

June 8, 1943.

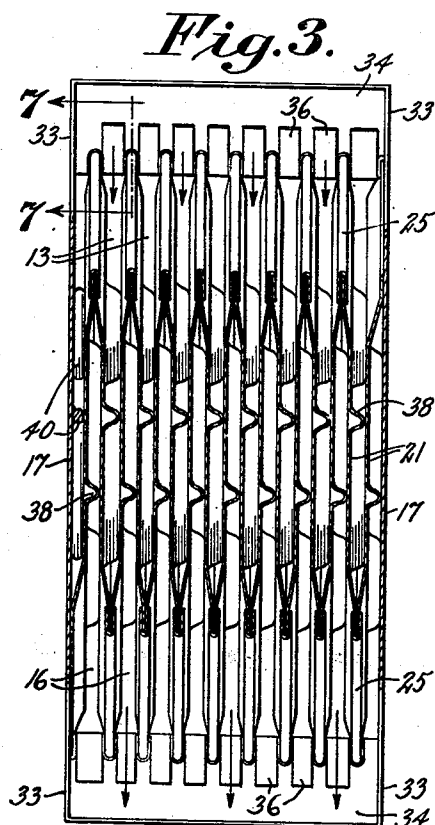
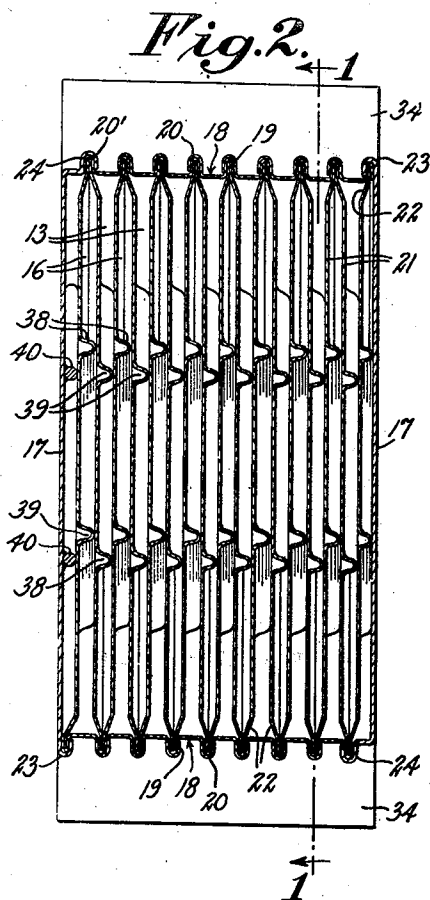
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2,321,110

HEAT EXCHANGER

Filed Aug. 25, 1936

4 Sheets-Sheet 1



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HEAT EXCHANGER

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*Fig. 4.*

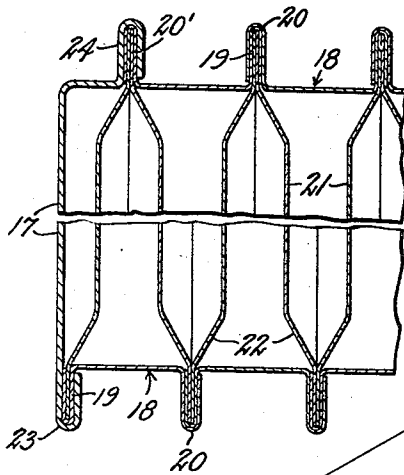


*Fig. 5.*

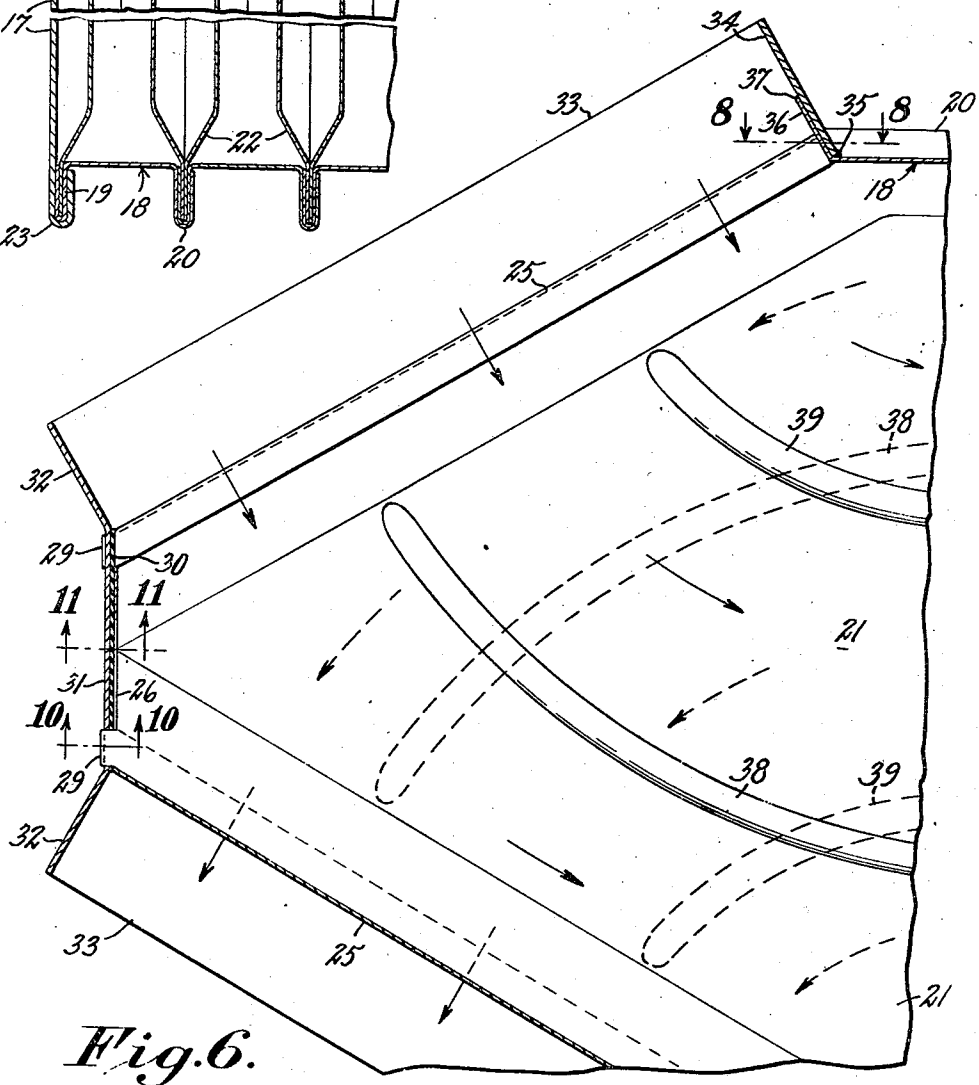
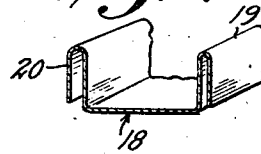


*Fig. 6.*

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Fig. 7.

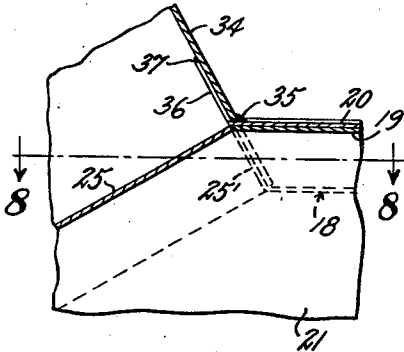


Fig. 8.

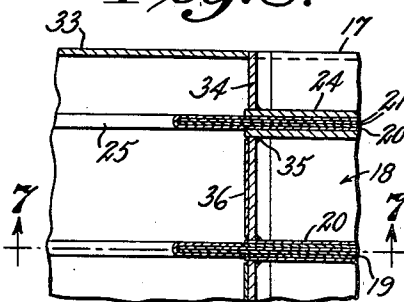


Fig. 9.

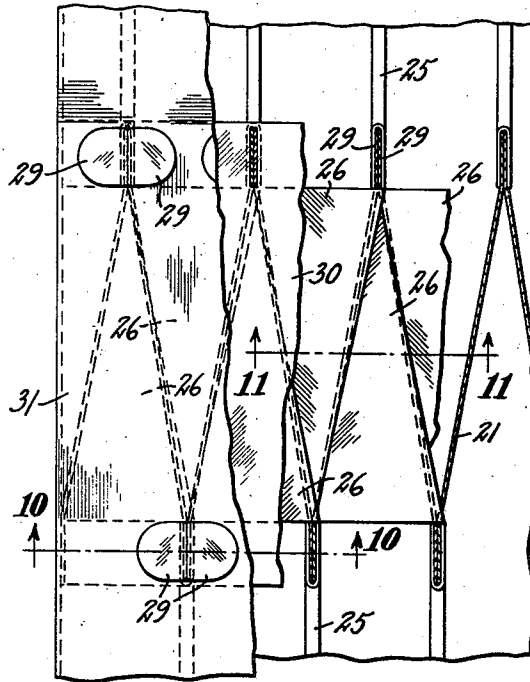


Fig. 10.

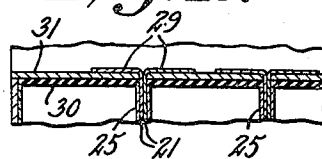


Fig. 12.

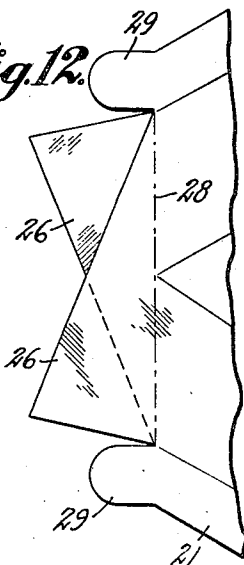
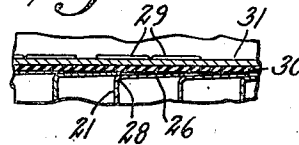


Fig. 11.



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*Fig. 14.*

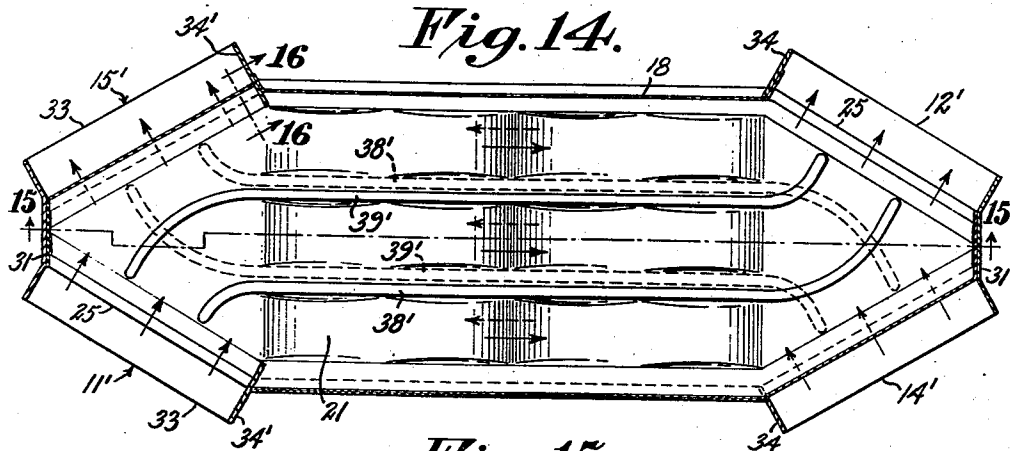


*Fig. 15.*

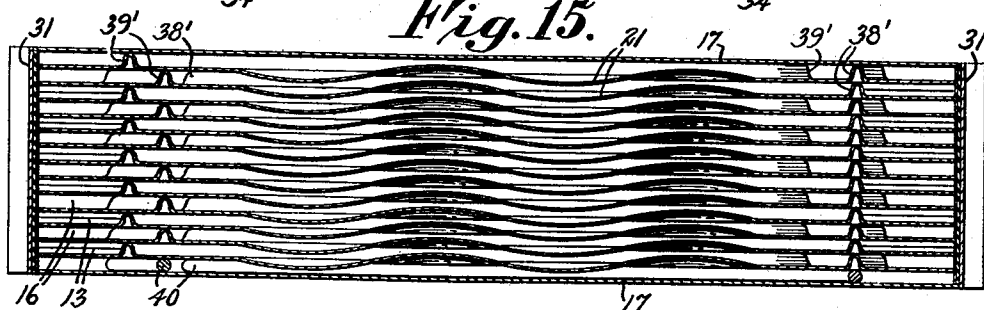


*Fig. 13.*

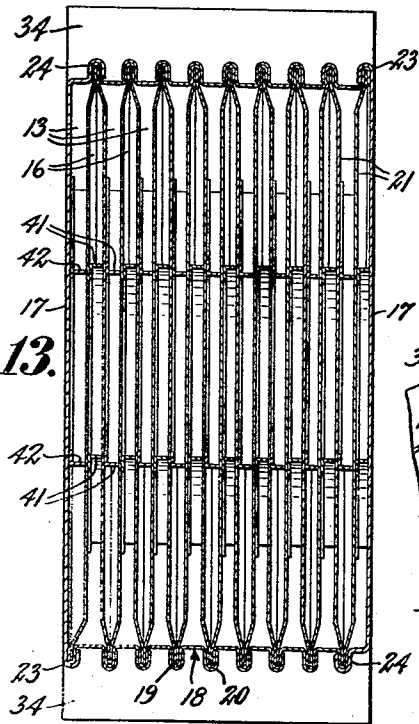


*Fig. 16.*

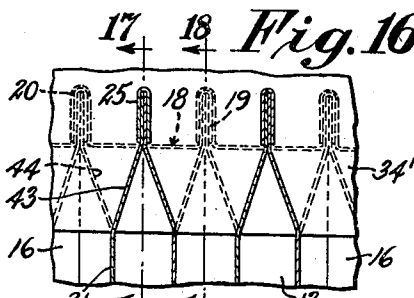


*Fig. 17.*

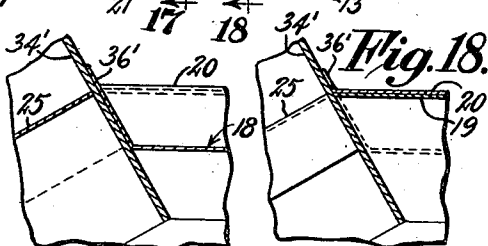
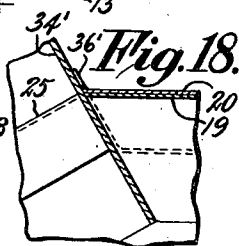


*Fig. 18.*



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## UNITED STATES PATENT OFFICE

2,321,110

## HEAT EXCHANGER

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Application August 25, 1936, Serial No. 97,746

17 Claims. (Cl. 257-245)

My invention relates to heat exchangers, and more particularly to heat exchangers of the type having a plurality of plates arranged to provide a number of closely adjacent passages for effecting heat transfer between fluids flowing through the passages.

The objects of my invention are to provide an improved heat exchanger utilizing a plurality of closely adjacent plates to obtain a relatively large amount of heat transfer surface in a minimum amount of space; to provide such a heat exchanger in which only a few different parts are required; to form the parts in such a manner that they can be quickly and easily assembled and at the same time insure an accurate spacing of the heat transfer plates; and to provide such a heat exchanger in which only a relatively small amount of welding or soldering is required to unite the parts.

The above and further objects and advantages of my invention will become apparent from the following description, taken in conjunction with the accompanying drawings forming a part of this specification, and of which Fig. 1 is a side sectional view of a heat exchanger embodying my invention taken on line 1-1 of Fig. 2; Figs. 2 and 3 are sectional views taken on lines 2-2 and 3-3, respectively, of Fig. 1; Fig. 4 is an enlarged fragmentary sectional view illustrating more clearly parts of the heat exchanger shown in Fig. 2; Fig. 5 is an enlarged fragmentary perspective view of a part of the heat exchanger shown in Figs. 2 and 4; Fig. 6 is an enlarged sectional view illustrating more clearly one end of the heat exchanger shown in Fig. 1; Fig. 7 is a fragmentary sectional view taken on line 7-7 of Figs. 3 and 8; Fig. 8 is a fragmentary sectional view taken on line 8-8 of Figs. 6 and 7; Fig. 9 is a fragmentary end view, with parts thereof in different sections, of the heat exchanger shown in Fig. 1; Figs. 10 and 11 are fragmentary sectional views taken on lines 10-10 and 11-11, respectively, of Figs. 6 and 9; Fig. 12 is an enlarged fragmentary side elevation of parts of the heat exchanger shown in Figs. 1 and 6; Fig. 13 is a sectional view similar to Fig. 2 illustrating a modification of the invention; Fig. 14 is a side sectional view similar to Fig. 1 illustrating a further modification of the invention; Fig. 15 is a sectional view taken on line 15-15 of Fig. 14; Fig. 16 is an enlarged fragmentary sectional view taken on line 16-16 of Fig. 14; and Figs. 17 and 18 are fragmentary sectional views taken on lines 17-17 and 18-18, respectively, of Fig. 16.

Referring to Figs. 1 to 3 inclusive, the heat ex-

changer embodying my invention comprises a casing 10 having inlet and outlet openings 11 and 12 for fluid flowing through one group of passages 13, and inlet and outlet openings 14 and 15 for fluid flowing through another group of passages 16 in the casing. The casing 10 is rectangular in section and formed of side members 17 and a plurality of individual closure strips 18 having raised U-shaped bends 19 and 20 along their longitudinal edges.

The side members 17 and closure strips 18 support and maintain in properly spaced relation a plurality of heat transfer plates 21 disposed alongside each other and extending between the opposite side walls of the casing having the inlet and outlet openings. The plates 21 and strips 18 are so constructed and arranged that they form a zigzag structure which extends across the casing to provide the passages 13 and 16. The plates 21 are of the general shape of the heat exchanger shown in Fig. 1 with parallel top and bottom edges intermediate the ends, and inwardly sloping edges at the ends adjacent the inlet and outlet openings of the casing. The top and bottom edges of the plates 21 throughout their length are offset laterally in opposite directions with the extreme edge portions substantially parallel to the main body portions of the plates. Thus, when several plates 21 are arranged alongside each other in the manner shown in Figs. 2 and 4, one edge of each plate except an outside plate abuts an edge of an adjacent plate and is spaced from the edge of an adjacent plate by a distance which is four times the amount of offset effected by the sloping parts 22 of the plates.

The closure strips 18 extend along the intermediate portion of the plates 21 and terminate at the inner edges of the openings 11, 12, 14, and 15. The closure strips 18 are four times the width of offset effected by the sloping parts 22 of the plates 21, and the U-shaped bends 20 are slightly larger than the U-shaped bends 19. The U-shaped bends 19 of the closure strips 18 receive and hold the abutting edges of two adjacent plates 21, and each of the U-shaped bends 20 receives and hold the U-shaped bend 19 of an adjacent closure strip 18.

The intermediate portions of the side members 17 between the inlet and outlet openings are provided with U-shaped bends 23 and 24, the U-shaped bends 23 receiving and holding a bend 19 of an outside closure strip 18 which in turn receives and holds an edge of an outside plate 21. The U-shaped bends 24 are offset inwardly with respect to the U-shaped bends 23 and receive and

hold a bend 20' of an outside closure strip which is the same size as the U-shaped bends 19 and in turn receives and holds the abutting edges of two adjacent plates 21 of which one is an outside plate.

The sloping abutting edges at the ends of the plates 21 are secured and held together by U-shaped strip members 25, as shown most clearly in Figs. 3 and 8. The abutting ends of closure strips 18 and strip members 25 are cut off at the proper angle and soldered or welded together, as indicated at 25' in Fig. 7.

In order to cover the triangular-shaped openings of the passages 13 and 16 at the extreme ends of the plates 21, the ends of the plates are provided with triangular-shaped projections 26, as shown in Fig. 12, the projections on alternate plates having the apex of the triangle pointed upward and the projections on the remaining plates having the apex of the triangle pointed downward. These triangular-shaped projections 26 are bent at 28 at the ends of the plates to cover similar shaped triangular openings formed at the ends of the passages 13 and 16, as shown in Figs. 9 and 11.

Adjacent the top and bottom sloping edges at the ends of the plates 21 are provided projections 29. With the top and bottom sloping edges of adjacent plates abutting each other, the projections 29 are arranged in pairs and in staggered relation. Gaskets 30 formed of suitable material, such as rubber, for example, fit over the bent triangular-shaped projections 26 and are provided with slots that coincide with the staggered projections 29. Cover plates 31 forming the end walls of casing 10 fit over the gaskets 30 with the projections 29 extending through slots in the cover plates. After the gaskets 30 and cover plates 31 are placed over the bent triangular-shaped projections 26, the projections 29 are bent in opposite directions to secure the gaskets and cover plates in position to seal the extreme ends of the passages 13 and 16.

The cover plates 31 project beyond the sloping edges of the plates 21 and extend between the side members 17 to form the outer walls 32 of duct sockets at the inlet and outlet openings 11, 12, 14, and 15. The ends of the side members project or extend above the sloping edges of the plates 21 to form two side walls 33 of the duct sockets. Plates or members 34 extend across the casing at the inner edges of the openings to form the inside walls of the duct sockets. The members 34 are notched to straddle the raised U-shaped bends 20 of the closure strips 18 and are welded or soldered thereto, as indicated at 35 in Figs. 7 and 8. Tabs 36 which project or extend from the ends of the closure strips 18 between the U-shaped bends 19 and 20 are bent upward and secured, as by welding indicated at 37 in Fig. 7, to the inner surfaces of the members 34.

It will now be understood that the passages 13 and 16 extend the entire length of the heat exchanger between the inlet and outlet openings 11, 12, 14, and 15. The passages 13 are open at the inlet and outlet 11 and 12 and closed at the inlet and outlet 14 and 15, so that fluid will flow through the passages 13 in the manner indicated by the solid arrows in Fig. 1; and conversely, the passages 16 between the passages 13 are open at the inlet and outlet 14 and 15 and closed at the inlet and outlet 11 and 12, so that fluid will flow through the passages 16 in the manner indicated by the dotted arrows in Fig. 1, the inlets

and outlets being arbitrarily chosen for counter-flow of fluids in the passages 13 and 16.

In order to maintain an accurate spacing between the heat transfer plates 21, particularly when the plates are relatively wide or thin, the plates may be indented or provided with longitudinal grooves 38 and 39. The grooves 38 and 39 of adjacent plates are close to each other, as shown in Fig. 2, so that the plates are rigidly spaced apart. To space one of the outside plates 21 from a side member 17 of the casing, longitudinal rods 40 are secured to the inner surface of the side member.

In addition to rigidly spacing the plates 21 the grooves 38 and 39 may also be utilized to insure a more uniform distribution of fluids over the surfaces of the plates 21. For this reason the grooves 38 extend along the entire length of the plates 21 and are curved at their ends toward the inlet and outlet openings, the spacing grooves in the passages 13 being curved upward at inlet and outlet openings 11 and 12, and the spacing grooves in the passages 16 being curved downward at the inlet and outlet openings 14 and 15.

In the heat exchanger just described only a relatively few different parts are required. All of the heat transfer plates 21 may be exact duplicates formed in one or more stamping operations to provide the laterally offset top and bottom edges, to form the grooves 38 and 39, and to provide the projections 29 and triangular-shaped projections 26. This is possible because in arranging the plates 21 alongside each other, alternate plates may be reversed longitudinally or turned 180° with respect to the remaining plates. By forming the grooves 38 and 39 on the plates so that they are spaced unequal distances from the side edges of the plates, therefore, the grooves will not coincide or nest when alternate plates are reversed longitudinally. Further, the reversing of alternate plates in their assembly also reverses the position of the triangular-shaped projections so that all of the projections when bent will cover the proper triangular opening at the ends of the plates 21.

In assembling the side members 17 and heat transfer plates 21 with the closure strips 18 and strip members 25, it is only necessary to apply pressure to the U-shaped bends 19 and 20 of the closure strips 18 and U-shaped bend of the strip members 25, as by a suitable knurling device, for example, to obtain a firm and intimate contact at the abutting edges of the plates which will effectively seal the heat exchanger against internal and external leakage. Only a small amount of welding or soldering is required at 25' at the abutting ends of closure strips 18 and strip members 25, at 35 to secure the inner walls 34 of the duct sockets to the closure strips 18, and at 37 to secure the tabs 36 to the inner surfaces of the members 34.

In Fig. 13 I have shown a modification which is similar to the embodiment just described and differs therefrom in that, in place of forming grooves 38 and 39 in the heat transfer plates 21, spaced angle members 41 are secured to the plates in a lengthwise direction to maintain the plates in rigid spaced relation as well as to insure a more uniform distribution of fluids flowing over their surfaces. The angle members 41 may be secured in any suitable manner to the plates 21, as by welding or brazing, for example, with all of the plates built up in the same manner whereby the plates are exact duplicates. In assembling the heat transfer plates alternate plates may be re-

versed longitudinally or turned 180° with respect to the remaining plates, as shown in Fig. 13, so that the angle members on each plate will contact a portion of an adjacent plate strengthened by an angle member. To space one of the outside heat transfer plates 21 from a side member 17 of the casing, spaced angle members 42 are secured to the inner surface of the side member.

In order to develop more turbulence of the fluids flowing through the passages of the heat exchanger to increase the rate of heat transfer, the heat transfer plates may be waved or corrugated. Such a modification is shown in Figs. 14 and 15 in which the portions of the heat transfer plates between the grooves 38' and 39' and the grooves and the top and bottom edges of the plates are corrugated or waved. The corrugations extend approximately between the inlet and outlet openings of the ends of the casing and deflect and change the direction of flow of the fluids in the passages to increase the rate of heat transfer between the fluids.

Although the inlets and outlets for the two groups of passages 13 and 16 are shown adjacent to the same side walls of the casing in the embodiment shown in Fig. 1, it may be desirable in certain instances to construct the heat exchanger in such a manner that the inlet and outlet for each group of passages are located at opposite side walls of the casing. In the modification shown in Fig. 14, for example, the inlet and outlet openings 11' and 12' for fluid flowing through one group of passages 13 and the inlet and outlet openings 14' and 15' for fluid flowing through the other group of passages 16 are located at the opposite side walls of the casing. To provide the inlet and outlet openings at opposite side walls of the casing it is only necessary to modify the construction at one end of the heat exchanger. The heat exchanger shown in Fig. 14 is similar to that described above and shown in Figs. 1 to 12 inclusive and differs therefrom only in the manner in which the sloping edges at the left hand portion of the plates 21 are secured together. Referring more particularly to Fig. 16, the top portion of the zig-zag structure formed by the plates 21 and enclosure strips 18 intermediate the inlet and outlet openings is indicated in dotted lines. Instead of securing together the same edges of the plates 21 at the sloping end portions at the inlet 11' and outlet 15' to provide a structure similar to that shown in Fig. 1, the heat transfer plates 21 are slotted inwardly from the top and bottom edges at the ends of the enclosure strips 18. The plates 34' forming the inside walls of the duct sockets at the inlet 11' and the outlet 15' are of greater depth than the plates 34 at the outlet 12' and inlet 14' and extend into the slots formed in the plates 21. The sloping ends of the plates 21, extending from the cross plates 34' to the extreme end of the casing, are offset at 43 in the opposite direction from the offset portions 44 of the intermediate portions to which the enclosure strips 18 are secured. It will now be apparent that between the inlets and outlets at the ends of the casing the plates 21 are offset in one direction and secured to an adjacent plate, whereas at the inlet 11' and outlet 15' the plates 21 are offset in the other direction and secured to an opposite adjacent plate by the U-shaped strip members 25. This is clearly shown in Figs. 17 and 18 wherein in Fig. 17 a sectional view of a strip member 25 is seen below the member 34' and a view in elevation of a U-shaped bend 20 of an enclosure strip 18 is

seen above the member 34'; and wherein in Fig. 18 a view in elevation of a strip member 25 is seen below the cross member 34' and a sectional view of the U-shaped bends 19 and 20 of adjacent enclosure strips 18 is seen above the member 34'. The tabs 36' at the ends of the closure strips 18 may be secured to the outer surfaces of the members 34' and the latter secured to the plates 21 at the slotted portions thereof by welding or soldering to effectively seal the passages 13 and 16 at the inlet and outlet 11' and 15', respectively.

It will now be understood that the passages indicated by the reference numerals 13 in Fig. 16, which in the first embodiment are open at the top wall of the casing and closed at the bottom wall of the casing, are in the present modification closed at the outlet 15' at the top wall of the casing and open at the inlet 11' at the bottom wall of the casing; and that the passages indicated by the reference numerals 16, which in the first embodiment are closed at the top wall of the casing and open at the bottom wall of the casing, are in the present modification open at the outlet 15' at the top wall of the casing and closed at the inlet 11' at the bottom wall of the casing.

In order to insure a uniform distribution of fluids flowing over the surfaces of the plates 21, the grooves 38' and 39' are so formed in the plates that the grooved portions of the plates extending into the passages 13 are curved downward at the inlet 11' and curved upward at the outlet 12'; and that the grooved portions of the plates extending into the passages 16 are curved downward at the inlet 14' and curved upward at the outlet 15'.

By providing the heat transfer plates 21 with side edges that are offset laterally in opposite directions the groups of openings of the passages 13 and 16 at the inlets and outlets gradually taper in width from twice the width of the spacing of the main body portions of the plates to the width of the spacing, as shown most clearly in Fig. 3, thereby providing an easy transition and smooth path of flow of fluids through the passages 13 and 16 from and to ducts connected to the duct sockets. Further, the particular construction of the heat exchanger provides inlets and outlets which are at such angles that an abrupt change in direction of the flow of fluids is avoided. The inlets and outlets may be formed at any desired angle and are preferably at such an angle that the static loss is reduced to a minimum.

Although I have shown and described several embodiments of my invention it will be apparent to those skilled in the art that various changes and modifications may be made without departing from the spirit and scope of my invention.

What is claimed is:

1. A heat exchanger including a casing having end walls and openings adjacent both ends of two opposite side walls, and heat transfer plates disposed alongside each other within said casing and extending between the side walls having the openings, said plates being so constructed and arranged that they form a zigzag structure extending across the casing to provide a plurality of closely adjacent passages between said plates, said casing including closure members having U-shaped bends to receive the edge portions of said plates to close the passages, said plates at the openings having one

edge portion connected to an edge portion of an adjacent plate and the other edge portion connected to the edge portion of an opposite adjacent plate, two of the openings adjacent opposite ends of the casing serving as an inlet and outlet for fluid flowing through alternate passages and the other two openings adjacent opposite ends of the casing serving as an inlet and outlet for fluid flowing through the other passages.

2. A heat exchanger including a casing having end walls and openings adjacent both ends of two opposite side walls, and a plurality of heat transfer plates disposed alongside each other within said casing and extending between the side walls having the openings, said plates having inwardly sloping edges at the openings, said plates being so constructed and arranged that they form a zigzag structure extending across the casing to provide a plurality of closely adjacent passages between said plates, said casing including closure members having U-shaped bends to receive the edges of said plates intermediate the openings to close the passages, strips at the openings provided with U-shaped bends to receive said sloping edges so that said plates have one sloping edge secured to a sloping edge of an adjacent plate and the other sloping edge secured to the sloping edge of an opposite adjacent plate, two of the openings adjacent opposite ends of the casing serving as an inlet and outlet for fluid flowing through alternate passages and the other two openings adjacent opposite ends of the casing serving as an inlet and outlet for fluid flowing through the other passages.

3. A heat exchanger including a casing having end walls and openings adjacent both ends of two opposite side walls, and a plurality of heat transfer plates disposed alongside each other within said casing and extending between the side walls having the openings, each plate having the longitudinal edges thereof offset laterally in opposite directions with the extreme edge portions substantially parallel to the main body portions of said plates, said plates being so constructed and arranged that they form a zigzag structure extending across the casing to provide a plurality of closely adjacent passages between said plates, said casing including enclosure members having U-shaped bends to receive the edge portions of said plates to close the passages, said plates at the openings having one edge portion connected to an edge of an adjacent plate and the other edge portion connected to the edge portion of an opposite adjacent plate, two of the openings adjacent opposite ends of the casing serving as an inlet and outlet for fluid flowing through alternate passages and the other two openings adjacent the opposite ends of the casing serving as an inlet and outlet for fluid flowing through the other passages.

4. A heat exchanger including a casing having end walls and openings adjacent both ends of two opposite side walls, and a plurality of heat transfer plates disposed alongside each other within said casing and extending between the side walls having the openings, said plates having inwardly sloping edges at the openings, each plate having the longitudinal edges thereof offset laterally in opposite directions with the extreme edge portions substantially parallel to the main body portions of said plates, said plates being so constructed and arranged that they

form a zigzag structure extending across the casing to provide a plurality of closely adjacent passages between said plates, said casing including enclosure members having U-shaped bends to receive the edge portions of said plates to close the passages, strips at the openings provided with U-shaped bends to receive said sloping edges so that said plates have one sloping edge secured to a sloping edge of an adjacent plate and the other sloping edge secured to the sloping edge of an opposite adjacent plate, two of the openings adjacent opposite ends of the casing serving as an inlet and outlet for fluid flowing through alternate passages and the other two openings adjacent the opposite ends of the casing serving as an inlet and outlet for fluid flowing through the other passages.

5. A heat exchanger including a plurality of heat transfer plates arranged alongside each other with each plate having substantially parallel opposed edges intermediate the ends and inwardly sloping edges at the ends, said plates having one edge abutting an edge of an adjacent plate and the other edge abutting an edge of an opposite adjacent plate to form a zigzag structure having a plurality of closely adjacent passages, structure for closing said passages at the extreme end of said plates, a plurality of closure strips for closing the passages between the edges of adjacent plates along the intermediate portions having opposed parallel edges, the sloping abutting edges at the ends of said plates being secured to each other to provide a plurality of openings, two groups of the openings at opposite ends of said plates serving as an inlet and outlet for fluid flowing through alternate passages and the other two groups of openings at the opposite ends of said plates serving as an inlet and outlet for fluid flowing through the other passages.

6. A heat exchanger including a plurality of heat transfer plates arranged alongside each other with each plate having substantially parallel opposed edges intermediate the ends and inwardly sloping edges at the ends, said plates having one edge abutting an edge of an adjacent plate and the other edge abutting an edge of an opposite adjacent plate to form a zigzag structure having a plurality of closely adjacent passages, structure for closing said passages at the extreme ends of said plates, a plurality of individual closure strips having U-shaped bends along their longitudinal edges for closing the passages between the edges of adjacent plates along the intermediate portions having opposed parallel edges, said strips having one bend adapted to receive and hold the abutting edges of two plates and the other bend adapted to receive and hold the adjacent abutting edges of two plates and a U-shaped bend of an adjacent closure strip, the sloping abutting edges at the ends of said plates being secured to each other to provide a plurality of openings, two groups of openings at opposite ends of said plates serving as an inlet and outlet for fluid flowing through alternate passages and the other two groups of openings at opposite ends of said plates serving as an inlet and outlet for fluid flowing through the other passages.

7. A heat exchanger including heat transfer plates arranged alongside each other to form a zigzag structure having a plurality of closely adjacent passages, said plates having one edge portion abutting an edge portion of an adjacent

plate and the other edge abutting an edge portion of an opposite adjacent plate, structure for closing said passages at the extreme ends of said plates, a plurality of closure strips extending intermediate the ends of said plates for closing the passages between the edge portions of adjacent plates and maintaining the latter in spaced relation, the abutting edge portions of said plates extending between the ends of said closure strips and the extreme ends of said plates being connected to provide a plurality of openings, two groups of the openings at opposite ends of said plates serving as an inlet and outlet for fluid flowing through alternate passages and the other two groups of openings at opposite ends of said plates serving as an inlet and outlet for fluid flowing through the other passages.

8. A heat exchanger including heat transfer plates arranged alongside each other to form a zigzag structure having a plurality of closely adjacent passages, said plates having one edge portion abutting an edge portion of an adjacent plate and the other edge abutting an edge portion of an opposite adjacent plate, structure for closing said passages at the extreme ends of said plates, a plurality of individual closure strips extending intermediate the ends of said plates for closing the passages between the edge portions of adjacent plates and maintaining the latter in spaced relation, said strips having U-shaped bends at their longitudinal edge portions, said strips having one bend adapted to receive and hold the abutting edge portions of two plates and the other bend adapted to receive and hold the adjacent abutting edge portions of two plates and a bend of an adjacent closure strip, the abutting edge portions of said plates extending between the ends of said closure strips and the extreme ends of said plates being connected together to provide a plurality of openings, two groups of the openings at opposite ends of said plates serving as an inlet and outlet for fluid flowing through alternate passages and the other two groups of openings at opposite ends of said plates serving as an inlet and outlet for fluid flowing through the other passages.

9. A heat exchanger including a plurality of heat transfer plates arranged alongside each other with each plate having substantially parallel opposed edges intermediate the ends and inwardly sloping edges at the ends, said plates being arranged to form a zigzag structure having a plurality of closely adjacent passages with said plates having one edge abutting an edge of an adjacent plate and the other edge abutting an edge of an opposite adjacent plate, a plurality of individual closure strips having U-shaped bends along their longitudinal edges for closing the passages between the edges of adjacent plates along the intermediate portions having opposed parallel edges, said strips having one U-shaped bend adapted to receive and hold the the abutting edges of two plates and the other bend adapted to receive and hold the adjacent abutting edges of two plates and a U-shaped bend of an adjacent closure strip, structure for closing the passages at the extreme ends of said plate, the abutting sloping edges of said plates being secured together to provide a plurality of openings, two groups of the opening at opposite ends of said plates serving as an inlet and outlet for fluid flowing through alternate passages and the other two groups of openings at the opposite ends of said plates serving as

an inlet and outlet for fluid flowing through the other passages.

10. A heat exchanger including a plurality of heat transfer plates arranged alongside each other to form a zigzag structure having a plurality of closely adjacent passages, said plates having one edge abutting an edge of an adjacent plate and the other edge abutting an edge of an opposite adjacent plate, structure for closing the passages at the extreme ends of said plates, a plurality of individual closure strips extending intermediate the ends of said plates for closing the passages between the longitudinal edges of adjacent plates, said strips having U-shaped bends along their longitudinal edges, said strips having one bend adapted to receive and hold the abutting edges of two plates and the other bend adapted to receive and hold the adjacent abutting edges of two plates and a bend of an adjacent closure strip, and U-shaped strip members for securing the abutting edges of said plates extending from said closure strips to the ends of said plates to provide a plurality of openings, two groups of the openings at opposite ends of said plates serving as an inlet and outlet for fluid flowing through alternate passages and the other two groups of opening at the opposite ends of said plates serving as an inlet and outlet for fluid flowing through the other passages.

11. A heat exchanger including a plurality of heat transfer plates arranged alongside each other with each plate having substantially parallel opposed edges intermediate the ends and inwardly sloping edges at the ends, said plates being arranged to form a zigzag structure having a plurality of closely adjacent passages with said plates having one edge abutting an edge of an adjacent plate and the other edge abutting an edge of an opposite adjacent plate, structure for closing said passages at the extreme ends of said plates, a plurality of individual closure strips for closing the passages between the longitudinal edges of adjacent plates along the intermediate portion having opposed parallel edges, said strips having U-shaped bends along their longitudinal edges, said strips having one bend adapted to receive and hold the abutting edges of two plates and the other bend adapted to receive and hold the adjacent abutting edges of two plates and a bend of an adjacent closure strip, and U-shaped strip members for securing the abutting sloping edges at the ends of said plates to provide a plurality of openings, two groups of the openings at opposite ends of said plates serving as an inlet and outlet for fluid flowing through alternate passages and the other two groups of openings at opposite ends of said plates serving as an inlet and outlet for fluid flowing through the other passages.

12. A heat exchanger including a plurality of heat transfer plates arranged alongside each other with each plate having substantially parallel opposed edges intermediate the ends and inwardly sloping edges at the ends, said plates having the edges thereof offset laterally in opposite directions with the extreme edge portions substantially parallel to the main body portions of said plates, said plates being arranged to form a zigzag structure having a plurality of passages between adjacent plates with said plates having one offset edge abutting an edge of an adjacent plate and the other offset edge abutting an edge of an opposite adjacent plate, structure for closing the passages at the

extreme ends of said plates, a plurality of closure strips for closing the passages between the edges of adjacent plates along the intermediate portions having opposed parallel edges, the abutting sloping edges of said plates being secured together to provide a plurality of openings, two groups of the openings at opposite ends of said plates serving as an inlet and outlet for fluid flowing through alternate passages and the other two groups of openings at the opposite ends of said plates serving as an inlet and outlet for fluid flowing through the other passages.

13. A heat exchanger including a plurality of heat transfer plates arranged alongside each other with each plate having substantially parallel opposed edges intermediate the ends and inwardly sloping edges at the ends, said plates having the edges thereof offset laterally in opposite directions with the extreme edge portions substantially parallel to the main body portions of said plates, said plates being arranged to form a zigzag structure having a plurality of passages between adjacent plates with said plates having one offset edge abutting an edge of an adjacent plate and the other offset edge abutting an edge of an opposite adjacent plate, structure for closing the passages at the extreme ends of said plates, a plurality of individual closure strips having U-shaped bends along their longitudinal edges for closing the passages between the edges of adjacent plates along the intermediate portions having opposed parallel edges, said strips having one bend adapted to receive and hold the abutting edges of two plates and the other bend adapted to receive and hold the adjacent abutting edges of two plates and a bend of an adjacent closure strip, the abutting sloping edges of said plates being secured together to provide a plurality of openings, two groups of the openings at opposite ends of said plates serving as an inlet and outlet for fluid flowing through alternate passages and the other two groups of openings at opposite ends of said plates serving as an inlet and outlet for fluid flowing through the other passages.

14. A heat exchanger as defined in claim 12 in which alternate plates are provided with longitudinal grooves which extend into alternate passages and are curved at their ends toward two groups of openings at opposite ends of said plates, and the other plates are provided with longitudinal grooves which extend into the other passages and are curved at their outer ends toward the other two groups of openings at opposite ends of said plates.

15. A heat exchanger as defined in claim 7, in which alternate plates are provided with longitudinal grooves which extend into alternate passages and are curved at their ends toward two groups of openings at opposite ends of said plates, and the other plates are provided with longitudinal grooves which extend into the other passages and are curved at their outer ends toward the other two groups of openings at opposite ends of said plates.

16. A heat exchanger including a casing of rectangular cross section, said casing being open at the ends thereof and having openings adjacent both ends of two opposite side walls, a baffle of zig-zag cross section comprising heat transfer plates arranged alongside each other within said casing to provide a plurality of closely adjacent passages, said casing including closure members having U-shaped bends to receive the edge portions of said plates to close the passages at the two opposite side walls of the casing having the openings, and means including a closure plate and a sheet of packing material for sealing the ends of the passages formed by said baffle and for dividing said casing into two ducts, one of said ducts communicating with two openings adjacent the ends of said casing and the other of said ducts communicating with the other openings adjacent the ends of said casing.

17. A heat exchanger including a casing having end walls and openings adjacent both ends of two opposite side walls, and heat transfer plates disposed alongside each other within said casing and extending between the side walls having the openings, said plates being arranged so that they form a zig-zag structure extending across the casing to provide a plurality of closely adjacent passages between said plates, said casing including enclosure members having U-shaped bends to receive the edge portions of said plates to close the passages, said plates at the openings having one edge connected to an edge of an adjacent plate and the other edge connected to the edge of an opposite adjacent plate, two of the openings adjacent opposite ends of the casing serving as an inlet and an outlet for fluid flowing through alternate passages and the other two openings adjacent opposite ends of the casing serving as an inlet and an outlet for fluid flowing through the other passages, and said plates being of wave form having alternating connected curves, whereby turbulence of fluids in the passages is effected without substantially impeding the flow of the fluids.

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