PATENT SPECIFICATION

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(54) PLATE HEAT EXCHANGERS AND PLATES THEREFOR

(71) We, HOECHST AKTIENGESELLSCHAFT, a body corporate organised according to the laws of the Federal Republic of Germany, of 6230 Frankfurt/Main 80, Postfach 80 03 20, Federal Republic of Germany, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:–

This invention relates to plate heat exchangers and to plates for such heat exchangers.

Plate heat exchanger having plates made of metallic materials cannot be used for certain applications since they cannot satisfy certain technical requirements regarding corrosion. Plate heat exchangers having plates made from polytetrafluoroethylene or hexafluoropropylene have been proposed, although they have the disadvantage that the design of such plates does not permit efficient, and hence economical, production. A further disadvantage is that heat exchange takes place via a thin separating wall which must be arranged between adjacent plates.

The present invention provides a plate heat exchanger which comprises a stack of heat exchanger plates so arranged that a flow space for primary or secondary heat exchange fluid is provided between each adjacent pair of plates, each plate having at least one surface which is provided with one or more ribs which divide the flow space into a plurality of channels and with a plurality of elongate projections extending across the entire width of each channel, each channel having a fluid inlet and a fluid outlet both of smaller cross-sectional area than the channel, the fluid inlets and the fluid outlets of the channels between each adjacent pair of plates communicating with a common fluid distribution conduit and a common fluid collection conduit, respectively, which conduits are defined by the pair of plates, the fluid distribution conduit and the fluid collection conduit communicating with fluid inlet and outlet means respectively, the fluid inlet and outlet means being arranged to allow primary and secondary heat exchange fluids to flow through alternate flow spaces.

Advantageously, each rib is broader at its ends than along the remainder of its length so as to form with an adjacent rib a fluid inlet and fluid outlet having cross-sectional areas smaller than that of the channel between the ribs.

The elongate projections which extend across the entire width of each channel and which, in use, cause turbulence in the fluid flowing through the channels, are preferably substantially perpendicular to the ribs and, in any channel, are suitably staggered along the length of the channel with respect to the elongate projections in the or each adjacent channel. Advantageously, the end portions of each elongate projection which join the ribs are thicker than the central portion of the elongate projection. This latter feature improves the rigidity of the plate. Alternatively, each plate may be corrugated in the direction of fluid flow in the channels, the corrugations, in use, causing turbulence in the fluid flowing through the channels.

The invention also provides a heat exchanger plate for a heat exchanger according to the invention, independent of each other exchange plate.

The plates according to the invention may be formed economically for example by pressing, casting or extrusion moulding. The plates according to the invention have the advantage that they may be produced economically from materials of low toughness or strength and can be assembled to form a heat exchanger without the use of a thin separating wall between adjacent plates to separate the heat exchange fluids.

Various forms of heat exchanger and plates according to the invention will now be described, by way of example, with reference to the accompanying drawings, in which

Figure 1 is a plan view of one form of plate according to the invention;

Figure 2 is a sectional view of a heat exchanger comprising a stack of plates shown in Figure 1, the section taken along the line I-I of Figure 1: and

Figures 3 to 6 are sectional views of heat exchangers according to the invention which comprises other forms of heat exchange plate.

Referring initially to Figures 1 and 2 of the accompanying drawings, a heat exchanger comprises a stack of plates 1 and two ends plates 1*a*. Each surface of the plates 1, and one surface of the plates 1*a* are provided with a peripheral groove 2 running all round for accommodating a seal ring 3. At the corners of the plate orifices 4, 5, 6, 7 are provided for the intake and discharge of the heat exchange fluids. A pair of the orifices 4, 6 and 5, 7 with grooves 8, concentric with the orifices, for accommodating seals (not shown), are provided in each case on each side of the plate, with the exception of plates 1*a*. Mixing of the primary and secondary heat exchange fluids is prevented by the seals in the grooves 8. The orifices 4, 5, 6, 7 of two or more plates assembled on each other, form a conveyor line into which distribution conduits 9 and collection conduits 10 lead. The conduits 9 and 10 are connected, via orifices of reduced cross-section or constrictions 11, to channels for the heat exchange fluid which channels are defined by ribs 12 and an exchange wall 13. The heat exchange between the primary and secondary heat exchange fluid takes place via the exchange wall 13. The channels so formed are interrupted by elongate projections which extend from one rib to its adjacent rib to form transverse walls 14, the walls 14 joining the ribs 12 by means of thickenings 15. The elongate projections or transverse walls 14 in any channel are staggered with respect to the projections or walls 14 in the or each adjacent channel. The channels of two adjacent plates form a "pipe", the half cross-section of which is displaced alternately by the transverse walls 14 on each of the two plates so that a particularly good degree of turbulence is achieved. The ribs 12 of adjacent plates are thus arranged opposite each other whilst the transverse walls 14 of adjacent plates and adjacent channels are offset to one another. In Figure 1 the ratio of the spacings of the transverse walls 14 to the spacings of the ribs 12 is chosen to be 2:1 although other ratios of these spacings are possible. With a ratio of 1:1 for example, the greatest degree of rigidity is acheived for the exchange wall 13. Adequate rigidity and turbulence can, however, be achieved if the height of the transverse walls 14 above the exchange wall 13 is less than that of the ribs 12; and furthermore, the total pressure drop in the heat exchanger is favourably affected.

The system, consisting of ribs 12 and transverse walls 14, forms a stable frame for the exchange walls 13 through which the actual heat exchange takes place. By means of the design according to the invention, the plate can be constructed from materials of lower rigidity than hitherto, for example from polytetrafluoroethylene which has a high chemical resistance. The exchange wall 13 can also be made very thin.

One heat exchange fluid passes from a distribution line 19 through orifices 6 into alternate distribution conduits 9 and from there via the nozzle-like constrictions 11 into the channels formed by the ribs 12 and the exchange wall 13 which channels are distributed over the whole of each plate. The fluid is deflected by the transverse walls 14 running across the fluid's path and turbulence occurs. Nozzle-like constrictions 11 are arranged again at the end of the channels in order to ensure uniform loading of all channels. The fluid passes, via the collecting conduit 10, into the orifice 4 and from there into a collection line 16. The surface of the distribution and collections conduits 9 and 10 serves also as a heat exchange surface. The other heat exchange fluid follows a similar flow path through the other alternate flow spaces from distribution line 18 to collection line 17.

Referring to Figures 3 to 6 of the accompanying drawings, other forms of plate designs are shown in which parallel ribs 12 running parallel to the direction of fluid flow are common to all embodiments. If the rigidity of the heat exchange plate material permits, the height of the transverse walls 14 can be less than that of the ribs 12 and any undesirable reduction in the degree of turbulence of the heat exchange fluid can be compensated by a corrugated or serrated shaping of the exchange walls 13 as shown in Figure 3. Additional turbulence is produced in the heat exchanger shown in Figure 3 by adjacent exchange walls 13 alternately converging and diverging, a nozzle-like effect being produced by the resulting constrictions 20.

Certain materials, for example cast metal, are more favourable than others from the point of view of production. In Figure 6, a heat exchanger is shown in which the plates differ in designed from the plates in Figure 2 solely by the serrated shaping of the exchange wall 13. This design has the advantage of a greater heat exchange surface relative to the projected plan area and, at the same time, good stiffening of the plate. This model can be produced particularly economically as an injection moulded model.

Although when using materials having low heat conductivities such as polytetrafluoroethylene, for the heat exchange plates, the heat transition coefficients of some other heat exchange plates such as plates of pressed metal can not be achieved with the plates according to the invention, the heat transition coefficients of standard tubular heat exchangers are achieved. The advantages of plate heat exchangers can therefore be utilized. The production of such plates is also economical, so that with this design a heat exchanger can be provided which can be subjected to extreme corrosive conditions and a considerable temperature stress. The plates according to the invention can of course also be successfully made from metal, for example cast metal or cast alloys, or glass.

Plate heat exchangers, which are formed from the plates according to the invention, can be used, with appropriate dimensioning of the entry and exit cross-sections and of the distribution and collection conduits of the plates, for liquid and/or gas heat exchange fluids.

WHAT WE CLAIM IS:–

1. A plate heat exchanger which comprises a stack of heat exchange plates so arranged that a flow space for primary or secondary heat exchange fluid is provided between each adjacent pair of plates, each plate having at least one surface which is provided with one or more ribs which divide the flow space into a plurality of channels and with a plurality of elongate projections extending across the entire width of each channel, each channel having a fluid inlet and a fluid outlet both of smaller cross-sectional area than the channel, the fluid inlets and the fluid outlets of the channels between each adjacent pair of plates communicating with a common fluid distribution conduit and a common fluid collection conduit, respectively, which conduits are defined by the pair of plates, the fluid distribution conduit and the fluid collection conduit communicating with fluid inlet and outlet means respectively, the fluid inlet and outlet means being arranged to allow primary and secondary heat exchange fluids to flow through alternate flow spaces.

2. A heat exchanger as claimed in claim 1, wherein each rib is broader at its ends than along the remainder of its length so as to form with an adjacent rib a fluid inlet and fluid outlet having cross-sectional areas smaller than that of the channel between the ribs.

3. A heat exchanger as claimed in claim 1 or claim 2, wherein the elongate projections are substantially perpendicular to the ribs.

4. A heat exchanger as claimed in any one of claims 1 to 3, wherein the end portions of each elongate projection which join the ribs are thicker than the central portion of the elongate projection.

5. A heat exchanger as claimed in any one of claims 1 to 4, wherein the elongate projections in any channel are staggered along the length of the channel with respect to the elongate projections in the or each adjacent channel.

6. A heat exchanger as claimed in any one of claims 1 to 5, wherein each plate is corrugated in the direction of the length of the ribs.

7. A heat exchanger as claimed in claim 1, substantially as hereinbefore described with reference to, and as shown in Figures 1 and 2 of the accompanying drawings.

8. A heat exchanger as claimed in claim 1, substantially as hereinbefore described with reference to, and as shown in, any one of Figures 3 to 6 of the accompanying drawings.

9. A heat exchanger plate as defined in any one of claims 1 to 8, independent of each other heat exchange plate.

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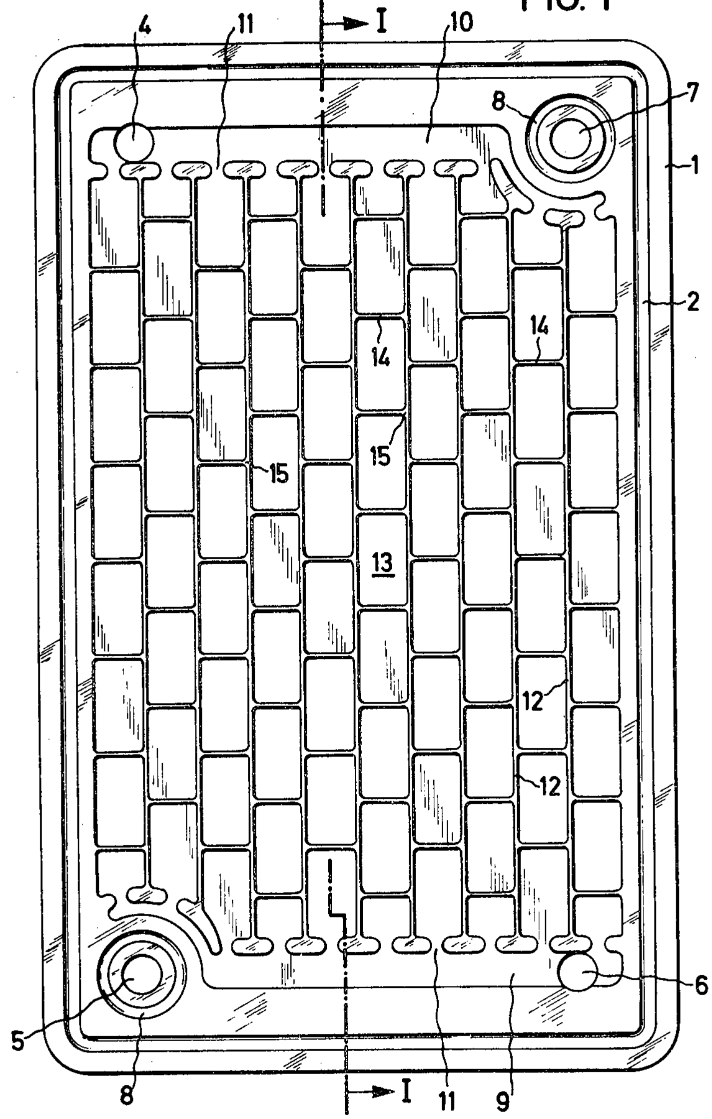
FIG. 1



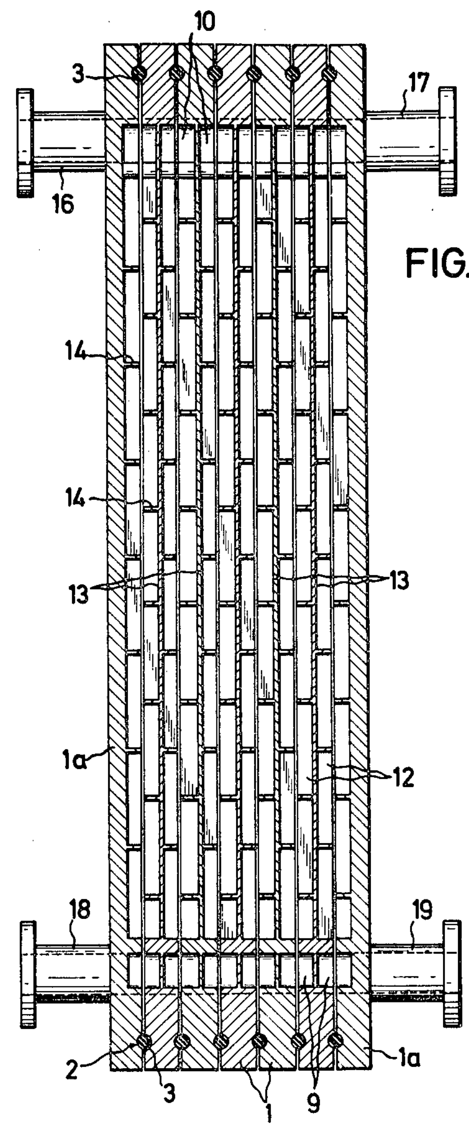


FIG. 2

1594740 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

FIG. 3

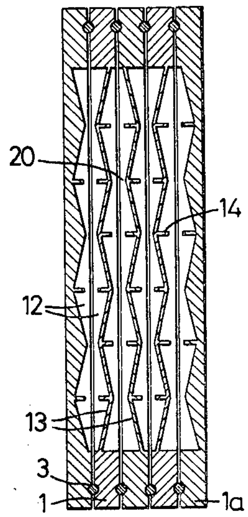


FIG. 4

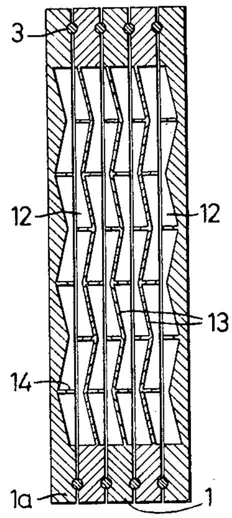


FIG. 5

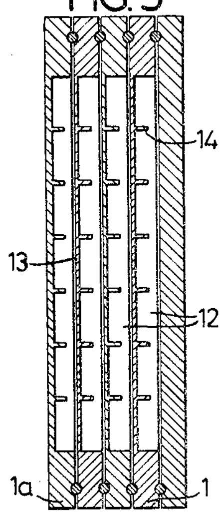


FIG. 6