March 10, 1959 F. W. PERSON 2,877,000

HEAT EXCHANGER

Filed Sept. 16, 1955 6 Sheets-Sheet 1

FIG. 1

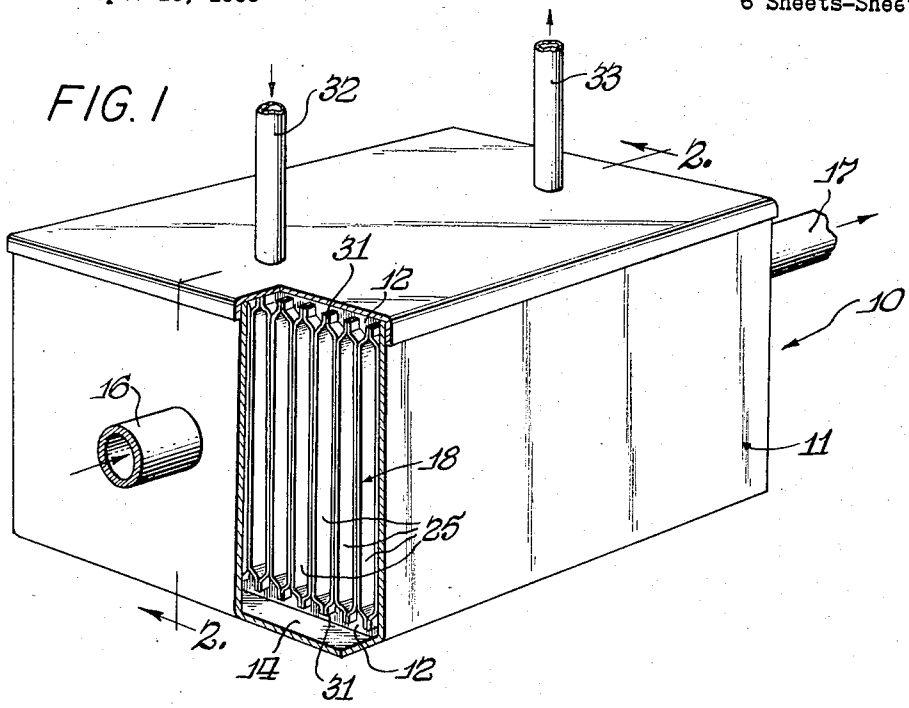
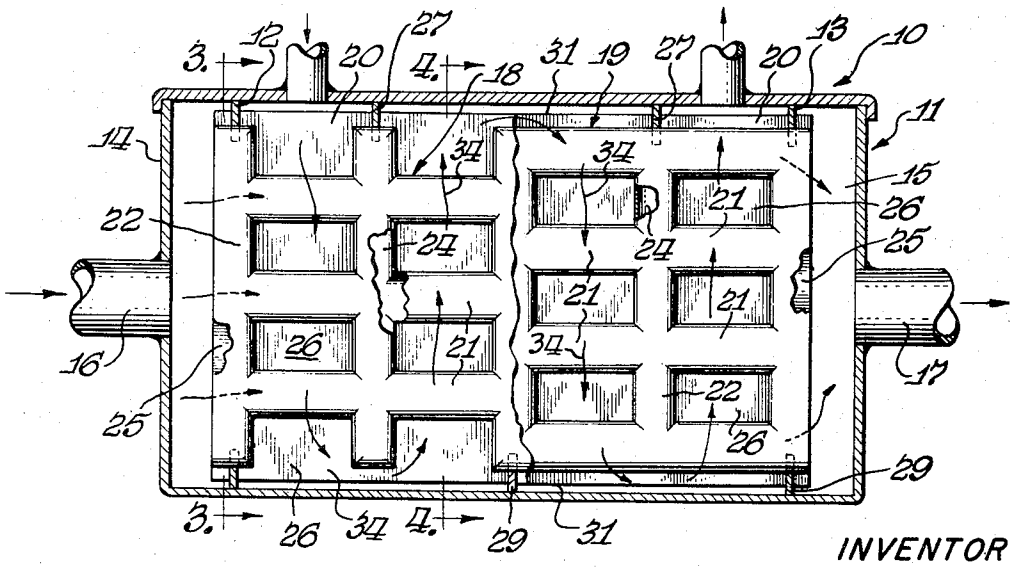



FIG. 2




INVENTOR
FRANK W. PERSON
Paul O. Pippel
ATTORNEY

March 10, 1959 F. W. PERSON 2,877,000

HEAT EXCHANGER

Filed Sept. 16, 1955 6 Sheets-Sheet 2

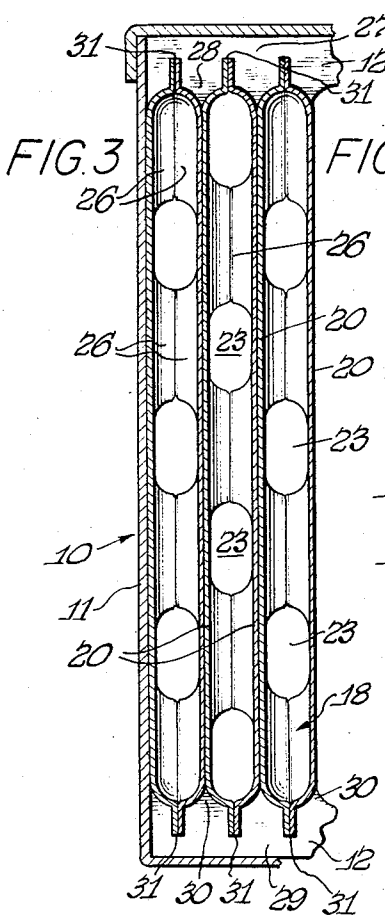


FIG. 3

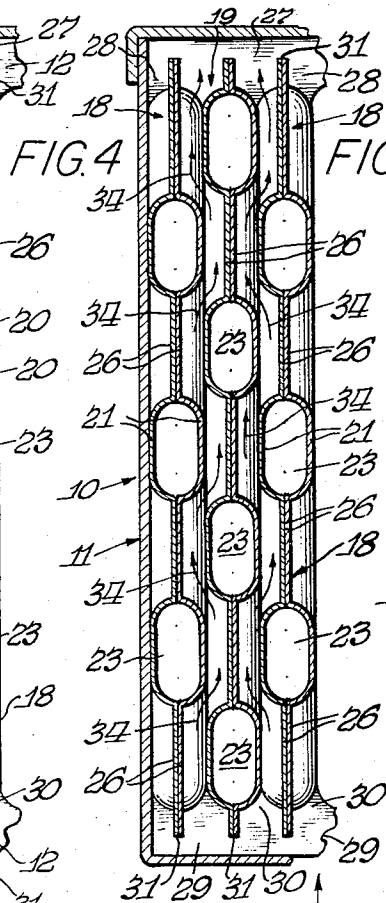


FIG. 4

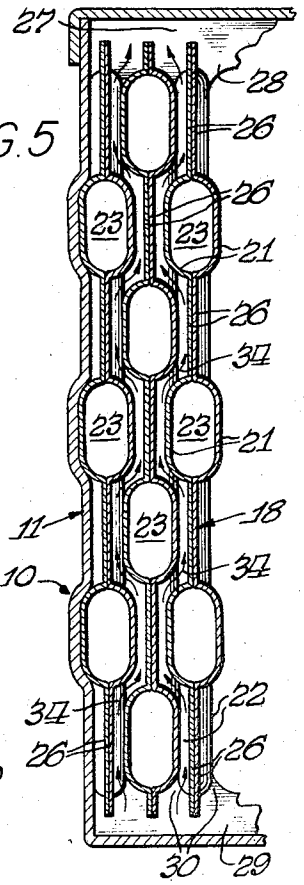
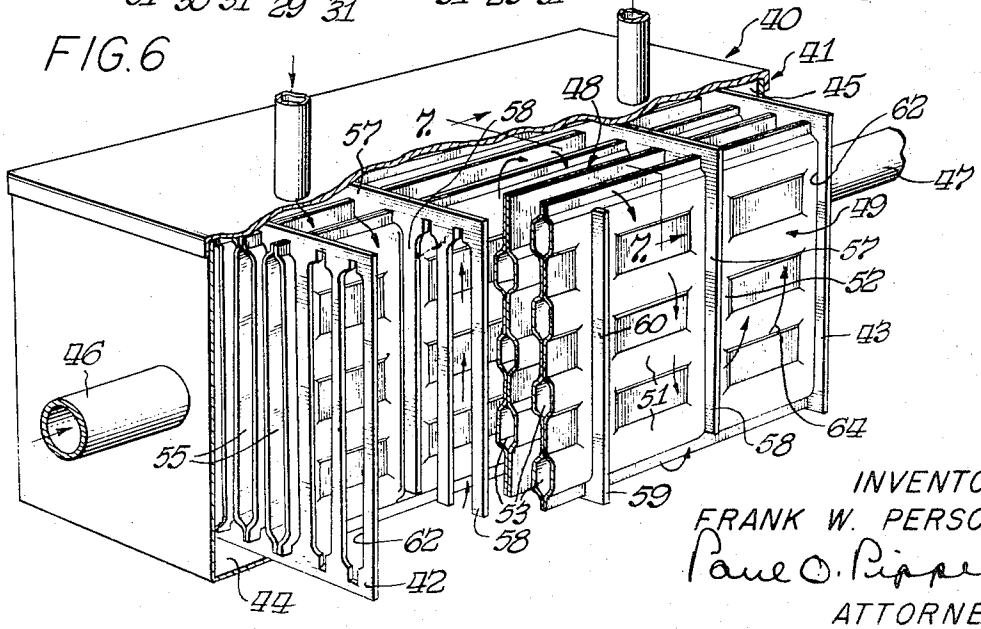


FIG. 5

FIG. 6



INVENTOR
FRANK W. PERSON
Paul O. Pippel
ATTORNEY

March 10, 1959 F. W. PERSON 2,877,000

HEAT EXCHANGER

Filed Sept. 16, 1955 6 Sheets-Sheet 3

FIG. 7

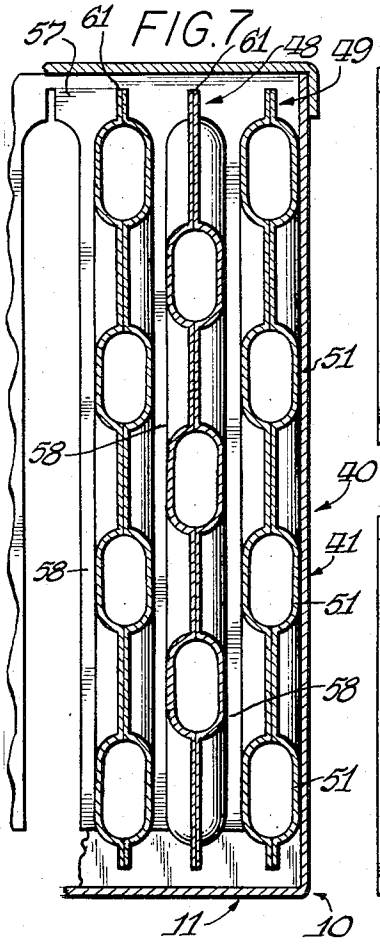



FIG. 8

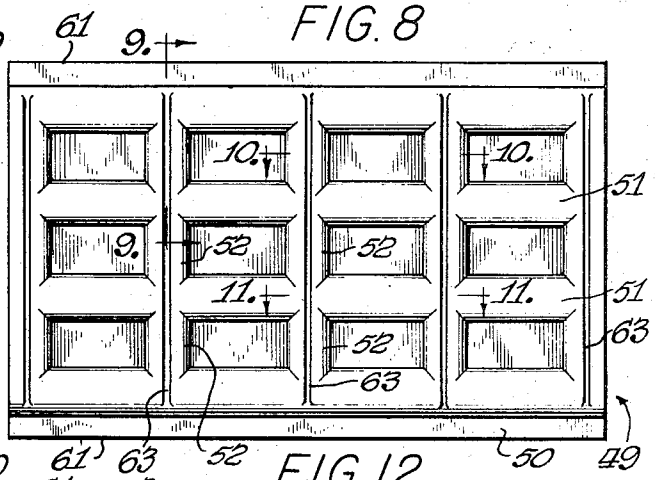



FIG. 12

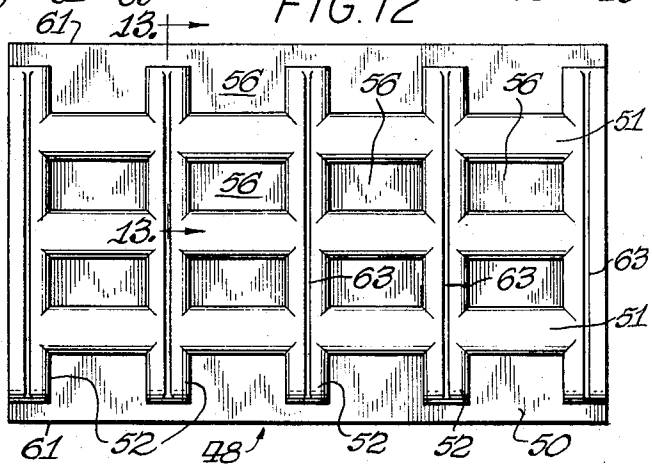



FIG. 9

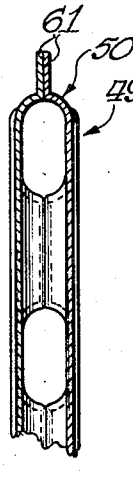



FIG. 13

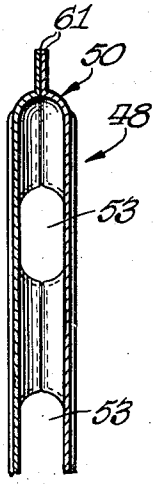



FIG. 10

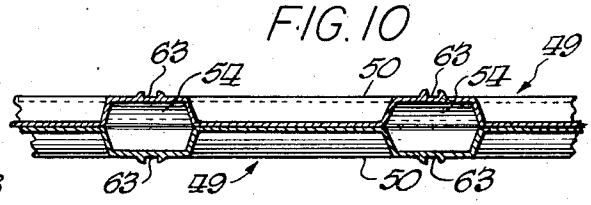
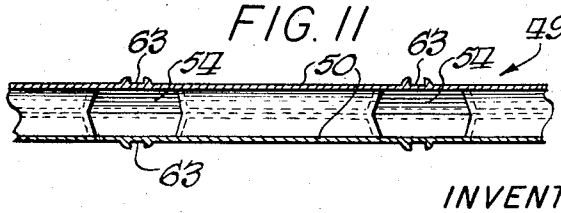



FIG. 11




INVENTOR
FRANK W. PERSON
Paul O. Pippel
ATTORNEY

March 10, 1959 F. W. PERSON 2,877,000

HEAT EXCHANGER

Filed Sept. 16, 1955 6 Sheets-Sheet 4

FIG. 14

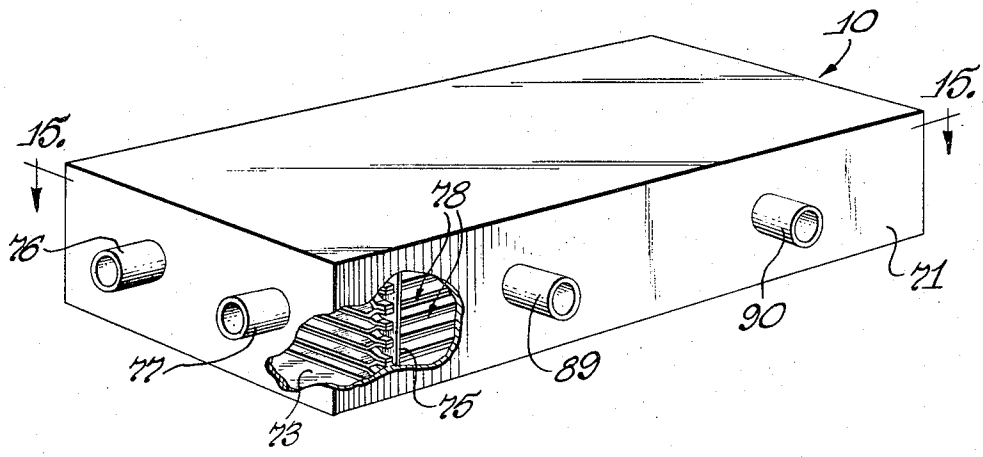



FIG. 15

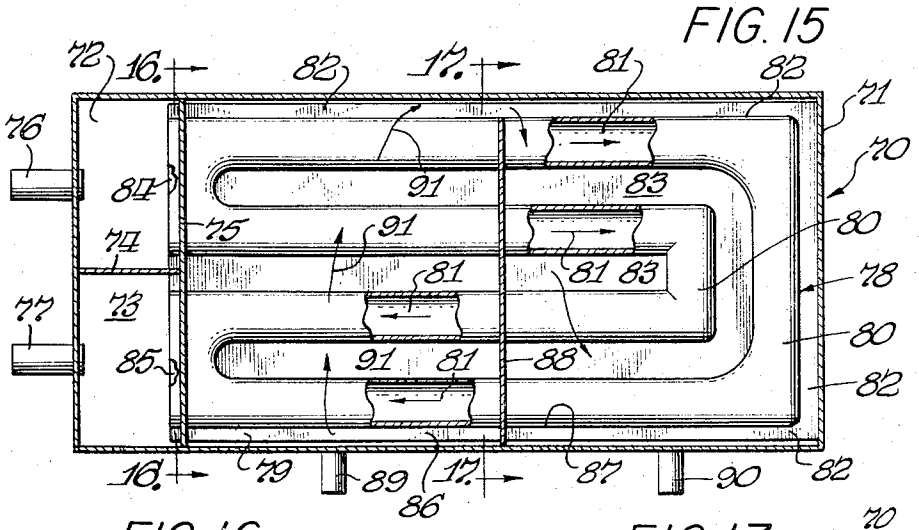



FIG. 16

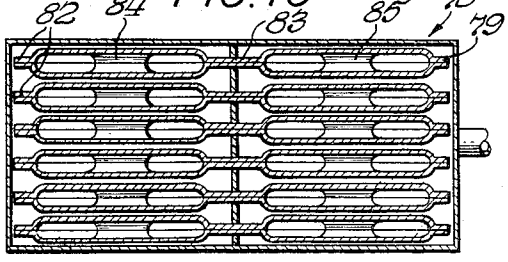
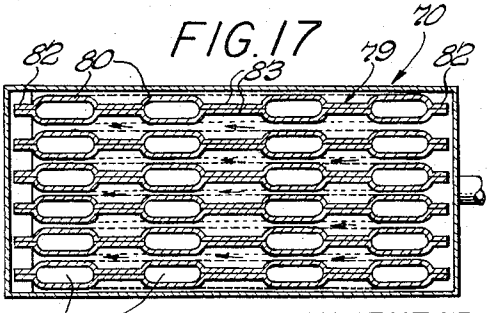



FIG. 17




INVENTOR
FRANK W. PERSON
Paul O. Pippel
ATTORNEY

March 10, 1959 F. W. PERSON 2,877,000

HEAT EXCHANGER

Filed Sept. 16, 1955 6 Sheets-Sheet 5

FIG. 18

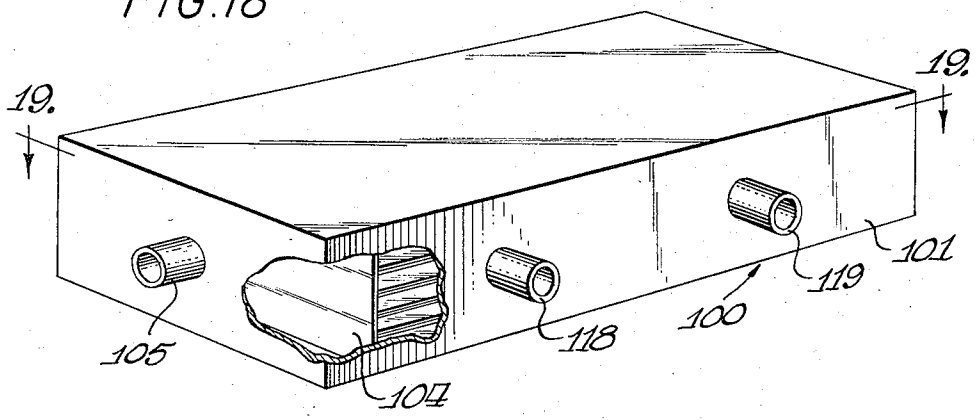



FIG. 19

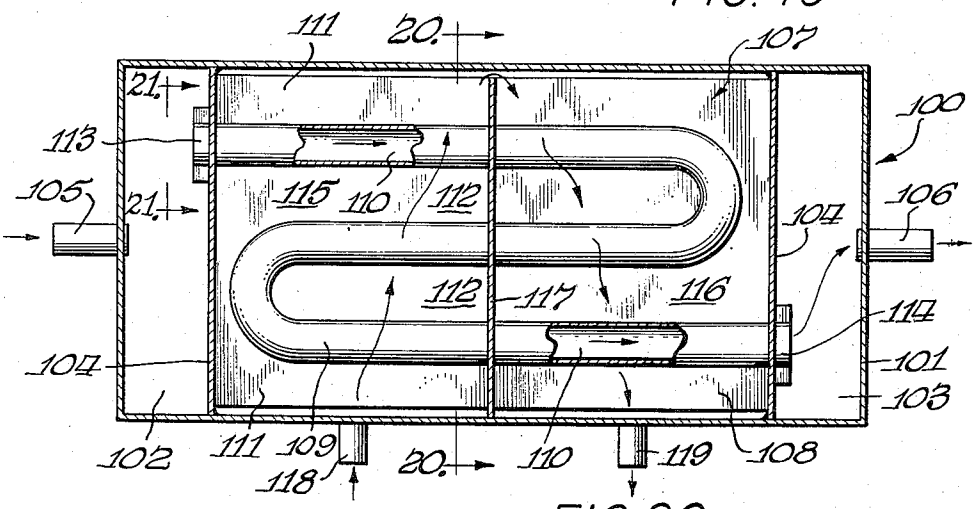



FIG. 21

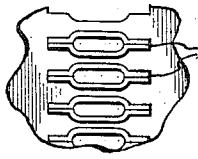
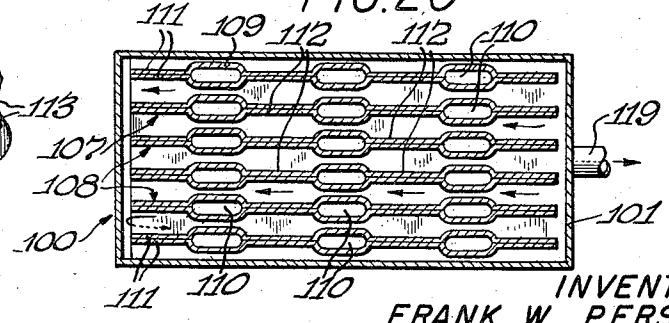



FIG. 20




INVENTOR
FRANK W. PERSON
Paul O. Pippel
ATTORNEY

March 10, 1959 F. W. PERSON 2,877,000

HEAT EXCHANGER

Filed Sept. 16, 1955 6 Sheets-Sheet 6

FIG. 22

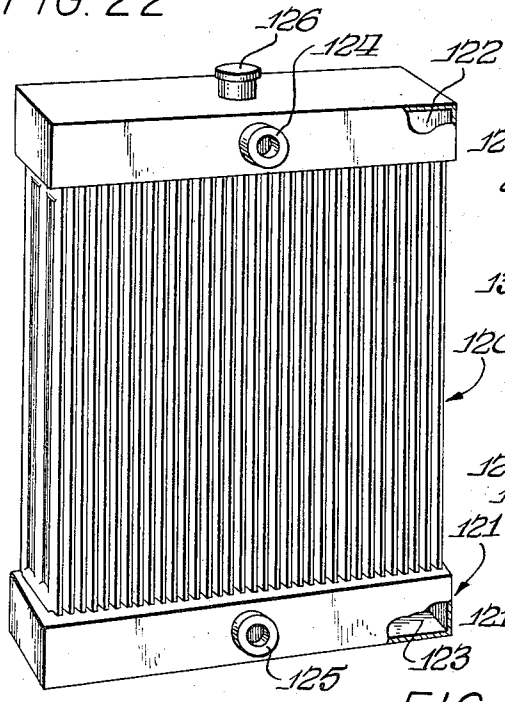



FIG. 24

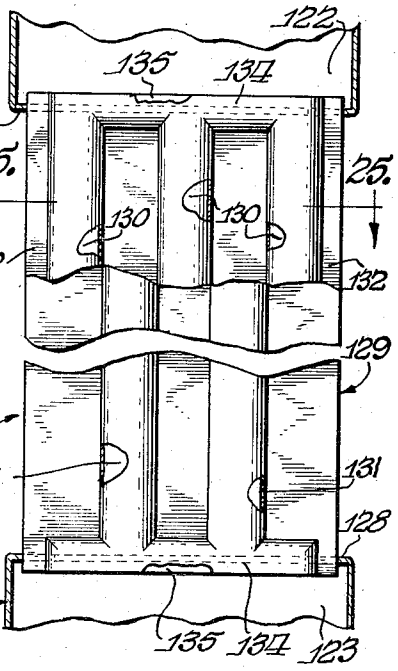
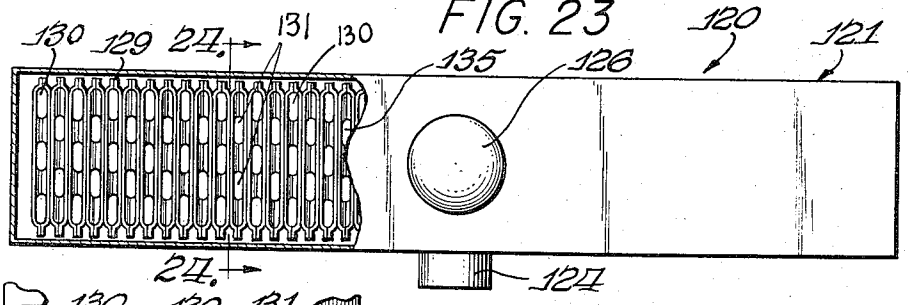



FIG. 23



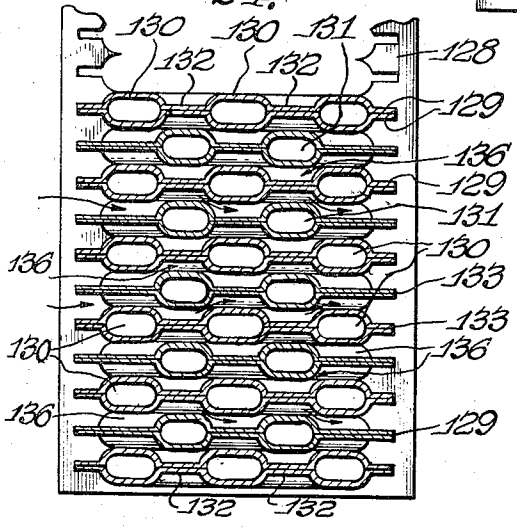




FIG. 25

INVENTOR
FRANK W. PERSON
Paul O. Pippel
ATTORNEY

United States Patent Office 2,877,000
Patented Mar. 10, 1959



2,877,000

# HEAT EXCHANGER

Frank W. Person, Downers Grove, Ill., assignor to International Harvester Company, a corporation of New Jersey

Application September 16, 1955, Serial No. 534,791

7 Claims. (Cl. 257—245)

This invention pertains to an improvement in heat exchangers.

Conventional heat exchangers usually comprise a pair of spaced headers or chambers suitably connected by a plurality of individual tubes. The tubes in turn extend through a plurality of perforations or holes provided in relatively thin laterally spaced fins. The manufacture of the individual fins, the tubes, and their subsequent assembly into a suitable heat exchanger core is a relatively costly operation and though numerous machines and assembly techniques have been devised, heat exchanger cores are still relatively costly to manufacture. In the development of the welding art, a welding process has been devised which permits the relatively cheap manufacture of metal envelopes or members having as a necessary part of their construction a plurality of tubular channels. This process is performed under various trade names but generally it can be called a "recrystallization" process. In the performance of the process a flat sheet, generally of aluminum or copper, has applied thereto a parting agent or organic compound. This parting agent may be applied to the sheet in printed form, the pattern of the said printing being the desired layout of the particular passages which are intended in the final product. A second sheet is then placed on top of the first-named sheet and both sheets are then subjected to a cold welding process. Such a cold welding process involves the use of pressure against the sheets and if necessary a low degree of heat may be employed during the application of said pressure. As the pressure is applied, a recrystallization of the contiguous sheets occurs thereby welding the said sheets together in all of the places except at the spots where the parting agent has been applied to the original sheet. Thus a suitable envelope results, certain contiguous portions of the envelope, however, not being welded together in view of the action of the parting agent or organic compound which has been used. The envelope is then subjected to either hydraulic or pneumatic pressure. In other words, the spaces which are not welded together are connected to a source of hydraulic pressure and they are literally blown up causing the envelopes to have a pluralitp of elongated bead-like projections which form the passages desired in the final product.

It has been found that this process is very inexpensive in manufacturing evaporator coils for refrigeration equipment. The so-called fins and tubular passages are thus integrally formed to provide an effective evaporator coil. It is a prime object of this invention, therefore, to provide an improved heat exchanger having a plurality of heat transfer members with the passages and fins integrally formed and so disposed as to provide a more efficient construction which will also permit the application of the above mentioned process or similar processes in its manufacture.

A still further object is to provide an improved heat exchanger consisting of a plurality of panels disposed in heat exchange relation to provide a circuitous passage for the flow of fluid therebetween.



A still further object is to provide an improved heat exchanger wherein the heat transfer members comprise a plurality of spaced envelopes which can easily be assembled with the unit or disassembled for maintenance purposes.

A still further object is to provide an improved heat exchanger for oil coolers or radiators, the heat exchanger or transfer unit comprising a plurality of individual panels adapted to be disposed in a position to secure maximum heat transfer efficiency.

These and other objects will become more readily apparent from a reading of the specification when examined in connection with the accompanying sheets of drawings.

Figure 1 is a perspective view, with a portion broken away, of a heat exchanger of a type generally utilized in connection with the cooling of liquids such as oil;

Figure 2 is a cross sectional view through the heat exchanger shown in Figure 1, the view being taken along the line 2—2;

Figure 3 is an enlarged cross sectional view taken substantially along the line 3—3 of Figure 2;

Figure 4 is a cross sectional view taken substantially along the line 4—4 of Figure 2;

Figure 5 is a view similar to Figures 3 and 4 showing a modified disposal of certain heat exchange members shown in Figures 1 through 4;

Figure 6 is a perspective view, with portions broken away to show the interior of the unit, the said unit comprising a heat exchanger of a type generally utilized in connection with the cooling of liquids;

Figure 7 is an enlarged sectional view taken substantially along the line 7—7 of Figure 6;

Figure 8 is a side elevational view of a heat transfer member or envelope of a type used in connection with the heat exchanger shown in Figure 6;

Figure 9 is a detailed view taken along the line 9—9 of Figure 8;

Figure 10 is a cross sectional view taken substantially along the line 10—10 of Figure 8;

Figure 11 is a cross sectional view, in enlarged form, taken substantially along the line 11—11 of Figure 8;

Figure 12 is an elevational view, similar to Figure 8, of another form of an envelope or heat exchange member;

Figure 13 is a cross sectional view enlarged and taken substantially along the line 13—13 of Figure 12;

Figure 14 is a perspective view of another modified type of heat exchanger, the said view having portions broken away to show certain interior portions of the unit;

Figure 15 is a cross sectional view taken along the line 15—15 of Figure 14;

Figure 16 is a cross sectional view, showing the disposition of a plurality of heat transfer members, the said view being taken along the line 16—16 of Figure 15;

Figure 17 is a view similar to Figure 16, the said view being taken substantially along the line 17—17 of Figure 15;

Figure 18 is a perspective view of another modified type of heat exchange unit, the said view having portions broken away to show an interior portion of the invention;

Figure 19 is a cross sectional view taken along the line 19—19 of Figure 18;

Figure 20 is a cross sectional view, showing the disposition of a plurality of heat transfer members, the said view being taken substantially along the line 20—20 of Figure 19;

Figure 21 is a detailed view taken substantially along the line 21—21 of Figure 19;

Figure 22 is a perspective view of a heat exchanger of a radiator type;

Figure 23 is an enlarged plan view of the radiator

shown in Figure 22, the said view having certain portions broken away;

Figure 24 is a cross sectional view taken substantially along the line 24—24 of Figure 23; and

Figure 25 is a sectional view, showing the disposition of a plurality of heat transfer members, the view being taken substantially along the line 25—25 of Figure 24.

Referring now particularly to Figures 1 through 4, a heat exchanger, suitable for the cooling of fluids, is generally designated by the reference character **10**. The heat exchanger **10** comprises a housing or casing **11** having a front baffle or wall **12** and a rear baffle or wall **13** providing an inlet chamber **14** and an outlet chamber **15**. The chambers **14** and **15** also may be respectively considered as inlet headers and outlet headers. An inlet conduit or connection **16**, provided on the casing **11**, is in communication with the inlet chamber **14**. In similar fashion an outlet conduit or connection **17** is in communication with the outlet chamber **15**.

A plurality of heat transfer members or envelopes are designated at **18** and **19**. Each of the envelopes **18** and **19** is formed of a pair of sheet metal members **20** which are positioned in contiguous relation. The sheet metal members **20** may be of aluminum or copper, or similar non-corrosive material. Each of the sheet metal members **20** is provided with a plurality of horizontal arcuate projections **21**, the said projections also being described as of elongated bead-like construction. Each sheet metal member further comprises a plurality of vertically disposed arcuate or bead-like projections **22** as best shown in Figure 2. The bead-like projections **21** are disposed in relatively complemental relation to provide a plurality of horizontally extending passages **23** and the vertical bead-like projections **22** are also positioned in complemental relation to provide a plurality of vertically extending passages **24**. The arrangement of the passages **23** and **24** is different in each of the members **18** and **19**, this difference also being well shown in Figures 3 and 4. Each of the envelopes **18** and **19** is also provided with vertical end passages **25** communicating with the horizontal passages **23** and vertical passages **24** and also providing for communication between the chambers **14** and **15**.

The transfer members **18** and **19** may be easily and suitably made by the process described above. When manufactured by such a process the members **18** and **19** are provided with a plurality of contiguous flat or bonded portions **26** which are disposed between the horizontal and vertical passages **23** and **24**, as indicated.

The heat transfer members **18** and **19** are positioned in vertical laterally spaced relation as best shown in Figures 2 and 3. Each vertical end passage **25** communicates with either the chamber **14** or **15**. The front baffles **12** and rear baffles **13** are suitably slotted to accommodate the members **18** and **19** and to retain the same in the said position. A plurality of intermediate upper baffles **27**, as best shown in Figure 2, are provided within the casing **11**. Each of the upper baffles is provided with suitably slotted portions **28** to accommodate the transfer members **18** and **19** and to suitably position the same within the casing. Likewise, the lower portion of the casing is provided with an intermediate lower baffle **29** also having suitably slotted portions **30** adapted to engage and maintain the transfer members **18** and **19** in suitably positioned relation. Each of the transfer members **18** and **19** is provided with horizontally extending oppositely disposed marginal edge portions **31**, these edge portions being suitably disposed in the slotted portions **28** and **30**.

The casing **11** is also provided with an inlet connection **32** and an outlet connection **33**, as best shown in Figures 1 and 2. Fluid may be directed through the inlet connection **32**, the same being circulated in the manner indicated by the arrows in a circuitous manner and being exhausted through the outlet connection **33**. The reference character **34**, applied to the arrows, shows in effect a circuitous passage for the flow of the fluid which is directed to the inlet connection **32**. As shown in Figure 4, this circuitous passage provided between the envelopes or transfer members permits the flow of fluid in such a circuitous manner that it sweeps across the bead-like projections and causes a high maximum of heat transfer. For instance, the connection **16** may be connected to the crank case of an engine so that hot oil flows through the passages **23** and **24** and out through the outlet **17**. As it flows through these passages, cooling fluid such as water, etc. may be directed into the casing **11**, the said fluid flowing in a circuitous and serpentine manner throughout the circuitous passages for effectively and efficiently cooling the oil which is coursing through the passages **23** and **24**.

The contiguous flat or bonded portions **26** also serve in the manner of fins to permit heat transfer as the cooling liquid sweeps through the circuitous arrangement of the bead-like projections. Thus a maximum heat transfer efficiency is effected. It can readily be seen that the lateral spacing of the transfer members **18** and **19** may be varied depending on the particular construction desired. Similarly, the bead-like projections can be staggered in different arrangements to secure maximum heat transfer efficiency. For instance, Figure 5 shows a variation in the design of the sheet metal members **20**. Since the elements are essentially the same as in Figures 1 through 4, the same reference characters are applied. In this particular case the vertical bead-like projections **22** are of more shallow depth than these above described. It is apparent in this modification that the outer surfaces of the vertical projections **22** are disposed inwardly of the outer surfaces of the bead-like projections **21**. Thus by placing the transfer members **18** and **19** as shown in Figure 5, a nesting of the staggered horizontal bead-like projections is possible to provide a greater number of the metal members in each heat exchanger and to decrease the size of the circuitous passages designated by the reference character **34** which is directed against the arrow showing the fluid flow. As indicated, the outer wall of the casing **11** may also be escalloped or formed to accommodate the change in shape of the sheet metal members **20** and **21**.

Referring now to Figures 6 through 13 a somewhat modified heat exchanger, designated by the reference character **40**, is disclosed. The heat exchanger **40** comprises a casing **41** having front baffles or walls **42** and rear baffles or walls **43**. The baffles **42** and **43** provide an inlet chamber or header **44** and an outlet chamber or header **45**. An inlet conduit or connection **46** is in communication with the inlet chamber **44** and an outlet connection **47** is in communication with the outlet chamber **45**.

As indicated in Figure 6, a plurality of envelopes or heat transfer members **48** and **49** are positioned in upright laterally spaced relation within the casing **41**. Each transfer member **48** and **49** comprises a pair of sheet metal members **50**, each of said members **50** being provided with a plurality of horizontal arcuate or bead-like projections **51** and a plurality of vertical arcuate or bead-like projections **52**. The transfer members **48** and **49** are similar to the ones above described and may be made with the same process above disclosed. The bead-like projections **51** of each member **50** are disposed in complemental relation to provide a plurality of horizontal passages **53**. Similarly, the vertical projections are disposed in complemental relation to purovide a plurality of vertical passages **54**. Opposite ends of each transfer member **48** are also provided with vertical end passages **55** in communication with the horizontal and vertical passages **53** and **54**, respectively. Only one of the vertical end passages **55** of each transfer member is shown in Figure 6 though it is apparent that each transfer member has opposite ver-

tical end passages 55 in communication with either of the chambers 44 and 45.

Each of the sheet metal members 50 is also provided with a plurality of relatively flat contiguous portions 56 disposed between the projections. As best shown in Figure 6, the casing also includes a plurality of intermediate upper baffles 57 of comb-shaped construction having fingers or teeth 58. Similarly, an intermediate lower baffle 59 is provided, the same also having a plurality of spaced teeth 60. Each of the sheet metal members has the contiguous flat portions 56 suitably bonded by welding as indicated in the above mentioned process or by other suitable bonding means. Furthermore, marginal edge portions 61 disposed on opposite sides of the members 48 and 49 are also suitably bonded together. By referring to Figure 6 it will be noted that the baffle 42 is slotted, as indicated at 62, to accommodate the ends of the transfer members 48 and 49. The wall or baffle 43 is similarly slotted.

As best shown in Figures 8 through 13, each of the transfer members 48 and 49 is provided with a plurality of vertical grooves 63 which are recessed in the surfaces of the vertical projections 52. When the envelopes 48 and 49 are positioned in the casing, as shown in Figures 6 and 7, the teeth 58 and 60 respectively, of the members 57 and 59, engage the said grooves 63, thus suitably maintaining the members 48 and 49 in suitable lateral spacing. Furthermore, the teeth serve to act as baffles so as to direct the flow of liquid which courses into the casing in a circuitous manner between the projections and in a serpentine direction as indicated by the arrows. As indicated by the arrows, the passage thus provided by the baffles is relatively circuitous or serpentine as designated by the reference character 64 which is directed to the arrows showing the course of liquid.

Referring now to Figures 14 through 17, another modified embodiment of the invention is disclosed. In these figures a heat exchanger 70 comprises a casing 71 having an inlet header or chamber 72 and an outlet header or chamber 73. As best shown in Figure 15 a baffle 74 and a wall 75 suitably separate said chambers. An inlet connection 76 is connected to the casing for communication with the chamber 72 and an outlet connection 77 communicates with the chamber 73.

As best shown in Figures 16 and 17, a plurality of heat transfer members or envelopes 78 are positioned within the casing 71. Each transfer member 78 consists of a pair of relatively thin sheet metal members 79, each of said members having a plurality of longitudinally extending bead-like projections, the said projections being positioned in complementary relation to provide a pair of generally U-shaped passages 81. The members 78 also comprise a plurality of marginal connected edge portions 82 and between the passages 81 a plurality of flat contiguous portions are provided on each of the members 78. As indicated by the "recrystallization" welding process above, the marginal contiguous edge portions may be suitably welded together to provide a fairly rigid structure with the passages provided therein. The heat transfer members 78 are positioned so that an opening 84, communicating with the passages 81, is positioned within the chamber 72. Likewise, an opening 85 also in communication with the passages 81 is positioned in the outlet chamber 73.

Within the casing 71 there is provided also an inlet chamber 86 and an outlet chamber 87 separated partially by means of a partition wall 88. As best shown in Figures 16 and 17, the bead-like projections of the transfer members 78 are positioned in spaced relation to provide for the passage of fluid or liquid therebetween. An inlet connection 89 communicates with the chamber 86 and an outlet connection 90 provides for the exhaust of liquid from the chamber 87. The circuitous passages provided by the adjacent transfer members are generally indicated by the reference character 91 which is directed toward the arrows showing the particular path of the liquid between said transfer members. Thus here, like in the constructions above disclosed, the sheet metal members which provide for the transfer of heat are made simply in panel form by the process described. Thus liquid flowing through the passages 81 can efficiently be subjected to heat transfer by the flow of fluid through the various circuitous passages provided by the heat transfer members. Again it is, of course, obvious that variations in the arrangement of the bead-like projections may be made so as in effect to stagger them or to place them in cruciform relation as shown in the embodiments above disclosed.

Reference is now had to Figures 18 through 21, wherein a heat exchanger 100 includes a casing 101 provided with laterally spaced headers or chambers 102 and 103. Walls 104 separate the chambers 102 and 103, the first of which is an inlet chamber and the second being an outlet chamber. An inlet connection 105 is in communication with the chamber 102 and an outlet connection 106 is in communication with the chamber 103.

As best shown in Figure 20, a plurality of heat transfer members or envelopes 107 are positioned horizontally and in vertically spaced relation. Each transfer member 107 is made of a relatively thin sheet metal material having a plurality of bead-like projections 109 positioned in serpentine relation to provide a passage 110. The sheet metal transfer members 107 include oppositely disposed connected marginal edge portions 111 and relatively flat contiguous portions 112 disposed between the passages 110. One end of the passage 110 opens as indicated at 113 into the inlet chamber 102 and the other end of the passage 110 opens as indicated at 114 into the outlet chamber 103.

Within the casing 101 an inlet chamber is designated at 115 and an outlet chamber at 116. The chambers 115 and 116 are separated by a partition wall 117. The partition wall 117 is spaced from one wall of the casing to permit the flow of liquid from the inlet chamber 115 to the outlet chamber 116. Thus it appears clear that fluid flowing into the chamber 115 flows in a circuitous path, as indicated by the arrow, over the projections and over the flat contiguous portions to effectively cool liquid flowing within the passages 110. The circuitous flow is, of course, occasioned by the positioning of the bead-like projections and these, of course, can be positioned in a number of various arrangements to provide different types of directed flow.

Figures 22 through 25 show a further modified embodiment of the invention. Herein a heat exchanger is designated by the reference character 120, the said exchanger being of the radiator type. The exchanger 120 comprises a casing 121 having upper and lower headers or chambers 122 and 123. An inlet connection 124 directs liquid to the inlet header 122 and an outlet connection 125 discharges liquid from the header 123. A radiator supply connection is indicated at 126.

The header 122 is provided with a lower wall 127 and the header 123 is provided with an upper wall 128. A plurality of heat transfer members or envelopes 129 are positioned in upright relation and relatively laterally spaced. The lower and upper walls 127 and 128 are suitably slotted to permit the ends of the transfer members 129 to be disposed in the headers 122 and 123. Each envelope or transfer member is comprised of a pair of relatively thin metal sheets, each of said sheets having bead-like projections which are disposed in complementary relation to provide a plurality of vertically extending passages 130 and 131. Here again the transfer members 129 may be made with a cold welding or "recrystallization" process as above described. Each transfer member comprises a plurality of flat contiguous portions 132 which are suitably bonded together. Likewise, opposite marginal edge portions 133 are suitably bonded together so that each transfer member is relatively rigid,

having the passages **130** and **131** disposed therein. As indicated in Figure 24, each of the relatively thin members of the transfer members **129** is also provided with a transversely extending bead **134**, the said beads being disposed in complemental relation to provide open end passages on opposite sides of the transfer members, the said passages **135** providing communication between the passages **130** and **131**. An upper transfer passage of each transfer member is disposed within the header **122** and the lower transfer passage **135** of each transfer member is disposed in the lower header **123**.

As indicated in Figure 25, the passages **130** and **131** are positioned in relatively staggered relation so as to provide a plurality of circuitous passages through which air may flow when the radiator is utilized as a heat exchanger. By staggering the bead-like projections in the manner disclosed, the passages **130** and **131** are staggered and air flow through said passages is of circuitous direction to effectively create a maximum efficiency heat exchange effect on the passages **130** and **131** and the liquid which is contained within the passages to be cooled. It is, of course, obvious again that various different staggered arrangements can be made, the most effective being, of course, the circuitous arrangement whereby the air sweeps all surfaces of the heat transfer member to effectively secure heat exchange efficiency.

Thus it is believed clear that various types of heat exchangers have been disclosed, each of said heat exchangers having novel type heat transfer members which may be manufactured by the simple process described. Maintenance of a heat exchanger of this type is relatively simple since all that need be done, if a transfer member is defective, is to remove the same and replace it with a new transfer member. The transfer members may thus be efficiently and cheaply manufactured and various staggered patterns of the bead-like projections may be utilized to secure the relatively circuitous passages which are disclosed. In assembly the units, of course, are solder dipped in the conventional manner to secure sealing relation of the passages and the chambers as required.

Thus it is believed that the objects of the invention have been fully achieved and that an improved heat exchanger and modifications thereof have been fully disclosed. Further modifications may, of course, be made which do not depart from the spirit of the invention as disclosed nor the scope thereof as defined in the appended claims.

What is claimed is:

1. A heat exchanger comprising a housing having spaced first chambers and a second chamber disposed adjacent said first chambers, a plurality of transfer elements disposed in said second chamber, each element comprising a relatively thin member having contiguous flat portions connected together and elongated raised portions positioned in complementary relation to provide a plurality of passages extending horizontally and vertically in cruciform relation, said passages communicating with said first chambers, the horizontal passages of one element being positioned relative to the horizontal passages of an adjacent element in staggered relation with the raised portions of one element being disposed opposite to the flat portions of an adjacent element to provide a plurality of circuitous passages within the second chamber, a plurality of partitions within said second chamber, each of said elements having a plurality of vertically extending slots disposed on opposite sides of said elements in alignment with the vertical passages, each of said partitions being of comb-shape and having a plurality of teeth engaging said slots to divide said second chamber into a plurality of sub-chambers whereby fluid flowing through said circuitous passages will move through said sub-chambers in meandering fashion.

2. A heat exchanger comprising a housing having spaced first chambers and a second chamber disposed adjacent said first chambers, a plurality of transfer elements disposed in said second chamber, each element comprising a relatively thin metal sheet member having contiguous flat portions connected together and elongated raised portions positioned in complementary relation to provide a plurality of passages extending horizontally and vertically in cruciform relation, said passages communicating with said first chambers, the horizontal passages of one element being positioned relative to the horizontal passages of an adjacent element in staggered relation with the raised portion of one element being disposed in opposite relation with respect to the flat portions of an adjacent element, to provide a plurality of second circuitous passages within said second chamber, a plurality of partitions within said second chamber, each of said elements having a plurality of vertically extending slots disposed on opposite sides of said elements, each of said partitions being of comb-shape and having a plurality of teeth engaging said slots to divide said second chamber into a plurality of subchambers whereby fluid flowing through said circuitous passages will move through said sub-chambers in meandering fashion.

3. A heat exchanger comprising a housing having spaced first chambers and a second chamber disposed adjacent said first chambers, a plurality of transfer elements disposed in said second chamber, each element comprising a relatively thin metal sheet member having contiguous flat portions connected together and elongated raised portions positioned in complementary relation to provide a plurality of passages extending horizontally and vertically in cruciform relation, said passages communicating with said first chambers, certain passages of one element being positioned relative to certain passages of an adjacent element in staggered relation, to provide a plurality of second circuitous passages within said second chamber, a plurality of partitions within said second chamber, each of said elements having a plurality of vertically extending slots disposed on opposite sides of said elements, each of said partitions being of comb-shape and having a plurality of teeth engaging said slots to divide said second chamber into a plurality of sub-chambers whereby fluid flowing through said circuitous passages will move through said sub-chambers in meandering fashion.

4. A heat exchanger comprising a housing having spaced first chambers and a second chamber disposed adjacent said first chambers, a plurality of transfer elements disposed in said second chamber, each element comprising a relatively thin member having contiguous flat portions connected together and elongated raised portions positioned in complementary relation to provide a plurality of passages communicating with said first chambers, certain passages of one element being positioned relative to certain passages of an adjacent element in staggered relation with the raised portions of one element being disposed adjacent to and opposite the flat portions of an adjacent element to provide a plurality of second circuitous passages within the chamber, a plurality of partitions within said second chamber, each of said elements having a plurality of vertically extending slots disposed on opposite sides of said elements, each of said partitions being of comb-shape and having a plurality of teeth engaging said slots to divide said second chamber into a plurality of sub-chambers whereby fluid flowing through said circuitous passages will move through said sub-chambers in meandering fashion.

5. A heat exchanger comprising a housing having spaced first chambers and a second chamber disposed adjacent said first chambers, a plurality of transfer elements disposed in said second chamber, each element comprising a relatively thin metal sheet member having contiguous flat portions connected together and elongated raised portions positioned to provide a plurality of passages communicating with said first chambers, the flat and raised portions of one element being offset with respect to the flat and raised portions of another element,

to provide a plurality of circuitous passages within said second chamber, a plurality of partitions within said second chamber, each of said elements having a plurality of vertically extending slots disposed on opposite sides of said elements, each of said partitions being of comb-shape and having a plurality of teeth engaging said slots to divide said second chamber into a plurality of sub-chambers whereby fluid flowing through said circuitous passages will move through said sub-chambers in meandering fashion.

6. A heat exchanger comprising a housing having spaced first chambers and a second chamber disposed adjacent said first chambers, a plurality of transfer elements disposed in said second chamber, each element comprising a relatively thin metal sheet member having contiguous flat portions connected together and elongated raised portions positioned to provide a plurality of passages communicating with said first chambers, the flat and raised portions of one element being offset with respect to the flat and raised portions of another element, to provide a plurality of circuitous passages within said second chamber, a plurality of partitions within said second chamber, each of said partitions being of comb-shape and having a plurality of teeth disposed between said elements to divide said second chamber into a plurality of sub-chambers whereby fluid flowing through said circuitous passages will move through said sub-chambers in meandering fashion.



7. A heat exchanger comprising a housing having spaced first chambers and a second chamber disposed adjacent said first chambers, a plurality of transfer elements disposed in said second chamber, each element comprising a relatively thin member having contiguous flat portions connected together and elongated raised portions to provide a plurality of passages communicating with said first chambers, the flat and raised portions of one element being offset with respect to the flat and raised portions of another element, to provide a plurality of circuitous passages within said second chamber, a plurality of partitions within said second chamber dividing said second chamber into a plurality of sub-chambers whereby fluid flowing through said circuitous passages will move through said sub-chambers in meandering fashion.

**References Cited in the file of this patent**

UNITED STATES PATENTS

| | | |
|---|---|---|
| 849,878 | Zivi | Apr. 9, 1907 |
| 2,029,083 | Prestage | Jan. 28, 1936 |
| 2,705,616 | Watson | Apr. 5, 1955 |