PLATE HEAT EXCHANGER

Filed Dec. 23, 1965 4 Sheets-Sheet 1

Fig. 1

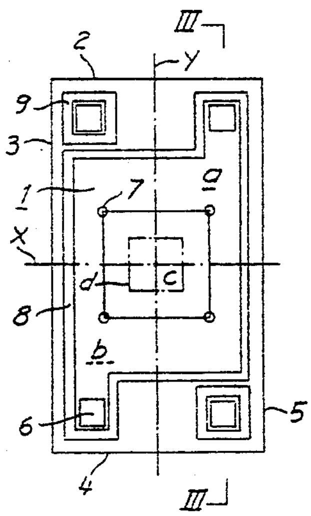

Fig. 2

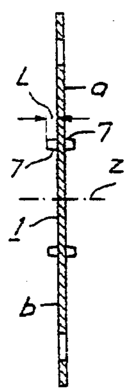

Fig. 3

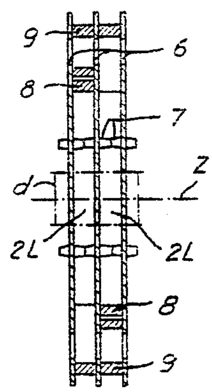

Fig. 4

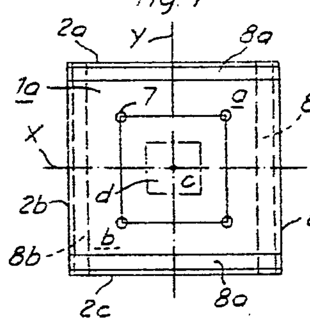

Fig. 5

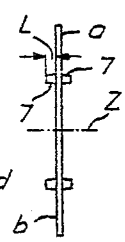

Fig. 6

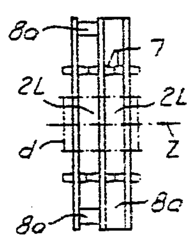

Fig. 7

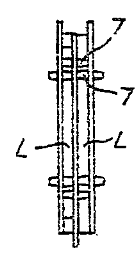

Fig. 8

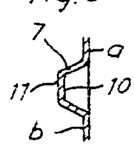

Fig. 9

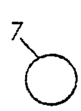

Fig. 10

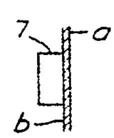

Fig. 11

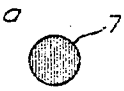

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PLATE HEAT EXCHANGER

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Fig. 12

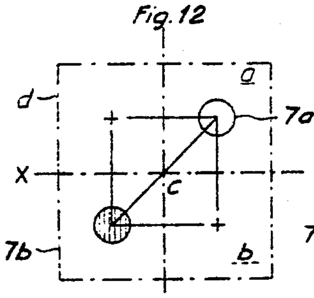

Fig. 13

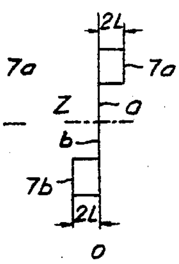

Fig. 14

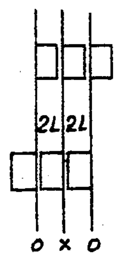

Fig. 15

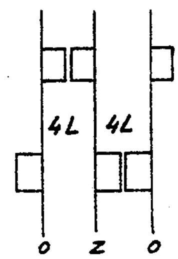

Fig. 12x

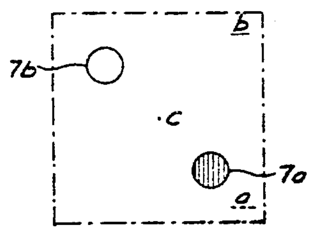

Fig. 16

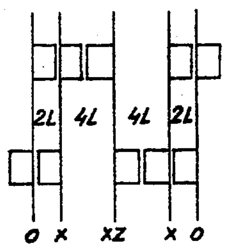

Fig. 12z

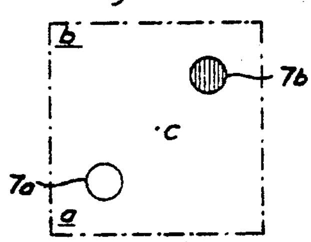

Fig. 12xz

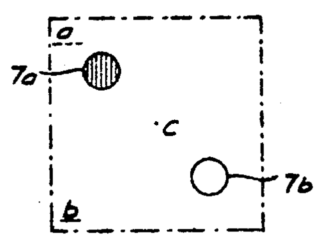

Fig. 17

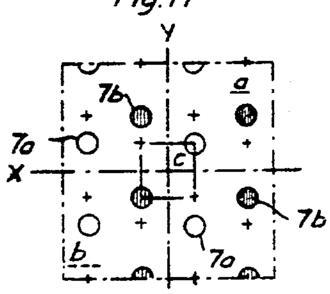

Fig. 18

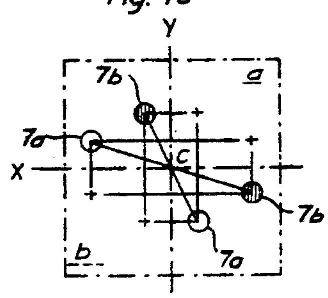

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PLATE HEAT EXCHANGER

Filed Dec. 23, 1965 4 Sheets-Sheet 3

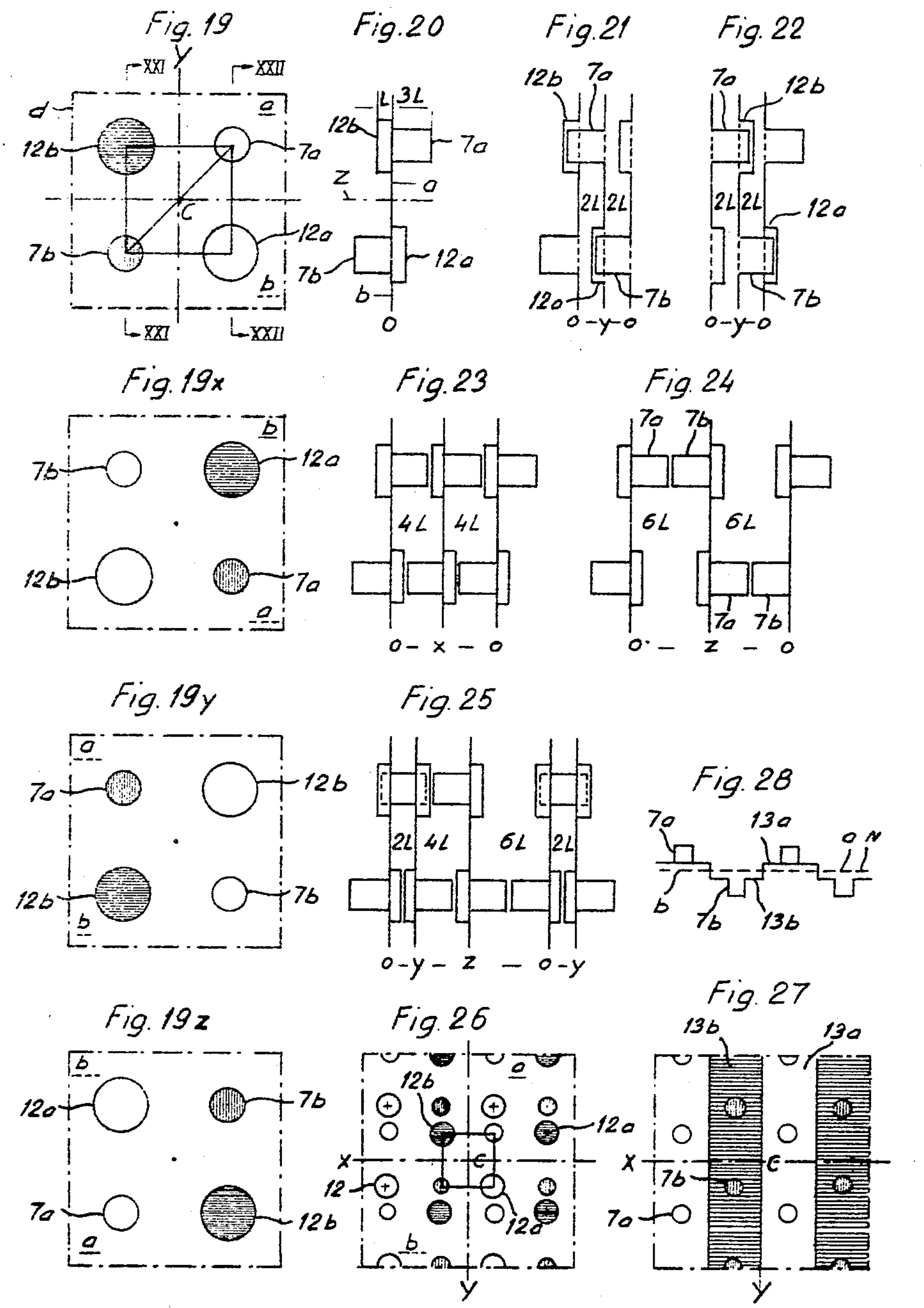

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PLATE HEAT EXCHANGER

Filed Dec. 23, 1965 4 Sheets-Sheet 4

Fig. 29

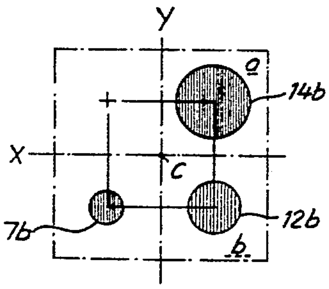

Fig. 30

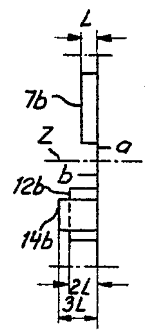

Fig. 31

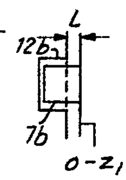

Fig. 32

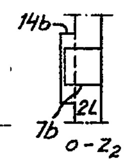

Fig. 33

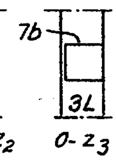

Fig. 29z1

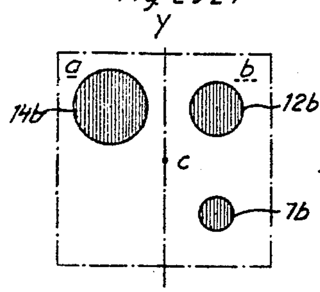

Fig. 34

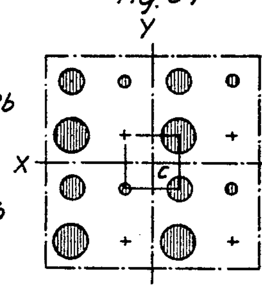

Fig. 35

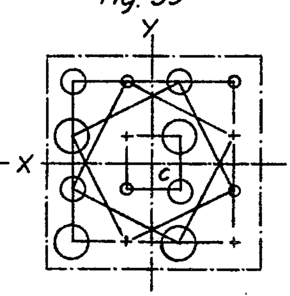

Fig. 29z2

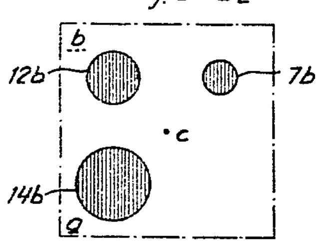

Fig. 29z3

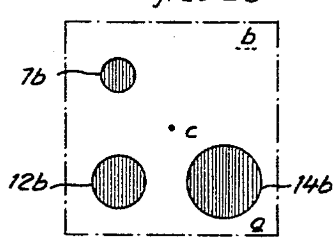

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PLATE HEAT EXCHANGER

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Claims priority, application Sweden, Dec. 29, 1964, 15,740
6 Claims. (Cl. 165—167)

ABSTRACT OF THE DISCLOSURE

Substantially identical heat transfer plates are held side-by-side in a pack to form interspaces between adjacent plates, the plates being ported and adapted to coact with marginal packings in the interspaces to define flow channels for passage of the heat exchange media through the pack; and adjacent plates have spacing projections and supporting surfaces adapted to abut each other in the interspaces, the projections also forming supporting surfaces. To enable variations in the spacing between adjacent plates, each plate is provided with such spacing projections and has its supporting surfaces situated in different planes parallel to the main plane of the plate; and the projections and supporting surfaces are distributed on the plate in a pattern such that when two adjacent plates are assembled side-by-side (as in the pack of plates) but in first and then in second relative positions, a spacing projection which in the first relative positions is adapted to abut a supporting surface situated in one plane is adapted in the second relative positions to abut a supporting surface situated in a different plane.

The disclosure

The present invention relates to plate heat exchangers with a plurality of identical heat transfer plates of thin pressed sheet metal, which side by side are kept together to form a pack with interspaces between adjacent plates limited by packings along the edges, which interspaces form channels for the conducting of the heat exchanging media, distance giving projections from one of the plates being in close contact with supporting surfaces on the other plate in the said interspace. The distance giving projections constitute themselves at the same time supporting surfaces.

The channels in such a pack get a certain channel characteristic on account of the length of the plates and their breadth and mutual distance which limits the useful magnitude of the flow through them to a fairly narrow range. A limited range of flow and a certain heating surface per channel means also a locked relationship between the medium temperature difference of the media and their temperature change.

A channel of a considerable length with a small distance between the plates is for instance suitable for giving a small flow a great temperature change. A large flow that is to be given a smaller temperature change requires a distance between the plates that is large in comparison to the length of the channel in order that the pressure fall will lie within practical limits, and in order that the heating surface will not be too large. If the channels in a pack of plates are too narrow and too long for a certain purpose so that the pressure fall increases too much, the latter can certainly be reduced if further plates and channels are added to the pack and the total channel area is thus increased, but this brings with it as well that expensive heating surface is sacrificed only in order to obtain a depreciation of the pressure fall, and that the heat

exchanger will get an over-capacity, i.e. gives a too great temperature change.

In order to satisfy at least as nearly as possible such different needs one has therefore hitherto been compelled to use plates, which differ at least as to the height of the distance giving projections so that different series of such plates form packs with larger or smaller distances between the plates.

In addition, there is frequently a need to vary the distances between the plates within one and the same pack, for instance when the flows of the respective heat exchanging media are of considerably different magnitudes, or in order to change the channel characteristic in some part of the pack for some other reason, which has been accomplished by means of intermingling plates of different shapes in the pack.

The invention aims at obviating those drawbacks by means of forming the distance giving projections of identical plates constituting the pack such that these plates can be put together to make packs with larger or smaller distances between the plates as well as packs with an optional distribution of larger or smaller such distances within the pack.

The invention is mainly characterized in that each plate is provided with distance giving projections and has its supporting surfaces situated in different planes parallel to the main plane of the plate, the projections and supporting surfaces being distributed on the plate in a pattern, as seen on a front elevation of the plate, such that when two such plates are put together so as to cover each other like in the pack of plates, but in different relative positions in other respects, the distance giving projections in the interspace between the plates, which in one relative position lie close to supporting surfaces situated in one plane, in another relative position will lie closely to supporting surfaces situated in a different plane, so that different relative positions will result in differently large distances between the put together plates.

The invention will be described more in detail below with reference to the drawings, in which—

FIGS. 1 and 2 show a plane view and a sectional view along line III—III of FIG. 1 respectively, of an embodiment of heat transfer plates for conventional heat exchangers of the kind to which the invention relates,

FIG. 3 shows a similar sectional view of a pack of three such plates,

FIGS. 4 and 5 show a plane view and a view of an edge respectively, of another embodiment of a heat transfer plate for another conventional heat exchanger of the kind to which the invention relates,

FIG. 6 illustrates a conventional pack of three such plates showing the edges of the plates,

FIG. 7 illustrates a pack of the same plates, made up according to one embodiment of the invention,

FIG. 8 illustrates a sectional view of one embodiment of a distance giving projection impressed in the plate,

FIGS. 9, 10 and 11 show symbols utilized in the following figures for the same distance giving projection as seen from the left, from the side and from the right in FIG. 8 respectively,

FIGS. 12 and 13 show a front view and a side view respectively, of a part *d* of FIG. 1 or 4 pressed according to one embodiment of the invention,

FIGS. 12*x*, 12*z* and 12*xz* illustrate the same part turned in three different positions,

FIGS. 14, 15 and 16 illustrate like part *d* of FIG. 3 or 6 each one combination of plates pressed according to FIG. 12 and put together to form a pack in mutual differently turned positions,

FIGS. 17 and 18 illustrate the impressions according to FIG. 12 on a larger part of the plate on a reduced scale, FIGS. 19 and 20 illustrate the part *d* pressed according to another embodiment of the invention,

FIGS. 19*x*, 19*y* and 19*z* illustrate the same part, each in a differently turned position,

FIGS. 21, 22, 23, 24 and 25 illustrate like the part *d* of FIG. 3 or 6 each one combination of plates pressed according to FIG. 19 and put together to form packs in mutual differently turned positions,

FIG. 26 illustrates impressions according to FIG. 19 on a larger part of the plate on a reduced scale,

FIGS. 27 and 28 show a front view and a side view respectively, of a modification of the pressing according to FIG. 26,

FIGS. 29 and 30 illustrate the part *d* pressed according to a further embodiment of the invention,

FIGS. 29*z* 1, 29*z* 2 and 29*z* 3 illustrate the same part turned in three different positions,

FIGS. 31, 32 and 33 illustrate like part *d* in FIG. 3 or 6 each one combination of plates pressed according to FIG. 29 and put together to form packs in mutual differently turned positions, and

FIGS. 34 and 35 illustrate a pressing according to FIG. 29 on a larger part of the plate on a reduced scale.

All the figures are schematical and only intended to serve as examples without limiting the scope. Identical details in the different figures are provided with the same reference marks.

In FIGS. 1 and 2, which illustrate a rectangular conventional heat transfer plate, numerals **2**, **3**, **4** and **5** refer to the edges of the plate, *a* and *b* to its respective sides, *x* and *y* to the respective center lines of the plates crossing each other in the center point *c* of the plate, and *z* (FIG. 2) a line through the center point of the plate and perpendicular to its main plane. The plate is in addition provided with a port **6** in each of its four corners and with distance giving projections **7** of the height L, four of which on each side of the plate are arranged one in each corner of an imaginary square with a center point *c*. When the plates lie together in a pack according to FIG. 3 such that they completely cover each other, the distance giving projections lie close together giving the distance 2L between the plates. An edge packing **8** around two of the ports of each plate and a packing ring **9** around each of the other ports are arranged in the formed interspaces in the usual way, such that one of the heat exchanging media which is led through two series of ports situated opposite to each other in the pack, is led through every second interspace between the plates, and the other heat exchanging medium, which is led through the two other series of such ports, is led through the other interspaces.

FIGS. 4 and 5 show a plate that can be regarded as a square part of the plate according to FIG. 1 with the center point *c* and with equally long edges **2***a*, **2***b*, **2***c* and **2***d*. The distances between the plates in a pack according to FIG. 6 will of course be 2L as well. With edge packings **8***a* arranged as illustrated a similar pack can be utilized for heat exchange in cross-flow, one of the heat exchanging media being led through the one interspace in a vertical direction, and the other medium being led through the other interspace in a horizontal direction.

The plates according to FIGS. 1 and 2 can be put together two and two so as to cover each other completely, but with one of the plates turned any of the following ways in relation to the other unturned plate (O-turned), namely:

(1) X-turned, i.e., turned 180° around the center line *x* so that edges **2** and **4** and sides *a* and *b* of the plate exchange their positions,

(2) Y-turned, i.e., turned 180° around the center line *y* so that edges **3** and **5** and sides *a* and *b* of the plate exchange their positions, and

(3) Z-turned, i.e., turned 180° around line *z* so that edges **2** and **4** as well as edges **3** and **5** of the plate but not the sides *a* and *b* exchange their positions.

The relative positions of the plates may therefore be designated as *o–x*, *o–y* and *o–z*.

The same applies in connection with square-shaped plates, for instance according to FIGS. 4 and 5, with the further possibility to Z-turn one of the plates stepwise 90°, i.e. to obtain three *o–z* relative positions, such that for instance edge **2***a* can exchange its position with any of edges **2***b*, **2***c* or **2***d*.

The pattern as seen on the plane of the plate, according to which the distance giving supports are distributed on the plate, has the effect, however, that however relatively positioned the plates are put together such as to cover each other completely, the distance giving supports of adjacent plates will meet according to FIG. 3 and FIG. 6 respectively, so that the distance will remain unvariably 2L. A distance L can be obtained, however, by displacing one of the plates according to FIG. 7 such that opposite distance giving supports by the side of each other rest against the adjacent plate. In this changed relative position will, as will be seen, the distance giving supports of the one plate lie close to supporting surfaces of the other plate, which are situated in another plane parallel to the main plane of the plate than the plane in which the tops of the opposite distance giving supports are situated, and form corresponding supporting surfaces in the relative position according to FIG. 6.

It is the achieving of an effect as described, by changing the relative positions of identical plates that is the basic idea of the present invention. To achieve this effect by displacing the plates as mentioned lies within the scope of the invention, but that method brings with it awkward complications in many cases. Plates according to FIGS. 1 and 2, for instance, then get into such relative positions that the ports and packings of adjacent plates will not be situated opposite to each other.

It is therefore a particularly important part of the invention thought to distribute the said distance giving supports and supporting surfaces according to a pattern such that the effect aimed at can be achieved by means of the different relative positions which are obtained by X–Y–Z-turnings only, the rectangular or square-shaped plates in all such relative positions covering each other completely. Examples of this are illustrated below with reference to the limited area *d* of FIGS. 1, 3, 4 and 6. Elements **7** thus forming distance giving supports or supporting surfaces in other planes than the main plane of the plate are then, according to FIG. 8 presumed to comprise projections **11** formed on the one side of the plate by means of impressions **10** on the other side of the plate. Seen on a front elevation in the drawing the projections are marked according to FIG. 9 and the impressions according to FIG. 11. Seen from the side the same element is marked according to FIG. 10.

FIGS. 12 and 13 illustrate the area *d* of an O-turned plate (*o*-plate) provided with two distance giving projections **7***a* and **7***b* lying one in each of two diagonally opposed corners of a rectangular quadrangle, in this case a square, with a center point *c* and forming projections of the height 2L above side *a* and side *b* respectively. In the other corners marked with a + the supporting points of the plate are situated for similar distance giving projections of the adjacent plates. FIG. 12*x* illustrates the same area of such a plate, X-turned (*x*-plate). If the *o*-plate is covered with the *x*-plate, the distance giving projections **7***a* of the *x*-plate will meet the side *a* of the *o*-plate at the lower right-hand cross in FIG. 12 and give the distance **2** L between the plates. If the said *x*-plate is then covered with an *o*-plate, the distance giving projection **7***b* of the *x*-plate will meet the side *b* of this *o*-plate at the upper left-hand cross of FIG. 12 and give the distance **2** L between these plates as well. This way a pack of three plates is obtained with all distances equal to 2L according to FIG.

14. The pack can be extended to any chosen size by adding further alternating *o*- and *x*-plates.

If on the other hand an *o*-plate is covered with a 180° Z-turned plate according to FIG. 12*z*, the distance giving projections **7*b*** of the *z*-plate and the distance giving projections **7*a*** of the *o*-plate will meet so that the distance between the plates will be 4L. If this *z*-plate is then covered with an *o*-plate, the distance giving projections **7*a*** of the *z*-plate will meet the distance giving projections **7*b*** of the said *o*-plate so that the distance between these plates will be the addition distance $2L+2L=4L$ as well. In that way one is able to form packs according to FIG. 15 from alternating *o*- and *z*-plates with all the distances between the plates equal to 4L.

FIG. 16 gives an example of what packs with optional varying distances may look like. Counted from the left in the figure the first distance 2 L is, like in FIG. 14, formed by one *o*- and one *x*-plate. Next distance is wanted to be 4L. This is obtained according to FIG. 15 from one *o*- and one *z*-plate, but as the one plate in FIG. 16 is an *x*-plate, the other plate must be a plate that is Z-turned in relation to the *x*-plate, i.e. an *xz*-plate according to FIG. 12*xz*, which may be obtained by first X-turning an *o*-plate and then Z-turning the *x*-plate obtained. Next distance is again wanted to be 4L, which is obtained by means of a further *x*-plate according to the rule that equal distances in a row will be formed by alternating plates turned the same way. The last distance 2L is formed according to FIG. 14 by means of a further *o*-plate.

FIG. 17 and 18 give an example of how a great number of such distance giving projections may be distributed in rows on the plate such that each projection **7*a*** on the one side *a* of the plate and a projection **7*b*** on the other side *b* of the plate will lie in diametrically opposed corners of a rectangular quadrangle with a center point *c*. Those supporting surfaces in the other corners of the quadrangle are marked with a cross, where the projections of the one plate lie closely against the other plate, X- or Y-turned.

FIGS. 19 and 20 give in connection with an *o*-plate an example of a pattern of distance giving projections by means of which three different plate distances may be obtained. Projections **7*a*** and **7*b*** are arranged like in FIG. 12 but have a height of 3L. In addition, there are further projections **12*a*** and **12*b*** at the points marked with a + in FIG. 12 pressed to the height L above side *a* and side *b*, respectively. FIGS. 19*x*, 19*y* and 19*z* show the look of the pattern when turning to *x*-, *y*- and *z*-plate, respectively.

If an *o*-plate is covered with a *y*-plate the projections **7*a*** of the *y*-plate will rest against the bottom of the impression forming the projection **12*b*** of the *o*-plate (FIG. 21), and the projection **7*a*** of the *o*-plate will rest against the bottom of the impression forming the projection **12*b*** of the *y*-plate (FIG. 22) such that the distance between the plates will be the subtraction distance $3L-L=2L$ (disregarding the comparatively small thickness of the sheet). If this *y*-plate is further covered with another *o*-plate, the projections **7*b*** of the *o*-plate will project into the projections **12*a*** of the *y*-plate (FIG. 21), and the projections **7*b*** of the *y*-plate will project into the projections **12*a*** of the *o*-plate (FIG. 22) such that the same distance 2L between the plates is obtained. Using alternating *o*- and *y*-plates packs can thus be obtained with all distances equal to 2L.

Utilizing alternating *o*- and *x*-plates the projections of different heights of the adjacent plates will rest against each other as shown in FIG. 23 such that the addition distances $3L+L=4L$ arise between the plates.

Utilizing alternating *o*- and *z*-plates, finally, projections **7*a*** and **7*b*** of the adjacent plates will, according to FIG. 24, rest against each other such that the addition distances $3L+3L=6L$ arise between the plates.

FIG. 25 gives an example of an optional distribution of the three possible distances in a pack of plates. Counted from the left in the figure, distance 2L is formed between one *o*- and one *y*-plate according to FIGS. 21 and 22. Next distance 4L is to be formed by a plate that is X-turned in relation to the *y*-plate, as the relative position must be *x* according to FIG. 23. This will become a *z*-plate. Next distance of 6L is formed analogously to FIG. 24 by means of an *o*-plate, and the end distance 2L is like the first distance formed by means of a *y*-plate.

FIG. 26 gives an example of how a great number of such distance giving supports may be distributed in rows on the plate. It differs from FIG. 17 only in that the plate at the points of the crosses is provided with distance giving projections **12*a*** and **12*b***, respectively. A modification of this arrangement consists, according to FIGS. 27 and 28, in that the rows of the distance giving projections **12*a*** and **12*b***, respectively, are substituted by ridges **13*a*** and **13*b***, respectively, which are pressed to the same height above the neutral plane N of the plate, in which, in their turn, distance giving elements **7*a*** and **7*b***, respectively, are pressed to their height above the neutral plane.

FIGS. 29 and 30 illustrate an arrangement of distance giving projections according to the invention, which will be suitable specially in connection with packs of square-formed plates, which are able to cover each other with one of the plates Z-turned 90, 180 or 270° in relation to the other, as illustrated by FIGS. 29*z* 1, 29*z* 2 and 29*z* 3, respectively. In this case the plate is in three corners of the above-mentioned quadrangle, which in this case will be a square, provided with the distance giving projections **7*b***, **12*b*** and **14*b***, respectively, pressed to the heights 3L, 2L and L above the one side *b* of the plate. In the relative positions O–Z1 and O–Z2, the distance giving projection **7*b*** of the *z*-plate meets (according to FIGS. 31 and 32, respectively), the *o*-plate at its distance giving projections **12*b*** and **14*b***, respectively, which gives the subtraction distances between the plates 3L—2L=L and 3L—L=2L, respectively. In the relative position O–Z3 the same distance giving projection meets, according to FIG. 33, the *o*-plate in the main plane, which gives the distance 3L between the plates.

FIGS. 34 and 35 give an example of how a greater number of such distance giving projections may be distributed in rows on the plate, FIG. 35 showing the squares, in the corners of which the distance giving projections are situated according to the arrangement shown in FIG. 29.

If the plates have some other multigonal shape, for instance have hexagonal or octagonal shape so that they may be Z-turned to 5 and 7 different relative positions, respectively, a correspondingly increased number of variants of distances may be obtained according to the same principle by means of distributing a correspondingly increased number of distance giving projections of an equally increased number of height variations in the corners of the hexagonal or octagonal plate respectively with a center point *c*. If the plates are circular the distance giving projections are distributed along a circle around their center point.

Contrary to the preceding arrangements, where the plates have projections on their both sides this arrangement will not, however, provide the possibility of obtaining packs by means of turning every second plate, in which packs large addition distances arise on account of the projections of adjacent plates being oppositely directed like for instance according to FIGS. 15, 23 or 24. Owing to the fact that the theoretical possibility of pressing the projections **7*b*** so much higher instead might be accompanied by practical difficulties, an arrangement according to FIG. 29 is as a rule suitable only in connection with comparatively small distances.

With the guidance of the examples illustrated and described a person skilled in the art will be able to arrange further modifications. The relative heights of the distance giving supports may for instance be varied such that different proportions between the varying interspaces will be obtained. The patterns illustrated in FIGS. 17, 26, 27 and 34 may be rearranged in the plane of the plate such as will result if lines *x* and *y* change places in the figures, the distance giving projections may have a shape differing from the circular form etc.

We claim:

1. A plate heat exchanger having a plurality of substantially identical heat transfer plates of thin pressed sheets held together in side-by-side relation in a pack and forming interspaces between adjacent plates, said plates having ports and being adapted to coact with marginal packings in said interspaces to define flow channels for passage of the heat exchange media through said pack, alternate ones of said interspaces being arranged for passage of one heat exchange medium and the other interspaces being arranged for passage of the other heat exchange medium, adjacent plates having spacing projections and supporting surfaces adapted to abut each other in said interspaces, said projections forming supporting surfaces, characterized in that each plate is provided with such spacing projections and has its supporting surfaces situated in different planes parallel to the main plane of the plate, said projections and supporting surfaces being distributed on the plate according to a pattern such that when two such adjacent plates are assembled side-by-side, as in the pack of plates, but in first and then in second relative positions, a spacing projection which in said first relative positions is adapted to abut a supporting surface situated in one plane is adapted in said second relative positions to abut a supporting surface situated in a different plane, whereby the spacing between the adjacent plates is varied.

2. A plate heat exchanger according to claim 1, in which each plate has a center point and horizontal and vertical center lines intersecting at the center point, each plate having on opposite sides a plurality of said projections of maximum and equal height as measured from the main plane of the plate, a said projection on one side of each plate being located in one corner of an imaginary quadrangle having two pairs of opposite sides parallel to said horizontal and vertical center lines, respectively, a said projection on the other side of each plate being located in a corner of said quadrangle diametrically opposite said one corner, said quadrangle having a center point coinciding with said center point of the plate, opposite sides of the plate having in the other two corners of the quadrangle, respectively, supporting surfaces for said projections of maximum height on the adjacent plates, said last supporting surfaces being of equal height less than said maximum height.

3. A plate heat exchanger according to claim 2, in which said supporting surfaces on opposite sides of the

plate and in said other two corners are flush with the respective sides of the plate.

4. A plate heat exchanger according to claim 1, in which each plate has a center point and horizontal and vertical center lines intersecting at the center point, each plate having on opposite sides a plurality of said projections of maximum and equal height as measured from the main plane of the plate, a said projection on one side of each plate being located in one corner of an imaginary quadrangle having two pairs of opposite sides parallel to said horizontal and vertical center lines, respectively, a said projection on the other side of each plate being located in a corner of said quadrangle diametrically opposite said one corner, said quadrangle having a center point coinciding with said center point of the plate, opposite sides of the plate having in the other two corners of the quadrangle, respectively, spacing projections of equal height less than said maximum height, each said projection of less height being formed by an impression in the opposite side of the plate and of sufficient width to allow a said maximum height projection of an adjacent plate to project into the impression and rest against its bottom.

5. A plate heat exchanger according to claim 1, in which each plate has on one side a plurality of said projections of different heights above said one side and formed by impressions of different depths in the other side, said projections being distributed in a pattern such that in said first relative positions of adjacent plates the highest projection of one plate rests against the bottom of a said impression of a certain depth in the adjacent plate, and in said second relative positions said highest projection rests against the bottom of a said impression of a different depth in said adjacent plate.

6. A plate heat exchanger according to claim 4, in which each said impression is elongated to provide a ridge supporting a plurality of said projections of maximum height, each elongated impression being adapted to receive against its bottom and from an adjacent plate a plurality of said maximum height projections.

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