(12) STANDARD PATENT (11) Application No. **AU 2007304875 B2**
(19) AUSTRALIAN PATENT OFFICE

(54) Title
Composite reinforced strip windable to form a helical pipe and method therefor

(51) International Patent Classification(s)
F16L 9/16 (2006.01) ***F16L 9/133*** (2006.01)
B29C 53/78 (2006.01) ***F16L 57/00*** (2006.01)
F16L 9/128 (2006.01)

(21) Application No: **2007304875** (22) Date of Filing: **2007.10.03**

(87) WIPO No: **WO08/040052**

(30) Priority Data

(31) Number	(32) Date	(33) Country
2006905464	**2006.10.04**	**AU**

(43) Publication Date: **2008.04.10**
(44) Accepted Journal Date: **2013.01.31**

(71) Applicant(s)
SEKISUI Rib Loc Australia Pty Ltd

(72) Inventor(s)
Harvey, Steven David Gerald;Melville, Shaun Thomas;Taylor, John Gerard

(74) Agent / Attorney
Madderns Patent & Trade Mark Attorneys, GPO Box 2752, ADELAIDE, SA, 5001

(56) Related Art
WO 1995/002779
US 4928735
JP 2004069036

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
10 April 2008 (10.04.2008)

PCT

(10) International Publication Number
WO 2008/040052 A1

(51) International Patent Classification:
F16L 9/16 (2006.01) *F16L 9/133* (2006.01)
B29C 53/78 (2006.01) *F16L 57/00* (2006.01)
F16L 9/128 (2006.01)

(21) International Application Number:
PCT/AU2007/001463

(22) International Filing Date: 3 October 2007 (03.10.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2006905464 4 October 2006 (04.10.2006) AU

(71) Applicant *(for all designated States except US)*: **RIB LOC AUSTRALIA PTY LIMITED** [AU/AU]; 587 Grand Junction Road, Gepps Cross, S.A. 5094 (AU).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **MELVILLE, Shaun, Thomas** [AU/AU]; 10 Denison Court, Hewett, S.A. 5118 (AU). **TAYLOR, John, Gerard** [AU/AU]; 11 Avenue Road, Prospect, S.A. 5082 (AU). **HARVEY, Steven, David, Gerald** [AU/AU]; 7 Reids Road, Highbury, S.A. 5089 (AU).

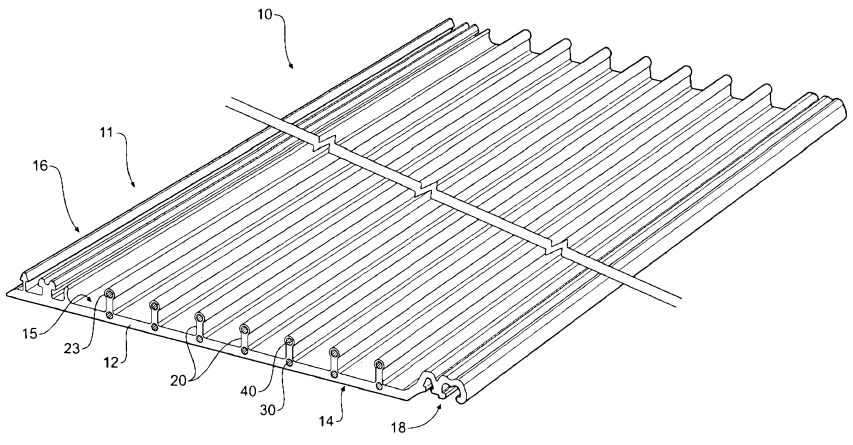
(74) Agent: **MADDERNS PATENT & TRADE MARK ATTORNEYS**; Level 1, 64 Hindmarsh Square, Adelaide, S.A. 5000 (AU).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

(54) **Title:** COMPOSITE REINFORCED STRIP WINDABLE TO FORM A HELICAL PIPE AND METHOD THEREFOR



(57) **Abstract:** A composite strip (10) windable to form a helical pipe for transporting fluid is disclosed. The composite strip comprises: an elongate plastic strip (11) having a base portion (12), the base portion (12) having an upper side defining an outer face (15); and at least one lengthwise extending composite rib portion (20) upstanding from the outer face (15) of the base portion (12). The rib portion (20) has a distal end (23) remote from the base portion (12). The composite rib portion comprises: an elongate inboard reinforcing member (30) disposed within or adjacent to the base portion (12); an elongate outboard reinforcing (40) member disposed within the distal end (20) of the rib portion (20) parallel to the inboard reinforcing member (30); and an elongate intermediate plastic web (23) portion extending between the inboard and outboard reinforcing members (30, 40). When wound into a helical pipe, the composite rib portion (20) reinforces the pipe against radial crushing loads.

WO 2008/040052 A1

COMPOSITE REINFORCED STRIP WINDABLE TO FORM A HELICAL PIPE AND METHOD THEREFOR

FIELD OF THE INVENTION

This invention relates to improvements to reinforced ribbed structures, and in particular to reinforced or strengthened helically wound pipes, tubes or conduits made from a composite of materials.

BACKGROUND

The following discussion providing some background to the invention is intended to facilitate a better understanding of the invention. However, it should be appreciated that the discussion is not an acknowledgment or admission that any of the material referred to was published, known or part of the common general knowledge as at the priority date of the application.

It is known that plastic pipes can be made by helically winding a plastic strip having a series of spaced apart upstanding ribs extending longitudinally of the strip, either at room temperature or at an elevated temperature where the plastic becomes more flexible. This form of helically wound tube is already known in the piping industry and is described in Patents by the applicant relating both to the form of the plastic strip, the form of the tube and the form of the machine by means of which the pipes or tubes are produced from such strips.

For these pipes to perform in a high performance applications, in order to attain the necessary degree of strength, the wall thickness of the plastic strip must be quite substantial, as well as that of the ribs. Alternatively the finished pipes or tubes can be reinforced with strengthening or reinforcing members.

In applications where the reinforced tubes or pipes are buried in a trench or subjected to high earth loads, the strength of the pipe or tube is of extreme importance.

The applicant's Australian Patent No. AU607431 discloses a method of producing a reinforced plastic tube utilising a reinforcing member placed between the ribs in such a manner that the deflection resistance of the finished pipe or tube is materially increased. The reinforcing member comprises a metal member having a profile of U-shape cross-section, the free ends of the reinforcing member being designed to engage beneath opposed flange formations of a pair of adjacent ribs to thereby lock the metal strip in position between the ribs and in turn stiffen the ribs and the finished pipe.

The applicant's Australian Patent No. AU661047 discloses an improvement over the disclosure of Australian Patent No. AU607431 referred to above. The improvement is provided by the provision of a reinforcing member having a central body portion of inverted U or V-shaped cross-section that has a radial height greater than the height of the ribs whereby the effective external diameter of the composite pipe is substantially increased. This provides a stiffer pipe.

The applicant's Australian Patent No. AU2003227090 discloses a further improvement over the disclosure of Australian Patent No. AU661047 referred to above. The improvement is provided by the provision of a reinforcing member having height to thickness ratio of at least 3:1 and orientated substantially perpendicular to the base of the strip. The inner face of the strip forms a continuous surface below the reinforcing strip. The provision of the aforementioned reinforcing strip reinforces the pipe against radial crushing loads in a more efficient way than prior art reinforcement, while the inner face provides a smooth internal pipe surface and separates the reinforcing strip from the fluid within the pipe.

Prior to commercialisation of applicant's Australian Patent No. AU2003227090, helically wound composite pipes were formed in a multi-stage operation. The plastic body was extruded and then was helically wound to form a pipe. Elongate steel reinforcing members were separately roll-formed into a profile providing the required stiffness (such as the inverted U or V-shaped profiles referred to above). The roll formed steel profile was then rolled to a radius approximating

that of the helically wound plastics body. Finally, the profiled and radiused reinforcing member or members were wound on to the outside of the plastics pipe to form a composite pipe of the requisite stiffness.

When using the reinforcing members disclosed in Australian Patent Nos AU607431 and AU661047, the step of rolling the steel reinforcing member to a radius of approximating that of the plastics pipe involved straining the steel reinforcing member beyond its elastic limit. This required the application of considerable force during the rolling process. In contrast, winding of the extruded plastics profile into a helical pipe generally requires much less force due to the material properties of the plastics. Using the composite profile of the applicant's Australian Patent No. AU2003227090 it became possible to wind a preformed steel and plastic composite strip directly into a pipe from a spool of composite profile.

An object of the present invention is to provide certain improvements, beyond those disclosed in the aforesaid Patent Specifications AU607431, AU661047 and AU2003227090, to strips windable into reinforced helically wound plastics tube or pipe and to pipes wound from such strips.

SUMMARY OF THE INVENTION

According to a first aspect of the invention there is provided a composite strip windable to form a helical pipe for transporting fluid, the composite strip comprising:

an elongate plastic strip having a base portion, the base portion having a lower side defining an inner face and an upper side defining an outer face;

at least one lengthwise extending rib portion upstanding from the outer face of the base portion, the rib portion having a distal end remote from the base portion;

an elongate inboard reinforcing member disposed within or adjacent to the base portion;

an elongate outboard reinforcing member disposed within the distal end of the rib portion parallel to the inboard reinforcing member; and

an elongate intermediate plastic web portion extending between the inboard

and outboard reinforcing members, the web portion together with the inboard and outboard reinforcing members forming a composite rib portion,

wherein, when wound into a helical pipe, the composite rib portion reinforces the pipe against radial crushing loads.

Preferably the outboard reinforcing member is constructed from a material having a higher Young's Modulus than that of the plastic strip and wherein the inboard reinforcing member is constructed from a material having a higher Young's Modulus than that of the plastic strip.

Preferably the inboard and outboard reinforcing members are completed encapsulated.

Preferably the reinforcing members are stranded or non-stranded filaments.

Preferably the reinforcing members are wire.

Preferably the composite strip includes a plurality of lengthwise extending composite rib portions upstanding from the outer face of the base portion.

Preferably the composite strip includes connecting formations on opposite edges thereof, the connecting formations adapted to interlock when the strip is wound in a helical path and adjacent edge portions of the strip overlap one another.

Preferably for each composite rib portion, a distance measured from the inner face of the strip upwards to a distal end of the composite rib portion is no greater than a distance measured from the inner face of the strip upwards to an apex of the connecting formations.

Preferably the strip has first and second elongate outboard reinforcing members disposed within the distal end of the rib portion positioned laterally offset

to first and second sides respectively of a plane bisecting the rib portion perpendicularly to the base.

According to a second aspect of the invention there is provided a composite strip windable to form a helical pipe for transporting fluid, the composite strip comprising:

an elongate plastic strip having a base portion, the base portion having a lower side defining an inner face and an upper side defining an outer face;

at least one lengthwise extending rib portion upstanding from the outer face of the base portion, the rib portion having a distal end remote from the base portion;

an elongate inboard reinforcing member disposed within or adjacent to the base portion;

first and second elongate outboard reinforcing members disposed within the distal end of the rib portion parallel to the inboard reinforcing member and positioned laterally offset to first and second sides respectively of a plane bisecting the rib portion perpendicularly to the base; and

an elongate intermediate plastic web portion extending between the inboard and outboard reinforcing members, the web portion together with the inboard and outboard reinforcing members forming a composite rib portion,

wherein, when wound into a helical pipe, the composite rib portion reinforces the pipe against radial crushing loads.

Preferably the outboard reinforcing member is constructed from a material having a higher Young's Modulus than that of the plastic strip and wherein the inboard reinforcing member is constructed from a material having a higher Young's Modulus than that of the plastic strip.

Preferably the inboard and outboard reinforcing members are completed encapsulated.

Preferably the reinforcing members are stranded or non-stranded filaments.

Preferably the reinforcing members are wire.

Preferably the composite strip includes a plurality of lengthwise extending composite rib portions upstanding from the outer face of the base portion.

Preferably the composite strip includes connecting formations on opposite edges thereof, the connecting formations adapted to interlock when the strip is wound in a helical path and adjacent edge portions of the strip overlap one another.

Preferably for each composite rib portion, a distance measured from the inner face of the strip upwards to a distal end of the composite rib portion is no greater than a distance measured from the inner face of the strip upwards to an apex of the connecting formations.

According to a third aspect of the invention there is provided a pipe comprising a helically wound composite strip, the composite strip comprising:

an elongate plastic strip having a base portion, the base portion having a lower side defining an inner face and an upper side defining an outer face;

at least one lengthwise extending rib portion upstanding from the outer face of the base portion, the rib portion having a distal end remote from the base portion;

an elongate inboard reinforcing member disposed within or adjacent to the base portion;

an elongate outboard reinforcing member disposed within the distal end of the rib portion parallel to the inboard reinforcing member; and

an elongate intermediate plastic web portion extending between the inboard and outboard reinforcing members, the web portion together with the inboard and outboard reinforcing members forming a composite rib portion,

wherein the composite rib portion reinforces the pipe against radial crushing loads.

Preferably the composite strip has first and second elongate outboard reinforcing members disposed within the distal end of the rib portion positioned

laterally offset to first and second sides respectively of a plane bisecting the rib portion perpendicularly to the base.

According to a fourth aspect of the invention there is provided a method of producing a pipe comprising the steps of:

a) extruding an elongate plastics strip, the strip having a base portion, the base portion having a lower side defining an inner face and an upper side defining an outer face, and at least one lengthwise extending rib portion upstanding from the outer face of the base portion;

b) introducing a lower reinforcing member into the base portion of the strip in a position adjacent to the at least one rib portion so as to form a sub-assembled composite strip;

c) winding the sub-assembled composite strip into a spool of strip or into a helically wound pipe;

d) introducing an upper reinforcing member into a top portion of the at least one rib portion so as to form an assembled composite strip,

whereby the step of introducing a lower reinforcing member occurs during or after the extruding step but before the winding step and whereby the step of introducing the upper reinforcing member occurs during or after the winding step.

Preferably the extruding and the introducing step b) occur together in a cross-head extrusion die.

Preferably the winding step c) comprises winding the sub-assembled composite strip into a pipe.

Preferably the introducing step d) includes tensioning the outer reinforcing member such that the pipe is prestressed.

Preferably the method further comprises the step of sealing the upper reinforcing member within the top portion of the at least one rib.

According to a fifth aspect of the invention there is provided a method of producing a pipe comprising the steps of:

a) extruding an elongate plastics strip, the strip having a base portion, the base portion having a lower side defining an inner face and an upper side defining an outer face, and at least one lengthwise extending rib portion upstanding from the outer face of the base portion, the rib portion having a distal end remote from the base portion;

b) introducing a lower reinforcing member into the base portion of the strip in a position adjacent to the at least one rib portion so as to form a sub-assembled composite strip;

c) bending the composite strip about an axis transverse to the base;

d) introducing an upper reinforcing member into the distal end of the at least one rib portion so as to form an assembled composite strip,

whereby the step of introducing a lower reinforcing member occurs during or after the extruding step but before the bending step and whereby the step of introducing the upper reinforcing member occurs during or after the bending step.

According to a sixth aspect of the invention there is provided a method of producing a pipe comprising the steps of:

a) extruding an elongate plastics strip, the strip having a base portion, the base portion having a lower side defining an inner face and an upper side defining an outer face, and at least one lengthwise extending rib portion upstanding from the outer face of the base portion, the rib portion having a distal end remote from the base portion;

b) introducing a first reinforcing member into either of: the base portion of the strip in a position adjacent to the at least one rib portion, or the distal end of the at least one rib portion so, as to form a sub-assembled composite strip;

c) bending the composite strip about an axis transverse to the base;

d) introducing a second reinforcing member into the other of: the base portion of the strip in a position adjacent to the at least one rib portion, or the distal end of the at least one rib portion so as to form an assembled composite strip,

whereby the step of introducing a first reinforcing member occurs during or

after the extruding step and whereby the step of introducing the second reinforcing member occurs during or after the bending step.

Specific embodiments of the invention will now be described in some further detail with reference to and as illustrated in the accompanying figures. These embodiments are illustrative, and are not meant to be restrictive of the scope of the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

Embodiments of the invention are illustrated in the accompanying representations in which:

Figure 1a shows a cross-sectional view of a composite strip according to an embodiment of the invention.

Figure 1b is a similar view to that of Figure 1a but shows alternative edge arrangements for joining adjacent convolutions of the strip.

Figure 2 shows an alternative embodiment of the invention.

Figures 3a and 3b are isometric views of the profiles of Figures 1 and 1b respectively.

Figure 4 is an isometric view of a pipe wound from the profile of Figure 1b.

Figure 5 is a cross-sectional view of a composite strip according to a further alternative embodiment of the invention, of the strip having a base reinforcing the portion.

Figure 6 is similar view to that of Figure 5 but shows adjacent profiles interlocking.

Figure 7a shows a cross-sectional view of a composite strip according to a further embodiment of the invention. Included within Figure 7a is an enlarged view of the composite rib portion of the composite strip.

Figure 7b is an enlarged view similar to the enlarged view of Figure 7a but shows an alternative composite rib portion 20.

Figures 7c, 7d, 7e, 7f, 7g and 7h show further alternative composite rib portions.

Figure 8a is a diagrammatic isometric view showing a composite strip being wound into a pipe in accordance with the further aspect of the invention.

Figure 8b shows a cross-sectional view of a composite strip according to a further embodiment of the invention, that composite strip being the same strip illustrated in Figure 7a.

Figure 9 is a cross-sectional view showing two convolutions of a composite strip according to a further embodiment of the invention.

Figures 10a, 10b, 10c and 10d are enlarged views similar to the enlarged view of Figure 7a, but show further alternative composite rib portions 20.

Referring to Figure 1a, an elongate composite strip 10 that is windable to form a helical pipe is shown. The composite strip 10 comprises an elongate plastic strip 11 and a pair of parallel spaced apart reinforcing members 30 and 40 separated by an intermediate plastic web portion 23. The plastic used for this embodiment of the invention is polyvinyl chloride (PVC) although other suitable plastics may be used including polyethylene.

The plastic strip 11 has a base portion 12 with a substantially flat inner face 14. A plurality of length-wise extending composite rib portions 20 project upward from the base portion 12. Each rib portion 20 has a distal end 26 remote from the base portion. In this embodiment, each composite rib portion 20 comprises an inboard reinforcing member 30 disposed within the base portion 12; an outboard reinforcing 40 member disposed within the distal end of the rib portion parallel to the inboard reinforcing member 30; and an intermediate plastic web portion 23 extending between the inboard and outboard reinforcing members 30 and 40.

The intermediate plastic web portion 23 holds the inboard and outboard reinforcing members 30 and 40 apart. This is particularly important in bending as it produces a much more effective stiffener than otherwise would be provided. For instance when the profile is wound into a helical pipe, the separation of the inboard and outboard reinforcing members 30 and 40 greatly strengthens the pipe against

radial crushing loads as compared to a similar pipe with similar reinforcing members that are not spaced apart in a radial direction.

The reinforcing members 30 and 40 shown in Figures 1a and Figure 1b has a substantially circular cross-section. These reinforcing members may be solid wire or stranded wire for instance.

An alternative embodiment of the invention is shown in Figure 2. With this embodiment, the reinforcing members 30 and 40 have a substantially rectangular cross-sectional shape. The reinforcing members 30 and 40 of Figure 2 could be strips of steel or aluminum. The resulting composite rib portions 20 have the appearance and function similar to "I" beams. These composite ribs offer significant efficiency advantages over the composite ribs disclosed by the applicants earlier Australia Patent Application No. AU2003227090 referred to above.

The composite rib portions 20 illustrated in Figures 1a, 1b and 2 are more efficient than the composite ribs of the aforementioned earlier application. Furthermore, equivalent stiffness can be provided with an overall rib height as indicated by the double headed arrow RH in Figure 2 significantly less than would otherwise be required. This has a number of advantages. For instance, in the application of pipe rehabilitation where a pipe may be wound within a host pipe, the resultant internal diameter of the newly wound pipe may be greater using the composite strip of Figures 1a, 1b or 2 as compared to the composite strip of the aforementioned application.

The outboard reinforcing members of both Figures 1a and 1b lie directly over their corresponding inboard reinforcing members in a lateral direction. In another embodiment of the invention (for instance as shown in Figure 9) the inboard and/or outboard reinforcing members may comprise multiple members and the centre of the outboard multiple reinforcing members (for instance) may lie directly over its corresponding inboard reinforcing member(s) in a lateral direction. The purpose of centring over the inboard reinforcing member(s) in a lateral direction is to provide a

balanced load and to reduce the tendency of the composite rib portions to collapse sideways under a radial crushing load.

In some applications it may be advantageous to match the rib height RH as indicated in Figure 2 to the height of the edge joining features as indicated by the double headed arrow labeled JH in Figure 2.

With the profile shown in Figure 1a, both the inboard and outboard reinforcing members 30 and 40 are completely encapsulated by plastic. This is particularly advantageous where the reinforcing members 30 and 40 are made from materials subject to corrosion (for instance steel).

Referring to Figure 1b, a composite strip 10 similar to that shown in Figure 1a is shown. The difference between the strips 10 of Figure 1a and Figure 1b are in the area of the edges 16 and 18. The edge details of Figure 1a provide a mechanical interlock between adjacent convolutions of the wound strip. In contrast, the edges of the profile in Figure 1b provide for a welded or fused joint between adjacent convolutions of the strip.

Fusing of the edges of the profile shown in Figure 1a can be achieved by solvent jointing as is commonly used in joining PVC pipes. Other joining means including welding and gluing may be suitable for PVC, polyethylene and other materials.

Various materials can be used for the inboard and outboard reinforcing members. Examples of materials that could be used for either the inboard or outboard reinforcing members include steel, stainless steel, aluminium, other metals, natural fibres, kevlar, synthetic fibres and high-strength plastics. For example, as shown in Figure 7f, a high-strength polymer can be welded directly on to the top of the rib.

In some applications it may be advantageous to precoat the reinforcing members. For instance, wire may be coated with PVC to help with bonding to the ribs of the composite strip. Wire in some applications will be coated to prevent corrosion for instance by galvanising. Polyethylene coated nylon cores that could be welded without damaging the internal fibres may also be suitable in some applications as reinforcing members.

In some applications it may be advantageous to serrate the surface of the reinforcing members to assist with the mechanical interlocking between the members and the surrounding plastic strip.

The reinforcing members may be twisted, braided, stranded, plaited or pre-processed by other means to give beneficial elongation or other properties.

The reinforcing members may be preheated to improve the bond strength between the members and the surrounding strip. Preheating the steel reduces the rapid cooling of the extruded plastic and reduces the brittleness of the material at that point.

The outboard reinforcing member in some applications may be different from the inboard reinforcing member. For instance, under some loading conditions it is only necessary for the outboard reinforcing member to be strong in tension (or have a high Young's modulus in tension) and it is only necessary for the inboard reinforcing member to be strong in compression (or have a high Young's modulus in compression). Natural fibres are strong in tension but are poor in compression and therefore may be suitable for the outer reinforcing member or members but not for the inner reinforcing member or members. Also, in some applications, the outboard reinforcing member may be more susceptible to degradation from corrosion, and in such circumstances this member could be a corrosion resistant material such as aluminium.

In many underground applications, the reinforcing members may alternate between tension and compression within each convolution of composite strip forming the helically wound pipe.

In the embodiments of the invention shown in Figures 1a and 1b, an array of seven lengthwise extending rib portions 20 spaced apart across the width of the strip are provided. In other embodiments in the invention more or less rib portions 20 may be provided.

Referring to Figure 4, a helically wound composite pipe 70 produced by helically winding the composite strip shown in Figures 1b, 2 and 3 is shown. Comparing Figures 1b and 4, it is apparent that the orientation of the reinforcing members 30 and 40 with respect to the flat side 14 of the base portion 12 remains substantially unchanged after the winding of the strip to form the pipe 70. The intermediate plastic web portions 23 provide support for the reinforcing strips 20 and 30 during the winding of the strip 10. During winding of the strip 10 to form a helical pipe, the reinforcing members 30 and 40 are bent about an axis substantially transverse to the strip 10.

The strip profiles shown in Figures 1a, 1b, 2a and 2b keep the mass of the profile to a minimum while at the same time maintaining the performance criteria required for a broad range of applications to ensure material costs are minimised.

Figure 7a shows a further embodiment of the invention similar to that shown in Figure 1a. With this embodiment of the invention, the ribs 20 are a less complex shape having simple parallel walls and the inboard and outboard reinforcing members have a smaller diameter. It should be appreciated that many other variations are possible and that the web portion 23 may have different shapes and thicknesses depending on specific design parameters that are required to be achieved. The profile or composite strip shown in Figure 7a can be produced by a crosshead extrusion process.

Referring now to Figures 7b, 7c and 7d, the enlarged views are shown of variants of the rib area 20. For instance, in Figure 7b an upwardly opening mouth is formed between projections 29a and 29b extending from the distal end 26 of the rib portion. The projections 29a and 29b are able to flex apart to allow installation of a wire outboard reinforcing member 40 into the position shown in Figure 7b. Bead 28 can then be formed to close the mouth between projections 29a and 29b either through a welding process, a solvent fusing process or a gluing process for instance.

In Figure 7d, the open mouth opens laterally. Again, the open mouth can be sealed either by gluing, fusing or welding.

Figure 7e shows a further variant of the rib portion 20 in which the inboard reinforcing member 30 is installed subsequent to extrusion of the base 12.

In Figures 7g and 7h, further variants are shown where the inboard reinforcing members 30 are installed subsequent to extrusion of the plastic strip 11 and where the reinforcing member 30 is installed from the underside or inside of the plastic strip 11.

Figure 7f shows a further variant of the composite rib portion 20 where the outboard reinforcing member 40 is high strength polymer that is welded, glued or co-extruded onto the distal end 26 of the composite rib portion 20.

The dimensions and shapes of the plastic strip 12, the reinforcing elements 30 and 40, and the intermediate plastic rib portions 23 can be varied to suit the diameter of the pipe to be wound. For example, a composite strip of the type shown in Figure 7a may have reinforcing members 30 and 40 made from wire 1.25 mm in diameter. In some applications wire diameters of 0.8mm or less may be appropriate or for composite strips for use in large diameter pipes, much thicker wires, perhaps of several millimetres in diameter may be used. Various grades of wire can be made. Rib heights can vary and may typically be between 5mm and 40mm (although in some applications smaller or larger rib heights will be appropriate).

Now referring to Figure 9, a further embodiment of the invention is illustrated. In this embodiment, first and second elongate outboard reinforcing members 42 and 44 are positioned laterally offset to first and second sides respectively of a plane p-p bisecting the rib portion 20 perpendicular to the base 12. With this arrangement, the composite rib portion 20 is stabilised. Should the composite rib portion 20 bend laterally to one side, then the tension in the reinforcing member on the opposite side will tend to straighten the composite rib portion 20 as the composite strip 10 is wound into a pipe or curved about an axis lateral to and below the base portion 12.

Referring now to Figures 10a, 10b, 10c and 10d, enlarged views are shown of further variants of the composite rib area 20. With these further variants, a reinforcing strip 100 is included in the composite strip portion 23. The reinforcing strip 100 is of the type described in the applicant's earlier above-referenced patent application AU2003227090. In some applications, it may be preferable to wind a helical pipe having just the reinforcing strip 100, as described in the aforementioned patent application AU2003227090, and then subsequently adding inboard and outboard reinforcing members 30 and 40 as illustrated in any one of Figures 10a, 10b, 10c and 10d.

As should be apparent from the above description, the composite rib portion 20 can be formed in many ways so as to create a composite strip having a composite rib portion where an inboard reinforcing member is disposed within or adjacent to the base portion and an outboard reinforcing member is disposed within the distal end of the rib portion with an intermediate plastic web portion extending between the inboard and outboard reinforcing members. Optionally, a further reinforcing member in the form of a strip 100 may also be included within or adjacent to the plastic web portion of the composite rib portion 23.

Methods of installing or joining the reinforcing members to the plastic strip 11 include but are not limited to: crosshead extrusion, welding using resistance heating,

welding using a laser, solvent fusing, gluing and/or mechanical attachment (for example clipping). The plastic strip can be extruded from PVC, or polyethylene (including high density polyethylene for instance). Where PVC is used, solvent fusing may be preferable to welding in many applications.

The addition of the reinforcing members 30 and 40 to the plastic strip 12 can also assist in improving the pressure rating of the pipe. The composite strips described above can further incorporate other elements to improve the pressure rating of the wound pipe. For instance, lamina of fibre fabric (eg glass fibre), plastic or steel may be provided to improve the pressure rating of the pipe. Any material having a Young's modulus and strength that exceeds that of the plastics material of the strip can be used. The lamina may be incorporated into the profile (strip 12) in any suitable way. For instance, the lamina may be welded to the base of the strip 12 or may be cross-head extruded into the base of the strip 12 to provide a strip 10 as shown in Figures 5 and 6.

Improved interlocking edge features may also be provided to enhance the pressure rating of the pipe. Examples of profiles constructed for high-pressure applications are shown in Figures 5 and 6. A mechanical lock is provided by a male edge member 16 and a female edge member 18 formed from the plastic strip 11. This profile is cross head extruded encapsulating the reinforcing members 30 and 40 as the composite strip 10 is produced obviating the need to add a sealing bead as previously described. A lamina 50 is incorporated into the base portion of the strip 11. The lamina 50 has a higher Young's modulus and strength than the PVC plastic strip 11. When wound into a helical pipe, this profile can provide a high pressure pipe suitable for conveying fluids under pressure. Although adjacent convolutions are not directly bonded bound together, the thickness of the plastic and design of the mechanical lock formed by adjacent edges 16 and 18 ensures that the pipe is able to withstand significant internal pressures.

Other embodiments of the invention may be provided with the lamina either bonded to the base of the strip 12 or embedded within the base of the strip 12.

Materials having directional properties may be used as or within the lamina. For instance, orientated plastic film strips that are strong in a longitudinal direction and weak in a transverse direction may be used. Such strips may improve the "hoop" strength of the wound pipe.

Plastic film strips that are strong in a transverse direction and weak in a longitudinal direction may also be used.

In some applications it will be desirable to form a lamina from two (or more) plastic film strips that are strong in mutually orthogonal directions thereby resulting in a composite of high strength in all directions.

Examples of suitable materials having directional properties include highly stretched polyolefin sheet. Such sheets have a high proportion of molecules orientated in the same direction which provides a high Young's modulus and yield strength.

The applicant's Australia Patent No. AU2003227090 titled "Composite Strip Windable To Form A Helical Pipe And Method Therefor" discloses other composite strip and composite pipe features together with methods of producing pipe. These features and methods could be used with the present invention and the disclosure of AU2003227090 is herewith incorporated in its entirety into this specification.

More generally, various percentages of short fibres with a high e modulus-(for instance glass fibres) can be dispersed through out the entire profile to provide improved performance. The incorporation of such fibres may improve the tensile strength of the composite strip and may improve the pressure rating of a pipe wound from such strips.

The various composite strips described and illustrated above can be manufactured in a variety of ways. In particular, the reinforcing members can be

added during the extrusion process (crosshead extrusion), after the extrusion process but before winding the composite strip on to a spool, during the spooling process, during the pipe winding process or after the pipe winding process.

Depending on the application, the pipe winding process can be underground within a pipe to be rehabilitated, aboveground on a construction site or in a pipe production factory.

As should be clear from Figure 7a to 7f, the inboard and outboard reinforcing members can be added at various points separately or together in the manufacturing processes up to and including post installation. For example, the inboard reinforcing member may be added at the extrusion stage via a crosshead extrusion process and the outboard reinforcing member may be added during or after the process of winding the composite strip 10 into a pipe 70.

Referring now to Figure 8a and 8b, a process whereby an outboard reinforcing member 40 in the form of a wire is added to the composite strip 10 during the pipe winding process is illustrated schematically. A pair of wire spools 50 are provided to feed wires 40 into grooves or slots 27 formed at the top of the rib portions 20.

In some applications it may be advantageous to add the wire at the spooling stage. For instance, with some rehabilitation projects, the addition of the wire on site might be too difficult.

Adding the wire at the spooler in some applications may be better than simply adding through cross head extrusion, as the strip is already bent, and therefore less stress is introduced into the strip which might ultimately either limit its use, or mean the size of the inner diameter of the spool needs to be increased thereby reducing the capacity of the spool (which then increases freight costs).

Optionally, a tensioner 60 may be provided so that the wire 40 is pre-tensioned. This results in a prestressed pipe 70 where the outer reinforcing members (wire) 40 are in tension and the inner reinforcing members are in compression.

Advantageously, the projections 29a and 29b are shaped with a lead-in as illustrated in Figure 8b. This lead-in, together with the flexibility of the projections 29a and 29b, allow the wires to snap into place when they are tensioned. Once firmly held in grooves 27, a bead may be added to seal the reinforcing member from the embodiment (may be desirable for steel wire for instance)

Adding the outboard reinforcing member after or even during the pipe winding process as described above and is illustrated in Figure 8a provides a number of significant advantages. Without either or both reinforcing member or members being in position at the point of winding the pipe, the forces are greatly reduced. This facilitates the winding process. Furthermore, with the process illustrated in Figure 8a and described above, very high composite strip enhanced pipe stiffness can be achieved because the pipe has already been formed and therefore it is not necessary to design the completed composite strip for windability.

Not adding either or both of the reinforcing members before spooling may allow an increase in the length of strip wound per spool as it is possible to commence spooling at a lower diameter.

In some applications, it can be advantageous to wind pipe directly after the production of the composite strip 10 without the intermediate step of spooling the composite strip. With the various embodiments of the invention described above, particularly those employing wire, whether stranded or unstranded, it is more cost efficient to run a continuous pipe making process. This is because very long lengths of wire are readily commercially available and so long lengths of pipes can be made in a continuous process without the need to employ labour to join the wire (reinforcing member). This continuous process can provide significant additional benefits including a reduction in inventory as compared to the process for winding a

pipe employing reinforcing members in strip form (such as that described in the Applicant's earlier Patent Application AU2003227090 refer to above).

Throughout the specification and the claims that follow, unless the context requires otherwise, the words "comprise" and "include" and variations such as "comprising" and "including" will be understood to imply the inclusion of a stated integer or group of integers, but not the exclusion of any other integer or group of integers.

While the present invention has been described in terms of preferred embodiments in order to facilitate better understanding of the invention, it should be appreciated that various modifications can be made without departing from the principles of the invention. Therefore, the invention should be understood to include all such modifications within its scope.

CLAIMS:

1. A composite strip windable to form a helical pipe for transporting fluid, the composite strip comprising:

an elongate plastic strip having a base portion, the base portion having a lower side defining an inner face and an upper side defining an outer face, the inner face having a substantially flat transverse cross-section;

at least one lengthwise extending rib portion upstanding from the outer face of the base portion, the rib portion having a distal end remote from the base portion;

an elongate inboard reinforcing member disposed within or adjacent to the base portion;

an elongate outboard reinforcing member disposed within the distal end of the rib portion parallel to the inboard reinforcing member; and

an elongate intermediate plastic web portion extending between the inboard and outboard reinforcing members, the web portion together with the inboard and outboard reinforcing members forming a composite rib portion,

wherein, when wound into a helical pipe, the composite rib portion reinforces the pipe against radial crushing loads.

2. A strip as claimed in claim 1 wherein the outboard reinforcing member is constructed from a material having a higher Young's Modulus than that of the plastic strip and wherein the inboard reinforcing member is constructed from a material having a higher Young's Modulus than that of the plastic strip.

3. A strip as claimed in claim 1 having first and second elongate outboard reinforcing members disposed within the distal end of the rib portion positioned laterally offset to first and second sides respectively of a plane bisecting the rib portion perpendicularly to the base.

4. A composite strip windable to form a helical pipe for transporting fluid, the composite strip comprising:

an elongate plastic strip having a base portion, the base portion having a lower side defining an inner face and an upper side defining an outer face;

at least one lengthwise extending rib portion upstanding from the outer face of the base portion, the rib portion having a distal end remote from the base portion;

an elongate inboard reinforcing member disposed within or adjacent to the base portion;

first and second elongate outboard reinforcing members disposed within the distal end

of the rib portion parallel to the inboard reinforcing member and positioned laterally offset to first and second sides respectively of a plane bisecting the rib portion perpendicularly to the base; and

an elongate intermediate plastic web portion extending between the inboard and outboard reinforcing members, the web portion together with the inboard and outboard reinforcing members forming a composite rib portion,

wherein, when wound into a helical pipe, the composite rib portion reinforces the pipe against radial crushing loads.

5. A strip as claimed in claim 4 wherein the outboard reinforcing member is constructed from a material having a higher Young's Modulus than that of the plastic strip and wherein the inboard reinforcing member is constructed from a material having a higher Young's Modulus than that of the plastic strip.

6. A strip as claimed in either one of claims 1 or 4 wherein the inboard and outboard reinforcing members are completed encapsulated.

7. A strip as claimed in either one of claims 1 or 4 wherein the reinforcing members are stranded or non-stranded filaments.

8. A strip as claimed in claim 7 wherein the reinforcing members are wire.

9. A strip as claimed in either one of claims 1 or 4 wherein the composite strip includes a plurality of lengthwise extending composite rib portions upstanding from the outer face of the base portion.

10. A strip as claimed in either one of claims 1 or 4 wherein the composite strip includes connecting formations on opposite edges thereof, the connecting formations adapted to interlock when the strip is wound in a helical path and adjacent edge portions of the strip overlap one another.

11. A strip as claimed in claim 10 wherein, for each composite rib portion, a distance measured from the inner face of the strip upwards to a distal end of the composite rib portion is no greater than a distance measured from the inner face of the strip upwards to an apex of the connecting formations.

12. A pipe comprising a helically wound composite strip, the composite strip comprising:

an elongate plastic strip having a base portion, the base portion having a lower side defining an inner face and an upper side defining an outer face, the inner face having a substantially flat transverse cross-section;

at least one lengthwise extending rib portion upstanding from the outer face of the base portion, the rib portion having a distal end remote from the base portion;

an elongate inboard reinforcing member disposed within or adjacent to the base portion;

an elongate outboard reinforcing member disposed within the distal end of the rib portion parallel to the inboard reinforcing member; and

an elongate intermediate plastic web portion extending between the inboard and outboard reinforcing members, the web portion together with the inboard and outboard reinforcing members forming a composite rib portion,

wherein the composite rib portion reinforces the pipe against radial crushing loads.

13. A pipe as claimed in claim 12 wherein the composite strip has first and second elongate outboard reinforcing members disposed within the distal end of the rib portion positioned laterally offset to first and second sides respectively of a plane bisecting the rib portion perpendicularly to the base.

14. A method of producing a pipe comprising the steps of:

a) extruding an elongate plastics strip, the strip having a base portion, the base portion having a lower side defining an inner face and an upper side defining an outer face, and at least one lengthwise extending rib portion upstanding from the outer face of the base portion;

b) introducing a lower reinforcing member into the base portion of the strip in a position adjacent to the at least one rib portion so as to form a sub-assembled composite strip;

c) winding the sub-assembled composite strip into a spool of strip or into a helically wound pipe;

d) introducing an upper reinforcing member into a top portion of the at least one rib portion so as to form an assembled composite strip,

whereby the step of introducing a lower reinforcing member occurs during or after the extruding step but before the winding step and whereby the step of introducing the upper reinforcing member occurs during or after the winding step.

15. A method as claimed in claim 14 wherein the extruding and the introducing step b) occur together in a cross-head extrusion die.

16. A method as claimed in claim 14 wherein the winding step c) comprises winding the sub-assembled composite strip into a pipe.

17. A method as claimed in the preceding claim wherein the introducing step d) includes tensioning the outer reinforcing member such that the pipe is prestressed.

18. A method as claimed in claim 14 further comprising the step of sealing the upper reinforcing member within the top portion of the at least one rib.

19. A method of producing a pipe comprising the steps of:

a) extruding an elongate plastics strip, the strip having a base portion, the base portion having a lower side defining an inner face and an upper side defining an outer face, and at least one lengthwise extending rib portion upstanding from the outer face of the base portion, the rib portion having a distal end remote from the base portion;

b) introducing a lower reinforcing member into the base portion of the strip in a position adjacent to the at least one rib portion so as to form a sub-assembled composite strip;

c) bending the composite strip about an axis transverse to the base;

d) introducing an upper reinforcing member into the distal end of the at least one rib portion so as to form an assembled composite strip,

whereby the step of introducing a lower reinforcing member occurs during or after the extruding step but before the bending step and whereby the step of introducing the upper reinforcing member occurs during or after the bending step.

20. A method of producing a pipe comprising the steps of:

a) extruding an elongate plastics strip, the strip having a base portion, the base portion having a lower side defining an inner face and an upper side defining an outer face, and at least one lengthwise extending rib portion upstanding from the outer face of the base portion, the rib portion having a distal end remote from the base portion;

b) introducing a first reinforcing member into either of: the base portion of the strip in a position adjacent to the at least one rib portion, or the distal end of the at least one rib portion so, as to form a sub-assembled composite strip;

c) bending the composite strip about an axis transverse to the base;

d) introducing a second reinforcing member into the other of: the base portion of the strip in a position adjacent to the at least one rib portion, or the distal end of the at least

one rib portion so as to form an assembled composite strip,

whereby the step of introducing a first reinforcing member occurs during or after the extruding step and whereby the step of introducing the second reinforcing member occurs during or after the bending step.

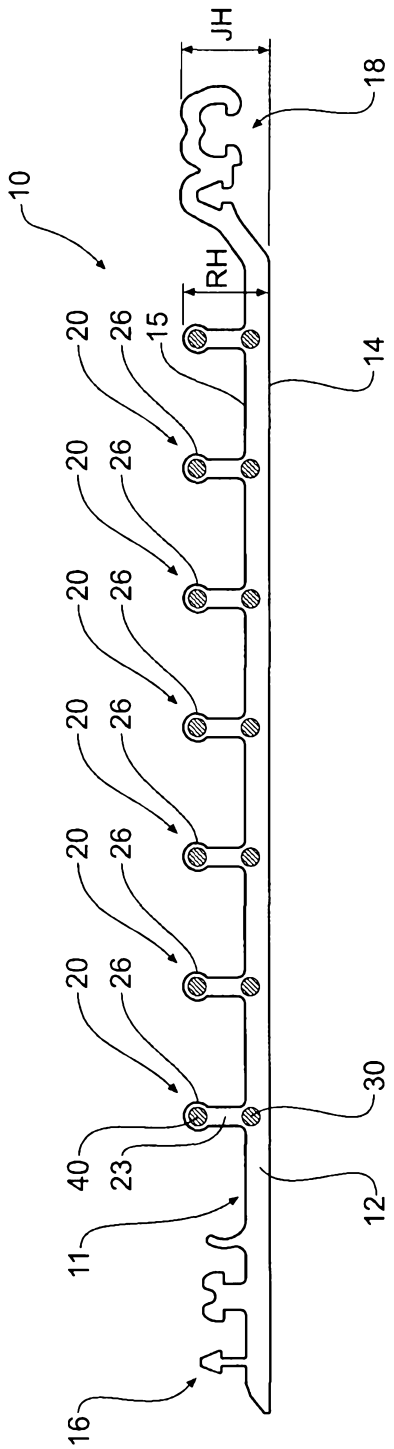

JH
18
10
RH
20
26
15
14
20
26
20
26
20
26
20
26
20
26
20
26
30
40
23
12
11
16

Fig 1a

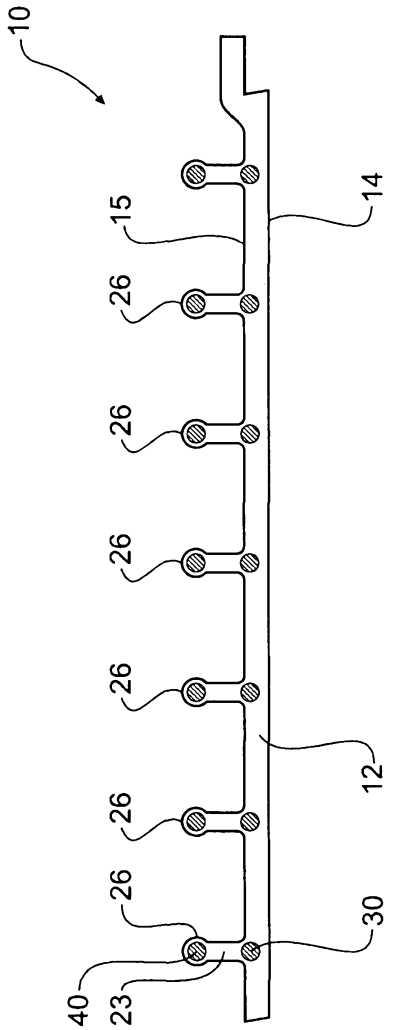

10
15
14
26
26
26
26
26
26
12
30
40
23

Fig 1b

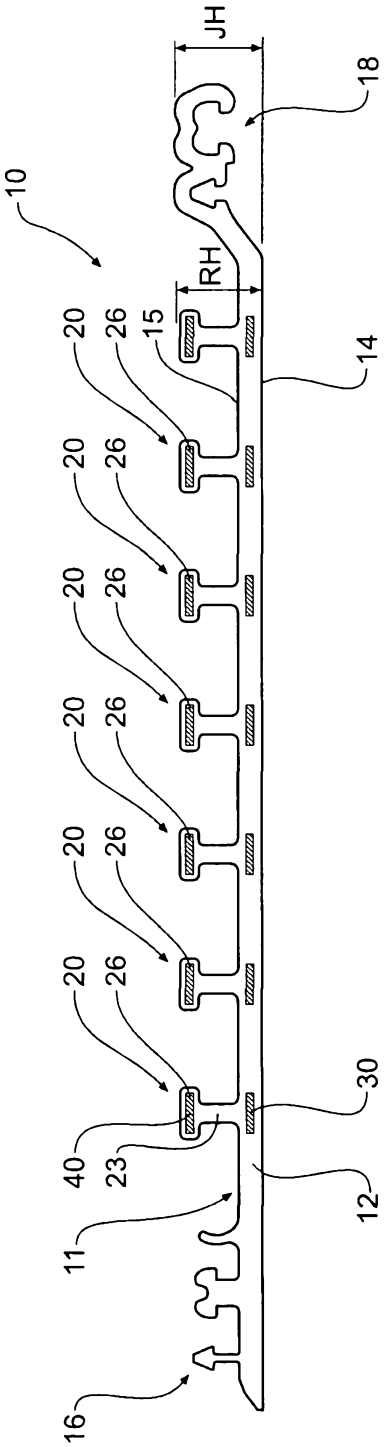


Fig 2

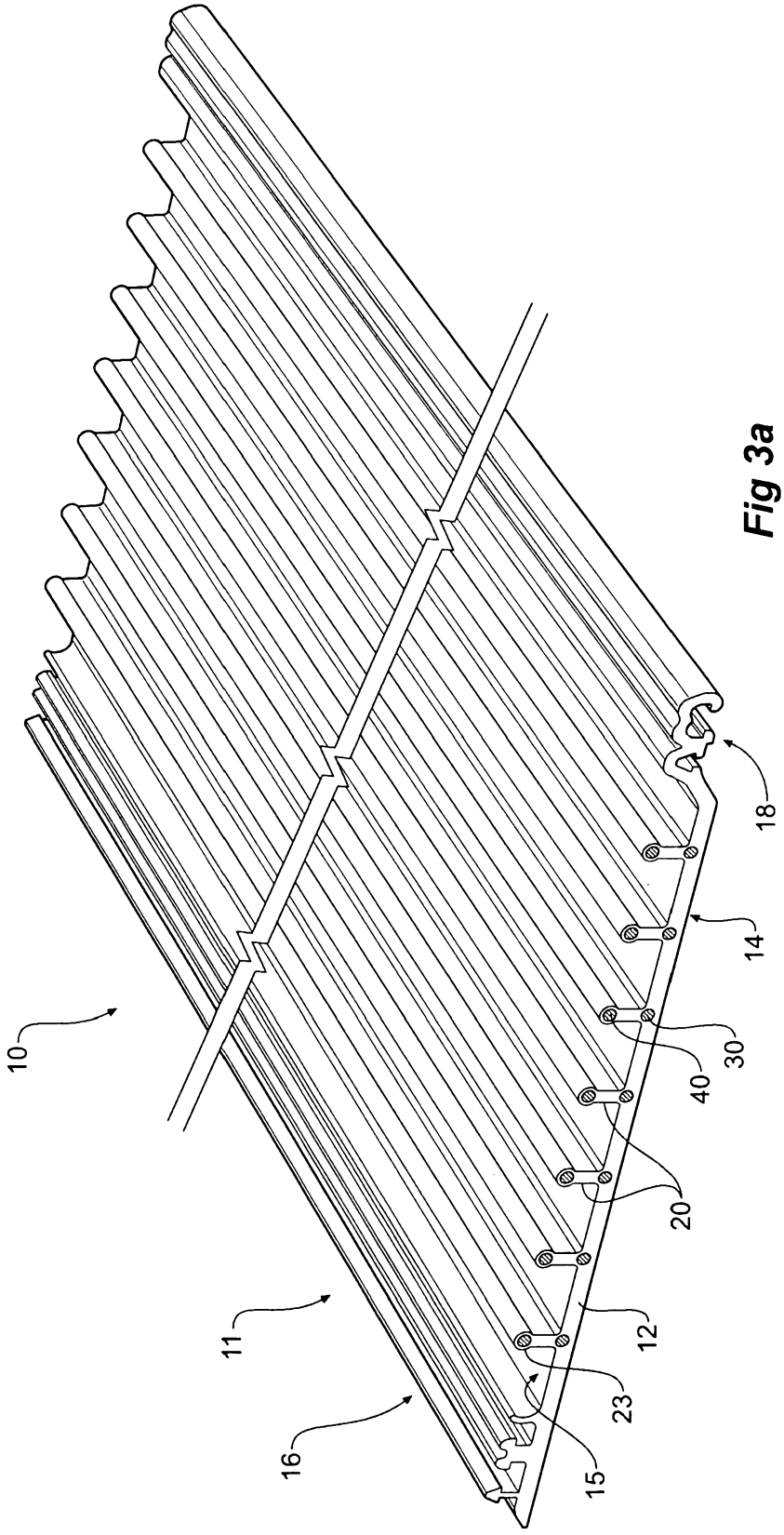


Fig 3a

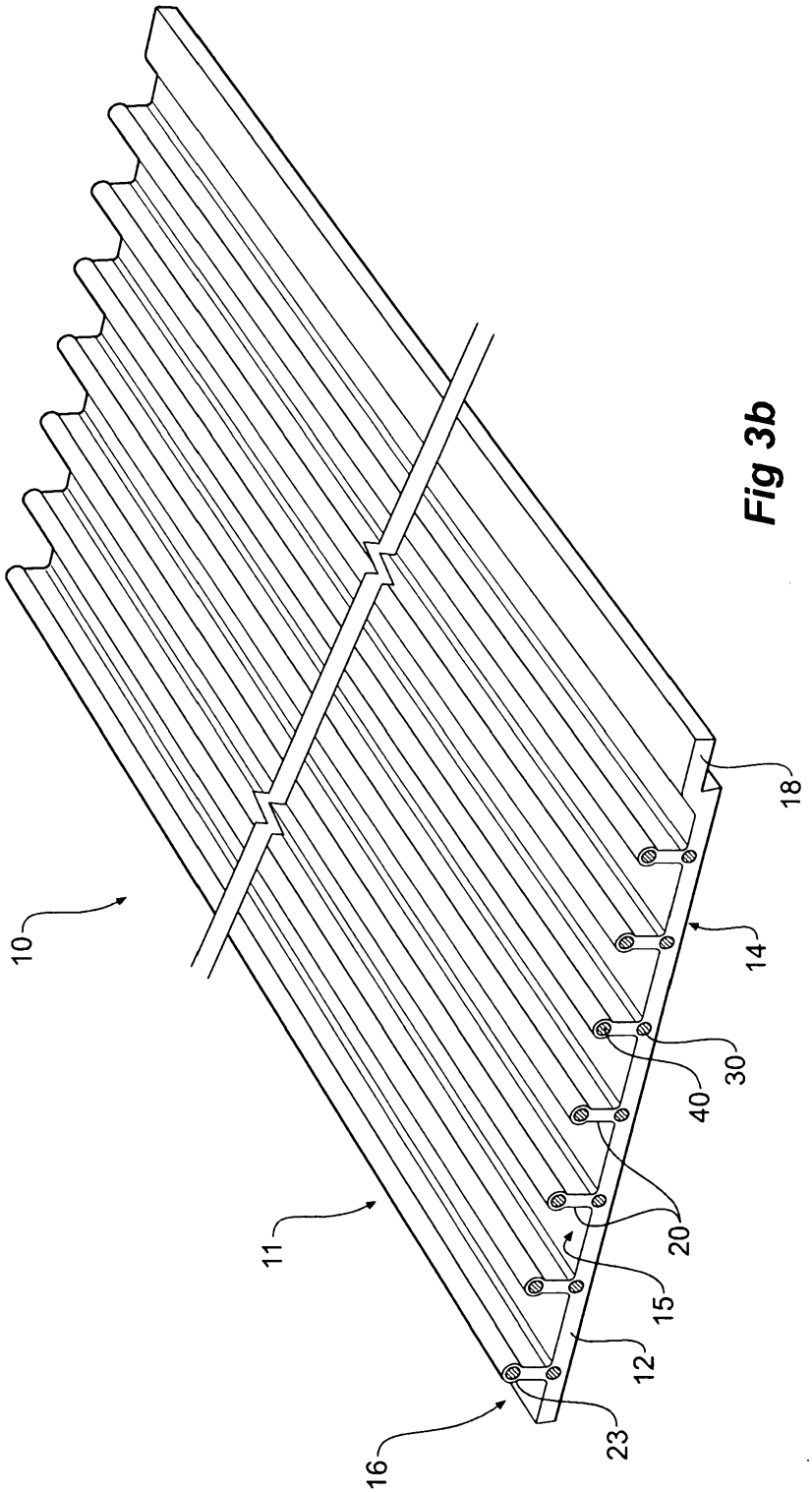


Fig 3b

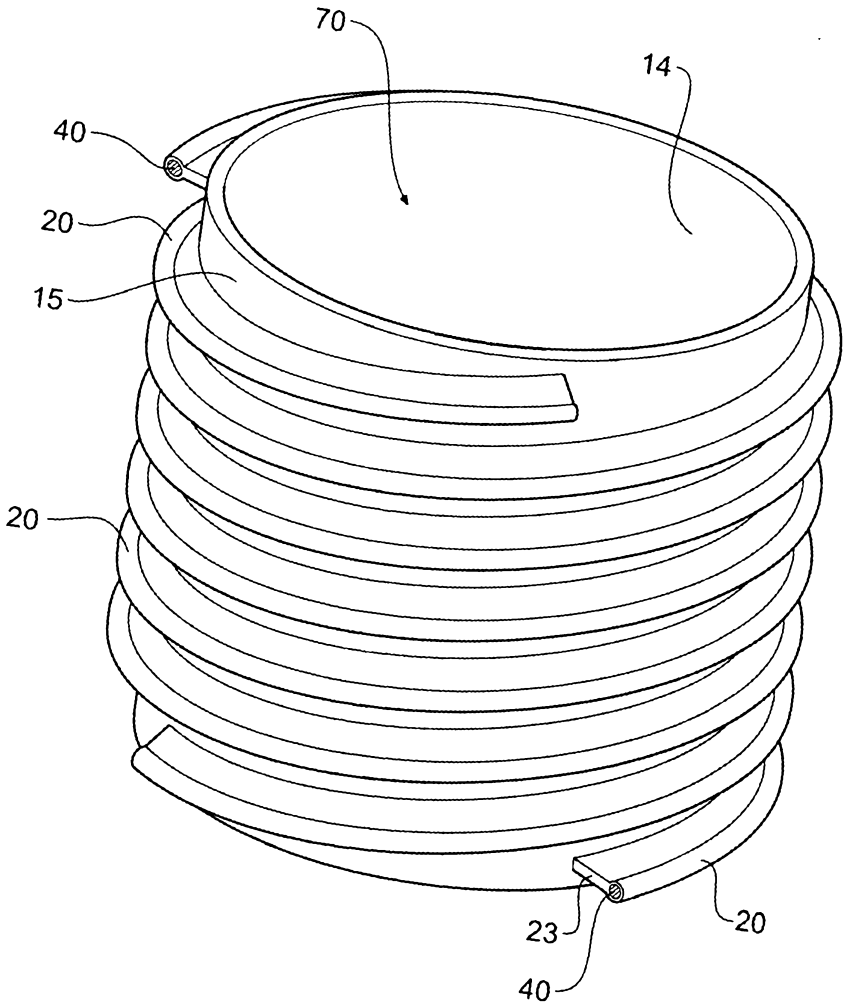


Fig 4

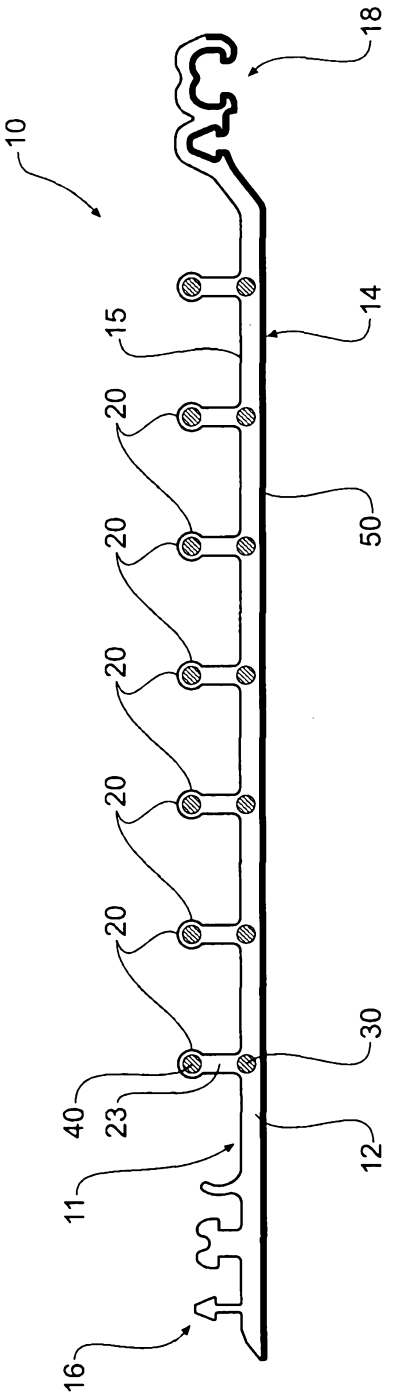


Fig 5

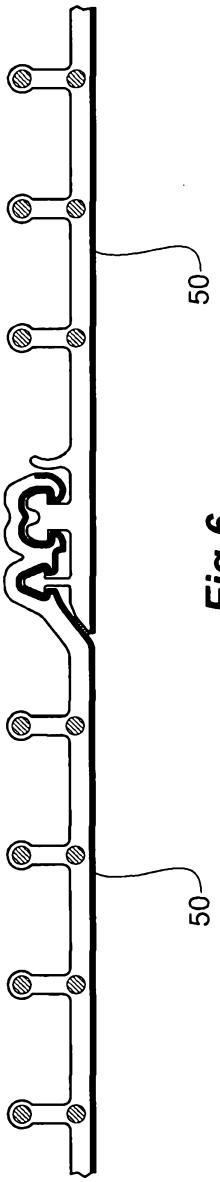


Fig 6

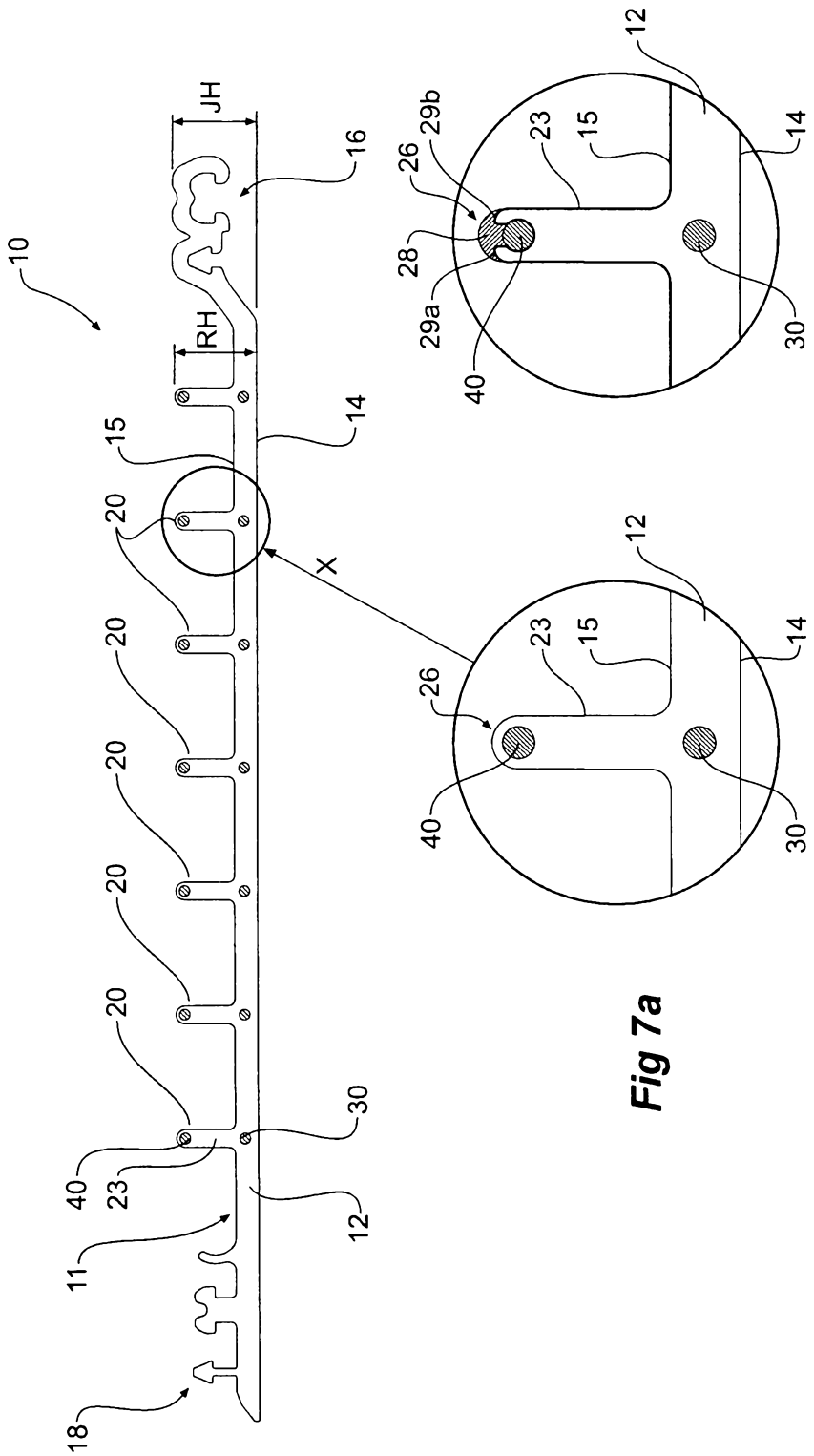


Fig 7a

Fig 7b

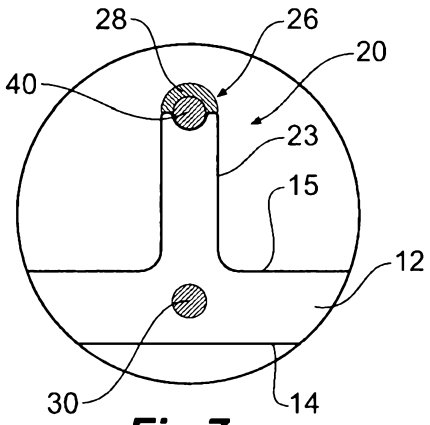


Fig 7c

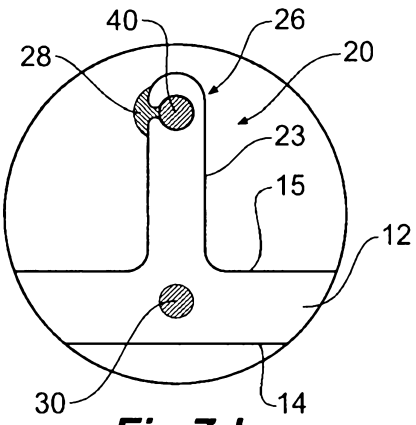


Fig 7d

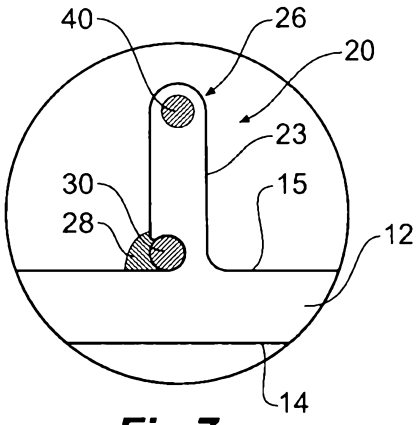


Fig 7e

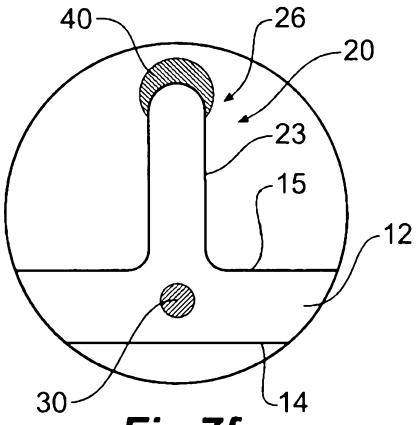


Fig 7f

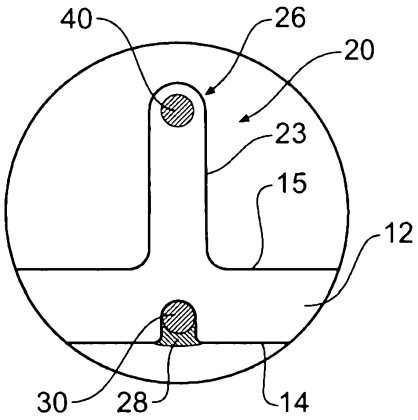


Fig 7g

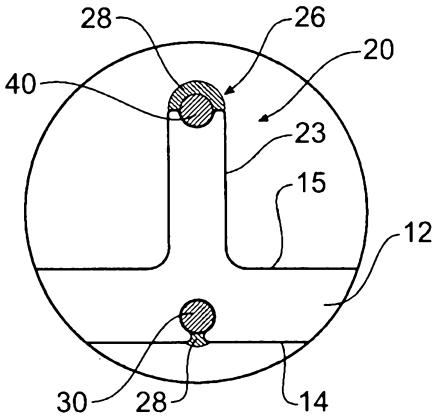


Fig 7h

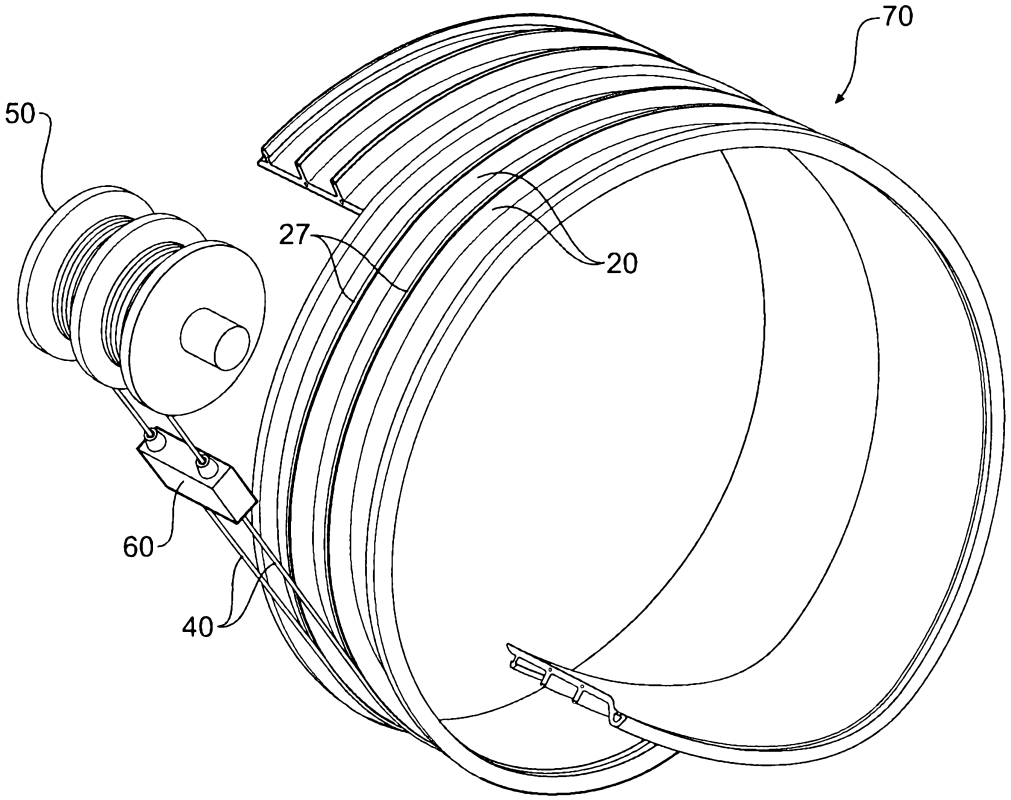


Fig 8a

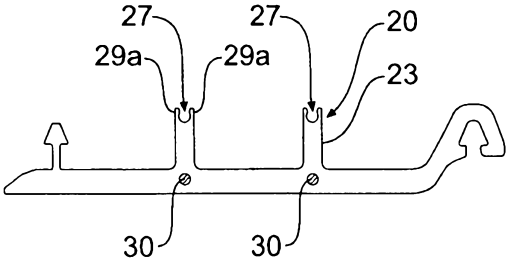


Fig 8b

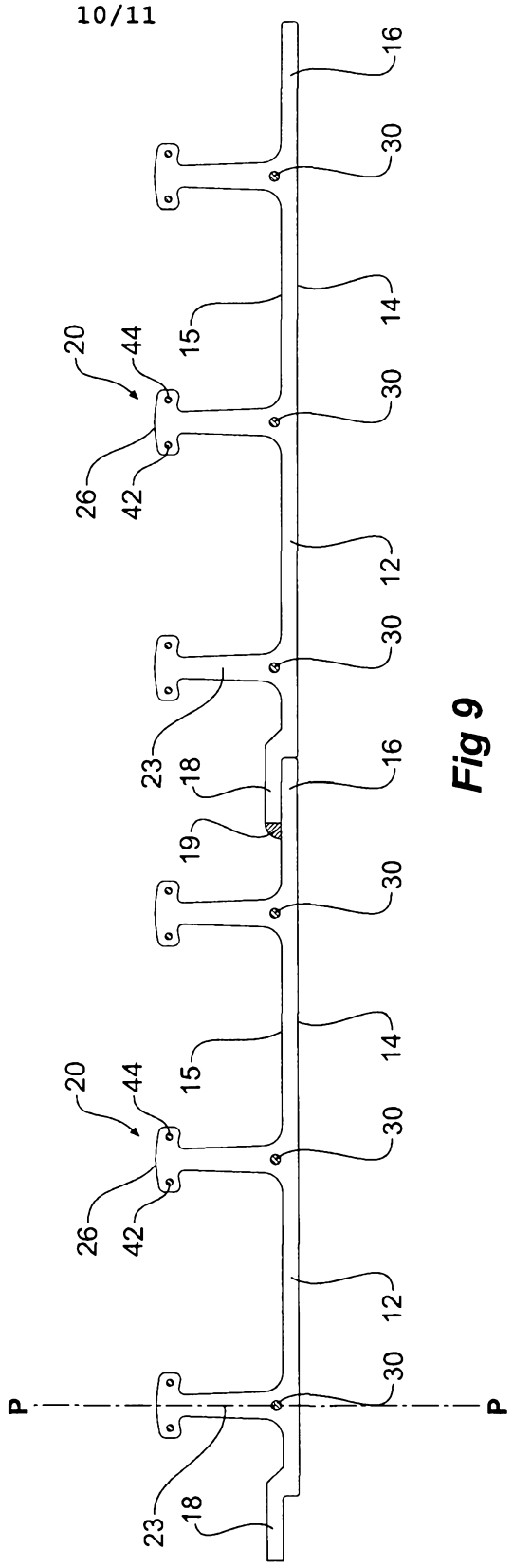

16
30
14
15
20
44
30
26
42
12
30
23
18
16
19
30
14
15
20
44
30
26
42
12
30
P
P
23
18

Fig 9

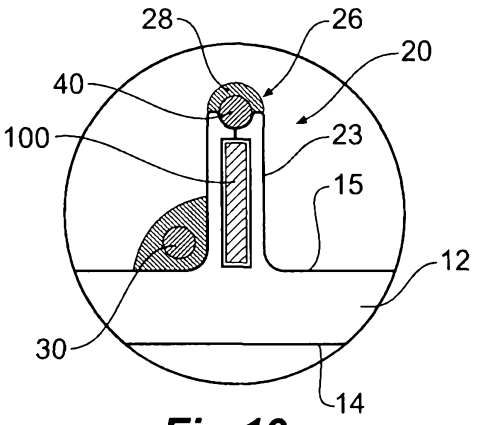


Fig 10a

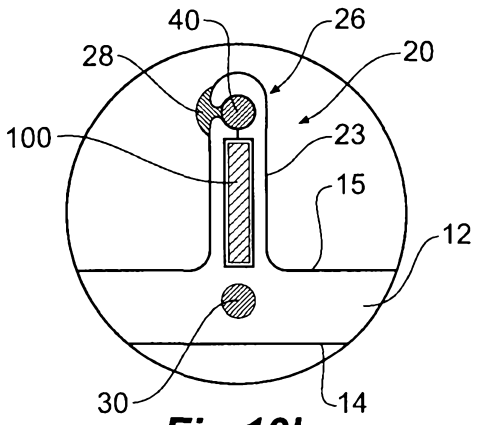


Fig 10b

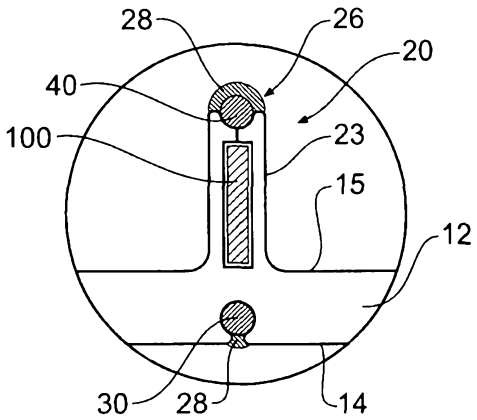


Fig 10c

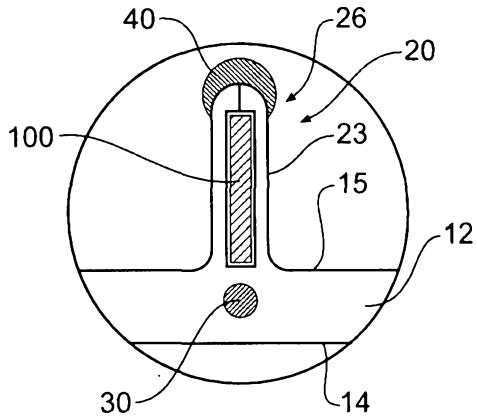


Fig 10d