

July 27, 1965

K. R. PRENTISS
HEAT EXCHANGER CONSTRUCTION INCLUDING
TUBULAR CLOSURE PLATES
Filed July 5, 1963

3,196,942

FIG. 2

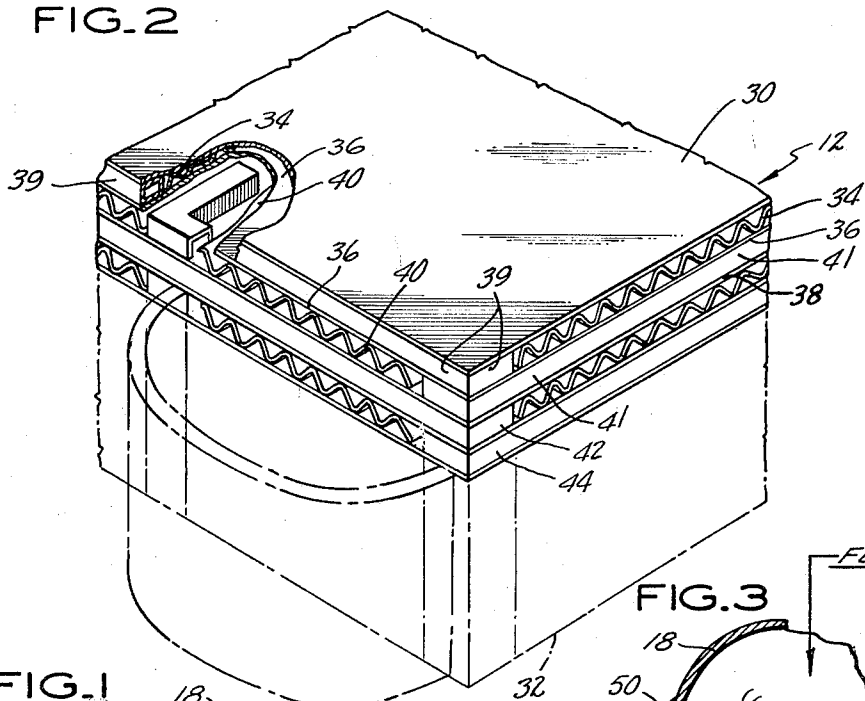


FIG. 1

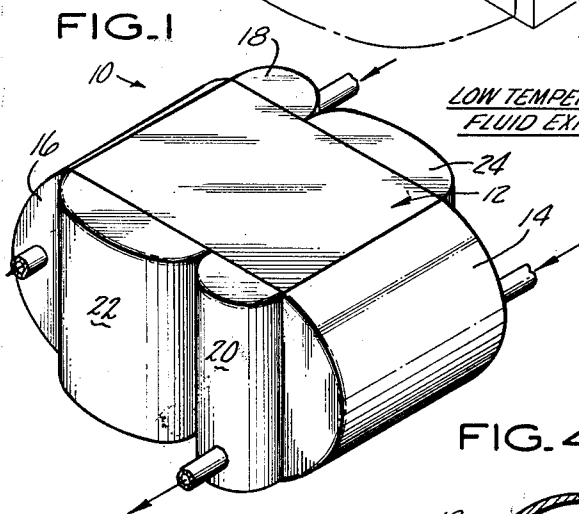


FIG. 3

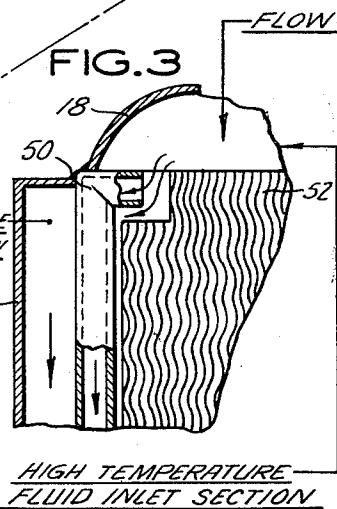
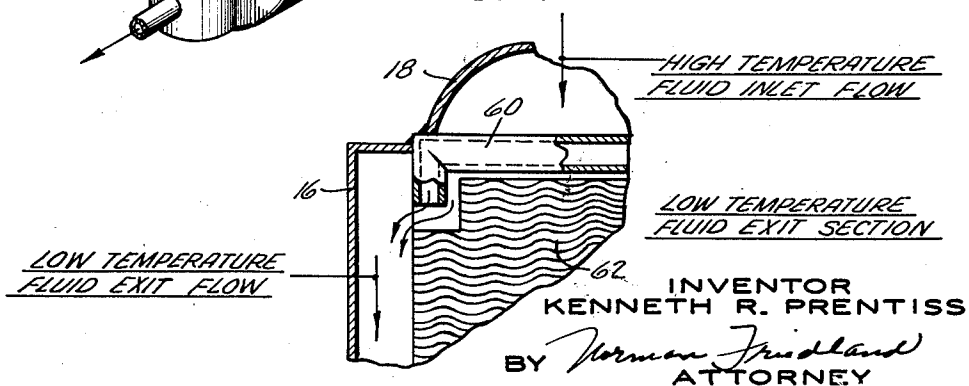


FIG. 4



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3,196,942 HEAT EXCHANGER CONSTRUCTION INCLUDING TUBULAR CLOSURE PLATES

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1 Claim. (Cl. 165-166)

This invention relates to heat exchangers and particularly to the construction of the core thereof.

Compact heat exchangers for high temperature service usually require the use of brazed stainless steel plate and fin type of heat exchanger cores. Normally, a high temperature fluid flowing through one set of heat exchanger passages is cooled by a low temperature fluid flowing through adjacent alternate passages. Two sides of each passage are formed by rectangular bars or tubes brazed between the plates which form the remaining two sides of the passage. Extended heat transfer surface (fins) brazed to the plates are used to transfer heat to or from the plates from or to the fluid flowing within the passage. Usually the heat exchanger fluids are in cross, counterflow arrangement with each other in order to provide near optimum thermal effectiveness. Fluid headers are attached to the heat exchanger core through core bands or extensions which are brazed or welded to the sides of the core.

The fluid flow arrangement and type of heat exchanger construction causes severe metal temperature differentials at the core fluid entrance and/or exit areas with resultant thermal stresses. During heat exchanger start-up, shutdown or change in operating conditions, the thermal gradients and resultant stresses become more severe, particularly in stainless steel heat exchangers because of the low metal thermal conductivity. I have found that when the core is constructed in accordance with this invention the thermal stresses within the plate and fin core will be reduced, the thermal stresses between the core and attached headers will be reduced, and a core structure which will readily accommodate a leak tight core-to-header weldment without the use of intermediate core bands or extensions will be realized.

In accordance with this invention the core of the heat exchanger is constructed to contain a plurality of rectangular tubes forming side walls. These tubes are hollow for defining fluid flow passages and are notched a short distance from the tube end and bent to form a ninety degree mitre elbow at each end of the tube. The core is assembled by alternately stacking cold and hot fluid passages in such a manner that the mitred corners form a solid wall for attachment of fluid headers on each side of the corner. This construction provides a suitable surface for welding the fluid inlet and exit headers to the core. The flow of fluid through the rectangular channel will establish heat transfer between the tube and the fluid, thus providing a mean metal temperature which approaches that of the plate and fins adjacent to the tube. As is generally well understood in the art the rate of fluid flow through the core of the heat exchanger is determined by the pressure differential between the inlet and outlet of said core. It is also well known convective conductance is the function of the rate of fluid flow. Since fluid flow is a function of the cross sectional area of the tubes, the desired convective conductance in the tubes may be regulated by proper selection of the hydraulic radius of the tubes. Another method of obtaining desired heat transfer convective conductance in the tubes is by adding turbulence promoters to the tubes. With proper design, the thermal gradient from the fluid headers into the core struc-

ture can be minimized for the most severe temperature differential or time-temperature situation encountered.

It is therefore an object of this invention to provide a plurality of stacked elongated hollow tubes, each of which are bent and rectangular in cross section, for defining leak tight cornered walls of a heat exchanger core for readily supporting headering.

It is a further object of this invention to provide a plurality of stacked hollow tube members arranged in indirect heat exchange relation wherein the hollow tubes form supporting surfaces for receiving headering and being arranged to provide fluid flow passages arranged to assure a less severe step change in temperature that was heretofore realized in conventional plate and fin heat exchanger cores.

Other features and advantages will be apparent from the specification and claim and from the accompanying drawings which illustrate an embodiment of the invention.

FIG. 1 is an isometric showing of a heat exchanger.

FIG. 2 is an enlarged fragmentary sectional view showing the core of the heat exchanger.

FIG. 3 is an enlarged fragmentary cross-sectional view taken through the high temperature fluid inlet section of FIG. 1; and

FIG. 4 is an enlarged fragmentary cross-sectional view taken through the low temperature fluid exit section of FIG. 1.

Referring now to FIG. 1 which generally shows a heat exchanger indicated by numeral 10 having a core 12, low temperature fluid inlet header 14 and low temperature fluid exit header 16, high temperature inlet fluid header 18, high temperature fluid exit header 20 and turning headers 22 and 24. Suitable piping are connected to each of the headers for conducting fluid into core 12 and discharging fluid therefrom. In essence, this is a cross flow heat exchanger which passes flow through a series of passes formed by the core so that hot air passages alternate with cold air passages for obtaining indirect heat transfer.

Referring now to FIG. 2 which is a showing of the core 12 which comprises top plate 30 and bottom plate 32 and a series of stacked layers of corrugated fins stacked therebetween defining the flow passages for the hot and low temperature fluid. As noted from this drawing, corrugated fin 34 extends through the core 12 and is sandwiched between top plate 30 and intermediate plate 36 defining therewith open ended channels. At the end of the fin is closure plate 39 which is a rectangular tubular member extending the length of the core. It is to be understood that a similar closure member is on the opposite end of the core and as will be appreciated from the description to follow, these closure members define the side and end walls of the core. The next layer is composed of ruffled fin which extends through the core transversely to the adjacent layer of the corrugated fins. As noted, this ruffled fin 40 is sandwiched between the intermediate plates 36 and 38 and together therewith define an open ended channel for accommodating the passage of hot air. The core is built up by alternating these layers as described. It will be noted that such a construction is customary in the heat exchange art and the details are eliminated here for facilitating the description of this invention. Preferably the material selected for this construction is stainless steel, but it is to be understood that any other material may be employed without deviating from the scope of this invention.

As noted from FIG. 2, the ruffled fins are closed off by a series of closure plates 39, 41, 42 and 44. This invention is concerned with these closure plates as they form the essence of the construction of this type of core.

As noted from FIGS. 3 and 4, these closure plates are formed from elongated tubular members rectangular in cross section. The rectangular members may be assembled in the core prior to being bent and when inserted in their proper position, they are bent substantially 90° forming the corners of the core. As is noted, a V-slot is cut into this tubular member in any known manner so that the end is readily and easily bent as is shown in FIGS. 2, 3 and 4. Also noted from these figures, the tubes are stacked adjacent to each other so that the overlay of the bent portion which extends only a relatively short distance adjacent the end of the fin defines a substantial rigid side corner having a flat surface for accommodating the headers. It therefore is a relatively simple procedure to weld the headers in any suitable manner to the surfaces as is shown by the drawings.

It will be appreciated that these closure members are hollow for accommodating the passage of fluid there-through. As can be seen from FIG. 3, the high temperature fluid entering the inlet header 18 is conducted through one of the tubular members identified by numeral 50. Another portion of this fluid enters the passage area between the closure tube and the fins 52 while the remaining portion enters the fin area of the passage. As illustrated in FIG. 4, the low temperature fluid stream discharges from the passage in the rectangular closure tube identified as numeral 60, while a portion of the fluid discharges between the closure tube and the fins 62 and the remaining portion leaves the fin area of the passage. The formed closure tube arrangement of this invention provides (1) solid leak tight corner walls for welding the headers to the core, (2) the flow of fluids through the tubes with the resultant heat transfer that precludes the severe step change in temperature between the header and the core and (3) the heat transfer rate gradient across the closure tubes adjacent to the tubes and through the fins that minimize the thermal gradient within the core resulting in minimum core thermal stresses.

Thus, it is apparent from the foregoing that this heat exchanger core construction provides solid leak tight corner walls for welding of the headering and the flow through the tubing provides a less severe temperature gradient across the corner areas without the use of core bands or extensions.

It is to be understood that the invention is not limited to the specific embodiment herein illustrated and described, but may be used in other ways without departing from its spirit.

I claim:

A cross-flow heat exchanger comprising a plurality of corrugated fin elements, flat parallel spaced plates sandwiching said corrugated fin elements and defining therewith a series of separate parallel open ended channels terminating at opposite edges of the elements, the corrugations of the fin element in each channel being at substantially 90° to the corrugations of the fin element in the next adjacent channel, means for spacing said flat plates and for minimizing the temperature gradient at the corners of the heat exchanger occasioned by the starting-up or shutting-down of the heat exchanger, said means including a plurality of spaced parallel hollow tubes of rectangular cross section adjacent the sides of said corrugated fin elements and disposed substantially parallel with the corrugations, each tube having an end portion on each end lying at substantially 90° to the corrugations extending a relatively short distance toward the fin element and adjacent the ends of the adjacent corrugated fin element, the ends of the tubes overlying a portion of a tube in a next adjacent channel thereby defining a continuous rigid corner surface at each end of each tube, headers mounted on said surfaces forming inlets and outlets for providing communication with the channels at opposite ends of the fin elements and said parallel hollow tubes, so that fluids passing through adjacent hollow tubes adjacent said corner surfaces are in indirect heat exchange relationship with each other for reducing the thermal gradient across said corner surface.

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