Aug. 28, 1951 J. W. BROWN, JR 2,566,161

HEAT EXCHANGER

Filed Feb. 16, 1946 2 Sheets-Sheet 1

Fig. 1

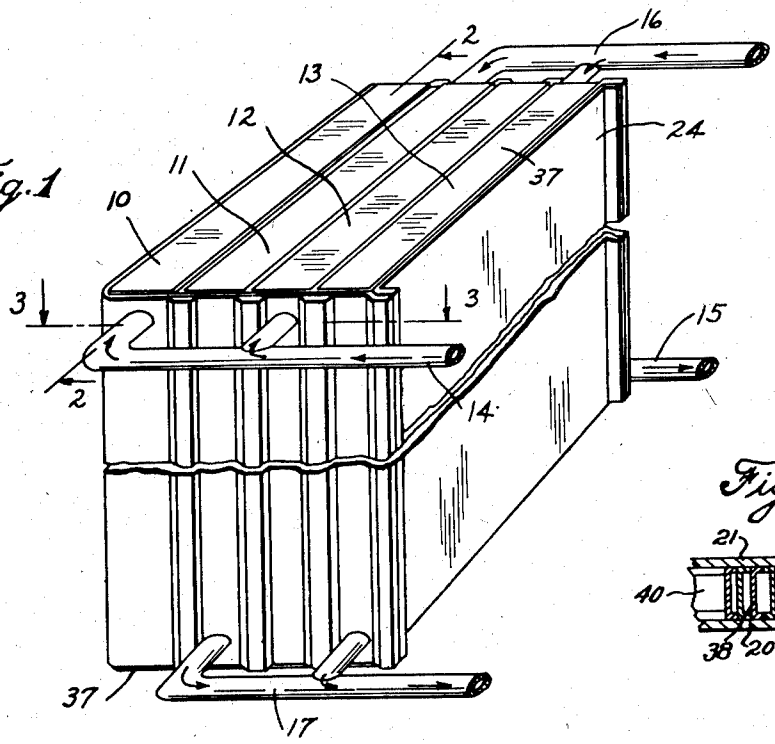


Fig. 3a

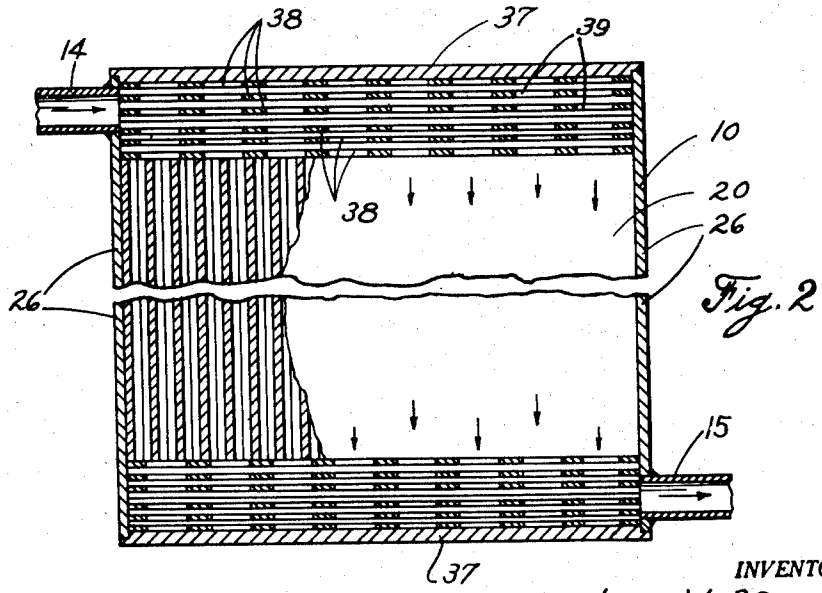


Fig. 2

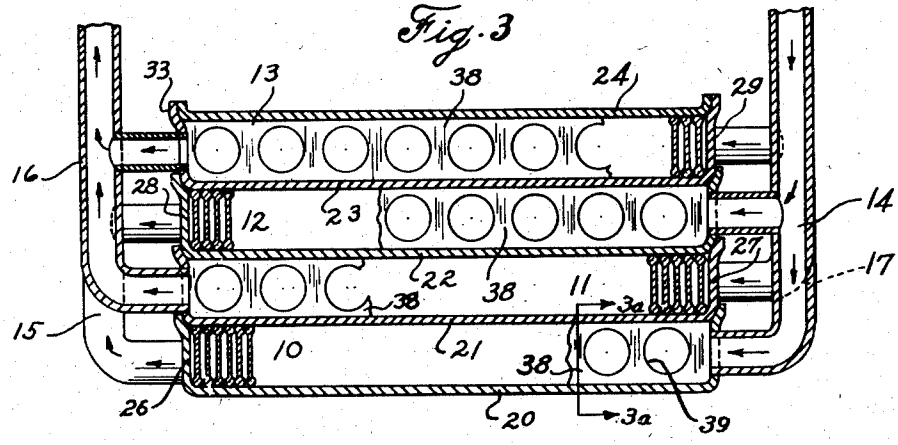
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HEAT EXCHANGER

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Fig. 3



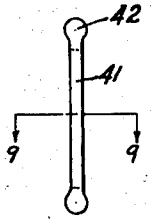


Fig. 4

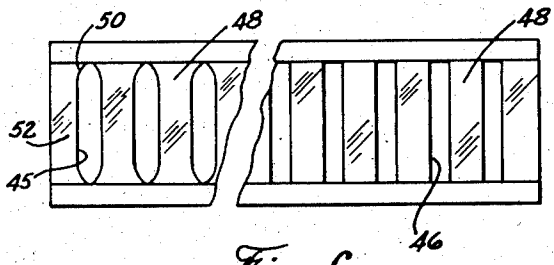


Fig. 6

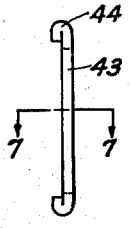


Fig. 5

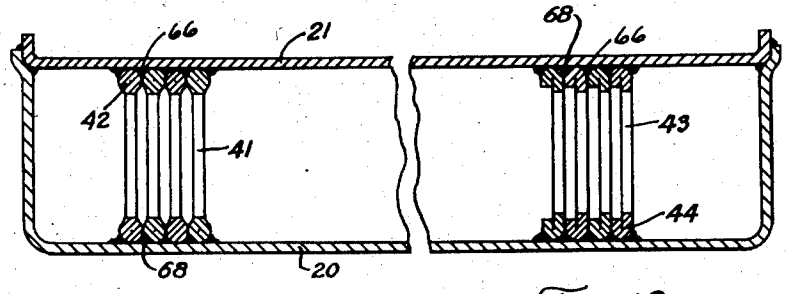


Fig. 10

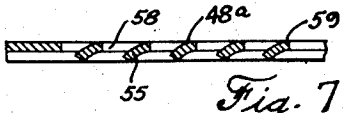


Fig. 7



Fig. 8

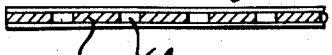


Fig. 9

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UNITED STATES PATENT OFFICE

2,566,161

HEAT EXCHANGER

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Application February 16, 1946, Serial No. 648,133

5 Claims. (Cl. 257—245)

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This invention relates to a heat exchanger and more particularly to a heat exchanger for use with commodities having low co-efficients of heat transfer, for example gases. Such commodities require extensive surface area in the heat exchanger element in order to obtain effective heat transfer and this requires a relatively large surface area in the path of the commodity flowing therethrough.

In the design of heat exchangers it has been determined that a very efficient arrangement of extended surface for interchange of heat between the fluid and side walls or plates of the fluid conduit comprises a series of parallel elements lying in the path of fluid flow and extending from one side wall to the other. Exchangers have been built in which this construction is embodied in a large number of parallel spaced pin elements extending between the side walls. A construction of this kind is illustrated and described in copending application, Serial No. 638,348, filed December 29, 1945, in the names of John W. Brown, Jr., and Robert W. Kaase, and assigned to my assignee. The construction there shown possesses excellent heat transfer efficiency and the pin-like elements perform the further function of acting as tension members to reinforce the side walls of the conduit and prevent their being bulged outwardly by pressure of the commodity within them.

The present construction in some respects constitutes an improvement on the exchanger disclosed in that application particularly with regard to the nature of the bond formed between the side walls or plates and the pin-like elements and the manner in which the elements are formed.

A general object of the invention is the provision of an extremely efficient heat exchanger of the type embodying elements with the form and heat transfer characteristics of pin-like members, and that is simple to construct, economical to manufacture and of improved strength. A further object is the provision of a heat exchanger in which the pin-like elements are provided in extruded or rolled metal strips, a number of which may be assembled together to form a heat exchanger packing. Another object of the present invention is to provide a heat exchanger in which the pin-like elements comprise a series of flat fins mounted substantially normal to the side walls in efficient heat conducting relation therewith and are bonded thereto. Still another object of the invention is to provide a construction in which the pin-like elements or

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fins are positioned with a high degree of accuracy with respect to each other so that they may be staggered to divert the fluid to new paths as it flows through the exchanger and thus to insure turbulent flow and improve the efficiency of heat transfer. An additional object of the invention is to provide a construction in which successive sheets are positioned with respect to each other to form with the adjacent side walls a series of interstices to receive and hold the molten bonding material that subsequently hardens to retain the exchanger together, and thus prevent the bonding material from coating the pin-like elements. Another object is the provision of a construction which may be adapted to provide pin-like elements or fins of many different types and arrangements, so that the most efficient design may be selected for the ducts for which the exchanger is designed.

Further objects and advantages of the invention will become apparent from the following description of a preferred form thereof, reference being made to the accompanying drawing. The essential characteristics are summarized in the claims.

Referring now to the drawings: Figure 1 is a perspective view illustrating the exterior appearance of one type of heat exchanger made according to the present invention; Figures 2 and 3 are sections through the heat exchanger of Figure 1 as indicated by the lines 2—2 and 3—3 thereon, the arrows of Fig. 3 showing concurrent flow; Figure 3*a* is a detail section as indicated by lines 3*a*—3*a* in Figure 3; Figure 4 is an end elevation of a single extruded packing sheet in which the pin-like elements are formed; Figure 5 is an end elevation of a modified form of packing sheet made from sheet stock folded along opposite edges; Figure 6 is a side elevation of the sheet of Figure 4 showing two shapes of fluid passages formed therein, one on each side of a break line; Figure 7 is a section through Figure 5 as indicated by the line 7—7 thereon showing the construction of one form of offset fins by choice illustrated with a rolled sheet member; Figure 8 is a section similar to Figure 7 showing a modified form of offset fin construction; Figure 9 is a section through Figure 4 as indicated by lines 9—9 thereon showing a further modification with the fins formed in an extruded sheet member so as to lie flat in the plane of the sheet; and Figure 10 is a fragmentary section as indicated by lines 10—10 in Figure 2, but enlarged to show the nature of the bond between the sheets and the side walls and illustrating on opposite

sides of a break line the sheet constructions of both Figures 4 and 5. It is to be noted that the taking of sections for Figures 7 and 8 through Figure 5 and Figure 9 through Figure 4 is only for convenience in utilizing a minimum of figures. Any of the fin constructions of Figures 7, 8 and 9 may be used with the type of sheet shown in either Figure 4 or Figure 5.

The preferred form of heat exchanger embodied in this invention is of a type wherein the commodity, as a fluid, flows between conduit side walls in the form of flat plates arranged to provide separate and contiguous passages so that two or more fluids may be passed through the device while separated from each other by the plates. To effect rapid and efficient transfer of heat from one fluid through the intervening side wall plate to the other fluid, the space between the plates and in the path of each commodity is filled with a heat conducting packing or matting. As the fluid flows through the packing the desired heat transfer takes place. In effect, this packing constitutes a large number of accurately spaced pin-like tension elements, hereinafter called fins, extending between the side walls and bonded to them to provide for efficient heat transfer to the side walls as well as for the reinforcement of the entire structure.

In the preferred form of the invention the fins are formed in strips which are preferably extruded and are of a flat cross section with beaded or bulbous edges. The bulbous edges hold adjacent strips at a predetermined distance from each other and also stiffen them. In a modified construction a similar result is obtained by forming flat strips with bent over edges to increase the effective thickness at the edges and also to stiffen it. As indicated from the drawings the fins themselves may be formed and shaped in different ways although in each case they are preferably formed in the strip by a blanking operation that provides passages through the strip for the commodity and produces the pin-like effect. Also, the fins preferably extend transversely of the strip from closely adjacent one edge thereof to closely adjacent the other in order that they may act as tension elements to reinforce the side walls to which the edges of the strip are bonded. The fins may be bent or offset from the general plane of the strip or they may be left parallel with and in the plane of the strip. The openings may take various shapes, although they are preferably elongate, and the ratio of opening to fin can be varied to suit the requirements of the service for which the exchanger is intended.

A heat exchanger constructed in accordance with the present invention is shown in Figures 1, 2 and 3. Such an exchanger may comprise a plurality, in the present case four, of substantially parallel fluid passages or conduits **10**, **11**, **12** and **13**. The passages **10** and **12** are in communication with a suitable inlet **14** and outlet **15** to permit passage of one fluid therethrough. In like fashion the other commodity passing through conduits **11** and **13** is admitted at an inlet **16** and discharged at an outlet **17**. It will be noted from Figure 1 that the arrangement described provides for counterflow of the fluids within the respective chambers although it will be apparent that concurrent flow can be provided if desired as shown in Fig. 3.

The conduits or chambers **10**, **11**, **12** and **13** are made up of nested, shallow channels or pans **20**, **21**, **22** and **23** respectively. The bottoms of the channels **21**, **22** and **23** act as side walls to separate the chambers or conduits **10** and **11**, **11** and **12**, and **12** and **13**, respectively. The bottom of the channel **20** has no heat exchange function inasmuch as only one face of it forms part of a conduit. The conduit **13** is closed by a plate **24** that conforms in shape to the bottom of a channel but has only sufficient side wall to permit it to nest properly in the vertical wall of the channel **23**. The manner in which the nesting of the channels and the plate **24** is accomplished is illustrated in Figure 3 showing the vertical walls of the several chambers that are formed by flanges **26**, **27**, **28** and **29** respectively. These flanges are formed at each of two opposite ends of the channel bottoms and are deformed outwardly adjacent their edges as indicated at **33** to receive telescopically the bottom of the adjacent nesting channel. In the case of the channel **23** the outward deformation **33** is to permit reception of the top plate **24**.

All of the channels and the plate **24** are brazed or soldered together after assembly, preferably by the method disclosed in my copending application referred to above.

End walls for the conduits may be provided by suitable plates **37** brazed or soldered in place. The fluid inlets and outlets extend through the apertures in the respective flanges as shown in Figures 1 and 2 and may be secured in place by brazing, soldering or other convenient means.

Packing is placed in the conduits **10**, **11**, **12** and **13** and bonded to the conduit side walls to act as a heat transfer medium between the commodity and the side walls. The packing includes a large number of fins that are straight and bonded to the side walls to provide extended heat exchanging surfaces and to serve as tension members that reinforce the heat exchanger structure against fluid pressures within the conduit.

The packing fills almost all of the interior of a conduit except a space at each end, across the exchanger, and adjacent the inlets **14** and **16** and the outlets **15** and **17**. This space is occupied by channel shaped members **38** mounted one against the other with their flanges lying along and bonded to the walls of the conduits and their bases normal thereto. The bases are provided with a series of large holes **39** to permit free flow of a commodity therethrough, and serve as tension members to prevent outward bulging of the conduit side walls due to pressure developed within the conduit. The channels also function to permit the commodity to distribute itself across the packing at each end as it flows through from an inlet to an outlet and thus insure effective utilization of all sections of the packing.

As noted above, packing that is used as a medium of heat exchange between the commodity and conduit sidewalls comprises a series of metal strips, preferably formed by extrusion, but not limited to such method of fabrication; and stacked face to face inside of each of the conduits **10**, **11**, **12** and **13**. The strips are so positioned that they extend up and down as shown in Figure 2 and lie substantially parallel to each other in planes normal to the walls of the conduits.

The preferred cross sectional form of sheet results from extruding a strip **40** with a cross section as shown in Figure 4 having a trim, flat central portion **41** and bulbous or beaded edges **42**. In addition to this preferred form of construction other forms such as that shown in Figure 5 may be employed. In this figure there is shown a flat strip **43** turned over and doubled back on itself at opposite edges **44** to form a con-

struction in cross section approximating the construction shown in Figure 4. The enlargements at the edges of the strips automatically space them at the proper distance from each other for the most advantageous fluid flow and heat transfer conditions when assembled. The enlarged edges also serve to stiffen or reinforce the individual strips.

In order to provide the required pin-like heat conducting fins, and insure turbulence of flow, openings as shown in Figures 6, 7, 8 and 9 are provided. In Figure 6 two kinds of elongate openings are shown; one type, at the left, having the form of an elongate oval as shown at **45**. The other type, at the right, is of rectangular shape and is indicated at **46**. In each case the openings (either **45** or **46**) leave between them a series of spaced pin-like sections or fins **48** that extend from one edge to the other of the sheet and are bonded at their ends through the edge portions to conduit walls, as **20** and **21**, to reinforce the same against the pressure of fluid within the conduit. So long as the sheet construction embodies, in accordance with heat exchanger requirements, the formation of an adequate number of such tension elements to withstand the internal pressures, the shape and size of the cut out openings **45** and **46** are not critical.

There is an advantage from the heat transfer standpoint in the use of the oval openings **45** with commodities such as steam having a high coefficient of heat transfer. This is because a thicker section of fin adjacent the outer edges of the strip, which section is indicated at **50**, will permit more efficient transfer of heat from the central portion of the fin as indicated at **52**. With other commodities having low coefficients of heat transfer, area considerations are more important than the capacity of the fins to transmit heat, and straight openings are then preferred. Considerations of heat exchanger efficiency and pressure drop in the fluid govern the spacing of fins and relative size of the parts.

It is frequently desirable to position the fins **48** so that they lie in the plane of the strip as shown in Figure 9. On the other hand it is sometimes desirable to bend the fins as shown in Figures 7 and 8 to provide a diverting passage for the fluid, causing it to travel laterally with respect to the sheets. In Figure 7 the fin **48***a* includes a tongue **55** struck outwardly from the plane of the strip leaving an opening **58**. The tongue remains joined to the strip by a portion **59** of the fin **48***a* that remains unbent and that acts as the tension member extending from one edge of the strip to the other.

Another bent type of fin is illustrated in Figure 8. In this figure elongate openings **60** are formed in the sheet stock **62** between fins **48***b*. The fins are then bent out of the plane of the strip as shown in that figure although their entire cross section remains joined at the ends to that material adjacent the strip edges; thus the cross section of the fins is uniform throughout and the fins are not weakened nor their heat transfer capacity diminished at the juncture of the fins with the edges of the strip. It is preferable in both of these modifications, however, that the amount the fins are bent out of the plane of the strip shall be no greater than that permissible without interference between the fins of the one strip and any part of the adjacent strips between which it is packed.

The fins lie in the plane of the sheet in the construction of Figure 9, and are indicated at **48***c* while the spaces between them are shown at **64**.

The strips described above are assembled in units in respective conduits **10**, **11**, **12** and **13**. The conduit **10** bounded by side walls **20** and **21** is partially shown in Figure 10. In this figure the extruded strip of Figure 4 and bent strip of Figure 5 are each shown bonded in place, one example being shown on each side of the break lines of the figures. In normal use a packing will be made up of only one kind of strip.

In each case it will be seen that the thickened edges of the strips not only space them properly, but also provide interstices **68** between the adjacent rounded edge surfaces and conduit side wall **20** or **21**. The surfaces of the rounded bulbous edge of the Figure 4 construction and the rounded bent construction of Figure 5 each form these interstices. Their function is an important one in that they each provide a long tubular opening of somewhat triangular cross section to receive and hold molten solder or other bonding material during the assembly operation.

At the time of assembly solder is interposed in sheets between sidewalls **20** and **21** respectively and the assembly of packing members therebetween. Then, as pressure and heat are applied the solder melts and is held by capillary attraction adjacent the surfaces which are to be bonded together. An excess of solder is ordinarily supplied in order to insure that sufficient solder will be present to create the required bond. The excess is retained between the contacting parts of adjacent strips preventing the solder from running off. Thus the fins remain substantially free from solder, and the possibility of solder clogging or restricting the openings is eliminated. While it is molten and as it hardens the solder is held in place and made available to complete a firm bond between sheet **20** or **21** and the packing members on each side of the respective interstices. Since these bonds and the bonds of the end members **38** extend over substantially the entire inner surface of the side walls **20** and **21** the packing members and end members are integrally bonded thereto as a unitary assembly. The bonds provide ample mechanical strength to withstand forces imposed thereon by fluid pressures within the conduits.

Various other changes and modifications may be made without departing from the spirit and scope of my invention. It is therefore to be understood that my patent is not limited to the preferred forms of the invention described herein, or in any manner other than by the scope of the appended claims.

I claim:

1. In a heat exchanger unit, the sub-combination comprising two side walls and, extending from one to the other thereof, a heat conducting packing made from a plurality of substantially contiguous individual members each bonded thereto and comprising a long and relatively narrow strip of metal shaped to be substantially thicker along opposite edges and for a substantial distance inwardly than at its midportion and provided with a plurality of elongate pin-like heat transferring fins formed integrally with the strip and extending from adjacent one of said opposite edges to adjacent the other edge, said members abutting mainly along the thick portions characterizing their opposite edges and being out of contact between such thick portions.

2. In a heat exchanger unit, the sub-com-

bination comprising two side walls and, extending from one to the other thereof, a heat conducting packing made from a plurality of substantially contiguous individual members each bonded thereto and comprising a long and relatively narrow metal strip shaped to be substantially thicker along its long edges and for a substantial distance inwardly than at its midportion and provided with a plurality of elongate heat transferring fins separated by elongate openings extending from adjacent one long edge to adjacent the other long edge to act as fluid passages for a commodity passed through said exchanger, said members abutting mainly along the thick portions characterizing their opposite edges and being out of contact between such thick portions.

3. In a heat exchanger unit, the sub-combination comprising a heat conducting packing made from a plurality of stacked substantially contiguous individual members, each comprising a long and relatively narrow metal strip provided with a series of fins struck from the flat strip surface and bent outwardly therefrom and integral spacer means taking the form of opposite portions extending continuously along opposite edges of said strips to space said fins from the next adjacent member, the individual members making up the packing being stacked with their enlarged portions in abutting relation to each other.

4. A heat exchanger comprising a closed structure having a pair of opposed side walls, inlet and outlet means communicating with the space between said side walls, a heat conducting packing between said side walls and extending from one to the other, said packing comprising a plurality of substantially contiguous individual metal strips abutting each other only at their edges each of which strips is formed with a series of offset fins separated from each other by openings extending transversely of said side walls

continuously from adjacent one wall to adjacent the other wall to provide fluid passages for a commodity passed through said exchanger, and a metallic bond between said strips and said plates to provide a heat conducting assembly.

5. A heat exchanger comprising a closed structure having a pair of opposed side walls, inlet and outlet means communicating with the space between said side walls, a heat conducting packing between said side walls and extending from one to the other, said packing comprising a plurality of individual metal strips with rounded edges in abutting relation to each other each of which strips has a plurality of integrally formed heat conducting fins separated by openings acting as fluid passages for a commodity to be passed through said exchanger, and a bond formed of heat conducting bonding material to provide a heat conducting unitary assembly of said side wall and said strips.

JOHN W. BROWN, JR.

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