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(56) Documents Cited:
GB 0110576 A
WO 2013/055618 A1
US 5669420 A
EP 0199557 A2
WO 2010/082058 A1
US 4597276 A

(58) Field of Search:
INT CL **B21C, B29C**
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(54) Title of the Invention: **Apparatus for forming a Pipeline**
Abstract Title: **Apparatus and Method for Forming a Pipeline by helical winding**

(57) An apparatus 1 for forming a pipeline from strip material 5, 7 comprises a body 2 having a central aperture 3, at least one forming roller 8, 9, 10, 11, 14, 15, 16, 17 mounted on the body, at least one mounting 4, 6 for a cassette of strip material on the body and a drive for rotating the body about the central aperture; wherein: the or each roller, the or each mounting and the cassettes of strip material are arranged so that strip material unwound from the or each cassette can be passed directly through at least one forming roller any further processing occurs. The body can then be rotated whilst a cylindrical mandrel 20 is progressed through the central aperture in order to helically wrap the mandrel in strip material and thereby form a pipeline. The forming roller(s) may be operable to plastically deform strip material to provide two or more asymmetric longitudinally extending ridges. A method for forming a length of pipeline using the apparatus is further provided.

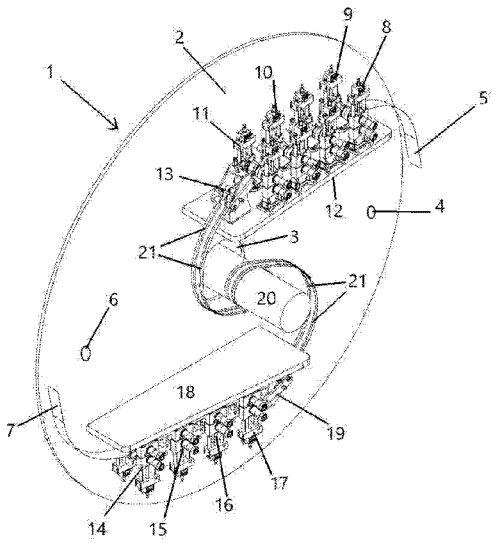

Figure 2

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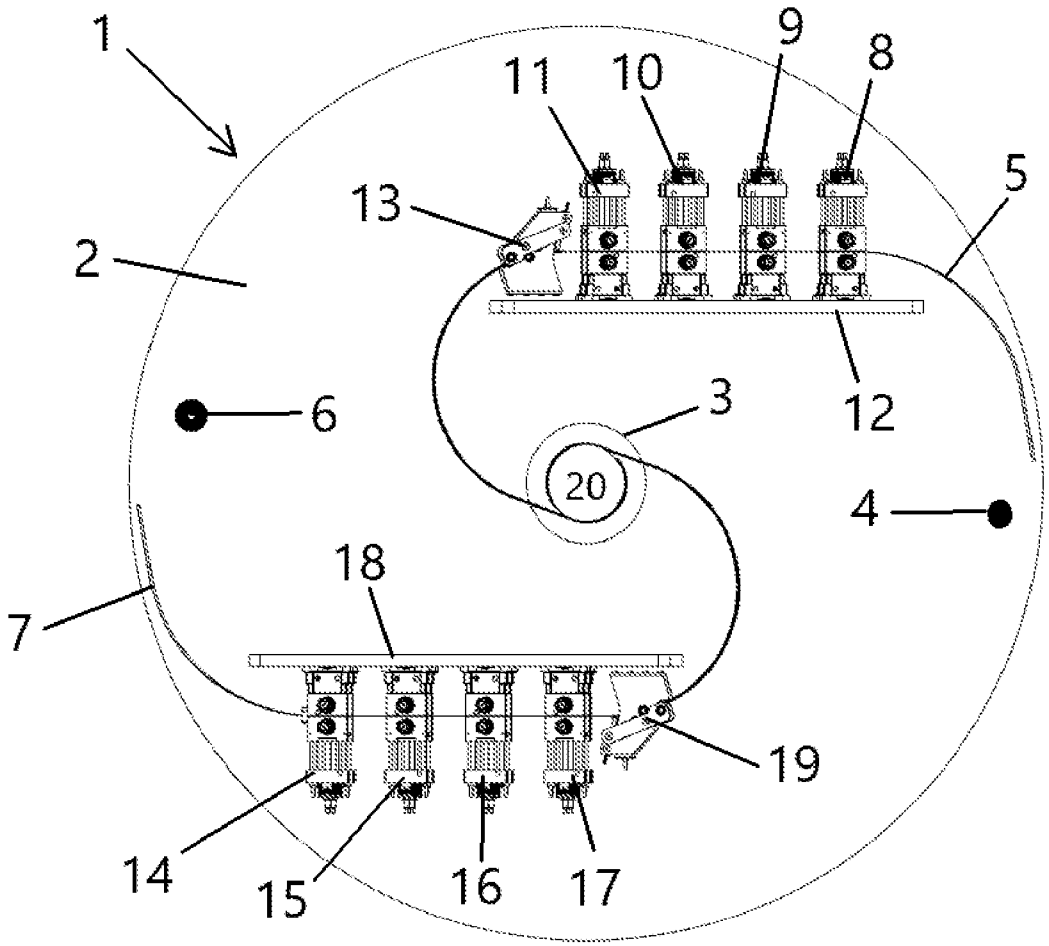

Figure 1

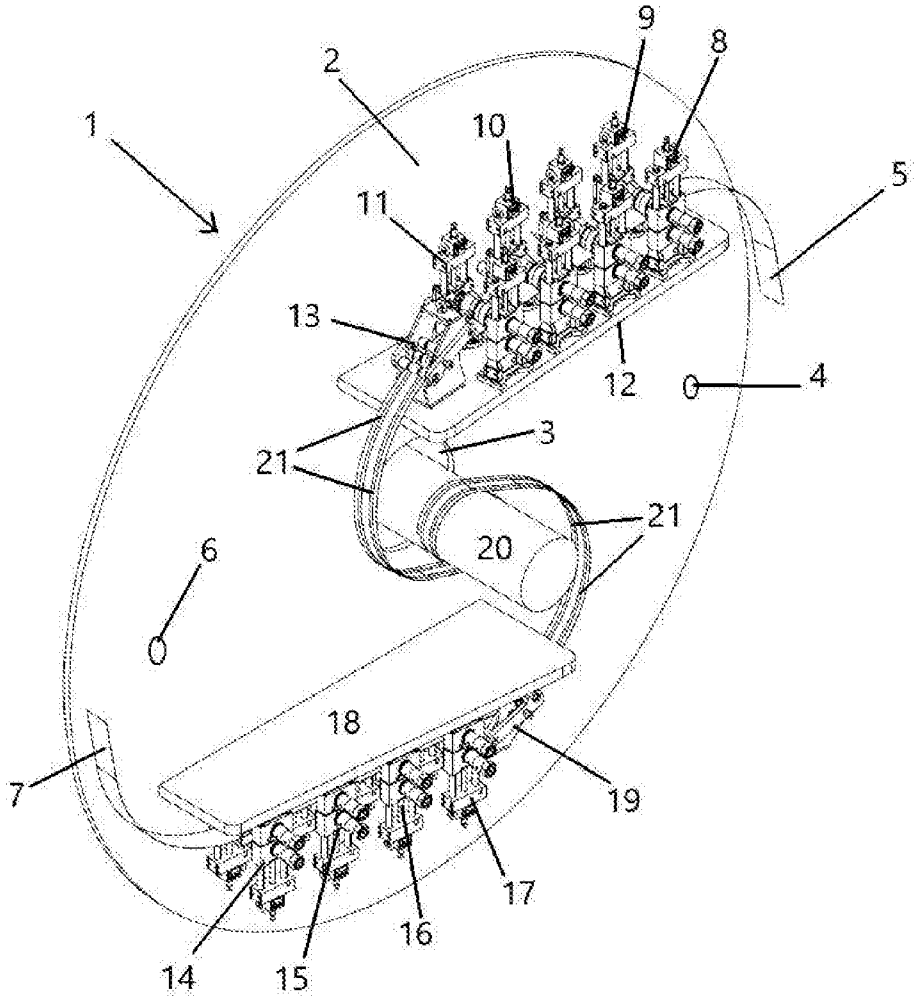

Figure 2

Apparatus for forming a Pipeline

Field of Invention

The present invention relates to the forming of pipelines from strip material, in particular to pipelines formed of helically wound strip material.

Background to the Invention

Methods of forming pipelines by helically winding one or more strips of material in an overlapping fashion are known. One such method is disclosed in GB2280889. This document discloses a pipe body having a wall formed of a plurality of layers is continuously made by winding a single strip of material. The strip of material may be deformed before winding to provide circumferentially extending ridges that overlap and nest within each other so that adjacent and overlapping sections of the material inter-lock and resist loads placed on the finished structure.

A pipeline formed in this manner may be provided with an internal liner, such as a metal or polymer pipeline. In some cases the liner may act as a mandrel about which the strips of material are helically wound.

GB2496137 discloses an improved method of forming a pipeline by helically winding strips of material and the associated pipeline. This method involves providing the strips of material with longitudinally extending asymmetric ridges that are formed to interlock with each other when a portion of a strip is overlaid with an adjacent portion of a strip. The pipeline of GB2496137 is particularly suitable for carrying hydrocarbon, gas or liquid products under pressure. The interlocking layers of strips of material can produce a very robust pipe construction that resists loads on the pipe. This is particularly true if the pipelines are formed of relatively strong materials such as martensitic steel.

As the pipeline is generally used for oil and gas production, there is a need for a method of forming a pipeline according to GB2496137 requires the processing of strip material to provide the longitudinally extending ridges and then subsequently wrapping the strip material in a helical manner to form a pipeline that can be done on-site, away from a factory setting, for example in remote oil or gas production facilities. It has been proposed to form the pipeline by

first processing a spool of strip material to provide a longitudinally extending ridge in the strip material, then winding the processed strip material on to another reel, then mounting the reels of processed strip material onto a winding machine, and finally winding the processed strip material to form a pipeline. However this method has been found to be problematic as after the longitudinal extending ridges are formed in the strip material spooling the material on a reel requires much more space than spooling flat strip material. It is estimated that in some embodiments spooling a strip material with ridges provided in accordance with GB 2496137 would result in a reel with five times the radius than prior to providing the ridges. This is because the ridges do not interlock with one another when the processed strip material is spooled on a reel; thus providing ridges on the strip material effectively significantly increases the thickness of the material for spooling purposes.

In light of the above there is a need for an improved method and apparatus for forming pipeline from strip material in which the strip material is provided with longitudinally extending ridges.

Summary of the Invention

The present invention provides an apparatus for forming a pipeline from strip material comprising:

a body having a central aperture;

a first forming roller mounted on the body;

a first mounting for a first cassette of strip material on the body; and

a drive for rotating the body about the central aperture; wherein:

the first forming roller and first mounting are arranged so that strip material unwound from a first cassette positioned on the first mounting can be passed directly through the first forming roller before any further processing occurs.

The apparatus of the present invention can be operated in the following manner. A first cassette of strip material is rotatably mounted on the first mounting and an end of the strip material is fed from the first cassette through the first forming roller. A mandrel is positioned through the central aperture of the body. The end of the strip material is then affixed to the mandrel. The drive is then operated to rotate the body about the central aperture as the mandrel is progressed through the central aperture relative to the body. The strip is then unwound from the cassette, formed by the first forming roller, and wrapped about the mandrel to form a pipeline.

The progression of the mandrel through the central aperture can be achieved by moving the body along the mandrel whilst holding the mandrel stationary. Alternatively, the progression of the mandrel through the central aperture can be achieved by moving the mandrel through the body whilst holding the body stationary. Alternatively both the mandrel and the body can be moved in opposing directions or in the same direction at differing speeds such that mandrel progresses relative to the body.

The apparatus of the present invention is advantageous in that it provides a compact apparatus for forming a pipeline from strip material. The apparatus allows a strip material to be formed, for example to have longitudinal ridges as disclosed in the prior art, after being unrolled from a cassette and before being wrapped around a mandrel. There is no need for the strip material to be re-rolled on a cassette after forming and before wrapping around a mandrel, rather by mounting the or each forming rollers on the body it is possible to combine the forming and wrapping steps in a single apparatus. This is achieved by having the body formed to be rotatable around a central aperture and mounting the or each forming rollers on the body to rotate about the central aperture during operation of the apparatus.

The strip material used with the present invention may be any material suitable for forming pipelines that can be rolled onto a cassette and formed by a roller. It is considered that the skilled person will understand which materials are suitable for use with the apparatus of the present invention. In embodiments of the invention the strip material may be steel, for example martensitic steel.

In simple embodiments of the invention the apparatus will comprise a single forming roller. However, in order to properly form a strip material it may be necessary that the strip material passes through two or more forming rollers after being unspooled from the cassette and before being wrapped about the mandrel. Therefore, the apparatus may comprise one or more additional rollers mounted on the body such that strip material from a first cassette passes through the first roller and then the or each additional roller before being wrapped around a roller.

For example, the apparatus may further comprise a second forming roller mounted on the body adjacent the first forming roller such that strip material passing through the first forming roller can be immediately subsequently passed through the second forming roller before any further processing occurs.

If the apparatus comprises a second forming roller it may further comprise a third forming roller mounted on the body adjacent the second forming roller such that strip material passing through the second forming roller can be immediately subsequently passed through the third forming roller before any further processing occurs.

If the apparatus comprises a third forming roller it may further comprise a fourth forming roller mounted on the body adjacent the third forming roller such that strip material passing through the third forming roller can be immediately subsequently passed through the fourth forming roller before any further processing occurs.

An apparatus may comprise further rollers positioned after a fourth forming roller such that strip material passing through the fourth forming roller can be immediately subsequently passed though the further rollers before any further processing occurs.

A forming roller of the apparatus of the present invention may be driven by an associated roller motor. A roller motor may drive a single forming roller or may drive two or more forming rollers. The apparatus of the present invention may further comprise one or more roller motors for driving the forming roller(s).

An apparatus according to the present invention may comprise a first cassette mounted on the first mounting. A first cassette may be provided with strip material spooled thereon. Preferably cassettes used with the apparatus of the present invention are easily removably mounted such that they can be replaced in a straightforward manner when strip material spooled thereon is exhausted. As will be readily understood a cassette is an apparatus on which a length of strip material can be spooled onto and unspooled from. The skilled person will be aware of suitable cassettes that can be used with the present invention.

Apparatus according to the present invention may operate with only a single cassette of strip material, such that a length of pipeline is formed from a single length of helically wound strip material. However, it may be preferable that the apparatus comprises mountings for two or more cassettes of strip material and the apparatus is capable of being used with two or more cassettes of strip material, such that a length of pipeline is formed from two or more lengths of helically wound strip material. That is, the apparatus of the present invention may have two, three, four, or more mountings for cassettes of strip materials mounted on the body.

Each mounting for a cassette is preferably provided with at least one associated forming roller mounted on the body in an appropriate positioned such that strip material unwound from a cassette mounted on the mounting may pass through the or each associated forming roller before being wound about a mandrel to form a pipeline. Each mounting may be provided with the same number of associated forming rollers mounted on the body such that strip material from each cassette passes through the same number of forming rollers before being wound on a mandrel. Alternatively, different mountings may have different numbers of associated forming rollers such that two or more different cassettes have a different number of associated forming rollers.

In embodiments of the invention the apparatus may comprise a second mounting for a second cassette of strip material on the body; and a fifth forming roller mounted on the body; wherein: the fifth forming roller and second mounting are arranged so that strip material unwound from a second cassette positioned on the second mounting can be passed directly through the second forming roller before any further processing occurs.

It is to be understood that if an apparatus according to the present invention comprises a "fifth" forming roller it need not necessarily comprise five forming rollers. Rather the "fifth" forming roller is an arbitrary name used to differentiate from the second, third, and fourth forming rollers described above. For example, an apparatus according to the present invention may comprise only two forming rollers: a first forming roller and a fifth forming roller. The naming of the sixth, seventh, and eighth forming rollers described below is similarly arbitrary.

An apparatus according to the present invention that comprises a fifth forming roller may further comprise a sixth forming roller mounted on the body adjacent the fifth forming roller

such that strip material passing through the fifth forming roller can be immediately subsequently passed through the sixth forming roller before any further processing occurs.

An apparatus according to the present invention that comprises a sixth forming roller may further comprise a seventh forming roller mounted on the body adjacent the sixth forming roller such that strip material passing through the sixth forming roller can be immediately subsequently passed through the seventh forming roller before any further processing occurs.

An apparatus according to the present invention that comprises a seventh forming roller may further comprise an eighth forming roller mounted on the body adjacent the seventh forming roller such that strip material passing through the seventh forming roller can be immediately subsequently passed through the eighth forming roller before any further processing occurs.

If the apparatus of the present invention comprises a second mounting it may also comprise a second cassette of strip material mounted on the second mounting.

The apparatus of the present invention is particularly suitable for forming pipeline from helically wound and overlapping strips of material, wherein the strip material is deformed to have one or more longitudinally extending ridges as described in the prior art. Therefore, is is advantageous for apparatus according to the present invention that the forming roller(s) is(are) operable to plastically deform flat strip material unwound from a cassette to provide one or more longitudinally extending ridges in the strip material, for example two or more longitudinally extending ridges may be provided in the strip material. Longitudinally extending ridges may be formed in any manner known to the skilled person, for example longitudinally extending ridges may be asymmetric as described in the prior art.

Each forming roller may be formed in any manner known to the skilled person. They may be driven to pull strip material therethrough. As discussed above Multiple forming rollers may be necessary to suitably deform strip material into an appropriate shape.

The apparatus may additional comprise one or more appropriately positioned exit rollers located after any forming rollers in order to direct strip material exiting the forming rollers.

The apparatus may also additionally comprise one or more wrapping rollers located at or near a mandrel to locate the strip on the mandrel when the apparatus is in use.

The present invention also provides of operating the apparatus of the present invention to form a length of pipeline. The method comprises the steps of:

positioning a cylindrical mandrel through the central aperture of the apparatus;

progressing strip material from a cassette mounted on a mounting through at least one forming roller; and

wrapping the cylindrical mandrel in the strip material progressed through a forming roller by rotating the body about the cylindrical mandrel whilst progressing the mandrel through the aperture.

The mandrel may form part of the final length of pipeline as an internal liner or may be removed after forming of the length of the pipeline such that the length of pipeline solely consists of wrapped strip material.

The rate of rotation of the body and/or the rate of progression of the mandrel relative to the boy may be controlled to ensure that the strip material is wound about the mandrel in an appropriate manner. For example, the rate of rotation of the body and/or the rate of progression of the mandrel may be controlled to ensure that lengths of strip material overlay each other and/or longitudinal ridges (or any other feature formed by the rollers) in the strip material interlock or are otherwise appropriately relatively positioned as the strip material is wound about the mandrel.

Further features and advantages of the present invention will be apparent from the preferred embodiment that is shown in the Figures and is described below.

Drawings

Figure 1 is a front view of part of an embodiment of an apparatus according to the present invention; and

Figure 2 is a perspective view of the embodiment of Figure 1.

An apparatus 1 for forming pipeline according to the present invention is shown in the Figures. The apparatus 1 comprises a body 2 with a central aperture 3 formed therethrough. A first mounting 4 is provided for a first cassette (not shown) carrying a first strip 5 of martensitic stainless steel. A second mounting 6 is provided for a second cassette (not shown) carrying a second strip 7 of martensitic strip steel. A first forming roller 8, a second forming roller 9, a third forming roller 10, and a fourth forming roller 11 are mounted on a first platform 12 affixed to the body 2 and are arranged such that the first strip 5 passes through each of the first, second, third, and fourth forming rollers 8, 9, 10, 11 in turn. A first exit roller 13 is positioned after the fourth forming roller 11 to direct the first strip 5 towards the central aperture 3.

A fifth forming roller 14, a sixth forming roller 15, a seventh forming roller 16, and an eighth forming roller 17 are mounted on a second platform 18 affixed to the body and are arranged such that the second strip 7 passes through each of the fifth, sixth, seventh, and eighth forming rollers 14, 15, 16, 17 in turn. A second exit roller 19 is positioned after the eighth forming roller 17 to direct the second strip 7 towards the central aperture.

When in use a cylindrical mandrel 20 is positioned centrally through the central aperture 3 of the body 2 and the first strip 5 and the second strip 7 are helically wound about the mandrel 20 to form a pipeline.

The apparatus 1 operates in the following manner. The first cassette is mounted on the first mounting 4 and the second cassette is mounted on the second mounting 6. The first strip 5 is then pulled through the first forming roller 8, the second forming roller 9, the third forming roller 10, the fourth forming roller 11, and the first exit roller 13 and an end of the first strip 5 affixed to the mandrel 20. The second cassette is mounted on the second mounting 6. The second strip 7 is then pulled through the fifth forming roller 14, the sixth forming roller 15, the seventh forming roller 16, the eighth forming roller 17, and the second exit roller 19 and an end of the second strip 7 affixed to the mandrel 20.

The body 2 is then driven to rotate about the mandrel 20 as the mandrel is progressed through the central aperture 3 relative to the body. The first, second, third, and fourth forming rollers 8, 9, 10, 11 act to form the first strip 5 to provide asymmetric longitudinal ridges 21 in the first strip before it is wrapped about the mandrel 20. The fifth, sixth, seventh, and eighty forming

rollers 14, 15, 16, 17 act to form the second strip 7 to provide asymmetric longitudinal ridges 21 in the second strip before it is wrapped about the mandrel. The longitudinal ridges 21 are formed to have the shape disclosed in GB2496137.

By rotating the body 2 about the mandrel 20 and progressing the mandrel through the central aperture the first strip 5 and the second strip 7 are helically wound about the mandrel to form a length of pipeline. The rate of progression of the mandrel 20 and the rate of rotation of the body 2 are controlled to ensure that the longitudinal ridges 21 of the first strip 5 and the second strip 7 overlap and interlock with one another to form a rigid and robust pipeline, as disclosed in GB2496137.

Unless otherwise indicated by context or the claims any feature of the embodiment of the invention shown in the drawings can be included in an embodiment of the invention independently from any other feature.

Claims

1. An apparatus for forming a pipeline from strip material comprising:
a body having a central aperture;
a first forming roller mounted on the body;
a first mounting for a first cassette of strip material on the body; and
a drive for rotating the body about the central aperture; wherein:
the first forming roller and first mounting are arranged so that strip material unwound from a first cassette positioned on the first mounting can be passed directly through the first forming roller before any further processing occurs.

2. An apparatus according to claim 1 further comprising:
a second forming roller mounted on the body adjacent the first forming roller such that strip material passing through the first forming roller can be immediately subsequently passed through the second forming roller before any further processing occurs.

3. An apparatus according to claim 2, further comprising:
a third forming roller mounted on the body adjacent the second forming roller such that strip material passing through the second forming roller can be immediately subsequently passed through the third forming roller before any further processing occurs.

4. An apparatus according to claim 3, further comprising:
a fourth forming roller mounted on the body adjacent the third forming roller such that strip material passing through the third forming roller can be immediately subsequently passed through the fourth forming roller before any further processing occurs.

5. An apparatus according to any preceding claim further comprising a first cassette mounted on the first mounting.

6. An apparatus according to any preceding claim further comprising:
a second mounting for a second cassette of strip material on the body; and
a fifth forming roller mounted on the body; wherein:

the fifth forming roller and second mounting are arranged so that strip material unwound from a second cassette positioned on the second mounting can be passed directly through the second forming roller before any further processing occurs.

7. An apparatus according to claim 6 further comprising:
a sixth forming roller mounted on the body adjacent the fifth forming roller such that strip material passing through the fifth forming roller can be immediately subsequently passed through the sixth forming roller before any further processing occurs.

8. An apparatus according to claim 7, further comprising:
a seventh forming roller mounted on the body adjacent the sixth forming roller such that strip material passing through the sixth forming roller can be immediately subsequently passed through the seventh forming roller before any further processing occurs.

9. An apparatus according to claim 8, further comprising:
an eighth forming roller mounted on the body adjacent the seventh forming roller such that strip material passing through the seventh forming roller can be immediately subsequently passed through the eighth forming roller before any further processing occurs.

10. An apparatus according to any of claims six to nine further comprising a second cassette of strip material mounted on the second mounting.

11. An apparatus according to any preceding claim, wherein the forming roller(s) are operable to plastically deform strip material to provide two or more longitudinally extending ridges in the strip material.

12. An apparatus according to claim 11, wherein the longitudinally extending ridges are asymmetric.

13. A method of forming a length of pipeline using the apparatus according to any preceding claim comprising the steps of:

positioning a cylindrical mandrel through the central aperture of the apparatus;

progressing strip material from a cassette mounted on a mounting through at least one forming roller; and

wrapping the cylindrical mandrel in the strip material progressed through a forming roller by rotating the body about the cylindrical mandrel whilst progressing the mandrel through the aperture.

Intellectual Property Office

Application No:	GB2206165.9	**Examiner:**	Heather Webber
Claims searched:	1 - 13	**Date of search:**	24 October 2022

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-13	GB 0110576 A (MURPHY STEPHEN JAMES) page 3 line 53-page 4 line 23 and figures
X	1 - 13	US 5669420 A (HERRERO et al.) column 16 line 29-column 17 line 4 and figures 25, 26
X	1-5, 11 - 13	US 4597276 A (LEGALLAIS et al.) see column line 52-column 4 line 39 and figures
X	1-5, 11 - 13	WO 2013/055618 A1 (BARTELL MACH SYS LLC) figure 2 and corresponding description
X	1-5, 11-13	WO 2010/082058 A1 (ITI SCOTLAND LTD) see page 6 line 13 - page 7 line 23 and figures
X	1-5, 11-13	EP 0199557 A2 (TI FLEXIBLE TUBES LTD) see pages 2 - 4 and figures

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

B21C; B29C

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC

Intellectual Property Office

International Classification:

Subclass	Subgroup	Valid From
B21C	0037/12	01/01/2006