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HEAT EXCHANGE APPARATUS

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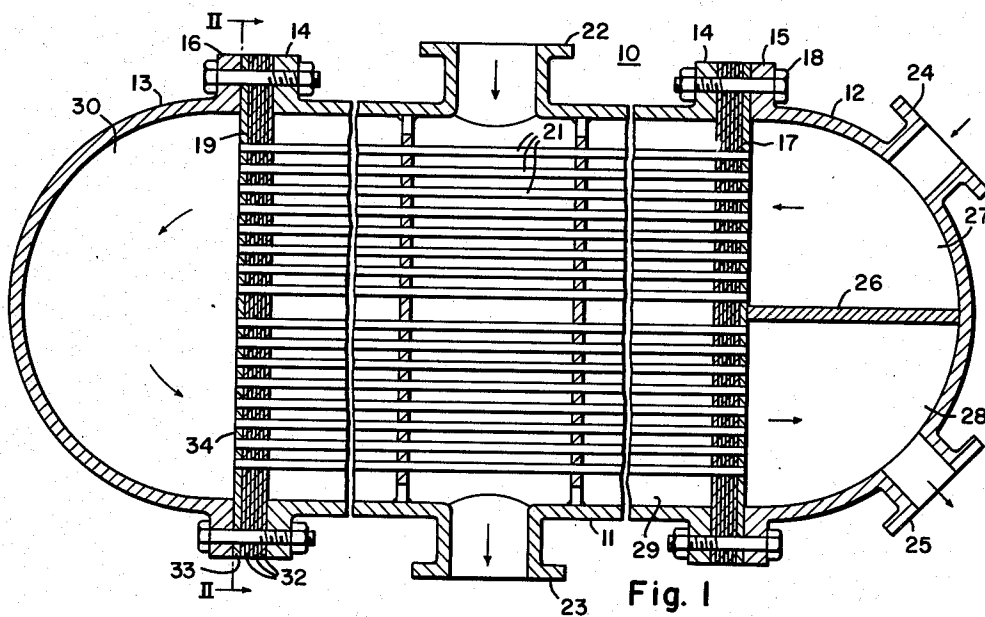


Fig. 1

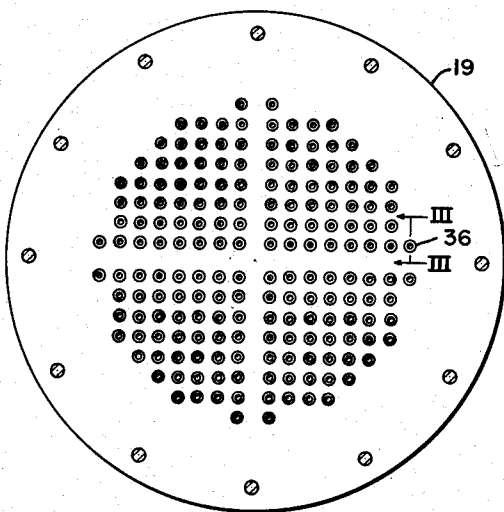


Fig. 2

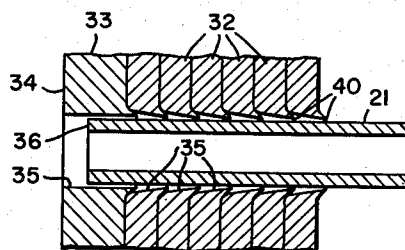


Fig. 4

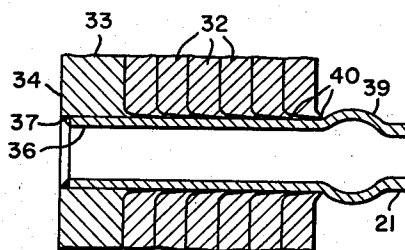


Fig. 3

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HEAT EXCHANGE APPARATUS

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This invention relates to heat exchangers of the shell and tube type and has for an object to provide a highly improved and more readily fabricated structural arrangement of this type.

In heat exchangers of the shell and tube type to which this invention relates, there is usually provided a casing within which is disposed a bundle of elongated tubular members through which a heating medium is passed. The tube bundle is supported at one end, at least, by partition structure, usually called a tube sheet, which divides the casing into two compartments. One of the compartments is employed to direct a heated fluid through the tubes, while the other compartment is employed to permit flow of a cooler fluid in good heat exchange relation with the outer surfaces of the tubes, with attendant heating of the cooler fluid. Heat exchangers of this type are usually supplied with fluids at high pressure and temperature. Accordingly, to safely withstand the pressures and temperatures to which it is subjected, the tube sheet must necessarily be of relatively thick cross-section. Such tube sheets have heretofore been fabricated as one-piece members by forging processes or the like. Forged members are inherently nonuniform in their physical properties and are usually subjected to X-ray examination or the like to ascertain whether or not hidden imperfections not otherwise detectable are present.

In addition to the above, a large number of holes must be drilled through the relatively thick tube sheet to accommodate the large number of tubes that are received therein. This is a time consuming and costly operation.

The manufacture of the above type of tube sheet becomes further complicated and more costly when one of the fluids is highly corrosive in nature. Under these circumstances, the face of the tube sheet in contact with the corrosive fluid is coated or clad with a layer of suitable corrosion resistant material such as stainless steel, Monel, nickel, etc. The corrosion resistant material is usually applied by well known weld deposition methods after the tubes are assembled to the tube sheet.

In view of the above, it is another object of the invention to provide a tube sheet or partition structure for heat exchangers of the above type wherein the partition structure is formed of a plurality of identical sheet metal plates, each of relatively thin cross-section but in sufficient number to provide the required thickness and structural strength to assume the mechanical and thermal loads imposed thereon during operation, and arranged in face-to-face abutment with each other to form a "stack."

It is another object of the invention to provide a fabricated partition structure of the above type adapted for employment with a fluid that is highly corrosive in nature, wherein one of the end plates is formed of a corrosive resistant metal, thereby to protect the other plates from corrosive attack by the fluid.

Yet another object of the invention is to provide apparatus of the above type in which the partition structure is formed of a plurality of sheet metal plates having aligned apertures tightly receiving the associated tubes and having novel means to prevent relative movement of the plates during operation.

Yet a still further object of the invention is to provide a novel and highly improved method of fabricating a tube and sheet structure of the above type.

In accordance with the invention, there is provided a heat exchanger structure having a casing and a partition structure disposed therein and dividing the casing into first and second compartments. The partition structure is formed of a plurality of stacked sheet metal plates, relatively thin in cross-section, similar in shape and disposed in face-to-face abutment with each other. Each of the plates has a plurality of apertures extending therethrough in a substantially identical pattern so that the apertures in one of the plates are disposed in axial registry with the associated apertures in the other plates. A bundle of elongated tubes is further provided having open ended portions snugly received in the apertures and disposed in fluid flow communication with the first compartment.

The plates are formed of the usual ferrous metals subject to corrosive attack by fluids but structurally capable of withstanding high pressures and temperatures. However, at least one of the end plates is formed of a dissimilar material, selected for its ability to withstand corrosive attack. Each of the tubes is welded adjacent its end by a continuous fillet to the corrosion resistant plate, thereby sealing the remainder of the tube plates against access of the corrosive fluid and further acting to prevent leakage through the partition from the first compartment to the second compartment.

A further feature of the invention resides in forming each plate in such a manner that the wall portions that define the apertures are provided with peripheral lips that are offset axially with relation to the plane of the associated plate. The plates are stacked with the offset lips disposed in nesting relation with each other to provide a keying effect.

After the tubes are received in the apertures, they are expanded by any suitable internal or retraction method into intimate abutment with the lips. The thus expanded tubes elastically deform the lips to augment the keying effect of the lips and minimize the possibility of relative separation of the plates during operation. During the expansion process those portions of the tubes adjacent one of the end plates are enlarged circumferentially. The other or open ends of the tube portions are bonded to the opposite end plate by welding, thereby clamping the plates together and further assuring that the plates will not separate in service.

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

FIG. 1 is an axial sectional view of a heat exchanger embodying the invention;

FIG. 2 is a sectional view taken on line II—II of FIG. 1 and showing in elevation the improved partition and tube structure;

FIG. 3 is a fragmentary sectional view, on a considerably larger scale, taken on line III—III of FIG. 2 to show details of internal structure; and

FIG. 4 is a view similar to FIG. 3 but showing the structure during fabrication.

Referring to the drawing in detail, in FIG. 1 there is shown a heat exchanger structure, generally designated 10, comprising casing structure including a cylindrical main body portion 11 and a pair of opposed head members 12 and 13 of any suitable form, such as hemispherical. The main body portion 11 and the head members 12 and 13 are each provided with peripheral outwardly extending flange portions 14, 15 and 16, respectively. A partition structure 17 of disc-like shape is clamped between the flanges 14 and 15 by a plurality of suitable bolts and nuts 18 while, in a similar manner, a second partition 19 is clamped between the flanges 14 and 16.

A bundle of open ended elongated tubes 21 are disposed within the main body member 11 and supported at their opposite ends by the partition or tube sheet structures 17 and 19. The tubes 21 are disposed in parallel spaced relation with each other in a predetermined configuration, such as shown in FIG. 2, and the main body member 11 is provided with an inlet fitting 22 and an outlet fitting 23. In a similar manner, the head member 12 is provided with an inlet fitting 24 and an outlet fitting 25 and an internal wall member 26 dividing the head member 12 into compartments 27 and 28. The main body member 11, together with the partition structures 17 and 19, defines a central compartment 29, while the partition structure 19 and the head member 13 define an end compartment 30.

As thus far described, the heat exchanger 10 is substantially conventional and operates in the following manner when a first fluid is admitted thereto through the inlet fitting 24 and a second fluid at a different temperature (or temperature and pressure) is admitted thereto through the inlet fitting 22. The fluid admitted through the inlet fitting 24 to the end compartment 27 is directed through the upper bank of the tube bundle 21 to the other end compartment 30 and returned to the lower compartment 28 through the lower bank of the tube bundle 21 and is thence directed therefrom through the outlet fitting 25. Concomitantly therewith, the fluid admitted by the inlet fitting 22 into the central compartment 29 flows past and around all of the tubes 21 and is thence directed outwardly through the outlet fitting 23 with resulting heat exchange between the two fluids by surface contact. For example, if the fluid in the tubes 21 is hotter than the fluid in the central compartment 29, the fluid flowing past the tubes becomes heated, with a resulting reduction in temperature of the other fluid.

In accordance with the invention, the partition structure 19 is formed of a plurality of sheet metal plates 32 and 33 of substantially identical circular configuration and disposed in face-to-face abutment with each other. The plates 32 and 33 are relatively thin in cross-section but their aggregate cross-sectional thickness is sufficiently great to withstand differential temperature and pressure stresses imposed thereon by the fluids flowing through the tubes 21 into the compartment 30 and the fluid flowing through the compartment 29. The plate 33 is at one end of the stack so that it has a face 34 exposed to the fluid in the compartment 30. Hence, to prevent or at least minimize corrosive attack by this fluid on the partition structure 19, the end plate 33 is preferably formed of any suitable corrosion resistant material, such as stainless steel.

As best shown in FIG. 3, the plates 32 and 33 are provided with a plurality of apertures 35 spaced and located in a predetermined pattern as shown in FIG. 2, and this pattern is duplicated in all of the plates so that, after assembly, the apertures 35 in each of the plates are disposed in axial registry with the associated apertures in the other plates.

The end portions 36 of each of the tubes 21 are received in the apertures 35 in a snug or tightly fitting manner, as best shown in FIG. 3; and the end faces of the tube end portions 36 are preferably joined to the end plate 33 by a circumferential fillet of weld material 37, thereby to prevent leakage of fluid from compartment 30 to the central compartment 29. This fillet has a two-fold purpose and is effective to integrate the tubes to the partition 19, as well as to effect the seal. Each of the tube end portions 36 is provided with a radially enlarged portion 39 disposed in abutment with the end plate 32. Accordingly, the plates 32 and 33 are maintained in clamped abutment with each other by the restraining forces of the weld fillets 37 and the enlarged tube portions 39.

In addition thereto, the tightly fitting relationship between the plates 32 and 33 and the tube end portions 36 is further enhanced by circumferential lip portions 40

defining the apertures 35 and disposed in offset relation to the plane of their associated plates, as best shown in FIG. 3.

The other partition structure 17 may be substantially identical to the partition structure 19, hence it requires no further description.

The method of manufacture of the above described tube and partition structure 19 is as follows. The plates 32 and 33 are first stamped out of large sheets to the circular configuration shown in FIG. 2. The thus formed circular plates are then subjected to a die punching operation to form the aperture 35. (The die punching tools have not been shown, since they may be of any suitable and well known type.) During the die punching operation the circumferential lips 40 defining the apertures are formed by the usual extrusion of metal by the punch.

The plates 32 and 33 are then stacked with their apertures 35 in registry with each other and with the lips 40 in nested relation with each other as shown in FIG. 4, and the tubes 21 are inserted into the apertures 35 to the degree shown in FIG. 4. It will be noted that in this stage of manufacture the end portions 36 of the tubes 21 are loosely received in the apertures 35 and the tubes are of uniform cross sectional shape throughout their lengths.

The tube end portions 36 are then expanded radially by any suitable retraction tool (not shown) received within the bore of the tubes. The tubes 21 are radially expanded only in the region adjacent to the partition structure 19 and within apertures 35. Accordingly, since the expansion effort is unrestrained at the right hand end, as viewed in FIG. 3, the radial enlargement 39 is thus formed. However, in the region disposed within the apertures 35 the expansion of the tubes is restrained and opposed by the lips 40 with the result that the lips are bent radially outwardly to a slight degree, thereby tightening their nesting relationship and further augmenting their keying effect on the plates 32 and 33. Concomitantly therewith, those portions of the tubes disposed within the apertures 35 are elongated in the direction of their open ends and maintained in firm and compressed abutment with the lips 40.

After expansion of the tubes as described above, the ends of the tubes are bonded to the plate 33 by the weld fillets 37. Accordingly, the plates 32 and 33 are maintained in intimate face-to-face abutment with each other by the joint clamping effect of the enlarged portions 39 and the weld fillets 37.

The weld fillets 37 are effective to provide seals for the apertures 35, preventing flow of fluid from the compartment 30 into the compartment 29.

It will now be seen that the invention provides a highly improved tube and sheet structure in which the sheet structure may be made to any thickness required by simply increasing or decreasing the number of plates, as required to assume the required stress and load.

It will further be seen that the invention provides a tube sheet structure having a corrosion resistant surface applied thereto in an expedient and inexpensive manner.

It will further be seen that there is provided a highly improved method of manufacturing a tube sheet structure for heat exchangers that obviates costly drilling of the apertures for receiving the tubes and employs the extruded lips formed in the aperture punching process for advantageously effecting a keying effect for the stack of plates. The keying effect is augmented by the plate clamping effect of the tube end portions received in the apertures to impart additional stiffness to the partition structure 19.

While the invention has been shown in but one form, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various changes and modifications without departing from the spirit thereof.

What is claimed is:

1. A heat exchanger structure comprising, a casing structure,

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partition structure dividing said casing into first and second compartments,
 said partition structure including a stack of more than two sheet metal plates of substantially similar shape disposed in face-to-face abutment with each other,
 said plates being of individual thickness insufficient to individually withstand operational stresses, but of aggregate thickness to withstand said stresses,
 each of said plates having a plurality of apertures extending therethrough in a substantially identical pattern,
 the apertures in one of said plates being disposed in axial registry with the associated apertures in the other plates,
 a bundle of elongated tubular members,
 said tubular members having portions received in said apertures and disposed in fluid flow communication with said first compartment,
 and means associated with said apertures providing a fluid tight seal between said first and second compartments.

2. A heat exchanger structure comprising,
 a casing structure,
 partition structure dividing said casing into first and second compartments,
 said partition structure including a stack of more than two sheet metal plates of substantially similar shape disposed in face-to-face abutment with each other,
 said plates being of individual thickness insufficient to individually withstand operational stresses, but of aggregate thickness to withstand the operational stresses,
 each of said plates having a plurality of apertures extending therethrough in a substantially identical pattern,
 the apertures in one of said plates being disposed in axial registry with the associated apertures in the other plates,
 a bundle of elongated tubular members extending through said second compartment,
 said tubular members having open end portions disposed with their axes in parallel relation with each other, said end portions being tightly received in said apertures and disposed in fluid flow communication with said first compartment,
 each of said tubular members having a peripherally enlarged portion within said second compartment and disposed in abutment with one of said plates,
 and means associated with said apertures and tubular end portions providing a fluid tight seal between said first and second compartments.

3. A heat exchanger structure comprising,
 a casing structure,
 partition structure dividing said casing into first and second compartments,
 said partition structure including a stack of more than two sheet metal plates of substantially similar shape disposed in face-to-face abutment with each other,
 each of said plates having a plurality of apertures extending therethrough in a substantially identical pattern,
 said apertures being defined by wall portions having peripheral lip portions offset with respect to the face of the associated plate,
 the apertures in one of said plates being disposed in axial registry with the associated apertures in the adjacent plate with said offset lip portions disposed in nested relation with each other,
 a bundle of elongated tubular members,
 said tubular members having open end portions tightly received in said apertures and disposed in fluid flow communication with said first compartment,
 said lip portions tightly engaging the wall portions of the apertures in the adjacent plates and said end por-

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tions and maintaining said plates in mutual abutment,
 and means for joining said end portions to said partition structure and providing a fluid tight seal between said first and second compartments.

4. A heat exchanger structure comprising,
 a casing structure,
 partition structure dividing said casing into first and second compartments,
 said partition structure including a stack of more than two sheet metal plates of substantially similar shape disposed in face-to-face abutment with each other,
 at least one of the outermost of said plates being formed of corrosion resisting material,
 each of said plates having a plurality of apertures extending therethrough in a substantially identical pattern,
 said apertures being defined by wall portions having peripheral lip portions offset with respect to the face of the associated plate,
 the apertures in one of said plates being disposed in axial registry with the associated apertures in the other plates with said lip portions disposed in nesting relation with each other,
 a bundle of elongated open-ended tubular members,
 said tubular members having their open-ended portions snugly received in said apertures and disposed in fluid flow communication with said first compartment,
 and weld fillets encompassing and connecting each of said end portions to said corrosion resisting plate,
 said weld fillets providing a fluid tight seal between said first and second compartments.

5. A heat exchanger structure comprising,
 a casing structure,
 partition structure dividing said casing into first and second compartments,
 said partition structure including a stack of more than two relatively thin sheet metal plates of substantially similar shape disposed in face-to-face abutment with each other,
 each of said plates having a plurality of punched apertures extending therethrough in a substantially identical pattern,
 the apertures in one of said plates being disposed in axial registry with the associated apertures in the other plates,
 a bundle of elongated tubular members,
 said tubular members having portions received in said apertures and disposed in fluid flow communication with said first compartment,
 and means associated with said apertures providing a fluid tight seal between said first and second compartments.

6. A heat exchanger structure comprising,
 a casing structure,
 partition structure dividing said casing into first and second compartments,
 said partition structure including a stack of more than two relatively thin sheet metal plates of substantially similar shape disposed in face-to-face abutment with each other,
 at least one of the outermost of said plates being formed of corrosion resistant material,
 each of said plates having a plurality of punched apertures extending therethrough in a substantially identical pattern,
 the apertures in one of said plates being disposed in axial registry with the associated apertures in the other plates,
 a bundle of elongated tubular members extending through said second compartment,
 said tubular members having open end portions disposed with their axes in parallel relation with each other, said end portions being tightly received in said

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apertures and disposed in fluid flow communication with said first compartment,
each of said tubular members having a peripherally enlarged portion within said second compartment and disposed in abutment with one of said plates,
and means associated with said apertures and tubular end portions providing a fluid tight seal between said first and second compartments.

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