

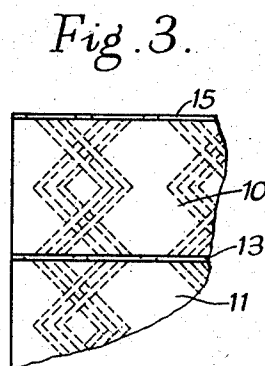
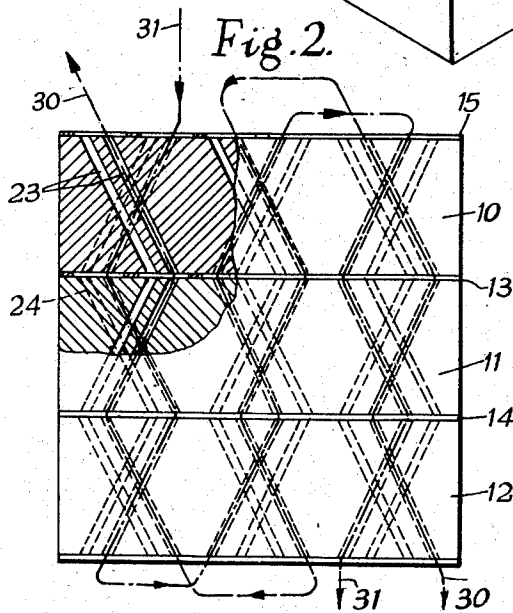
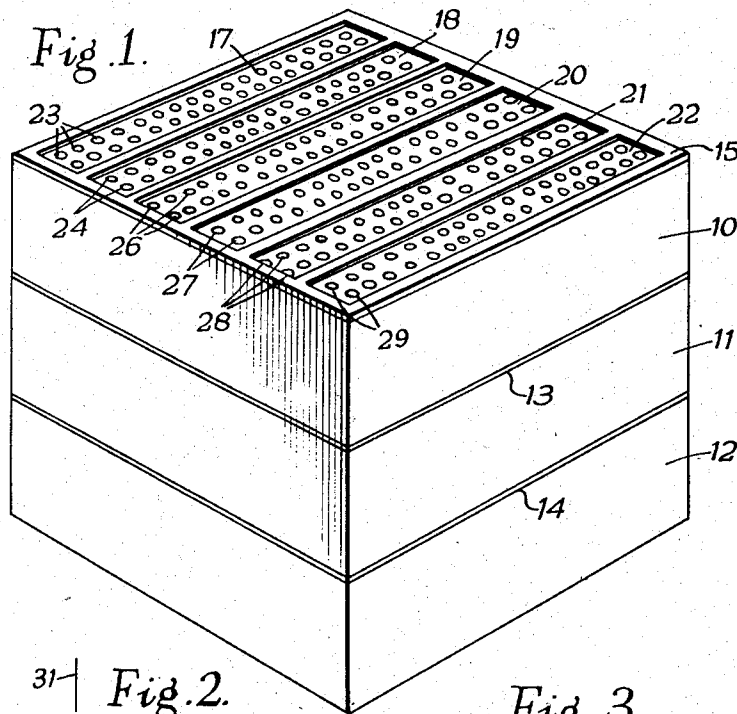
May 19, 1959

A. HILLIARD
HEAT EXCHANGERS

2,887,304

Filed Aug. 3, 1956

5 Sheets-Sheet 1



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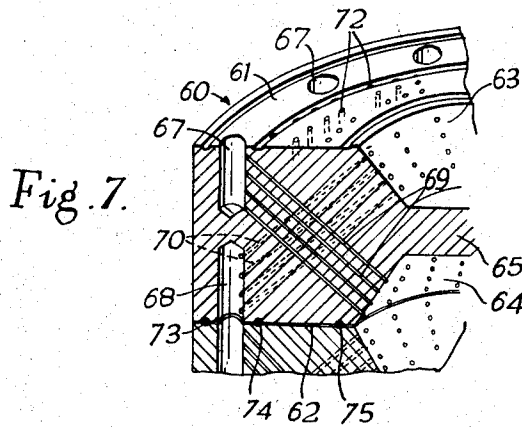
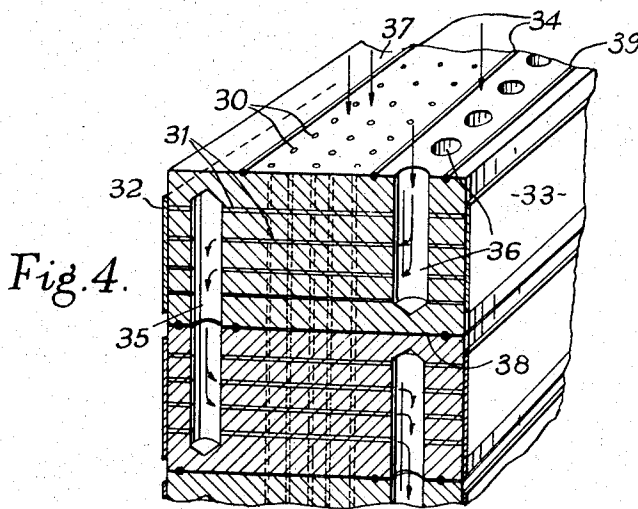
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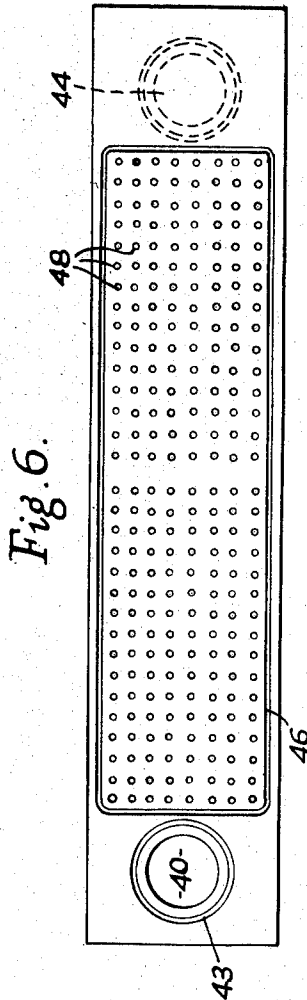
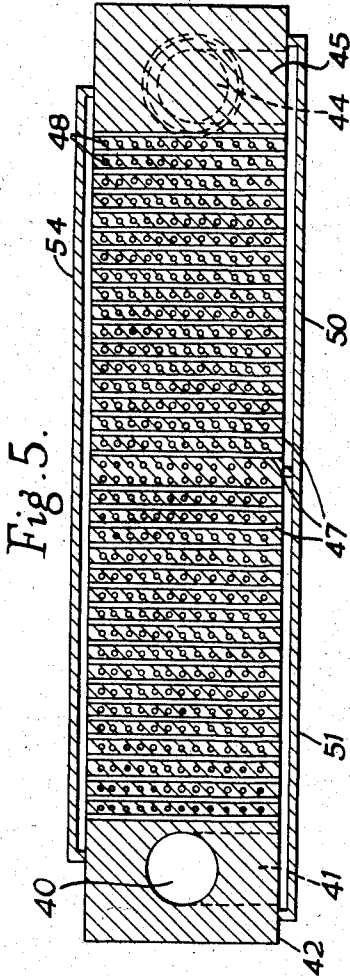
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Fig. 8.

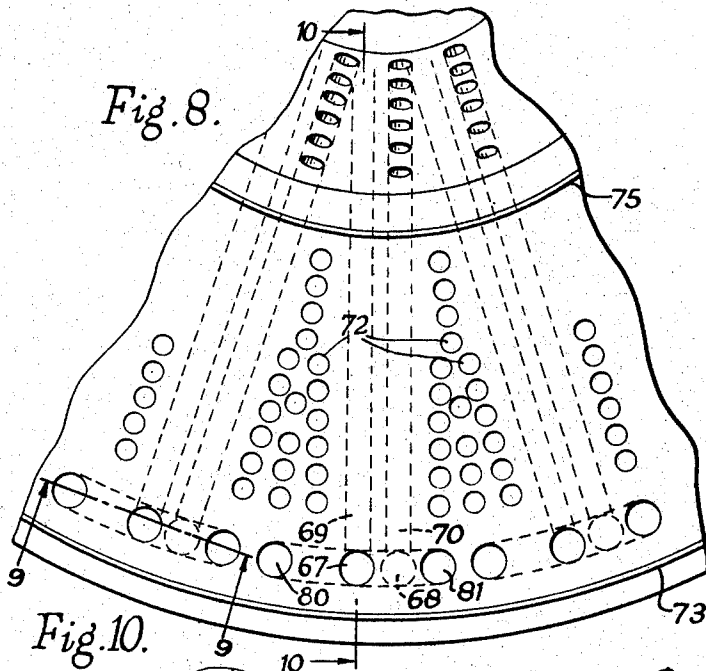
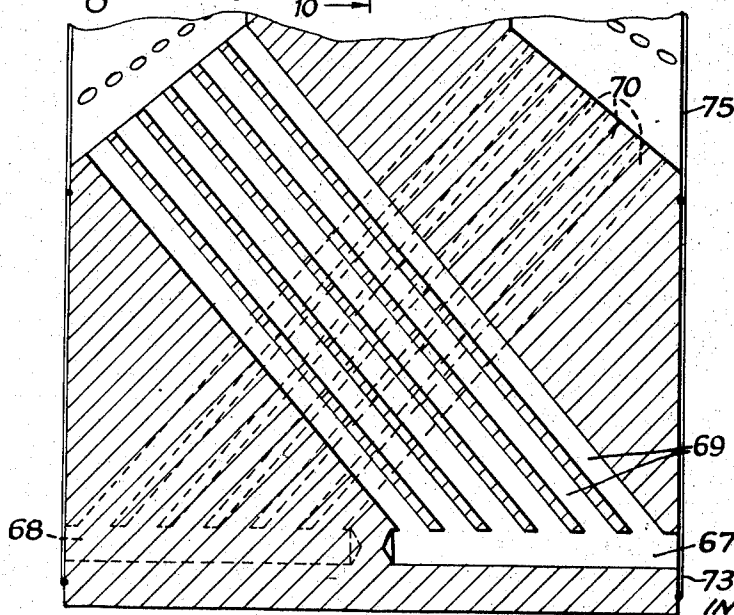


Fig. 10.



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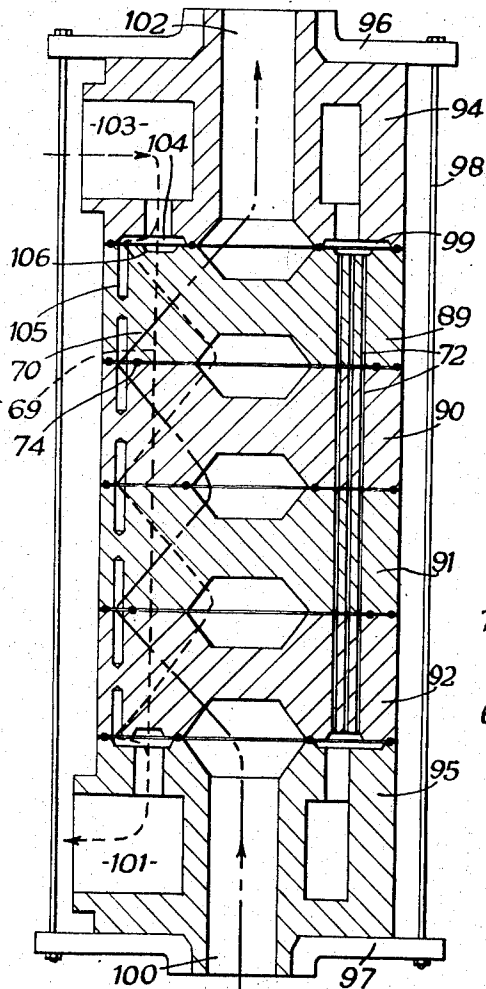


Fig. 11.

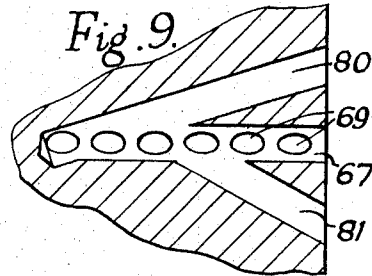
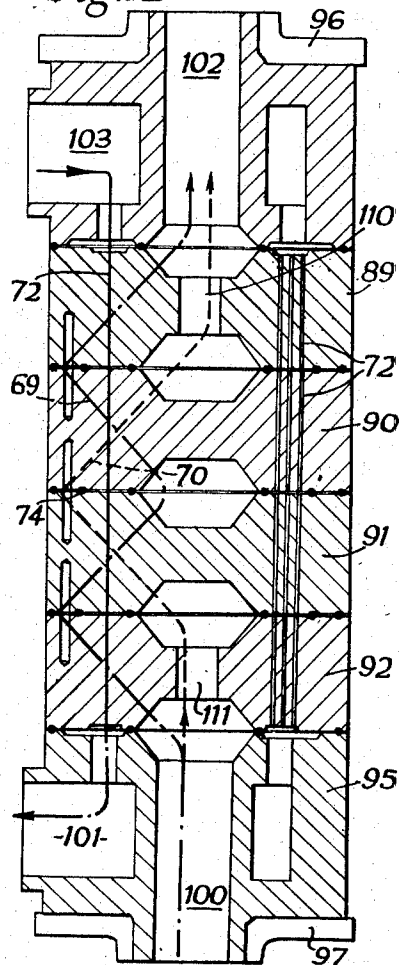


Fig. 12.



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HEAT EXCHANGERS

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5 Claims. (Cl. 257—241)

This invention relates to heat exchangers of the kind in which a plurality of sets of ducts for passage there-through of two heat exchange media respectively are provided in a block of material in heat exchange relationship with each other. Heat exchangers of this kind are described in British patent specifications Nos. 736,305, 739,906, 756,327 and 756,240.

Heretofore (except for heat exchangers which were totally immersed in one of the heat exchange media) when two or more such blocks were mounted (to form a column) with suitable gaskets at their end surfaces to seal off the sets of passages of one heat exchange medium from those of the second heat exchange medium, it was necessary to provide an outer casing or shell for the conveyance of the second heat exchange medium from one block to the next. Said shell which completely surrounded the column of blocks, involved the provision of a sliding joint to accommodate differential expansion between the casing (usually made from metal) and the column of blocks which may be made from graphite.

Alternatively, if lateral headers were used instead of the aforesaid shell to convey the second heat exchange medium from one block to the next, the gaskets of the latter had to cross the gaskets relating to the first series of passages, which involved danger of leakage and necessitated careful and costly manufacture.

If the second heat exchange medium was corrosive, and if the aforesaid shell or the headers were made from metal, the latter had to be provided with corrosion resistant linings.

It was necessary to remove the shell or the lateral headers to locate leakage of a gasket.

The main object of the present invention is to provide heat exchangers which can be built up from blocks to form a column without involving crossing gaskets, which do not require the use of an outer shell or external lateral headers for the conveyance of the second heat exchange fluid from one block to the next, and which permit visual observation of at least some of the gaskets between the blocks.

A further object of the invention is to obviate the use of a sliding joint to allow for differential thermal expansion of the materials of construction.

According to the present invention a heat exchange block is provided in which at least one end of the block has at least two openings for different heat exchange media whereby they can be surrounded by gaskets that do not cross each other, said openings communicating through the block by means of at least two corresponding sets of ducts which extend transversely across each other in the block.

By such a construction a heat exchanger can be made by connecting two or more blocks end to end whereby the heat exchange media can flow through the blocks without requiring an outer casing for conducting fluid from one block to the next and without gaskets crossing over each other.

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The invention also offers other advantages: for example, the outer gaskets can be visible which facilitates detection of leaks; different flow arrangements can be achieved with a given form of block; easier dismantling and reassembly is possible; and metal strengthening bands around the blocks will not need protection against corrosive fluids.

Any convenient shape and number of blocks, e.g. cylindrical or rectangular blocks of graphite or other material preferably of high heat conductivity, may be mounted to form a column with gaskets between adjacent blocks or several columns side by side secured together by tie-bars or other means and provided with headers at the ends of the column and inlet and outlet means for the media.

Some constructional forms of the invention will now be described by way of example with reference to the accompanying diagrammatic drawings wherein:

Figure 1 is a perspective view of a column of blocks made in accordance with the invention;

Figure 2 is a view of said column partly in side elevation and partly in section;

Figure 3 shows similar blocks having a modified form of ducting;

Figure 4 is a view partly in section and partly in perspective of a similar column with a further modified form of ducting;

Figure 5 is a sectional view of another form of block;

Figure 6 shows the block of Figure 5 in plan;

Figure 7 is a view partly in section and partly in perspective showing cylindrical blocks;

Figure 8 shows a part plan view of a modified form of ducting;

Figures 9 and 10 are sectional views on lines 9—9 and 10—10 respectively on Figure 8; Figure 9 has been rotated through about 90 degrees in the clockwise direction in relation to the section 9—9; and

Figures 11 and 12 are sectional views of heat exchangers made with cylindrical blocks and illustrating different flow paths achieved with the same standard blocks.

In the construction shown in Figures 1 and 2 blocks 10, 11, 12 are shown disposed in the form of a column with gaskets 13, 14 between adjacent blocks. A similar gasket 15 is shown on the top block 10. Each gasket surrounds separate rectangular areas 17, 18, 19, 20, 21, 22. Openings in the top surface of the block 10 are formed by the ends of ducts 23 that extend through the block to the opposite end surface into the area corresponding to 18 thereby extending transversely across ducts 24 the ends of which form openings in the area 18. The ducts 24 extend through the block to form openings in the area of the opposite surface corresponding to area 17. In the next block 11 the ducts change direction and again cross each other, and so on. By suitable header means the ducts 23, 24 at the lower surface of the block 12 can be connected with the next adjacent sets of ducts 26, 27 and from the top surface of block 10 the ducts 26, 27 communicate with ducts 28, 29. Thus the dash lines 30 in Figure 2 show the path of one medium and the dot and dash lines 31 show the path of the other medium. The blocks may be clamped between header plates by means of tie-bars.

Figure 2 indicates a triple pass flow. The flow may however be arranged for single pass flow or multi-pass flow. More than two heat exchange media may if desired be passed simultaneously through suitably connected ducts.

As the ducts change direction at each interface a turbulence of the media is ensured which improves efficiency of heat exchange.

As many blocks as required can be assembled without

crossing gaskets. Since no outer casing is required, the gaskets are visible and any leakage can at once be seen and both media could be corrosive to metals, the blocks being made of graphite.

The adjacent faces of the blocks may be close together as it is unnecessary to provide turbulence spaces between them.

The arrangement of the ducts leaves the strongest parts of the blocks at and near their side surfaces which ensures best mechanical strength to withstand clamping pressure of the tie-bars.

In the modification shown in Figure 3 the ducts are of etchelon shape giving a similar effect.

In the alternative construction shown in Figure 4 ducts 30 pass through the blocks from end to end and other ducts 31 are drilled through the blocks in the direction from side to side of the blocks at right angles to the ducts 30 and have their ends blocked by plates 32, 33 and communicate with manifolds 35, 36 which provide openings in the end surfaces of the blocks in areas separate from the openings of the ducts 30 so that the separate areas can be surrounded by gaskets 34, 39 which do not cross. These manifolds open into the upper and lower end surfaces 37, 38 respectively of the block. One heat exchange fluid flows through the ducts 30. The other fluid flows through the manifolds 36 into the ducts 31, and into the manifolds 35. This fluid then flows into the manifold corresponding to 36 of the next block. Suitable gaskets are provided as before.

Another constructional form of the invention is shown in Figures 5 and 6 which show a block having a manifold 40 at one end opening into the top end surface and branching at 41 so as to open out into the side face 42. Another manifold 44 at the other end of the block opens into the bottom end face of the block and branching at 45 into the surface 42. Ducts 47 are drilled transversely through the block. Other ducts 48 are drilled through the block at right angles to the ducts 47. A header plate 50 connects the manifold branch 45 to one half of the ducts 47 on the side 42. A header plate 51 connects the manifold branch 41 to the other half of the ducts 47 on the same side 42. A header plate 54 connects all the ducts to each other on the opposite side of the block. Thus one fluid passes from manifold 44, 45, header 50, right hand ducts 47 into header 54. The fluid then flows through the other half of the ducts 47 to header into the manifold 40, 41 and then into the manifold corresponding to 44 of the next block which is reversed end to end in relation to the first block. The header plates may be replaced by flat plates and the blocks recessed to form header spaces. The other fluid flows through the ducts 48 of one block into similar holes in the next block.

Thus gaskets or packing rings 43, 46 can surround different areas on the same end surface of the block without crossing each other, the areas leading to separate series of ducts 47, 48 which extend transversely across each other in the block.

In the construction shown in Figure 7 of the accompanying drawings the blocks 60 are cylindrical and their end flat faces 61, 62 abut, i.e. are parallel to and adjacent the similar faces of adjacent blocks. These flat faces are formed with deep frustoconical recesses or manifolds 63, 64 separated from each other by a wall 65. Near the periphery of the block and parallel to the axis thereof are an upper series of manifold recesses 67 in line with a similar lower series of manifold recesses 68, each forming openings in the end surfaces of the blocks in areas separate from the areas of the openings in said end surfaces formed by the manifolds or recesses 63, 64. Two series of ducts 69, 70 are drilled from the recesses 63, 64 to the recesses 67, 68 crossing each other diagonally. The fluid media from 63 passes through ducts 70 and manifolds 68 to the manifold corresponding to 67 of the next block then through ducts such as 69

and manifold 64 into the next manifold such as 63 and so on. A third set of ducts 72 are drilled through the block parallel to the axis thereof. The blocks are somewhat spaced apart from each other and provided with gaskets 73, 74, 75, the outer one (73) of which can be seen through the gap between the blocks which facilitates detection of leaks. The second heat exchange fluid passes through these ducts from one block into the space between adjacent blocks surrounded by the gaskets 74, 75 and into the corresponding ducts of the next block.

The gasket 74 or 75 may be omitted if the same fluid passes through the ducts 70 and 72 or 69 and 72 respectively.

The construction shown in Figures 8, 9 and 10 is in general similar to that of Figure 7 but the grouping of the ducts is more precise. Thus the ducts 72 are arranged in triangular shaped radial groups spaced apart from each other and the sets of ducts 69, 70 are disposed between the said groups. The manifold 67 has branches 80, 81, to provide ample cross-sectional area for flow of fluid.

Figures 11 and 12 show a complete heat exchanger consisting of four blocks 89, 90, 91, 92 arranged end to end in a vertical column with an upper header 94 and a lower header 95 and top and bottom plates 96, 97 connected together by tie-bars 98 so as to clamp the whole heat exchanger together. The blocks are cylindrical as in Figures 7 to 10. The vertical ducts 72 are connected at the interfaces of the blocks by turbulence spaces 99. The header 95 provides two inlet or outlet openings 100, 101 and the header 94 has similar openings 102, 103.

In Figures 11 and 12 the blocks are of identical shape except for the gasket grooves which in Figure 11 are arranged so that one heat exchange medium enters from 103 and passes through an opening 104 in the header into a manifold 105 and a turbulence chamber 106 so that this medium passes through two sets of ducts and leaves in a similar manner through the outlet 101 in the bottom header. The other medium enters at 100 and passes by the third set of ducts to the outlet 102.

In Figure 12 the gaskets are differently arranged and a hole 110 is bored centrally through the top block and a similar hole 111 is bored centrally through the bottom block. The set of passages 69 is omitted in the first block 89 and the set of passages 70 is omitted in the last block 92. In this case the medium entering at 100 divides into two streams passing through the two set of crossing ducts and uniting again in a common stream leaving at 102. The other medium passes from 103 through the ducts 72 to the outlet 101.

If the two sets of crossing ducts have a different heat exchange area and/or different cross-sectional areas, a third combination becomes possible.

Further by using these three combinations with a poly-pass system many other arrangements are possible.

The blocks may be formed of metal, graphite or other material.

In all constructions the sets of ducts are brought either directly or by manifold to separate areas on the same face of the block whereby the two fluids from one block flow from one face of one block into ducts or manifolds in the abutting face of the next block thereby avoiding the use of gaskets which cross each other.

As no shell is required, this reduces not only the respective cost of the assembly (a stainless steel shell, for example, can be very expensive) but also makes the assembly much lighter and more handleable. This in turn makes it practicable to use larger blocks and assemble a greater number of blocks together than would be convenient if the additional weight of the shell had to be contended with. The absence of an outer shell further obviates the necessity for floating headers or other arrangements to compensate for differential expansion between

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heat exchanger and shell which can be costly and troublesome.

Another important practical advantage of the invention is that it permits accommodation of very large heat exchange areas in a single heat exchanger and that the blocks are detachable, which not only facilitates cleaning and repairing (if this should ever be necessary) but if any block is accidentally damaged it can be replaced at a much lower cost than if the assembled blocks were cemented together or otherwise fixed together non-detachably.

If the blocks are made from graphite then the orientation of the graphite crystals can be controlled to ensure best heat transfer conditions between the sets of heat exchange passages.

I claim:

1. A heat exchanger comprising a homogeneous solid block having two openings for different heat exchange media in each of the end surfaces thereof, said openings being positioned in first and second areas of each of said surfaces, said openings communicating with at least two corresponding sets of ducts which extend transversely across each other in the block and are separated from each other, said ducts comprising short straight drilled holes within the solid block and the ducts of one set being closely adjacent the ducts of the other set where the ducts of the first set cross the ducts of the second set with opposite ends of said one set of ducts communicating with the opening of the first area of said one end surface and the opening of said second area of said second end surface, and the opposite ends of said second set of ducts communicating with the opening of said second area of said one end surface and the opening of said first area of said second end surface, the ducts of each set being interposed between the ducts of the other set whereby simple headers may be used at the opposite ends of the solid blocks.

2. A block as claimed in claim 1 wherein the block is rectangular and at least one set of the ducts extends therein in the direction from side to side of the block but opens into manifold recesses which constitute said openings in the ends of the block.

3. A block in which at least one end surface of the block has at least two openings for different heat exchange media, said openings being positioned in different areas of said surface such that they can be surrounded by gaskets that do not cross each other, said openings communicating with at least two corresponding sets of ducts which extend transversely across each other in the block and are separated from each other, said ducts comprising short, straight drilled holes, the ducts of one set being closely adjacent the ducts of the other set where the ducts of the first set cross the ducts of the second set, the ducts of each set being interposed between the ducts of the other

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set, said openings being spaced apart over the major part of the areas of said surface; said block being cylindrical and has a central manifold recess at each end and a circular series of manifold recesses at each end around the central manifold recess, said recesses forming said openings in the ends of the block and each set of ducts opens at one end into the central manifold recess and opens at the other end into the series of manifold recesses.

4. A block as claimed in claim 3 wherein each of the two sets of ducts opening into the manifold recesses is arranged in a series of groups around the axis of the block and another set of ducts is located between adjacent groups and passes directly from end to end through the block.

5. A heat exchanger comprising at least two solid homogeneous blocks each having in each of two opposite surfaces at least two openings for different heat exchange media, said openings being spaced over substantially the whole area of said surfaces, all four said surfaces being parallel to each other, one of said surfaces of the first block being disposed closely to one of the surfaces of the second block, so that these two surfaces are adjacent each other while the other two surfaces are remote from each other, the openings in one of the surfaces in each block being connected respectively to the openings in the other surface of said block by two sets of ducts which extend transversely across each other in the block, whereby heat exchange occurs between one set of ducts and the other set through the solid material of the block, the ducts comprising straight drilled holes, each duct extending from one opening at one end of a block to an opening at the other end of the same block, the ducts of one set being closely adjacent of the other set where the ducts of the first set cross the ducts of the second set, the ducts of each set being interposed between ducts of the other set, said openings being spaced apart over the major part of the area of said surface, packing between said adjacent surfaces which separates the openings in each surface from each other but permits media from the two openings in one surface to pass respectively to the two openings of the other adjacent surfaces, means to conduct the media respectively to the openings in one of said remote surfaces, and means to conduct said media respectively away from the openings in the other remote surface.

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