Aug. 18, 1959 O. S. McGUFFEY 2,900,175

PLATE HEAT EXCHANGE UNIT

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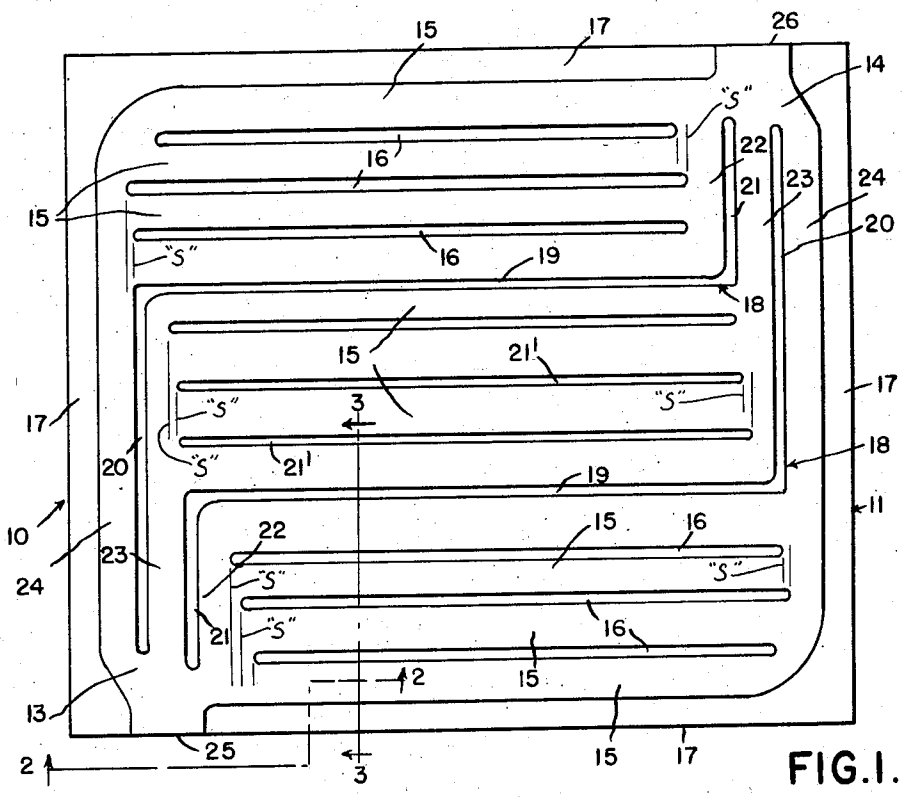


FIG.1.

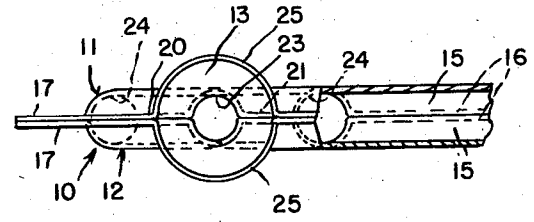


FIG.2.

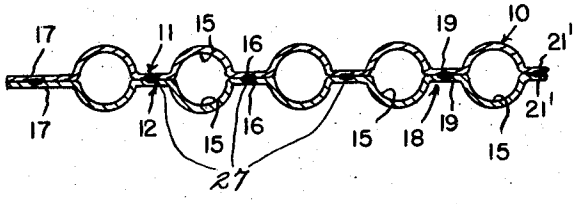


FIG.3.

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FIG. 4.

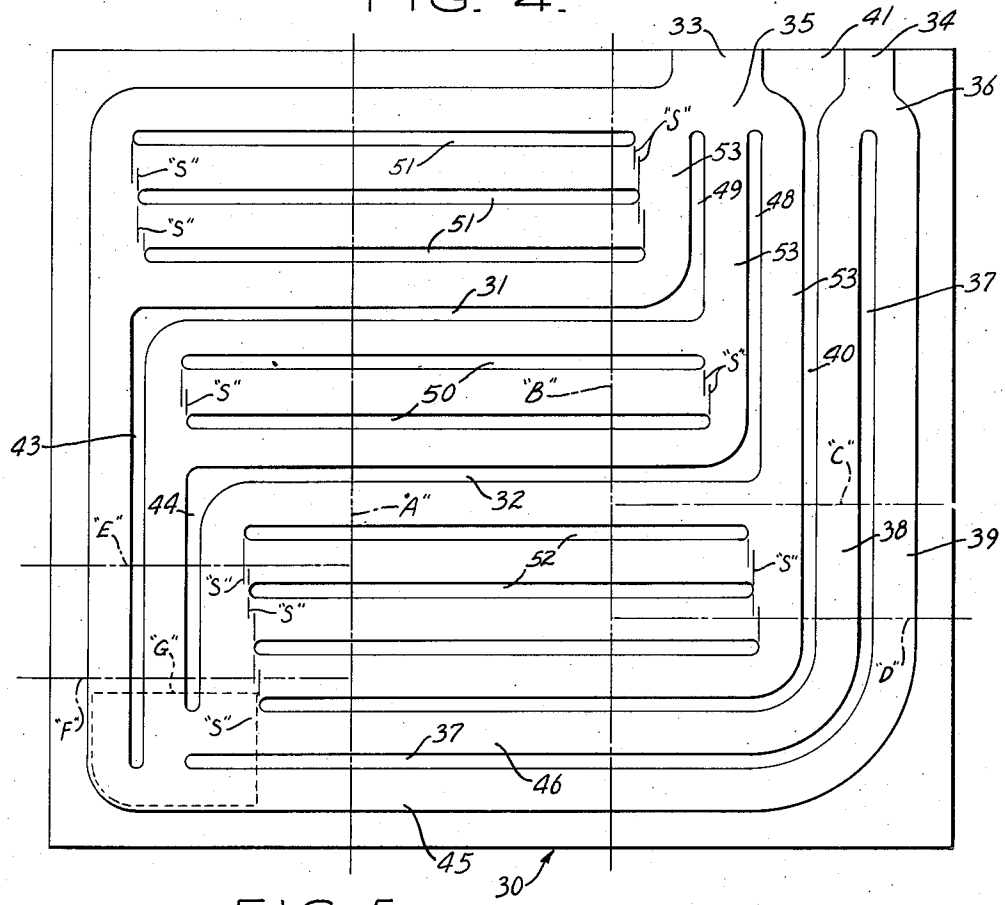
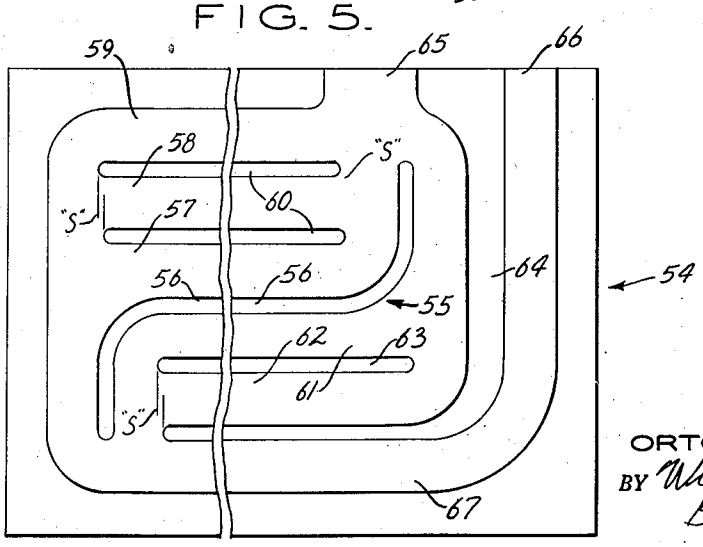


FIG. 5.



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FIG. 6.

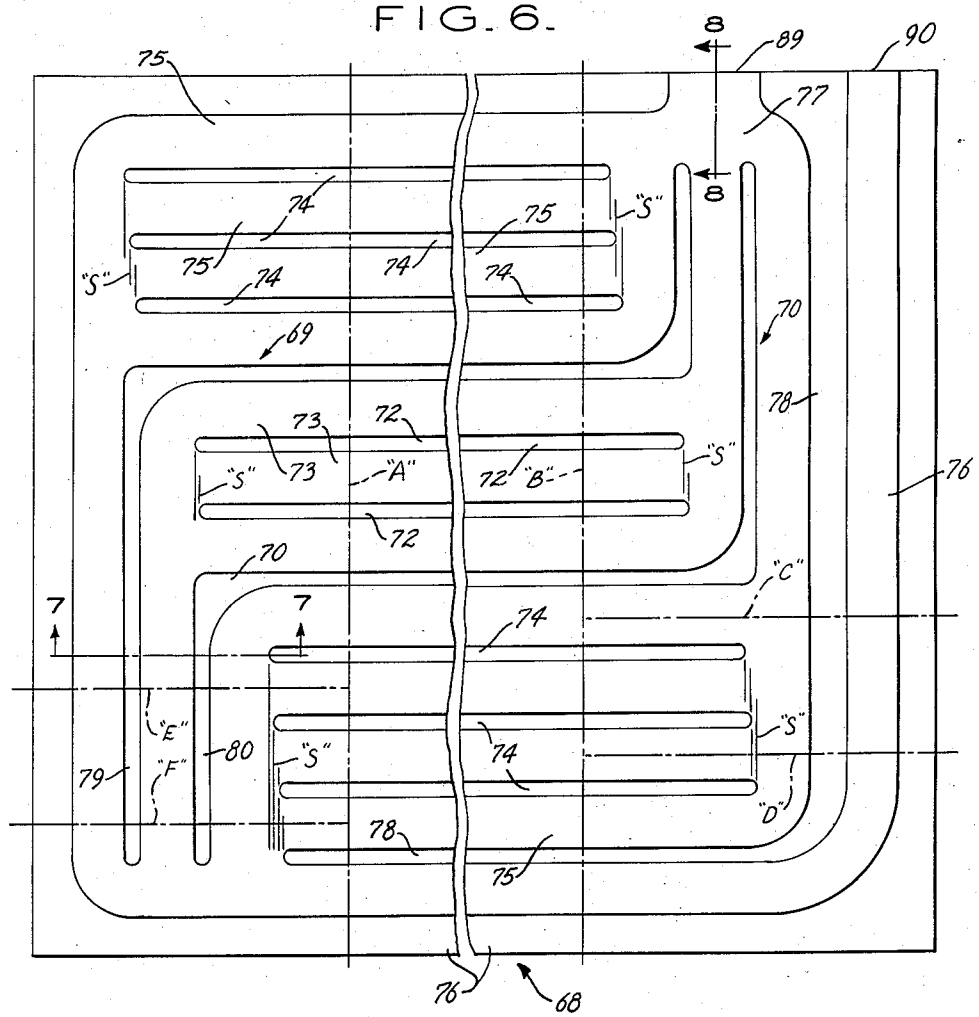


FIG. 7.

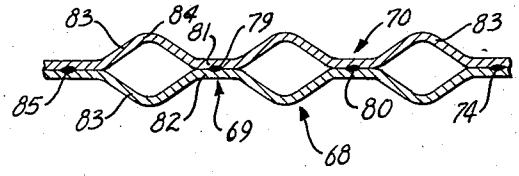
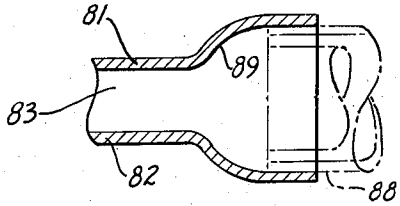


FIG. 8.



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FIG. 10.

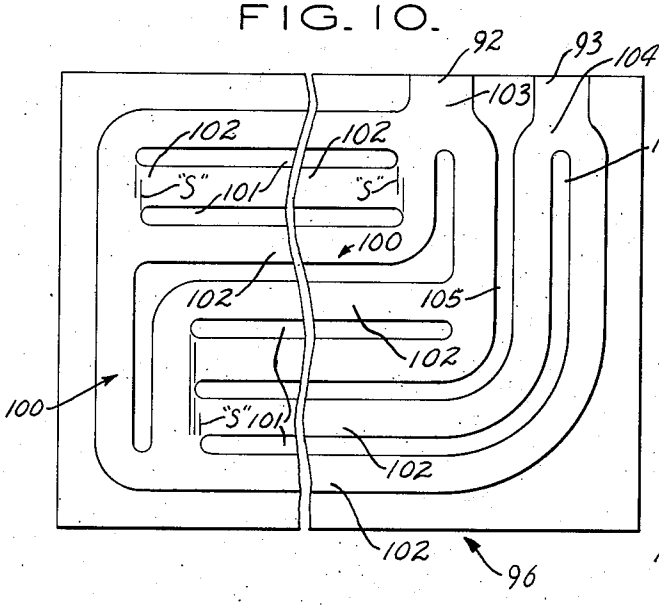


FIG. 9.

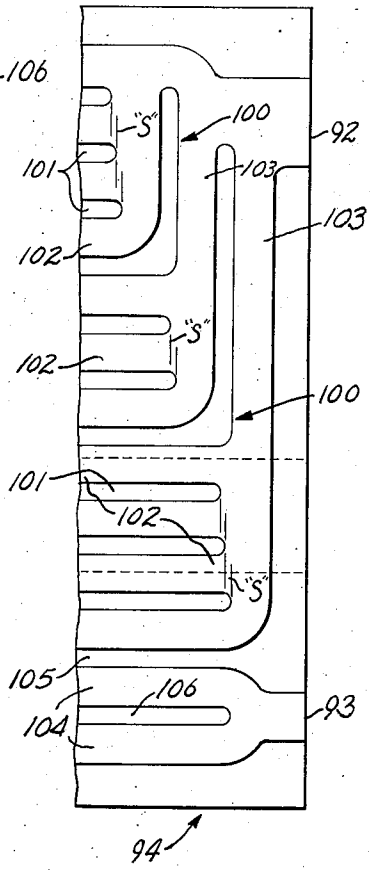
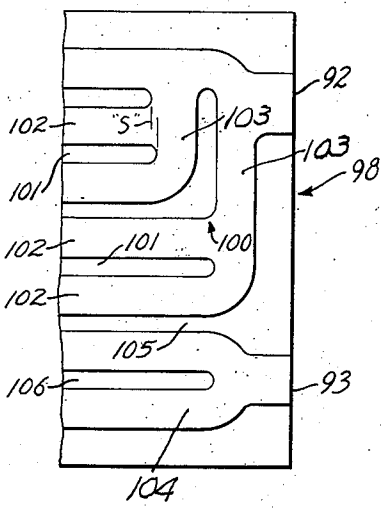


FIG. 11.



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FIG. 12.

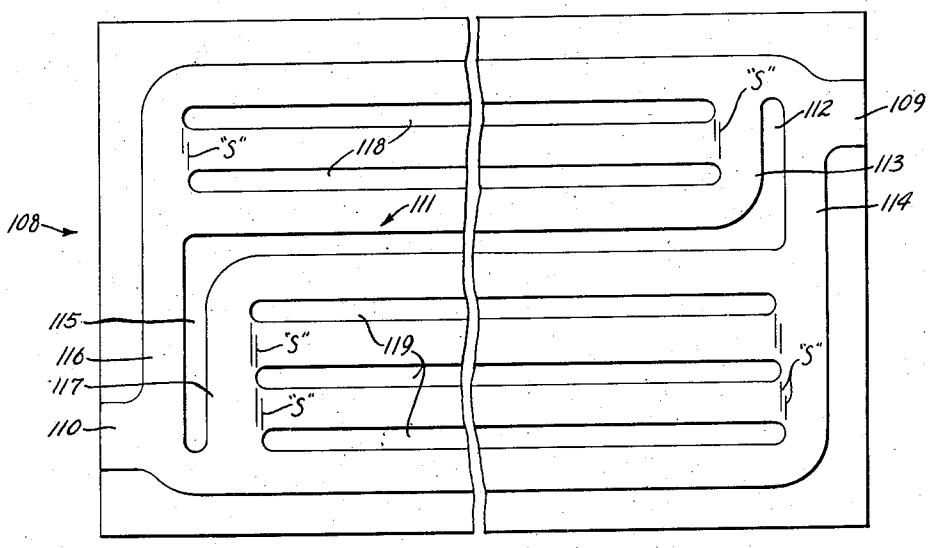


FIG. 13.

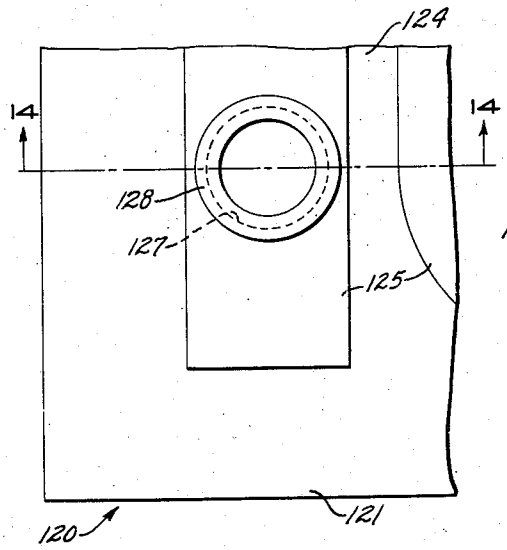
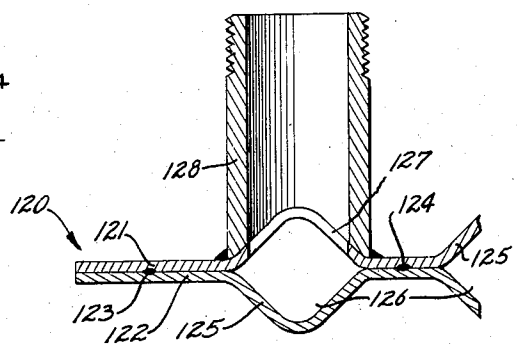


FIG. 14.



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PLATE HEAT EXCHANGE UNIT

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Application March 28, 1958, Serial No. 724,749

30 Claims. (Cl. 257—256)

The present invention relates to an improved plate-type heat exchange unit having a built-in circulatory coil. Units of this type are commonly and widely employed as immersion heaters for liquid tanks or like vessels in which a variety of processing operations are performed. The present application is a continuation-in-part of my copending application, Serial No. 534,925, filed September 19, 1955, now abandoned.

Internal coil type plate heat exchange units as heretofore fabricated commonly have transverse header and longitudinal distributory ducts or passages separated from one another along weld zones at which the plates of the unit are secured in facing relation, the transverse header ducts communicating with and being of greater width than the longitudinally extending circulatory passages for greater flow handling capacity. It follows that the welded plate connections on either side of the headers are necessarily loaded considerably more heavily by the pressure of the heat transfer fluid than other welds, as those spanned by the plates at the longitudinal passages. In consequence, it is a common occurrence for welded zones on one or the other side of the header, or between the header and the ends of the longitudinal welds, to tear free under beam loading stress and destroy the unit locally, rendering it useless.

There is also another operational drawback in plate units of this type, in that the distribution and flow of the heat transfer medium (and its condensate in the case of a heater) from header to circulating or distributor passages, and vice versa, has usually not been uniform and smooth. The pressure fluid may be unduly directed into one set of passages, resulting in bypassing of others and non-uniform thermal transfer across the surface of the unit.

A uniformly distributed, non-turbulent and smooth flow of a heating medium through a heat transfer unit is, of course, to be desired, but equally desirable is a flow of its condensate through and out of the unit in the easiest and most expeditious manner. Upon entering any given duct or passage of the unit the heating medium, for example, steam, condenses as it traverses the passage and forms as a film on the inner surface of the latter; and the principle underlying the present invention is that this condensate film, if it builds up to an excessive degree, detracts from the efficiency of heat transfer through the wall of the passage to as great or greater extent as external fouling of the unit. This principle is given effect, in the unit, according to the several embodiments of the invention by devising internal weld formations, at which the constituent plates of the unit are secured to one another, of such shape and disposition as to subdivide the interior of the unit into two or more independent sets of passages, each independently receiving a metered proportion of the heating medium at the unit's intake, and each conveying the medium in independent fashion, and without interference, along parallel paths to a discharge portion of the plate unit.

Reaction of the condensate film to heat transfer is greatly dissipated, since it is pushed along the paths of the respective sets in a much easier and more rapid way.

It is therefore one of the general objects of the present invention to provide an internal coil-type plate heat exchange unit adapted to internally circulate a fluid heat exchange medium under relatively high pressure and with optimum thermal efficiency; and to these ends the unit has improved provisions to increase its pressure containing ability by diminishing the distance of area bridging welds, thus reducing internal beam loading stress under pressure.

Coupled with this is the further general object of improving the distribution and flow of the pressure fluid and condensate through the unit, thereby to improve efficiency in a marked degree. This is accomplished by improved provisions both to insure a uniform distribution of the heat exchange medium, upon initial entry, into several distinct sectors of the unit, and to insure the flow of the medium and its condensate through these sectors in independent, preferably parallel paths, without any possibility of interference or starving any one heat transfer area of the unit as compared with another, and thereby retarding the transfer action of the unit as a whole. Condensate film at the internal transfer surfaces is thus dissipated with ease and rapidity; and the result is an average improvement in efficiency of from 22%–27% as compared with prior plate type coil units of corresponding capacity.

In general, the plate unit of the invention is constructed of embossed plates welded together to provide the necessary transverse header and longitudinal circulatory or distributor passages or ducts, in which an improved scheme of welding the plates makes possible the better pressure containment and fluid distribution mentioned above.

In accordance with the invention, the transverse header and longitudinal circulatory or distributor formations, as embossed in the individual component plates of the heat exchange unit, are separated by internal weld zones, including zones of generally Z-shaped outline, whereby no internal circulatory passage in the unit is unsupported across a materially greater width than any other passage or duct portion. This signifies that, under a given high internal pressure, no duct formation, in particular in the header duct portions of the unit, is loaded, in the manner of an end supported beam, under a total fluid pressure force materially in excess of that acting on any other duct formation.

At the same time the generally Z-shaped weld zone or zones which in part function to afford the desired divided header feature are so devised as to define independent sets of distributor passages producing the desired improved uniformity of the heat distribution by better dissipating the action of condensate film in resisting heat transfer at the internal surfaces of the plate.

More specifically, it is an object of the invention to provide a plate-type heat exchange unit of the above character, in which longitudinally extending circulatory or distributor passages are separated by longitudinally extending weld zones at which the constituent shaped plates are secured to one another; and in which certain of these weld zones have extensions in the form of transversely extending, preferably right angled weld zones at the opposite ends thereof which lie in and subdivide intake or discharge header ducts or passages.

This arrangement not only has the advantage of producing the improved pressure containment and distribution of fluid flow mentioned above, but also improves the heat transfer unit structurally, particularly as regards its manufacture in an overall arcuate or circular outline for certain special installations. The subdividing of the

intake and discharge headers makes it possible to keep the unit flat at its intake and discharge areas, i.e., with the outer plate surfaces no farther apart in these zones than their outer surfaces at which the embossments forming the circulatory passages are formed. Thus, the split header affords adequate and uniform fluid handling capacity and pressure containment comparable to those of a non-split header design, and it can be roll formed to arcuate outline, whereas this is impractical in a unit in which headers of adequate capacity necessarily flare outwardly substantially beyond the remainder of their embossed surfaces.

The foregoing as well as other objects will be made more apparent as this description proceeds, especially when considered in connection with the accompanying drawings, wherein:

Fig. 1 is a top plan view of a plate-type heat exchange unit in accordance with one embodiment of the invention;

Fig. 2 is a fragmentary view in somewhat enlarged scale, partially in end elevation and partially broken away and in section, as along line **2—2** of Fig. 1;

Fig. 3 is a fragmentary, somewhat enlarged, view in transverse vertical section along the line **3—3** of Fig. 1;

Fig. 4 is a plan view of a unit in accordance with a modification of the principle of the invention as applied to a plate of a given capacity;

Fig. 5 is a plan view of another modification for a plate unit of a smaller size;

Fig. 6 is a broken plan view of an alternative form in a larger size;

Figs. 7 and 8 are fragmentary sectional views on lines **7—7** and **8—8**, respectively, of Fig. 6, showing typical details of plate sectioning of a sort different from that of Fig. 3;

Figs. 9, 10, 11 and 12 are broken and partial views of still further modified embodiments of the invention in plate units of different sizes and fluid capacities;

Fig. 13 is a fragmentary plan view showing a plate unit in accordance with a further modification, in which a header opens transversely of the unit, rather than through an edge margin thereof; and

Fig. 14 is a fragmentary section on line **14—14** of Fig. 13.

The improved built-in coil, plate-type heating unit in accordance with one embodiment of the invention shown in Figs. 1, 2 and 3 is generally designated by the numeral **10**. It is fabricated in its entirety of a pair of like sheet-metal plates **11, 12** of a suitable rigid material resistant to erosion, or chemical attack by the liquid which it is intended to heat or cool, as an immersion type unit, as well as by the fluid which is internally circulated in unit **10** as a heating or cooling agent.

In accordance with the invention as shown in Figs. 1–3, the plates **11** and **12** are embossed to provide vertical or transverse intake and discharge header formations, generally designated **13, 14** in Fig. 1 and connecting horizontal or longitudinal circulatory and distributor duct or passage formations **15** which open at their opposite ends to the respective duct formations **13, 14**.

The plates **11, 12**, in which these formations are incorporated by an embossing operation, are identical, the functions of the header duct formations **13, 14** being interchangeable. Thus, as illustrated, there are three horizontally or longitudinally extending weld zones **16** adjacent the top and bottom of each plate, as viewed in Fig. 1, which parallel one another in equally spaced relation to partially define four horizontally or longitudinally extending distributor passage formations **15**. As will be understood, these weld zones lie coplanar with one another and with a flat marginal flange **17** which extends around the sides and ends of each of the plates **11, 12**. The longitudinal, coplanar weld zones or formations terminate in a predeterminedly spaced relationship, approximately equal to the spacing of the zones **16** from one another, to the flange **17** at one end of the plate.

In accordance with the invention, a pair of special, angularly shaped weld zones or formations of approximately **Z**-shaped outline are provided on each of the plates **11, 12**, inwardly of the series of three parallel formations **16** described above, these special formations being designated **18** and having the function of subdividing the respective vertical or transverse header formations **13, 14** to improve pressure containment and circulatory efficiency in the manner contemplated by the invention, as generally described above.

Each of the special formations **18**, which are exactly similar to one another, includes a horizontally or longitudinally extending weld zone length **19** arranged parallel to the weld formations **16** and of somewhat greater length than the latter; a first and longer, vertically or transversely extending header subdividing formation **20** integral with and at a right angle to the longitudinal portion **19**; and a second and shorter, vertical or transverse formation **21** in a similar right angle, integral relation to the formation **19**.

As illustrated in Fig. 1, the special **Z**-shaped weld formations **18** are in a nested relationship to one another, spaced by an intermediate set of intervening parallel straight weld zones **21'** similar to the sets of zones **16** on either outer side of the formations **18**, but offset slightly in the longitudinal direction relative to the latter. Thus, the transverse portion **21** of each special intermediate formation **18** lies inwardly of, and in spaced parallel relation to the longer transverse portion **20** of the other special formation **18**. The weld portions **20** are spaced inwardly of the respective marginal flanges **17** of the plate **11** or **12**, a distance approximately equal to the spacing of the ends of the respective straight weld zone formations **16** from the margins **17**; and the shorter transverse portions **21** are similarly spaced inwardly from the longer transverse portions **20**.

It will also be noted that the ends of the respective weld zones **16** and **21'** of the respective sets are longitudinally offset or stepped slightly relative to one another, in a manner and for a purpose to be described.

The effect of all of this is to subdivide the width of the respective intake and discharge header formations **13** and **14**, constituting in either of those formations three split header passage formations, **22, 23, 24**, which are defined between adjacent ends of each set of straight longitudinal weld formations **16**, a shorter transverse weld extension **21** of the special weld formation **18**, a longer transverse extension **23** of a formation **18**, and a coplanar end margin **17**.

In completing the improved plate **10**, the two plate components **11, 12** are placed in vertically registering relationship of their various respective weld formations **16, 18** and **21'**, which subdivide the center set of longitudinal passages and the sets on opposite sides thereof, and are then welded into a rigid internal coil assembly. An enlarged intake opening **25** of circular shape and substantial size is formed which opens through one side margin of the unit **10**, and a similar discharge opening **26** is formed to extend through the opposite side margin and adjacent the opposite corner of the unit **10**, in opposed relation to the opening **25**. However, such an angled relationship of the passages **23, 24**, featuring a **Z**-shaped intermediate weld or welds, is not essential in accordance with the invention, as the other illustrated embodiments make clear. The intake and discharge provisions may be arranged at a common side of the unit **10** or otherwise, in accordance with the requirements of the installation.

In the joining of the plates **11**, the margins **17** are preferably seam welded throughout their **L**-shaped lengths; whereas spot-welds are preferably employed in securing the internal zones **16, 18, 19, 20, 21** and **21'** of the two

plates to one another, as indicated by the reference numeral **27** in Fig. 3.

Such spot-welds will be formed at the extreme ends of each of the straight longitudinal weld zone formations **16** and **21'**, at spaced points along the length thereof, as well as at spaced points along the length of the special angled formations **18**, particularly along the respective shorter and longer transverse extensions **21, 20**, respectively, of the latter.

It is seen that a maximum width of any given transverse header passage subdivision **22, 23** or **24**, is no greater than the width of any longitudinal distributor passage defined by the trough-like longitudinal formations **15** of the coacting plates **11, 12**. The longitudinal spacing of welds **27** along the weld zones may be of the order of 5/16"–¾" in a unit wherein the transverse passage spacings are up to 1".

An integral built-in coil heat transfer unit, fabricated as described, at least cuts in half the bridge distance or spacing between spot-welds at critical points in its construction, hence, at least halves the total force acting on the metal between those welds to tear the same free. In this connection, it is desirable that the respective passage defining formations **15** of the plates **11, 12**, as well as the sectional outline of the passage subdivisions **22, 23, 24** of transverse headers **13, 14**, be of a curved circular section, so as to minimize possible whip action exerting increased stress on the critical weld points when the internal duct work of the unit **10** is pressurized. I have found that by following the principles set forth above it is possible to produce a heat transfer unit which will successfully withstand a fluid pressure of 1000 pounds per square inch, enabling the manufacturer to supply a unit of 200 pounds per square inch rating, with a 5 to 1 safety factor.

In addition to greatly improved pressure containment, the plate unit **10** secures a better and more even distribution of the fluid heating or cooling medium in circulating therethrough, hence better thermal efficiency at all pressures. The Z-shaped weld formations **18** properly apportion the pressure fluid entering the respective subdivided intake duct portions **22, 23, 24**, and distribute it properly for divided and entirely independent flow of it and its condensate through the several sets of longitudinal distributor passages defined by the intermediate weld zones **21'** and weld zones **16** on either outer side thereof.

This type of independent, parallel-path flow is of the greatest importance in that it facilitates and expedites the removal of condensate film forming within the passages. A heat medium, as steam, enters the divided or split header, is distributed as between the several sets of independent longitudinal passages, performs its function and condenses on the inner surfaces of the unit in the form of a film. However, the opposition of such film to rapid and efficient heat transfer is at a minimum, since there is a minimum opposition to its being pushed along the passages to the discharge header.

Further, in respect to the action at longitudinal circulatory passages **15**, it is to be noted, referring to Fig. 1, that the ends of the respective longitudinal weld zones **16** and **21'** of each set of welds are arranged, subject to limitations imposed at the corners of the plate unit, in a slightly offset or progressively stepped relation to one another in the longitudinal sense. This stepping is designated S in all embodiments. Thus, with the unit **10** disposed vertically as in Fig. 1, or in a 180° inverted vertical position (inasmuch as it is interchangeable as regards its intake and discharge), the stepped relationship of the weld zones **16, 21'** at their ends further improves the distribution into and through the respective longitudinal passages **15** of the three sets, by giving enlarged access to the inner passages. In short, throughout the entire area of the plate unit **10** there is no likelihood of local excess surface heating or cooling, due either to improper by-passing of an undue proportion of the incoming fluid or trapping a portion, or both.

Moreover, at the opposite, discharge ends of the respective passages **15** (left hand end as viewed in Fig. 1) the longitudinally offset or stepped relations at S also exist, but in the reverse sense (i.e., with the ends of weld zones **16** or **21'** offset slightly outwardly beyond the ends of zones therebeneath). By this feature the advantage is had that any condensate from an upper passage **15** will not drop into a passage therebeneath, or onto the weld zones **16** or **21'** of the latter passage. Erosion of the metal over a period of time by such drippage on a local zone is thus prevented. The overlap or stepping S is slight, in any of the embodiments shown, i.e., of the order of one sixteenth inch in a typical plate unit, and is shown exaggerated in the drawings for the purpose of clarity.

Fig. 2 of the drawings shows the enlarged header **25** of the embodiment under consideration. An advantage of subdividing the intake and discharge headers by the weld formations **18** is that not only does this permit adequate header capacity and pressure containment for a given size installation, it also enables the plates of the unit **10** to be kept flat at the intake and discharge areas, i.e., with their outer surfaces no farther apart than the outer surfaces of the various embossments forming the longitudinal passages **15**. To this end, the enlargement **25**, as well as that at **26**, may be formed by swedging the assembled plates to the desired size of intake or discharge mouth. It follows that the plate unit **10**, and other embodiments to be described, may be roll formed after assembly to one another in a desired arcuate outline of any desired radius, with the header openings being swedged after the roll-forming operation. This is a decided advantage over previous plate-type heat transfer units of non-split header construction and of corresponding header capacity and pressure containment. The outwardly flared header zones necessarily incorporated in such units make it impossible, as a practical matter, to roll form the latter for special tank installations.

Fig. 4 of the drawings shows an alternative embodiment of the principles of the invention, in that among other features the intake and discharge openings of the plate unit, which is generally designated **30**, are arranged to open through the same margin of the unit, in this case a longitudinal or horizontal margin, and, moreover, adjacent a corner end thereof. The unit **30** is fabricated of embossed sections secured to one another preferably by marginal seam welding and spot welding at the internal weld zones, as in Figs. 1, 2 and 3. Hence further illustration in respect of sectional details of this modification is not necessary. Sectional contours may be as shown in Fig. 3, or in the alternative as in Fig. 7, to be described.

The unit **30** of Fig. 4 may be typically produced in a rectangular outline of, say, 21 inches on its vertical or transverse dimension, and of any desired length in the longitudinal or horizontal direction. Thus, as a practical feature and in the interest of die standardization, it is practical in accordance with the invention to form the plates of the unit **30** by assembling die parts which will properly emboss the two opposite longitudinal ends of the plate in a desired outline of weld zones at either end of a central die portion, as in the area between the vertical dot-dash theoretical lines A and B of Fig. 4, and such central die portion may be furnished in any desired length to afford longitudinal weld formations determined by the size of the installation in question.

In a similar way, multiple die parts may be employed to form subordinate component parts of the two end portions on either outer side of the lines A and B. Such die parts may be, as determined by the weld contours at either plate end, of outlines such as are indicated between the horizontal dot-dash theoretical lines C, D and/or E, F.

It is seen that the principles of the invention afford great flexibility and versatility as to the operations of manufacturing plate units in any of the various designs and sizes represented in the embodiments of Figs. 1, 4, 5, 6, 9, 10 and 11.

In the form shown in Fig. 4 there are two of the Z-shaped internal weld zones **31, 32**, arranged in a nested relationship to one another similar to that of Fig. 1. An intake opening **33** and a discharge opening **34** of somewhat smaller size are shown, opening through the same upper corner margin of the plate unit **30**. Intake 33 is in communication with an intake header or duct, generally designated **35**, and the discharge opening **34** is in communication with a discharge header, generally designated **36**; and in this case the discharge header **36** is subdivided for improved pressure containment, as well as improved distribution of outgoing fluid and/or condensate flow, by a weld zone **37** of laterally inverted L-shaped outline. This zone defines the parallel discharge header passages **38, 39** of reduced width.

A further weld zone **40** of similar inverted L-shaped outline separates the discharge header **36** from the intake header **35**, terminating at an upper flared weld area **41** between the intake and discharge openings **33, 34**. Divider weld zone **40** parallels the zone **37**.

In respect to the remainder of the modified plate **30**, the arrangement of the Z-shaped welds **31, 32** is generally similar to what is shown in Fig. 1. This is subject to the exception that, of the two left hand downturned outer and inner legs or ends **43, 44**, respectively, of the Z-shaped formations, the former is brought farther down than the latter. Thus leg **43** controls the distribution of fluid or condensate into the bottommost of two discharge passages **45, 46** separated by the L-shaped divider **37**, while the other leg **44** acts similarly in respect to the uppermost passage **46** of the two.

As for the opposite upstanding, outer and inner legs **48, 49**, respectively, of the Z-welds **32, 31**, they terminate coextensively in the vertical sense, and substantially as shown in Fig. 1.

As indicated specially by dotted line in Fig. 4, the offsetting S of the ends of the longitudinal weld zones of the several sets, i.e., the zones **50** between the horizontal reaches of Z-formations **31, 32**, and the sets of longitudinal weld zones **51, 52** on either side of the latter, has the effect of better distributing the entry of pressure fluid from the subdivided passages **53** of intake header **35** to the respective sets. The offset or stepped relation S also better controls the flow at discharge, i.e., into the passages **45, 46** from the area G of generally rectangular outline shown in dotted line in Fig. 4.

It also prevents destructive erosion by dripping of condensate as mentioned above. The end extensions protrude beyond the vertical leg of the Z-section which separates one set of passages from the next one, thereby providing thorough access for all condensate into the entrance of the discharge outlet passages **45, 46**.

The unit **30** of Fig. 4 is one of good pressure-containing character and thermal efficiency, both factors governed in a large measure by the provision of the Z-shaped internal welds and the relationship of the longitudinal welds to them and to one another. Distances or area bridging successive weld points or zones are substantially uniform through the structure, with the result that beam loading action under high internal pressure is locally equal throughout. As regards thermal efficiency, the unit **30** is improved in this respect due to better condensate dissipation and control, having this advantage in common with all of the other illustrated embodiments.

Fig. 5 of the drawings depicts a heat transfer plate unit, generally designated **54**, of lesser dimension in the vertical or transverse sense than that of Figs. 1 and 4, but incorporating the basic structure of Fig. 4, and its operational advantages. Here, in view of the diminished size, a single Z-shaped central divider weld **55** is employed. It has a horizontal portion or length **56** separating a set of intake passages **57, 58, 59** thereabove defined by a set of longitudinal weld zones **60** from a further set of intake passages **61, 62** therebelow separated by the longitudinal weld zone **63** on the opposite side of Z-weld **55**.

A weld zone **64** of laterally inverted L-shaped outline, terminating in a flared marginal weld area between corner inlet and discharge openings **65, 66**, separates a condensate outlet passage **67** from the passages **57, 58, 59, 61, 62**. Weld offsets or steps S are present; and the operation of this modification is essentially the same, with corresponding advantages in point of pressure containment and thermal efficiency, as the two embodiments previously described.

The further modified embodiment shown in Fig. 6, is generally designated **68** and, as indicated by the dot-dash theoretical lines A—F, is capable of standardized production using the optional special dies for the several areas of the respective constituent plates of the unit, as governed by desired size and weld outline.

Since it is believed that the principles of the invention are now clearly understood from what has been described in connection with Figs. 1 through 5, the various relationships characterizing the plate unit **68** will be only generally referred to and identified by reference numeral.

Thus, two nested internal, Z-shaped weld zones are generally designated **69, 70**, with two horizontal or longitudinal weld zones **72** therebetween defining intermediate longitudinal fluid passages **73** in conjunction with the horizontal portions of the Z-welds **69, 70**. Sets of further longitudinal weld formations **74** and passages **75** are disposed on opposite sides of the latter.

As in Fig. 5, there is a single laterally inverted L-shaped discharge header or passage **76** separated from the divided header intake passage **77** by a weld zone **78** of inverted L-shape. It will be noted that the downturned ends or legs **79, 80** of the Z-welds **69, 70** terminate coextensively at the horizontal entrance of the discharge passage **76**, substantially in the horizontal line of the L-shaped weld zone **78**. Here again, the passage ends of the respective longitudinal weld zones **74** are offset, stepped or staggered at S for the advantageous effects of distribution and erosion prevention.

An optional sectional formation of two component plates **81, 82** of the unit **68** (or indeed any of the units shown), as an alternative to the section appearing in Fig. 3, is illustrated in Fig. 7. Duct or passage formations **83** are embossed which are of obtusely angled cross section, with the apices thereof mildly rounded at **84**, and the plates **81, 82** are secured together by the respective marginal seam and internal spot welds **85** and **89**, respectively. The result is a plate construction in which adequate flow capacity is had, while minimizing whip action likely to impose sudden and undue stress on the welds under heavy pressure.

Fig. 8 of the drawings shows an appropriate intake fitting **88**, in dotted line, as applied to the marginal intake opening of the plate unit **68** of Fig. 6, this opening being designated **89**, while the marginal discharge opening is designated **90** (Fig. 6). Openings **89** and **90** are preferably swedged to the desired size following the welding of the unit **68**.

Figs. 9, 10 and 11 of the drawings show three different contemplate embodiments of the invention in which the intake and discharge openings, in all three forms designated **92** and **93**, respectively, open through a common side margin of the plate structure. Thus, in the modification of Fig. 9 these openings are in substantially spaced vertical or transverse relation to one another adjacent the respective ends of a transverse margin of the plate unit, which is in this instance generally designated **94**. In the embodiment of Fig. 10, the openings are, as in

Figs. 4, 5 and 6, at a common longitudinal or horizontal margin of the plate unit, generally designated 96; while in Fig. 11 the plate unit 98 has an intake opening 92 and discharge opening 93 substantially spaced transversely from one another along one transverse margin.

In these three formations the principles of the invention are carried into effect by weld formations, headers, ducts and passages similar to those employed in the preceding forms. Thus, in order to avoid needless repetition, corresponding parts and relationships are in each form designated by corresponding reference numerals. These provisions include the Z-shaped weld formations 100, the longitudinal weld formations 101 and passages 102 defined thereby, the intake and discharge headers or ducts 103, 104, respectively, and the laterally inverted L-shaped weld formations 105, 106, one or both of the headers being equipped therewith, reducing the weld bridging distance. All three embodiments possess advantages in regard to pressure containment and improved efficiency by reason of improved uniformity of distribution of flow, as described in relation to the preceding modifications.

Fig. 12 illustrates a further modification in the form of a plate unit 108 of smaller size and simpler design than the embodiment of Figs. 1–3, but having in common with it the fact that the intake and discharge ports or openings 109, 110, respectively, are through diagonally opposed corner edge zones, in this case on the vertical or transverse edges. Like the form of Fig. 1 these openings may be interchangeably used. The intermediate Z-shaped weld formation 111 has a leg 112 subdividing the header to which port 109 opens into passages 113, 114; and its opposite leg 115 similarly subdivides the other header into passages 116, 117. Two independent sets of passages, on either side of Z-weld 111, are separated by the respective longitudinal welds 118, 119.

The improvements of the invention are not limited to plate structures in which the intake and discharge are through edge openings of the plate unit. Thus Figs. 13 and 14 show a typical installation in which a plate unit 120 has plates 121, 122 welded along marginal and interior lines 123, 124, and embossments 125 providing passages 126 of the sort shown in Fig. 7. One of these has a terminal portion at which the embossment 125 is apertured at 127 at 90° to the plane of the assembled plate unit 120. A tubular fitting 128 is appropriately shaped at its inner end to fit the embossment, and is welded or otherwise secured in pressure tight relation to the plate 121 about the aperture 127.

This type of plate unit is suitable for special installations in which a marginal header opening is not practical or desirable; and the plate unit 120 of Figs. 13 and 14 may be considered to incorporate all of the other structural features described and shown in the other figures.

What I claim as my invention is:

1. A built-in coil type heat transfer unit for immersion heating and related heat transfer operations involving the circulation through the unit of a heat transfer fluid under substantial pressure, said unit comprising a pair of sheet metal plates assembled in face-to-face relation and marginally sealed fluid tight to one another, at least one of said plates being formed to provide between the plates tubular, transversely extending intake and discharge headers and tubular, longitudinal distributor passages located between said headers, said headers respectively communicating with intake and discharge openings through the sealed plate margin, said longitudinal distributor passages being separated from one another and into sets, including a center set and sets on opposite sides thereof, by zones of substantially Z-shaped outline along which said plates are secured to one another, which zones terminate substantially short of the respective opposite ends of the plates between which said sets are disposed, there being a pair of such secured zones located between said intermediate set of longitudinal passages and the respective sets of passages on opposite sides thereof, which pair of secured zones are provided with transverse extensions at their opposite ends located in said respective headers, said extensions subdividing said headers into header passages of lesser width at the ends of said longitudinal passages and said plates being secured together along said transverse extensions to reduce the fluid pressure beam loading of the plates in the zones of said headers.

2. A built-in coil type heat transfer unit for immersion heating and related heat transfer operations involving the circulation through the unit of a heat transfer fluid under substantial pressure, said unit comprising a pair of sheet metal plates assembled in face-to-face relation and marginally sealed fluid tight to one another, at least one of said plates being formed to provide between the plates tubular, transversely extending intake and discharge headers and tubular, longitudinal distributor passages located between said headers, said headers respectively communicating with in take and discharge openings through the sealed plate margin, said longitudinal distributor passages being separated from one another and into sets, including a center set and sets on opposite sides thereof, by zones of substantially Z-shaped outline along which said plates are secured to one another, which zones terminate substantially short of the respective opposite ends of the plates between which said sets are disposed, there being a pair of such secured zones located between said intermediate set of longitudinal passages and the respective sets of passages on opposite sides thereof, which pair of secured zones are provided with transverse extensions at their opposite ends located in said respective headers and running toward the respective marginal openings of the latter, said extensions subdividing said headers into header passages of lesser width at the ends of said longitudinal passages and said plates being secured together along said transverse extensions to reduce the fluid pressure beam loading of the plates in the zones of said headers.

3. A built-in coil type heat transfer unit for immersion heating and related heat transfer operations involving the circulation through the unit of a heat transfer fluid under substantial pressure, said unit comprising a pair of sheet metal plates assembled in face-to-face relation and marginally sealed fluid tight to one another, at least one of said plates being formed to provide between the plates tubular, transversely extending intake and discharge headers adjacent and within respective opposite transverse ends thereof and tubular, longitudinal distributor passages extending between said headers, said headers opening through the sealed plate margin, said longitudinal distributor passages being separated from one another by parallel longitudinal zones along which said plates are secured to one another, which zones terminate substantially short of said respective opposite plate ends, there being transverse end extensions of at least one of said longitudinal secured zones which are located in said respective headers and run toward the respective marginal openings of the latter, said extensions subdividing said headers into header passages of lesser width at the ends of said longitudinal passages and said plates being secured together along said transverse extensions to reduce the fluid pressure beam loading of the plates in the zones of said headers.

4. A built-in coil type heat transfer unit for immersion heating and related heat transfer operations involving the circulation through the unit of a heat transfer fluid under substantial pressure, said unit comprising a pair of sheet metal plates assembled in face-to-face relation and marginally sealed fluid tight to one another, at least one of said plates being formed to provide between the plates tubular, transversely extending intake and discharge headers adjacent and within respective opposite transverse ends thereof and tubular, longitudinal distributor passages extending between said headers, said headers

opening through the sealed plate margin at diagonally opposed zones of said unit, said longitudinal distributor passages being separated from one another by parallel longitudinal zoes along which said plates are secured to one another, which zones terminate substantially short of said respective opposite plate ends, there being transverse end extensions of a pair of said longitudinal secured zones which are located in said respective headers and run toward the respective marginal openings of the latter, said extensions subdividing said headers into header passages of lesser width at the ends of said longitudinal passages and said plates being secured together along said transverse etxensions to reduce the fluid pressure beam loading of the plates in the zones of said headers.

5. A built-in coil type heat transfer unit for immersion heating and related heat transfer operations involving the circulation through the unit of a heat transfer fluid under substantial pressure, said unit comprising a pair of sheet metal plates assembled in face-to-face relation and marginally sealed fluid tight to one another, at least one of said plates being formed to provide between the plates tubular, transversely extending intake and discharge headers adjacent and within respective opposite transverse ends thereof and tubular, longitudinal distributor passages extending between said headers, said headers opening through the sealed plate margin at diagonally opposed zones of said unit, said longitudinal distributor passages being separated from one another and into sets, including an intermediate set and sets on opposite sides thereof, by parallel longitudinal zones along which said plates are secured to one another, which zones terminate substantially short of said respective opposite plate ends, there being a pair of such secured zones located between said intermediate set of longitudinal passages and the respective sets of passages on opposite sides thereof, which pair of secured zones are provided with transverse extensions at their opposite ends located in said respective headers and running toward the respective marginal openings of the latter, said extensions subdividing said headers into header passages of lesser width at the ends of said longitudinal passages and said plates being secured together along said transverse extensions to reduce the fluid pressure beam loading of the plates in the zones of said headers.

6. A built-in coil type heat transfer unit for immersion heating and related heat transfer operations involving the circulation through the unit of a heat transfer fluid under substantial pressure, said unit comprising a pair of sheet metal plates assembled in face-to-face relation and marginally sealed fluid tight to one another, at least one of said plates being formed to provide between the plates tubular, transversely extending intake and discharge headers adjacent and within respective opposite transverse ends thereof and tubular, longitudinal distributor passages extending between said headers, said headers opening through the sealed plate margin in substantially longitudinally spaced relation to one another, said longitudinal distributor passages being separated from one another by parallel longitudinal zones along which said plates are secured to one another, which zones terminate substantially short of said respective opposite plate ends, there being transverse end extensions of at least one of said longitudinal secured zones which are located in said respective headers and run toward the respective marginal openings of the latter, said extensions subdividing said headers into header passages of lesser width at the ends of said longitudinal passages and said plates being secured together along said transverse extensions to reduce the fluid pressure beam loading of the plates in the zones of said headers.

7. A heat transfer unit adapted to internally circulate a fluid heat transfer medium under substantial pressure, comprising a pair of plates marginally secured together in face to face relation, at least one of which is provided with concave formations facing the other to afford fluid intake and discharge headers between the secured plates and longitudinal circulatory passages communicating therewith, said headers communicating with the exterior of said unit and said plates being in contacting relation to one another in longitudinally extending secured zones separating said longitudinal passages and ending in adjacent spaced relation to at least one of said headers, said zones including at least one secured zone of substantially Z-shaped outline having a longitudinal portion separating passages on opposite sides thereof and transverse portions each spaced inwardly of a secured margin of the plates and outwardly of one of the ends of a longitudinally extending secured zone, thereby to reduce the bridging distance and resultant beam loading of said plates between said last named margin and zone end when said plates are under internal pressure.

8. A heat transfer unit adapted to internally circulate a fluid heat transfer medium under substantial pressure, comprising a pair of plates marginally secured together in face to face relation, at least one of which is provided with concave formations facing the other to afford fluid intake and discharge headers between the secured plates and longitudinal circulatory passages communicating therewith, said headers opening marginally through said plates and said plates being in contacting relation to one another in longitudinally extending secured zones separating said longitudinal passages and ending in adjacent spaced relation to at least one of said headers, said zones including at least one secured zone of substantially Z-shaped outline having a longitudinal portion separating passages on opposite sides thereof and transverse portions each spaced inwardly of a secured margin of the plates and outwardly of one of the ends of a longitudinally extending secured zone, thereby to reduce the bridging distance and resultant beam loading of said plates between said last named margin and zone end when said plates are under internal pressure.

9. A heat transfer unit adapted to internally circulate a fluid heat transfer medium under substantial pressure, comprising a pair of plates marginally secured together in face to face relation, at least one of which is provided with concave formations facing the other to afford fluid intake and discharge headers between the secured plates and longitudinal circulatory passages communicating therewith, said headers communicating with the exterior of said unit and said plates being in contacting relation to one another in longitudinally extending secured zones separating said longitudinal passages and ending in adjacent spaced relation to at least one of said headers, as well as in transversely extending secured zones at least one of which is located in a header and subdivides the width of the latter, said zones including at least one secured zone of substantially Z-shaped outline having a longitudinal portion separating passages on opposite sides thereof and transverse portions each spaced inwardly of a secured margin of the plates and outwardly of one of the ends of a longitudinally extending secured zone, thereby to reduce the bridging distance and resultant beam loading of said plates between said last named margin and zone end when said plates are under internal pressure.

10. A heat transfer unit adapted to internally circulate a fluid heat transfer medium, comprising a pair of plates marginally secured together in face to face relation, at least one of which is provided with concave formations facing the other to afford fluid intake and discharge headers between the secured plates and longitudinal circulatory passages communicating therewith, said headers communicating with the exterior of said unit and said plates being in contacting relation to one another in longitudinally extending secured zones separating said longitudinal passages and ending in adjacent spaced relation to at least one of said headers, said zones including at least one secured zone having a longitudinal

portion separating passages on opposite sides thereof, there being a set of at least two longitudinal zones on one side of said longitudinal portion, the zones of which set have corresponding ends thereof arranged in longitudinally stepped relation to one another.

11. A heat transfer unit adapted to internally circulate a fluid heat transfer medium, comprising a pair of plates marginally secured together in face to face relation, at least one of which is provided with concave formations facing the other to afford fluid intake and discharge headers between the secured plates and longitudinal circulatory passages communicating therewith, said headers communicating with the exterior of said unit and said plates being in contacting relation to one another in longitudinally extending secured zones separating said longitudinal passages and ending in adjacent spaced relation to at least one of said headers, said zones including at least one secured zone having a longitudinal portion separating passages on opposite sides thereof, there being a set of at least two longitudinal zones on one side of said longitudinal portion, the zones of which set have corresponding opposite ends thereof arranged in longitudinally stepped relation to one another, with the transversely outermost thereof over-extending the inner at one end and being over-extended by the inner at the opposite end.

12. A heat transfer unit adapted to internally circulate a fluid heat transfer medium under substantial pressure, comprising a pair of plates marginally secured together in face to face relation, at least one of which is provided with concave formations facing the other to afford fluid intake and discharge headers between the secured plates and longitudinal circulatory passages communicating therewith, said headers opening marginally through said plates and said plates being in contacting relation to one another in longitudinally extending secured zones separating said longitudinal passages and ending in adjacent spaced relation to at least one of said headers, as well as in transversely extending secured zones at least one of which is located in a header and subdivides the width of the latter, said zones including at least one secured zone of substantially Z-shaped outline having a longitudinal portion separating passages on opposite sides thereof and transverse portions each spaced inwardly of a secured margin of the plates and outwardly of one of the ends of a longitudinally extending secured zone, thereby to reduce the bridging distance and resultant beam loading of said plates between said last named margin and zone end when said plates are under internal pressure, there being a set of at least two longitudinal zones on one side of said longitudinal portion of said Z-shaped zone, the zones of which set have corresponding opposite ends thereof arranged in longitudinally stepped relation to one another, with the transversely outermost thereof over-extending the inner at one end and being over-extended by the inner at the opposite end.

13. A heat transfer unit adapted to internally circulate a fluid heat transfer medium, comprising a pair of plates marginally secured together in face to face relation, at least one of which is provided with concave formations facing the other to afford a transverse header between the secured plates and longitudinal circulatory passages communicating therewith, said header communicating with the exterior of said unit and said plates being in contacting relation to one another in longitudinally extending secured zones separating said longitudinal passages and ending in adjacent relation to said header, certain of said secured zones including a transverse portion subdividing said header into independent and separated header passages and a longitudinal portion separating certain of said longitudinal passages on its opposite sides into independent sets of at least one passage each, which sets of separated longitudinal passages communicate respectively with said separated passages of said header whereby to provide for independent parallel flow of fluid through said respective header passages and said sets.

14. A heat transfer unit adapted to internally circulate a fluid heat transfer medium, comprising a pair of plates marginally secured together in face to face relation, at least one of which is provided with concave formations facing the other to afford transverse headers between the secured plates and longitudinal circulatory passages communicating therewith, said headers communicating with the exterior of said unit and said plates being in contacting reltaion to one another in longitudinally extending secured zones separating said longitudinal passages and ending in adjacent reltaion to said headers, said secured zones including transverse portions subdividing each of said headers into independent and separated header passages and a longitudinal portion separating certain of said longitudinal passages on its opposite sides into independent sets of at least one passage each, which sets of separated longitudinal passages communicate respectively with said separated passages of said headers whereby to provide for independent parallel flow of fluid through respective ones of said header passages and said sets.

15. A heat transfer unit adapted to internally circulate a fluid heat transfer medium, comprising a pair of plates marginally secured together in face to face relation, at least one of which is provided with concave formations facing the other to afford transverse headers between the secured plates and longitudinal circulatory passages communicating therewith, said headers communicating with the exterior of said unit and said plates being in contacting relation to one another in longitudinally extending secured zones separating said longitudinal passages and ending in adjacent relation to said headers, said secured zones including a generally Z-shaped zone having transverse portions subdividing said respective headers into independent and separated header passages and a longitudinal portion connecting said transverse portions and separating certain of said longitudinal passages on its opposite sides into independent sets of at least one passage each, which sets of separated longitudinal passages communicate respectively with said separated passages of the respective headers, whereby to provide for independent parallel flow of fluid through said respective header passages and said sets.

16. A heat transfer unit adapted to internally circulate a fluid heat transfer medium, comprising a pair of plates marginally secured together in face to face relation, at least one of which is provided with concave formations facing the other to afford transverse headers between the secured plates and longitudinal circulatory passages communicating therewith, said headers communicating with the exterior of said unit and said plates being in contacting relation to one another in longitudinally extending secured zones separating said longitudinal passages and ending in adjacent relation to said headers, said secured zones including a generally Z-shaped zone having transverse portions subdividing said respective headers into independent and separated header passages and a longitudinal portion connecting said transverse portions and separating certain of said longitudinal passages on its opposite sides into independent sets of at least one passage each, which sets of separated longitudinal passages communicate respectively with said separated passages of the respective headers, whereby to provide for independent parallel flow of fluid through said respective header passages and said sets, the plates of said transfer unit having their outer side surface extremities in parallel planes throughout practically the entire side area of the unit.

17. A heat transfer unit adapted to internally circulate a fluid heat transfer medium under substantial pressure, comprising a pair of plates seam welded marginally together in face to face relation and provided with outwardly embossed, concave formations to afford fluid intake and discharge headers between the secured plates and longitudinal circulatory passages communicating therewith, said headers communicating with the exterior

of said unit through the margin of said plates and said plates being spot welded to one another in longitudinally extending zones separating said longitudinal passages and ending in adjacent spaced relation to at least one of said headers, as well as in transversely extending secured zones at least one of which is located in a header and subdivides the width of the latter, said zones including at least one zone of substantially Z-shaped outline having a longitudinal portion separating passages on opposite sides thereof and oppositely extending transverse portions each spaced inwardly of a welded margin of the plates and outwardly of an adjacent end of a longitudinal welded zone, thereby to reduce the bridging distance and resultant beam loading of the welds of said plates between said last named margin and zone end when said plates are under internal pressure, there being a set of at least two longitudinal welded zones on one side of said longitudinal portion of said Z-shaped zone, the zones of which set have corresponding opposite ends thereof arranged in longitudinally stepped relation to one another, with the transversely outermost thereof over-extending the inner at one end and being over-extended by the inner at the opposite end.

18. A heat transfer unit in accordance with claim 17, in which said unit is generally rectangular and said headers open through opposed marginal edges of said unit.

19. A heat transfer unit in accordance with claim 17, in which said unit is generally rectangular and said headers open through opposed marginal edges of said unit and adjacent diagonally opposed corners of the latter.

20. A heat transfer unit in accordance with claim 17, in which said unit is generally rectangular and said headers open through a single marginal edge of said unit.

21. A heat transfer unit in accordance with claim 17, in which said unit is generally rectangular and said headers open through a single marginal edge of said unit and adjacent one end of said edge.

22. A heat transfer unit in accordance with claim 17, in which said unit is generally rectangular and said headers open through a single marginal edge of said unit and in substantially spaced relation adjacent the respective ends of said edge.

23. A heat transfer unit in accordance with claim 17, in which said unit is generally rectangular and said headers open through a single longitudinal marginal edge of said unit.

24. A heat transfer unit in accordance with claim 17, in which said unit is generally rectangular and said headers open through a single longitudinal marginal edge of said unit and adjacent one end of said edge.

25. A heat transfer unit in accordance with claim 17, in which said unit is generally rectangular and said headers open through a single transverse marginal edge of said unit.

26. A heat transfer unit in accordance with claim 17, in which said unit is generally rectangular and said headers open through a single transverse marginal edge of said unit and in substantially spaced relation adjacent the respective ends of said edge.

27. A heat transfer unit in accordance with claim 17, in which said unit is generally rectangular and in which said headers open through opposed longitudinal marginal edges of the unit and adjacent diagonally opposed corners of the latter.

28. A heat transfer unit in accordance with claim 17, in which said unit is generally rectangular and in which said headers open through opposed transverse marginal edges of the unit and adjacent diagonally opposed corners of the latter.

29. A heat transfer unit in accordance with claim 17, in which at least one of said headers opens through a side surface of one of said plates.

30. A heat transfer unit adapted to internally circulate a fluid heat transfer medium, comprising a pair of plates marginally secured together in face to face relation and having means of generally Z-shaped outline therebetween affording a pair of spaced transverse headers between the secured plates and independent and parallel longitudinal circulatory passages independently communicating with said headers, said headers communicating with the exterior of said units, said Z-shaped means including transverse portions subdividing said respective headers into independent and separated header passages and a longitudinal portion between said transverse portions separating certain of said longitudinal passages on its opposite sides into independent sets of at least one passage each, which sets of separated longitudinal passages communicate respectively with said separated header passages, whereby to provide for independent parallel flow of fluid through said respective header passages and said sets.

References Cited in the file of this patent

UNITED STATES PATENTS

1,823,788	Dewoitine	Sept. 15, 1931
2,156,544	Raskin	May 2, 1939
2,200,426	Lehman	May 14, 1940
2,496,558	Philipp	Feb. 7, 1950
2,626,130	Raskin	Jan. 20, 1953
2,699,325	Hedin	Jan. 11, 1955
2,848,200	Jacobs	Aug. 19, 1958

FOREIGN PATENTS

674,264	France	Oct. 21, 1929