

Nov. 1, 1966

W. H. STAHLHEBER

3,282,334

HEAT EXCHANGER

Filed April 29, 1963

4 Sheets-Sheet 1

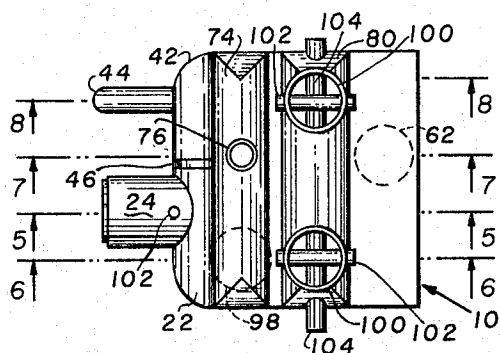


FIG. 2

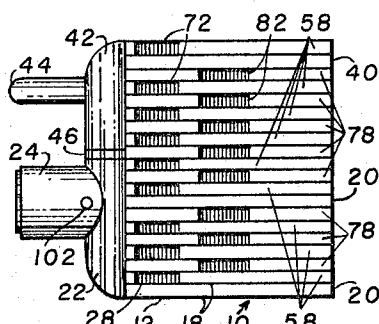


FIG. 3

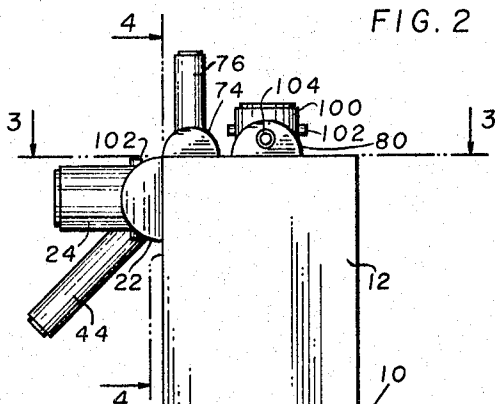


FIG. 1

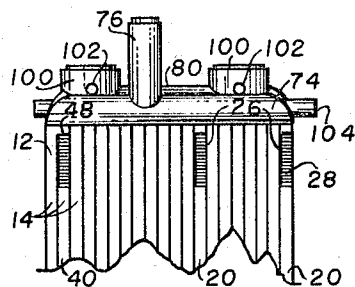


FIG. 4

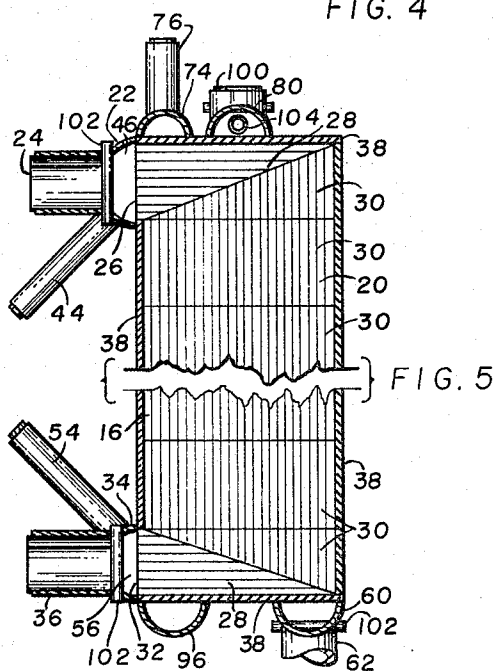


FIG. 5

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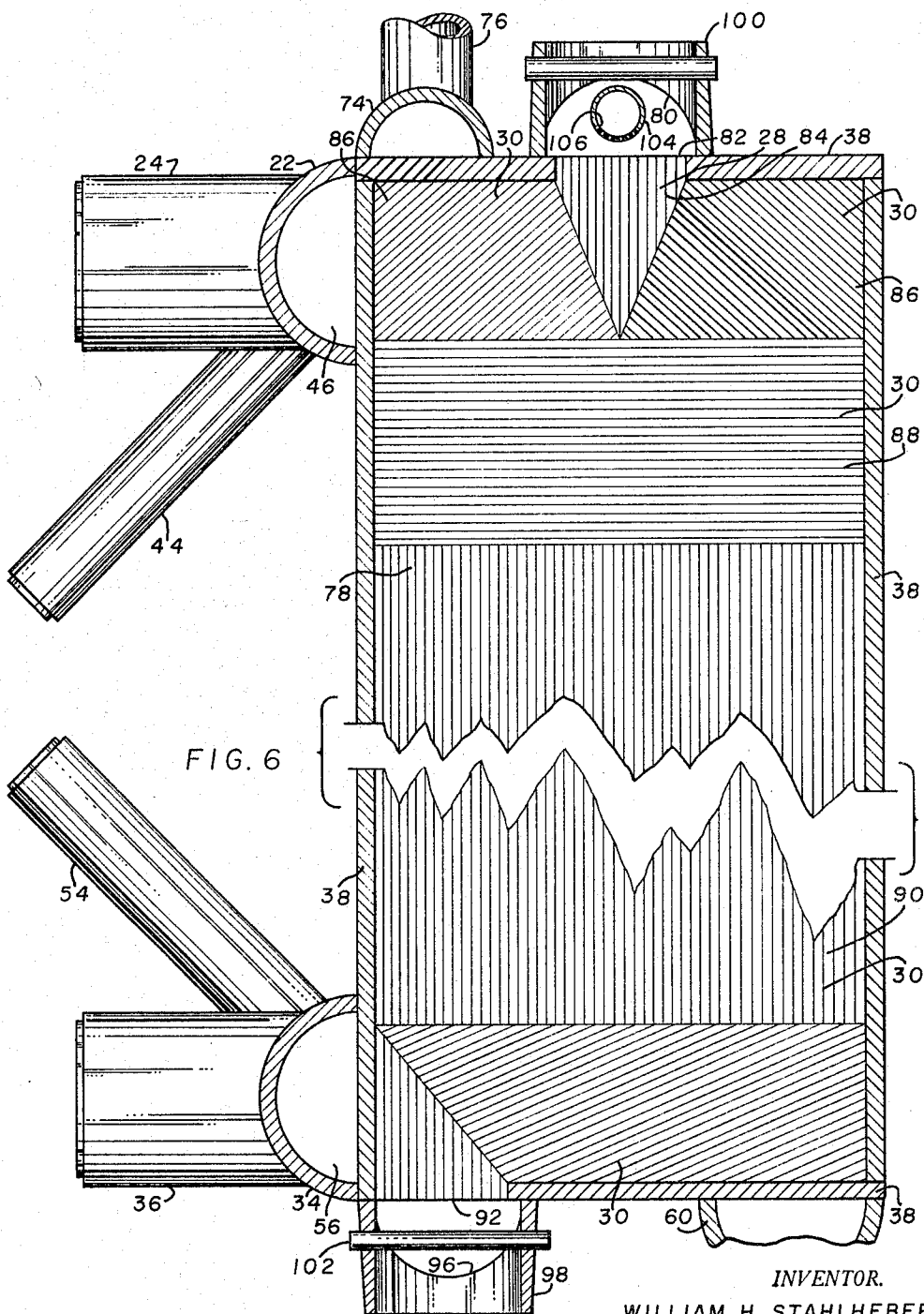


FIG. 6

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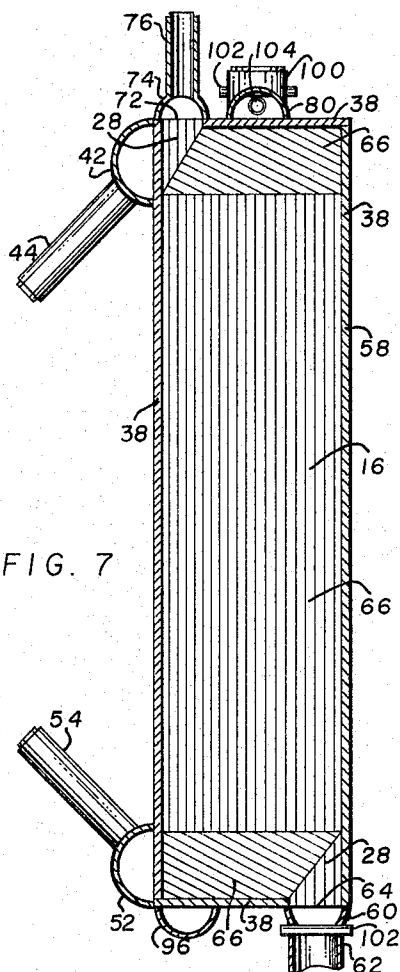


FIG. 7

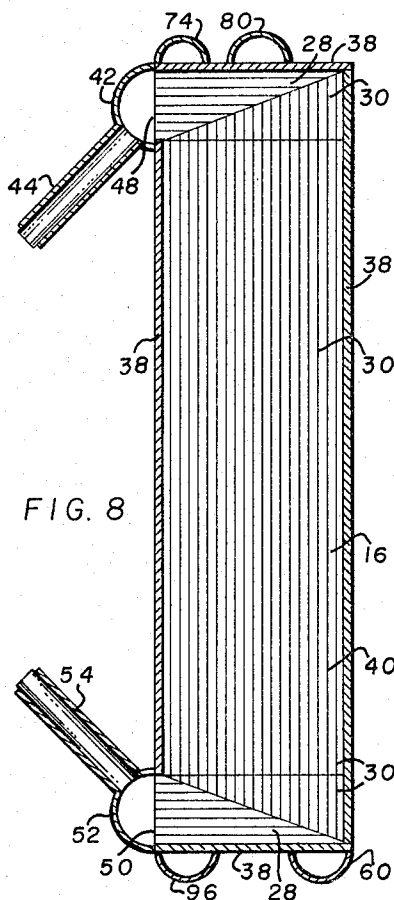


FIG. 8

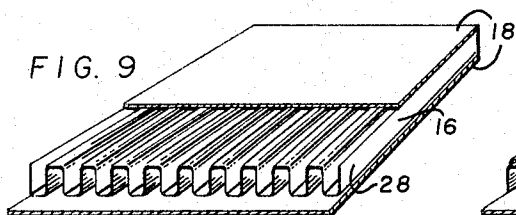


FIG. 9

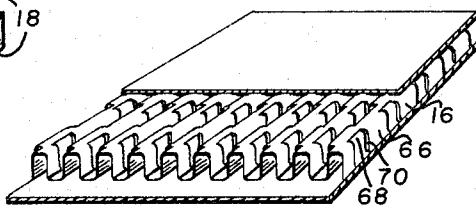


FIG. 10

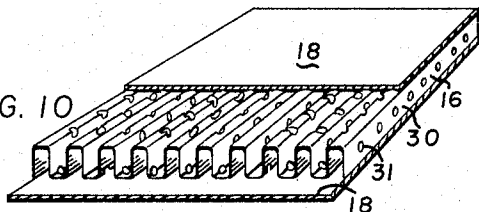


FIG. 11

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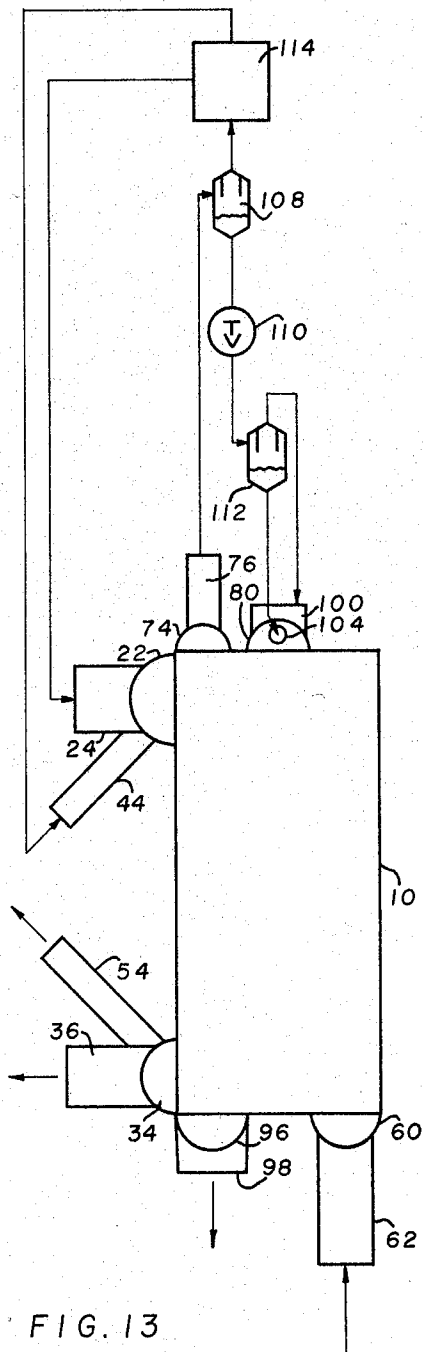


FIG. 13

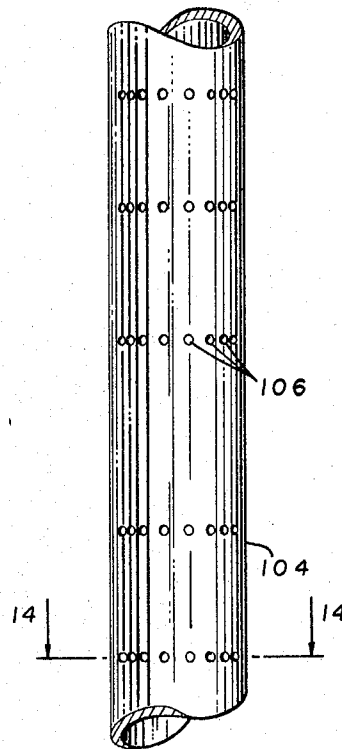


FIG. 12

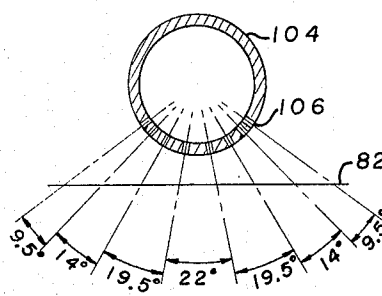


FIG. 14

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3,282,334

HEAT EXCHANGER

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12 Claims. (Cl. 165-166)

This invention relates to heat exchangers and especially to heat exchangers having spaced metallic plates forming passages for the flow of heat exchange fluids. More particularly the present invention relates to such heat exchangers specifically adapted for the flow of a two-phase fluid, i.e., liquid and gas.

In refrigeration apparatus it often becomes necessary to introduce the refrigerant fluid into a heat exchanger core as a mixture of refrigerant gas and refrigerant liquid. One method of introducing a two-phase heat exchange fluid into a heat exchanger core is illustrated in U.S. Patent No. 1,978,382 wherein the liquid portion of the heat exchange fluid is sprayed from a nozzle as a fine dispersion into a vapor conducting header. In such a method of distributing liquid and gas within a heat exchanger core, the uniform distribution of liquid is obviously highly dependent upon the flow rate of the gas.

It is a prime object of this invention to provide a means for introducing both gas and liquid to the same passages of a heat exchanger core which permits relatively large changes in flow rates without substantially affecting the uniformity of distribution.

It is a further object of this invention to provide a gas-liquid distribution means which is useful with brazed heat exchangers.

It is another object of this invention to provide a gas-liquid distribution means which constitutes an integral part of a heat exchanger.

Still a further object of this invention is to provide a gas-liquid distribution means for a heat exchanger having spaced metallic plates for conducting a plurality of confined fluids.

These and other objects will become more apparent as this specification proceeds to describe this invention with reference to the accompanying drawings in which:

FIGURE 1 is a side elevational view of a metallic plate heat exchanger having four sets of headers for four distinct or separate fluids, one header of which is equipped with gas-liquid distributing means for a two-phase heat exchange fluid;

FIGURE 2 is a top view of the heat exchanger shown in FIGURE 1;

FIGURE 3 is a sectional view taken along 3-3 of FIGURE 1 just below the top headers;

FIGURE 4 is a sectional view of a portion of the heat exchanger taken along 4-4 of FIGURE 1 just inside of the upper side headers;

FIGURE 5 is a vertical section taken along 5-5 of FIGURE 2 of a single plate-like passage associated with one of the side headers;

FIGURE 6 is an enlarged section taken along 6-6 of FIGURE 2 of a single plate-like passage associated with the top header employing gas-liquid distribution means for a two-phase heat exchange fluid;

FIGURE 7 is a vertical section taken along 7-7 of FIGURE 2 of a single plate-like passage associated with the other top header;

FIGURE 8 is a vertical section taken along 8-8 of FIGURE 2 of a single plate-like passage associated with the other side headers;

FIGURE 9 is a perspective view of a portion of the distributor fin material used in the heat exchanger plate-like passages;

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FIGURE 10 is a perspective view of a portion of the perforated fin material used in the heat exchanger plate-like passages;

FIGURE 11 is a perspective view of a portion of the serrated fin material used in one of the heat exchanger plate-like passages;

FIGURE 12 is an enlarged elevation of a portion of the sparge pipe liquid distributor;

FIGURE 13 is a diagrammatic illustration showing the operation of the invention; and

FIGURE 14 is a section taken at 14-14 of FIGURE 12.

Referring to FIGURES 1-4, it will be seen that elongated heat exchanger 10 has a core 12 comprised of a stack of elongated longitudinally extending plate-like passages 14. Each passage is formed generally by interposing fin material 16 between two spaced metallic plates 18 in a manner well known to those skilled in the art. The composite of these plate-like passages may then be brazed together as an integral unit. Each elongated passage bears an inlet and an outlet opening so as to accommodate the flow of heat exchange fluid therethrough.

The heat exchanger 10 is equipped to handle four different or separate streams of heat exchange fluid simultaneously. Consequently four separate inlet and outlet headers are mounted on core 12. Three of the headers make fluid communication with a plurality of plate-like passages. The number of passages associated with any given header is a matter of choice and design and is not considered as part of my invention. These separate headers will be described now in conjunction with their associated plate-like passages.

Plate-like passages 20 are provided with an inlet header 22 having inlet pipe 24 mounted at the upper side of core 12. Fluid entering pipe 24 is distributed by header 22 to passage side inlets 26 of passages 20 as seen in FIGURE 5. The fluid is distributed across the width of passages 20 by a triangular section of imperforate laterally extending distributor fin material 28. This imperforate distributor fin material is more clearly illustrated in FIGURE 9. It is comprised of a layer of corrugated sheet metal such as aluminum. After the heat exchanger is brazed the high and low portions of the corrugations are bonded to the spaced metallic plates 18 at the sides of the passages.

Once distributed within the passage, the heat exchange fluid will move longitudinally through longitudinally extending porous fin material 30 to the opposite end of passage 20. This porous fin material is more clearly illustrated in FIGURE 10. This fin material is also formed from corrugated sheet metal such as aluminum. However, prior to forming the corrugations, the sheet metal is perforated with circular apertures 31. These apertures may cover about ten to twenty percent of the total sheet metal surface.

After the heat exchange fluid has reached the far end of the passage 20, it is collected by another triangular section of imperforate laterally extending fin material 28 and conveyed to side outlet 32. The fluid from outlet 32 of each passage 20 is collected in outlet header 34 at the lower side of core 12 and hence passed out of pipe 36. The fluid is confined within each passage by side bars 38 interposed between plate 18 at the periphery thereof.

While the flow of fluid through passages 20 has been described as in the direction from header 22 to 34, it will be understood that the direction of fluid flow could be reversed if desired. It will also be understood that the fin material as herein described functions to guide the exchange fluid as well as to provide extended heat exchange surface.

A plate-like passage 40 is provided with an inlet header 42 having an inlet pipe 44 mounted at the upper side of core 12 adjacent header 22. Partition member 46 separates headers 42 and 22. Fluid entering pipe 44 is distributed by header 42 to passage side inlet 48 of passage 40 as best seen in FIGURES 8. The fluid is distributed across the width of passage 40 by a triangular section of imperforate laterally extending distributor fin material 28. It then passes along the length of the passage through perforated longitudinally extending fin material 30 to a second triangular section of imperforate laterally extending fin material 28 to side outlet 50 where it is collected by outlet header 52 at the lower side of core 12. The exchange fluid egresses through pipe 54. Partition 56 (FIGURES 5 and 6) prevents fluid flow between headers 34 and 52. Side bars 38 confine the fluid to the passage in the same manner as described in conjunction with passages 20. It should here again be understood that direction of flow may be reversed if desired.

A third set of plate-like passages 58 is provided with an inlet header 60 having an inlet pipe 62 mounted at the bottom of core 12. Fluid entering pipe 62 is distributed by header 60 to passage bottom inlets 64 of passages 58 as best seen in FIGURE 7. The fluid after passing into inlets 64 passes to a generally triangular section of imperforate longitudinally extending fin material 28 and hence to a section of serrated diagonally extending fin material 66 in the form of a trapezoid.

Serrated fin material 66 is comprised of a layer of corrugated sheet metal such as aluminum wherein each corrugation is provided with a series of offset portions 68 producing a series of slits 70 therein. The particulars of this fin material are more fully described in U.S. Patent Number 3,016,921.

The fluid after being distributed across the width of each passage 58 moves upward through longitudinally extending fin material 66 to a second trapezoidally shaped section of diagonally extending serrated fin material 66 and hence to top outlet 72 via a generally triangular section of imperforate longitudinally extending fin material 28. Fluid from the several outlets 72 is collected in top header 74 from whence it egresses through pipe 76. Again it is evident that the fluid is confined within the passage 58 by side bars 38 as hereinbefore described in connection with passages 20 and 40 and further that the direction of fluid flow may be reversed if desired.

A fourth set of plate-like passages 78 is provided with an inlet header 80 mounted at the top of core 12 adjacent header 74. Each passage 78 has a fluid inlet 82 opening into header 80. Fluid entering inlet 82 passes downward (FIGURE 6) along a generally triangular section 84 of imperforate longitudinally extending fin material 28. Fluid passing from the two lower sides of triangular fin section 84 is distributed along the width of the passage 78 via trapezoidally shaped fin sections 86 of porous diagonally extending fin material 30. One such trapezoidal section is disposed on each side of the previously mentioned triangular section 84. Below the trapezoidal sections 86 is arranged a rectangular section 88 of porous laterally extending fin material 30. It will be noted that fluid passing from the trapezoidal distributor sections 86 must pass through section 88 in a direction normal to the fins of fin material 30. Since the fin material is provided with perforations covering about ten to twenty percent of its surface, greater fluid resistance is offered in the longitudinal direction than in the horizontal direction. Section 88 has for this reason been identified as the hardway.

The function of the hardway section 88 is to more uniformly distribute fluid passing from the perforated distributor section 86. After thorough distribution along the passage width in the hardway section, the heat exchange fluid passes through a central packing section 90 of porous longitudinally extending fin material 30 from whence it enters a trapezoidally shaped section of porous diagonally extending fin material 30 where the fluid is

diverted to one side of the passage 78 and delivered to outlet 92 via a generally triangularly shaped imperforate longitudinally extending fin section 94. Header 96 collects exchange fluid from each outlet 92 and delivers the same through outlet pipe 98. It will be understood as hereinbefore explained that the heat exchange fluid is confined within each passage 78 by side bars 38 interposed between the spaced plates 18 at the periphery thereof.

Particular attention is called to transversely extending header 80 which is mounted over inlets 82 of passages 78. Header 80 is comprised of a semi-circular cylindrical section having closed ends. Projecting upward from the convex side adjacent each end is a gaseous fluid inlet pipe 100. Pipes 100 and previously mentioned pipes 98, 24, 36, and 62 are provided with reinforcing pins 102.

Header 80 as well as the other headers of the heat exchanger may be brazed to the core at the time the plate passages are brazed together or the headers may be brazed or otherwise secured to the core thereafter.

Extending longitudinally within header 80 and through the ends thereof is sparge pipe 104. Sparge pipe 104 extends over each inlet 82 of passages 78. A row of eight radially extending generally circular apertures 106 (see FIGURE 12) are located in the sparge pipe above each inlet 82. Sparge pipe 104 is of the purpose of uniformly distributing a liquid among and within the passages 78 substantially independent of the velocity of gas or vapor entering inlets 82 of passages 78.

However, to achieve uniform distribution of liquid at the inlet 82, I have found that the spacing of radially extending apertures 106 must be unequal. Thus, it will be noted that the apertures at the ends of each row are more closely spaced than the apertures near the center of the row. In the sparge pipe herein disclosed the aperture angular spacing within each row is 9.5°, 14°, 19.5°, 22°, 19.5°, 14° and 9.5° as best seen in FIGURE 14. The axes of the generally circular apertures of each row extend radially from sparge pipe 104 through the face of its respective passage inlet 82 at points uniformly spaced across the face of said inlet. Thus, with this particular spacing it has been found that substantially uniform distribution of liquid may be achieved at inlet 82. Fin sections 84 and 86 maintain this distribution as the liquid is spread throughout the width of each passage 78. The hardway section 88 substantially completes the distribution of both liquid and gas prior to entering the central packaging section 90 of the heat exchanger package.

Operation

The operation of my heat exchanger will now be described with particular reference to FIGURE 13. The cryogenic process in which I have chosen to illustrate my invention involves the separation of a particular gaseous constituent from a mixture of gases which in combination present a boiling point extending over a wide range of temperatures. The process involves cooling said gaseous mixture thereby liquifying the constituents in the order of their respective boiling temperatures. The separated constituents are then reheated by passing them in counter-current heat exchange relation with the incoming warm gaseous mixture. My heat exchanger has been found useful in this heat exchange step.

The gaseous mixture is introduced under relatively high pressure into heat exchanger 10 at inlet pipe 62 of header 60. The warm gaseous mixture is cooled in passages 58 whereby a portion of said mixture is condensed. This liquid condensate and remaining gas move out of passages 58 to header 74 and outlet pipe 76. The gas-liquid mixture is moved to separator 108 where the gaseous constituents are separated from the liquid constituents. The liquid thus separated is then passed through a throttling valve 110 or equivalent expansion device wherein a portion of said liquid constituent is vaporized to effect

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substantial cooling of the remaining liquid constituent. The thus cooled mixture of gas and liquid is delivered to a second separator 112 where the cooled mixture is separated into a gaseous portion and liquid portion. The gaseous portion of this cooled mixture is introduced into heat exchanger passages 78 via inlet pipe 100 and header 80. The liquid portion of this cooled mixture is delivered to sparge pipe 104 from whence it is uniformly distributed across each inlet 82 of each passage 78. Since substantial cooling effect is achieved by vaporization of the remaining liquid as it passes through passages 78, it will be obvious to those skilled in the art that this liquid must be uniformly distributed in order to vaporize all the remaining liquid and to achieve maximum cooling throughout the heat exchanger.

It will thus be understood that the function of separator 112 is to facilitate the uniform distribution of both phases of a gas-liquid mixture within heat exchange passages 78 by means of header 80, sparge pipe 104, and the associated distributing fin material of each passage.

The gaseous portion separated in separator 108 may undergo further separation at 114 such as for example by further cooling in additional heat exchangers. The cooling effect of these separated gaseous constituents may be recovered by passing the separated gaseous constituents respectively to inlet pipes 24 and 44 and hence to headers 22 and 42, passages 26 and 48, outlet headers 34 and 52, to outlet pipes 36 and 54. The separated gaseous constituents thus give up sensible heat to the warmer gaseous mixture entering inlet pipe 62.

It will be understood that the constituents leaving pipes 36 and 54 are thus separated from the gaseous mixture entering pipe 62 in a most economical manner. The success of such a process is largely dependent upon efficient heat exchange for which my invention represents an essential improvement, especially in such cryogenic applications.

Although I have described in detail the preferred embodiment of my invention. I contemplate that many changes may be made without departing from the scope or spirit of my invention, and I desire to be limited only by the claims.

I claim:

1. A plate type heat exchanger apparatus comprising a plurality of elongated metallic plates disposed in superposed spaced relationship defining a plurality of elongated plate-like passages in the spaces therebetween; said plurality of passages including a first group of passages and a second group of passages, the passages of said first group being disposed in heat exchange relationship with the passages of said second group; sealing means sealingly extending between said plates along the periphery thereof defining the width and length of said passages; header means for conducting a first heat exchange fluid through said first group of said passages for heat exchange with fluid in said second group of said passages; each passage of said second group of passages including an inlet adjacent one end of said heat exchanger and an outlet adjacent the other end of said heat exchanger for ingress and egress of heat exchange fluid; a header overlying said inlets for conducting a gaseous heat exchange fluid thereto; a sparge pipe mounted within said header externally of said inlets; means for supplying a gaseous heat exchange fluid to said header and a liquid heat exchange fluid to said sparge pipe; a plurality of liquid fluid outlets spaced longitudinally along said sparge pipe each in alignment with one of said inlets for directing a liquid heat exchange fluid uniformly into said inlets; and distributor means within each of said passages of said second group adjacent the inlet thereof for substantially uniformly distributing across the width of each passage both gaseous and liquid heat exchange fluids simultaneously introduced into said inlets from said header and said sparge pipe respectively.

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2. The apparatus as defined by claim 1 wherein said distributor means includes a section of perforated corrugated metallic fin material having crests extending substantially perpendicular to the general direction of fluid flow through said section for simultaneously substantially uniformly distributing both liquid and gaseous heat exchange fluids across the width of the passage.

3. The apparatus as defined in claim 1 wherein said distributor means includes a section of corrugated metallic fin material having crests extending obliquely to the longitudinal axis of the passage toward the inlet of the passage.

4. The apparatus as defined by claim 1 wherein said distributor means includes a first section of perforated corrugated metallic fin material having the crests thereof extending substantially perpendicular to the general direction of fluid flow through said first section and a second section of corrugated metallic fin material disposed between said first section and the inlet of the passage and having crests extending obliquely to the longitudinal axis of the passage toward the inlet of the passage.

5. The apparatus as defined by claim 4 wherein said distributor means further includes a third section of imperforate corrugated metallic fin material disposed between said second section and the inlet of the passage and having crests extending parallel to the longitudinal axis of the passage toward the inlet of the passage.

6. The apparatus as defined by claim 1 wherein each of said sparge pipe liquid fluid outlets includes a plurality of generally circular outlet apertures having axes extending outward from said sparge pipe through the face of a passage inlet at points uniformly spaced across said face.

7. The apparatus as defined by claim 1 wherein each of said sparge pipe liquid fluid outlets includes a plurality of generally circular outlet apertures having axes coextensive with a plane substantially perpendicular to the axis of said sparge pipe.

8. In a heat exchanger having a plurality of elongated longitudinally extending plate-like heat exchange passages each having an inlet underlying a common header, the improvement for simultaneously distributing gas and liquid heat exchange fluids uniformly across each of said passage comprising in combination a sparge pipe disposed within said common header having a plurality of liquid fluid outlets each directed toward one of said inlets and a first section of perforated corrugated metallic fin material disposed in each of said passages and having crests abutting the walls of said passages and extending substantially perpendicular to the general direction of fluid flow through said first section.

9. The apparatus defined by claim 8 wherein said improvement includes a second section of corrugated metallic fin material disposed in each of said passages between the first section and the inlet and having crests extending obliquely to the longitudinal axis of the passage toward the inlet of the passage.

10. The apparatus defined by claim 9 wherein said improvement further includes a third section of imperforate corrugated metallic fin material disposed in each passage between the second section and the inlet and having crests extending parallel to the longitudinal axes of the passages.

11. The apparatus as defined by claim 8 wherein each of said outlets includes a plurality of generally circular outlet apertures having axes extending outward from said sparge pipe through the face of a passage inlet at points uniformly spaced across said face.

12. The apparatus as defined by claim 8 wherein each of said outlets includes a row of at least four generally circular apertures having radially extending axes passing through an inlet wherein the angular spacing of said apertures adjacent at least one end of said row is less than the angular spacing of said apertures adjacent the center of said row.

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