

[54] **HEAT EXCHANGER WITH BACKED THIN TUBES**
[76] Inventor: **Herbert G. Johnson**, 17 North Drexel Avenue, Havertown, Pa. 19083
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[58] Field of Search..... **165/133, 151, 182, 173, 178; 29/157.3 V, 523; 264/94, 249**

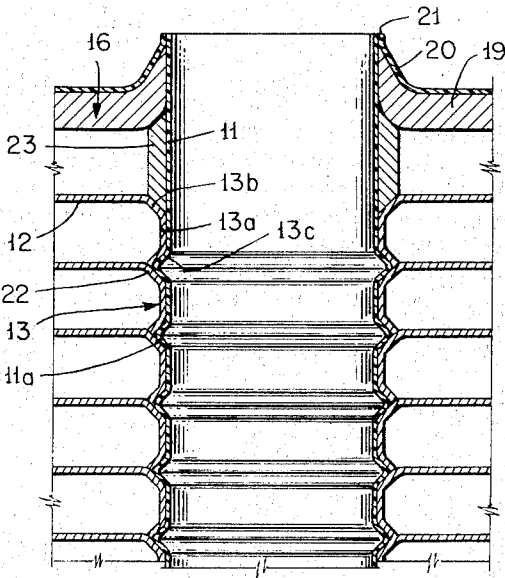
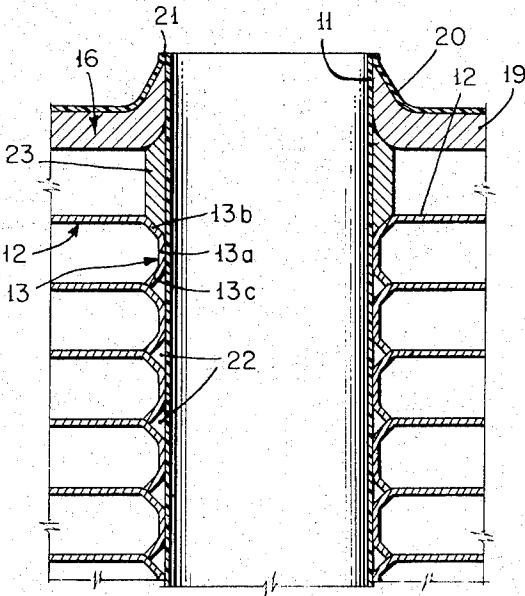
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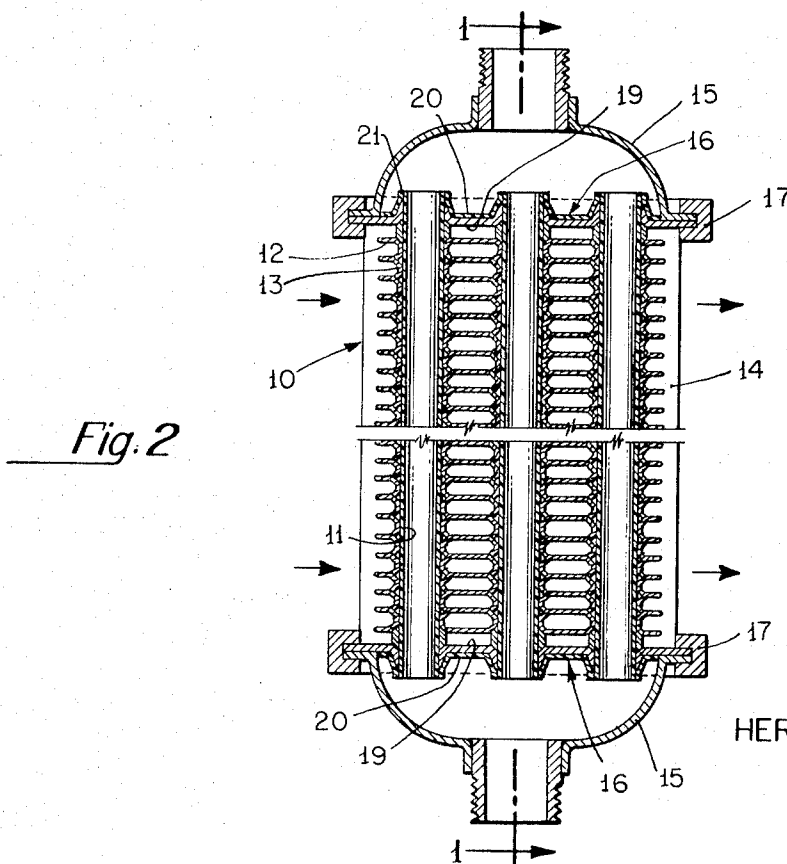
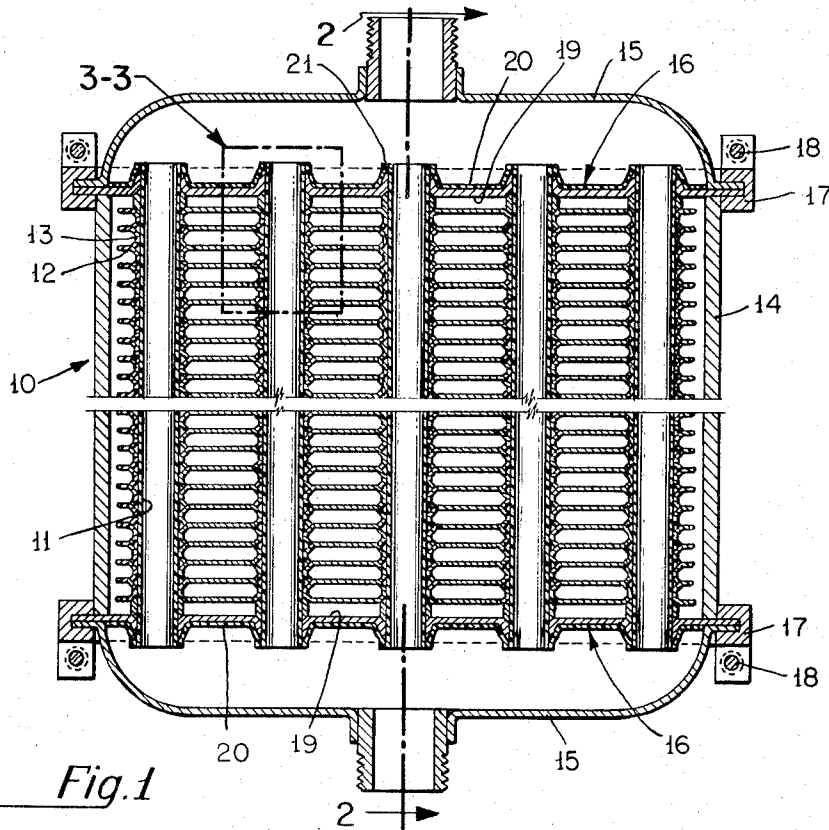
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Primary Examiner—Allan D. Herrmann

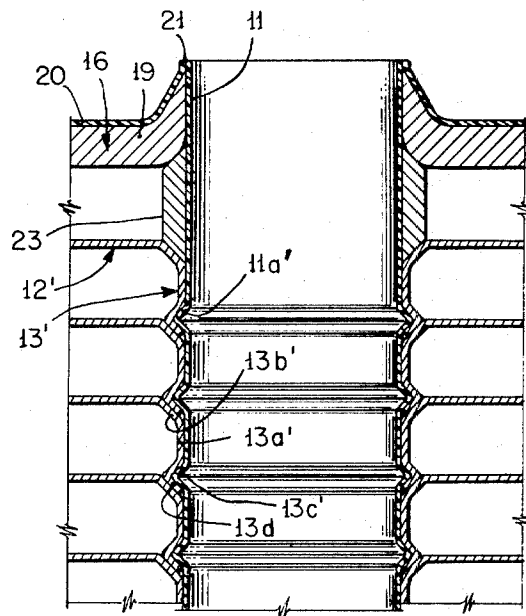
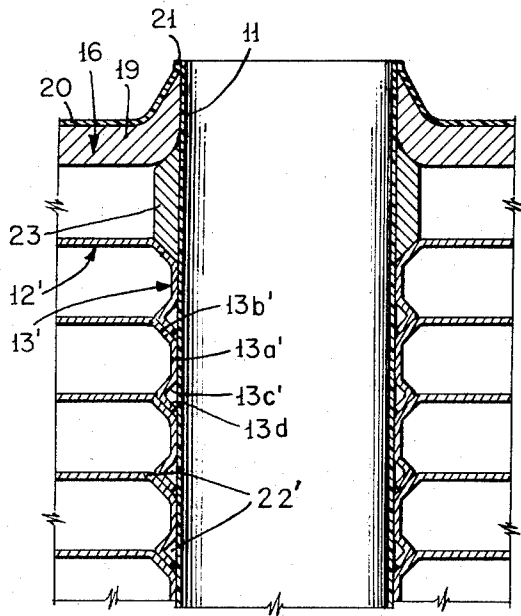
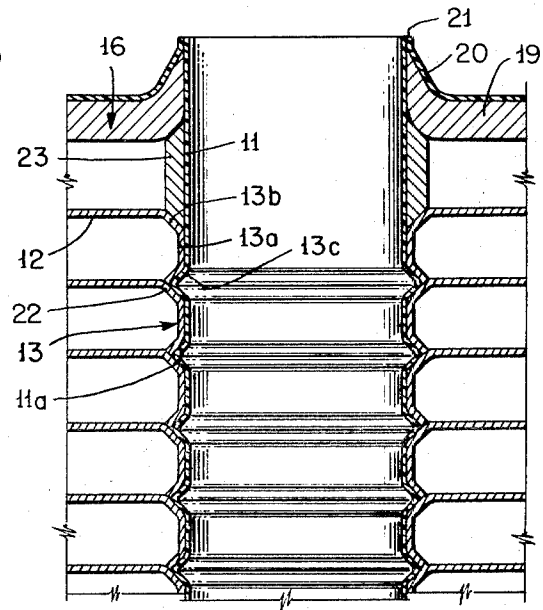
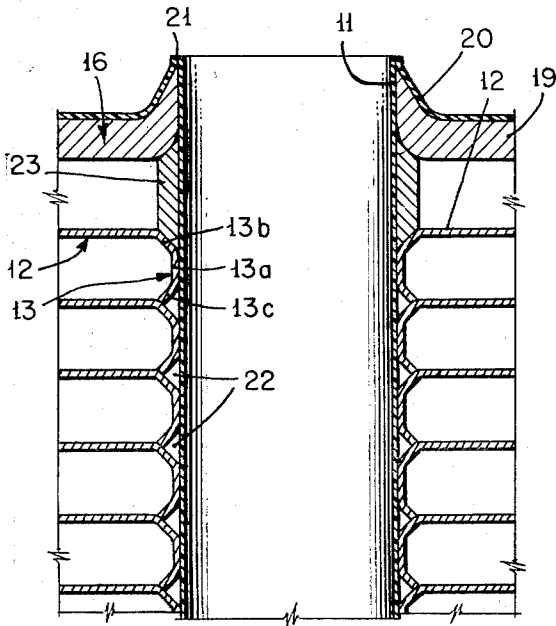
[57] **ABSTRACT**
This application discloses a heat exchanger having thin lining tubes, as of plastic or metal, deformed against structural tubular backing and thermal exchange elements to provide extensive effective thermal transfer contact and support with contoured securement between tubes and backing elements which obviates relative displacement and relieves differential thermal change in length and stresses. Also the method of making the assembly.

9 Claims, 6 Drawing Figures





INVENTOR
HERBERT G. JOHNSON



INVENTOR.
HERBERT G. JOHNSON

HEAT EXCHANGER WITH BACKED THIN TUBES

BACKGROUND OF INVENTION

In my U.S. Pat. No. 3,426,841 of Feb. 11, 1969 and No. 3,489,209 of Jan. 13, 1970 there are disclosed heat exchanger constructions in which inner corrosion resistant tubes, as of plastic, bathed by one fluid, are arranged in thermal transfer relationship with external structural thermal exchange elements which are bathed by another fluid.

In the patent constructions the liner tubes are pressure-balanced at their tube plate connections and backed by outer structural elements so that the liner tubes may be relatively thin, thus permitting the use of plastics for the liner tubes even though the coefficient of thermal transfer is relatively small. Nevertheless, in this patented construction the inner tubes are not completely backed and over small areas must withstand considerable pressure and must be made thick enough to withstand such local high pressures without damage.

SUMMARY OF INVENTION

The present invention provides an improved construction in which much thinner tubes can be used by being contour-distorted into intimate contact with all surfaces of the backing supporting thermal exchange elements thus increasing thermal transfer effectiveness and preventing relative displacement even when the tubes are disposed in a vertical position and are subjected to long periods of differential thermal stresses.

The invention also embraces a method of assembly in which backing thermal transfer structural elements having tubular collars or sleeves and lateral fins are slipped successively over a bank of tubes, the tubes secured to a tube sheet, and the tubes then expanded by high fluid pressure into intimate contour contact with the collars or sleeves of the structural backing elements and other surrounding backing elements. In the preferred construction the collars or sleeves of the structural elements are purposely made with concave enlargements to provide for expansion of the tubes into them to more fully obviate relative axial displacement and achieve the most efficient thermal transfer relationship. In the forms herein illustrated these concave contour deformations are formed at the ends of the collars or sleeves, preferably as annular grooves or negative corrugations into which positive corrugations or ribs of the tubes are disposed in final assembly. In one form the grooves are formed by bent flanges on the ends of one backing element resting at the end against bent webs of adjacent backing elements; and in another form the corrugations or grooves are formed entirely on the end portion of one backing element with one side of the corrugation resting on a bent web of an adjacent backing element, thus providing greater radial strength at the joints.

DRAWINGS

The objects, advantages, and features of novelty of the invention will be apparent from the following description of selected exemplary embodiments thereof, reference being made to the accompanying drawings, wherein:

FIG. 1 is a longitudinal section of a heat exchanger or thermal transfer construction embodying the present

invention but before expansion of the lining tubes, the section being taken on the line 1—1 of FIG. 2;

FIG. 2 is a longitudinal section taken on the line 2—2 of FIG. 1;

FIG. 3 is an enlarged section taken on the zone 3—3 of FIG. 1;

FIG. 4 is a view like FIG. 3 but showing the final assembly after the liner tubes have been expanded into the contour concavities of the backing elements;

FIG. 5 is a view like FIG. 3 but showing a modified embodiment;

FIG. 6 is a view like FIG. 5 but showing the final assembly after the liner tubes have been expanded into the contour concavities of the backing elements.

SPECIFIC DESCRIPTION

The invention is illustrated in connection with the use of very thin plastic liner tubes supported by metal finned backing thermal transfer elements. At present the preferred plastic is polyethylene (pipe grade, class III, high density, non-oriented, about $\frac{3}{4}$ inch O.D., 0.020 inch thick); but other plastics of various kinds or certain metals like aluminum and other fairly soft metals may be used, the selection depending to some extent on the service and kind of fluids handled. Polypropylene, fluorocarbons, and the like are known types which may be noted.

The thermal exchange unit illustrated may be an automobile radiator 10 in which a cooling fluid or liquid such as water is circulated through lining tubes 11 and in which a disposal fluid or gas such as air is circulated over finned thermal transfer tube-backing elements 12 which have collars or sleeves 13 surrounding the tubes. The direction of air flow is indicated by arrows in FIG. 2.

The particular heat exchange unit illustrated has an open-sided body casing 14, chamber-forming pipe-connected caps or headers 15, and tube sheets 16 secured together in sealed relationship by grooved rim clamp members 17 and tie bolts or screws 18. Corrosion resistant metals are used if the fluids concerned require it.

Two tube sheets are shown herein, although as shown in U.S. Pat. No. 3,489,209 (FIG. 10) the principles are applicable to heat exchange units having a single tube sheet, suitable means being provided to protect the outer ends of the bent U-shaped tubes. The tube sheets are composite, comprising a strength member 19 of metal and a plastic liner 20 which has nipples 21 fused or otherwise secured and sealed to the ends of the tubes.

As shown in FIG. 3, the collars or sleeves 13 of the thermal-transfer tube-backing elements have straight tubular web portions 13a, intermediate inclined web portions 13b, and terminal inclined web portions 13c. The ends of the web portions 13c of one element abut against the sides of the web portions 13b of the collar of an adjacent element, leaving annular contour concavities, negative corrugations, or grooves 22 between the inclined web portions of the collars.

If it is not desired to place the finned heat transfer elements directly against the tube sheets it is convenient to provide spacer rings 23 between them so that the lining tubes are completely backed by structural elements throughout their entire length except at

their ends which are disposed in a fluid pressure balanced location.

As initially installed, the tubes 11 are of uniform diameter and of a size small enough to permit the collars or sleeves of the thermal transfer backing elements to be readily slipped over them. Finally, as shown in FIG. 4, after full assembly, with the tubes sealed at the tube sheets, the tubes are expanded by applied fluid at sufficient pressure and temperature to form protrusions, positive corrugations, or ribs 11a and fully fill the contour spaces within the encasing structural elements.

In service the liner tubes are not required to take any load at any point and may be made extremely thin so as to provide efficient thermal exchange even though their particular thermal transfer resistance may be relatively high. The contour engagement also fully obviates relative movement between tubes and backing elements. Such tendency for relative movement might be caused by gravity if the tubes are disposed in a non-horizontal position or by the differences in thermal expansion coefficients of plastic tubes and metal backing elements with repeated heating and cooling in use, especially over long periods of time.

The embodiment shown in FIGS. 5 and 6 is generally like the first embodiment and the same reference characters are applied to common parts, but the collars or sleeves 13' of the thermal transfer elements 12' have a terminal flange 13d in addition to the web portions 13a', 13b', 13c' and this end flange 13d rests on the web 13b' of the adjacent collar or sleeve. This provides a somewhat stronger resistance to radial loads and somewhat better joint seal when the parts are forced together in assembly than the first embodiment. A somewhat smoother backing surface is assured for the lining tube in case there may be manufacturing flaws.

In making the assembly the tubes are first sealed to a lower tube sheet, or otherwise secured in accurate position in case a single tube sheet is used, then the finned thermal transfer elements have their collars or sleeves slipped down over the tubes, then the upper tube sheet is pressed into position and the tube ends sealed, the intermediate rings being applied when used. The assembly, with headers 15 and body spacer 14 are secured together in sealed relationship by the clamp members 17 and bolts 18. Finally, the tubes are expanded by fluid at sufficient pressure and temperature into the concavities of the structural backing elements. If the plastic material is of a suitable type it is strengthened and fiber-oriented by the expansion procedure.

Insofar as the construction, materials, assembly, and principles of my prior patents are used herein the same considerations and advantages apply. The present improvement makes it feasible to use much thinner lining tubes, to obtain more efficient thermal transfer, to more fully insure against tube rupture in service, and to obviate the possibility of creep or displacement of the tubes relative to the structural backing elements in service.

While certain embodiments of the invention have been disclosed for purposes of illustration, it is to be understood that there may be various embodiments and modifications within the general scope of the invention.

I claim:

1. A heat exchanger, comprising in combination an outer tubular backing structure extending completely in supporting continuity between tube end connections at pressure fluid chambers and having contour concavities along its length and an inner lining tube which is too thin and weak to alone withstand applied internal pressure and having in-situ pressure-formed projections along its length fitting tightly in full heat exchange and backed relationship with the full interior surface of the outer tubular backing structure, the inner lining tube being fully backed throughout its length by the continuous outer tubular backing structure for the complete distance between the tube end connections and pressure chambers to avoid the application of pressure fluid to any portion of the inner lining tube where it is not fully supported by the outer tubular backing structure.

2. A heat exchanger as set forth in claim 1, wherein the concavities in the outer tubular structure comprise annular grooves pre-formed on collars of finned thermal transfer elements stacked on the tube and wherein the inner lining tube is expanded in-situ to fully fill the annular grooves.

3. A heat exchanger as set forth in claim 2, wherein the pre-formed annular grooves are formed by an inclined end flange on one collar abutting an inclined intermediate web of an adjacent collar.

4. A heat exchanger as set forth in claim 2, wherein the pre-formed annular grooves are formed by an inclined web and inclined terminal flange on one collar, the terminal flange lying upon an inclined intermediate web of an adjacent collar.

5. A heat exchanger as set forth in claim 1, wherein the inner lining tube is formed of a plastic with its projections formed in-situ in form-fitting shape in the concavities and all other portions of the outer tubular backing structure.

6. A heat exchanger as set forth in claim 5, in which the plastic is polyethylene.

7. A heat exchanger as set forth in claim 2, wherein a plurality of tubes and outer tubular backing structures therefor are provided and in which the inner tubes are of plastic material and extend through a tube sheet of an end connection and are fused to nipples of a plastic tube sheet liner in pressure-balanced relationship in a pressure fluid chamber on the liner side of the tube sheet.

8. The method of making a heat exchange assembly which includes very thin inner lining tubes within an outer tubular backing structure with internal contour concavities disposed between tube end connections at pressure fluid chambers, which comprises: assembling inner lining tubes of uniform diameter within the outer tubular backing structure with the entire length of the inner lining tubes between tube end connections completely backed by the outer tubular structure, and expanding the thin inner lining tubes into the outer tubular backing structure throughout its length to fit into intimate backing and heat exchange relationship therewith and to form contour projections in-situ which fully fill the concavities of the outer tubular backing structure.

9. The method as set forth in claim 8, wherein the outer tubular backing structure comprises interfitting collars on finned heat exchange elements which are

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stacked on the inner lining tubes to form annular grooves at their ends, and in which the inner lining tubes are of plastic material expanded in-situ to fill the outer tubular backing structure and are fused at their ends to a plastic component at end connections in pressure-balanced relationship in the pressure fluid chambers.

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