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(54) Title: COILABLE PIPE WITH MINIMALLY ANGLED CORRUGATIONS

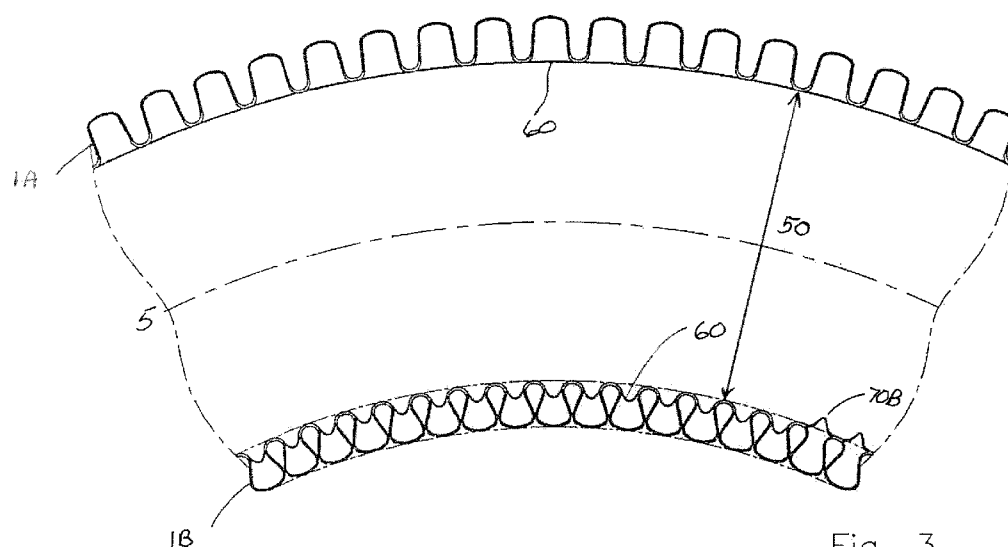


Fig. 3

(57) Abstract: A corrugated pipe, according to the invention, comprises an outer wall with minimally angled corrugations that is thus flexible enough to adapt to pipe deformations due to coiling without sacrificing any significant amount of structural integrity. The sides of the corrugations form an angle of less than 10° with a radial plane of the pipe. The pipe includes a flexible inner layer can fold into the corrugation cavity and/or bulge out to the inner part of the pipe. The pipe is made from standard polyolefins, and when flexed, has the structural integrity characteristics of a typical pipe formed of the same material.



COILABLE PIPE WITH MINIMALLY ANGLED CORRUGATIONS**TECHNICAL FIELD**

[0001] The present invention relates to coilable corrugated pipes. More specifically, the present invention relates to a coilable double-wall corrugated pipe that is coilable even at large diameters.

BACKGROUND

[0002] Corrugated plastic pipe is widely used in construction, especially in sewage and drainage applications. Double walled corrugated pipes provide good hydraulic flow and are more cost-effective than solid (i.e. non-corrugated) plastic or concrete alternatives. Additionally, corrugated pipes are more flexible than non-corrugated alternatives, and are thus able to accommodate some deflection that would damage a more rigid pipe (for example, limited deflections during installation or natural ground movement that may occur after installation).

[0003] A corrugated pipe has regularly spaced annular peaks and valleys along its outer wall, which form the corrugations. A typical double-wall corrugated pipe has an outer corrugated wall and a smooth inner wall forming an inner tube that is attached to the inner side of the valleys and extends in the length of the pipe.

[0004] The outer corrugated layer is formed first by extruding a layer of plastic into a forming mold and

then using blow molding and vacuum forming methods to form the plastic into the mold profile/shape. While the outer corrugated layer is still hot, an inner layer is laid into the molds and then the outer and inner layers are compressed together between the mold valley and an inner forming mandrel to create a welded bond between the outer and inner layers.

[0005] The outer corrugations on a typical pipe have a corrugation profile, with their sides generally forming an angle of about 13° relative to a radial plane of the pipe. To comply with the applicable standard for sewage use, pipes must pass flexibility testing in which they are deformed up to approximately 70% of their original diameter. In use, the pipes can be exposed to conditions causing significant deformation.

SUMMARY

[0006] The present invention provides a double walled corrugated pipe with an outer wall that has corrugations with sides that are minimally angled relative to a pipe's radial plane and that is thus flexible enough to adapt to pipe flexing and bending without significantly sacrificing the structural integrity of the corrugated pipe. The sides of the corrugations form an angle less than 10° with a radial plane of the pipe. The angled corrugations allow for separation of the pipe from the mold blocks while allowing for some bending deformation. A flexible inner layer is fused to the inside of the corrugations and this inner layer can fold or bend into the inner portion of corrugations and/or bulge out to the inner

part of the pipe. The pipe is made of standard polyolefins, and when unflexed, has the structural integrity characteristics of a typical pipe formed of the same materials.

[0007] The present invention provides a double wall pipe comprising:

- an outer corrugated wall with successive annular peaks, said annular peaks being regularly spaced along a longitudinal axis of said pipe, and with successive annular valleys between the annular peaks, said annular peaks and valleys being connected by side segments and said annular peaks and valleys defining corrugations, and
- a deformable inner layer, said inner layer being attached to said outer wall within said outer wall at said annular valleys and bridging between said side segments,

wherein the side segments form an angle of less than 10° with a radial plane of said pipe, said radial plane being perpendicular to said longitudinal axis of said pipe and the flexible inner layer formed to accommodate bending of the pipe.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The present invention will now be described by reference to the following figures showing preferred embodiments of the invention, in which identical reference numerals refer to identical elements and in which:

Figure 1 is a side cross-sectional view of a length of the double walled pipe when straight;

Figure 2 is a side cross-sectional view of a length of the pipe when flexed or coiled showing the different deformations of the outside tensioned wall relative to the compressed inside wall;

Figure 2A shows the lines of bending in the pipe of Figure 2;

Figure 3 is a side cross-sectional view of a length of the pipe, flexed or coiled to a greater degree than in Figure 2; and

Figure 3A shows the lines of bending in the pipe of Figure 3.

DETAILED DESCRIPTION

[0009] Referring to **Figure 1**, a double wall corrugated pipe 3 is illustrated in side cross-section, with a reference line marking the pipe's longitudinal axis 5. A single corrugation 10 has a rounded, flat, peaked or double crowned crest 15, a valley 20, and two side segments 30. The angle 40 is the angle formed by one of the side segments 30 and a radial plane 55 perpendicular to the longitudinal axis 5. The corrugation is preferably symmetrical, i.e., the angles formed by each side segment 30 and the radial plane all correspond and the corrugations are repeated and joined to each other. The pipe configuration is consistent as shown in Figure 1.

[0010] The inside diameter of the pipe is marked by reference arrow 50. The inside diameter 50 is the distance across the interior of the pipe when a flexible inner

layer 60 is neither folded into a corrugation nor bulged outward into the interior of the pipe 3: i.e., the approximate inside diameter is the distance between dotted reference lines 70A and 70B. In a preferred embodiment, the inner layer bows slightly into a corrugation as shown and, due to this shape, will deform into the corrugation cavity when the corrugation is compressed due to bending, as shown in Figures 2 and 3.

[0011] The inner layer 60 is flexible or deformable to allow folding or bending of the inner layer into a corrugation cavity 17 of the pipe. The flexible inner layer 60 can also bulge outwards into the interior of the pipe of the inside diameter 50. The flexible inner layer may be formed to have a bias causing folding in a particular direction by a combination of control of the air pressure between the inner layer and the outer layer and of the air pressure between the inner layer and the forming mandrel under the inner layer in relation to the atmospheric pressure. The final pressure is reached once the pipe and the air inside the corrugation has cooled and any responsive wall deformation (due to pressure differential) has occurred. For pipes with an inside diameter 50 of between 10 millimetres and 1500 millimetres (1.5 metres), the angle 40 can be between 1° and 10° without impeding the pipe's flexibility or coilability. The steep orientation of the walls allows for outward pivoting of the walls of the corrugation to accommodate tension (outer wall) and a reverse direction of pivoting of the sidewalls of the corrugation at the inner wall that is undergoing compression when bent or flexed.

[0012] Note that, to achieve this angle 40, the side segments are within this 10° angle to release from the mold profile. Note also that the side segments 30 cannot be truly vertical, as the pipe would not separate from the mould. If the angle is not small, pivoting for compression is difficult as the angle of the walls require more force to pass through a center point where the walls, if not distorted, would be vertical.

[0013] **Figure 2** shows a side cross-sectional view of the pipe 3 when flexed, coiled or bent in the manner shown. Reference line 5 again marks the longitudinal axis of the pipe and reference arrow 50 marks the inside diameter of the pipe. Because of the flexing or coiling, the flexible inner layer 60 behaves in three different ways, as illustrated by representative corrugations 80A, 80B, and 80C.

[0014] In corrugation 80A, the flexible inner layer 60 is stretched so that it is neither folded into the corrugation nor is it bulged outwards. Any formed curve of the flexible inner layer may be straightened. In corrugation 80B, the flexible inner layer 60 folds into the corrugation so that the excess material does not hinder flexibility. In corrugation 80C, the excess material of the flexible inner layer 60 has bulged outwards from the corrugation and into the interior of the pipe 3, again allowing the pipe to flex or coil. The range of flexibility demonstrated by the flexible inner layer 60 allows the corrugated outer wall to stretch or compress in response to coiling and flexing. The preferred inward curved wall across a corrugation cavity has a preferred length of at least 10% relative to a non-curved wall. Curving of the wall assists in both controlled compression

deformation as well as providing length that straightens during tensioning.

- [0015] In some applications, the depth of the curved wall across a corrugation relative to the length of the chord is 10 to 25%. As can be appreciated, inward curving of the wall provides the bias direction for deforming of the wall into a corrugation when the corrugation sidewalls are moved inwardly.
- [0016] The term "flexible" is used to describe the ability of the inner layer to accommodate deformation due to stretching or compression. The wall shape and material selection assists in responding by appropriate deformation and is consistent around the pipe circumference allowing for any angle of bending.
- [0017] Figure 2 shows the corrugated outer wall stretching and compressing in response to the flexing or coiling of the pipe 3. The corrugations on the convex side of Figure 2, noted as 1A, have stretched out to move with the convex inner layer. On the concave side, side 1B, the corrugations have compressed into each other, in an "accordion-style" fold. By being close to a vertical angle, it is possible to move through the zero angle and then to the negative angles as shown. If the original angle is too great, it is difficult to move, as shown.
- [0018] **Figure 3** shows a side cross-sectional view of the pipe 3 flexed or coiled to a greater degree than in Figure 2. Reference line 5 again marks the longitudinal axis of the pipe and reference arrow 50 marks the inside diameter of the pipe. Note the greater curvature of reference line 5, when compared to the same reference line in Figure 2.

[0019] In response to the greater curvature of the pipe 3, the inner layer 60 is stretched on the convex side of the pipe (side 1A). On the concave side, side 1B, the flexible inner layer is folded and/or bulged to a more substantial degree than in Figure 2. As can be seen, the apex of each fold or bulge is further from the dotted reference line 70B. Additionally, because of the greater curvature, the corrugations on the concave outer wall (side 1B) are more closely compressed than they are in Figure 2. Here, the corrugations are so close that the sides of the corrugations are touching.

[0020] This pipe can be manufactured using conventional corrugators and equipment, requiring little or no modification. Forming the outer corrugations before the inner layer allows the inner layer to retain its elasticity, so that the inner layer will be able to fold and bulge as necessary.

[0021] During forming, the inner wall can be biased into or out of the corrugation to provide a bias the direction for deformation. Having the inner wall curved into the corrugation is preferred. The inner layer and the outer wall can be made of the same material or of different materials. For example, the inner layer and the outer wall may both be formed of polyethylene (PE), polyphenylene ether (PPE), polypropylene (PP), or other plastics, or the inner layer may be formed of one plastic while the outer wall is formed of another. The best choice of material depends on the intended use of the pipe. The thickness of the inner layer can be reduced to assist in deformation and the material selected to be tolerant of the bending.

[0022] As the present invention can be made of standard materials, it has whatever structural integrity characteristics those materials provide when formed as disclosed. When uncoiled or unflexed, this pipe generally has all the structural integrity of a typical double-walled pipe made of the same materials while be more tolerant of bending deformation, as described.

[0023] As shown in the drawings, the double wall thickness at each valley 20 is much stiffer than the single thickness inner wall layer 60 that bridges across side segments 30. The material selected to extrude the inner wall layer 60 can be chosen to accommodate tensioning on the outer wall of the pipe when bent and controlled buckling to accommodate compression at the inner wall of the pipe relative to the bend. The length of this inwardly curved segment is preferably at least 10% greater than if this segment was straight.

[0024] In addition to providing flexibility with respect to meeting new standards, the present coilable double wall pipe provides advantages in installation and allows for a non-straight installation path. Connectors typically are more prone to damage and/or installation issues. Reducing the number of connectors simplifies installation and reduces potential problems. Some curvature of the installation path allows continuous pipe to be installed with less connectors. Large coils of pipe also provide installation advantages as the coil can be unwound as the pipe is installed. The size of coils will vary widely and is dependent on pipe size, pipe material,

pipe stiffness properties and installation requirements and limitations.

[0025] Forming the inner wall layer 60 to curve into the corrugation (when the pipe is straight) has the advantage of providing a direction of buckling into the corrugation as well as allowing the wall to straighten at the outside bend as it is placed in tension. This particular shaping of the inner wall layer automatically provides these advantages regardless of the bend direction. More inward curving of the wall provides additional deformation compensation, however, the flow characteristics of the pipe may be less desirable as the inner wall layer is less straight. A balance between these features is possible and can be made based on the particular pipe application.

[0026] A person understanding this invention may now conceive of alternative structures and embodiments or variations of the above all of which are intended to fall within the scope of the invention as defined in the claims that follow.

We claim:

1. A double wall pipe comprising:

- an outer corrugated wall with successive annular peaks, said annular peaks being regularly spaced along a longitudinal axis of said pipe, and with successive annular valleys between said annular peaks, said annular peaks and valleys being connected by side segments and said annular peaks and valleys defining corrugations;
- a deformable inner layer, said inner layer being attached to said outer wall within said outer wall at said annular valleys and bridging between said side segments; and

wherein said side segments form an angle of less than 10° with a radial plane of said pipe, said radial plane being perpendicular to said longitudinal axis of said pipe.

2. The double wall pipe of claim 1, wherein said double wall pipe is a sewage or drainage pipe.

3. The double wall pipe of claim 1, having an inside diameter of at least 200 millimeters.

4. The double wall pipe of claim 1 wherein said inner layer is curved as the inner layer spans across a corrugation cavity, curves into the corrugation cavity.

5. The double wall pipe of claim 4, wherein said inner layer, as it spans a corrugation cavity, is of a length at least 10% greater than an equivalent straight line distance between said sides of the corrugation.

6. The double wall pipe of claim 4 wherein said inner layer across a corrugation cavity has a depth of curvature of 10 to 25% of a chord distance across the corrugation.

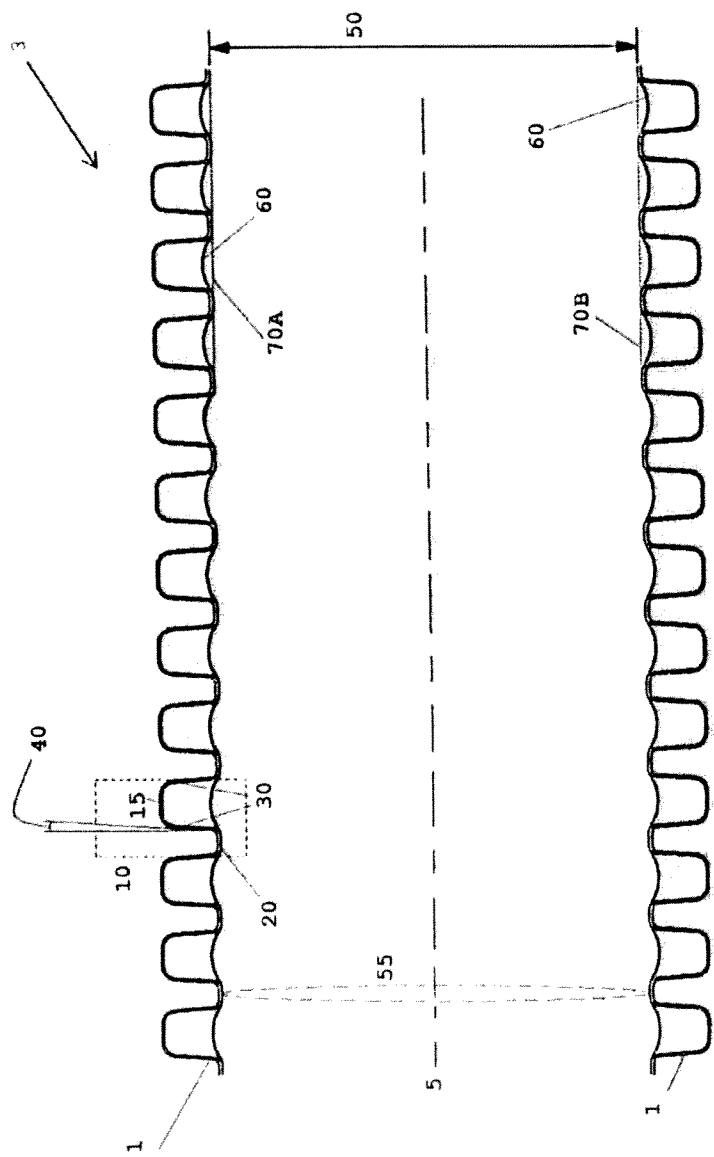


FIG. 1

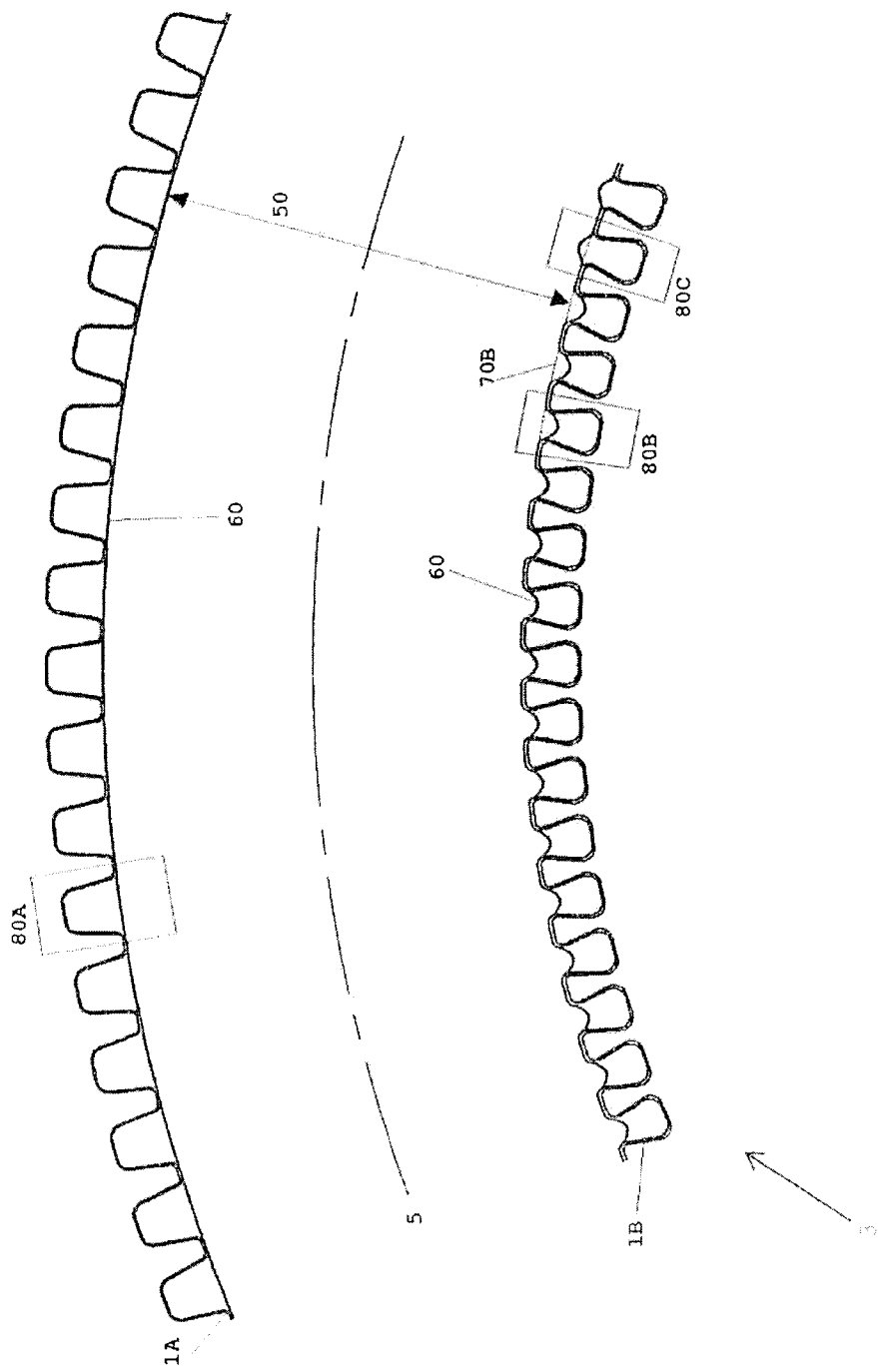


FIG. 2

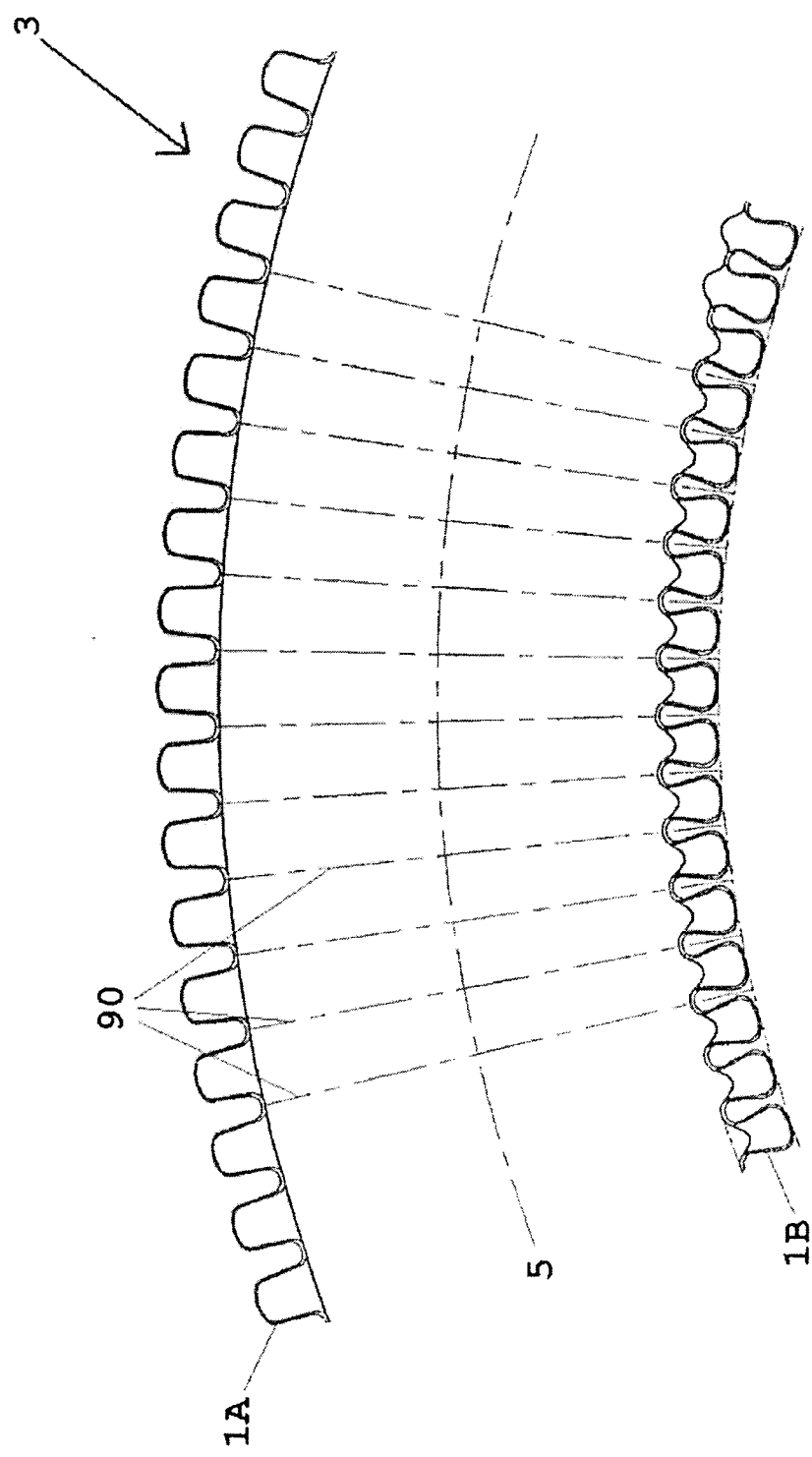
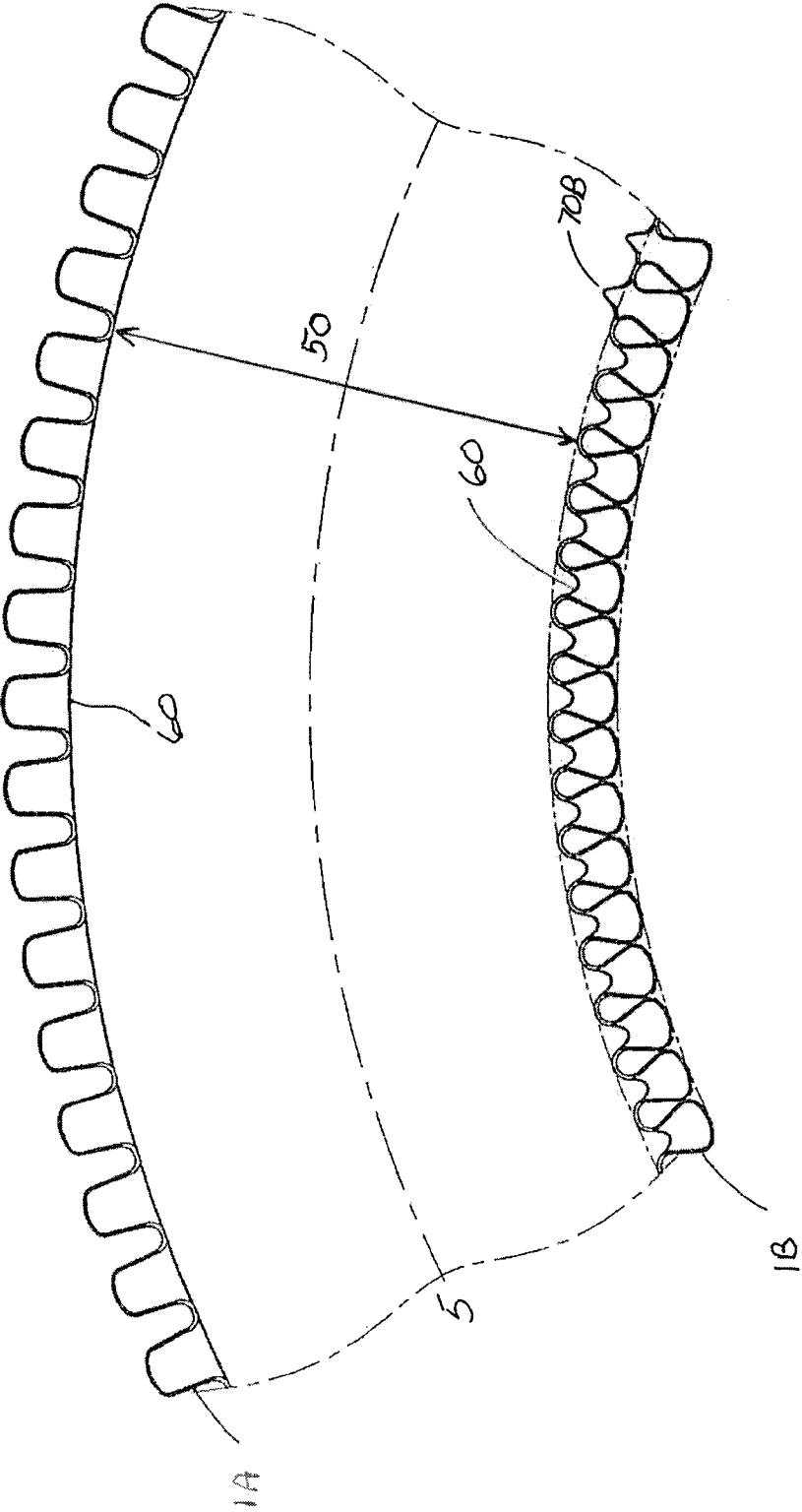


FIG. 2A

Fig. 3



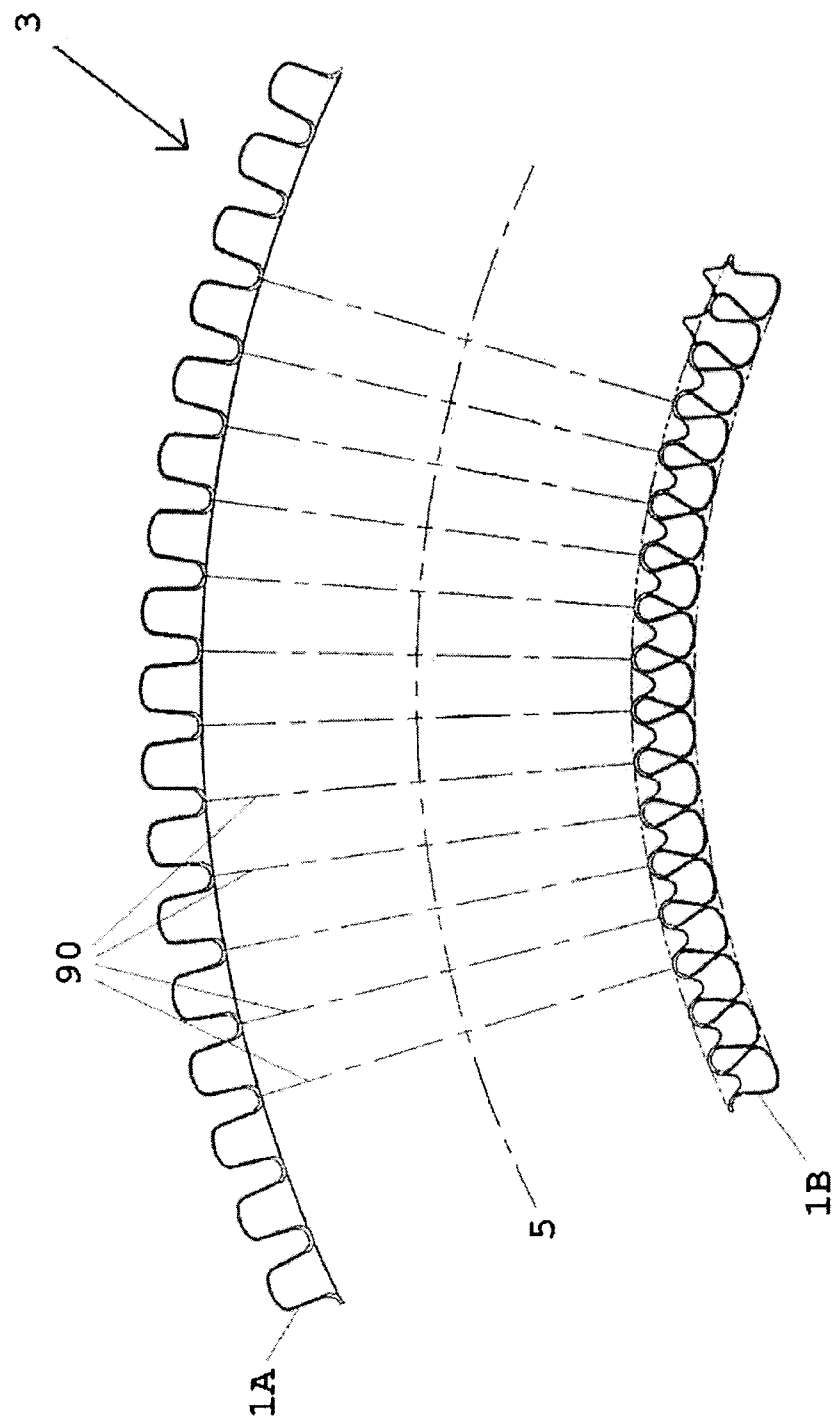


FIG. 3A

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CA2018/000143

A. CLASSIFICATION OF SUBJECT MATTER
 IPC: **F16L 11/20** (2006.01), **F16L 11/15** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
 IPC: F16L 11/20 (2006.01), F16L 11/15 (2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
 IPC: F16L 11/11 (2006.01)

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
 Questel Orbit (fampat); Keywords (flat+, flex+)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US6186182B1, (YOON) 13 February 2001 (13-02-2001) *Whole document*	1-6
X	EP1724508A2, (KRIESI) 22 November 2006 (22-11-2006) *Whole document*	1, 4-6
X	CN202203542U, (LI et al.) 25 April 2012 (25-04-2012) *Whole document*	1, 4-6
X	EP2019242A2, (BUETTNER) 28 January 2009 (28-01-2009) *Whole document*	1, 4

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* "A" "E" "L" "O" "P"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance earlier application or patent but published on or after the international filing date document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) document referring to an oral disclosure, use, exhibition or other means document published prior to the international filing date but later than the priority date claimed	"T" "X" "Y" "&"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art document member of the same patent family
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 31 August 2018 (31-08-2018)

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Name and mailing address of the ISA/CA
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INTERNATIONAL SEARCH REPORT

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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A	US2009206595A1, (LUPKE et al.) 20 August 2009 (20-08-2009) *Par [0049]*	1-6
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Information on patent family members

International application No.
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