March 28, 1967 D. L. SOUTHAM 3,311,166

HEAT EXCHANGER

Filed July 2, 1964

Fig. 1

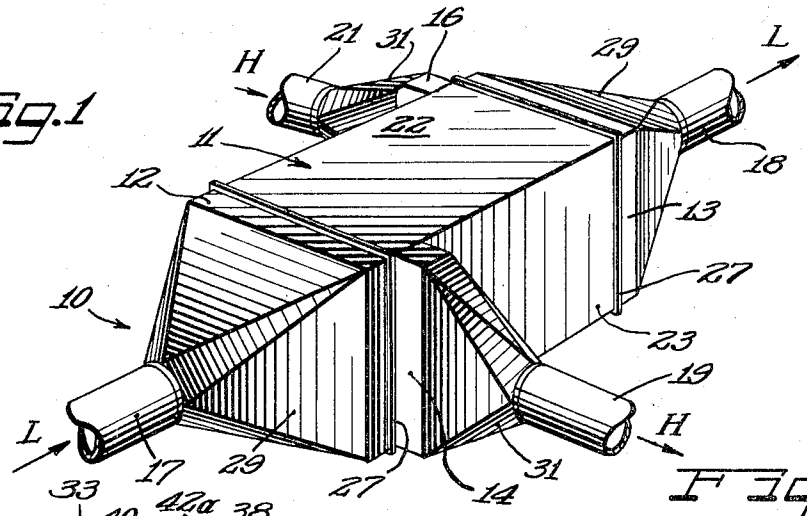


Fig. 4

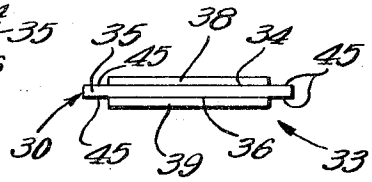
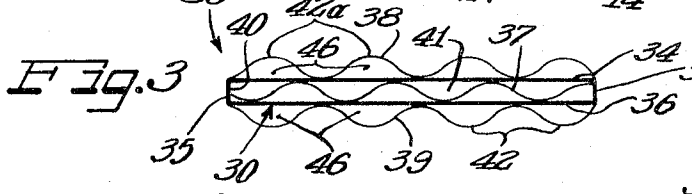


Fig. 3



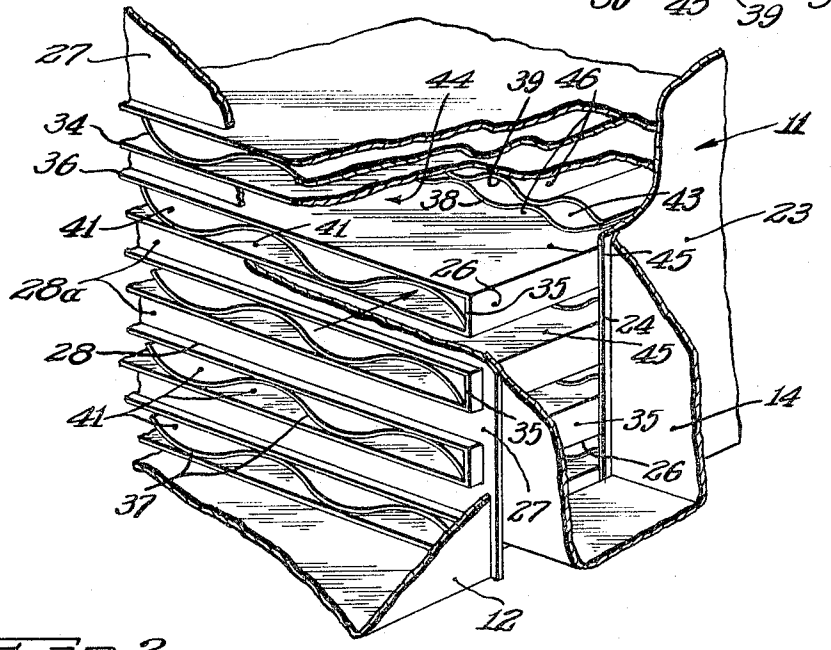


Fig. 2

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HEAT EXCHANGER

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The present invention generally relates to a heat exchanger and heat exchanger units and more particularly relates to a compact counter flow heat exchanger and heat exchanger units.

Previous compact heat exchangers are exemplified by the Hammond Patent No. 2,812,165 dated Nov. 5, 1957 and the Holm Patent No. 2,875,986 dated Mar. 3, 1959 These compact heat exchangers have heat exchanger corrugations with important manufacturing limitations. The corrugations do not effectively provide heat transfer between two counter flowing fluids and further, increase the weight and size of the heat exchanger. Close machine tolerances and thick corrugations having large mating surfaces were necessary for sealingly joining the inlet ducts to the corrugations. However, the heat exchangers were relatively impossible to inspect the flaws therein.

In many applications and uses, a heat exchanger having maximum weight and size reduction and providing effective heat transfer between counterflowing fluids is of the utmost desirability.

The present invention provides a relatively light compact heat exchanger having a core with a plurality of rectangular ducts mounted therein. Each duct has internal corrugations extending the surface area of the duct for the passage of a low pressure fluid and shorter corrugations attached to the top and bottom surfaces for forming counter flow passages for a high pressure fluid. A pair of end headers are connected at the ends of the core and are in direct flow communication with the internal corrugations of the rectangular ducts while adjacent ducts form a pair of second headers at opposite ends of the core which are in angular flow communication with the counter flow passages. A pair of side ducts are attached to opposite sides of the core at opposite ends thereof and are in communication with the second headers and at angles to the axes of the passages formed by the shorter corrugations.

My compact counter flow heat exchanger lends itself to high production techniques, effective heat transfer, reduced weight, and is readily inspectable for flaws therein.

Therefore, it is an object of the present invention to provide an improved compact heat exchanger.

It is another object of the present invention to provide a compact counter flow heat exchanger having a plurality of heat exchanger units with each heat exchanger unit comprising a duct having internal corrugations extending the length thereof and shorter corrugations attached to the top and bottom surfaces thereof.

It is still another object of the present invention to provide a counter flow heat exchanger having a plurality of ducts forming the heat exchanger passages for two counter flowing fluids with said ducts forming the header for at least one of the fluids.

It is still another object of the present invention to provide a heat exchanger unit adapted to be placed in a heat exchanger core and said unit being a duct with internal corrugations extending the internal length and width thereof and having external corrugations on the outer top and bottom surfaces thereof which are shorter than the internal corrugations and extend intermediate the two ends of said duct.

It is another object of the present invention to provide a heat exchanger unit which comprises a rectangular duct having internal corrugations and external corrugations attached to the top and bottom surfaces of the duct and

extending intermediate the two ends thereof to provide opposite end lands on the top and bottom surface of the duct.

It is further another object of the present invention to provide a heat exchanger having a core with a plurality of rectangular ducts with internal corrugations extending the surface area of said ducts and each of the ducts having shorter corrugations on the top and bottom surfaces thereof, square or rectangular header plates attached to the ends of the heat exchanger core and separating the passages formed by the internal and external corrugations, end headers connected to said header plates and communicating with said internal corrugation passages, second headers formed at each end of and within the heat exchanger core by adjacent ducts, the second header communicating with the passages formed by said external shorter corrugations, and conduit means connected to each of the headers.

Other objects, features and advantages of the present invention will become more apparent after a careful consideration of the following description taken in conjunction with the drawing wherein like reference numerals refer to like and corresponding parts.

In the drawing:

FIGURE 1 is a partial perspective view of a heat exchanger constructed in accordance with the principles of the present invention;

FIGURE 2 is an enlarged partial view with parts cut away from the heat exchanger as illustrated in FIGURE 1 and as constructed in accordance with the principles of the present invention;

FIGURE 3 is a front view of a heat exchanger unit constructed in accordance with the principles of the present invention; and

FIGURE 4 is a side view of the heat exchanger unit as is illustrated in FIGURE 3.

As shown in the drawing:

The heat exchanger of the present invention has a heat exchanger core with a plurality of basic heat exchanger units. Each basic heat exchanger unit comprises a rectangular duct having internal and external corrugations. The internal corrugations preferably extend substantially the entire surface area of the duct and form internal flow passages principally for the passage of low pressure drop fluid. The external corrugations are attached to the outer top and bottom surfaces of the duct and extend the entire width of the duct but only a portion of the length thereof intermediate the ends of the duct. The top and bottom external corrugations form external flow passages having both ends facing flat land areas at both ends of the duct. The basic heat exchanger units are stacked such that the short adjacent external corrugations form some more external flow passages therebetween and adjacent duct end lands form external headers at each end of the external flow passages for delivering and receiving a high-pressure fluid. An end header is also attached to each end of the heat exchanger core to separate the high-pressure external passages from the low-pressure internal passages. The end headers have header plates with a series of rectangular cut-outs that receive the individual ducts of the basic heat exchanger units and rectangular headers attached to said header plates for delivering and receiving fluid from the duct internal fluid flow passages. Suitable conduit means are attached to each end header. A pair of rectangular ducts are connected at opposite sides and adjacent opposite ends of the heat exchanger core. The side ducts communicate with the external headers to deliver and receive fluids therefrom.

Referring to FIGURE 1 there is illustrated a heat exchanger **10** having a rectangular core **11**, a pair of rectangular end headers **12** and **13**, with one being

attached to each end of the rectangular core; a pair of rectangular side ducts 14 and 16 mounted on opposite sides and adjacent opposite ends of the core, with the duct 14 mounted adjacent the end header 12 and the duct 16 mounted adjacent the end header 13; round inlet and outlet conduits 17 and 18 are respectively connected to the headers 12 and 13 by polygonal transition ducts 29; and round inlet and outlet conduits 19 and 21 respectively connected to the rectangular side ducts 14 and 16 by polygonal transition ducts 31.

Referring to FIGURES 3 and 4, there is illustrated a heat exchanger unit 33 which is to be stacked in the heat exchanger core 11. The unit 33 comprises a rectangular duct 30 having a top and bottom walls 34 and 36 spaced a predetermined distance apart and interconnected by spaced parallel side walls 35 to form an internal duct passage 40. Within the internal passage 40, an internal corrugation 37 is suitably attached to the internal surfaces of the top and bottom walls 34 and 36 to divide said duct passage into a plurality of longitudinally extending internal fluid flowing passages 41. The internal corrugation extends for substantially the length and width of the rectangular duct 30.

Respectively attached to the outer surfaces of the top and bottom duct walls 34 and 36 are longitudinally extending external corrugations 38 and 39 with the longitudinal crests 42*a* of the top external corrugation 38 being directly opposite the longitudinal crests 42 of the bottom external corrugation 39. Thus, when the heating units 33 are stacked in the heat exchanger core 11 (FIGURE 2), the adjacent external corrugations will have their crests contacting each other so as to define external flow passages 43 between corrugations 38 and 39 and alternating flow passages 46 alongside passages 43 bottomed by the walls 34 and 36. The external corrugations 38 and 39 extend substantially the width of the duct 30 but for only a predetermined portion of the length thereof so that flat land areas 45 are provided beyond the ends of the corrugations on the outer surfaces of the top and bottom walls 34 and 36 at both ends thereof. The top and bottom wall land areas of adjacent stacked ducts are utilized to form headers 44 for the external flow passages 43 and 46. Flow passages 43 and 46 are referred to as external flow passages because they are outside of the duct 30 which is defined by the walls 34, 35 and 36 enveloping the corrugation 37.

It is of course understood that in some heat exchange applications, if desired, the internal corrugation 37 may be eliminated and only the internal passage 40 used. Also, a heat exchanger may be formed with stacked heat exchanger units having one external corrugation attached to either the top or bottom duct walls and being stacked such that the flat surface of the next adjacent duct contacts the external corrugation to form external flow passages therewith. Further, a heat exchanger may be formed with stacked ducts having both top and bottom external corrugations, one external corrugation and/or no external corrugations to provide proper external heat exchange flow passages.

Referring to FIGURES 1 and 2, the open ended rectangular core 11 has parallel top and bottom walls 22 interconnected by two off-set side walls 23 having off-set ends 24. The off-set ends 24 of each side wall 23 are spaced inwardly a predetermined distance from the ends of the top and bottom walls 22.

The ducts 30 are longer than the core top and bottom walls 22 such that their ends extend outwardly a predetermined distance from both of the core open ends and preferably both ends of the duct external corrugations 38 and 39 are spaced inwardly a predetermined distance from the side wall off-set ends 24 to form inlets 26 for the headers 44 with the adjacent spaced duct side walls 35.

A rectangular header plate 27, having a greater cross-sectional area than the cross-sectional area of the core 11 and a plurality of spaced parallel rectangular slots 28 formed therein, is attached to each end of the rectangular core 11 and to the headers 12 and 13. The polygonal transition ducts 29 are attached to the headers 12 and 13 and their respective round conduits 17 and 18 to duct a low-pressure gas from a round section to a rectangular section and vice versa.

The header plates 27 have a plurality of cut-outs or slots 28 which are sized such that the headers may slide over the rectangular core 11 with the open ends of the rectangular ducts 30 passing therethrough. For example, the cut-outs 28 are rectangular and have their length equal to the external width of the ducts 30 and their width equal to the external thickness of the ducts 30 so that they project through the cut-outs and the header plates 27 abut against the ends of the core top, bottom, and one side wall and are spaced a predetermined distance from the core side wall off-set ends 24, to form the rectangular inlets 26. The intermediate land areas 28*a* between the slots 28 of the head plates 27 form end walls for the headers 44. Thus, the head plates 27 effectively separate the internal fluid flow passages 41 from the external fluid flow passages 43 and 46.

In operation, a plurality of rectangular heat exchanger units 33 are slid into an open ended rectangular core 11 with their ends projecting beyond both ends of the core end and the core has side walls with each side wall being off-set ends of the core. The end header plates 27 are slid on the ends of the heat exchanger units to form the external flow passage headers 44 and to separate the external flow passages 43 and 46 from the internal flow passages 41. The header plates are suitably sealingly attached to the core and heat exchanger units by welding or suitable gasket means thereon. Also, suitably attached to the off-set ends of the core side walls are rectangular ducts 14 and 16. A low pressure gas L is delivered to the round inlet conduit 17 and therefrom by the transition duct 29 to the rectangular header 12 and into the relatively round internal duct passages 41 and therethrough to the end header 13, the transition duct and round outlet 18 which is concentric with the round inlet 17. With this arrangement the gas flows in a relatively straight line with minimum pressure drop. Simultaneously, a high-pressure gas H is delivered by the round inlet conduit 21 to the headers 44 by the rectangular duct 16 and the transition duct 31. The duct 16 directs the gas at right angles to the axis of the external flow passages 43 and 46 with the headers 44 directing the gas into the external passages 43 and 46. The gas flows through the external passages into the headers 44 at the opposite end thereof and out the ducts 14 and 31 into the outlet conduit 19. The conduit 19 has its axial center line at right angles to the axial center lines of the external flow passages.

Further, if desired, the external shortened top and bottom corrugations 38 and 39 can be cut on a bias both at the inlet and outlet ends thereof to distribute the flow of gas more evenly.

Therefore, it is seen where I have provided a heat exchanger utilizing a plurality of stacked basic heat exchanger units that need not be permanently attached to the walls of the heat exchanger core while also permitting the maximum heat exchanger effectiveness with a compact unit and a unit which has reduced size and weight.

It will be of course understood that modifications and variations of the foregoing preferred exemplary embodiment of the invention may be effected without departing from the spirit and scope of my invention and it will be understood that I intend that this invention be limited only by the scope of the hereunto appended claims.

I claim as my invention:

1. A counter-current heat exchanger comprising:

a core having flat parallel top and bottom walls and flat parallel side walls,

a plurality of heat exchanger units in said core each of which comprises:

an elongated duct shaped rectangularly in transverse cross-section and having flat spaced parallel top and bottom walls, only one corrugation within said duct winding up and down transversely across the width of said duct into engagement with said top and bottom walls and extending longitudinally the full length of said duct to provide a plurality of longitudinally extending internal flow passages within said duct each of which is completely separated from adjacent flow passages across the entire width of said duct, and

a pair of external corrugations mounted respectively on the outside surfaces of said top and bottom walls and extending longitudinally a distance less than the length of said duct to provide land areas at both ends of said duct adjacent said external corrugations, the longitudinal crests of said external corrugations mounted on said top wall being directly opposite the longitudinal crests of the external corrugations mounted on said bottom wall,

said heat exchanger units being arranged in stacked relation so that the crests of the external corrugations of adjacent heat exchanger units contact each other to provide a plurality of longitudinally extending external flow passages outside of said ducts, each of which is completely separated from adjacent flow passages across the width of said units, and so that said land areas between each of said ducts extend substantially across the entire transverse extent

thereof to define internal headers for the distribution of fluid flow within the flow passages of said corrugations,

a pair of header plates located respectively at the ends of said units enclosing said internal headers at the ends of said core,

first transition duct means mounted on the side walls of said core adjacent the ends thereof and in communication with said internal headers, and

second transition duct means mounted at the ends of said core and in communication with said internal flow passages.

2. The heat exchanger as defined in claim 1 and including:

means forming transversely extending rectangular cutouts in said header plates for receiving the ends of said ducts.

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