Dec. 14, 1948. W. M. SIMPSON 2,456,455

HEAT EXCHANGER

Filed Oct. 17, 1944 3 Sheets-Sheet 1

Fig. 1.

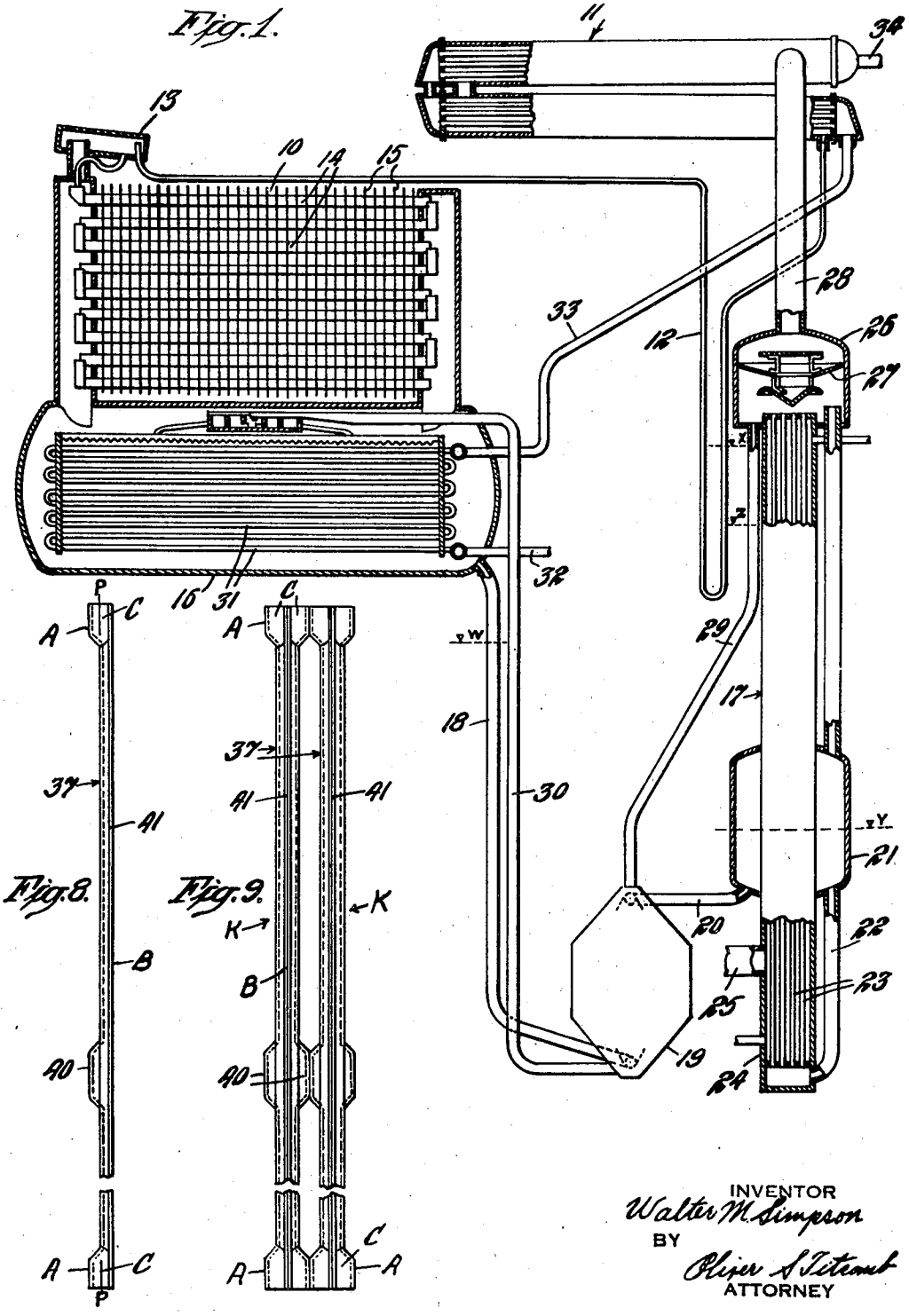


Fig. 8.

Fig. 9.

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Fig. 2.

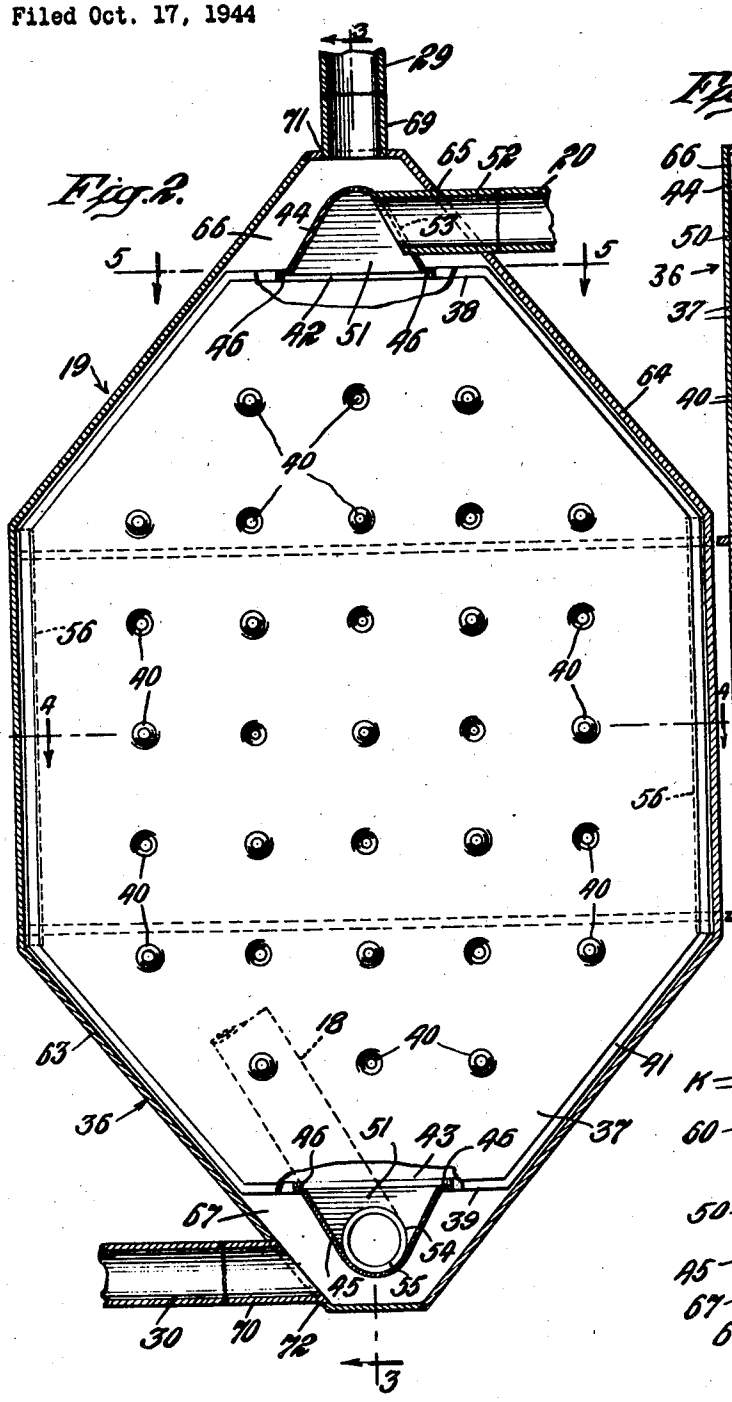
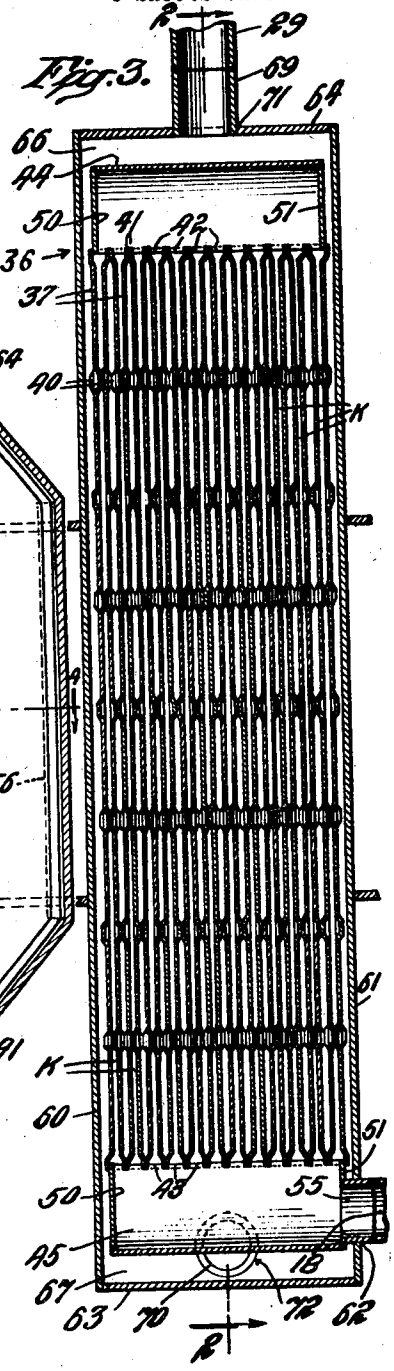


Fig. 3.



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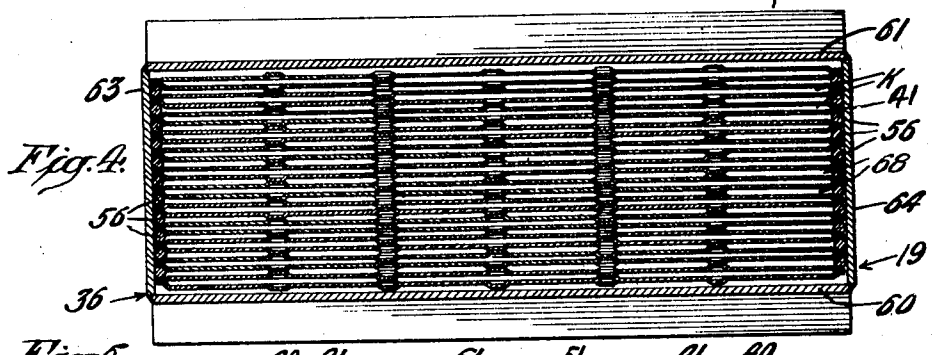


Fig. 4.

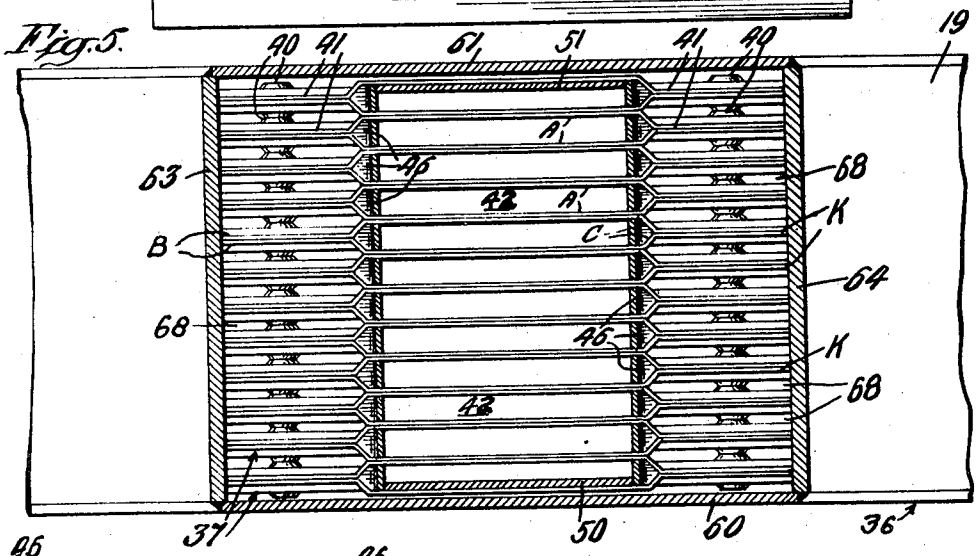


Fig. 5.

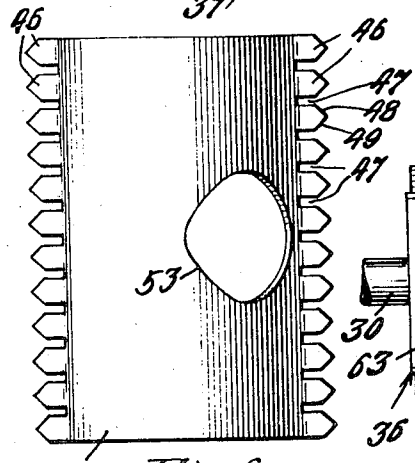


Fig. 6.

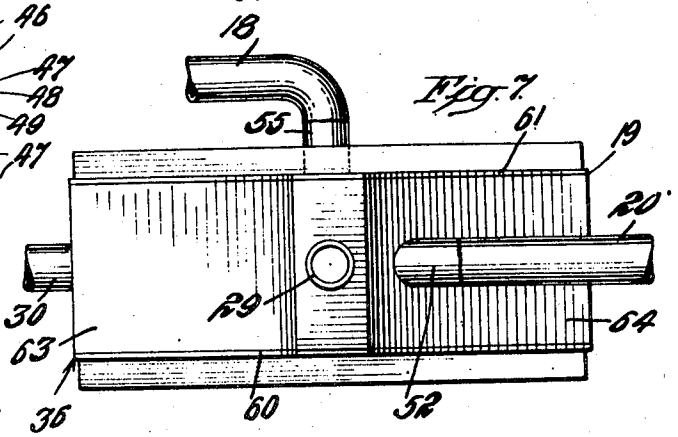


Fig. 7.

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UNITED STATES PATENT OFFICE

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HEAT EXCHANGER

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Application October 17, 1944, Serial No. 559,083

4 Claims. (Cl. 257—245)

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The present invention relates to liquid heat exchangers particularly adapted for use in absorption refrigeration systems and more particularly to the internal plate construction and the method of assembly.

It has heretofore been proposed to provide heat exchangers having a series of interconnected plates enclosed within a casing to form a series of adjacent passages constituting separate paths of flow. In such heat exchangers, one series of passages are connected together through openings in the sides of adjacent plates. This arrangement of the plates produces dead spaces or pockets between the openings and the periphery of the plates where there is no liquid flow. As a result, substantially no heat is transferred through the plates at the pockets or dead spaces, so that the heat exchanger must be made larger than necessary to produce the desired heat exchange. Also with such constructions, each successive plate must be welded to the next adjacent plate either at the periphery or around the openings in the plates to build up the structure. These welding operations must be performed manually with a torch which requires considerable time and a skilled operator. Furthermore the joints around the openings between adjacent plates must be welded on the inside before the next adjacent plate is assembled and these joints cannot be tested until the entire structure is completely assembled. Therefore, if a leak occurs in the joint between the openings of adjacent plates the entire assembly must be discarded.

One of the objects of the present invention is to provide a heat exchanger of the type indicated having the inlet and outlet openings of adjacent passages at the periphery of the heat transfer plates to facilitate welding and avoid dead spaces whereby to render the entire surface of the plates effective for heat transfer.

Another object is to provide a heat exchanger of the type indicated comprising a series of heat transfer plates of identical construction with adjacent plates arranged in reversed relationship.

Another object is to provide a method of assembling the heat transfer plates which facilities the operation by reducing the time required to a minimum, reducing the possibility of leakage and adapting the plates to be welded by machine.

Still another object of the invention is to provide a heat exchanger which is of simple and compact construction, economical to manufacture and one which is efficient in operation.

These and other objects will become more apparent from the following description and drawings in which like reference characters denote like parts throughout the several views. It is to be expressly understood, however, that the drawings are for the purpose of illustration only and not a definition of the limitations of the invention, reference being had for this purpose to the appended claims.

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In the drawings:

Fig. 1 is adiagrammatic view of an absorption refrigeration system incorporating the heat exchanger of the present invention;

Fig. 2 is an enlarged longitudinal sectional view through the heat exchanger showing the contour of the heat transfer plates and the headers connecting the passages between certain of the plates;

Fig. 3 is a sectional view taken in line 3—3 of Fig. 2 showing the arrangement of the plates to provide a series of separate passages through the heat exchanger;

Fig. 4 is a sectional plan view taken on line 4—4 of Fig. 2 showing the arrangement of the plates in the casing;

Fig. 5 is an enlarged sectional view taken on line 5—5 of Fig. 2 and showing the outwardly flaring offset relationship of the central portions of each pair of plates to provide openings therebetween;

Fig. 6 is a plan view of the header for connecting the series of inlet openings between the plates of adjacent pairs at one end thereof;

Fig. 7 is an enlarged plan view of the heat exchanger showing the construction of the casing;

Fig. 8 is an enlarged longitudinal view of one of the heat transfer plates showing the offset relationship of portions of the peripheral flange at opposite sides of its medial plane; and

Fig. 9 is an enlarged view of several pairs of adjacent plates showing the cooperating portions of the flanges for forming closed chambers having inlet and outlet peripheral openings at opposite ends.

The heat exchanger of the present invention is particularly adapted for use with absorption refrigeration systems and is shown applied to a system of the type illustrated and described in the United States Letters Patent No. 2,282,503, granted to Albert R. Thomas et al., on May 12, 1942, and entitled "Refrigeration." In a system of this type, liquid refrigerant such as, for example, water is introduced into the upper part of an evaporator or cooling element 10 from a condenser 11 through a path of flow including a U-shaped tube 12 and flash chamber 13. The liquid refrigerant evaporates in the evaporator

10 with consequent absorption of heat from the ambient fluid, such as a stream of air flowing over the exterior surface of the tubes 14 and fins 15 of the evaporator. The refrigerant vapor formed in the evaporator 10 flows to an absorber 16 in which the vapor is absorbed into a liquid absorbent such as, for example, a water solution of lithium chloride, lithium bromide, or the like.

The absorption liquid enriched with refrigerant is conducted from the absorber 16 to a generator 17 through a conduit 18, one of the paths of flow through the liquid heat exchanger 19 constituting the subject matter of the present invention, conduit 20, vessel 21 and conduit 22. The generator 17 comprises a plurality of riser tubes 23 enclosed within a shell 24 forming a chamber to which steam is supplied through a conduit 25 from a suitable source of supply. The heating of the riser tubes 23 by the steam causes refrigerant vapor to be expelled from the absorption solution and the expelled vapor is effective to raise the absorption liquid by gas or vapor lift action.

The expelled vapor passes from the upper ends of the riser tubes 23 into a vapor separating chamber 26 having suitable baffles 27 therein and thence flows through a conduit 28 to the condenser 11 where the vapor is liquefied. The liquid refrigerant formed in the condenser 11 flows by gravity into the U-shaped tube 12 to the upper part of the evaporator 10, as explained above, to complete the refrigeration cycle.

The raised absorption liquid from which refrigerant vapor has been expelled is conducted from the upper part of the generator 17 to the absorber 16 to absorb refrigerant vapor, this liquid being conducted to the absorber in a path of flow including a conduit 29, a second path of flow through the liquid heat exchanger 19 and conduit 30. The heat liberated by the absorption of refrigerant vapor in the absorber 16 is taken up by a cooling medium such as, for example, water which flows upwardly through vertically disposed banks of pipes 31 in the absorber. The cooling water is introduced into the lower ends of the banks of pipes through a conduit 32 and is discharged from the upper ends of the banks of pipes through a conduit 33. The conduit 33 is connected to the condenser 11, so that the cooling water also may be utilized to effect cooling of the condenser. The cooling water is discharged from the condenser 11 through a conduit 34.

The system operates in a partial vacuum with generator 17 and condenser 11 operating at one pressure and evaporator 10 and absorber 16 operating at a lower pressure. The pressure differential between the high and low pressure sides of the system is maintained by liquid columns in the up-leg of the U-shaped tube 12 between the condenser 11 and evaporator 10 and in the conduits 18 and 30 connecting the absorber 16 and heat exchanger 19. The liquid level in the U-shaped tube is indicated by the reference character X; the liquid levels in the conduit 18 and vessel 21 connected thereto through the heat exchanger 19 are indicated by the reference characters W and Y; and the liquid level in the conduit 29 connected to the conduit 30 through the heat exchanger 19 is indicated by the reference character Z.

In accordance with the present invention, the heat exchanger 19, illustrated in detail in Figs. 2 to 9, comprises a closed casing 36 and a series of heat transfer plates 37 in the casing forming adjacent passages constituting separate paths of flow therein. All of the plates 37 are of identical construction and of generally octagonal form with relatively short sides 38 and 39 at each end, see Fig. 2. Each plate has a series of laterally projecting bosses or buttons 40 pressed outwardly therefrom with the adjacent bosses projecting from opposite sides of the medial plane P of the plate, see Fig. 3. A flange 41 at the edge of the plate 37 extends around its entire periphery. As shown most clearly in Fig. 8, the end portions A of the flange 41 are offset laterally to one side of the medial plane P of the plate while the portions B of the flange are offset laterally from the opposite side of the medial plane. As shown in Fig. 5, the portions A of the flanges 41 are located centrally at the ends 38 and 39 of the plates and are connected to the portions B by intermediate portions C extending at an angle to and across the medial plane of the plates 37. It will be observed by reference to Figs. 8 and 9 of the drawings that the portions A and B of the flanges 41 are offset a distance equal to the offset of the bosses 40.

The construction of the heat exchanger 19 is best described by the method of assembling the parts. The first step of the method of assembly consists of arranging a pair of plates 37 in reverse relationship so that the portions B of the flanges 41 are in abutting relationship and the portions A of the flanges flare outwardly away from each other as shown most clearly in Fig. 9. It will be observed that the alternate projecting bosses 40 on the pair of plates 37 abut each other in the plane of the offset portions B of the flanges 37. The pair of plates 37 may be held in aligned relationship in a suitable fixture or the abutting bosses 40 of one pair may be spot welded to hold the plates in proper alinement. The abutting portions B of the flanges 37 are then welded together in any suitable manner. Preferably, the portions B of the flanges 37 are welded in an electric seam welding machine to facilitate the operation and reduce the time required.

When the flange portions B of a pair of plates 37 have been welded together, the assembled plates constitute a closed compartment K having inlet and outlet openings 43 and 42 between the flange portions A at opposite ends of the compartment. A number of similar compartments K are formed by welding the flange portions B of reversed pairs of plates 37. Because of the individual compartment construction, the welded joint between the flange portions B may be easily and quickly tested by inserting each compartment K into a suitable testing apparatus.

The next step of the method of assembly consists of arranging the desired number of compartments K in side by side relationship. Preferably the compartments are assembled in a suitable fixture to hold them in aligned relationship. The portions A of the flanges 41 of each compartment K then abut the corresponding flange portions A of adjacent compartments in the manner shown in Fig. 5 due to their offset relationship. Such abutting engagement of the flange portions A and the abutting engagement of the bosses 40 hold the series of compartments in spaced relationship. The abutting portions A of the flanges 41 of adjacent compartments K are then welded together to integrate all of the plates 37 into a single structure. This welding operation may be performed in a seam welding machine or may be performed manually with a gas torch.

After the plates 37 have been assembled in the manner described above the central openings 42 and 43 at opposite ends of the compartments K

are connected together by suitable headers 44 and 45. The header 44 is of generally channel-shaped form, see Fig. 2, and extends throughout the width of the assembled plates 37, see Fig. 3. As illustrated in Fig. 6, the side edges of the header 44 are flared laterally and serrated to provide a series of teeth 46 separated by slots 47. The end portions of the teeth 46 are beveled to provide sides 48 and 49 of a contour corresponding to the angular portions C of the flanges 41 at the ends of the openings 42 of the series of compartments K. Header 44 is suitably dimensioned so that it overlies the series of openings 42 with the teeth 46 fitting the ends of the openings, see Fig. 5, and the slots 47 permit adjacent teeth to straddle the flange portions A of adjacent compartments K. The teeth 46 are then welded to the portions A and C of the flanges 41 to seal the joints therebetween.

The ends of the header 44 are closed by end caps 50 and 51. The end caps 50 and 51 are positioned adjacent the portion A of the flanges 41 of the outermost plates 37 at each end of the assembled structure and the caps are welded to the edges of the header 44 and flange portions A, Figs. 3 and 5. An end of a pipe nipple 52 is then inserted into a circular opening 53 in the side of the header 44 and is welded thereto to seal the joint therebetween.

The header 45 at the lower end of the compartments K is assembled in the same way as the header 44 and is of identical construction with the header 44 except that it has an opening 54 in one of the end caps 51 instead of in the side thereof. A pipe nipple 55 is inserted in the opening 54 in the end cap 51 and welded thereto to seal the joint therebetween. Preferably, rods 56 are welded between the vertically extending edge portions of adjacent compartments K to strengthen the structure, see Fig. 4. The assembled structure as thus far described comprises a plurality of closed compartments K arranged in spaced relationship and connected at opposite ends by headers 44 and 45.

To complete the heat exchanger 19, casing side plates 60 and 61 are positioned at opposite sides of the compartment assembly. The plates 60 and 61 are of substantially the same contour as the heat transfer plates 37 but are of slightly larger dimensions and extend beyond the ends of the compartments K and headers 44 and 45. Side plate 61 is provided with a hole 62 which aligns with and receives the pipe nipple 55 projecting from the header 45. Edge plates 63 and 64 are then placed between the side plates 60 and 61 and fit closely adjacent the sides of the assembled compartments K. The edge plate 64 is provided with a hole 65 through which the pipe nipple 52 extends to permit the edge plate to be positioned closely adjacent the assembled compartments K. Edge plates 63 and 64 are then welded to the side plates 60 and 61 and the abutting ends of the edge plates are welded to each other to provide an integral casing surrounding the heat transfer plates 37. Pipe nipples 52 and 55 are also welded to the edge plate 64 and side plate 61, respectively, to seal the joints therebetween.

It will be observed that the assembled heat exchanger 19 comprises a casing 36 having a series of spaced compartments K therein with chambers 66 and 67 between the ends of the compartments and the ends of the casing. All of the plates 37 forming the compartments K are held in spaced relation to each other by the abutting engagement of the laterally projecting bosses 40 which resists buckling of the plates. The central openings 42 and 43 at the ends of the compartments K are connected by the headers 44 and 45 positioned in the chambers 66 and 67 and the sides of the headers are spaced from the sides of the chambers, see Fig. 2. Thus the chambers 66 and 67 are connected to the passages 68 between the compartments K at the sides of the headers 44 and 45 and liquid is supplied to or exhausted from the chambers by pipe nipples 69 and 70 connected to openings 71 and 72 in the edge plates 64 and 63 of the casing 36. The heat exchanger 19 is assembled in the refrigeration circuit by welding the pipe nipples 52 and 55 to the conduits 20 and 18 and welding the pipe nipples 69 and 70 to the conduits 29 and 30, respectively. In certain instances it may be desirable to insert the ends of the conduits 29 and 30 into the openings 71 and 72 in the casing 36 and weld the ends of the conduits directly to the casing. A preferred form of construction of the heat exchanger having now been described in detail the mode of operation of the heat exchanger is explained as follows.

Absorption liquid enriched with refrigerant flows from the absorber 16 through the conduit 18 and enters the header 45 at the lower end of the heat exchanger 19, see Fig. 3. The absorption liquid flows upwardly from the header 45 through the central inlet openings 43 into the series of closed compartments K. The absorption liquid continues to flow upwardly through the compartments and through the outlet openings 42 at the opposite ends thereof into the header 44. From the header 44, the liquid flows through the pipe nipple 52 and into the conduit 20 where it completes its circuit through the chamber 21 and conduit 22 to the base of the generator 17.

Absorption solution from which the refrigerant has been expelled flows from the upper end of the generator 17 downwardly through the conduit 29 and the pipe nipple 69 into the chamber 66 at the upper end of the heat exchanger. The absorption liquid flows on either side of the header 44 between the header and the edge walls 63 and 64 of the casing and enters the passages 68 between adjacent compartments K. The absorption liquid continues to flow by gravity through the passages between adjacent compartments K and discharges into the chamber 67 at the bottom of the casing. The absorption liquid flowing between the compartments K is comparatively warm while the absorption liquid flowing through the compartments is comparatively cold. During the flow of the liquids in opposite directions through the separate passages in the heat exchanger, the heat of the warm liquid will be transferred to the relatively cool liquid through the heat transfer plates 37 and the intimate contact of the separate liquids with the opposite sides of the plates produces an efficient heat transfer. The liquid in the chamber 67 then flows through the pipe nipple 70 and conduit 30 to the top of the absorber where it is directed over the banks of pipes 31 in intimate contact with the refrigerant vapor to absorb the latter therein.

It will now be observed from the foregoing description that the present invention provides a novel construction and arrangement of elements in a liquid heat exchanger. It will also be observed that the present invention provides a novel heat transfer plate construction which adapts a series of separate passages to be formed by a series of identical plates. It will still further be observed that the present invention provides a

novel method of assembling the parts of a heat exchanger which simplifies the operation, reduces the cost of manufacture and eliminates dead spots or pockets so that the entire surface of the plates are operative to transfer heat.

While a preferred form of construction and method of assembly are herein illustrated and described it will be understood by those skilled in the art that modifications may be made in the form of the construction and in the steps of the method without departing from the spirit or scope of the invention. Therefore, without limiting myself in this respect the invention is defined by the appended claims.

What is claimed is:

1. A liquid heat exchanger comprising a casing having inlet and outlet ports at opposite ends, a series of closed compartments in the casing arranged in spaced relation to each other and having peripheral openings at opposite ends in side by side abutting engagement adjacent the inlet and outlet ports in the casing, said compartments providing parallel paths of flow for circulating liquids through the compartments and between the compartments and said compartments being of less length than the casing to provide chambers therebetween, and a header in each chamber having side walls spaced from the side walls of the casing and joined to the ends of the compartments to connect the peripheral openings therein and seal the joints between the headers and compartments whereby the entire area of the compartments and headers constitute heat transfer surfaces without any dead spaces of trapped liquid in the two paths of flow for the circulating liquids.

2. A liquid heat exchanger comprising a casing having inwardly converging sides at opposite ends with inlet and outlet ports at said opposite ends adjacent the apex of the converging sides, a series of separate closed compartments in the casing arranged in spaced relation to each other and having peripheral openings at their opposite ends in side by side abutting engagement, said compartments being of substantially the same contour as the casing and providing parallel paths of flow throughout the width of the casing for circulating liquids through the compartments and between the compartments and said compartments being of less length than the casing to provide chambers therebetween, and a header in each chamber having side walls spaced from the side walls of the casing and welded to the ends of the compartments to connect the peripheral openings therein and seal the joints between the headers and compartments whereby the entire area of the compartments and headers constitute heat transfer surfaces without any dead spaces of trapped liquid in the two paths of flow for the circulating liquids.

3. A liquid heat exchanger comprising a casing having inlet and outlet ports at opposite ends,

a series of closed compartments arranged in spaced relation in the casing to provide parallel paths of flow for circulating liquids through the compartments and between the compartments, said compartments being of less length than the casing to provide chambers therebetween, each of said compartments comprising a pair of reversed plates having continuous peripheral flanges, the flanges of each pair of plates having portions offset on one side of the plates and welded together to seal the joint and portions offset on the opposite sides of the plates to provide peripheral openings, the openings in adjacent compartments being arranged in side by side relationship with abutting walls therebetween, a header in each chamber spaced from the walls of the casing, and said headers being welded to the flanges to connect the adjacent openings and seal the joints between the headers and compartments whereby the entire area of the compartments and headers constitute heat transfer surfaces without any dead spaces of trapped liquid in the two paths of flow of the circulating liquids.

4. A liquid heat exchanger comprising a casing having inlet and outlet ports at opposite ends, a series of closed compartments in the casing to provide parallel paths of flow through the compartments and between the compartments, each of said compartments comprising a pair of reversed plates having continuous peripheral flanges, the greater portion of the flanges of each pair of plates being offset on one side of the plates and welded together to seal the joint and the portions at opposite ends being offset on the opposite sides of the plates to provide peripheral openings, the openings in adjacent compartments being arranged in side by side relationship with abutting walls therebetween, and a header at each end of the compartments having teeth projecting into the ends of the openings and welded to the flanges to connect the adjacent openings and seal the joints between the headers and compartments.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,272,925	Duffy	July 16, 1918
1,576,410	Connery	Mar. 9, 1926
1,740,145	Bates	Dec. 17, 1929
2,287,281	Thomas	June 3, 1942
2,361,691	Jendrassik	Oct. 31, 1944

FOREIGN PATENTS

Number	Country	Date
527,585	Great Britain	Oct. 11, 1940
264,945	Germany	Oct. 1, 1913