Nov. 4, 1969 G. MEISTER ET AL 3,476,179

PLATE-TYPE HEAT EXCHANGER

Filed Oct. 11, 1967 4 Sheets-Sheet 1

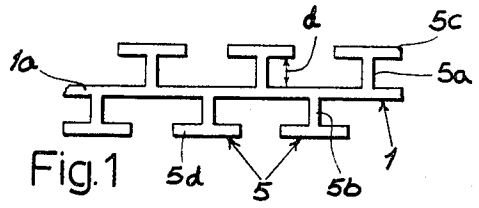


Fig. 1

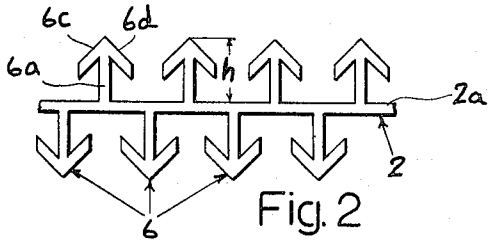


Fig. 2

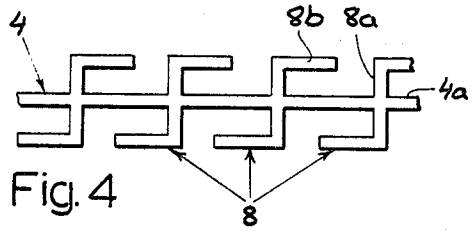


Fig. 4

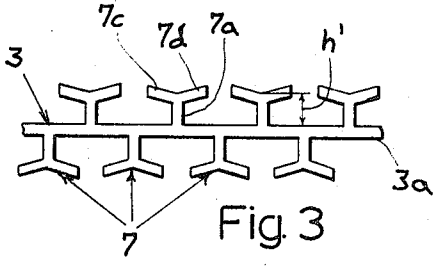


Fig. 3

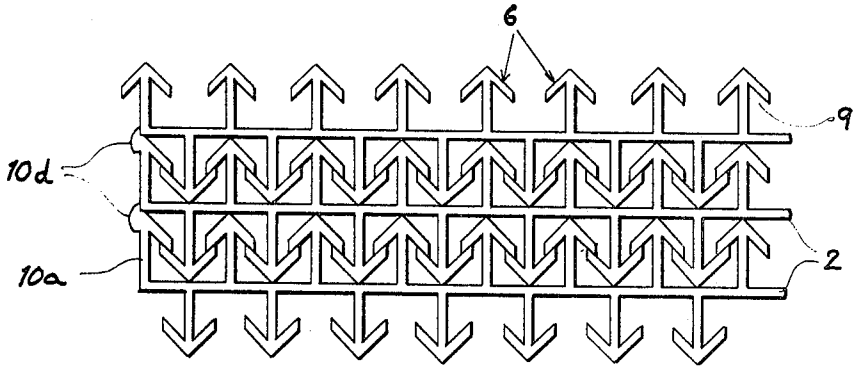


Fig. 5

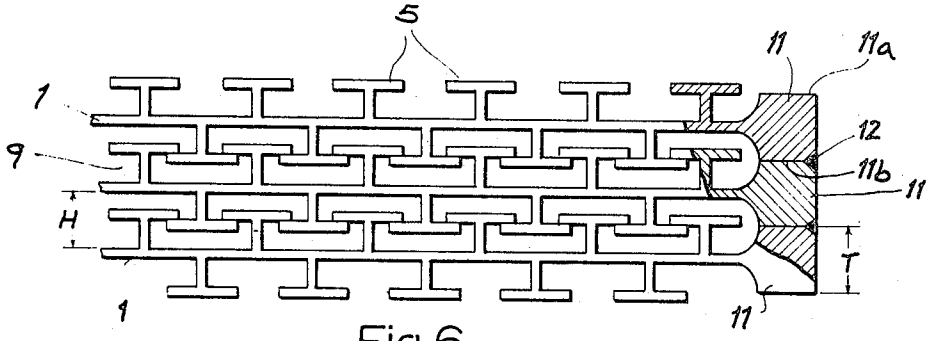


Fig. 6

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PLATE-TYPE HEAT EXCHANGER

Filed Oct. 11, 1967 4 Sheets-Sheet 2

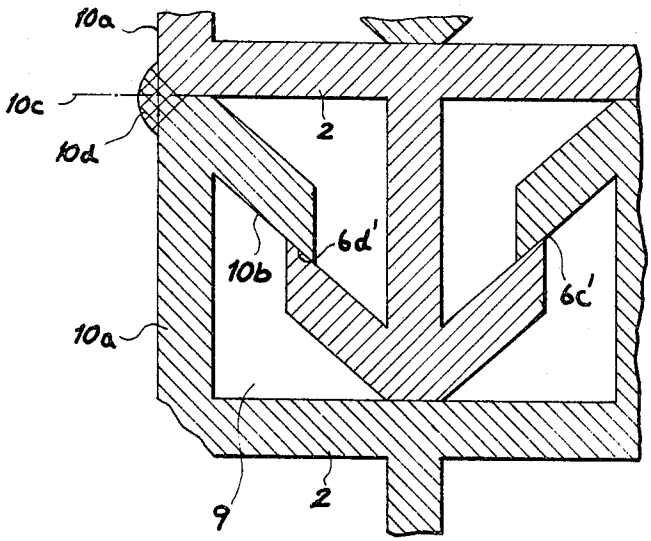


Fig. 5A

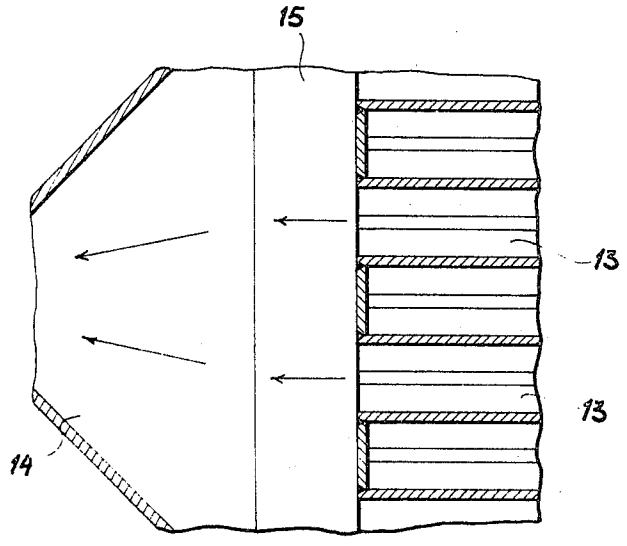


Fig. 8C

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PLATE-TYPE HEAT EXCHANGER

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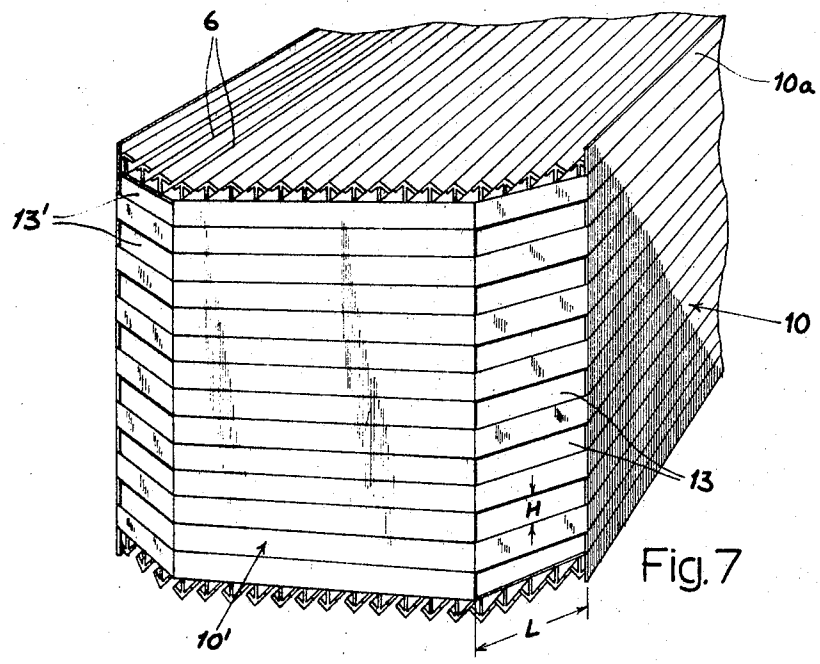


Fig. 7

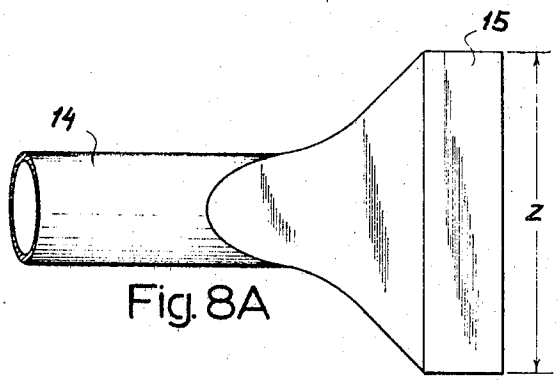


Fig. 8A

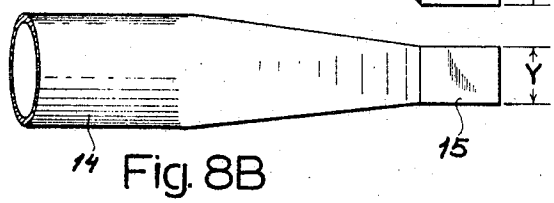


Fig. 8B

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PLATE-TYPE HEAT EXCHANGER

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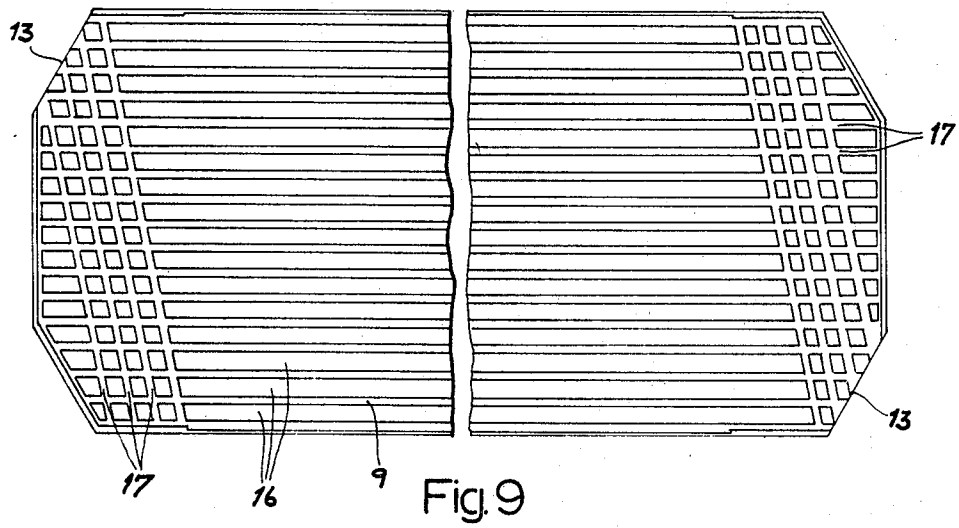


Fig. 9

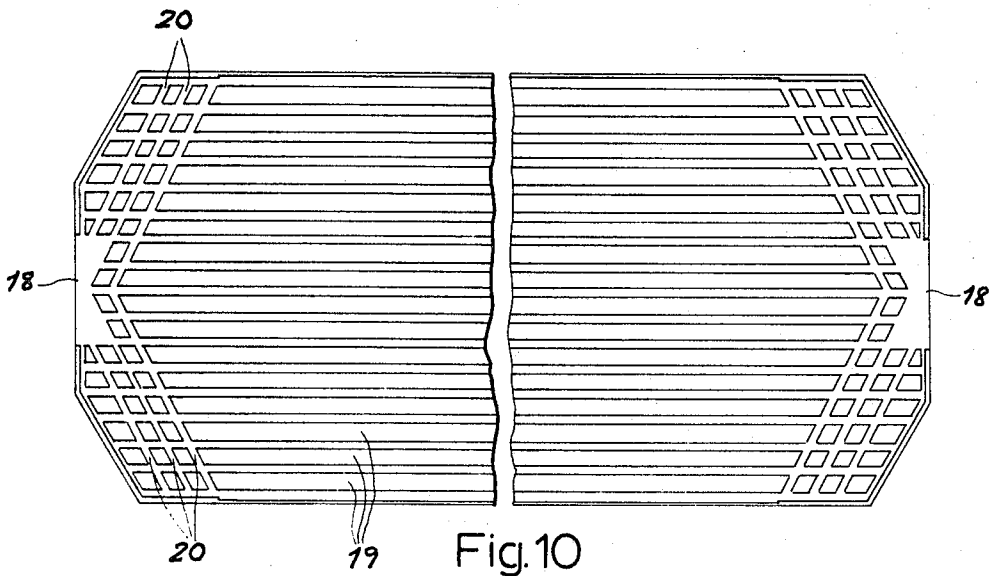


Fig. 10

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3,476,179

PLATE-TYPE HEAT EXCHANGER

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Claims priority, application Germany, Oct. 12, 1966, L 54,797
Int. Cl. F28f 3/08
U.S. Cl. 165—166 11 Claims

ABSTRACT OF THE DISCLOSURE

A plate-type heat exchanger having a stack of generally parallel transversely spaced unitarily extruded aluminum plates defining between their respective fluid compartments communicating with slot-like manifolds, the pairs of plates defining each compartment having longitudinally extending parallel ribs of T, L or Y section interfitting with the ribs of the other plate of each pair and interengaging with said other ribs for limiting deformation of said plates relatively to one another.

Our present invention relates to a plate heat exchanger of the general type in which an indirect heat exchange between fluid is effected via a plate-like heat-conductive barrier separating two heat-exchange chambers which have relatively narrow cross-sections so that the effective flow cross-section across each plate is minimized and heat-transfer efficiency is correspondingly high.

Plate-type heat exchangers wherein fluids pass, for indirect heat exchange between them, on opposite sides of a plate-like partition separating the heat-exchanging chambers from one another have been commonly used to effect heat exchange between viscous liquids and even gaseous fluids in which heat transfer within the fluid is a problem. It has been recognized that the efficiency of indirect heat exchange and especially the speed at which the heat exchange is effective, i.e. the rate of temperature rise of a fluid throughout its bulk, is a function of the surface area of the heat exchanger and is inversely proportional to the thickness of the layer of fluid flowing over the heat-exchange surface. Accordingly, plate exchangers have been designed to provide a relatively large heat-exchange surface area with a relatively narrow sheet-like flow cross-section along the heat-transfer plates. The plates can be provided in accordance with earlier proposals with webs or fins which increase the surface-area contact with the fluid. In its simplest form, a heat exchanger of this characteristic has a generally rectangular outline and is composed of a multiplicity of stacked, vertically spaced parallel plates with the two fluids flowing through alternate compartments. In order to improve the structural characteristics of the assembly, increase the ability of the plates to withstand bending and buckling stresses and prevent thermal distortion within the interior of the heat exchanger, it has been proposed bridge pieces within the body of the heat exchanger or to specially design the plates so that they can be secured together in force-transmitting relationship. These improvements, while increasing the structural integrity of the unit, also incraese sharply its manufacturing cost and complexity. As an alternative to these complex configurations, it has been suggested to increase the thickness of the plates so as to resist the transfer stresses arising from the existing of pressure differentials between the heating and cooling fluids in indirect heat exchange across the plate. While these systems have provided longitudinally extending ribs projecting the plates defined in each compartment, they have required salt-bath soldering of soldered-coated members and like techniques for securing the plates together. The added costs of these processes have rendered the proposed solutions impractical.

It is, therefore, an object of the present invention to provide an economical plate heat exchanger in which the complex manufacturing processes and configurations required heretofore can be avoided.

Another object of this invention is to provide an improved method of manufacturing a plate-type heat exchanger of high structural integrity and strength with a minimum of costly manufacturing steps.

Still another object of our invention is to provide an improved plate-heat exchanger capable of withstanding thermal and pressure-differential stress, adapted to afford a high degree of heat exchange rapidly end efficiently, and adapted to be assembled in a particularly convenient and economical manner.

These objects and others which will become apparent hereinafter are fulfilled in accordance with the present invention in a heat exchanger having a multiplicity of generally parallel plate stages defining between them compartments for the heat-exchanger fluid, the plates being provided upon their opposite surfaces with transversely projecting longitudinally extending parallel profiled ribs having flanged portions interfitting with the ribs of adjacent plates in force-transmitting relationship preventing distortion between the paired plates. According to an important aspect of this invention, the flanged portions of the ribs grip one another along surfaces of the ribs facing the respective plates so that the flanges of the ribs can be considered to form overhangs beneath which the ribs of an adjacent plate engage. Advantageously, the ribs are spaced apart by a distance equal to or greater than the width of the flanged portions so that the plates defined in each compartment can be joined by sliding each plate into and along another of these plates parallel to the ribs.

Thus, according to a specific feature of this invention, the plate-type heat exchanger comprises a stack of generally horizontal, vertically superimposed individual plates of similar configuration in interfitted relationship with the ribs of one plate interengaging with those of the overlying and underlying plates to form an integral structure in which the ribs prevent relative movement of the plates. Each of the plates can be considered as consisting of a generally planar base unitarily formed with ribs which project perpendicularly to the base from the opposite faces therewith, the ribs extending parallel to one another with a uniform transverse spacing and having identical profiles except as indicated hereinafter for the web portions on the peripheries of the plates. The ribs, which lie in respective vertical planes, run in the direction of movement of the fluids through the respective compartments and interengage with one another by virtue of their transverse flanges. The term "transverse flange" is here used to describe a flanged portion angularly adjoining each rib and running the full length thereof so as to impart a "profile" to the rib. The flange may project at right angles from the rib so that it lies in a horizontal plane parallel to the base (in the case of T-section, L-section, or angular profiles) or may be oblique to the rib, e.g. inclined at an angle of 45° thereto. In the later case, a pair of flanges may symmetrically converge toward the rib at the same angle and impart a Y-section or arrow-like profile, depending upon the direction of convergence. In either case, the flange of each rib is formed unitarily, i.e. as part of a single extruded body, and provided on the rib at a location remote from the respective base. The dimensions of the platens and their ribs are so selected that the plates can be easily interfitted with the ribs in mutual parallel relationship by rela-

tively displacing the plates longitudinally and inserting them into one another in end-to-end relationship. Upon such insertion, the interengaged flanges and ribs preclude movement perpendicularly to the bases and perpendicularly to the ribs. As a result of the complementarily interfitting shapes of the ribs of the adjoining plates, the stack of heat-exchanger plates is insensitive to pressure differentials across the compartments and requires neither tensioning elements spanning the stack nor solder junctions between the ribs and the opposing plates.

According to another feature of this invention, the lateral flanges of the interfitting ribs bear upon the flanges of the opposing ribs between these flanges and their bases, i.e. the flanges of one base grip the flanges of the other behind one another, so that the presence of pressure differentials tending to burst the compartment are resisted by a firm interengagement of the flanges. The configurations of the ribs prevent nonuniform and changing pressure conditions in either of the streams from distorting the individual plates or the entire stack. Since the tendency toward deformation is sharply reduced, the plates can be made substantially thinner than has hitherto been the case, i.e. may have a thickness of the order of a centimeter or of fractions thereof so that a larger number of stages may be provided in a given volume and heat transfer rates across the intercompartment partitions sharply increase. The overall efficiency is, moreover, promoted by the ribs or webs integral with the bases of the plates since these ribs or webs promote heat transfer in the manner of conventional cooling ribs.

According to still another aspect of this invention, an improved heat exchange of the character described can be made by extruding each of the plates, over their entire width, as a single aluminum or aluminum-alloy body in a continuous aluminum-profiled extrusion step. The plates are cut to identical lengths from the continuous extrusion and are then stacked by inserting the plates successively into the previously formed plates parallel to the direction of extension of the ribs. Consequently, assemblies of practically any length can be produced without limitation. Another advantage of the present system resides in the elimination of complex sealing assemblies. The plates are formed along their longitudinal edges with connecting webs or thickened marginal portions which can be welded to the corresponding portions of the adjacent plates to maintain the plates against relative longitudinal displacement while forming sealed peripheries therealong. The seams can be closed by a fillet of weldment. It should also be noted that solder methods can be used to join the plates together along their marginal portions.

Still another feature of this invention resides in the formation of openings in the form of horizontal but vertically spaced slides along corresponding edges in the sealed periphery of the plates, the openings to each compartment being advantageously disposed directly opposite one another in the stack.

The openings form the inlet and outlet means for passing one or another of the fluids through the respective compartments, the openings of adjoining chambers being disposed at alternate locations so that individual fluids can be passed through the chambers in heat-exchange relationship through a particular partition. A manifold inlet or outlet communicates with all of the vertically spaced openings along a corresponding edge for delivering fluid to or removing it from alternate chambers in parallel. The manifold preferably has a slot-shaped mouth whose width (i.e. horizontal dimension) is equal to the length of the slot-like opening with which it communicates and whose height (i.e. vertical dimension) is equal to the height of the stack of plates forming the heat-exchanger unit. The manifold duct can be connected by welding with the heat-exchanger stack. Additionally, it has been found to be desirable to provide the openings obliquely to the direction of extension of the ribs and to cut through the ribs to form distribution channels therein in a correspondingly oblique direction. This arrangement, whereby distribution canals are formed transversely to the ribs adjacent the openings, ensures efficient and uniform distribution of the fluid among the channels between the ribs.

The above and other objects, features and advantages of the present invention will become more readily apparent from the following description, reference being made to the accompanying drawing in which:

FIG. 1 is an end view of a heat-exchanger plate embodying this invention, the ribs thereof having T-shaped sections or profiles;

FIG. 2 is a view similar to FIG. 1 in which the ribs have arrow-like profiles;

FIG. 3 is another end view of a heat-exchanger plate whose ribs have flanges oblique to the ribs;

FIG. 4 is a view similar to FIG. 3 of a heat-exchanger plate with angular or L-section profile;

FIG. 5 is an end view, showing the interfitting relationship of the plates of a stack according to this invention;

FIG. 5A is a detailed sectional view thereof;

FIG. 6 is a view similar to FIG. 5, partly in section, illustrating a modification of the system;

FIG. 7 is a diagrammatic perspective view of a heat-exchanger stack embodying this invention;

FIG. 8A is an elevational view of a manifold duct according to this invention;

FIG. 8B is an end view of this duct;

FIG. 8C is a detailed sectional view showing the relationship of the duct to the stack of FIG. 7;

FIG. 9 is a plan view of the stack of heat-exchanger plates of FIG. 7 illustrating the distribution canals thereof; and

FIG. 10 is a view similar to FIG. 9 of another embodiment of this invention.

Prior to discussing the system of the present invention in detail, it should be noted that any of the configurations of FIGS. 1 through 4 for the individual plates is intended to be used with either of the arrangements of FIG. 5 or 6 and the plan configuration of either of FIG. 9 or 10, as will become apparent hereinafter. For convenience only, the arrow-shaped configuration of FIG. 2 is shown to be utilized in the systems of FIGS. 5 and 7 while the T-shaped configuration of FIG. 1 is represented as used in FIGS. 6, 9 and 10.

In FIG. 1, we show an extruded aluminum plate, in end view, adapted to be assembled (FIG. 6) into a heat-exchanger stack, the plate **1** being formed with a horizontal planar base **1***a* unitarily having ribs **5** whose shanks **5***a* and **5***b* project perpendicularly from the base **1***a* and are unitary and integral therewith. Thus the shanks **5***a* and **5***b* run parallel to one another and lie in respective vertical planes while being laterally offset on the opposite side of the base **1***a* so that the shanks or webs **5***b* are disposed substantially midway between the shank **5***a* and vice versa. At locations remote from the base **1***a*, the shanks **5***a* and **5***b* are formed integrally and unitarily with lateral flanges **5***c* and **5***d* in the form of horizontal heads defining T-sections with the respective shanks. The distance *d* between the overhanging heads **5***c* or **5***d* and the base **1***a* is substantially equal to half the height of the respective compartment to be formed therefrom, as will be described in greater detail hereinafter in connection with FIG. 6.

In the modification of FIG. 2, the plate **2** likewise has a horizontal base **2***a* extruded integrally with a plurality of ribs **6** in stacked relationship on opposite sides of the plates. Each rib **6** comprises a shank **6***a* extending perpendicularly to the base **2***a* and formed in its free extremity with a pair of flanges **6***c* and **6***d* which converge toward one another away from the base **2***a* and thus impart an arrow-shaped configuration to each rib. The height *h* of the ribs **6** is here approximately equal to the depth of the channel (see FIG. 5). The flanges **6***c* and **6***d* intersect one another approximately at right angles and include

angles of approximately 45° with the respective shanks **6***a*.

FIG. 3 shows a plate **3** whose general planar base **3***a* carries a multiplicity of identical longitudinally extending Y-profiled ribs along its opposite side, as has been previously described. Each of the ribs **7** comprises a vertical shank **7***a* (perpendicular to the base **3***a* and unitarily extruded therewith), carrying a pair of lateral flanges **7***c* and **7***d* which converge toward the shank **7***a* but are oblique thereto. In this embodiment, the height *h'* of the shank **7***a* is equal approximately to half the depth of the chamber formed between the plates **3** when the latter are stacked.

FIG. 4 represents an embodiment wherein the plate **4** has a base **4***a* which is extruded unitarily with angle ribs **8** of L-section. Unlike the system of FIGS. 1 through 3, the ribs on opposite sides of the base **4***a* are not laterally offset but are aligned on opposite sides of the base. A laterally offset arrangement is, however, also desirable here. Each of the ribs **8** comprises un upstanding shank **8***a* carrying an overhanging flange **8***b* designed to engage behind the corresponding flange of an adjacent plate. It has been found that the aligned position of the webs (FIG. 4) is particularly favorable to efficient heat transfer between the fluids in the compartments on opposite sides of the plates.

In FIG. 5, I show one method of securing a stack of plates **2** (see FIG. 2) together with a flanged rib **6** in interfitting relationship. To this end, the flanges **6***c* and **6***d* have their undersides **6***c'* and **6***d'* engaged by the underside of the complementary rib co-operating therewith (see FIG. 5A). Thus, between the sets of ribs, a multiplicity of longitudinally extending channels **9** are formed on opposite sides of the plates. Along the longitudinal marginal portion of the plates **2**, we provide upstanding webs **10***a* having only a single inwardly directed flange **10***b* and which are designed to abut the adjacent plate at a surface represented by the dash-dot line **10***c* in FIG. 5A. A bead of weldment **10***d* extending along the seam between the plates sealingly closes the channels **9** and prevents relative longitudinal movement of the plates **2**. Since the plates **2** are composed of the same material, the weld **10***d* often produces a monolithic metal structure at these junctions.

In FIG. 6, we show a modified system for joining the plates **1**. In this system, the plates **1** are formed with identical thickened marginal portions **11** in the form of beads having horizontal abutment surfaces **11***a* and **11***b* adapted to bear respectively upon the upper and lower adjacent plates. When the plates are superimposed as illustrated in FIG. 6, they form compartments **9** between them whose height H is equal to twice the dimension *h* described earlier. Thus the thickness T of the beads **11**, which are of prismatic configuration, is substantially equal to the distance H between the bases of the plates. Along the outer periphery, the seams between the beads **11** are closed by weldments **12**.

After the plates have been assembled as previously described (see FIG. 7 in which the stack of plates **2** is shown in diagrammatic form), the webs **10***a* form closed walls **10** and **10'** which are left open at **13** and **13'** at alternate locations on the right- and left-hand corners of the stack, respectively, Corresponding openings may be provided at the far corners of the generally rectangular or prismatic stack. As indicated in FIG. 7, the openings **13** are generally slot-shaped and have thickness H corresponding to the spacing between the plates and a length L defined by the corner (see FIG. 9) of the outline imparted to the plate. A manifold duct **14** (FIGS. 8A through 8C) communicates concurrently with all of the vertically aligned coplanar openings **13**, **13'**, etc. of the alternate chambers so that the overall height Z of the slot-shaped mouth **15** of the funnel-like manifold is equal to *n*x**H** where *n* is the total number of plates in the stack and a width Y equal to the length L of the openings **13** or **13'**. As shown at FIG. 8C, the slot-shaped mouth **15** received fluid from the openings **13** when in position. Once this heat-exchange fluid is supplied to one set of compartments via openings **13'** and removed through corresponding openings at the other side, while the other heat-exchange fluid is admitted through opening **13** and discharged at the diagrammatically opposite end of the respective stages.

In FIGS. 9 and 10, we show two arrangements whereby the openings **13** or **18** are provided on the opposite ends of the plates. In the former arrangement, the openings are provided at diagonally opposite corners of a plate of generally octagonal outline to communicate with canals **17** oblique to one another formed in the ribs **16** by slotting at oblique lines therethrough. The slotting can be effected by a milling machine or the like and forms channels which communicate with the chambers **9** between the ribs. On the left side of FIG. 9, the channels **17** deliver fluid to the compartments **9** while on the right side, the channels **17** connect fluid therefrom and deliver it to the exit opening **13**. Similarly, in FIG. 7, oblique channels **20** diverge from each of the openings and are formed by milling or saw-type cutters as previously described. The canals **20** are here symmetrically provided on opposite sides of a longitudinal median plane through the assembly.

The invention described and illustrated is believed to admit of many modifications within the ability of persons skilled in the art, all such modifications being considered within the spirit and scope of the appended claims.

We claim:

1. In a plate-type heat exchanger, the improvement which comprises a stack of generally parallel transversely spaced plates defining between respective pairs of plates on either side of each plate, respective fluid compartments separated by the plates, the plates defining each compartment each being unitarily extruded with generally coextensive planar bases unitarily provided each with a plurality of similar transversely spaced continuous longitudinally extending parallel ribs projecting perpendicularly from opposing sides of each base in opposite directions, said ribs having unitary longitudinally continuous laterally extending flanges on either side of the rib and spaced from the respective base and engaging behind corresponding flanges of the plates on opposite sides of the plate carrying said flanges, and interfitting with said flanges of the other plate of each pair and interengaging with said other flanges for limiting deformation of said plates relatively to one another.

2. The improvement defined in claim **1** wherein said ribs have generally T-shaped profiles with the crossbar of the "T" forming said flanges.

3. The improvement defined in claim **1** wherein said ribs are of generally arrow-shaped profile with the flanges of each rib converging away from the respective base.

4. The improvement defined in claim **1** wherein said ribs have Y-shaped profiles with the arms of each Y converging towards the respective base.

5. The improvement defined in claim **1** wherein each of said ribs has an angle profile with only a single flange projecting at right angles from each rib.

6. The improvement defined in claim **1** wherein the ribs projecting from opposite sides of the respective base of each of said plates are located substantially midway between the ribs of the other side of the respective plate.

7. The improvement defined in claim **1** wherein at least some of said plates are provided with edge webs extending transversely to the respective base and sealingly welded to the adjoining plates about at least part of the periphery of said stack.

8. The improvement defined in claim **7** wherein said edge webs are relatively thick marginal portions of the respective plates in surface contact with one another.

9. The improvement defined in claim **1**, further comprising means forming vertically spaced slot-like openings at a side of said stack between said plates, and manifold means communicating with said openings along said side

for circulating fluid through the chambers between said plates.

10. The improvement defined in claim 9 wherein said manifold means is a generally funnel-shaped member with a slot-like mouth having a length corresponding substantially to the height of said stack and a width corresponding to the length of said openings.

11. The improvement defined in claim 9 wherein said plates are formed with distribution channels communicating with said openings and oblique to said ribs.

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