

Sept. 24, 1963

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3,104,701

HEAT EXCHANGER

Filed Jan. 18, 1956

3 Sheets-Sheet 1

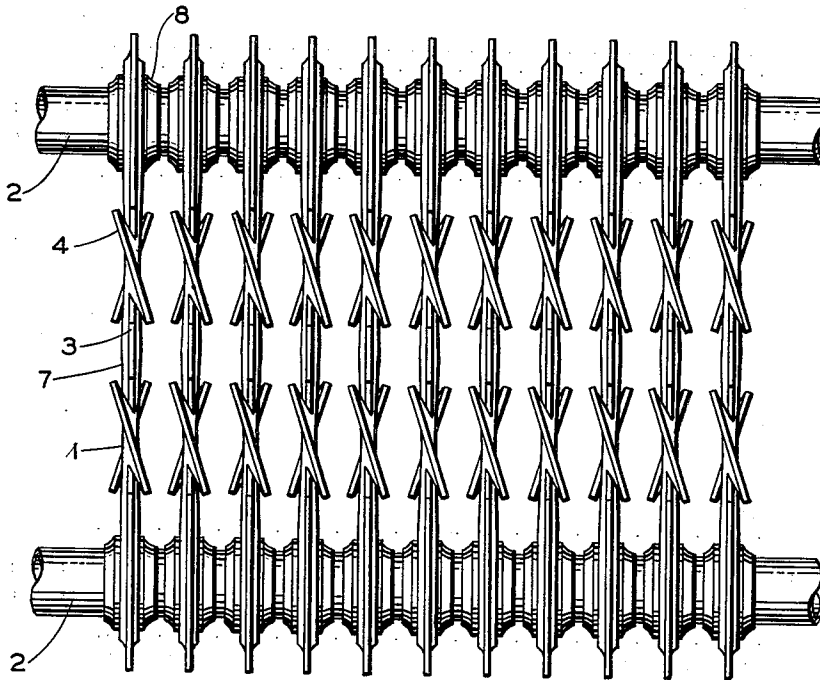


FIG. 1

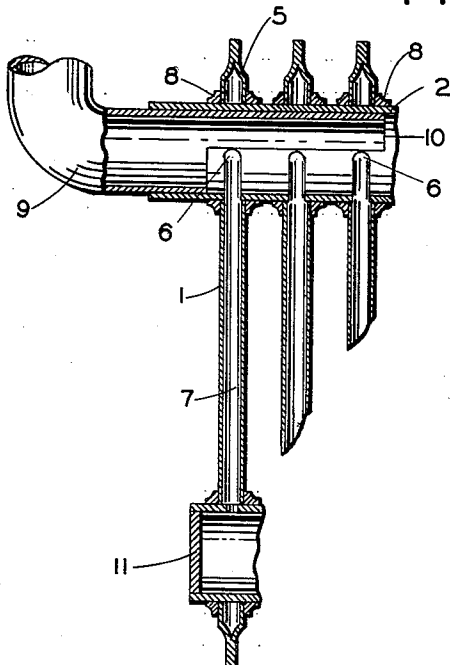


FIG. 2

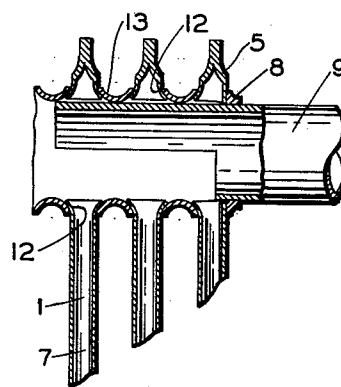


FIG. 3

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3 Sheets-Sheet 2

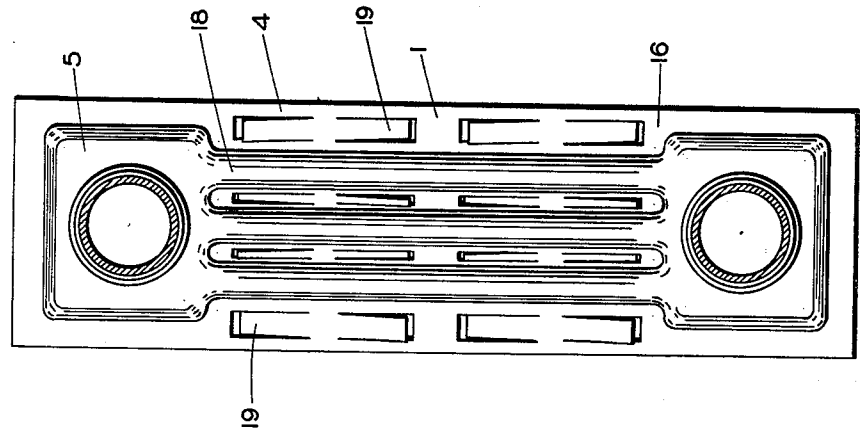


FIG. 6

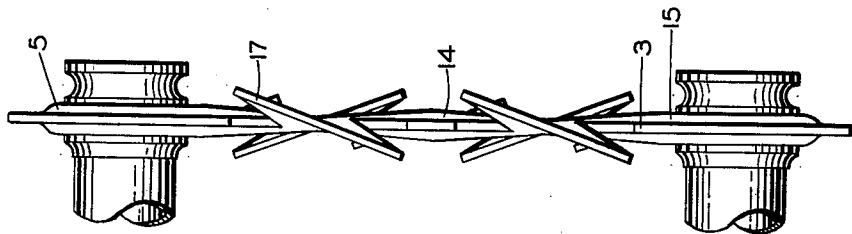


FIG. 5

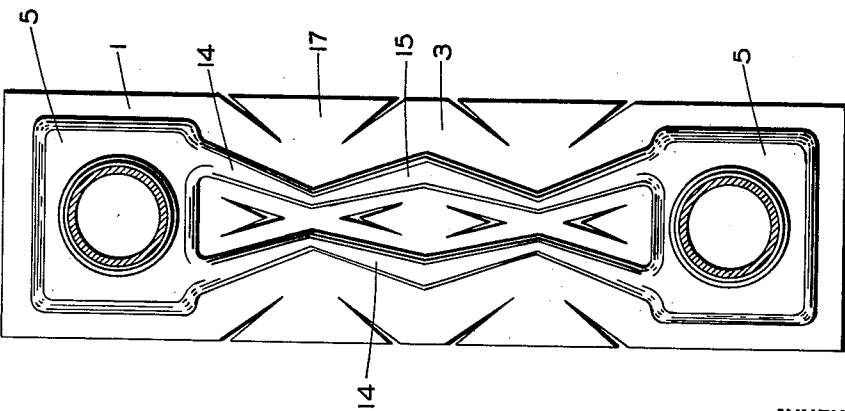


FIG. 4

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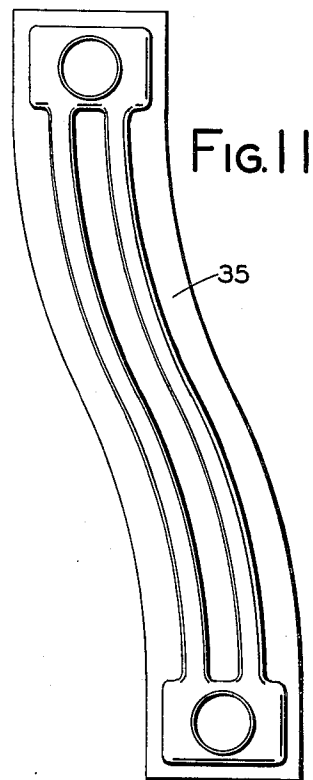
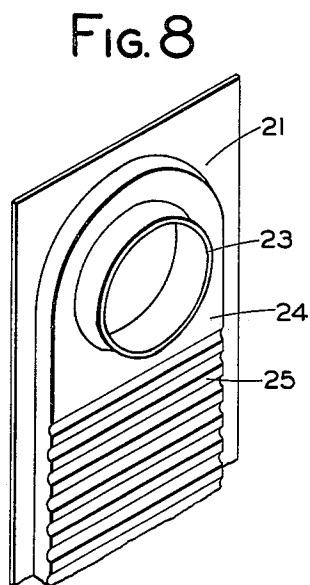
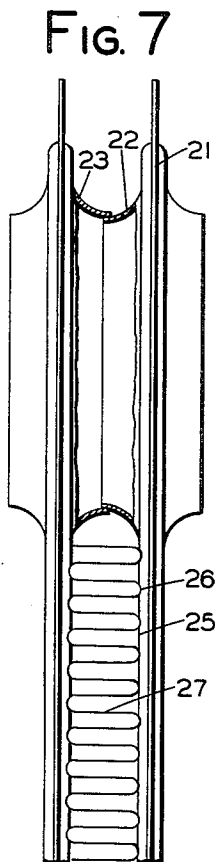
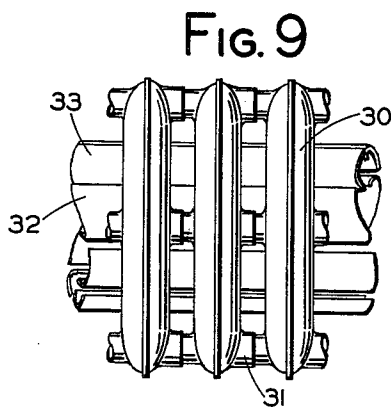
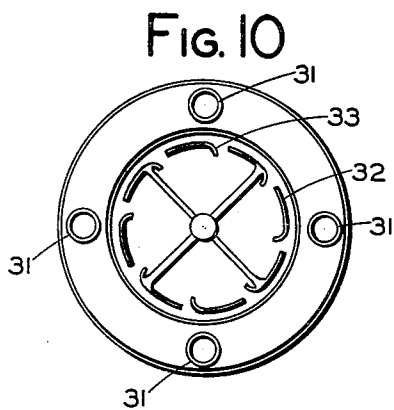
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3 Sheets-Sheet 3



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1

3,104,701

HEAT EXCHANGER

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This invention relates to sheet metal fabrication and the assembly of sheet metal parts and more specifically to the fabrication and assembly of radiators.

In the fabrication and assembly of radiators, and particularly sheet metal sectional radiators, a plurality of tubes are attached either to common headers or to common boiler pipes. The connections between the tubes should be strong enough to prevent warping and twisting and at the same time provide a water tight seal between the tubes which will remain water tight when subjected to the changing temperatures and to external forces tending to cause leaks through the joints as may be caused by twisting the radiator during installation or repair, or other handling. When the tubes are fabricated of sheet metal it is customary to weld or crimp join the peripheral edges of the tubes but this is susceptible to leakage and general deterioration.

The efficiency of a radiator section is affected by the efficiency of the individual tubes which make up the section. The fluid carrying conduits of each tube are generally straight and of uniform cross section throughout their entire length. Although conduits of this type give satisfactory results they do have the disadvantage of preventing optimum heat transfer by the fluid in the conduits to the tube because of the unrestricted flow of the fluid creating an insulating film along the walls of the conduits.

It is therefore an object of this invention to provide a simple, rigid, fluid tight joint for connecting the radiator tubes to boiler pipes. A further object of this invention is to position the connections inwardly of the peripheral edges of the tubes so that they are protected by the extremities of the tubes. Another object of this invention is to provide a simple and dependable connection between the boiler pipes and the source of fluid to be carried in the tubes. Another object of this invention is to provide conduits for radiator section tubes which will increase the heat transfer from the fluid in the conduits to the tubes. Another object of this invention is to provide radiator tubes having more efficient heat transfer characteristics. Another object of this invention is to provide sheet metal radiator tubes which are substantially leakproof and are sufficiently flexible to avoid rupturing when subjected to vibrations but are sufficiently rigid to prevent wind flutter. Another object of this invention is to provide radiator tubes which are easily and inexpensively fabricated in any desired shape or design to conform to the intended operative environment. Another object of this invention is to provide a radiator wherein separate corrugated fins may be more easily attached between adjacent radiator tubes and wherein the attachment of the fins to the tubes lends itself to better heat transfer from the tubes to the fins.

The foregoing objects and advantages, as well as others which will become apparent, are accomplished as follows. Each radiator tube of this invention has one or more conduits opening into transverse apertures in the extremities of the tube. A radiator section is made up of a plurality of tubes joined together in one of two manners. In the first instance, a boiler pipe passes through the transverse apertures at each end of the tubes and this pipe is provided with slots opening into the conduits or tube header to permit free flow of fluid through the tubes. In a modified form of the connection the periphery of each transverse aperture in the tubes is provided with an outwardly extending flange. Collector rings mate with the flanges on

2

adjacent tubes and the joints are secured by soldering. The radiator tubes, forming one phase of the invention, are formed by the process described in U.S. Patent 2,690,002. The process of the aforesaid patent comprises interposing a pattern of weld inhibiting material between superposed component sheets, and pressure welding the adjacent surfaces of the sheets together in the areas not separated by the weld inhibiting material. Subsequent to the welding operation, sufficient fluid pressure is injected within the sheet, in the areas defined by the weld inhibiting material, to expand the areas so that the portions of the sheet opposite the material are bulged out of the plane of the sheet into the desired system of tubular passageways. This process has a particular advantage in the type of radiator tubes utilized in this invention since it permits a wide variety in the configuration of the conduits and is also well adapted to the formation of fins on the conduits because there are no seams between the conduit and fin to retard heat transfer. This materially increases the heat transfer from the fluid in the conduit to the surrounding air, and to further increase the heat transfer these fins may be provided with smaller fins stamped therefrom to deflect and control the currents of air between the radiator tubes. The assembled radiator is connected to the supply of the heating or cooling fluid by any conventional connector head, the connector having a tubular portion inserted into the boiler tube, or through a plurality of radiator tube apertures, as the case may be. This end has a cut out portion to prevent blocking the flow of water through the boiler tube slots, or into the radiator tube headers or conduits in the second form of the invention.

To increase the transfer of heat from the fluid in the conduits to the tubes it has been found to be particularly advantageous to provide the conduits with a venturi-tube configuration. This particular configuration provides for a scrubbing action by the fluid flowing through the conduits against the conduit walls so that the effect of an insulating film on the conduit walls is greatly reduced, if not for all practical purposes eliminated entirely.

Having described the nature and substance of this invention in a general way, the following is a detailed description of the preferred embodiments thereof with reference to the accompanying drawings in which:

FIGURE 1 is an elevational front view of a radiator showing various features of one of the embodiments of the invention;

FIGURE 2 is an elevation view in section showing the connection between the radiator tubes of FIGURE 1 and the external connection to the fluid supply but showing another embodiment of the tubes;

FIGURE 3 is an elevation view in section similar to FIGURE 2 but showing another embodiment of the connection between the radiator tubes;

FIGURE 4 is a front view of a radiator tube of FIGURE 1;

FIGURE 5 is a side view of the radiator tube shown in FIGURE 4;

FIGURE 6 is a front view of a radiator tube of FIGURE 2;

FIGURE 7 is an elevation view partly in section showing another embodiment of the connection between the radiator tubes and the addition of fins between the tubes;

FIGURE 8 is a perspective view of a radiator tube of FIGURE 7;

FIGURE 9 is an elevation view of another embodiment of the invention;

FIGURE 10 is a sectional view taken on the line 10—10 in FIGURE 9; and

FIGURE 11 is a front view of another embodiment of a radiator tube.

Referring to FIGURE 1, a radiator section comprises a plurality of spaced tubes 1 connected at each extremity

3

to a boiler pipe 2. Each tube is provided with a major fin 3 and a plurality of sub-fins 4 bent out of the plane of the tube to assist in deflecting the currents of air, thereby increasing the rate of heat transfer.

In FIGURE 2 the connection between the tubes of FIGURE 1 is shown in section. A boiler pipe 2 passes through aligned apertures in the header portion 5 of the conduit system in each radiator tube 1. The radiator tubes 1 are so spaced on the boiler pipe 2 that spaced slots 6 in the boiler pipe 2 each open into a tube header 5 to permit the flow of fluid in the tube through the tube conduits 7. Collector rings 8 snugly but slidably engage the boiler pipe 2 and each abuts a side of a radiator tube 1 to provide additional rigidity in the entire section and a fluid tight joint. The radiator tube, collector ring and boiler tube seams are then soldered so that there are no exposed seams. The collector rings may be omitted, if desired, and each tube may be soldered directly to the boiler without the benefit of reinforcement by the collector rings. A pipe 9 having a connection to an external fluid supply source is inserted into an open end of the boiler pipe 2. The end of the pipe inserted into the boiler pipe has an approximately semi-cylindrical portion 10 cut out to permit passage of the fluid through the adjacent slots 6 in the boiler pipe 2 and into the conduits 7. The radiator section boiler pipe openings not used for external connections may be closed with any conventional plug, such as plug 11 which is soldered in place.

FIGURE 3 shows another embodiment of the connection between the tubes. Each aperture in the header portion of each tube 1 is provided with an outwardly extending flange 12. In assembling the section a collector ring 13 is inserted between the tubes and engages the flanges 12 on the adjacent tubes. The collector ring 13 and tube sections 1 are then soldered together. In this case the connection pipe 9 is merely inserted through the apertures in the radiator tubes and is provided with a collector ring 8 which is soldered to the connection pipe 9 and radiator tube 1. However, the pipe and tube may be soldered to each other without the addition of a collector ring, if desired. In any event, the outer face of first and last tubes of the section are not provided with a flange about the aperture.

FIGURES 4 and 5 show tubes provided with at least two intermediate portions forming corresponding venturi conduits 14 having headers 5. The venturi conduits are substantially frusto-conical cylinders 15 in which both the width and depth of the conduit varies substantially proportionally up to the point where it joins another frusto-conical section. As shown in FIGURE 4 conduit 14 is obtained by having an adjacent pair of frusto-conical cylinders 15 joined together at the smallest cross-section of this pair of frusto-conical sections or cylinders 15 to form a venturi conduit 14 having a constriction at the point of juncture, of these sections, which is progressively enlarged to the largest cross-section of this adjacent pair of sections. In addition, each of these pairs of joined frusto-conical sections of venturi conduits 14 is joined in series in an adjacent pair of joined frusto-conical sections or venturi conduits 14 at their largest cross-section of the frusto-conical sections. By utilizing conduits having a venturi-tube configuration the insulating surface film on the inside of a conduit is for all practical purposes eliminated. As additionally illustrated in FIGURE 4, the elimination of this fluid film is further facilitated by joining each of the frusto-conical sections or cylinders 15, to an adjacent section or cylinder, at an angle to form bends in the tubes extending between headers 5 including a bend where the union between two frusto-conical sections or cylinders 15 forms a constriction in the venturi conduits 14. Fluid flowing through a straight tube of substantially constant cross section inherently tends to create a film on the inside wall of the conduit. This film remains substantially fixed or static relative to the conduit wall and the fluid flowing through the conduit

4

is moving relative to the film. In other words, the insulating film in effect serves as a liner within the conduit. By providing the radiator tubes with conduits having a venturi-tube configuration as shown by conduits 14 in FIGURES 4 and 5 the formation of an insulating surface film is retarded on the inner walls of the conduits because of the change in velocity of the fluid as it passes through the restriction in the venturi-tube and also, because of the turbulence of the fluid as it passes through a tube of this type. The venturi conduits are particularly adapted to the elimination of hot spots in a radiator tube through the proper relative positioning of the reduced and enlarged portions of the conduit since with reduced portions will tend to be hotter than the enlarged portions. This type of tube is particularly adapted to fabrication by the process described in the aforementioned patent because it is merely necessary to deposit the desired venturi-tube type design on the sheets prior to welding them together by hot rolling.

When fabricated by this process the radiator tube is actually a single sheet of metal in which the conduits and headers have walls spaced apart. This is of particular advantage in heat transfer since there are no seams between the conduit and the fin portion 3 of the tube 1 shown in FIGURES 1, 4 and 5. The heat transfer characteristics of a tube are even more improved by the provision of small fins 4 in a different plane than the major portion of the fin 3. The small fins 4 as shown in the drawings are stamped from and bent out of the plane of the larger fin 3 as best seen in FIGURE 5. The small fins 4 may assume any shape to give optimum results in any particular application.

FIGURE 6 shows a front view of a tube of the type shown in FIGURES 2 and 3. In this modification the conduits 18 are straight, however, these conduits may assume any configuration desired. Fins 16 are provided with small fins 19 stamped from and bent out of the inner portion of the larger fin 16. In tubes of this type a maximum amount of heat transfer from the fluid in the conduits to the air surrounding the tubes is provided because of the continuity of the metal, or lack of seams between the conduits and headers, and the large and small fins. The small fins may be bent in any desired manner to facilitate deflecting the air from one tube to the other thereby giving a decided increase in the scrubbing action of the air on the tube surface.

FIGURES 7 and 8 show another embodiment of the invention in which the radiator tube headers 21 are provided with connecting flanges such as 22 and 23 which slip into similar connecting portions on the adjacent tubes. The outside diameter of flange 22 is substantially the same as the inside diameter of flange 23. The connecting flanges of the tubes mesh with a relatively fluid tight fit but may be soldered or otherwise sealed. As shown in FIGURE 8 each tube is formed with a pillow type conduit 24. The outer surface of each side of the conduit of these tubes is provided with grooves 25 so spaced as to receive the reentrant bends 26 of a fin 27 which is inserted between adjacent tubes. The fins are soldered to the tubes in any conventional manner. The grooves 25 permit easier seating of the fins 27 and also provide a larger bearing surface between the contacting portions of the fin and the tube providing better heat transfer between the members.

It should be noted that the connections shown in FIGURES 3, 7 and 8 facilitate easier replacement of radiator tubes since it is merely necessary to break the connection between adjacent tubes and remove the section whereas with the connection shown in FIGURES 1 and 2 it is necessary to remove all of the end tubes if it becomes necessary to replace an inside tube.

FIGURES 9 and 10 show a radiator having a plurality of donut type tube sections 30. The tube sections 30 may be provided with any desired number of connections 31 which may be of any of the previously disclosed

types. A cylindrical type finned blower is mounted within the assembled radiator. The fins 33 may be so set as to blow air outwardly past the radiator tubes or to draw air inwardly between the radiator tubes, depending on the intended operative environment. Alternatively, the blower may encase the outer periphery of the radiator.

In FIGURE 11 is shown a radiator tube 35 having a curved configuration indicating the adaptability of the aforementioned process to the formation of radiator tubes of various configurations to suit a particular operative environment.

It should be noted that in the radiators herein described the headers are integral with each tube and that there is a complete circulation of the fluid within the radiator through the elimination of any header pockets in which the fluid can remain motionless. Additionally, each header is provided with an integral fin to further increase the heat transfer capacity of the radiator. The integral headers also greatly reduce the number of connections between the conduits and a conventional header facilitating the assembly of the radiator and eliminating the number of points at which leaks can occur.

Radiator tubes of the aforementioned process display a great deal of rigidity and eliminate wind flutter because each tube is formed with integrally distended portions. Referring to FIGURE 2 it will be seen that the supply pipes 2 connected to the ends of the tubes provide a very rigid radiator. Although the radiator tubes individually have great rigidity because they are in themselves an integral unit and not composed of separate welded or soldered parts, still they are sufficiently flexible to resist breaking when exposed to extreme vibration. The process of fabrication permits varying the tube capacity to provide greater or less volume in that portion of the tube or the assembled radiator which is exposed to the greatest amount of air flowing across the respective surfaces.

Having thus described the preferred embodiments of the invention it is to be clearly understood that the invention is not to be limited thereby. Specifically, the radiator tubes of this invention may be fabricated from aluminum, copper, steel or any other metal which may be fabricated by the process described in the aforementioned patent. However, that portion of the invention dealing with the connection between the radiator tubes, that is, the structure of the tube as it relates to the specific connections, is not to be limited to tubes made of any particular material nor to tubes fabricated by the aforementioned process since this portion of the invention is equally adaptable for use with tubes fabricated by many other methods, as well as tubes and boiler pipes fabricated out of materials such as plastics, ceramics or glass or any other desired material. Nor is the invention to be limited to the sub-fins having any particular configuration nor to tubes of any particular configurations since these considerations relate primarily to the operative environment of the particular radiator section. Throughout the specification certain joints have been referred to as soldered, however, the invention is not to be limited thereby and these joints may be welded or cemented with a good thermocement or any other similar binder and/or sealer, rather than solder. Although several specific modifications and details are set forth in the foregoing, it will be understood that various changes may be made without departing from the spirit and scope of this invention, and this invention is therefore not to be limited to such specific modifications and details except as set forth in the appended claims.

I claim:

1. A heat exchanger comprising a pressure welded seamless metal sheet having internally disposed therein a tubular conduit bulged out of the plane of said sheet; pressure welded portions of said sheet laterally defining said conduit in said sheet and also forming a seamless integral extension of the walls of said conduit; and said tubular conduit is provided with at least two intermediate portions connected in series with one another and each portion narrowed into a constriction.

2. The heat exchanger of claim 1 wherein said constriction is a venturi type constriction.

3. A heat exchanger comprising a series of pressure welded seamless metal sheets in spaced substantially parallel relationship with each other, each of said sheets having internally disposed therein a tubular conduit bulged out of the plane of said sheet; pressure welded portions of said sheet laterally defining said conduit in said sheet and also forming a seamless integral extension of the walls of said conduit; and said conduit having at least one intermediate portion thereof narrowed into a constriction and each of said sheets including at least a substantial peripheral heat exchanger fin portion and spaced header portions bulged out of the plane of said sheet in communicating relationship with the ends of said conduit, apertures through each of said header portions aligned with corresponding apertures in adjacent sheets, a pipe passing through each of said aligned apertures and having slots in the portions of said pipe contained within each of said header portions for communicating relationship with said header portions, and fluid tight means securing each tube sheet in sealing relationship to said pipes, said fluid tight means being disposed externally of said tube sheets.

4. The heat exchanger of claim 3 wherein said intermediate portion is formed of two conduit sections having a frusto-conical configuration with said sections joined together at the smallest cross-section of said sections to form a constriction which is progressively enlarged to the largest cross-section of said sections.

5. The heat exchanger of claim 3 wherein said constriction is a venturi type constriction.

6. The heat exchanger of claim 3 wherein said fluid tight means connecting said pipe to each tube sheet comprises a collector ring slidably received on and secured in sealing relationship to said pipe and externally to one wall of said tube sheet.

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