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⑤④ **Stacked plate/fin-type heat exchanger.**

⑤⑦ A stacked plate heat exchanger 10 which employs two types of finned plates for providing cross-flow of fluids, especially for cooling a hot liquid flow by a gas flow. The first plate 12 has a flat bottom 16 and a peripheral wall 26 on the top side. The central region of the plate 12 supports upstanding spaced fins 20 forming channels 22 the ends of which are contiguous with internal manifolds 24 at the end regions of the plate 12. A manifold port 28 is formed through the plate 12 in each end region. The second plate 14 has a flat bottom 34 and spaced fins 20' forming channels 22' in the central region extending downwardly from the top surface 36 of the plate 14. The end regions each have a manifold port 28' extending therethrough in the same locations as the manifold ports 28 of the first plate 12 so that interior manifolds are formed thereby when the plates are stacked. The top surfaces of the fins 20 and peripheral wall 26 of the first plate 12, and of the fins 20' and the end regions of the second plate 14, form flat planes.

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STACKED PLATE/FIN-TYPE HEAT EXCHANGER

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Background of the Invention

1. Field of the Invention

This invention relates to plate/fin-type heat exchangers and to open-faced finned plates which can be stacked to form cross-flow heat exchangers.

2. Description of the Prior Art

The plate/fin-type heat exchangers are mainly of the channel and rib-type construction. Countercurrent flow can be achieved; however, manifolding a plate stack which must separate the fluids at entry and exit becomes extremely complex. Since the manifolding of the crosscurrent heat exchangers is comparatively simple, this heat exchanger system is more widely used although it is less efficient than the countercurrent system and it induces serious thermal and mechanical stresses.

One countercurrent system which has attempted to solve the manifolding problem of the countercurrent heat exchanger is taught by

Campbell et al, U.S. Patent No. 3,305,010. Campbell et al teach a heat exchanger having superposed stacked plate and fin elements and complex manifolding means for introducing fluids of different temperatures into opposite ends of the assembly. However, Campbell et al do not teach a plate which serves as both the plate and the fin, nor does Campbell et al teach means for internally manifolding the plate within the plate's plane.

Another countercurrent system, is that of Alfa-Laval described in The Proceedings of the 5th OTEC Conference, Miami, Florida (Feb. 1978) Pages VI 288-320. The Alfa-Laval concept consists mainly of a pack of thin metal plates, a frame and means of keeping the pieces together. The plates are suspended between horizontal carrying bars at top and bottom and compressed against the stationary frame plate by means of tightening bolts and a movable pressure plate. The frame plate is equipped with nozzles for inlet and outlet connections. Every plate is sealed around its perimeter with a gasket and cemented into a pressed track. Flow ports at each of the plate corners are individually gasketed and thus divide the interplate spaces into two systems of alternating flow channels. Through these, the two media pass, the warmer medium giving up heat to the cooler by conduction through the thin plates. This gasket arrangement eliminates the risk of media interleakage. The plate, which is the basic element of this concept, has a corrugated pattern stamped on it. These corrugations can be arranged to create an unlimited number of plate patterns. The specific pattern results from a careful trade-off between pressure drop and convective heat transfer characteristics.

The gaskets in the Alfa-Laval system are cemented to the plates in pressed tracks, and are generally made of elastomers like natural rubber, nitrile, butyl, neoprene, viton, etc. The material selection depends upon the working conditions; however, the upper limits are about 360 PSI and about 400°F.

The present invention can be distinguished from that of Alfa-Laval in many ways, some of which include: (1) that the Alfa-Laval system requires gaskets which limit operating pressure and temperature; (2) that the Alfa-Laval system has no contact fins or essential flat plate bottoms for providing the plate-to-plate contact necessary to obtain the optimum heat transfer coefficient.

Requirements of gas/liquid coolers such as for air-to-oil or air-to-water generally require a low pressure drop of approximately 0.5 psi in H_2O on the air side and also must fit in areas such as in front of an automotive radiator where the depth allowed is less than 1.5 inches. Moreover, the effectiveness required of these designs is less than 50% and a cross flow design as well as a counterflow design can be considered. Current designs of a serpentine fin tube approach and others suffer from inappropriate contact area to the liquid tube and require fluid velocity control devices on the liquid side to match the required convective conditions. Moreover, the manufacture soldering and brazing and assembly of these previous designs does not lend itself to a hands-off mass production automated approach.

Objects of the Invention

An object of the present invention is to provide a one-piece internally manifolded fin plate for a plate/fin-type heat exchanger.

Another object of the present invention is to provide an open-faced fin plate which incorporates a plurality of fin configurations for enhancement of heat transfer through increased surface area and plate-to-plate contact.

Still another object of the present invention is to provide a heat exchanger having simplified manifolds.

Yet a further object of the present invention is to provide a simple manifolding means for an internally manifolded plate stack.

Still another object of the present invention is to provide a cost efficient and effective crossflow heat exchanger.

Another object of the present invention is to provide a heat exchanger having plates relatively free from mechanical and thermal stresses.

Still another object of the present invention is to provide a heat exchanger which can be manufactured inexpensively.

Summary of the Invention

The invention comprises a stacked plate/fin-type heat exchanger and two types of finned plates for use therein. The first plate, preferably employed for transferring liquids, is an open-faced plate with a flat bottom and a top formed with an upstanding peripheral wall. Upstanding spaced fins are formed in the central portion of the top side leaving concave end regions between the fin regions and the peripheral wall which are internal manifolds. Ports are formed transversely through the plate, one through each manifold region. The channels between the fins extend between the two manifold regions. The heights of the fins and peripheral wall are the same so that their top surfaces are an equiplanar surface.

The second plate, preferably employed for transferring gases, is an open-faced plate with a flat bottom and spaced fins in the central portion of the top side thereof. The end regions have top surfaces having the same height as the top surfaces of the fins so that an equiplanar surface is formed by the top surfaces of the fins and end regions. A port is formed transversely through the plate in each end region so that, when the first and second plate are stacked, their manifold ports coincide to form an interior, or leader, manifold. It is also preferable that the plates have 180° complementarity, i.e., when a plate in the stack is azimuthally rotated 180° with respect to the others, its ports still coincide with the ports of the other stacks.

The top plate can be covered by a flat plate, the bottom of each plate acting as a cover for the plate below. The plates may be bonded or gasketed, as desired.

5 The fins and channels of the second plate are formed in a direction crosswise to the direction of those on the first plate.

The invention provides an efficient, simple, easily manufactured, easily assembled, relatively inexpensive plate-stack heat exchanger which does not require external manifolding if a liquid is to be air-cooled therein.

10 Other objects, advantages and novel features of the present invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawing.

Brief Description of the Drawings

15 Fig. 1 is an isometric exploded view of a plate stack for a heat exchanger in accordance with the present invention.

Fig. 2 is an exploded isometric view of a plate stack with a different type of first plate.

Fig. 3 is an isometric view of a cover plate.

20 Fig. 4 is a schematic illustration of various shapes of fins and channels that may be employed in the invention.

Fig. 5 is a schematic illustration of one type of an interrupted fin that may be employed in the invention.

Fig. 6 is a partial schematic illustration of a type of fin having a sinuous shape.

25 Fig. 7 is a partial schematic illustration of a type of fin having a herringbone shape.

The same elements or parts throughout the figures of the drawing are designated by the same reference characters, while equivalent elements bear a prime designation.

Detailed Description of the Preferred Embodiments

Fig. 1 shows an exploded stack 10 of three plates 12, 14 and 12'. Two differently formed plates 12 and 14 are employed. The first plate 12 is an open-faced plate formed with a flat bottom 16. The top surface 17 of the plate 12 supports an upstanding peripheral wall 18 which has a height h_1 . The central region of the first plate 12 supports a plurality of upstanding spaced fins 20, preferably parallel to each other, with channels 22 inbetween. The end region between the ends of the fins 20 and the end peripheral wall 26 forms a depression, or concavity, which defines an interior manifold 24 through which a manifold port 28 is drilled. As may be seen, there is a manifold 24 and manifold port 28 at each end of the plate 12. The top surfaces of the fins 20 are also of height h_1 so that the top surfaces of the fins and the wall form a flat plane. The channels 22 and fins 20 are formed so that their axes extend substantially in the same direction as a line drawn between the manifold ports 28.

The second plate 14 is also an open-faced plate formed with a flat bottom 34. The height of the second plate 14 between the bottom 34 and the top surface 36 is h_2 ; preferably h_2 is greater than h_1 if first plate 12 is used for liquid flow, such as hot oil, and second plate 14 is used for fluid flow, such as cooling air. The central region of the second plate 14 also contains fins 20' and channels 22' the channels 22' extending downwardly from the top surface 36. The fins 20' and channels 22' are contiguous to end regions 32, each of which is formed with a manifold port extending transversely therethrough at such a location that, when the plates are stacked, the manifold ports 28, 28' coincide to form internal manifolds in the stack. The flow of fluid through the manifold ports and the first-plate grooves is shown by the arrows and lines

designated A and B. The flow of fluid through the second plate grooves is shown by the arrow designated C. One or both of these directions can be reversed, of course.

It should be noted that the plates 12 and 14 can each be azimuthally rotated by 180° and the ports will still coincide. 180° complementarity can be retained even if each port in a plate is offset the same distance but in opposite direction from the longitudinal center line of the plate. This would, of course, have to be done with all plates in a stack.

Another type of first plate 38 is illustrated in Fig. 2. Here, the central region comprises fins 20" and channels 22", the two side fins 40 and 42 taking the place of the peripheral wall on each side of the plate 38. The end regions are flat, the top surfaces 44 lying below the top surfaces 30 of the fins 20" and preferably in the plane of the bottom of the channels. An end closure, or dike, member 46, roughly U-shaped, is placed upon the surface 44 of each end region to mate at both ends with the corresponding ends of the side fins 40 and 42 to form an embankment therewith around the periphery of the plate 38; an internal manifold 24' is formed thereby at each end region. Manifold ports 28" are formed in the internal manifold region of each plate 38 to coincide with the manifold ports 28' of the second plate 14 when the two are stacked.

The dike members 46 are bonded, or otherwise sealed, to the end regions to form an end closure. The bottom of the second plates 14 should also be sealed to the top of the underlying first plates 12 (or 38) to prevent leakage of the fluid flowing through the channels 22" and internal manifolds 24' of the first plates 12 (or 38). This may be done, for example, by brazing in a brazing die with plate-to-plate brazing foils, or

with gaskets. Sealing between the bottoms of the first plates 12 and the tops of the second plates 14 may be unnecessary if the second plates 14 are used to transfer a gas but might be desired for stability of the stack 10.

5 In any particular stack, the first plates may be below the second plates.

10 The first plate 12 (Fig.1) may be formed, for example, by an impact extrusion process in which the forming die presses the flat plate so that the fins and peripheral wall, or frame are extruded into the channels of the die.

 The second plate 14 may be formed by an extrusion process in which the forming die simply extrudes the channels and fins of the central region.

15 Thus, the dike-member plate 38 may be formed by extruding the fins over the whole area of the basic plate and then machining off the fins on the end regions of the plate to provide the end surfaces to which the dike members can be fitted to form end closures.

20 Fig. 3 shows a simple plate which can be used as a cover plate 48 for the stack 10. The cover plate 48 can be bonded or bolted to the stack 10. The cover plate and a similar bottom plate may provide outwardly extended surfaces with bolt hole or notches to bolt together the complete stack assembly. The top plate or bottom plate or both can provide inlet and outlet conduits for the plate stack assembly.

25 The fins 20,20' and channels 22,22' can have variously shaped cross-sections as shown in Fig. 4. The conventional channel and fin shape with sharp corners is represented by numeral 50. However, channels with rounded corners 52, U-shaped channels 54, V-shaped channels 56, trapezoidal channels 58, etc., are also within the scope of the invention, as well as interrupted fins 60, for example, as shown in Fig. 5. The

channels may also be of different widths on the same plate. The fins 20,20' can also be of serpentine shape 62 (Fig.6) or other non-linear configuration, as shown in the herringbone configuration of Fig. 7.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

What is claimed and desired to be secured by Letters Patent of the United States is:

- 1 1. A plate stack assembly for a heat exchanger comprising:
 - 2 at least one first plate having a flat bottom and an
 - 3 upstanding peripheral wall on the top side thereof and upstanding spaced
 - 4 fins in the central region of said top side forming channels therebetween,
 - 5 the heights of the peripheral wall and fins being identical, the plate
 - 6 having opposed internal manifold regions between said fins and the
 - 7 peripheral wall at each end, each manifold region being formed with a
 - 8 manifold port therethrough from top to bottom of said plate, the axes of
 - 9 the fins being substantially in the same direction as a line connecting
 - 10 the manifold ports; and
 - 11 at least one second plate of the same shape and dimensions as
 - 12 the first plate except in the direction transverse to the plane of the
 - 13 plates, said second plate having a flat bottom and upstanding spaced fins
 - 14 in the central region of the top side thereof forming channels
 - 15 therebetween and having opposed end regions the heights of which are
 - 16 identical with the heights of said fins, each said end region being formed
 - 17 with a manifold port therethrough at the same location as the first-plate
 - 18 manifold port at the same end, the axes of the fins being substantially
 - 19 crosswise to a line connecting the manifold ports,
 - 20 so that when said first and second plates are stacked,
 - 21 said manifold ports coincide to form a different transverse
 - 22 manifold at each end and the bottom of one plate is in contact
 - 23 with the upper edge of the fins on the other plate below to
 - 24 form covered channels in said other plate, the flows of fluids
 - 25 through said plates being cross flows.

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1 2. An assembly as in Claim 1, further including:

2 a cover plate of the same dimensions as the other plates
3 except in the direction transverse to the plane of the plates for covering
4 the top of the topmost plate.

1 3. An assembly as in Claim 1, wherein:

2 said plate stack assembly is formed from a plurality of first
3 plates and a plurality of second plates.

1 4. An assembly as in Claim 1, wherein:

2 the raised peripheral wall extends only along both sides of
3 said central region of said first plate

4 said assembly further including dike members extending along
5 the wall-free portions of said first plate between the peripheral walls on
6 each side of the plate to form an internal manifold region on each end,

7 the height of said dike members being such that their
8 top surfaces are equiplanar with the top surfaces of the
9 fins when the dike members are in place on said first plate.

1 5. An assembly as in Claim 2, wherein:

2 the plates are bonded together.

1 6. An assembly as in Claim 2, wherein:

2 the fins in said first plate form parallel channels.

1 7. An assembly as in Claim 2, wherein:
2 the fins in said second plate form parallel channels.

1 8. An assmebly as in Claim 4, wherein:
2 said dike members are bonded to the first plate, and said
3 plates are bonded together.

1 9. A plate for a plate stack assembly for a heat exchanger
2 comprising:
3 a plate having a flat bottom and an upstanding wall on the
4 top side thereof extending along the periphery of the top side and having
5 upstanding spaced fins in the central region thereof forming channels
6 therebetween, the heights of the peripheral wall and fins being identical,
7 the plate having opposed internal manifold regions between said fins and
8 the peripheral wall at each end, each manifold region being formed with a
9 manifold port therethrough from top to bottom of said plate, the axes of
10 the fins being substantially in the same direction as a line connecting
11 the manifold ports.

1 10 A plate as in Claim 9, wherein:
2 said fins form parallel channels.

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11. A plate as in Claim 9, wherein:

the upstanding peripheral wall extends only along both sides of said central region of said plate; and

said plate further includes dike members extending along the wall-free portions of the plate between the peripheral walls on each side to form an internal manifold region on each end,

the height of said dike members being such that their top surfaces are equiplanar with the top surfaces of the fins when the dike members are in place on the plate.

12. A plate for a plate stack assembly for a heat exchanger comprising:

a plate having a flat bottom and upstanding spaced fins in the central region of the top side thereof forming channels therebetween and having opposed end regions the heights of which are identical with the heights of said fins, each said end region being formed with a manifold port therethrough the top surfaces of said fins and end regions forming an equiplanar surface, the axes of the fins being substantially crosswise to a line connecting the manifold ports.

13. A plate as in Claim 9 to 12, wherein:

said fins are substantially rectangular in cross-section.

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Fig.1.

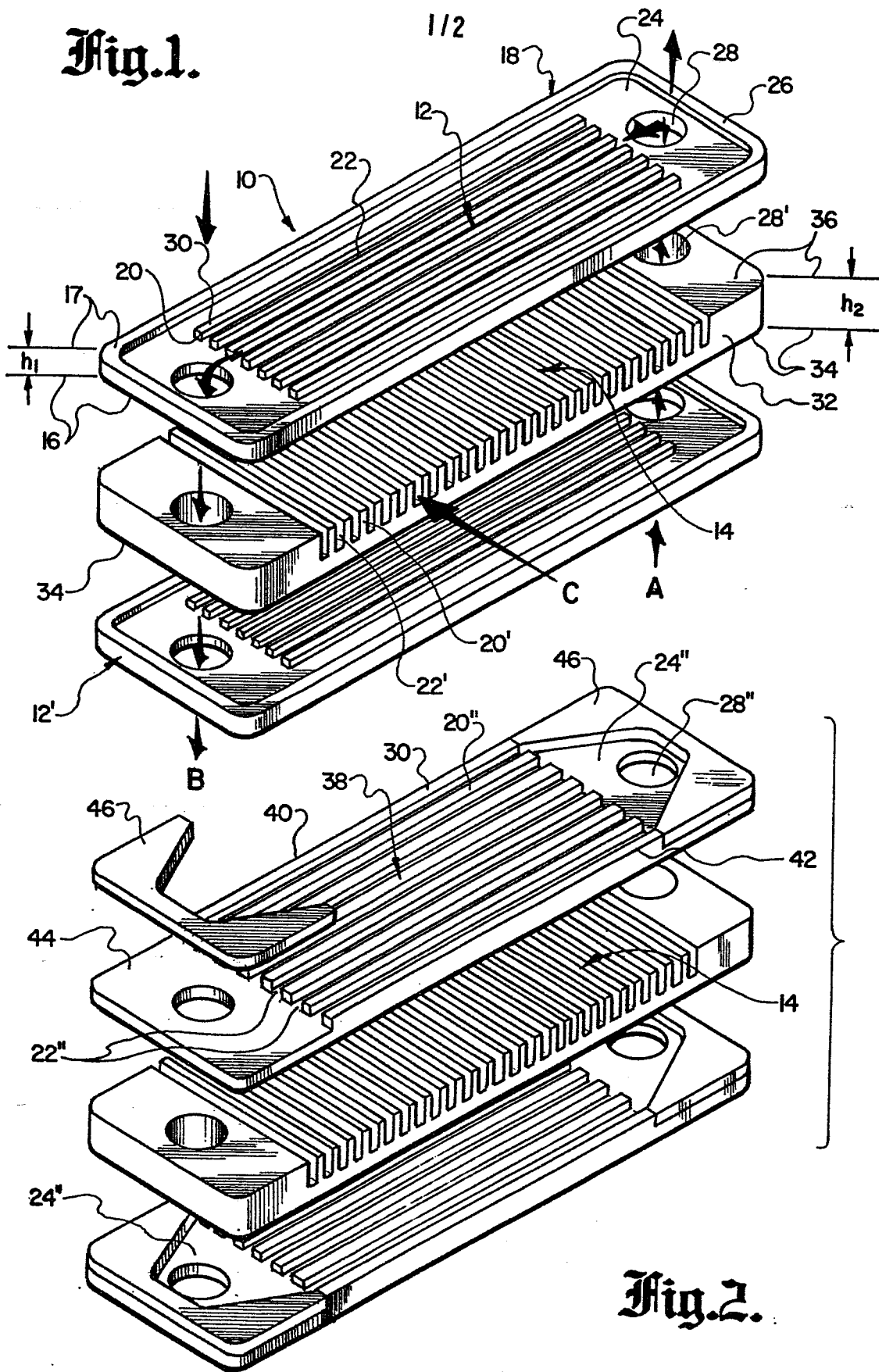


Fig.2.

Fig. 3.

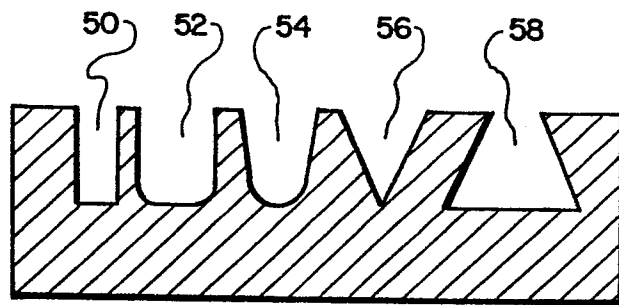
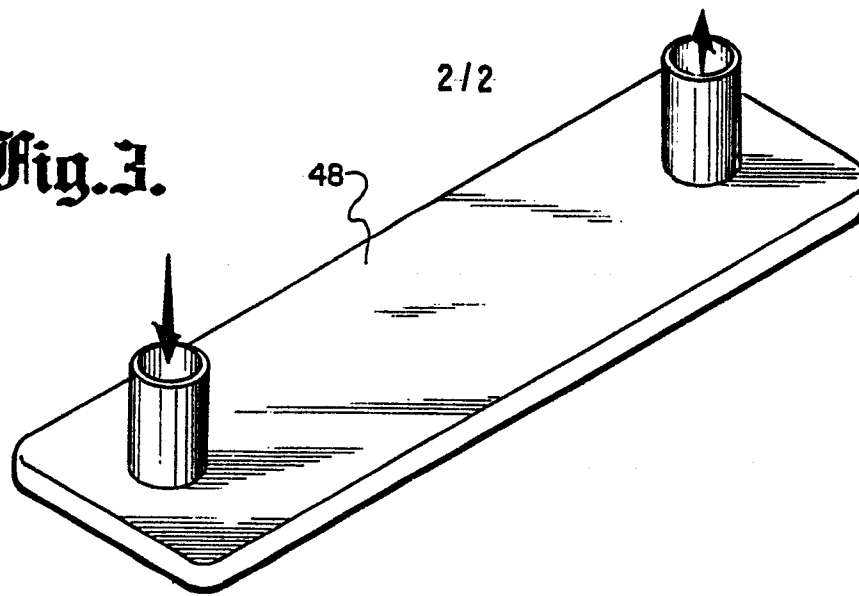


Fig. 4.

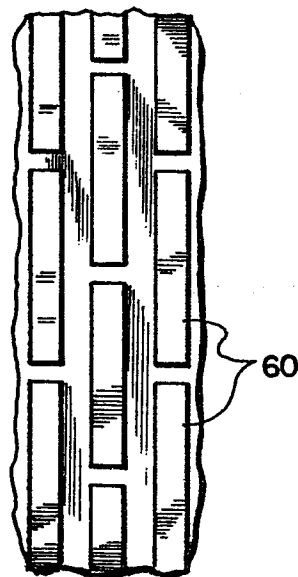


Fig. 5.

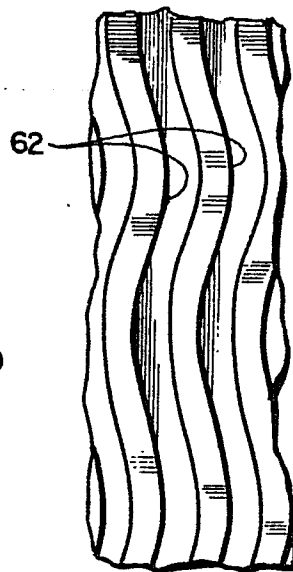


Fig. 6.

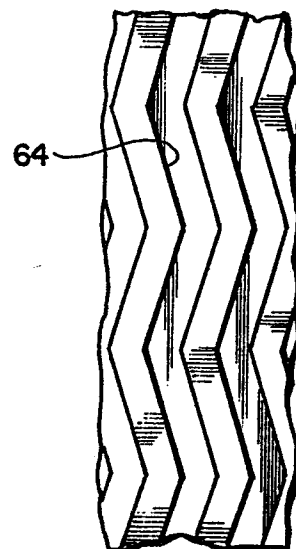


Fig. 7.