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(71) Applicant: **PAUL MUELLER COMPANY**
P.O. Box 828
Springfield, MO 65801(US)

(72) Inventor: **Uges, Peter Gerard Hans**
Engelse Schans 1
NL-7137 MS Lievelde(NL)
Inventor: **Van Asselt, Jozef Garrie J.**
Esstraat 47
NL-7131 CK Lichtenvoorde(NL)
Inventor: **Mueller, Paul**
1622 East Walnut
Springfield Missouri 65801(US)
Inventor: **Waynick, William Richard**
P.O. Box 88
Walnut Grove Missouri 68770(US)
Inventor: **Shirey, Phillip Gregory**
Route 1, Box 149
Nixa Missouri 65714(US)

(74) Representative: **de Vries, Johannes Hendrik Fokke et al**
Octrooibureau Los en Stigter B.V. P.O. Box 20052
NL-1000 HB Amsterdam(NL)

(54) Plate-type heat exchange unit and method of forming same.

(57) A heat exchange unit utilizing a sandwich plate-type construction with multiple plates joined together such as by welds in selected patterns extending substantially over the unit. Inner plates are pillowed to define an inner fluid passage within the inner plates and between the joints. Other plates outwardly of the inner plates are also pillowed to define outer fluid passages between the joints at each side of the inner passage, thus providing three or more parallel fluid passages for heat transfer therebetween.

The plate-type heat exchanger is formed by joining plates together in selected joining patterns, and expanding selected plates relative to other plates to pillow the selected plates to form at least one inner fluid passage between plates and at least two other fluid passages outwardly of the inner passage at each side thereof.

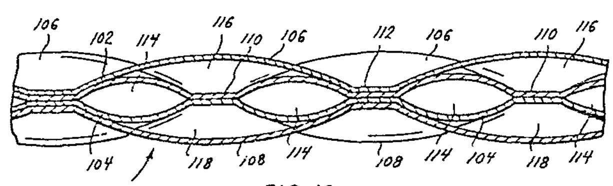

FIG. 10.

EP 0 206 416 A2

Plate-type heat exchange unit and method of forming same

This invention relates to heat exchangers, and more particularly those of a sandwich multiple plate construction where the plates are joined such as by welding or other suitable means in a selected pattern and are then expanded by inflation to pillow selected ones of the plates and define fluid passages between the plates and joints.

Heat exchange units of this general type and their method of construction are generally known. U.S. Patent 3,458,917 to Mueller and owned by the same company as the present application is an example of such a heat exchange unit and the method of making same. That patent discloses such a unit with two plates welded together and inflated to define a heat exchanger with a single fluid passage. It is known to use such heat exchangers in either the flat configuration or coiled as disclosed in U.S. Patents 4,146,089; 4,179,902; 4,305,456; and 4,351,271, all issued to the same company to which this application is assigned.

Although commercially successful, such heat exchangers have the disadvantage of having only a single fluid passage. Hence, an improvement over such heat exchangers is shown by U.S. Patent 4,484,623, also owned by the same company. In this patent there is shown a heat exchange unit, which also may be either flat or coiled, and which is of a three wall construction providing two separate parallel fluid passages. This heat exchanger has the advantage that it is selfcontained in that the fluids between which heat is to be transferred both flow within the heat exchanger itself, as opposed to there being just one of the fluids within the heat exchange unit and the other fluid in a chamber into which the heat exchanger must be inserted.

This three-wall, two-passage construction has also been commercially successful, but had certain disadvantages. Among these is the difficulty in keeping the center wall from buckling when inflating the outer walls to form the two parallel passages. When each of the walls are of the same material and thickness, it has been found that there is a tendency for the center wall to buckle when the others are inflated to pillow the outer wall. To prevent this buckling, it has been customary for the center wall to be of thicker plate than the outer walls, but this decreases the heat exchange efficiency between the fluids flowing through the parallel passages.

A modification of the three-wall, dual-passage configuration is disclosed in U.S. patent application Serial No. 06/681,873 filed December 14, 1984, entitled "Dual-Walled Coiled Plate Heat Exchanger With Vented Interface", and assigned to the same company as the present application. In that application there is disclosed a sandwich, plate-type heat exchanger generally of the type referred to above having three walls and two passages, but utilizing four plates. The outer two plates are inflated to pillow and define with the inner plates two parallel fluid passages. The inner plates are not pillowed, but instead are left flat with the slight spacing between them being vented to serve as a safety in the event of leakage between the two passages. Hence, the spacing between the two center plates does not serve as a fluid passage during normal operation.

The heat exchange unit of the present invention possesses the important advantages of the three-wall configuration, but eliminates certain of the disadvantages while providing certain additional advantages of its own. In accordance with the present invention the heat exchange unit is of the sandwich plate-type and includes multiple plates joined together, such as by spot or seam welding or other suitable means, in a selected pattern. Selected inner plates are inflated causing the plates to expand and pillow the joints and define an inner fluid passage between the inner plates and joints. While maintaining equal pressure on opposite sides of the inner plates, selected outer plates are also inflated to cause them to expand and pillow and define with inner walls additional fluid passages at both sides of the inner passage. In a preferred embodiment of the invention, the walls of the inner passage are both expanded by inflation to pillow in opposite directions, and the outer wall of each outer passage is also expanded to pillow in a direction away from the inner passage so that the cross sections of the outer passages are essentially crescent shaped. Hence, at least three parallel fluid passages are formed with one as an inner passage and the others as outer passages with an outer passage on each side of the inner passage. By adding more plates, additional parallel passages are provided, each having pillowed walls.

The heat exchange unit of the present invention has numerous advantages. It retains the advantage of the three-wall, dual-passage heat exchanger as being self-contained such that more than one fluid can pass through the heat exchanger itself. In addition, the heat exchanger of the present invention increases the parallel passages to at least three or more so that the available heat exchange surface is at least doubled. For example, with one fluid flowing through the inner passage and another fluid through two outer passages, one on each side of the inner passage, there is provided two heat transfer walls rather than one between the two fluids. The various passages can be connected in two or more parallel flows, or if desirable can be connected in series. By using two or more parallel flows the pressure drop is considerably reduced, and yet the pillowed configuration and weld pattern creates a turbulent flow to provide a high "U" value even at low velocity.

In forming the heat exchange unit in accordance with the present invention, first the inner plates comprising the walls of the inner passage are inflated under pressure to expand these plates to a pillowed configuration between the joints. Thereafter, while maintaining pressure in the inner passage, the next most outer plates to constitute the outer walls of the next outer passages are inflated to cause them to expand and pillow between the joints and form the next outer passages. If there are additional outer plates, these also are inflated under pressure while maintaining pressure within the previously formed passages to cause these further outer plates to expand and pillow and define additional outer passages. The walls may be of a single plate configuration, or selected walls may be of dual plate configuration. Also the joint pattern joining the inner plates may differ from the joint pattern joining the outer plates.

During the second and any following inflation stages or steps, preferably equal pressure is maintained on opposite sides of the previously inflated and pillowed walls, such that these walls remain in their position while the other walls are inflated to the outside. This equality of pressure may be achieved by coupling the next passages to be inflated with the one or more passages previously inflated so that these next passages are inflated at the same pressure that exists within the previously inflated passages. Although, during a given step in the process, the pressure within previously formed passages should be equal to the pressure in the passages to be formed during that step in the process, it should be understood that the inflation pressures may vary from one step of the process to another to determine the degree of inflation or pillowing for selected passages. Hence, the pillow height for the walls of a given passage is dependent on the inflation pressure used during the step of the process to form that passage, the kind and thickness of material used for the walls, the number of plates in the wall, and the joint pattern.

These and other advantages of the invention are apparent from the description to follow.

Fig. 1 is a cross-sectional view of a heat exchange unit of the present invention taken along the spot welds showing a three passage configuration with the wall of single plate construction;

Fig. 2 is a cross-sectional view of another embodiment of a heat exchange unit of the present invention taken along the spot welds and showing a five passage configuration with the walls of a single plate construction;

Fig. 3 is a cross-sectional view similar to that of fig. 1 and showing a modification with the walls of the inner passage of a dual plate construction;

Fig. 4 is a cross-sectional view of a heat exchange unit of the embodiment of Fig. 1 but taken along the spot welds and an end seam;

Fig. 5 is a cross-sectional view similar to Fig. 4 but showing a modification thereof;

Fig. 6 is a cross-sectional view similar to Fig. 4 but showing a modification thereof;

Fig. 7 is a cross-sectional view of a heat exchange unit of the embodiment of Fig. 3 but taken along the spot welds and an end seam;

Fig. 8 is a partial plan view of a modified form of the heat exchange unit of the present invention;

Fig. 9 is a view in section taken generally along the line 9-9 of Fig. 8; and

Fig. 10 is a view in section taken generally along the line 10-10 of Fig. 8.

With reference to the drawing, and particularly Fig. 1, there is shown a heat exchange unit 10 of the present invention, having inner plates 12 and 14, and outer plates 16 and 18. The plates are typically stainless steel, although they may be of any suitable material that will expand and pillow under pressure, maintain that configuration, and possess the necessary heat exchange properties under the conditions with which the unit is to be used.

The plates are joined together by welds, such as spot welds 20, as shown, which extend through all of the plates. Seam welds or other suitable means for joining the plates could also be used. Also preferably, the spot welds are uniformly spaced over substantially the entire unit as taught by the previously referenced patents. Between the inner plates 12 and 14 is defined an inner passage 22 for the flow of a fluid therein; between the plates 12 and 16 is an outer passage 24; and between the plates 14 and 18 is another outer passage 26, the passages 24 and 26 being on opposite sides of the inner passages. The walls of the inner passage defined by the plates 12 and 14 are expanded or pillowed outwardly and also define the inner walls of the outer passages. The outer walls 16 and 18 of the outer passages are also expanded and pillowed outwardly away from the inner walls to define generally crescent shaped outer passages 24 and 26.

To form the heat exchange unit of Fig. 1, the inner walls are inflated under pressure to cause them to pillow outwardly along with the outer walls. Thereafter, with equal pressure maintained on opposite sides of the inner walls 12 and 14, the outer walls are caused to further pillow outwardly relative to the inner walls and create the outer passages 24 and 26. Although, as the passages 24 and 26 are being formed, the pressure within those passages should equal the pressure in the previously formed passage 22, it should be understood that this inflation pressure may be different from that previously used to form the passage 22. Thus, inflation pressures may be selected to determine the degree of inflation or pillowing of the various passages.

Thus, there is formed a heat exchange unit having three parallel passages, such that, for example,one fluid may flow through the inner passage and another through the two outer passages with the advantages as previously enumerated.

Fig. 2 shows another embodiment of the invention wherein a heat exchange unit 30 has an inner passage 32, intermediate passages 34 and 36 on opposite sides of the inner passage, and outer passages 38 and 40 located outwardly of the intermediate passages and on opposite sides thereof. The various passages are defined by inner walls 42 and 44, intermediate walls 46 and 48, and outer walls 50 and 52 as shown. All of the walls are shown to be of a single plate construction. Hence, the embodiment of Fig. 2 is essentially the same as that of Fig. 1 except that there are more crescent shaped parallel passages.

The method of forming the embodiment of Fig. 2 is essentially the same as that for Fig. 1 with the passages formed by inflation beginning with the inner passage and progressing outwardly to inflate the outer passages. Hence, first the passage 32 is inflated at a selected pressure to pillow the walls 42 and 44. Next, while maintaining equal pressure of a selected amount on opposite sides of the walls of the passage 32, the intermediate passages 34 and 36 are inflated to pillow the walls 46 and 48. Finally, while maintaining equal pressure of a selected amount on opposite sides of the previously inflated walls 42, 44, 46, and 48 the passages 38 and 40 are inflated to pillow the walls 50 and 52. As with the method of forming the embodiment of Fig. 1, the pressure used for a given step of the process may be the same or different from that used for other steps of the process to determine the degree of inflation or pillowing of the various passages.

Fig. 3 is a modification of Fig. 1, and shows a heat exchange unit 60 with inner passage 22 and outer passages 24 and 26. However, rather than the inner walls 12 and 14 being of a single plate construction, these walls are of a dual plate construction with plates 62 and 64 constituting wall 12 and plates 66 and 68 constituting wall 14. The dual plate construction may be for safety reasons as explained in said co-pending application, such as where gas flows through the inner passage and water through the outer passages. Hence, the spacing between the plates 62 and 64 and the spacing between the plates 66 and 68 may be vented. The method of forming the unit of Fig. 3 is essentially the same as that for the unit of Fig. 1.

Fig. 4 is the heat exchange unit of Fig. 1 showing an embodiment of the seams about the perimeter of the unit. In the Fig. 4 embodiment there are weld seams 70 and 72 extending about the perimeter of the unit, which weld the plates 12 and 16 together and the plates 14 and 18 together to seal the outer passages. These weld seams do not weld the inner plates 12 and 14 together so that there remains fluid flow to the inner passage past the weld seams 70 and 72. The inner plates extend past the outer plates and the weld seams 70 and 72 and are sealed at the perimeter of the unit by a weld seam 74 which is spaced outwardly of the seams 70 and 72. Hence, between the seams 70, and 72 and 74, is a chamber 76 that is in fluid flow communication with the inner chamber 22. For parallel flow of the same fluid through both outside passages an external connection (not shown) is required.

Fig. 5 is the heat exchange unit of Fig. 1 showing another embodiment of the seam configuration at the perimeter of the unit. In Fig. 5 there is a first weld seam 80 at the perimeter of the unit and welding the two inner plates 12 and 14 together to seal the inner passage. The outer plates 16 and 18 extend beyond the inner plates and the seam 80 to a second weld seam 82 at the perimeter of the unit. Just interiorly of the seam 82 is a passage 84 in fluid flow communication with the outer passages 24 and 26. The passage 84 provides an internal connection for parallel fluid flow of the same fluid through both outer passages.

Fig. 6 is the heat exchange unit of Fig. 1 showing a single weld seam 90 at the periphery of the unit and sealing all of the passages. Hence, as with the embodiment of Fig. 4, for parallel flow of the same fluid through both outside passages an external connection (not shown) is required.

Fig. 7 shows the heat exchange unit of Fig. 3 with the inner walls 12 and 14 of a dual plate construction, and with perimeter seams for sealing selected ones of the passages and with the passage 76 in fluid communication with the inner passage 22. A weld seam 90 seals the outer plate 16 to the outer plate 64 of the wall 12, and another weld seam 92 seals the outer plate 18 to the outer plate 68 of the wall 14. The dual plates extend beyond the seams 90 and 92 to perimeter weld seams 94 which welds plates 62 and 66 together to seal the passage 76. The slight spacings between plates 62 and 64, and plates 66 and 68, are not fully closed by the weld seams, but instead are left at least partially open and may be vented.

Referring to Fig. 8 through 10, there is shown a modified form on another embodiment of the heat exchange unit of the present invention. There is shown a heat exchange unit 100 similar to that of Fig. 1 and having inner plates 102 and 104, and outer plates 106 and 108. The plates 102 and 104 are joined by spot welds 110 and 112 which preferably are uniformly spaced over substantially the entire unit. The outer plates 106 and 108 are joined by the spot welds 112, but not the spot welds 110. In other words, the welds 110 join only the inner plates, while the welds 112 join both the inner and outer plates together.

Between the inner plate 102 and 104 is defined an inner passage 114 for the flow of a fluid therein; between the plates 102 and 106 is an outer passage 116; and between the plates 104 and 108 is another outer passage 118, the passages 116 and 118, being on opposite sides of the inner passage. The walls of the inner passage defined by the plates 102 and 104 are expanded or pillowed outwardly and also define the inner walls of the outer passages. The outer walls 106 and 108 of the outer passages are also expanded and pillowed outwardly away from the inner walls to define generally crescent shaped outer passages 116 and 118. Because there are fewer welds joining the outer plates than the inner plates, the pillows formed between the welds of the outer plates are longer than those formed between the welds of the inner plates. Hence, the outer pillows are larger than if the outer plates were joined by all of the welds joining the inner plates. As a consequence thereof the space between the outer plates and the inner plates may be much bigger, which creates a larger hydraulic diameter. This large hydraulic diameter is advantageously since it enables a lower pressure drop with viscous fluids. Further the maximum flow of fluid through the outer passage may be increased considerably and it is made possible to use gas instead of only liquid through the outer passages by maintaining a low pressure drop.

To form the heat exchange unit of Fig. 8 through 10, the two plates 102 and 104 are placed face to face and joined, such as by welding, in a selected joint pattern, such as, for example, the uniform spot weld pattern shown, to joint the inner plates with welds 110. Next, the outer plates are placed at each side of the previously welded inner plates, and all of the plates are joined together in a selected joint pattern, such as, for example, the uniform spot weld pattern shown, to join all of the plates with welds 112. Next, first the inner and then the outer walls are inflated as with the embodiment of Fig. 1 to pillow the walls between the welds and create the inner and outer passages. Herein the inflation pressure for creating the outer passages is lower or equal to the inflation pressure required for forming the inner passages. This depends on the number of spots and their pattern only used for the inner plates and the number of spots and their pattern used for the inner and outer plates. By lowering the inflation pressure a lower risk of rupture during the manufacturing process is achieved.

While this embodiment is of a single plate construction, and is described with three passages, it should be understood that the same principles will apply to a dual plate construction similar to that of Fig. 3, and with a greater number of passages similar to Fig. 2. Also, while this embodiment is shown and described using spot welds of uniform distribution and where there are approximately twice as many welds joining the inner plates as there are joining the outer plates, it is to be understood that other types of joints and joint patterns could be used.

Hence, there has been described a heat exchange unit of a plate-type construction representing a significant improvement over prior art units. While the embodiments described have three and five parallel passages with single plate and dual plate wall construction, and have various joint patterns with various perimeter seam configurations, it is to be understood that the principles of the invention apply within practical limits to units having three or more passages. Also, within practical limits any of the walls can be of multiple plate construction. Other joint patterns may be used, and there may be other perimeter seam configurations that can be used. It is further to be understood that the heat exchange unit of this invention may be either flat or coiled, and may include seam baffles to serpentine selected passages.

There are various changes and modifications which may be made to applicant's invention as would be apparent to those skilled in the art. However, these changes or modifications are included in the teaching of applicant's disclosure, and it is intended that the invention be limited only by the scope of the claims appended hereto.

Claims

1. A heat exchange unit comprising at least four walls of plates jointed together in selected joining patterns, said walls being expanded between joints to pillow and define at least three fluid passages within said walls and between said joints, one such fluid passage being an inner passage, and two other passages being outer passages with at least one outer passage at each side of said unit.

2. The heat exchange unit of claim 1 further comprising additional walls of plates joined with said other walls in a selected joining pattern, all of

said walls being expanded between joints to pillow and define at least five fluid passages within said walls and between said joints, one such fluid passage being an inner passage, at least two other fluid passages being intermediate with at least one at each side of said inner passage, and at least two other fluid passages being outer passages located outwardly of the intermediate passages with at least one at each side of said unit.

3. The heat exchange unit of claim 1 or 2, wherein the joining pattern joining some of the plates is of a different pattern than the joining pattern joining other plates.

4. The heat exchange unit of claim 3 wherein the joining pattern defining the inner passage is different from the joining pattern defining the outer passages.

5. The heat exchange unit of claim 4, wherein the joints in the joining pattern defining the inner passage are more closely spaced than the joints in the joining defining the passages located outwardly of the inner passage.

6. The heat exchange unit of claim 5, wherein some of the joints join only the inner plates and the other joints join both the inner and outer plates together.

7. The heat exchange unit of one of claims 1-6 further comprising a first seam at the perimeter of said unit joining the walls of said inner passage, and a second seam at the perimeter of said unit and outwardly of said first seam joining outer walls of outer passages together, there being defined a passage between said seams in communication with said outer passages but not said inner passage.

8. The heat exchange unit of one of claims 1-6, further comprising first seams at the perimeter of said unit joining walls together to seal the outer passages at said seam but not the inner passage, and a second seam outwardly of said first seam at the perimeter of said unit for sealing said inner passage, whereby between said seams is formed a passage in communication with said inner passage.

9. The heat exchange unit of claim 8 wherein each wall of said inner passage is constructed of at least two plates, the spacing between the plates of each such wall being at least partially open at both seams.

10. A method of forming the plate-type heat exchange unit of one of claims 1-9 having multiple passages defined between multiple plates, comprising the steps of:

joining plates together in a selected joining pattern;

expanding selected plates relative to other plates to pillow said selected plates to form at least one inner fluid passage therein and at least two other fluid passages outwardly of said inner passage at each side thereof.

11. The method of claim 10, wherein the joining step further comprises:

joining first selected plates together in a first joining pattern;

joining second selected plates together in a second joining pattern different from the first pattern.

12. The method of claim 11 wherein said second selected plates are joined after said first selected plates are joined.

13. The method of claim 12 wherein said second selected plates include all of the plates.

14. The method of claim 11, wherein the first selected plates are inner plates, the inner passage being formed therebetween.

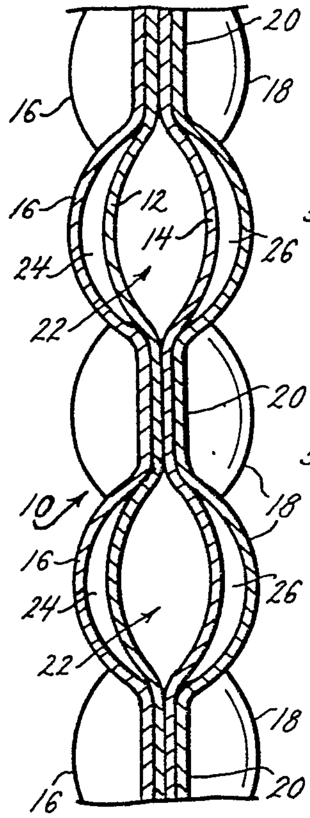

FIG.1.

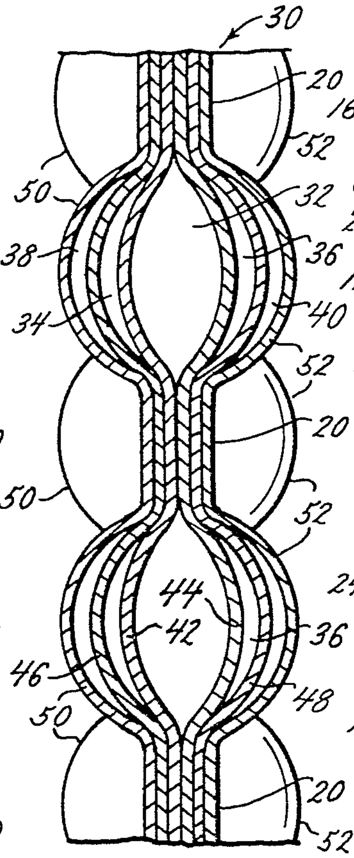

FIG. 2.

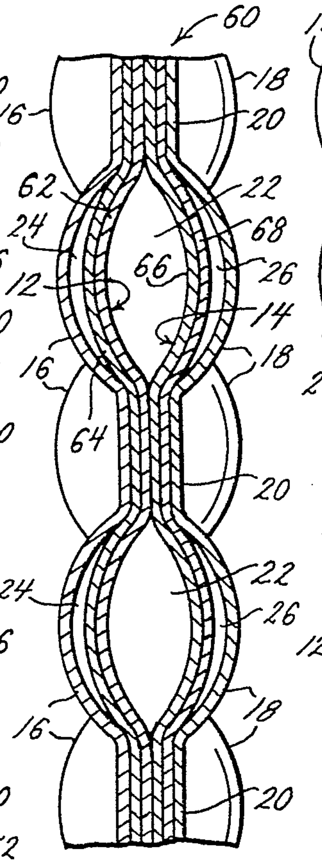

FIG.3.

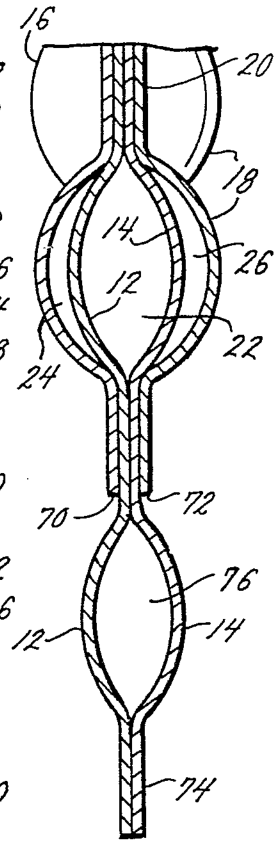

FIG.4.

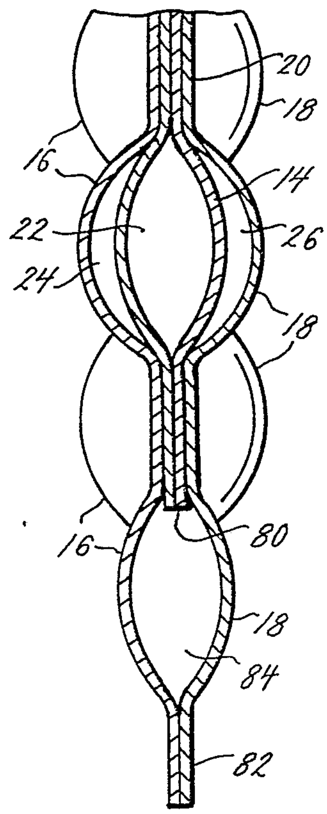

FIG. 5.

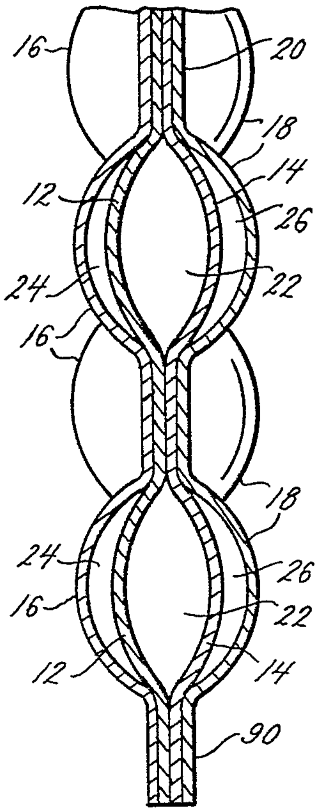

FIG. 6.

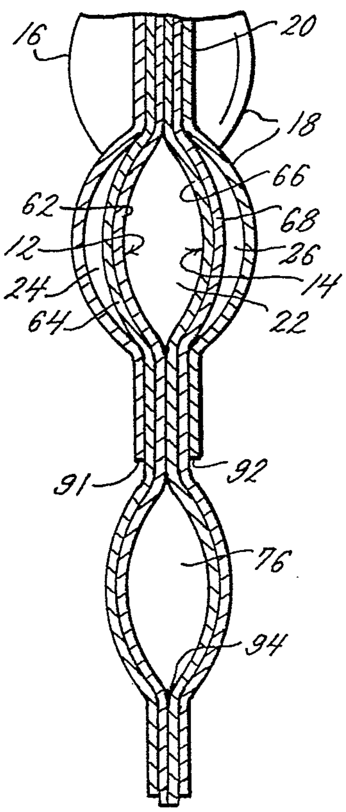

FIG. 7.

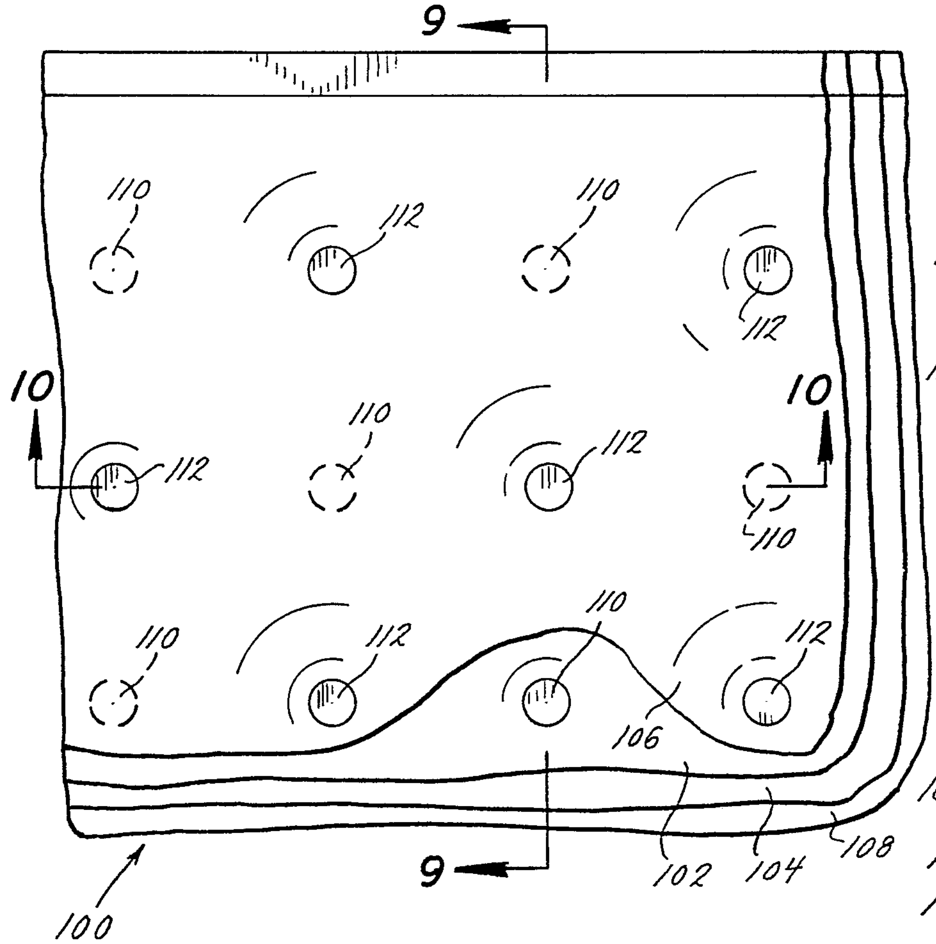

FIG. 8.

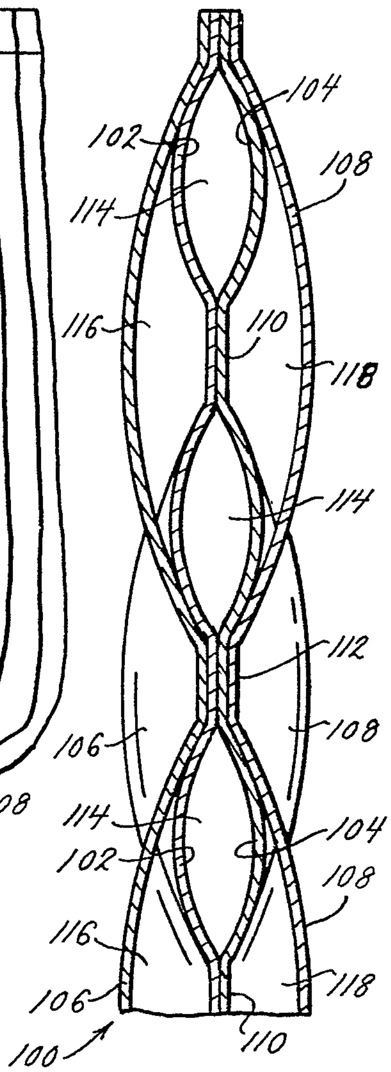

FIG. 9.

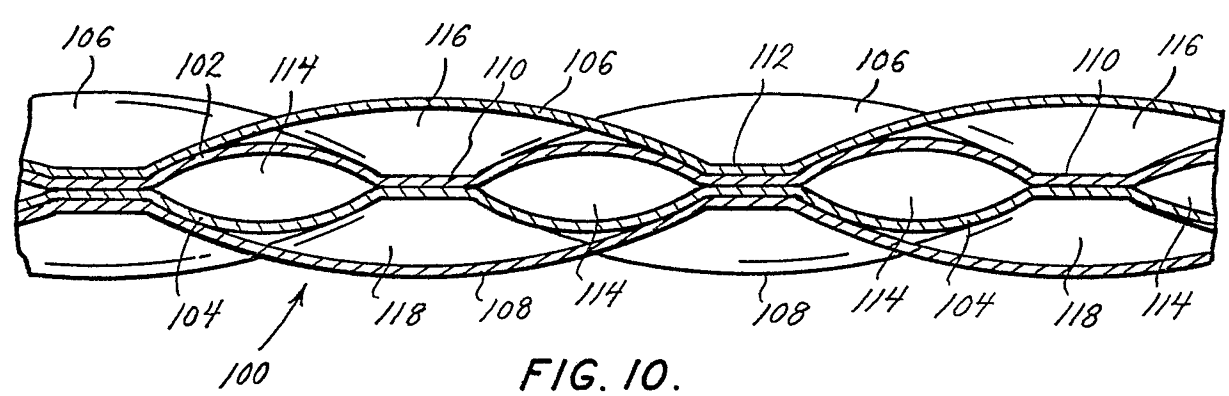

FIG. 10.