United States Patent

Delaere

[15] **3,638,434**

[45] **Feb. 1, 1972**

[54] **FLEXIBLE STRUCTURAL PLATE PIPES AND THE LIKE**

[72] Inventor: **Albert Henri Delaere,** Waterloo, Belgium

[73] Assignee: **Davum,** Villeneuve La Garenne, France

[22] Filed: **Jan. 20, 1970**

[21] Appl. No.: **4,371**

[52] **U.S. Cl.**.....**61/16,** 61/45, 52/245, 138/43

[51] **Int. Cl.**.....**F16l 9/22,** E21d 11/20

[58] **Field of Search** 61/45, 16; 138/43, 100, 155, 138/173; 29/155; 52/80, 245

[56] **References Cited**

UNITED STATES PATENTS

2,042,327 5/1936 Whitescarver.....61/45

2,062,706 12/1936 Freeze et al. 61/45

Primary Examiner—Jacob Shapiro

Attorney—Sughrue, Rothwell, Mion, Zinn & Macpeak

[57] **ABSTRACT**

A curved quadrilateral corrugated plate for constructing flexible segmented curved-section structures such as structural plate pipes. The plate comprises on each of its four edge portions assembly apertures which are formed in the flanks of the corrugations. The positions of the apertures on the flanks are such that when two identical plates are assembled by overlapping their edge portions, all the pairs of apertures of the plates are respectively in coaxial superimposed relation to each other.

A flexible curved-section segmented structure comprising an assembly of said corrugated plates is disclosed.

8 Claims, 13 Drawing Figures

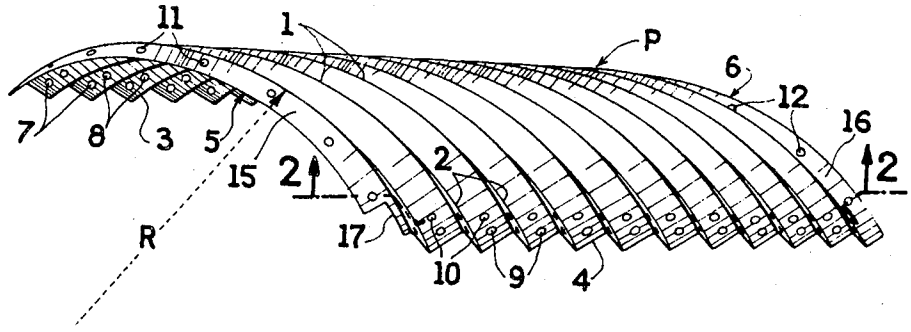


FIG. 1

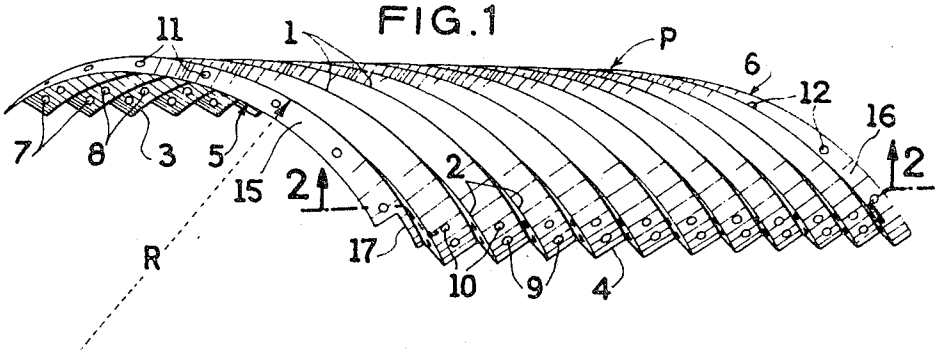


FIG. 2

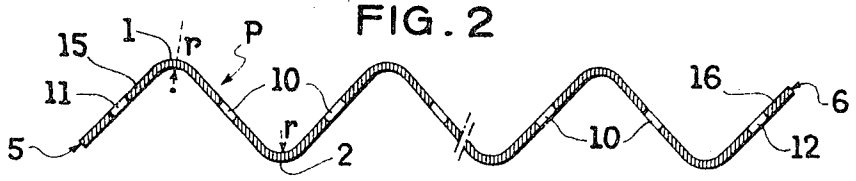


FIG. 2a PRIOR ART

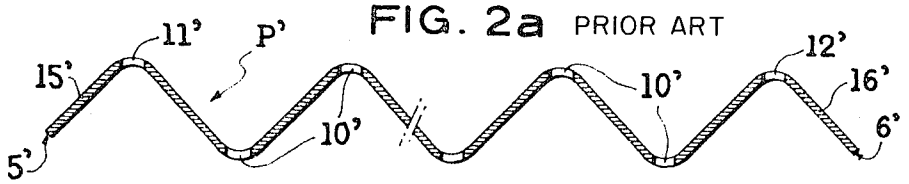
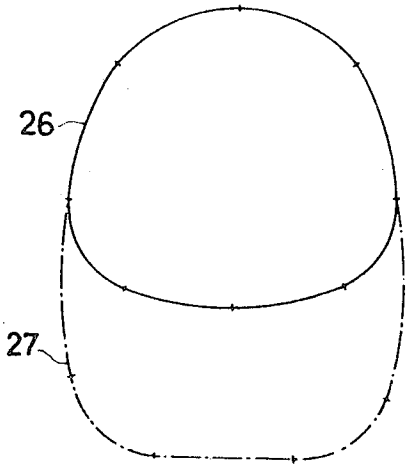


FIG. 12



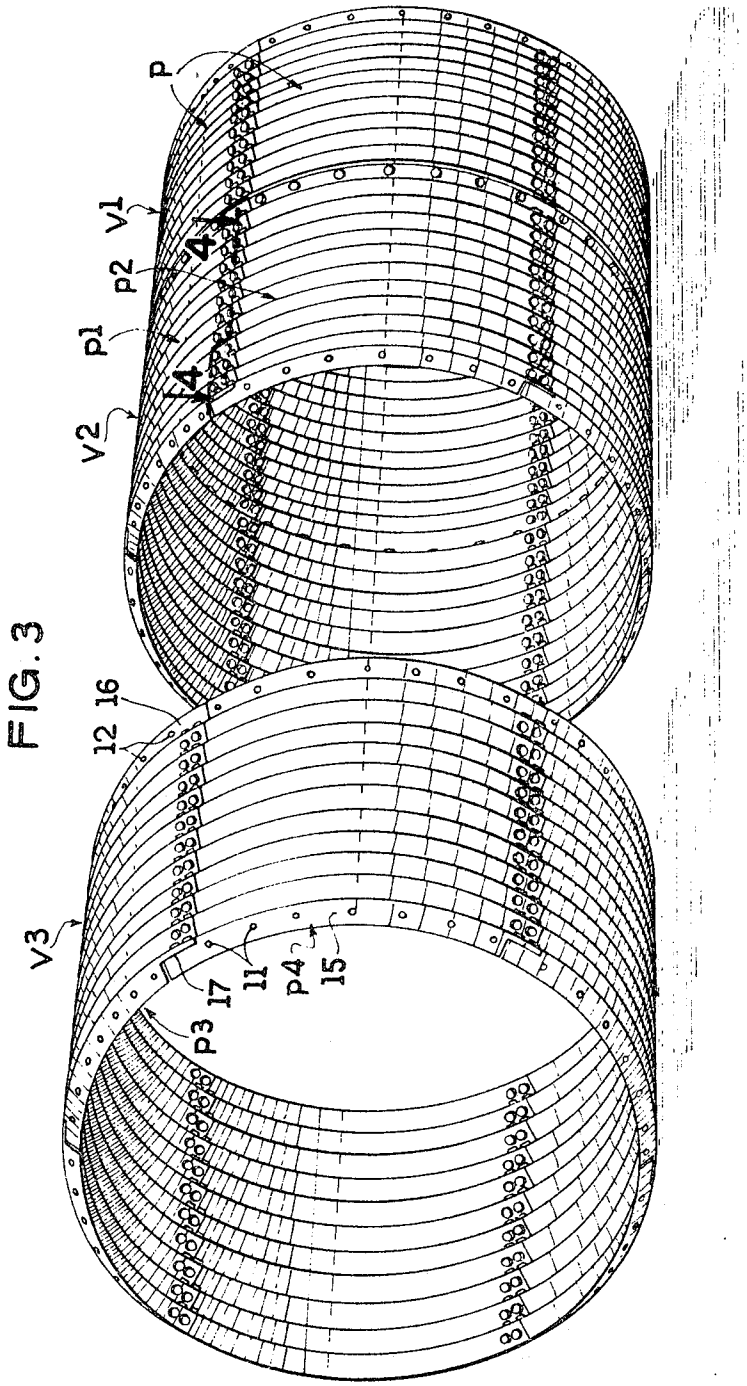


FIG. 3

FIG. 4

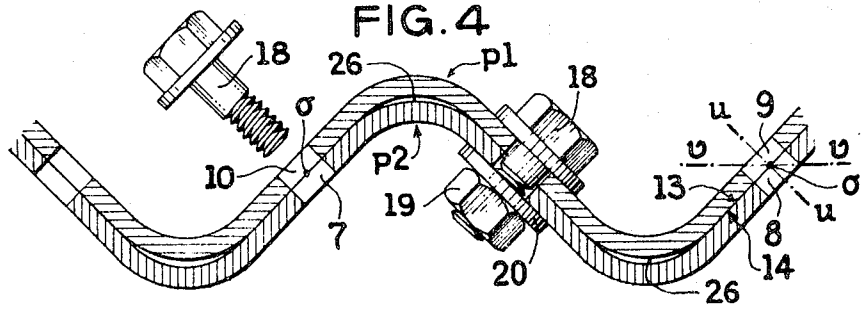


FIG. 5

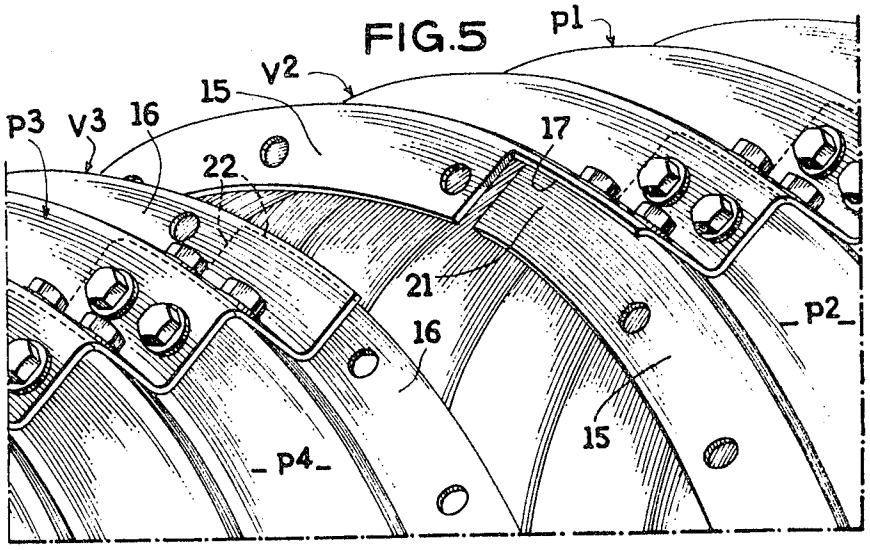


FIG. 6

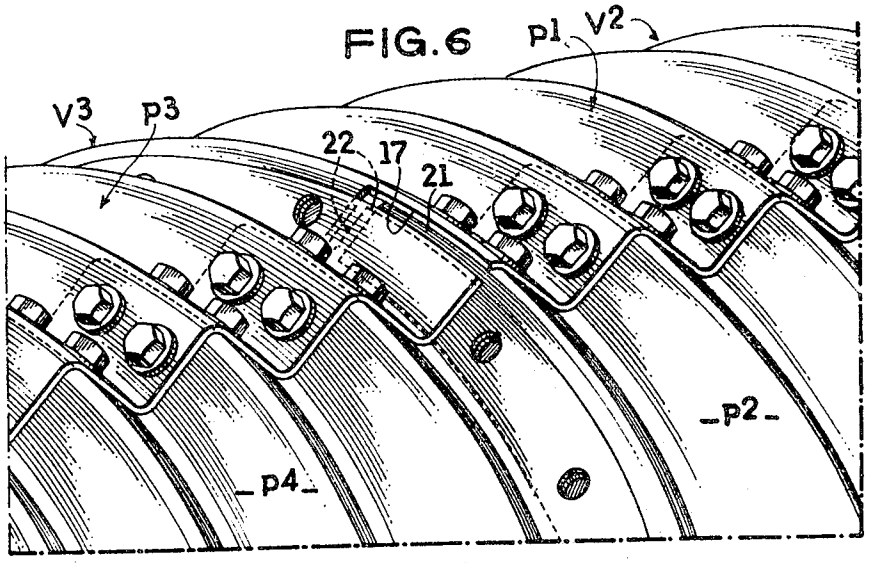


FIG. 7

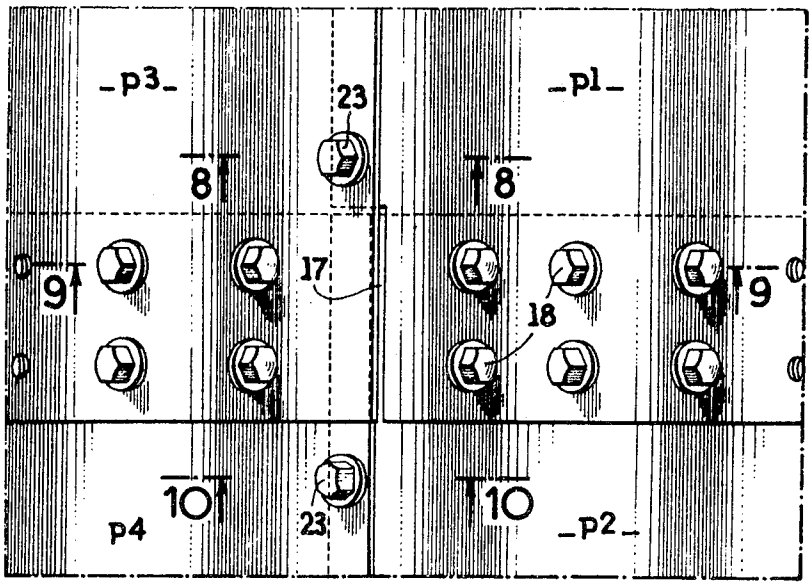


FIG. 8

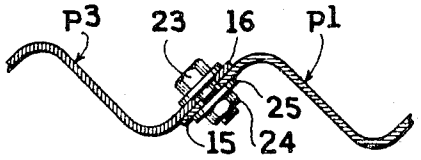


FIG. 9

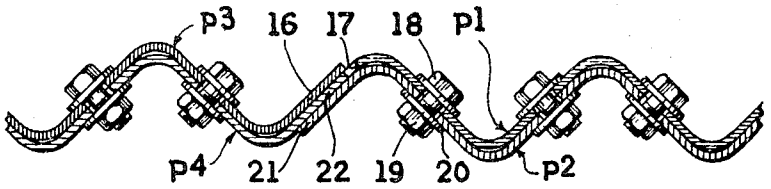


FIG. 10

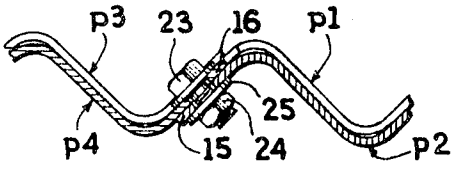
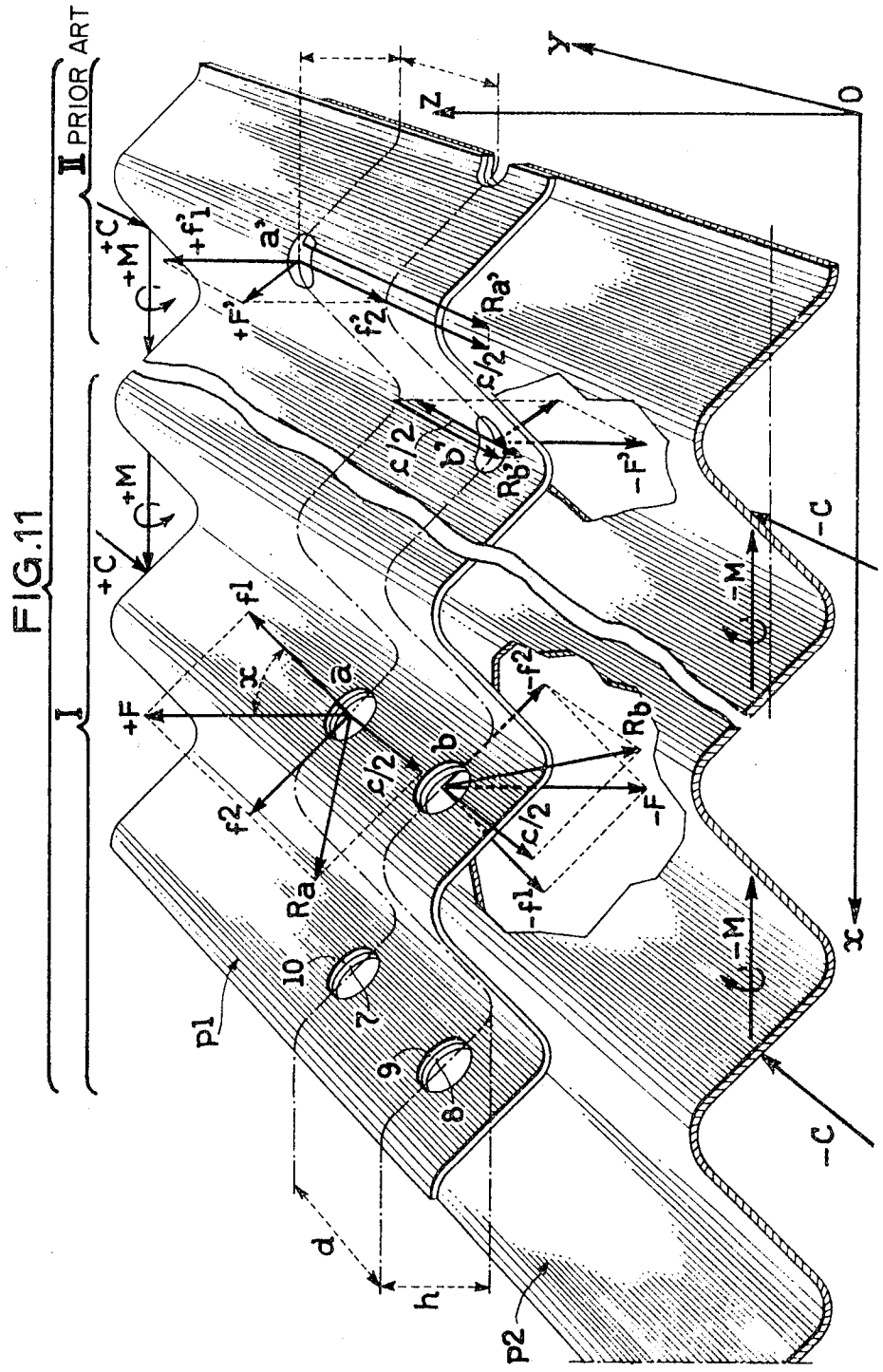


FIG.11


PRIOR ART
II
I
+C'
+M'
+f'1
a'
+F'
f'2
Ra'
c/2
c/2
b'
Rb'
-F'
-c
+M
+C
f1
x
+F
a
-f2
Rb
b
c/2
f2
-F
c/2
Ra
-f1
-M
10
7
9
8
p1
d
h
p2
z
y
0
x
-M
-c

FLEXIBLE STRUCTURAL PLATE PIPES AND THE LIKE

The present invention relates to structural plate pipes and other structures constituting flexible conduits intended to be covered with earth fill so as to form passages under the ground.

Thus embedded, the structural plate pipes or other flexible conduits are subjected to pressures by the fill which surrounds them and as a result their walls are compressed to roughly the same extent throughout their periphery. These pressures are due to the weight of the fill and the live loads on the surface of the ground.

In normal use, the cross section of the flexible pipes flattens under the action of the loads, this flattening is often sufficient to result in permanent deformation of the walls at certain points.

Thus the walls of flexible metal pipes undergo stress in two ways:

a. Outside pressures tend to shorten the perimeter of the pipe and consequently its walls are subjected to a roughly uniform peripheral compressive thrust.

b. The flattening of the section, which has for effect to modify the radius of curvature of the wall at a large number of points in one direction or the other, subjects the wall of the structure to bending moments of variable direction and intensity.

These structures having a curved or bent shape and a closed circular section or other section, are usually fabricated from an assembly of corrugated plates which are bent in a direction perpendicular to the folds or corrugations. However, owing to the presence of these folds or corrugations, the assembly of superimposed edge portions of the plates by means of bolts, rivets or other elements for fastening, tightening the plates together and transmitting all the stresses from one plate to the other, presents problems which have not been solved in a satisfactory manner from the point of view of both facility of erection of the assemblies and the strength and resistance of the latter, as well as of the assembled plates.

It is current, if not exclusive, practice to assemble the corrugated plates by providing in these plates apertures for the passage of fastening elements at such points that the centers of these apertures are located on the curved lines of the crests and valleys of the folds or corrugations. Consequently, these apertures are located in regions of the plates where the fibers are subjected to the highest stresses resulting from the bending moments and where the curvature of the inner and outer faces is maximum. These regions are furthermore outside the zones of contact between the plates, so that the plates are not positively locked together, since the fastening remains elastic and the pressure at which the plates bear against each other remains low and distributed over large areas.

Further, the fastening elements must usually bear on two curved faces, one of which is concave and the other convex, and consequently must have bearing faces of the same shape. This renders the utilization of conventional assembling elements difficult.

In addition to these very important drawbacks, which will be explained hereinafter, there is another very serious drawback, above all when the structure is tubular and has a closed cross section, since, owing to the fact that the apertures for the passage of the assembling and tightening elements are located in the valleys or crests of the corrugations (or folds) of each bent plate, the assembly of two circumferential arcuate edge portions parallel to the curved lines of the crests and valleys of the corrugations or folds requires that the end corrugations of two neighboring plates be overlapped and fitted one inside the other, which renders strictly impossible the assembly of the structure in two stages, namely by first constructing ring sections and then assembling the ring sections in end-to-end relation.

The object of the invention is to provide a corrugated plate which is bent or curved in such manner that the lines of the crests and valleys of the corrugations or folds are curved in planes containing said crests and valleys and is intended for the construction of curved-section structures, such as culverts, said plate being so improved as to remedy the aforementioned drawbacks.

The invention provides a plate which comprises adjacent each of its edges assembly apertures whose axes are perpendicular to the flanks of the folds or corrugations and whose positions on said flanks differ from one edge to the opposite edge of the plate and are such that by the overlapping of the opposite edge portions pertaining to said edges of two identical plates, all the pairs of apertures pertaining to these edge portions are coaxial.

Owing to this feature, in the region of each assembly point, the united plates bear positively against each other by the flanks of their corrugations and this precludes any elastic bending when tightening them together. Further, the two assembly holes are strictly coaxial so that the fastening element can occupy practically the whole of the section of these apertures, which imparts optimum shear strength to the assembly.

According to another feature, adjacent each of the longitudinal corrugated edges perpendicular to the curved crest lines of the plate, the assembly apertures have their centers arranged along at least two lines parallel to the edges, so that, after assembly, the fastening elements pertaining to two neighboring apertures taken from each line, can very effectively transmit the bending moments from one plate to the other.

According to another feature, which is possible to the fact that the assembly apertures are provided on the flanks and not on the crests or valleys of the corrugations or folds, the plate is made to terminate on its two curved edges in a male annular corrugation flank at one end of the plate and in a female corrugation flank at the other end.

Consequently, when erecting a structure it is possible to first assemble the plates in the form of ring sections which are subsequently brought axially together merely by placing the male portion of one ring section axially against the female portion of the other ring section. The erection of the structure, in particular if it has a closed cross-sectional shape, is considerably facilitated.

According to a further feature, the plate comprises in one of its corners, defined by a circumferential edge and a longitudinal edge, a rectangular notch whose length measured along the circumferential edge is equal to at least the extent of the overlapping between the considered plate and an identical adjacent plate, this overlapping being determined by the positions of the assembly apertures provided along said longitudinal edge portion of the plate.

This notch facilitates the assembly in the crossing region between a circumferential seam and a longitudinal seam, since it avoids the necessity of deforming the unnotched corners which would otherwise be superimposed in this region when tightening the plates together.

Another object of the invention is to provide a flexible structure having a curved and corrugated wall of curvilinear, annular or nonannular cross-sectional shape, said structure comprising plates which are identical as concerns the aforementioned features and interconnected by fastening elements each of which extends through the coaxial apertures formed in two of the superimposed edge portions of two adjacent plates.

In this structure, the fastening elements serve to assemble the plates and to transmit all the forces from one plate to the other.

Further features and advantages of the invention will be apparent from the ensuing description with reference to the accompanying drawings.

In the drawings:

FIG. 1 is a perspective view of an improved plate according to the invention;

FIG. 2 is a partial sectional view, taken along the broken line 2—2 of FIG. 1, on an enlarged scale;

FIG. 2*a* is a similar view, for comparison purposes, of a plate of conventional type;

FIG. 3 is a perspective view of a tubular pipe having a circular cross section in the course of erection, this pipe comprising plates of the type shown in FIGS. 1 and 2;

FIG. 4 is a cross-sectional view taken along the broken line 4—4 of FIG. 3, on an enlarged scale, of a portion of one of the longitudinal seams of the structure shown in FIG. 3, before and after the tightening together of the assembly;

FIG. 5 is a partial perspective view of two end portions of two ring sections before assembly, in the region of the intersection between a circumferential seam and a longitudinal seam;

FIG. 6 is a view similar to FIG. 5, after the ring sections have been brought together;

FIG. 7 is a corresponding partial plan view thereof;

FIGS. 8, 9 and 10 are partial sectional views taken along lines 8—8, 9—9 and 10—10 of FIG. 7;

FIG. 11 is a diagram showing, in side-by-side relation at I and II, the overlapping for the purpose of forming a longitudinal seam respectively between two plates according to the invention and two plates of conventional type, with a geometric representation of the forces which will be set up in the assembly which is assumed to be finished;

FIG. 12 is a diagram showing other possible forms of structures having closed curvilinear contours which can be constructed in accordance with the invention, it being understood that the invention encompasses any structure having an open or closed section.

In the embodiment of the invention shown in FIGS. 1 and 2, the basic element of the invention is a plate P of strong material which is generally of metal, sheet metal or the like, but which can also be a strong and rigid plastics material such as superpolyamide. This plate is corrugated or folded in accordance with a profile which can be generally of any kind provided that each flank of a corrugation or fold has a roughly plane portion throughout its length.

In the embodiment shown in FIG. 2, the profile is roughly sinusoidal, the crests 1 and the valleys or roots 2 of a corrugation or fold being curvilinear and having a radius of curvature r which is not critical.

When viewed in plan the presently described plate P has a rectangular or square shape, at any rate when it concerns the fabrication or construction of a cylindrical structure, since it can have a trapezoidal or other shape in the case of special structures.

In any case, it has two pairs of edges which, in the case of plates which are rectangular in plan, are parallel and define two longitudinal edges 3, 4 and two circumferential edges 5 and 6.

This plate is bent or curved in such direction that the crest lines 1 and the valley lines 2 are curved, for example so as to have a radius of curvature R which could be if desired constant. Consequently, the longitudinal edges 3 and 4 of the plate are corrugated or folded, the neutral axis of the corrugations or folds being rectilinear whereas the circumferential edges 5 and 6 have a curved or arcuate shape, for example a part-circular shape.

This plate has the following particular features:

- adjacent its four edges and parallel to these edges it has rows of assembly apertures formed in the flanks of the corrugations;
- adjacent each of the two longitudinal edges 3 and 4 it has two parallel rows of circular apertures 7, 8 or 9, 10, each flank having for example two apertures or a single aperture, the aperture alternating from one row to the other;
- adjacent each arcuate or curved edge 5 or 6, a single row of assembly apertures 11 or 12 is provided; the same number of apertures 11 and apertures 12 is provided and they have the same positions in the circumferential direction in respect of each edge;
- the positions of the apertures on the two longitudinal edges differ from one edge to the opposite edge and are such that when the opposite edge portions of two identical plates are superimposed, the apertures pertaining to these edge portions are coaxial; in the illustrated embodiment, in which the plates must be assembled in the manner of tiles of a roof with one outer edge and one opposite inner edge, the relative positions of the apertures 7, 10 and 8, 9 are seen in the sectional view of FIG. 4 which shows that the apertures 7, 8 of the lower plate P^2 each have the center of its upper end on the face 13 coinciding at o with the center of the lower end on the face 14 of the aperture 9 or 10 of the plate P^1; the axes of these apertures coincide on line u—u; moreover, in the illustrated embodiment, the neutral line v—v of the assembly obtained passes through point o;
- the two arcuate edges 5 and 6 are the edges of two frustoconical flanks or flanges, namely a male flank 15 and a female flank 16;
- the plate has in one of its corners, defined by the longitudinal edge 4 (or 3) and the circumferential edge 5 (or 6), a notch 17 formed in the male flank 15 (or female flank 16); it extends circumferentially from the longitudinal edge 4 (or 3) along an arcuate length which is equal to at least the extent of the overlapping or seam between two assembled adjacent plates, this extent depending on the positions of the two rows of apertures 9, 10 (or 7, 8) relative to the longitudinal edge 4 (or 3).

With reference now to FIG. 2*a*, which shows, for comparison with FIG. 2, the conventional arrangement of curved and corrugated plates P′ for the construction of structural plate pipes or the like. In the plates P′, all the assembly apertures, whether they be longitudinal or transverse, are provided at 10′, 11′, 12′ on the crests and in the valleys of the corrugations or folds; consequently, the arcuate edges 5′ and 6′ define two flanks 15′ and 16′ which are both male or female, depending on the direction in which the sheet is bent. This reference to the conventional arrangement has been made to permit a more ready understanding of the considerations which will be explained hereinafter with reference to FIG. 4 and FIG. 11.

According to the embodiment shown in FIGS. 1 and 2, the plates can be assembled along their longitudinal and circumferential edges so as to constitute a structure having a curvilinear section, as the pipe shown in the course of assembly in FIG. 3. This structural plate pipe having an annular circular section is to be made up of ring sections V^1, V^2, V^3 . . . The ring sections V^1 and V^2 have already been assembled; the third ring section V^3 is shown separate from the other two.

Each of these ring sections is formed for example by six plates, such as plate P shown in FIG. 1, which are assembled by longitudinal seams. Each ring section therefore terminates at each of its ends in a male frustoconical edge portion or flange 15 and in a female frustoconical edge portion or flange 16 corresponding to the male flanks and female flanks of each of the initial plates.

The longitudinal assemblies of the plates of each ring section and then the circumferential assemblies of the ring sections with each other after their male and female frustoconical edge portions have been brought together, are achieved by means of nuts and bolts, rivets or other assembling elements, which pass through pairs of superimposed and coaxial apertures of the longitudinal and circumferential edge portions of the various plates.

FIG. 4 shows, on an enlarged scale, a portion of one of the longitudinal assemblies between the superimposed edge portions of two plates, for example plates P^1 and P^2 of the ring section V^2 of FIG. 3. The apertures 8, 9 and 7, 10 are superimposed, for the reasons explained hereinbefore, and engaged in each pair 8, 9 or 7, 10 of coaxial apertures is a bolt 18 provided with a tightening nut 19 and an interposed washer 20.

As concerns the circumferential assembly between the ring sections and the function of the notch 17 of each plate, reference will be had to FIGS. 3 and 5—10 which show the assembly corners common to the two plates P^1, P^2 of the ring section V^2 and to the plates P^3 and P^4 of the ring section V^3. The ring section V^2 comprises in the right corner of the male flank 15 of each of its plates, such as P^1 for example, the notch

17 which provides a free space on the left corner 21 of the corresponding male flank 15 of the subjacent neighboring plate P^2, whereas in respect of the ring section immediately to the left, for example ring section V^3, the female flank 16 of its plate P^4 extends to 22 under the female flank 16 of the superjacent plate P^3, so that when the ring section V^3 is fitted by its frustoconical female edge portion onto the frustoconical male edge portion of the ring section V^2, the space afforded by the notch 17 can accommodate the end portion 22 of the flank 16 of the plate P^4 of the ring section V^3. After assembly, on each side of the zone corresponding to the notch 17, there are the overlapping flanks 15 and 16 of the plates P^1, P^3 (FIG. 8) or P^2, P^4 (FIG. 10) of the two ring sections and, in the region of this notch (FIG. 9), the corresponding portions 21 and 22 of the flank 15 of the plates P^2 and P^4 and of the flank 16 of the plate P^3.

FIG. 9 shows the bolts 18 and nuts 19 and the washers 20 of the longitudinal assembly seams, whereas FIGS. 8 and 10 show the bolts 23, nuts 24 and washers 25 of the circumferential assembly seams.

Owing to the invention, the structures obtained have, relative to the known structures employing plates assembled by means of apertures formed in the crests and in the valleys of the corrugations, very important advantages and in particular the following:

1. Owing to the fact that the inner faces of the apertures coincide in each pair of apertures, since these apertures are coaxial, the bolts can be easily engaged; the clearance provided for the bolts can therefore be extremely small so that, for a given bolt section, the apertures are smaller than if they had not been coaxial; consequently, the plates are not so weakened by these apertures; for a given strength, the plates can therefore be thinner.

2. The resistance to bending moments is considerably increased.

It is known that the longitudinal seams of flexible structural plate pipes are subjected to compression and bending forces which can be of the same order of magnitude and are transmitted from one plate to the other by the assembly bolts.

With the plates and in the structures according to the invention, the apertures 7, 8, 9, 10 for the passage of the bolts are disposed in such regions that the centers *o* (FIG. 4) of the pairs of coaxial apertures are on a cylindrical surface coaxial with the pipe.

The result of this arrangement is that each pair of bolts, one of which is located in one of the two rows of apertures and the immediately adjacent other bolt, located in the other row, transmits from one plate to the other the bending moments in the form of a couple of forces perpendicular to the cylindrical envelope surface of the structure. Each of these forces, transmitted from one plate to the other by a bolt, can be split up into two forces, namely one along the axis of the bolt and the other perpendicular to this axis, but these components are both contained in a plane perpendicular to the direction of the main compressive stress, whereas, in the case of the conventional arrangement, one of the components is parallel to this main stress.

In the conventional construction there is an algebraic addition of the transverse parallel components and unequal resultants in the same direction whereas, in structures according to the invention, there is a geometric composition of the stresses whose resultants transverse to the bolts are of equal value but different in direction.

To justify the foregoing, reference can be had to FIG. 11 in which part I relates to the invention and part II to the case of plates of known type.

Let h be the depth of a corrugation, d the center distance between the apertures 7, 8 or 9, 10 and x the angle of the axis of a bolt relative to the vertical.

Each corrugation is subjected to a bending moment M and a compression C.

The bending moment M is transmitted from the plate P^1 to the plate P^2 by the bolts (not shown) which extend through these plates at a and b. This produces at a vertical force $+F=M/d$, at b a force $-F$. The force F can be split into two forces: $+f_1=F\cdot\cos x$ along the axis of the bolt and $f_2=F\cdot\sin x$ perpendicular, which gives at a with the force $C/2$ a resultant:

$$R_a=\sqrt{\frac{C^2}{4}+\frac{M^2}{d^2}\sin^2 x}$$

At b there is a resultant R_b which is equal in absolute value to R_a. All the bolts arranged in accordance with the invention must therefore resist a shear force R_a and a pulling off force f_1.

In the conventional construction (part II of FIG. 11), the apertures are located at points such as a' and b'. The bending moment M produces at a' the force:

$$F'=\frac{M}{\sqrt{d^2+h^2}}$$

and at b' the force $-F'$ F' can be split into two forces: $f'_1=(Md/d^2h^2)$ which is vertical and along the axis of the bolt and $f'_2=(Mh/d^2+h^2)$ is parallel to OY

Here, f'_2 is added algebraically to the force C_2 and gives:

at a': $R_{a'}=(C/2)+(Mh/d^2+h^2)$

at b': $R_{b'}=(C/2)-(Mh/d^2+h^2)$ which can be negative.

The most highly stressed bolts must therefore resist a shearing force R_a and a pulling off force f'_1.

The advantage of the invention can be appreciated from the ratio $R_{a'}/R_a$ which can in practice reach 1.225; further, as the apertures at a and b are never subjected to tensile stress, as indicated by the direction of the forces R_a and R_b the apertures can be shifted nearer to the edges of the plates with no danger of their tearing and this enables the distance between the center lines of the apertures to be increased for a given overlapping or seam and $R_{a'}/R_a$ can be easily increased to 1.4.

For given stresses, and in particular for a given bearing strength, the thickness of the plates can be reduced by 20–30 percent which results in substantial economy.

3. At all assembly points, the flanks of the two plates bear closely against each other in a zone of high pressure surrounding each bolt 18 or 23 so that by tightening the nut 19 or 24 the plates are caused to bear intimately against each other and perfectly positive tightening or fastening is achieved with no elastic distortion of the plates.

On the other hand, with a plate of conventional type, as shown in FIG. 2*a*, the bolts extend through the crests and valleys of the corrugations at 11' and 10', namely at points where the two plates are not in contact, since a more or less gap 26 (FIG. 4) remains between the concave and convex faces of the two assembled plates so that a fastening at these points can be no more than an elastically yieldable, that is, a nonpositive fastening. The fastening or tightening force exerted by the bolts is therefore rather evenly distributed over large areas, namely those of the flanks of the corrugations in direct contact with each other. At no point in this contact does the fastening or tightening pressure reach a value sufficient to oppose, by the effect of seizure, the sliding of the plates relative to each other.

4. Owing to the plane faces on which the head of the bolt 18 or 23 and the washer 20 or 25 bear, the bolt head, the washer and the nut 19 or 24 can be conventional parts having plane bearing faces. This is not the case when fastening the plates together at the crests and valleys of the corrugations, as explained hereinbefore.

5. Owing to the fact that the assembly apertures are located on the corrugation flanks, they can be produced with no inconvenience by a punching operation, since any cracks produced by the punching are smaller, because the punched surfaces are plane. These cracks are practically harmless since the edges of the apertures are never subjected to tensile stress.

On the other hand, when the apertures are punched in regions of the plate having a very small radius of curvature, cracks and burrs are always associated with these apertures and tend to initiate rupture. The situation is worsened when these defects—which are rendered more serious by the fact

that the punching operation is carried out under less perfect conditions—are in zones of high tensile stresses which often exceed the yield strength. This can give rise to open cracks which are liable to spread and cause the apertures to split open and even result in the complete rupture of the section of the corrugated plate.

It must be understood that the structural plate pipe of closed circular section shown in FIG. 3 as an example of a structure including the plates according to the invention, is not an exclusive example since the invention encompasses any other similar structure irrespective of the shape of the section which may be annular or unannular.

FIG. 12 shows in full line at 26 a modification in the shape and in dot-dash line at 27 another modification. These shapes differ from that of the pipe shown in FIG. 3 in that the cross-sectional shape does not have a constant radius of curvature. It will be understood that the structures 26 and 27 include plates bent at different radii of curvature.

Having now described my invention what I claim and desire to secure by Letters Patent is:

1. A curvilinear quadrilateral plate for the construction of flexible curvilinear segmented structures, said plate being defined by a first longitudinal edge and an opposed second longitudinal edge, a first transverse curvilinear edge and an opposed second transverse curvilinear edge and comprising corrugations having crest portions and valley portions which are curvilinear in parallel transverse planes intersecting said plate and extend to said longitudinal edges and flank portions interposed between said crest portions and said valley portions and inclined with respect to said planes, each flank portion having a convex face and a concave face, said first curvilinear edge defining a male corrugation flank portion whose convex face constitutes a tapered male assembly face and said second curvilinear edge defining a female corrugation flank portion whose concave face constitutes a flared female assembly face, said plate comprising means defining assembly apertures in said corrugation flank portions, said apertures having axes perpendicular to said flank portions and comprising first apertures adjacent and arranged alongside said first longitudinal edge and second apertures adjacent and arranged alongside said second longitudinal edge, third apertures in said male flank portion and fourth apertures in said female flank portion, said first apertures having positions relative to one another and relative to said planes of said crest portions and valley portions on the convex faces of said flank portions which are identical to the positions of said second apertures on the concave faces of said flank portions, and said third apertures having positions on said convex male face relative to one another and relative to a neutral axis of the cross section of the corrugations which are identical to positions of said fourth apertures on said concave female face, whereby said plate is capable of being assembled in partially overlapping relation with transversely adjacent plates identical thereto and in abutting relation with longitudinally adjacent plates identical thereto, with the first and second apertures of transversely adjacent plates and the third and fourth apertures of the longitudinally adjacent plates in superimposed coaxial relation to each other.

2. A plate as claimed in claim 1, wherein said first apertures and second apertures pertaining are arranged on a plurality of lines respectively substantially parallel to said first longitudinal edge and said second longitudinal edge.

3. A curvilinear plate for the fabrication of flexible bent curvilinear segmented structures, said plate being defined by a first longitudinal edge and an opposed second longitudinal edge, a first transverse curvilinear edge and an opposed second transverse curvilinear edge and comprising corrugations having crest portions and valley portions which are curvilinear in parallel transverse planes intersecting said plate and extend to said longitudinal edges and flank portions interposed between said crest portions and said valley portions and inclined with respect to said planes, each flank portion having a convex face and a concave face, said first curvilinear edge defining a male corrugation flank portion whose convex face constitutes a tapered male assembly face and said second curvilinear edge defining a female corrugation flank portion whose concave face constitutes a flared female assembly face, said plate comprising means defining assembly apertures in said corrugation flank portions, said apertures having axes perpendicular to said flank portions and comprising first apertures adjacent and arranged alongside said first longitudinal edge and second apertures adjacent and arranged alongside said second longitudinal edge, third apertures in said male flank portion and fourth apertures in said female flank portion, said first apertures having positions relative to one another and relative to said planes of said crest portions and valley portions on the convex faces of said flank portions which are identical to the positions of said second apertures on the concave faces of said flank portions, and said third apertures having positions on said convex male face relative to one another and relative to a neutral axis of the cross section of the corrugations which are identical to positions of said fourth apertures on said concave female face, said first apertures and second apertures being located in positions midway between said crest portion planes and valley portion planes on the convex face and concave face respectively of the corrugations and said third apertures and fourth apertures being located on a neutral axis of the cross section of the corrugations on said convex male face and concave female face respectively.

4. A curvilinear plate for the fabrication of flexible bent curvilinear segmented structures, said plate being defined by a first longitudinal edge and an opposed second longitudinal edge, a first transverse curvilinear edge and an opposed second transverse curvilinear edge and comprising corrugations having crest portions and valley portions which are curvilinear in parallel transverse planes intersecting said plate and extend to said longitudinal edges and flank portions interposed between said crest portions and said valley portions and inclined with respect to said planes, each flank portion having a convex face and a concave face, said first curvilinear edge defining a male corrugation flank portion whose convex face constitutes a tapered male assembly face and said second curvilinear edge defining a female corrugation flank portion whose concave face constitutes a flared female assembly face, said plate comprising means defining assembly apertures in said corrugation flank portions, said apertures having axes perpendicular to said flank portions and comprising first apertures adjacent and arranged alongside said first longitudinal edge and second apertures adjacent and arranged alongside said second longitudinal edge, third apertures in said male flank portion and fourth apertures in said female flank portion, said first apertures having positions relative to one another and relative to said planes of said crest portions and valley portions on the convex faces of said flank portions which are identical to the positions of said second apertures on the concave faces of said flank portions, and said third apertures having positions on said convex male face relative to one another and relative to a neutral axis of the cross section of the corrugations which are identical to positions of said fourth apertures on said concave female face, said first apertures and second apertures being located in positions midway between said crest portion planes and valley portion planes on the convex face and concave face respectively of the corrugations and said third apertures and fourth apertures being located on a neutral axis of the cross section of the corrugations on said convex male face and concave female face respectively, said plate comprising in a corner of said plate defined by one of said longitudinal edges and one of said curvilinear edges, a notch which is formed in the flank flange portion defined by said one curvilinear edge and extends in a direction parallel to said one curvilinear edge to an extent no less than overlapping between the plate and a transversely adjacent identical plate, said overlapping depending on positions of said first and second apertures relative to said longitudinal edges.

5. A rectangular curvilinear structural plate for the construction of a flexible curvilinear segmented structural plate pipe, said plate being defined by a first longitudinal edge and an opposed second longitudinal edge, a first transverse curvilinear edge and an opposed second transverse curvilinear edge and comprising corrugations having crest portions and valley portions which are curvilinear in parallel transverse planes intersecting said plate and extend to said longitudinal edges and flank portions interposed between said crest portions and said valley portions, said first curvilinear edge defining a male corrugation flank portion whose convex face constitutes a tapered male assembly face and said second curvilinear edge defining a female corrugation flank portion whose concave face constitutes a flared female assembly face, said plate comprising means defining assembly apertures in said corrugation flank portions, said apertures having axes perpendicular to said flank portions and comprising first apertures adjacent and arranged alongside said first longitudinal edge and second apertures adjacent and arranged alongside said second longitudinal edge, third apertures in said male flank portion and fourth apertures in said female flank portion, said first apertures having positions relative to one another and relative to said planes of said crest portions and valley portions on the convex faces of said flank portions which are identical to the positions of said second apertures on the concave faces of said flank portions, and said third apertures having positions on said convex male face relative to one another and relative to a neutral axis of the cross section of the corrugations which are identical to positions of said fourth apertures on said concave female face, said first apertures and second apertures being located in positions midway between said crest portion planes and valley portion planes on the convex face and concave face respectively of the corrugations and said third apertures and fourth apertures being located on a neutral axis of the cross section of the corrugations on said convex male face and concave female face respectively.

6. A flexible curved-section segmented structure comprising a plurality of curvilinear plates assembled in adjacent relation to one another, so as to have edge portions thereof in overlapping relation to edge portions of adjacent plates, each plate being defined by a first longitudinal edge and an opposed second longitudinal edge, a first transverse curvilinear edge and an opposed second transverse curvilinear edge and comprising corrugations having crest portions and valley portions which are curvilinear in parallel transverse planes intersecting said plate and extend to said longitudinal edges and flank portions interposed between said crest portions and said valley portions, said first curvilinear edge defining a male corrugation flank portion whose convex face constitutes a tapered male assembly face and said second curvilinear edge defining a female corrugation flank portion whose concave face constitutes a flared female assembly face, said plate comprising means defining assembly apertures in said corrugation flank portions, said apertures having axes perpendicular to said flank portions and comprising first apertures adjacent and arranged alongside said first longitudinal edge and second apertures adjacent and arranged alongside said second longitudinal edge, third apertures in said male flank portion and fourth apertures in said female flank portion, said first apertures having positions relative to one another and relative to said planes of said crest portions and valley portions of the convex faces of said flank portions which are identical to the positions of said second apertures on the concave faces of said flank portions, and said third apertures having positions on said convex male face relative to one another and relative to a neutral axis of the cross section of the corrugations which are identical to positions of said fourth apertures on said concave female face, and fastening elements extending through the coaxial apertures in the abutting male and female flank portions and in the overlapping longitudinal edge portions and fastening together the assembled plates, said fastening elements being capable of transmitting force from said plates to adjacent plates.

7. A flexible curved-section structure as claimed in claim 6, comprising in each plate a notch in a corner of the plate defined by one of said longitudinal edges and one of said curvilinear edges, said notch being formed in one of said male flank and female flank portions and extending transversely of said plate along said one flank portion to an extent no less than the extent of the overlapping between edge portions pertaining to said longitudinal edges of said adjacent plates.

8. A flexible segmented structural plate pipe comprising a plurality of coaxial annular pipe sections in end-to-end relation to one another, each annular section comprising a plurality of curvilinear plates in peripherally adjacent relation to one another, each of said plates being defined by a first longitudinal edge and an opposed second longitudinal edge, a first transverse curvilinear edge and an opposed second transverse curvilinear edge and comprising corrugations having crest portions and valley portions which are curvilinear in parallel transverse planes intersecting said plate and extend to said longitudinal edges and flank portions interposed between said crest portions and said valley portions and inclined with respect to said planes, each flank portion having a convex face and a concave face, said first curvilinear edge defining a male corrugation flank portion whose convex face constitutes a tapered male assembly face and said second curvilinear edge defining a female corrugation flank portion whose concave face constitutes a flared female assembly face, said plate comprising means defining assembly apertures in said corrugation flank portions, said apertures having axes perpendicular to said flank portions and comprising first apertures adjacent and arranged alongside said first longitudinal edge and second apertures adjacent and arranged alongside said second longitudinal edge, third apertures in said male flank portion and fourth apertures in said female flank portion, said first apertures having positions relative to one another and relative to said planes of said crest portions and valley portions on the convex faces of said flank portions which are identical to the positions of said second apertures on the concave faces of said flank portions, and said third apertures having positions on said convex male face relative to one another and relative to a neutral axis of the cross section of the corrugations which are identical to positions of said fourth apertures on said concave female face, a longitudinal edge portion defined by said second longitudinal edge of each plate being in overlapping relation to a longitudinal edge portion defined by said first longitudinal edge of a peripherally adjacent plate in each annular pipe section, the male flank portions and female flank portions of the plates in axially adjacent annular pipe sections being in abutting relation to one another, and fastening elements extending through coaxial first apertures and corresponding second apertures and coaxial third apertures and corresponding fourth apertures of said plates and rigidly interconnecting said plates.

* * * * *