronting surfaces of plates 36 a uniform distance. The dimples 49 on the two side dimple plates are likewise of uniform height. In FIGS. 2 and 3 the side dimple plate 47 is shown, the other side dimple plate 47' being of the same construction but reversely disposed. In the embodiment of FIGS. 2 and 3, in order to provide for progressively restraining the flexing of the plates 36, a vertical strip of material secured to the face of the plate is positioned to confront each of the three rows of dimples 49 on the side spacer plate 47. The laterally outermost strip of such vertical strips, designated 50, is the thickest of the three, thereby leaving a narrow space d'' between its inner face and the outer face of the confronting dimples. The intermediate strip 51 has a thickness less than that of strip 50, thereby producing a spaced d' between it and the confronting row of dimples. The laterally innermost strip 52 is thinnest so that the space d between it and its row of dimples is the largest of such three spaces.

As a result of such construction, it will be apparent that the plates 36 are restrained from sidewise flexing in progressively increasing degrees in a direction laterally outwardly toward their edges. The spacer strips 50, 51, and 52, which may be made of metal or any other durable constructional material suitable for the purpose at hand, may be secured to the heat exchanger plates 36 in a number of suitable ways. When the heat exchanger plates and spacer strips are both of metal, they may conveniently be secured together as by welding.

The heat exchanger fragmentarily shown in FIGS. 4 and 5 is of generally the same construction as that of FIGS. 1, 2, and 3; consequently, parts in FIGS. 4 and 5 which are the same as those of the first described embodiment are designated by the same reference characters with an added prime. For distinctiveness, however, the vertically extending side spacer plate shown in FIGS. 4 and 5 is designated 55, the dimples in the three laterally spaced vertical rows thereof being designated 56. In the construction shown in FIGS. 4 and 5, spacer strips 57, 59, and 60, which are of progressively decreasing thickness, are connected to the outer ends of the dimples 56 and the respective rows thereof, as shown. Thus the spacer strips become a part of the side spacer plates, the outer surfaces of the strips 57, 59, and 60 being spaced from the confronting surface of the heat exchanger plates 36' by increasing distances, as shown. The spacer strips may conveniently be secured to the dimples 56, when such parts are made of metal, as by spot welding.

The upper and lower main spacer plates 44' and 44'' may be constructed in a manner generally similar to

that of either FIGS. 2 and 3 on the one hand and FIGS. 4 and 5 on the other. Thus the dimples of such main plate portions may either confront spacer strips of varying thickness secured to the heat exchanger plates, or may have spacer strips of varying thickness secured thereto. With either construction, flexing of the heat exchanger plates 36 at their upper and lower ends is progressively restrained in directions toward their upper and lower edges.

The above described construction not only provides a simple manner of restraining flexing of the heat exchanger plates in the desired degree at their edges, but provides a construction whereby the channels of the heat exchanger may be readily cleaned mechanically when necessary. To accomplish this, all that is necessary is to remove the top or the bottom plate, or both, from the housing and to withdraw from the various channels the spacer plate means. By having the respective channel systems open at the top and bottom chambers, the short spacer plates 44' and 44'' can be readily removed by grasping the exposed edge portions thereof once the end plates of the housing have been removed. The shortness of these plates facilitates their removal in spite of the scale which may have built up opposite their dimples. Once the end plates 44' and 44'' have been removed, the main spacer plate 44 can be caused to fall out or can be readily removed in other manners. Following removal of the central spacer plate portions, it is then possible to force the side spacer plate members inwardly to free them in their channels, following which they may be vertically removed from the channels.

In the foregoing description taken in conjunction with the accompanying drawing, various embodiments of the invention have been illustrated and described. It will be clear to those skilled in the art, however, that such description and illustration are only by way of illustration and that other useful modifications and variations as would suggest themselves to those skilled in the art may be employed without departing from the spirit and scope of the invention. Thus it is to be understood that since certain changes may be made in the above construction and different embodiments of the invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

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

1. In heat exchanger construction, a pair of spaced flexible heat exchanger plates forming a channel for the passage of heat exchange medium therebetween, and separate spacer means mounted in said channel for limiting the flexing of said plates toward each other, said spacer means having a portion for limiting the flexing of a portion of said plates between in varying degree, said portion of said spacer means being formed as a dimple plate with dimples formed out of the material thereof extending laterally to one side and the other of the plane of said plate, said dimple plate being positioned between the flexible plates of a channel, said dimples being uniform in height, said spacer means including strips of material of various thicknesses secured in opposed relationship with respect to said rows of said dimples, the sum of the heights of the respective opposed dimples and spacer means being less than the distance between the confronting surfaces of the flexible heat exchanger plates and the main, base portion of the dimple plates at the location of said dimples and spacer means aligned therewith when the heat exchanger plates are relaxed.

2. In heat exchanger construction as in claim 1, said strips of material being secured to said heat exchanger plates.

3. In heat exchanger construction as in claim 1, said strips of material being secured to the said dimple plate

of said spacer means and overlying the rows of dimples thereon.

4. In heat exchanger construction as in claim 1, the strips of material increasing in thickness in one direction along the dimple plate.

5. In heat exchanger construction, a pair of spaced flexible heat exchanger plates forming a channel for the passage of heat exchange medium therebetween, and separate spacer means mounted in said channel for limiting the flexing of said plates toward each other, said spacer means having an intermediate portion lying within a portion of said channel intermediate a pair of the borders thereof formed to limit flexing of said plates toward each other to a uniform extent, said spacer means including separate bordering portions for limiting the flexing of bordering portions of said plates between said intermediate portion of said channel and said pair of borders thereof in varying degree, said bordering portions of said spacer means being formed as bordering dimple plates with dimples formed out of the material thereof extending laterally to one side and the other of the plane of each of said plates, said bordering dimple plates being positioned between the edges of the intermediate portion of the spacer means and the borders of said channels, said dimples being uniform in height, said bordering portions of said spacer means including strips of material of various thicknesses secured in opposed relationship with respect to said rows of said dimples, the sum of the heights of the respective opposed dimples of the bordering dimple plates and spacer means being less than the distance between the confronting surfaces of the flexible heat exchanger plates and the main, base portion of the dimple plates at the location of said dimples and spacer means interposed therebetween when the heat exchanger plates are relaxed.

6. In heat exchanger construction as in claim 5, said strips of material being secured to said heat exchanger plates.

7. In heat exchanger construction as in claim 5, said strips of material being secured to the said bordering portions of said spacer means and overlying the rows of dimples thereon.

8. In heat exchanger construction as in claim 5, the strips of material increasing in thickness in the direction from the inner edges of the bordering portions of said spacer means toward the respective borders of said plates.

9. In heat exchanger construction, a plurality of pairs of spaced flexible heat exchanger plates forming channels for the passage of heat exchange medium therebetween, every other one of said channels forming one passage means for the passing of one heat exchange medium through said heat exchanger, the remainder of said channels forming another passage means for another heat exchanger medium, separate pairs of inlet and outlet means for said heat exchange media for said one and another passages, means for sealing the portions of said heat exchanger plates between their edges save where said passages are in communication with said inlet and outlet means, said one passage being open at one end position of said heat exchanger and said other passage being open at the other end position of said heat exchanger, chamber forming means overlying said ends of said heat exchanger and having the interiors thereof in communication with said respective open passages, said chamber forming means being formed with removable end walls, spacer means positioned in said passages for limiting the extent of flexing of said flexible heat exchanger plates of said pairs toward each other, said spacer means comprising intermediate spacer members extending throughout the major portion of the central extent of said passages between said ends thereof and separate bordering spacer members positioned along the edges of said intermediate spacer members, said bordering spacer members being

positioned in passages formed with open ends having portions accessible through said open ends of the respective end chambers so that said extending portions may be gripped for removal of said bordering spacer members on removal of said end plates from said chambers, said intermediate spacer members having uniform lateral extent throughout and said bordering spacer members increasing in lateral extent in a direction away from said intermediate spacer members whereby flexing of said flexible plates will be permitted to substantially uniform extent throughout the portions of the same opposed to said intermediate spacer members and will be limited to increasing extent toward the borders of said passages, said bordering portions of said spacer means being formed as bordering dimple plates with dimples formed out of the material thereof extending laterally to one side and the other of the plane of each of said plates, said bordering dimple plates being positioned between the edges of the intermediate portion of the spacer means and the borders of said channels, said dimples being uniform in height, said bordering portions of said spacer means including strips of material of various thicknesses secured in opposed relationship with respect to said rows of said dimples, the sum of the heights of respective opposed dimples of the bordering dimple plates and spacer means being less than the distance between the confronting surfaces of the flexible heat exchanger plates and the main, base portion of the dimple plates at the location of said dimples and spacer means aligned therewith when the heat exchanger plates are relaxed.

10. In heat exchanger construction, a plurality of pairs of spaced flexible heat exchanger plates forming channels for the passage of heat exchange medium therebetween, every other one of said channels forming one passage means for the passing of one heat exchange medium through said heat exchanger, the remainder of said channels forming another passage means for another heat exchanger medium, separate pairs of inlet and outlet means for said heat exchange media for said one and another passages, means for sealing the portions of said heat exchanger plates between their edges save where said passages are in communication with said inlet and outlet means, said one passage being open at one end position of said heat exchanger and said other passages being open at the other end position of said heat exchanger, chamber forming means overlying said ends of said heat exchanger and having the interiors thereof in communication with said respective open passages, said chamber forming means being formed with removable end walls, spacer means positioned in said passages for limiting the extent of flexing of said flexible heat exchanger plates of said pairs toward each other, said spacer means comprising intermediate spacer members extending throughout the major portion of the central extent of said passages between said ends thereof and separate bordering spacer

members positioned along the edges of said intermediate spacer members, said bordering spacer members being positioned in passages formed with open ends having extending portions extending out through said open ends into the respective end chambers so that said extending portions may be gripped for removal of said bordering spacer members on removal of said end plates from said chambers, said intermediate spacer members having uniform lateral extent throughout and said bordering spacer members increasing in lateral extent in a direction away from said intermediate spacer members whereby flexing of said flexible plates will be permitted to substantially uniform extent throughout the portions of the same opposed to said intermediate spacer members and will be limited to increasing extent toward the borders of said passages, said bordering portions of said spacer means being formed as bordering dimple plates with dimples formed out of the material thereof extending laterally to one side and the other of the plane of each of said plates, said bordering dimple plates being positioned between the edges of the intermediate portion of the spacer means and the borders of said channels, said dimples being uniform in height, said bordering portions of said spacer means including strips of material of various thicknesses secured in opposed relationship with respect to said rows of said dimples, the sum of the heights of respective opposed dimples of the bordering dimple plates and spacer means being less than the distance between the confronting surfaces of the flexible heat exchanger plates at the location of said dimple and spacer means aligned therewith when the heat exchanger plates are relaxed.

11. In heat exchanger construction as in claim 10, said strips of material being secured to said heat exchanger plates.

12. In heat exchanger construction as in claim 10, said strips of material being secured to the said bordering portions of said spacer means and overlying the rows of dimples thereon.

13. In heat exchanger construction as in claim 10, the strips of material increasing in thickness in the direction from the inner edges of the bordering portions of said spacer means toward the respective borders of said plates.

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55 CHARLES SUKALO, *Primary Examiner.*