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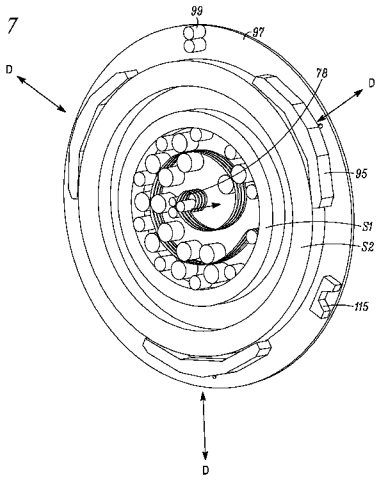
FIG. 7



(57) Abstract: An apparatus (50) for and method of manufacturing helically wound tubular structures (116) includes coaxial rotating face plates (74, 89, 97), capable of rotation at different angular speeds. A plurality of forming rollers (76) and diameter defining rollers (78) are mounted on the inner faceplate (74, 89), which, in operation, cause a strip material (80) to be plastically deformed into a helical winding which may be lain down in abutting or self-overlapping relationship to form said tubular structure (116). A plurality of support rollers are mounted in a circle on the inner faceplate (74, 89) at a distance from the axis exceeding that of the outermost forming roller and serve to support the stock of strip material.

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APPARATUS FOR AND METHOD OF MANUFACTURING A HELICALLY WOUND TUBULAR STRUCTURE

The present invention relates to a winding apparatus and a method of manufacturing structures and relates particularly to the manufacture of pipes and longitudinal structures formed by winding strips of material, such as metal, Kevlar, plastic, glass fibre, composites of such materials or strips formed from layers comprising one or more of said materials in a helical relationship. Other structures such as storage vessels, towers and support structures may also benefit from features described herein.

Presently it is known to manufacture tubular structures by winding pre-formed metal strip onto a rotating mandrel such that the strip is deposited onto the mandrel in a self-overlapping manner and is retained in place by mechanical deformation of an edge thereof such that it interlocks with an adjacent edge, thereby to retain the strip in place on the final structure. EP0335969 discloses an apparatus for forming a helically wound tubular structure formed from a flat strip of metal wound onto a mandrel. The flat strip is fed from one or other of a pair of supply spools mounted concentrically with the axis of the tubular structure to be made. A rotating winding head is used to wind the strip onto the mandrel and includes a plurality of powered forming rollers which impart an initial form to the cross section of the metal strip before it is passed to a final set of rollers that lay the strip onto the mandrel and then swage over an edge of the strip so that it becomes mechanically locked to the previous layer over which it is wound. This is a complex process. Also provided is a mechanism for ensuring the strip supply is maintained constant and this mechanism includes speed control of the forming rollers. The coaxial supply bobbins are fed from an external supply spool so as to maintain the supply thereof. A welding station is used to join one end of the strip material to another.

US4738008 discloses a winding apparatus for forming a non-rotating helix of metal strip having a rotating store of metal strip provided radially outward of a winding head and means for providing the store of material to the winding head which rotates at a different speed to the store of material. In this process it is necessary to stop the process when the strip material has been consumed and a fresh supply thereof is added before production can be recommenced. This can be a very lengthy process.

It is an object of the present invention to provide an apparatus for and method of manufacturing tubular structures which reduces and possibly overcomes some of the problems associated with the prior art.

Accordingly, the present invention provides a winding apparatus comprising an inner faceplate rotatably mounted for rotation about a longitudinal axis X-X and having an output station thereon; an outer faceplate radially outward of said inner faceplate and being rotatably mounted for rotation about said longitudinal axis X-X; wherein said inner faceplate comprises a plurality of forming rollers for receiving a strip of material and supplying said strip to said output station and a plurality of inner support rollers for supporting said strip, said support rollers being arranged in a circle around the axis X-X at a distance from the axis exceeding that of the outermost forming roller, said inner and outer faceplates are substantially co-planar and said apparatus further includes a drive mechanism for driving each of said faceplates relative to each other about said longitudinal axis X-X.

Advantageously, this arrangement permits the outer and inner portions of the stock of material to be rotated at different speeds, facilitating the controlled consumption of stock at the forming station. Additionally, variation of angular speeds of different elements in the arrangement permits a reduction or even

elimination of downtime for reloading of stock, by continuing consumption during the reloading. This allows for greater uniformity of the manufactured helical winding.

According to a further aspect of the invention said inner faceplate includes a strip support at an outer diameter thereof and onto which, in operation, a supply of strip material may be wound.

According to a further aspect of the invention said apparatus further comprises a brake for preventing rotation of said outer faceplate as and when desired.

According to another aspect of the invention loading may be performed with minimal interruption or without interruption of the inner winding process, by which strip material taken from the inner portion of the stock is wound on to a central core or mandrel. This reduces downtime and may facilitate continuous supply of the strip material toward to the core, so that the final helical winding is uniform along the length of the manufactured pipe.

The present invention will now be more particularly described by way of example only with reference to the accompanying drawings in which:

Figures 1 to 3 are partial cross-sectional views of different types of tubular structure that may be formed by the apparatus described herein;

Figure 4 is a side view of an arrangement including a winding head apparatus as described herein;

Figure 5 is a schematic side elevation of an apparatus according to aspects of the present invention;

Figure 6 is a front view of the forming head taken in the direction of arrow A in figure 4;

Figure 7 is a detailed view of the forming head of figures 4 to 6; and

Figures 8 to 12 are end views of the winding head and illustrate various stages in the operation thereof.

Referring now to Figure 1 of the drawings, a tubular body indicated generally at 10 forms a pipe for use in a pipe system such as a pipeline carrying hot fluids (which may also be under pressure). The tubular body may comprise an inner portion in the form of an inner hollow core 12 which may be formed by any one of a number of forming processes known to those skilled in the art and an outer load carrying casing discussed in detail later herein. In the preferred process the inner pipe comprises a continuously formed core, as will also be discussed in detail later herein however, one may have a core made from a plurality of discrete lengths inter-engaged with each other so as to form a long length. The outer casing indicated generally at 14 is formed on the inner hollow core 12 by helically winding a strip 16 of material onto the outer surface 12a of the core 12 in an abutting or self-overlapping fashion similar to the manner which is described in detail for the formation of a pipe on a mandrel in the specific descriptions of the applicants U.K. Patent No. 2,280,889 and U.S. Patent No. 5,837,083. The strip may be wound under tension and may have one or more transverse cross-sectional steps 18 and 20 each of which is preferably of a depth corresponding to the thickness of the strip 16. The steps 18, 20 are preferably preformed within the strip 16, each extending from one end of the strip 16 to the other to facilitate an over-lapping centreless winding operation in which each convolution of the strip accommodates the overlapping portion of the next convolution. Whilst the strip may comprise any one of a number of materials such as a plastic, a composite material or indeed metal, it has been found that metal is particularly suitable in view of its generally high strength capability and ease of forming and joining as

will be described later herein. Examples of suitable metals include steel, stainless steel, titanium and aluminium, some of which are particularly suitable due to their anti-corrosion capabilities. The internal surface 16i of the strip 16 and the outer surface of the pipe 12o may be secured together by a structural adhesive, as may the overlapping portions of the strip. The use of an adhesive helps ensure that all individual components of the tubular member 10 strain at a similar rate. The application of the adhesive may be by any one of a number of means but one particularly suitable arrangement is discussed in detail later herein together with a number of other options.

Figure 2 illustrates an alternative arrangement in which the flat strip 16 is formed such that step 28 divides the strip into longitudinal portions and is also provided with ridges 30 running longitudinally thereof. The ridges are shaped to produce an external ridge and an internal groove into which an external ridge of a previously deposited portion nestles during forming.

Figure 3 illustrates a still further arrangement in which the strip comprises a simple flat strip wound in abutting relationship and provided in multiple layers which may be staggered as shown.

Referring now more particularly to figure 4, from which it will be seen that an apparatus 50 for manufacturing helically wound structures comprises: an optional pre-forming portion 52, in which a core 54 is formed; a forming station, shown schematically at 56 and described in detail later herein; and a post forming section, shown generally at 58 and including a number of optional features discussed later. In one arrangement of the optional pre-forming portion 52 there is provided a store of flat strip material in the form of a roll of metal strip 60 and a plurality of feed rollers 62 which feed the strip to forming rollers 64 and 66 which in turn roll the edges of the strip together around a central mandrel 68 so as to form a tubular structure 54 having confronting edges abutting each other (not shown). A welding apparatus shown generally at 70 and including a welding head

72 is used to weld together the confronting edges in a manner well known in the art and therefore not described further herein. An alternative core forming process might comprise the manufacture of a plurality of discrete lengths of tubular structure, each of which are provided with inter-engaging features on confronting ends thereof such as to allow a plurality of said lengths to be assembled into a long section of core. When employing such a core arrangement one may replace the strip forming and welding arrangement with a suitable feed mechanism (not shown) for feeding a plurality of said discrete lengths into the forming station in a continuous manner. Once formed, the core of whatever description is fed into the forming station 56, which is best seen with reference to figure 4.

Referring to the drawings in general but particularly to figure 5 which is a side elevation of the forming station 56. Upon a front portion of a faceplate 74 are mounted a plurality of forming rollers 76 and a set of diameter defining rollers, shown generally at 78. As shown, the forming rollers are profiled so as to form a cross-sectional form to the strip as best seen in figures 1 or 2. It will, however, be appreciated that the forming rollers could impart an alternative form to the strip or may, in some circumstances, be eliminated all together. When provided, the forming rollers are best provided as a plurality of confronting rollers (best seen in figure 5) between which the strip 80 is sandwiched as it passes therebetween so as to impart the desired profile into the strip in a progressive manner, with each pair of rollers increasing the deformation of the strip until the final desired profile is formed. As shown, the forming rollers are each driven by means of a drive gear 82 each of which is mounted for rotation about an axis on said faceplate and engages on one side with a forming roller and on another side with a sun gear 84 formed on a speed controlled or non rotating portion 86, which is described in detail later herein. As the faceplate 74 rotates in the direction of arrow C (figure 6), gears 76 82 rotate therewith but, as they are coupled to the sun gear 84, they are caused to rotate about their axes and drive the strip through the pinch formed between confronting forming rollers 76. As shown, the forming rollers are each

slightly staggered along longitudinal axis X and the axis of rotation of each roller varies in accordance with the spiral angle as the strip 80 passes from the supply thereof to the diameter defining rollers 78. It will, however, be appreciated that a simpler non staggered arrangement may be used where there is sufficient room to shape the strip and then position it correctly before applying it to the diameter defining rollers 78.

In order to ensure an even feed of strip material from a supply thereof it may be desirable to provide a supply thereof in the form of an annular stock supply shown generally at 88. Figure 5 shows the elements of the drive mechanism for rotating the various parts of the arrangement as explained herewith. The stock support 90, which contains the stock 88 of material 80, comprises two coaxial faceplates (89, 97), which may also be coplanar. The outer and inner portions of the spool of stock 80 may be respectively mounted on the two faceplates (89, 97) of the stock support 90. The outer portion of the spool 80 is loaded on the outer faceplate 97 of the stock support and is constrained by adjustable strip brakes 95 which hold the spool of stock 80 on the outer faceplate 97 whenever desired. The movement of the adjustable strip brakes 95 is indicated by the double-headed arrow D in Figures 5 and 7. The strip brakes may be spring-loaded or displaced by means of actuators shown at 79 (figure 5) In addition to the strip brakes 95 the stock support is preferably further constrained by one or more strip retainers 117, schematically shown in Figures 8-12, which are mounted on the outer faceplate (89,97) between the strip brakes 95.

Figure 5 shows a preferred form of the inner faceplate 74, 77, 89. The inner faceplate comprises a front portion 74 which is substantially annular in form connected via a cylindrical portion 77 to a back portion 89 which is parallel to the front portion 74 and also substantially annular in form. The three portions of the inner faceplate are coaxial and contain a coaxial hole 114, as shown in Figures 5 and 6. In an alternative form the cylindrical portion 77 may reduced or even eliminated, such that the front portion 74 is in contact with the back portion 89

and is substantially coplanar with it. The back portion 89 of the inner faceplate may be substantially coplanar with outer faceplate 97.

Advantageously, the inner portion of the spool 80 is supported by means of inner support rollers 87 which are mounted on the inner faceplate 74, 89 positioned outside said forming station, being circumferentially spaced around longitudinal axis X-X. The inner support rollers 87 may be mounted on the back portion 89 of the inner faceplate 74, 77, 89 as in Figure 5. Alternatively, they may be mounted on the front portion 74. Said support rollers 87 cooperate with an inner portion of the stock of strip material 88 and allow the stock to rotate about axis X-X. The strip material 80 is removed from an inner diameter of said stock thereof and fed between two support rollers 87 via a first strip supply guide roller 94 mounted for rotation on said back portion 89 of said inner faceplate 74,89 about an axis substantially perpendicular thereto.

By means of independent drive mechanisms respectively comprising motors 94 and 96 the outer faceplate 97 and the inner faceplate 74, 89, may be driven at different angular speeds. Figure 5 illustrates how the outer faceplate 97 and the inner faceplate 89 are connected to the drives. Motor 96 is connected via gear mechanisms 92, 97 to the outer faceplate and its activation causes the outer portion of the spool 80 to rotate about the axis X-X. Motor 94 drives the inner portion of the strip 80 via gear mechanism 91 and rollers 87 mounted on the inner faceplate, as described previously.

Motors 94 and 96 are connected to and controlled by computer 140 shown in Figure 4. The control of the motors by computer 140 is performed according to standard control methods.

Also shown in Figures 6 and 7 is the diameter defining roller arrangement seen generally at 78 and which between them act to curve the strip material by plastically deforming it around one of the rollers such as to define the diameter of

the exiting strip. This arrangement is not central to the present application and the reader's attention is drawn to the present applicant's patent application PCT/GB2006/050471 which describes this feature in detail. An optional adhesive applicator 106 may also be mounted on the front portion of inner faceplate 74 for rotation therewith. The applicator may take a number of forms for supplying adhesive to the strip after it has been formed and one particular arrangement is shown in which a storage cassette 108 is provided with a roll of adhesive strip 110. The storage cassette 108 is mounted for rotation about a spindle 112 mounted on the faceplate for rotation therewith such that upon rotation of the faceplate adhesive strip may be dispensed onto the surface of the strip 80 as it is lain down onto the core 54 (figure 5). The strip of adhesive may be provided in the form of a strip having a backing and this backing may be removed by backing removing means (not shown) prior to said adhesive being applied. It will be appreciated from the cross–sectional view of figure 4 that the inner faceplate 74, 89 includes a central hole 114 for receiving a core or liner 54 onto which said strip material 80 may be wound so as to form a final structure 116. The central hole may be provided with a central support trunion 86 having a hollow centre which defines said central aperture 114 for receiving said core or liner 54. When provided, the trunion may be mounted within said central hole 114 by means of bearings 113, such that said faceplate 74 can rotate about said trunion 86. Referring now once again to figure 4, an optional post forming section 58 may include such things as an optional drive mechanism 152 and adhesive curing heater 154.

Referring to the drawings in general, it will be appreciated that a tubular structure may be manufactured by causing the faceplate 74 to rotate. This action in turn will cause the strip material 80 to be drawn from the cassette, passed through forming rollers 76 and into diameter defining rollers 78 at which point the desired diameter is formed by appropriate positional control of rollers 78. As the strip exits the diameter defining rollers it is directed towards the core 54 and wrapped therearound in a self overlapping or abutting arrangement best appreciated with

reference to Figures 1 to 3. Before the strip is finally deposited onto the core it may be supplemented by an adhesive dispensed as a strip thereof from dispenser 106. Continuous rotation of faceplate will cause continuous deformation and deposition of the strip 80 and this process will continue so long as there is a supply of strip material within the cassette store. Once the strip material has been depleted it is necessary to transfer fresh material onto the apparatus and weld one end to the other before recommencing operations. This process is described in detail later herein. It will also be appreciated that some forms of structure need not have a core and the above process may be undertaken without a core being supplied to the faceplate. In such an arrangement it may be necessary to provide a support to the initial portion of tubular structure formed but once an initial portion has been formed the structure will be self supporting as new layers are effectively deposited down on a stable multi layer structure.. Structures without cores are, therefore, within the scope of the present invention.

The various stages of the winding process and replenishment steps will now be more particularly described with reference to Figures 8 to 12.

As described earlier, the inner faceplate 74, 89 and the outer faceplate 97 of the stock support 90 may be rotated at different speeds. Figure 9 illustrates how the stock of strip material may be treated as distinct portions of a continuous strip material, supported on the different faceplates of the stock supply 90. There may be at least one annular space between the two portions, bridged by one coil or part of one coil of elongate material.

The outer portion of the spool cooperates with and is held by adjustable strip brakes 95 located circumferentially on outer faceplate 74, 97, while the inner portion cooperates with rollers 87, as described previously. The inner faceplate

89 and the outer faceplate 97 and the corresponding drive mechanisms are connected to and controlled by the computer 140 (see Fig. 4).

By varying the speeds of the inner and outer parts of the cassette it will be appreciated that material can be transferred from one portion of the spool to the other. If the whole spool rotates at the same speed, material consumed from the inner circumference of the inner portion is replaced by material from outer portion. If the speed of rotation of the outer portion is increased beyond that of the inner portion the inner portion will cease to strip off material from the outer portion and, as depletion of the inner portion continues, due to consumption of stock at the core, then the outer portion will peel off stock from the inner portion and a space will be created between the inner and outer portions. If the speed of rotation of the outer portion is decreased below that of the inner portion, the inner portion will peel material from the outer portion. It will be appreciated that controlling the relative speeds of the inner and outer portions effectively manages the transfer of material between the inner and outer portions of the spool, as well as the size of the space between the two portions.

A fully loaded stock support 90 is shown in Figure 8. As the support 90 is rotated, material is extracted from the inner circumference of the stock and laid on the core. It will be seen that the outer portion is rotated at a higher speed eg 69.8 rpm, than the inner portion, eg 60 rpm. As described above, these relative speeds will cause the generation of space between the inner portion S1 and outer portion S2 of the spool, as shown in Figure 9. Variation of the speeds of S1 and S2 will cause material to be transferred between the two spools.

The following section describes a sequence of consumption and reloading processes with respect to Figures 8-12.

Figure 8 illustrates a fully loaded supply of stock at the start of the sequence. In normal operation of the arrangement material is consumed from inner circumference of the stock S1 with all parts of the stock supply 90 rotating at 60 rpm as in Figure 8. The end of the strip material is fixed to the rotating outer faceplate 97 of the stock supply 90 by means of adjustable clamping means 99 provided on the outer faceplate 97. Material consumed at the centre is automatically replaced by material from the outer portion.

As consumption continues the transfer of material from the outer portion S2 to the inner portion S1 leads to the exhaustion of material on the outer annular faceplate as in Figure 10.

Figure 11 depicts stock distribution after further depletion of material from the inner portion of the stock, at which point the rotation of the complete stock supply 90 is stopped. The outer annular faceplate 97 of the stock supply 90 is held stationary by means of a pin or bolt 75 which cooperates with recess 115 fixed on the outer faceplate 97. This facilitates the attachment of a new feed stock to the end of the current stock. The end of the current stock, still held in place by clamping means 99, may be attached to the end of the new feed stock by welding or any other suitable attachment method. The cassette of new feed stock is not shown in the figures.

After the attachment step is complete clamping means 99 is released and the new feed stock may be wound from the external feed onto the supply stock 90, by rotation of the central inner faceplate 89 by means of the drive mechanism described previously. At this stage the outer faceplate 97 is still locked in a stationery position by bolt 75 and remains stationery until the loading is complete. The feed stock is introduced into the stock supply via the open clamping means 99.

When the feed stock has been completely wound onto the stock supply 90, the device is fully loaded. The supply 90 is then ready for renewed consumption from the inner circumference of the newly loaded stock, thereby returning to the beginning of the sequence, as depicted in Figure 8.

The arrangement may also include a sensor, such as an optical sensor, for monitoring the amount of material in one or either of the portions of the spool, connected to a computer and VDU, whereby the visual display indicates to the user the amount of stock available and the time available, calculated by the computer, before attachment of the new stock must be completed. This is not shown in the figures.

Optionally, the reloading may occur without causing any interruption to the central process of winding material onto the core, as described later. As an alternative to the above arrangement, managing the depletion of stock from the individual portions S1 and S2, as indicated earlier, may also allow continuous consumption of stock from the rotating inner circumference of the inner portion S1, while stock is reloaded at the outer portion.

In this embodiment the drive mechanism for the outer portion S2 is modified. A plurality of drive rollers (not shown) impinge directly on the outer portion S2 and serve to both rotate the stock of material and to contain it. The drive 94, 91, described earlier is connected (connection not shown in the figures) to the driver rollers, rather than the outer annular faceplate 97 as described in previous embodiments. The inner circular faceplate continues to rotate and feed the post forming station 58, whereby the inner portion S1 is fed by the outer portion S2, as in Figure 9. By stopping the rotation of the roller wheels the outer portion of the stock may be held stationery. New feed stock may then be attached to the outer portion S2, while the outer portion S2 continues to feed the inner portion. As long as the attachment is completed before the outer portion S2 of material is exhausted, consumption of material from the rotating inner portion need not be

interrupted. By virtue of control exercised on the depletion of individual portions of the spool the helical manufacturing process may therefore be continuous.

Additional features of this machine include feedback control from the computer to ensure the product diameter is maintained within desired limits and/ or altered according to desired parameters. It will be appreciated that as one can control the degree of plastic deformation of the strip as it passes through the radius forming rollers 78 one can also control the final diameter of any tubular structure formed by this apparatus.

It will be appreciated that the described arrangement ensures an even supply of material. It also forms a complex interlocking profile in the material and winds the material onto a core at predetermined curvature, thereby providing a robust structure in the final windings as well as a suitable tensile compression.

It will also be appreciated that the apparatus may be used on strips of other materials such as Kevlar, plastic, glass fibre, composites of such materials or strips formed from layers comprising one or more of said materials. Indeed the machine lends itself particularly to use with some of these materials as it is able to pre-tension the strip as it is wound onto the final form of the tubular structure being formed. When used with composite materials having a portion of metal in the strip provided either as a layer or as part of any woven form thereof, said metal will act to maintain a degree of rigidity in the strip that will assist with the location thereof on the rollers and in maintaining a final curvature. Materials such as glass-fibre or Kevlar may be reinforced by a resin or other such material in the manner well known to those skilled in the art and, therefore, not described further herein. Clearly, any such materials may simply be wound into the desired shape without needing to be provided with a cross-sectional profile as described earlier herein.

Additionally, this arrangement advantageously provides a means of continuous or near continuous supply of winding material. Downtime for reloading of the apparatus with new stock is reduced, thereby also facilitating greater uniformity of the helical winding produced

It will also be appreciated that the above described method and apparatus may be used to cover an already existing pipeline with an outer casing. In this arrangement the already existing pipeline forms a core and the machine simply rotates around the core and moves therealong so as to lay down the outer wrap of strip material onto the pipeline. Such an approach could be employed when one wishes to repair or strengthen an already existing pipeline.

Still further, it will be appreciated that if portion 86 (fig5) is driven then it may benefit from being separately supported for rotation in bearings 200 provided in a fixed structure 202 and further provided with a drive mechanism shown generally at 204 and including, for example, a motor 206, driving gear 208 and driven gear 210, the latter of which is provided on portion 86. Preferably, the controller is also connected to the motor for control thereof and for this purpose one may also provide control line 212 shown generally in figure 6.

CLAIMS

1. A winding apparatus comprising;

   – an inner faceplate rotatably mounted for rotation about a longitudinal axis X-X and having an output station thereon;
   – an outer faceplate radially outward of said inner faceplate and being rotatably mounted for rotation about said longitudinal axis X-X;

   wherein said inner faceplate comprises a plurality of forming rollers for receiving a strip of material and supplying said strip to said output station and a plurality of inner support rollers for supporting said strip, said support rollers being arranged in a circle around said axis X-X at a distance from the axis X-X exceeding that of the outermost forming roller, said inner and outer faceplates are substantially co-planar and said apparatus further includes a drive mechanism for driving each of said faceplates relative to each other about said longitudinal axis X-X.

2. A winding apparatus as claimed in either of claims 1 wherein said apparatus includes a faceplate brake for preventing rotation of said outer faceplate as and when desired.

3. A winding apparatus as claimed in claim 2 wherein said faceplate brake comprises a friction brake.

4. A winding apparatus as claimed in claim 3 wherein said faceplate brake comprises a pin mounted on a non-rotatable portion of said apparatus and a recess in said outer faceplate for receiving said pin.

5. A winding apparatus as claimed in any one of clams 1 to 4 wherein said apparatus further includes a strip brake for preventing an outer diameter of

any strip material wound onto said outer faceplate rotating relative to said outer faceplate.

6. A winding apparatus as claimed in claim 5 wherein said strip brake comprises a plurality of friction brakes mounted for radial movement on said outer faceplate and including a friction surface for engagement with an outer diameter of any strip material wound onto said outer faceplate.

7. An apparatus as clamed in any one of claims 1 to 6 wherein said apparatus further includes a pair of feed rollers mounted on an outer diameter of said outer faceplate for receiving a supply of strip material to said apparatus and for guiding said strip towards said inner faceplate.

8. An apparatus as claimed in any one of claims 1 to 7 wherein said apparatus further includes a strip clamping and cutting station.

9. An apparatus as claimed in any one of claims 1 to 8 wherein said inner faceplate further includes a central bore for receiving a supply of core material onto which strip supplied to said apparatus may be wound.

10. An apparatus as claimed in claim 9 wherein said apparatus further includes a core supply mechanism for supplying a continuous or semi-continuous supply of core material to said apparatus.

11. An apparatus as claimed in Claim 10 further comprising a servo mechanism for positioning the core supply mechanism relative to the inner faceplate.

12. An apparatus as claimed in Claims 1 to 11 further comprising roller wheels mounted on the outer circumference of the outer faceplate, each roller wheel comprising a friction surface for engaging directly with the outer

surface of the stock of material, and a drive mechanism for rotating said roller wheels.

13. An apparatus as claimed in any one of Claims 1 to 12 further comprising a monitoring means for monitoring the amount of strip material present in said apparatus.

14. A method for supplying a strip of material, in an apparatus comprising an inner faceplate with support rollers arranged in circle around its axis and an outer faceplate, the faceplates being rotatable at independent variable speeds about a common axis, the method comprising the steps of:

- loading a stock of strip material onto said faceplates by winding said strip material onto the support rollers ,
- consuming stock of said strip material from the inner circumference of the stock between adjacent support rollers, by rotating said inner faceplate, and
- replenishing the stock of said strip material at the inner faceplate from the outer faceplate

15. A method as claimed in Claim 14 further comprising the step of stopping the rotation of the outer faceplate.

16. A method as claimed in Claim 15 wherein the rotation stopping step comprises friction braking

17. A method as claimed in Claim 16 wherein the rotation stopping step comprises inserting a pin movably mounted on a fixed portion of said apparatus into a recess on said outer faceplate

18. A method as claimed in any one of Claims 14 to 17 further comprising the step of preventing rotation of the outer portion of said wound stock relative to the outer faceplate by clamping the outer circumference of said wound stock by strip brakes mounted on the outer faceplate.

19. A method as claimed in any one of Claims 14 to 18 further comprising a clamping step wherein the free end of said wound stock is selectively clamped to the the outer faceplate

20. A method as claimed in any one of Claims 14 to 19 further comprising the step of reloading a new stock of strip material into the apparatus

21. A method as claimed in Claim 20 wherein the reloading step comprises the steps of

- stopping rotation of the outer faceplate,
- unclamping the free end of the remaining stock on the outer faceplate
- attaching the free end of the stock to be replaced to the free end of the replacement stock
- winding the replacement stock by rotating the inner faceplate.

22. A method as claimed in Claim 21 wherein the stopping step further comprises stopping rotation of the inner faceplate.

23. A method as claimed in Claim 21 wherein, by continued rotation of the inner faceplate, consumption from the inner circumference of the stock is continuous.

24. A method as claimed in Claim 14, further comprising the step of reloading a new stock of strip material into the apparatus, said outer faceplate

further comprising outer support wheels positioned around its outer circumference, the reloading comprising the steps of

- stopping rotation of the outer faceplate,
- attaching the free end of the stock to be replaced to the free end of the replacement stock
- winding the replacement stock by rotating the outer support wheels

25. A method as in any one of Claims 14 to 24 further comprising the step of transferring stock of strip material between the inner and outer faceplates by varying their respective speeds.

26. A computer program product comprising a readable medium for storing instructions for implementing the method of Claims 14 to 25.

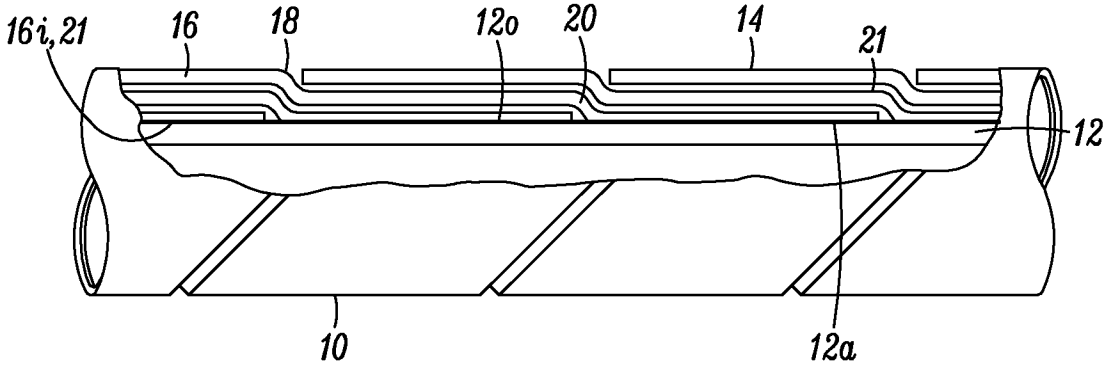

16i, 21
16
18
12o
20
14
21
12
10
12a

FIG. 1

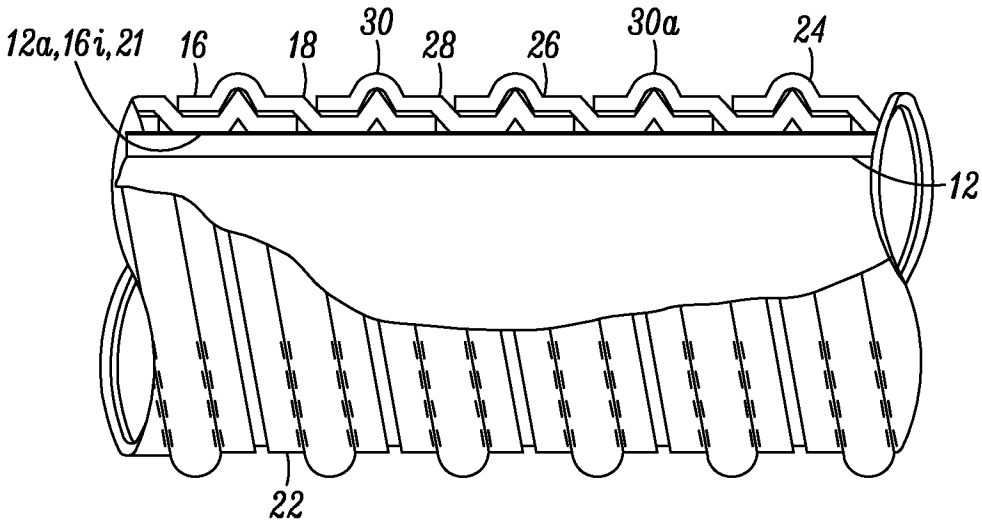

12a, 16i, 21
16
18
30
28
26
30a
24
12
22

FIG. 2

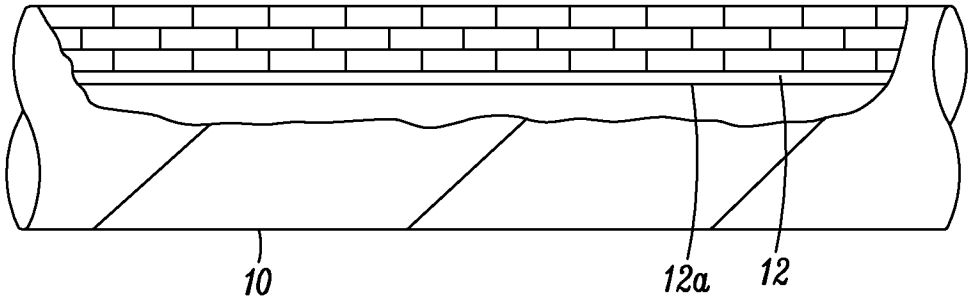


FIG. 3

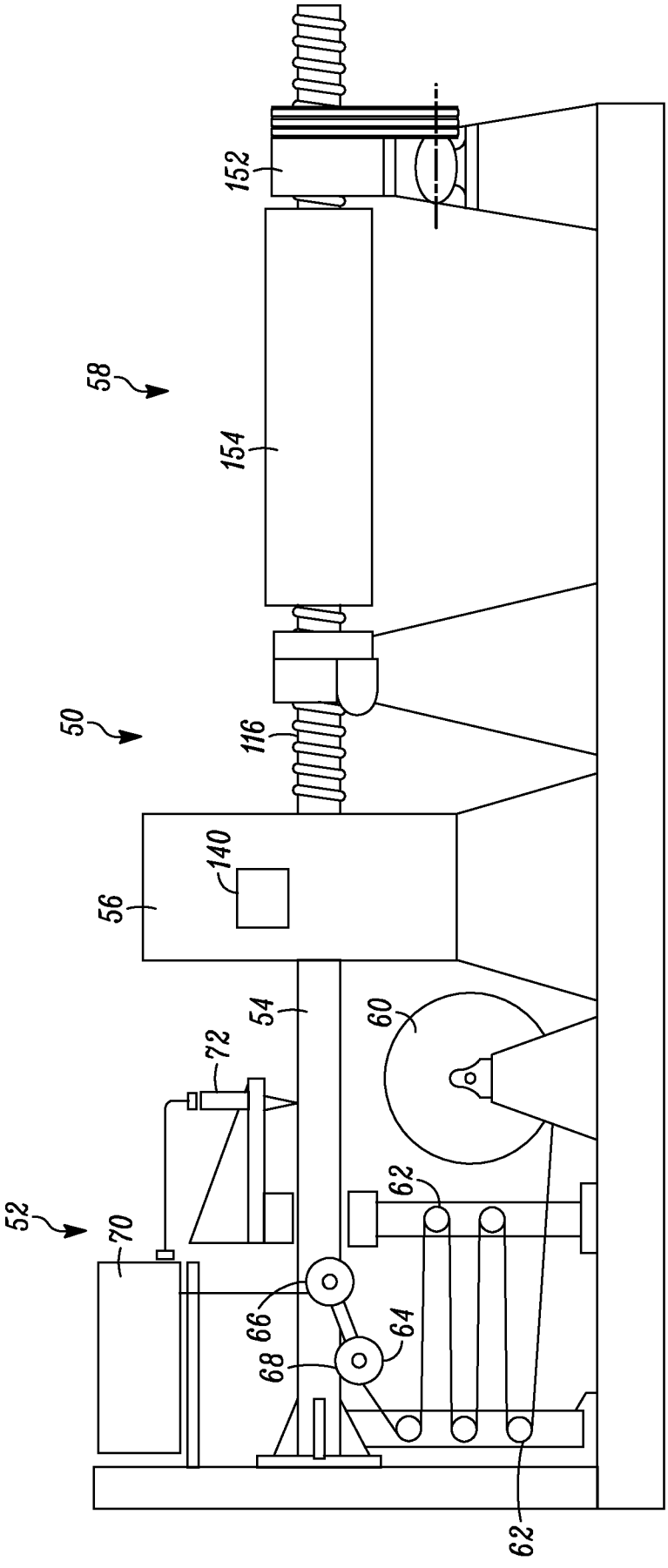
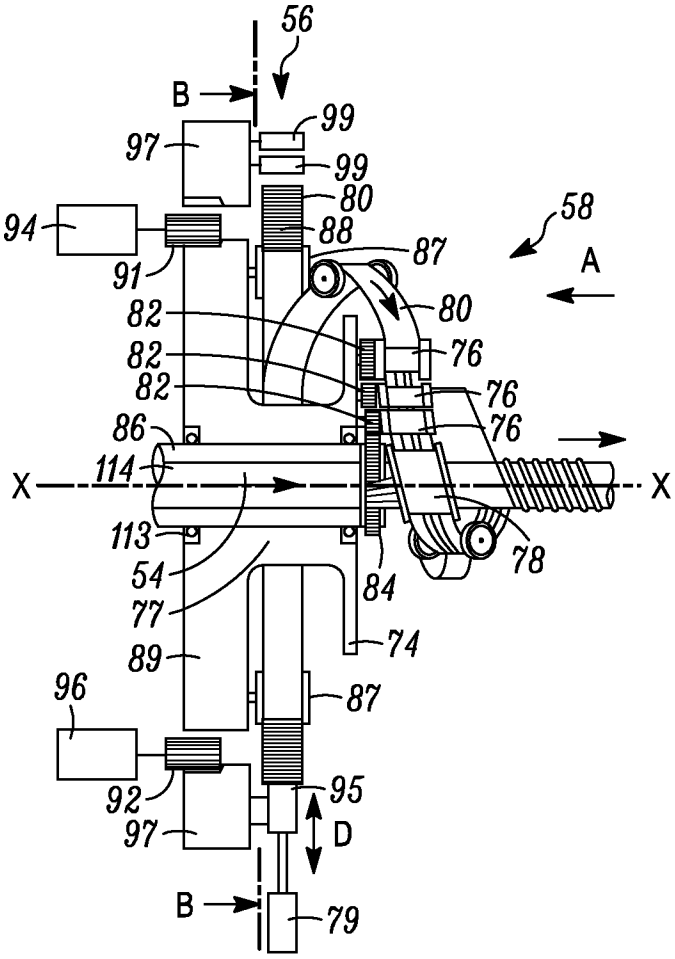


FIG. 4


56
B
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A
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80
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86
76
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96
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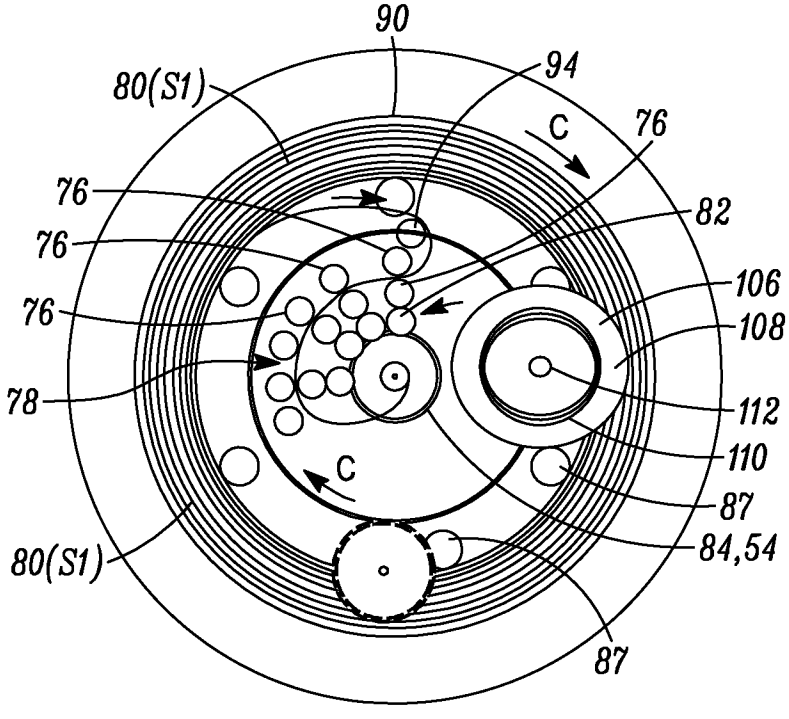
95
97
D
B
79

FIG. 5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80(S1)
C
76
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82
76
106
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108
78
112
110
C
87
80(S1)
84,54
87

FIG. 6

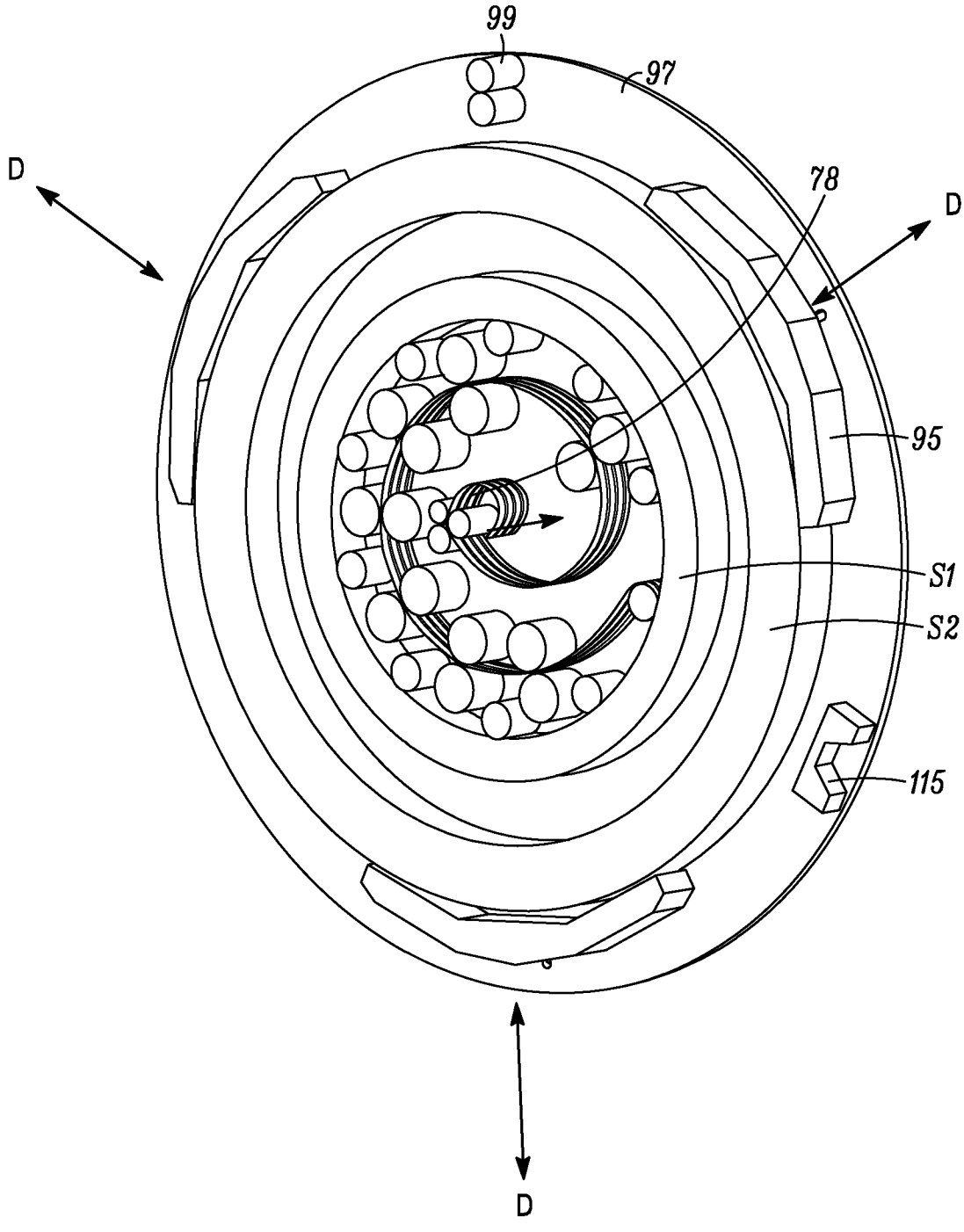

FIG. 7

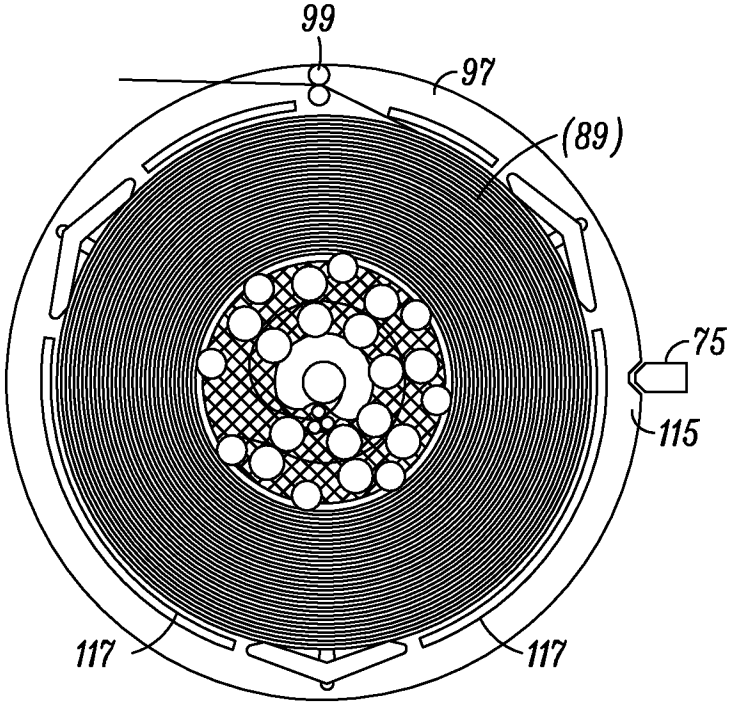

FIG. 8

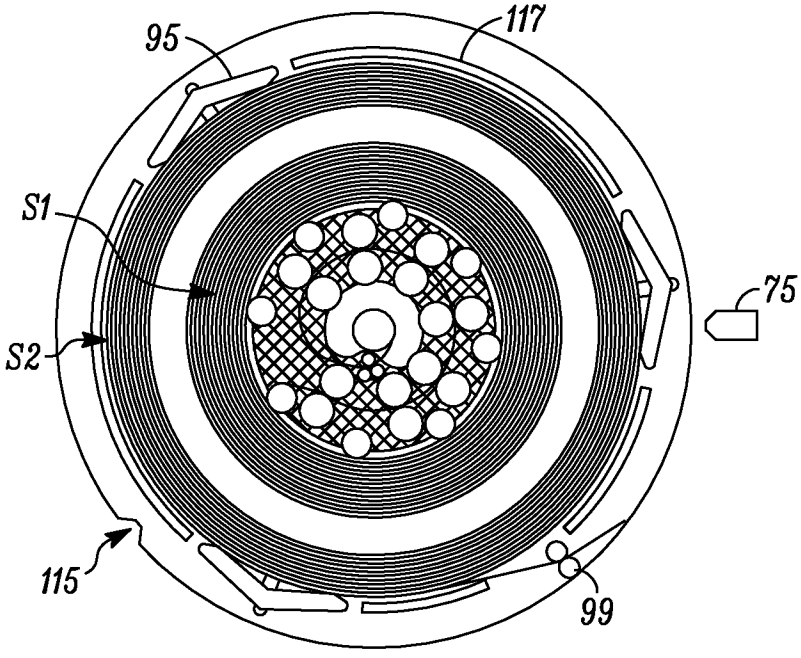

FIG. 9

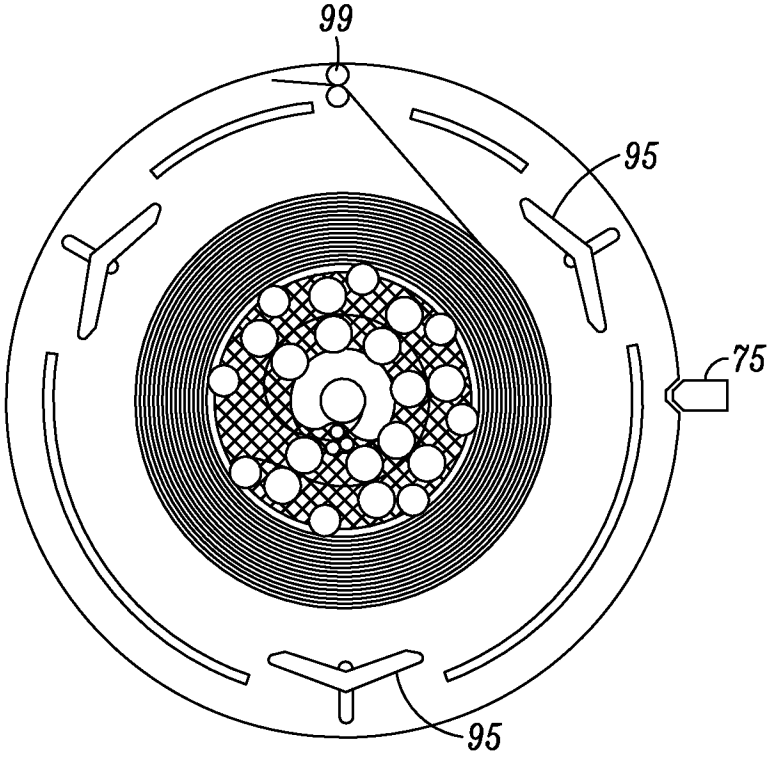

FIG. 10

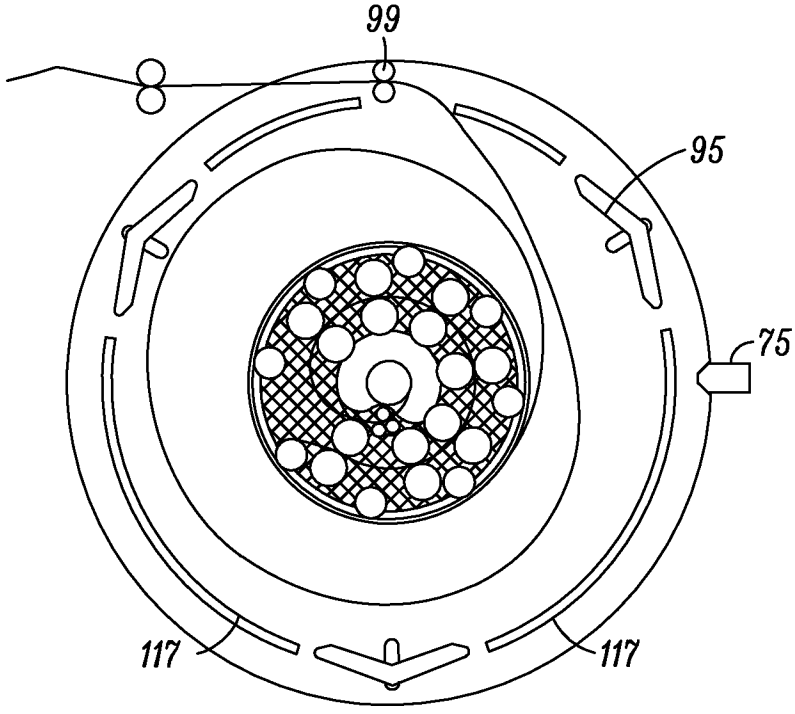

FIG. 11

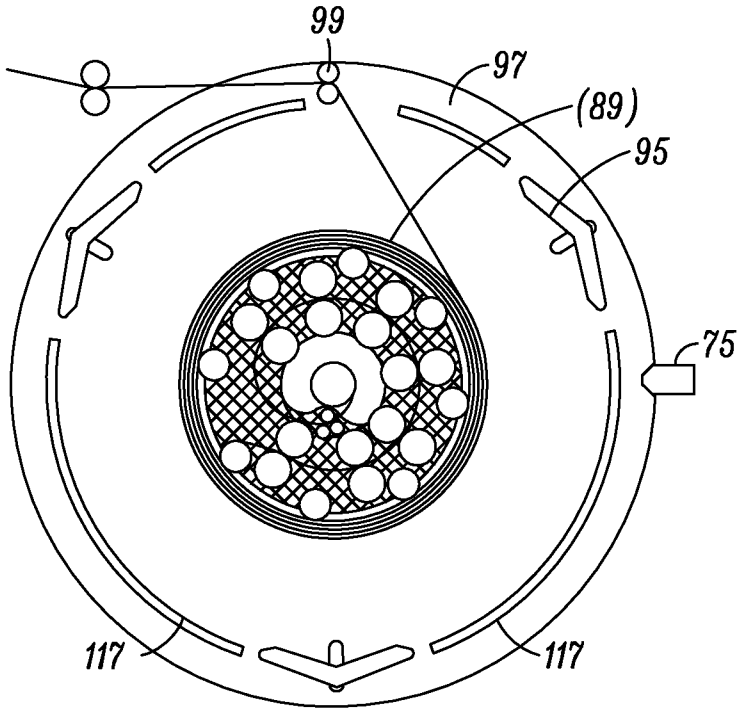

FIG. 12

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2010/050054

A. CLASSIFICATION OF SUBJECT MATTER
INV. B21C37/12 B21C49/00 B29C53/68 B65H20/26
ADD.

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)
B21C B29C B65H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 1 010 167 A (GUITON CHARLES) 17 November 1965 (1965-11-17) the whole document	1-25
A	US 4 505 438 A (SENDZIMIR TADEUSZ [US] ET AL) 19 March 1985 (1985-03-19) column 3, line 11 - column 6, line 7; figures 1-4	1,14
A	US 4 895 011 A (VARGA ANDRE [CA]) 23 January 1990 (1990-01-23) the whole document	1,8,13, 14,20
A	GB 2 433 453 A (ITI SCOTLAND LTD [GB]; HELICAL PIPELINES LTD [GB]) 27 June 2007 (2007-06-27) cited in the application figures 3-5	1,9,10, 14,20

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

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" 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)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" 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

"X" 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

"Y" 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

Date of the actual completion of the international search	Date of mailing of the international search report
20 April 2010	03/05/2010

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Fax: (+31–70) 340–3016	Ritter, Florian

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB2010/050054

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 26
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claims Nos.: 26

The subject-matter of claim 26 is so unclear that no meaningful search could be carried out. Claim 26 relates to a computer program which comprises a readable medium for storing instructions. But a program cannot comprise a physical entity like a storage medium. Furthermore it is completely unclear which steps of the method shall be controlled by this computer program (Article 6 PCT).

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guideline C-VI, 8.2), should the problems which led to the Article 17(2) declaration be overcome.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2010/050054

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
GB 1010167	A	17-11-1965	DE	1199095 B	19-08-1965
			FR	1378838 A	20-11-1964
			NL	6403866 A	12-10-1964
			US	3296784 A	10-01-1967
US 4505438	A	19-03-1985	NONE		
US 4895011	A	23-01-1990	BR	9000221 A	13-11-1990
			CA	2007970 A1	20-09-1990
			DE	69015851 D1	23-02-1995
			DE	69015851 T2	07-09-1995
			DK	17790 A	21-09-1990
			EP	0389085 A1	26-09-1990
			ES	2070272 T3	01-06-1995
			HU	54583 A2	28-03-1991
			JP	2856808 B2	10-02-1999
			JP	3166153 A	18-07-1991
			MX	172402 B	15-12-1993
			NO	900248 A	21-09-1990
GB 2433453	A	27-06-2007	AU	2006327969 A1	28-06-2007
			CA	2632644 A1	08-06-2007
			CN	101346197 A	14-01-2009
			EP	1971450 A1	24-09-2008
			WO	2007072079 A1	28-06-2007
			JP	2009520604 T	28-05-2009
			US	2009165518 A1	02-07-2009