July 2, 1957 J. J. BANKER 2,797,900

FLUID HEAT EXCHANGE UNIT WITH PLURAL HEADER TERMINALS

Filed Dec. 24, 1952 8 Sheets-Sheet 1

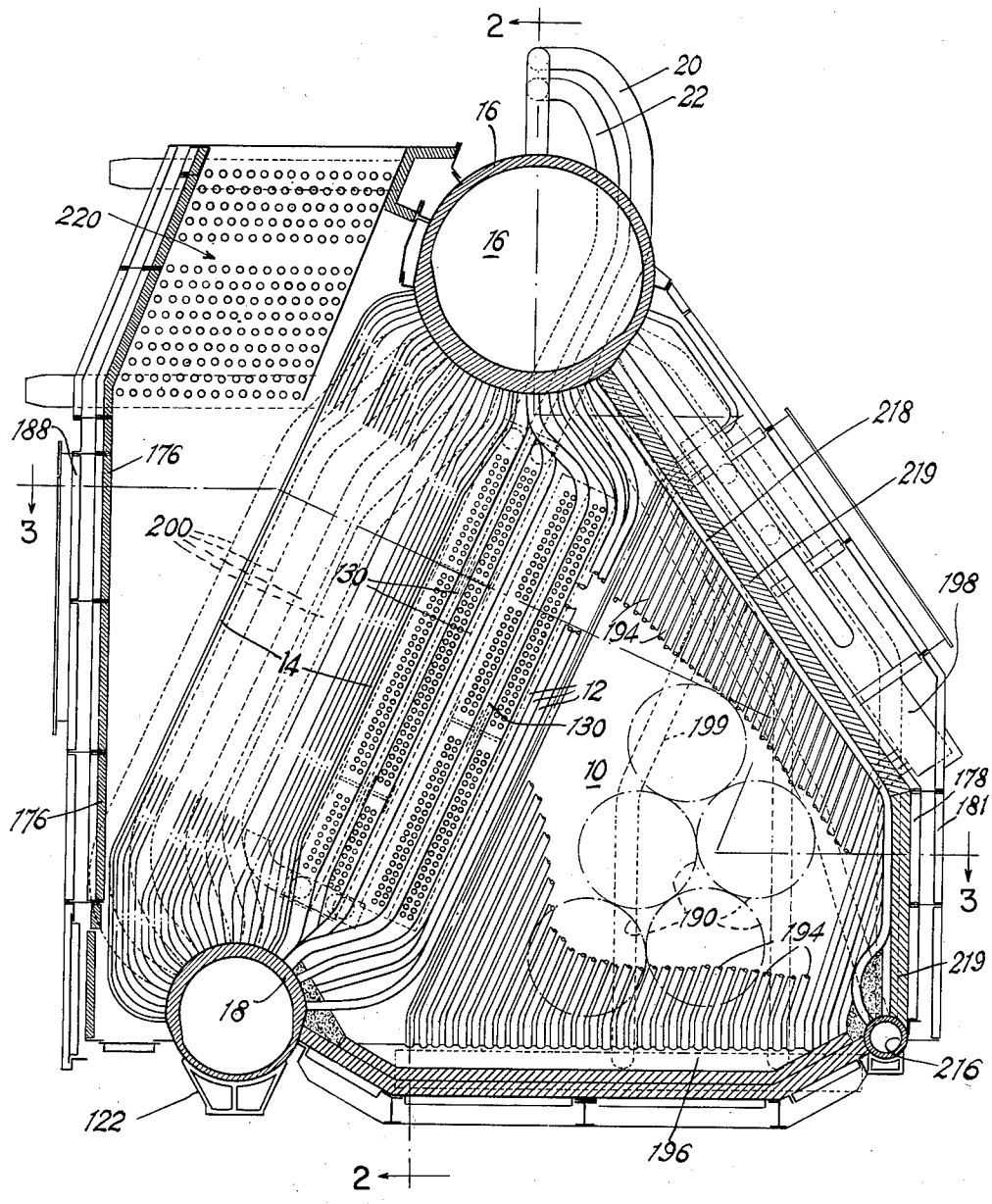


FIG. 1

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FLUID HEAT EXCHANGE UNIT WITH PLURAL HEADER TERMINALS

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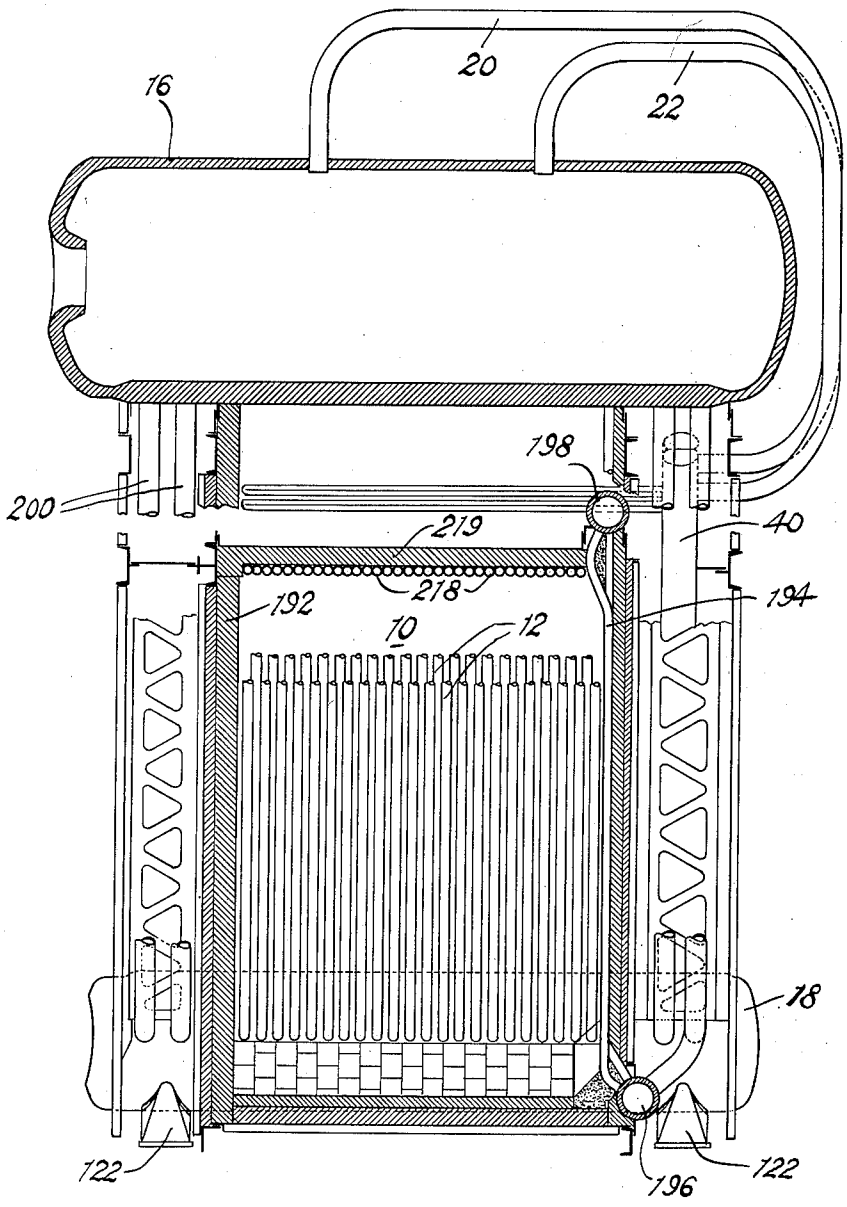


FIG. 2

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FLUID HEAT EXCHANGE UNIT WITH PLURAL HEADER TERMINALS

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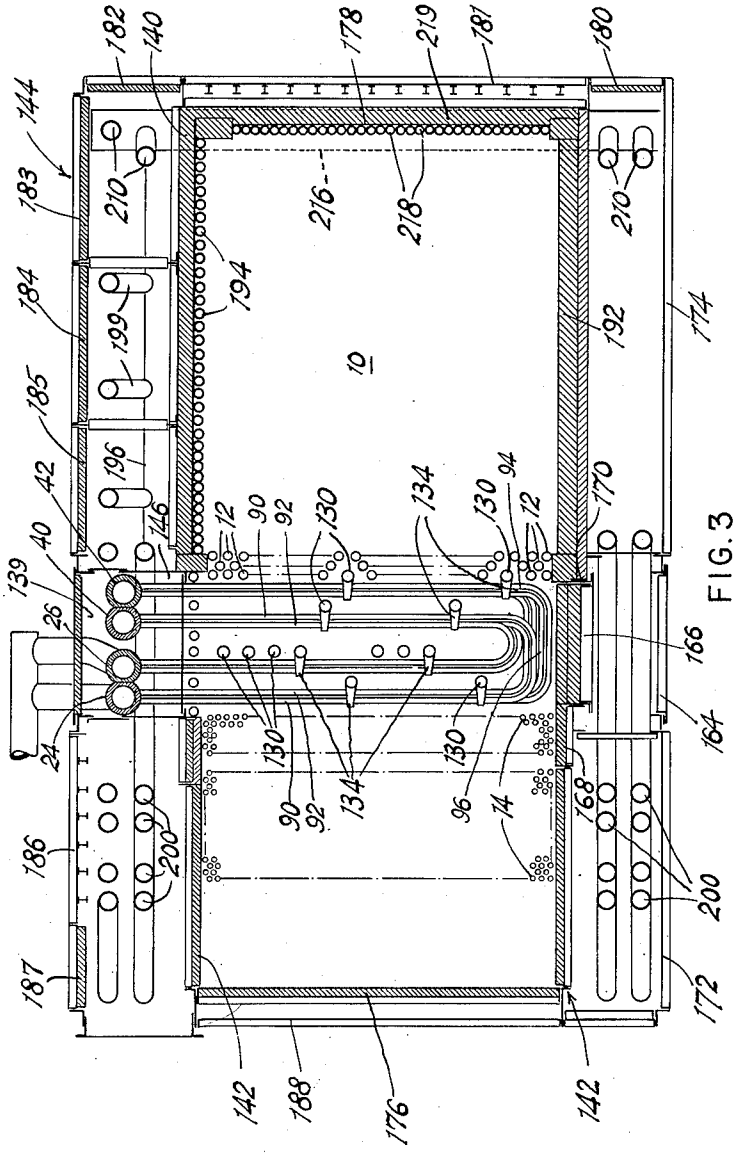


FIG. 3

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FLUID HEAT EXCHANGE UNIT WITH PLURAL HEADER TERMINALS

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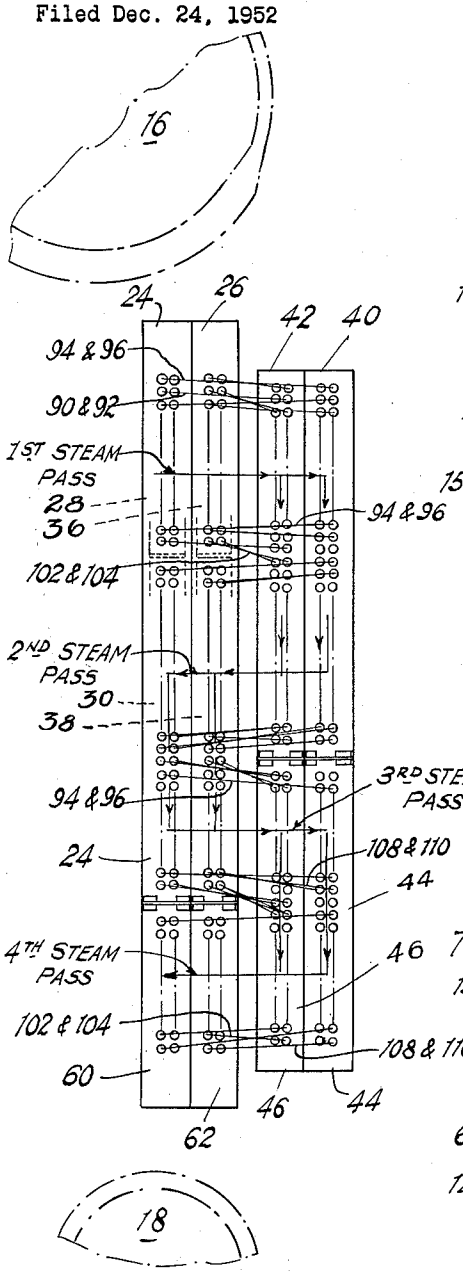


FIG. 4

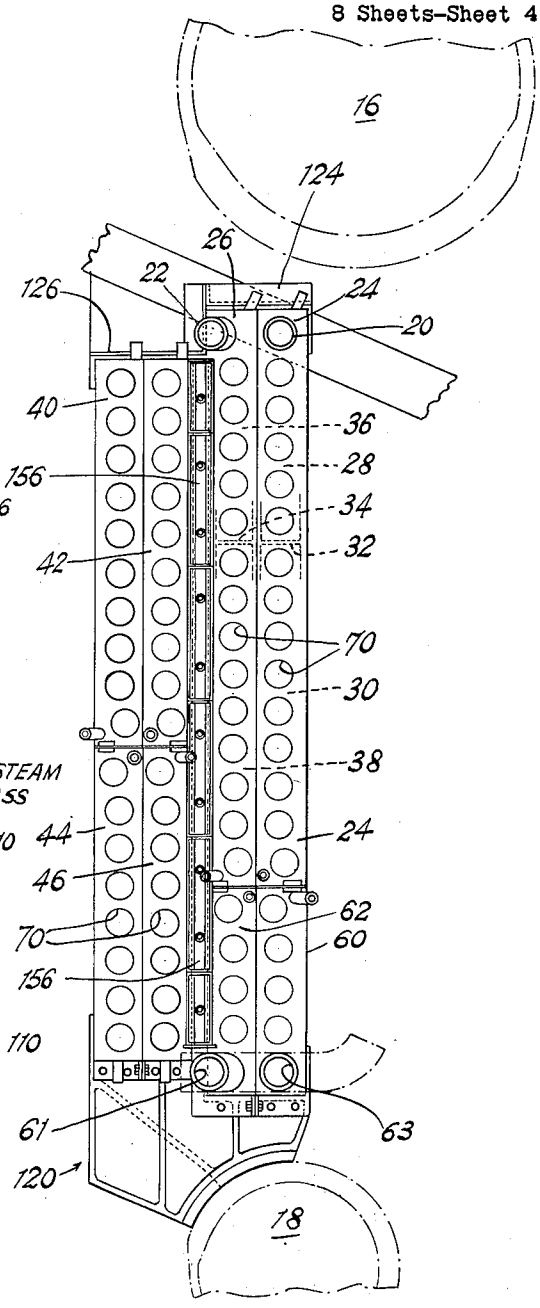


FIG. 5

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FLUID HEAT EXCHANGE UNIT WITH PLURAL HEADER TERMINALS

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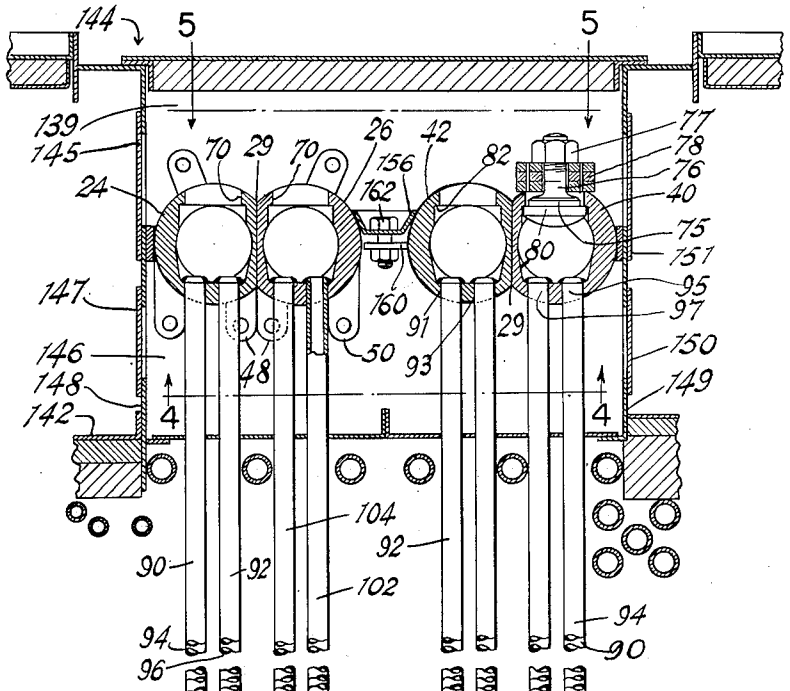
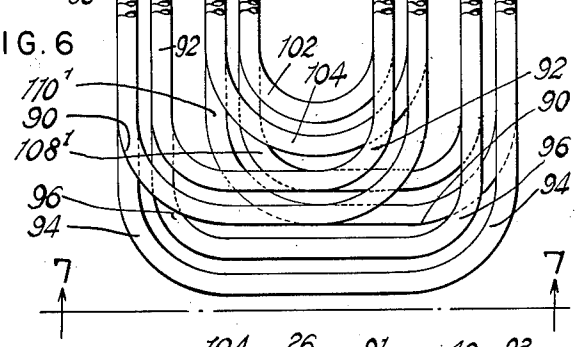


FIG. 6



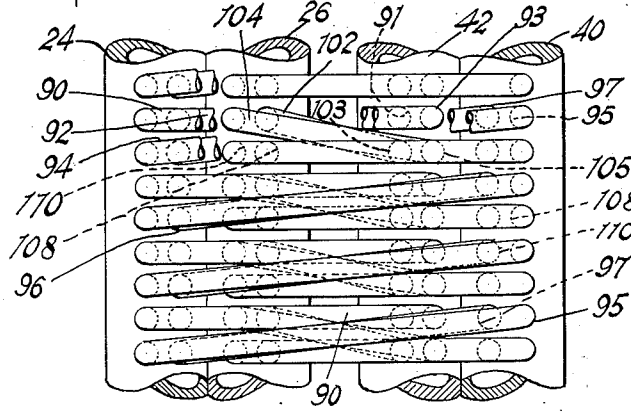


FIG. 7

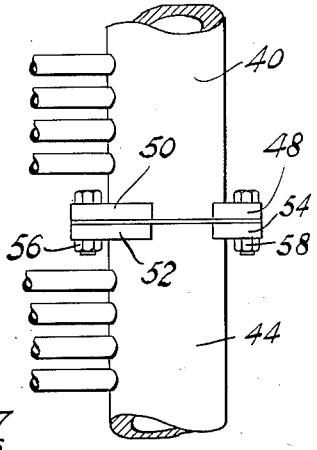


FIG. 8

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FLUID HEAT EXCHANGE UNIT WITH PLURAL HEADER TERMINALS

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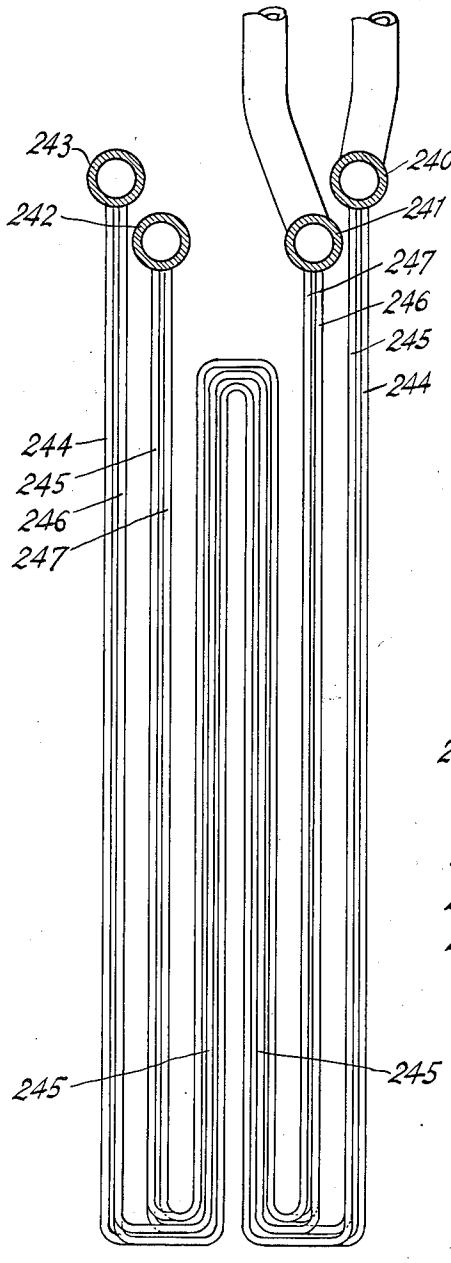


FIG. 9

"A" PLATEN

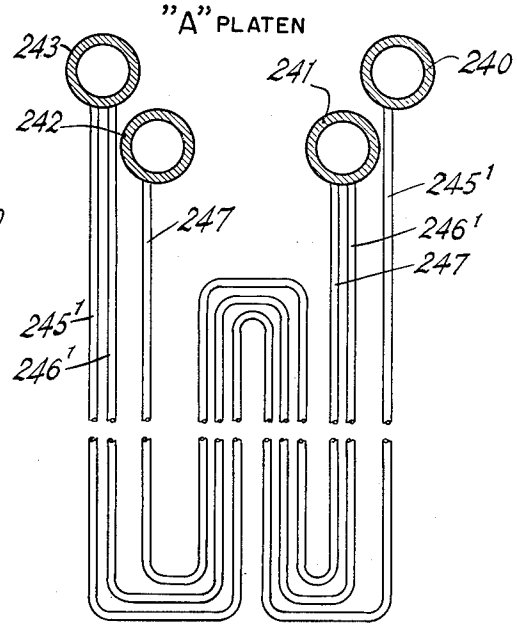


FIG. 10

"B" PLATEN

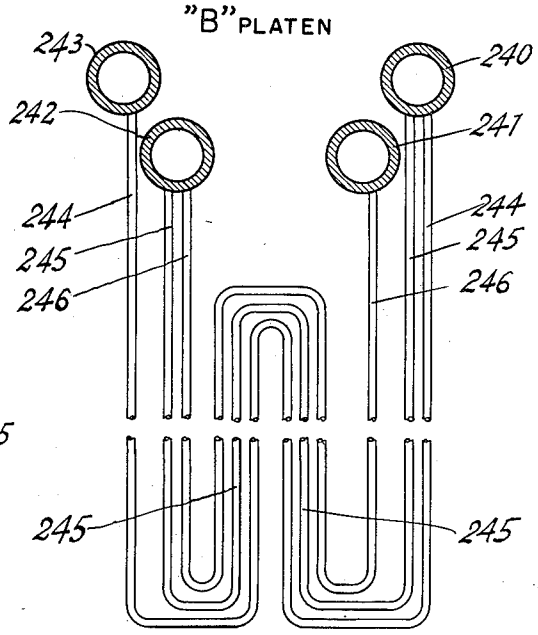


FIG. 11

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FLUID HEAT EXCHANGE UNIT WITH PLURAL HEADER TERMINALS

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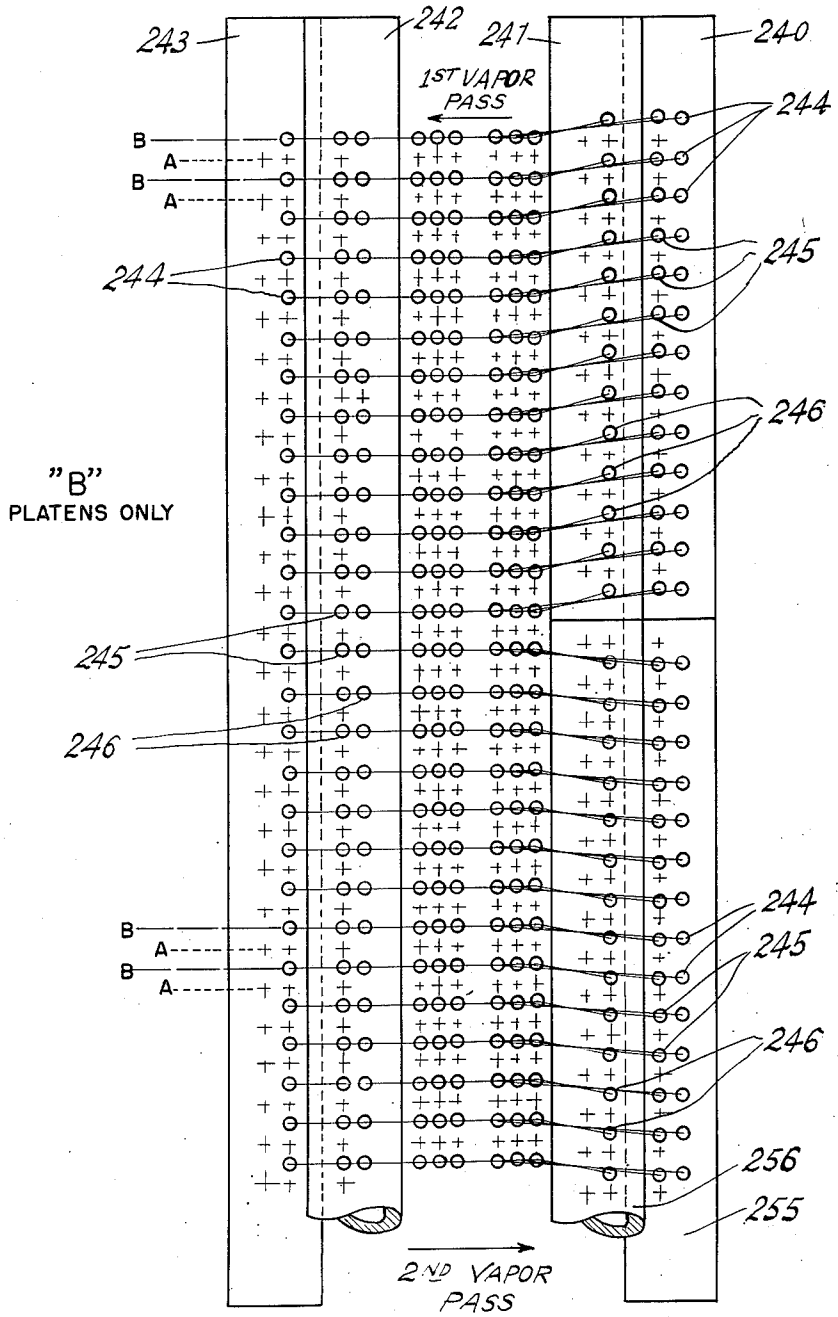


FIG. 12

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FLUID HEAT EXCHANGE UNIT WITH PLURAL HEADER TERMINALS

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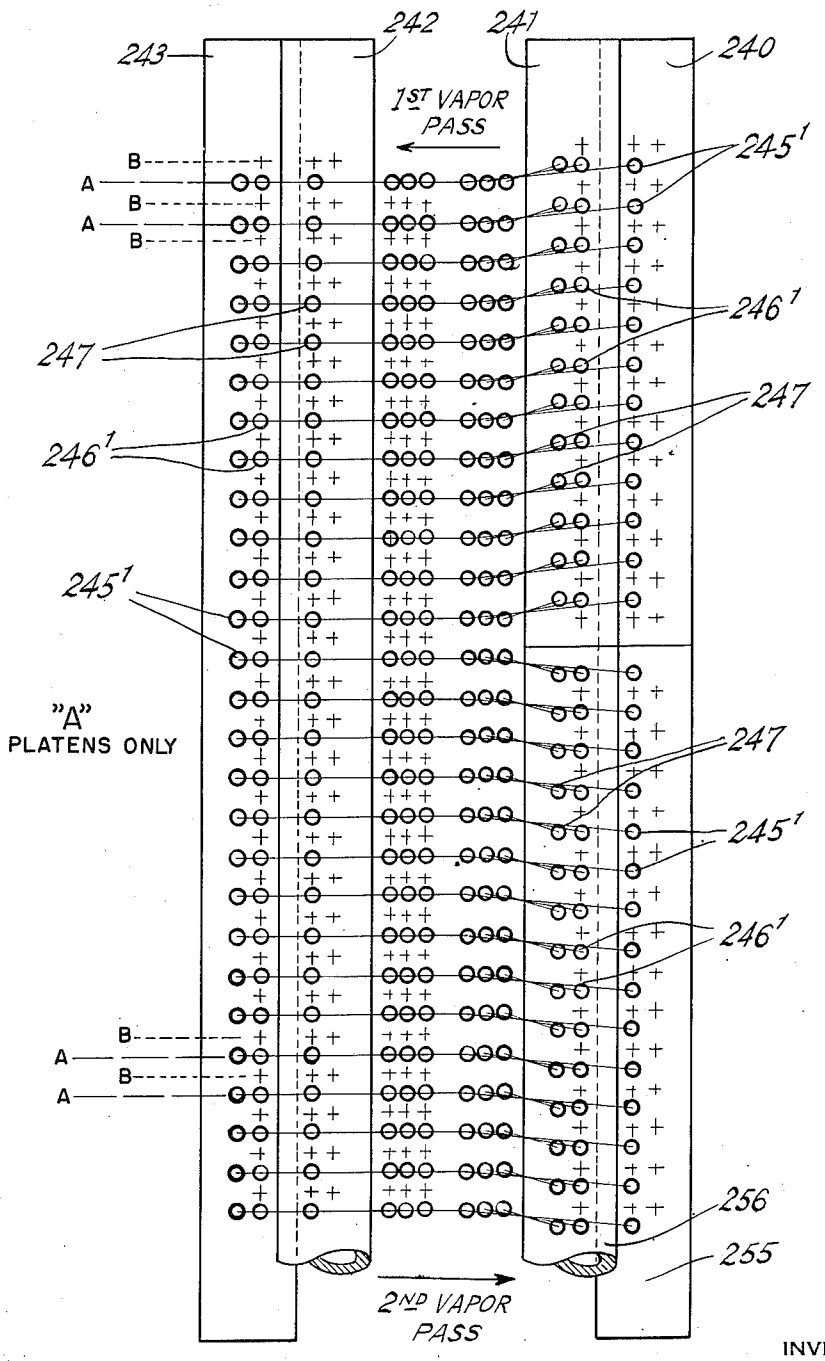


FIG. 13

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2,797,900

FLUID HEAT EXCHANGE UNIT WITH PLURAL HEADER TERMINALS

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Application December 24, 1952, Serial No. 327,776

5 Claims. (Cl. 257—235)

This invention relates to fluid heat exchange apparatus exemplified herein as a part of a vapor generating and superheating unit for operation at high vapor temperatures and pressures.

More specifically, the invention is concerned with a particular convection heater especially promoting uniform heat exchange in a plurality of fluid flow paths, eliminating the use of the excessively large headers, reducing the amount of high cost alloy metal previously thought necessary because of the pertinent high temperatures, and facilitating repair and maintenance of the apparatus. In accomplishing the above indicated results the invention involves a convection auxiliary heater having a plural header arrangement coacting with a specific arrangement of connecting heater tubes. In a mose specific sense the invention involves a multiple vapor pass superheater consisting of a multiplicity of spaced tubes so connecting sets of small diameter headers that the vapor flows in multiple passes, with each group of tubes leading from a plurality of small diameter headers to another set or plurality of small diameter headers in communication with the tubes of the last vapor pass constructed of high cost alloy steel, such material being necessary on account of the high temperatures involved. The amount of such high cost material is not only substantially reduced by the pertinent arrangement and construction of headers, but it is also reducer by the fact that for a given header capacity less material is necessary for constructing a plurality of small diameter headers than would be necessary for a single header of much larger diameter.

The illustrative unit includes spaced groups of upright vapor generating tubes extending across the path of gas flow from a furnace, and a bank of horizontally extending superheater tubes disposed within the space between the groups of steam generating tubes. This bank of superheater tubes is formed by spaced return bend tubes with their inlet and outlet ends disposed at the same side of the installation and connected to headers at that side. Specifically, the headers and tubes are so arranged that there is a plurality of vapor passes from the inlet to the outlet of the superheater. In each vapor pass a group of return bend tubes conducts vapor from a plurality of upright small diameter headers to another and adjacent group of small diameter headers, the tubes in each group being arranged so as to promote uniform heating results by the effective mixing of the vapor heated in the different tubes of the group. This is effected by an arrangement whereby some of the tubes of each group have their inlet ends connected to one inlet header chamber, while the remaining tubes of that group have their inlet ends connected to another inlet header chamber. As to the connections of the outlet ends of each group of tubes with the outlet header chambers for that group, the tubes of the group leading from the same inlet header chamber are divided as to their outlet connections, between a plurality of other small diameter header chambers.

To more clearly understand the invention, reference should be made to the following description and to the

accompanying drawings which relate to a disclosure of a preferred form of the invention embodied in a steam generating and superheating installation.

In the drawings:

Fig. 1 is a vertical section through the illustrative unit with some of the furnace wall tubes broken away to indicate the positions of the fuel burners;

Fig. 2 is a vertical section at 90° to the Fig. 1, and taken on the multiple plane section line 2—2 of Fig. 1;

Fig. 3 is a plan section on the multiple plane section line 3—3 of Fig. 1;

Fig. 4 is a fragmentary diagrammatic view (in the nature of an elevation at 4—4 of Fig. 6) illustrating the arrangement of the superheater tubes and header chambers to provide a plurality of steam passes in the superheater;

Fig. 5 is a fragmentary view in the nature of an elevation on the line 5—5 of Fig. 6, of the superheater headers, showing their arrangement, supports, and operative connections;

Fig. 6 is a fragmentary plan showing the arrangement of the cross-connected U-tubes connecting the different superheater headers;

Fig. 7 is a fragmentary end elevation (on the line 7—7 of Fig. 6) of the superheater tubes and headers indicated in Fig. 6;

Fig. 8 is a fragmentary view showing the manner in which some of the superheater headers are secured together in upright positions and in end to end relationship;

Fig. 9 is a fragmentary elevation of the cross-connected superheater platens of another embodiment of the superheater;

Fig. 10 is a detail elevation showing one arrangement of tubes in alternate superheater platens in the embodiment of Figs. 9, 12 and 13;

Fig. 11 is a detail showing of the tubes in the Figs. 9, 12 and 13 superheater platens arranged alternately with respect to the Fig. 10 platen arrangement;

Fig. 12 is a diagrammatic view in the nature of an end elevation of tubes and header arrangement of the Fig. 9 superheater embodiment indicating the Fig. 11 superheater platens and omitting for the sake of clarity, the Fig. 12 superheater platens; and

Fig. 13 is a view similar to Fig. 12, but omitting the Fig. 11 superheater platens, and indicating the Fig. 10 superheater platens.

The fluid heat exchange apparatus illustrated as a vapor generator in Fig. 1 of the drawings includes a fuel fired furnace **10** from which the gases pass rearwardly over spaced groups **12** and **14** of upright vapor generating tubes. These tubes deliver vapor and liquid mixtures to the vapor and liquid chamber provided by drum **16** and the tubes are connected at their lower ends to the water or liquid chamber formed by the lower drum **18**.

Within the space between the groups of steam generating tubes there is disposed a bank of superheater tubes formed by U-tubes arranged as illustrated in Figs. 3, 6, and 7. These U-tubes are connected at their ends to different sets of small diameter headers, the arrangement and construction of which is specifically illustrated in Figs. 3 to 8 inclusive. These superheater headers and tubes are arranged to provide for four steam or vapor passes from the inlet of the superheater to its outlet. Steam flows from the drum **16** through the saturated steam conduits **20** and **22** (Fig. 1) to the inlet headers **24** and **26** which are small diameter steel headers secured in contact along adjacent flattened sides as indicated at **29** in Fig. 6. The inlet header **24** has an upper inlet chamber **28** separated from a lower inlet header chamber **30** by a diaphragm **32** and a similar diaphragm **34** separates upper and lower chambers **36** and **38** of the inlet header

26. The inlet chambers 28 and 36 of the inlet are connected by the U-tubes to intermediate headers 40 and 42. The vapor flow from the inlet header chambers 28 and 36 to the first intermediate headers 40 and 42 constitutes the first of the vapor passes, and the particular arrangement of U-tubes in this pass will be later discussed.

In the second vapor pass of the superheater, vapor flows to the lower parts of the intermediate headers 40 and 42 through a similar arrangement of U-tubes to the lower chambers 30 and 38 of the inlet headers 24 and 26. This constitutes the second vapor pass of the superheater.

The chambers 30 and 38 are header chambers and they are also chambers in one of the intermediate vapor passes. Hence, they may be referred to as intermediate header chambers.

In a third superheater vapor pass, vapor flows from the lower parts of the chambers 30 and 38 of the headers 24 and 26 to intermediate headers 44 and 46 which are secured to and in vertical alignment with the intermediate headers 40 and 42. The headers 44 and 46 are of the same diameter as the headers 40 and 42 and are arranged in a similar manner relative to each other. The particular manner of securing the headers 44 and 46 to the headers 40 and 42 and the relation is illustrated in Figs. 5, 6, and 8. For such securement, each header 40 and 42 has radial lugs such as 48 and 50 (Fig. 8) welded thereto and corresponding lugs 52 and 54 are welded to the upper ends of the lower headers 44 and 46. These lugs are aligned and are secured together by means illustrated at 56 and 58.

Short superheater outlet headers 60 and 62 are secured to the lower ends of the inlet headers 24 and 26 in the same manner as that in which the headers 44 and 46 are secured to 40 and 42, and for the fourth vapor pass the lower parts of the headers 44 and 46 are connected to the headers 60 and 62 by an arrangement of U-tubes such as those above mentioned. Superheated vapor passes from the headers 60 and 62 through the outlets 61 and 63 to a point of use.

Because of the higher temperature of the steam entering the outlet headers 60 and 62, these headers or the pertinent tubes are formed of steel of high heat resistance, such as stainless steel or steel usually referred to as "18–8". The headers 44 and 46 also may be formed of this material but the longer headers 24, 26, 40 and 42 do not attain such high temperatures as require this high cost steel. The cost of the original installation is materially reduced because of the illustrative small diameter header construction and because of the particular arrangement of the headers and tubes.

The first factor in the reduction of original cost flows from the use of a plurality of small diameter headers instead of a single large diameter header. For instance, for a certain inlet header capacity requirement, a single inlet header would not only have to be of greater diameter, but the wall thickness of the header would have to be much greater than the wall thickness of the small diameter headers, and for this reason the single header construction would have to involve a greater amount of the high cost alloy steel. The second factor in the reduction of the original installation cost resides in the header construction whereby the outlet headers are of short lengths, due to the overall arrangement of the superheater components, and are secured as separate elements to the inlet headers or intermediate headers.

Another advantage of the illustrative header construction is that it provides for effective accessibility to the ends of the U-tubes for seal welding through the handholes such as those indicated at 70 in Fig. 6. With this arrangement the ends of certain tubes of two rows of U-tubes are accessible through each handhole, and the entire circumference of each tube end may be readily seen through each handhole. Each handhole for the superheater headers is pressure sealed by closure means in-

volving elements 75—78, as illustrated in Fig. 6. The head 75 of the bolt 76 being somewhat oval shaped so that it may be inserted within the handhole opening and then turned 90° so that its flange 80 rests against the shoulder 82 in pressure tight relationship.

For attaining more uniform fluid and metal temperatures throughout the superheater, the U-tubes within each vapor pass of the superheater are arranged so that a number of U-tubes conduct vapor from a single header chamber to different header chambers, connected to the outlet ends of those tubes. For example, the U-tubes 90 and 92, as illustrated in Fig. 6, have their inlet ends connected to the header 24 and their outlet ends connected to the header 42 at 91 and 93. Next beneath the inlet ends of the tubes 90 and 92 are two U-tubes such as 94 and 96 which have their inlet ends connected to the header 24 and their outlet ends connected to the header 40 at 95 and 97, as indicated in Fig. 7.

Below the inlet ends of the tubes 94 and 96, there are other U-tubes similar in size and design to U-tubes 90 and 92 which connect the header 24 directly to the header 42. Thus, each chamber of the header 24 has even-numbered pairs of tubes connecting to a chamber in the header 40 and the intervening or odd-numbered pairs of tubes connected to a chamber in header 42. In a similar manner, each chamber in the header 26 is connected by alternate pairs of tubes to the headers 40 and 42. In the arrangement shown in Figs. 6 and 7, the pair of upper U-tubes 102 and 104 have their inlet ends connected to the header 26 and their outlet ends connected to the header 42 and 103 and 105, respectively.

Next below the inlet ends of the tubes 102 and 104 along the header 26, there are the inlet ends 108 and 110 of other U-tubes. These U-tubes have larger U-bends as indicated at 108′ and 110′ and they have their outlet ends 108″ and 110″ connected to the header 40.

The above indicated alternating arrangements of U-tubes and headers is repeated in the different vapor passes of the superheater so as to provide for effective mixing of vapor in the different U-tubes and the consequent prevention of overheating of individual tubes. This arrangement thus is characterized by effective equalization of metal temperatures.

The superheater header constructions above described are appropriately supported in the operative positions in which they are shown in the drawings. For such support purposes, Fig. 5 indicates a saddle 120 supported upon the drum 18, which in turn may be supported by pedestals 122 (Fig. 1). The lower end of the superheater headers is suitably secured to the saddle 120 as generally indicated in Fig. 5. At their upper ends the superheater header constructions are secured to steelwork such as that indicated at 124 and 126.

Within the bank of superheater tubes the latter are maintained in their operative relationships by upright large diameter tubes such as 130 connecting into the circulating system of the unit. These tubes have transversely extending lugs such as 134 secured thereto, for directly supporting the U-tubes of the superheater. For additional support and spacing, the superheater tubes may be threaded through openings in upright steel plates (not shown) in a manner well known in the art.

As indicated in Fig. 3 of the drawings the superheater headers are disposed within a chamber 139 extending from the plane of the furnace wall 140 and the inner boiler casing 142 to the plane of the outer casing generally indicated at 144. The chamber 146 for the superheater tubes and headers is sealed off from the space between these two casings by such plates as 145 and 147—151 and suitable connecting plates, and the header chamber 139 is closed by a removable outer casing section 154. The latter facilitates access to the superheater headers for maintenance and repair.

For sealing the space between the adjacent headers 42 and 26, vertically aligned sealing channels such as 156

are held tightly against those headers in the manner indicated in Fig. 6 of the drawings. At successive upright positions, lugs such as 160 are secured to the headers as by welding and the channels are secured to the lugs by bolts 162, wedging the channels into tightly fitting relation with the contacting headers.

Referring again to Fig. 3 of the drawings, access to the other end of the superheater is provided by a removable panel 164 of the outer casing and the aligned removable panel 166 of the inner casing. The latter is secured in gas-tight relationship to the adjacent panels 168 and 170 of the inner casing and the outer panel 164 is normally secured in gas-tight relationship with the adjacent panel 172 and 174 of the outer casing. The inner casing includes the end walls 176 and 178 and the outer casing includes the cooperating panels or sections such as 180—188.

The furnace is fired by burners such as 190 preferably disposed in the furnace wall 192 opposite a wall including the wall tubes 194 connected into the circulation of the unit through the lower header 196, upper header 198, and appropriate circulatory connections from these headers to the drums 16 and 18. For affording an adequate supply of water or other liquid to the lower drum 18, this drum is directly connected to the liquid space of the drum 16 by a plurality of large diameter downcomers such as 199, similar downcomers 200 connecting the lower drum 18 with the drum 16, all of the downcomers being preferably arranged within the spaces between the inner casing and the outer casing and at opposite sides of the unit as clearly indicated in Fig. 3. Similarly arranged within such spaces at opposite sides of the installation are the downcomers 210 connecting the drum 16 with the lower header 216 for the wall tubes 218 of the front furnace wall 219 which are connected directly to the drum 216 as indicated in Fig. 1.

The furnace gases after passing over the steam generating tubes to the superheater tubes pass over the tubes of an economizer generally indicated at 220.

The modified superheater indicated in Figs. 9 to 13 inclusive is one which may be substituted for the previously described superheater, and in the vapor generating setting as disclosed in the drawings and described above. Like the described superheater, the superheater of Figs. 9 to 13 has a plurality of vapor passes and it has an arrangement of upright small diameter superheater headers adapted for disposition at one side of the gas pass.

The modified superheater also has a plurality of inlet headers cross-connected to a plurality of intermediate headers which, in the second vapor pass, are cross-connected by superheater tubes to a plurality of smaller outlet headers. The inlet headers are indicated at 240 and 241 in Figs. 9 to 13, and the intermediate headers are indicated at 242 and 243. Vapor flows from the inlet headers to the upper parts of the intermediate headers through multiple loop or continuous loop superheater tubes such as those indicated at 244—247, Fig. 9 being a composite view of the A platens of Fig. 10, and the B platens of Fig. 11 with these platens in adjacent operative positions. Inspection of these views will indicate that each A platen omits the tube 244 and each B platen omits the tube 247. The platens are disposed horizontally in parallel positions with the A and B platens alternating at successive levels through the height of the headers. This is indicated in Figs. 12 and 13 where Fig. 12 indicates by circular cross-sections of the superheater tubes the B platens only, the levels of the intervening A platens being indicated by intersecting centerlines. In Fig. 13, the positions of the A platens are indicated by the circles of the superheater tubes, and the intervening B platens are indicated by the crossed centerlines. From an inspection of Figs. 9 to 13, it will be seen that, in the first vapor pass of the superheater, vapor flows through the alternatively arranged A and B platens from the inlet headers 240 and 241 to the upper parts (or intermediate header chambers) of the intermediate headers 242 and 243. In the B platens vapor flows from the inlet header 240 through the tubes 244 and 245 to the intermediate headers 242 and 243, the tube 244 leading through its loops to the intermediate header 243 and the tube 245 leading through its similar loops to the header 242. From the inlet header 241 a single tube 246 leads through similar loops to the intermediate header 242. Immediately beneath each B platen is an A platen which has multiple loop superheater tubes 245' and 246' corresponding to 245 and 246 of each B platen, but omits a superheater tube corresponding to 244 and adds the superheater tube 247. In the A platens, vapor flows from the inlet header 240 through the tube 245', with its multiple loops, to the header 243. From the companion inlet header 241, vapor flows from the superheater tube 246' to the intermediate header 243. The superheater tube 247 conducts vapor from the inlet header 241 to the intermediate header 242. In the succeeding vapor pass the superheated vapor flows from the lower chambers of the intermediate headers 242 and 243 to the superheater outlet headers 255 and 256 which are secured directly beneath the inlet headers 240 and 241 in a manner similar to that described with reference to the outlet headers 60 and 62 of the first superheater embodiment. The lower parts of the intermediate headers are connected with the outlet headers 255 and 256 by alternating A and B platens of the same structure and characteristics as those above described with reference to the first vapor pass.

Thus, in each vapor pass there is a plurality of small diameter headers cross-connected by superheater tubes to a plurality of intermediate or outlet header chambers. Also, from each header chamber at the inlets of the superheater tubes for each pass, there are immediately adjacent tubes leading from a single inlet header with one of the adjacent tubes having its outlet connected to one other header chamber and the other of the adjacent tubes having its outlet end connected to a different header chamber. This arrangement is regarded as a characteristic which is common to both superheater embodiments.

The inlet headers of the Figs. 9 to 13 embodiment are supplied with vapor in a manner similar to that of the first superheater embodiment and the outlet headers of the second embodiment have superheater vapor outlet tubes similarly leading from the headers 255 and 256 to a point of use. The superheater tubes of the second embodiment are also intended to be supported in a vapor generating unit in a manner similar to the support of the tubes of the first embodiment.

The headers 240—243, 255 and 256 of the second superheater embodiments are intended to be disposed in an access chamber similar to that indicated at 139 in Fig. 3 with the spaces between the headers closed in a similar manner. In this connection, it is to be noted that, with removable spaced closure elements between headers 241 and 242, access may be readily had to the intermediate loops of the superheater tubes of the second embodiment.

The illustrative arrangement of the superheater tubes and headers provides for effective mixing of the fluid in each pass without the use of intermediate external cross-over junction headers or other connectors between passes as this is accomplished within the unit by the specific arrangement of the tube and header flow paths used for the superheater proper.

The illustrative arrangement of the superheater tubes and headers also reduces the number of rows of tubes attached to each header or header chamber, thereby providing a reduced header size with reduced thermally created stresses under the high temperature conditions.

The illustrative arrangement of the superheater tubes and headers permits a multiplicity of steam passes to be used in a given unit with a limited number of tube rows per header without excessive steam pressure drop. This

is due to the relatively large flow area obtained through the tubes and the short length of steam path through each tube.

The use of the pertinent multiplicity of steam passes has the effect of keeping the quantity of higher grade tube alloys to a minimum due to the division of the unit into a number of paths which more nearly fit the temperature gradients; due to the velocity of the steam in each pass; and due to tube spacing. The invention allows more control of these factors by the designer as fluid pressure drop characteristics are not as restricting as in other cases which involve a large number of tube rows per header and do not have the pertinent multiplicity of steam passes.

The illustrative arrangement also permits all tubes to have straight legs without bends, allowing installation and removal of the tubes through fixed superheater tube supports.

For constructional reasons, particularly in assembly and especially where tube ends are welded to the headers, it is desirable to keep the number of rows of tubes to a minimum in each header. This permits the maximum degree of accessibility to the header tube ends through the handhole openings. This is accomplished in this illustrative unit by paralleling a divided steam flow through the superheater headers and tubes, providing for equalization of steam pressure and temperature conditions by intermixing due to the peculiar tube and header arrangement.

As the thickness of superheater tubes is greatly dependent upon metal temperatures for any given material, it is desirable to keep the metal temperatures to a minimum. This is accomplished in the illustrative unit without sacrificing the advantages of multi-steam passes and without introducing excessive fluid pressure drops. The steam velocity especially in the hotter steam passes is under control, and this steam velocity is an important factor in the ultimate metal temperatures encountered. In particular, the outlet passes where the highest grade alloys are encountered can be made small with a minimum of heating surface and number of tubes, without having an excessive pressure drop through the overall superheater.

It is to be understood in the consideration of this invention and in the terminology employed in the description that many terms are used primarily for the purpose of description and are not to be taken as limitations. For example, the general installation may be referred to as a steam generator, and the superheater may be referred to as a steam superheater. Likewise, the upper drum may be referred to as a steam and water drum. It is also to be understood that the use of the installation may involve liquids other than water, and the installation is to be considered generally a vapor generator or other fluid heat exchange installation. As a further example the superheater construction is to be considered as equally advantageous in vapor heating installations such as those which might be employed in chemical industries or in oil refineries.

As to specific terminology, pertinent to the invention, reference will first be made to the disclosure of Figs. 4 and 5. In each of these figures there may be said to be two upright header assemblies, with each assembly including two header columns. Each header column includes an upper header and a lower header in end to end relationship and in upright alignment. The entire header structure of Fig. 4 or Fig. 5 may be considered as means presenting inlet header chambers and outlet header chambers arranged externally of a heat exchange zone and at the same side thereof. When the header chambers are considered from the standpoint of steam or vapor flow, each steam or vapor pass has a plurality of inlet header chambers, and a plurality of outlet header chambers. However, when all of the steam passes are considered as a part of the total steam flow, there are inlet header chambers at the top of the two header columns, at the upper left corner Fig. 4 and two final outlet header chambers at the lower left part of Fig. 4. Between the initial inlet chambers, and the final outlet chambers there are, of course, a plurality of pairs of intermediate header chambers, and these may be referred to as different groups of intermediate header chambers.

With reference to pertinent terminology relating to the superheater tubes connecting the plural inlet header chambers to the plural outlet header chambers reference is made to Figs. 12 and 15. Here, two inlet header chambers are shown connected to two outlet header chambers by two types of platens. Fig. 12 shows the "B" platens the individual structure of which is indicated in Fig. 10. Fig. 13 shows the "A" platens which are further indicated in Fig. 11. These platens may be also referred to as groups of tubes and the expression "groups" may refer to a plurality of platens in any single steam path.

The gas pass for the superheater tubes may be also referred to as a heat exchange zone.

While the invention has been described with reference to the specific embodiment illustrated in the drawings, it is to be understood that it is not to be taken as limited to all of the details thereof. It is rather to be considered as of a scope commensurate with the scope of the subjoined claims.

What is claimed is:

1. Convection fluid heat exchange apparatus including first and second contiguous inlet headers in one group, first and second contiguous outlet headers in another group spaced from the first group, means forming a gas pass, and pairs of return bend tubes connecting said headers and forming a bank of spaced tubes across the gas pass, said pairs including a plurality of pairs of tubes leading from the first inlet header with one tube of each of the latter pairs having its outlet end connected to the first outlet header and the outlet end of the second tube of the same pair connected to the second outlet header, said pairs also including other pairs of tubes leading from the second inlet header with one of the tubes of each pair having its outlet end connected to the first outlet header and the other tube of the same pair having its outlet end connected to the second outlet header.

2. In multiple fluid pass fluid heat exchange apparatus, spaced apart groups of separate and contiguous small diameter tubular headers presenting two paired inlet header chambers in one group and two paired and separate small diameter outlet header chambers in another group for each fluid pass, a multiplicity of pairs of return bend tubes forming a bank of spaced tubes across the gas pass for each fluid pass, each pair of tubes of a total of about one-half of all of the pairs of tubes for each fluid pass leading from a first inlet header chamber with one tube of each pair having its outlet end connected to a first header chamber and a second tube of the same pair connected to a second outlet chamber, each of the remaining pairs of tubes for the same fluid pass leading from the second inlet header chamber with one of the tubes of that pair having its outlet end connected to the first outlet header chamber and the other tube of the same pair having its outlet end connected to the second outlet header chamber, means for delivering a liquid to be added to said inlet header chambers, and means for conducting the heated fluid for the outlet header chambers of the last fluid pass.

3. Convection fluid heat exchange apparatus including first and second paired and contiguous inlet headers in a first group, first and second paired and contiguous outlet headers in a second group spaced from the first group, means forming a gas pass, pairs of return bend tubes connected to said headers in a cross-over arrangement and forming a bank of spaced tubes across the gas pass, said pairs including a plurality of pairs of tubes leading from the first inlet header with one tube of each of the latter pairs having its outlet end connected to the first outlet header and the second tube of the same pair connected to the second outlet header, said pairs also including other

pairs of tubes leading from the second inlet header with one of the tubes of each of the pairs having its outlet end connected to the first outlet header and the other tube of the same pair having its outlet end connected to the second outlet header, said headers presenting a plurality of inlet header chambers and a plurality of outlet header chambers for each of a plurality of series connected fluid passes in which the bank of tubes in a succeeding fluid pass conduct fluid transversely of the gas pass and in directions reversely related to the direction of fluid flow in the immediately preceding fluid pass, the tubes and header chambers of each fluid pass having an arrangement similar to the above specified cross-over arrangement, and separate tubular outlet headers for the last fluid pass secured in end-to-end relation to the headers of one of said groups of headers.

4. Convection fluid heat exchange apparatus including first and second paired and contiguous inlet headers in a first group, first and second paired and contiguous outlet headers in a second group spaced from the first group, means forming a gas pass, pairs of return bend tubes connected to said headers in a cross-over arrangement and forming a bank of spaced tubes across the gas pass, said pairs including a plurality of pairs of tubes leading from the first inlet header with one tube of each of the latter pairs having its outlet end connected to the first outlet header and the second tube of the same pair connected to the second outlet header, said latter pairs also including other pairs of tubes leading from the second inlet header with one of the tubes of each of the pairs having its outlet end connected to the first outlet header and the other tube of the same pair having its outlet end connected to the second outlet header, said headers presenting a plurality of inlet header chambers and a plurality of outlet header chambers for each of a plurality of series connected fluid passes in which the bank of tubes in a succeeding fluid pass conduct fluid transversely of the gas pass and in directions reversely related to the direction of fluid flow in the immediately preceding fluid pass, the tubes and header chambers of each fluid pass having an arrangement similar to the above specified cross-over arrangement, a separate pair of tubular outlet headers for the last fluid pass secured in end-to-end relation to the headers of said second group of headers, and a separate pair of tubular headers secured in end-to-end relation to the headers of the first group of headers and presenting the inlet header chambers for the last fluid pass.

5. In multiple fluid pass convection fluid heat exchange apparatus, a first pair of adjacent and parallel separate small diameter headers in a first header group, a second pair of adjacent and parallel separate small diameter headers in a second header group spaced substantially from the first group, each of said headers of the first pair having a transverse diaphragm intermediate its length to provide separate header chambers therein, a third pair of adjacent and parallel separate small diameter headers arranged in end to end relation to the headers of the first pair and presenting inlet header chambers for the last fluid pass, a fourth pair of adjacent and parallel separate small diameter headers arranged in end to end relation to the headers of the second pair and presenting outlet header chambers for the last fluid pass, means forming a gas pass, and pairs of return bend tubes connecting the header chambers and forming banks of spaced tubes across the gas pass, said pairs of tubes including in each fluid pass a plurality of pairs of tubes leading from a first inlet header chamber of one pair of headers with one tube of each of the latter pairs having its outlet end connected to a first outlet header chamber of another pair of headers and the outlet end of the second tube of the same pair connected to the second outlet header chamber of the other pair of headers, said plurality of pairs of tubes including in the same fluid pass other pairs of tubes leading from the second inlet header chamber of the same pair of headers with one tube of each of the latter pairs having its outlet end connected to the last mentioned first outlet header chamber and the other tube of the pair having its outlet end connected to the last mentioned second outlet header chamber, said arrangement of pairs of header chambers and connecting tubes constituting a cross-over arrangement for each fluid pass with the successive fluid passes arranged for series flow from the first pair of headers to the fourth pair of headers.

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