Abstract Title: Reinforced elongated elements, such as tubes, method and device for producing same and use thereof

The invention relates to a reinforced elongated element, to the method and device for producing same and to the use thereof. According to the invention, the reinforced elongated element (12) comprises an elongated core (22) which is covered with at least one layer (33) of a composite material comprising a plurality of slivers (32) which are wound around the core, each of said slivers (32) being produced with glass or carbon yarns or fibres (35) which are embedded in a thermoplastic resin matrix (34). The inventive elongated element can take the form of very long tubes which can be used offshore.
REINFORCED ELONGATED ELEMENTS, SUCH AS TUBES, METHOD AND DEVICE FOR PRODUCING SAME AND USE THEREOF

The invention relates to the technical field of fabricating elongate elements such as tubes, e.g. offshore tubes.

Until now, very heavy steel tubes have been fabricated that present problems of corrosion at sea, and that are also difficult to weld.


The method and the device described in that document make it possible directly to prepare section members that are solid or tubular and regardless of their section.

OBJECTS OF THE INVENTION

The new technical problem to be solved is to be able to fabricate tubes of very great length, in general limited only by the dimensions of the factory or possibly of transport.

Concerning the invention, it is possible to fabricate tubes having a length greater than 30 meters (m), and possibly as long as 100 m or even more.

The invention is not restricted to fabricating tubes of circular section, but can be used for fabricating members of other sections, such as members of flat or square section, masts for boats, blades for wind turbines.

The invention also makes it possible to fabricate tubes in a manner that does not depend on the shape of the tube section. The shape may be arbitrary.

Another technical problem that the invention seeks to solve is fabricating a tube with a resin that is thermoplastic as opposed to thermosetting.
The invention thus seeks to replace heavy steel tubes that present problems of corrosion and that are also difficult to weld.

In an off-shore structure of metal type, beyond a certain length, e.g. a depth of 1500 m, weight becomes so great that such structures can no longer withstand their own weight.

The invention also enables that problem to be solved.

In a first aspect, the invention covers as a novel product, a reinforced elongate element comprising a core of elongate shape coated with at least one layer of composite material comprising a plurality of tapes wound around said core, each of the tapes being made from reinforcing threads or fibers, e.g. glass or carbon threads or fibers, embedded in a matrix of thermoplastic resin. The reinforcing threads or fibers are preferably continuous. Thus, the threads or fibers are advantageously of great length, generally corresponding substantially to the length of the tape.

In the context of the invention, the thermoplastic resin is itself commercially available in the form of granules. Concerning the fabrication of the tape used in the invention, it is possible to use the method and the apparatus as described in above-mentioned document FR-A-2 031 719. Naturally other techniques for fabricating tape of this type could be used.

Concerning the use of thermoplastic resin, its mechanical strength is much greater compared with using thermosetting resin, in particular in terms of impact resistance.

The use of thermoplastic resin also makes it easier to make tubes.

Since the invention fabricates elongate elements such as tubes or tubular elements out of a thermoplastic resin, their use must be restricted to locations in which the temperature does not exceed 100°C, i.e. either in the
ground, or at sea where an advantageous application lies in the off-shore industry, in particular for oil installations.

When making tubes that may be as long as 100 m, the tubes are subsequently connected to one another by connector devices that may be made of metal so as to ensure perfect sealing, such devices being commercially available, in particular from the supplier Freyssinet International located in France.

In a variant embodiment, the said core of elongate shape is made of a metal or a metal alloy, in particular steel, preferably stainless steel.

In another variant embodiment, the core is made of a thermoplastic material, in particular "nylon", preferably of the same kind as the thermoplastic resin used for making the matrix of the tape.

In yet another variant embodiment, the thermoplastic resin includes or is constituted by polyamide 11 or polyamide 12.

In yet another advantageous embodiment of the invention, the core presents a shape that is essentially convex.

In a presently preferred embodiment, the core of elongate shape mainly or essentially presents a hollow tubular shape of the tube type.

In an advantageous embodiment of the invention, the tapes are wound around the core at a predetermined angle relative to the longitudinal axis of the elongate element, depending on the mechanical strength desired for the intended application.

For example, said angle lies in the range from 20° to 70°. For applications of the "off-shore type", the intended angle presently lies in the range from 30° to 60°.

For "wind-turbine blade" type applications, the intended angle presently lies in the range from 20° to 70°.
In an advantageous embodiment, it is possible to provide at least one and preferably a plurality of layers of composite material of the same kind or of different kinds, in particular tapes that are different or that are disposed at different winding angles.

In another particular embodiment, it is possible to provide at least one layer made of a composite material comprising a thermoplastic resin and using threads or fibers, e.g. glass threads or fibers, as reinforcement, it being possible to wind said threads or fibers at predetermined winding angles about the preceding layer.

In yet another advantageous embodiment, provision is made for the outermost layer on the elongate element to be made of composite material comprising a plurality of tapes also wound around the preceding layer, said tape comprising a matrix of thermoplastic resin and reinforcement in the form of threads or fibers, e.g. glass or carbon threads or fibers.

By means of the invention, it is no longer necessary to have a protective layer for protecting the elongate element, the layer of thermoplastic composite material itself constituting a protective layer because of its mechanical strength, in particular its impact resistance.

In impact resistance testing, it will be found that for thermosetting resins of the "epoxy" type, the energy needed to achieve rupture is generally one-fifth of the energy needed to rupture thermoplastic resins. This demonstrates the advantage of being able to make elongate elements with thermoplastic resins as in the present invention.

In a second aspect, the present invention also provides a method of fabricating reinforced elongate elements, the method being characterized in that it comprises:

a. providing a support element for supporting a core of elongate shape, the support element including
displacement means for moving the core of elongate shape in translation;

b. providing at least one cassette and advantageously a plurality of cassettes for storing tapes made of composite material comprising a matrix of thermoplastic resin having embedded therein threads or fibers, e.g. threads or fibers of glass or carbon;

c. providing rotary drive means for setting each cassette into rotation;

d. providing synchronization means for synchronizing the displacement in translation of the core of elongate shape and the means for setting each tape-containing cassette into rotation;

e. providing at least one heater device for heating thermoplastic resin to a temperature greater than its melting temperature during a period of time that is sufficient to ensure complete melting of the thermoplastic resin and bonding of the layer of composite material on said core or on the preceding layer;

f. implementing synchronized displacement in translation of the core of elongate shape and winding at a predetermined angle of at least one tape by setting at least one cassette for storing tape into rotation;

g. causing a layer to be formed either by unreeling a sufficient number of tapes to form said layer, or by implementing a plurality of passes in translation of said core to enable said tapes to be wound; and

h. after said heating, cooling or allowing to cool, thus obtaining the reinforced elongate element.

Optionally, the operation of deposing an additional layer or a plurality of layers can be begun again using tapes of a different kind.

Advantageously, means are provided for adjusting the winding angle of each tape about said core.

In an advantageous implementation of the method of the invention, a plurality of successive devices are provided for supporting cassettes of said tapes in order
to deposit a plurality of layers of composite material during a single movement in translation of the element of elongate shape.

In an advantageous implementation of the invention, each tape is wound with predetermined tension, e.g. a traction force of about 1 decanewton (1 kilogram) per tape so that when the thermoplastic resin is melted, the threads or fibers embedded in the resin of each tape are caused to automatically shift towards the center and thus towards the core by an internal tension effect, thereby obtaining a pressing effect against the core or the preceding layer.

According to the invention, the heater device for heating the thermoplastic resin is so oriented as to avoid heating the core or the preceding layer in order to avoid degrading it.

In an advantageous implementation of the invention, the heating is implemented with the help of nozzles delivering hot air at a temperature that is not less than the melting temperature of the thermoplastic resin used.

The invention thus makes it possible to use hot air alone which is naturally less aggressive relative to the matrix than a flame as is used in the prior art.

In an advantageous implementation of the invention, an elongate element is used that is of tubular shape and of arbitrary polygonal or circular section, and that is advantageously hollow so as to form tubes or pipes for transporting material, in particular fluid, and in particular, optionally-liquid gas or oil.

The invention is not restricted to a particular shape of elongate element since by using tapes they can be matched closely to any geometrical shape. Nevertheless, the invention is advantageously used for reinforcing cores that are essentially convex in shape, i.e. that do not include any hollows in their outer surface, since it is extremely difficult to apply said tapes to said hollows.
In a third aspect, the invention also provides apparatus for fabricating reinforced elongate elements, the apparatus being characterized in that it comprises:

a. providing a support element for supporting a core of elongate shape, the support element including displacement means for moving the core of elongate shape in translation;

b. providing at least one cassette and advantageously a plurality of cassettes for storing tapes made of composite material comprising a matrix of thermoplastic resin having embedded therein threads or fibers, in particular threads or fibers of glass or carbon;

c. providing rotary drive means for setting each cassette into rotation;

d. providing synchronization means for synchronizing the displacement in translation of the core of elongate shape and the means for setting each tape-containing cassette into rotation;

e. providing at least one heater device for heating thermoplastic resin to a temperature greater than its melting temperature during a period of time that is sufficient to ensure complete melting of the thermoplastic resin and bonding of the layer of composite material on said core or on the preceding layer;

f. providing control means for synchronized control of synchronization means for synchronizing the movement in translation of the core of elongate shape and of the means for setting each tape storage cassette into rotation; the control means being provided either to wind a number of tapes that is sufficient to form at least one layer of composite material comprising a plurality of tapes wound around the core of elongate shape, or to perform a plurality of passes in translation of said core in order to wind said tapes; and

g. said control means being provided to control each heater device to heat to a temperature greater than a
melting temperature of the thermoplastic resin during a period of time that is sufficient to melt completely the thermoplastic resin and bond a layer of composite material on said core or on the preceding layer.

With apparatus of the invention, in order to accelerate cooling of the resulting reinforced elongate element, it is possible to provide cooling means downstream from the heater device(s).

In a variant embodiment of the apparatus of the invention, the apparatus can be designed to allow the operation to be started again in order to deposit an additional layer or a plurality of layers with tapes of a different kind. In this context, provision can also be made for at least one second assembly comprising at least one cassette and advantageously a plurality of cassettes for storing tapes, either identical in kind or of different kinds.

Thus, in an advantageous embodiment of the apparatus of the invention, a plurality of successive devices are provided for supporting cassettes of said tapes, so as to make an element of elongate shape in a single movement in translation with a plurality of layers of composite materials deposited thereon.

In another advantageous embodiment of the apparatus of the invention, tension adjustment means can be provided for adjusting the winding tension of each tape to a predetermined value, e.g. by providing for said tension adjustment means to enable adjustment to be performed on a traction force of about 1 decanewton (1 kilogram) per tape, such that while the thermoplastic resin is melted, the threads or fibers embedded in the resin of each tape are automatically shifted towards the center and thus towards the core, by adding an internal tension effect, thereby achieving an effect of pressing against the core or the preceding layer.

In an advantageous embodiment of the invention, the heater device for heating the thermoplastic resin is so
oriented as to avoid heating the core or the preceding layer in order to avoid degrading it.

In yet another advantageous embodiment of the apparatus of the invention, provision can be made for the heater device to comprise nozzles delivering hot air at a temperature that is not less than the melting temperature of the thermoplastic resin used.

In a fourth aspect, the present invention also covers the use of the above-mentioned reinforced elongate elements, in particular as obtained by the method of the invention or from the fabrication apparatus of the invention, in order to fabricate pipes for burying in the ground or for use off-shore, in particular on the sea bed.

It can thus be understood that the invention does indeed enable the above-specified technical problems to be solved, and consequently provides a solution that is novel and not obvious to the person skilled in the art.

Other objects, characteristics, and advantages of the invention appear clearly in the light of the following explanatory description made with reference to a presently preferred embodiment of an apparatus of the invention, and enabling the above-described method of the invention to be implemented, the embodiment being given purely by way of illustration and thus not limiting the scope of the invention in any way.

The apparatus of the invention is shown in the accompanying figures, and forms an integral part of the invention, and as a result any characteristic of the apparatus that appears to be novel over any state of the art is claimed both as general means and functionally, as are technical equivalents thereof.

In the examples, temperatures are given in degrees Celsius, the pressure is atmospheric pressure, and the atmosphere is air unless specified to the contrary.
Figure 1 is a simplified overall side view of a first embodiment of an apparatus of the invention, given by way of illustration.

Figure 2 is an enlarged view of a portion of the apparatus made in accordance with the invention and showing the means for imparting rotation, e.g. in the form of a wheel or turntable, serving to support the tape-containing cassettes.

Figure 3 is an enlarged view of a portion of the apparatus made in accordance with the invention showing the detail of the operation of laying the tapes contained in the cassettes.

Figure 4 shows the detail of a cassette, showing clearly how the tape is stored reeled on the cassette and how it is unreeled.

Figure 5 shows the detail of a reinforced element of elongate shape obtained by the invention with a layer made up of a plurality of tapes 32.

Figure 6 is a detail view referenced VI in Figure 5 showing the construction of a tape made by combining a matrix of thermoplastic material and reinforcing threads or fibers, e.g. threads or fibers of glass or carbon.

With reference to Figures 1 to 6, an apparatus of the invention is given overall reference number 10 and is characterized in that it comprises:

a. Providing a support element 20 for supporting a core 22 of elongate shape, having displacement means enabling said core of elongate shape to be moved in translation T, said displacement means being well known to the person skilled in the art and therefore not shown therein.

b. Providing at least one cassette 30, and advantageously a plurality of cassettes 30 (here 12) for storing tapes 32 made of composite material comprising a matrix (34) of thermoplastic resin having reinforcing threads or fibers (35) embedded therein, e.g. glass or carbon threads or fibers.
c. Providing rotary drive means 36 for each cassette 30, said rotary drive means 36 comprising for example a rotary shaft 37 about which the cassettes 30 are free to rotate. In the presently preferred embodiment shown in Figure 1, the rotary shafts 37 are themselves supported by a turntable 38, itself set into rotation by conventional rotary drive means well known to the person skilled in the art. These elements together constitute the rotary drive means 36 for each cassette 30.

d. Providing conventional synchronization means (61) well known to the person skilled in the art, and in order to simplify the figure, represented herein by displacement means 20 for moving the core 22 of elongate shape in translation, and means 36 for imparting rotary drive to each tape-containing cassette 30, by the presence of two respective connections 62 and 64.

e. Providing at least one heater device 50 for heating the thermoplastic resin 34 to a temperature higher than its melting temperature during a length of time that is sufficient to achieve complete melting of the thermoplastic resin and bonding of the layer 33 of composite material on said core 22 or on the preceding layer.

f. Providing control means 60 for synchronized control over a connection 68 of the synchronization means 61, the means 20 for moving the core 22 of elongate shape in translation, and the means 36 for imparting rotary drive to each tape-containing cassette 30.

These control means 60 are designed:

- either to unreel a number of tapes 32 that is sufficient to form at least one layer 33 of composite material comprising a plurality of tapes wound around the core 22 of elongate shape (as shown in Figure 1 and even more visible in Figures 2 and 3);

- or else to perform a plurality of passes in translation of said core so as to wind said tapes in
equivalent manner and as is easily understood by a person skilled in the art.

g. The control means 60 are also designed to act over a connection 66 to cause each heater device 50 to take up a temperature greater than a melting temperature of the thermoplastic resin 34 during a length of time that is sufficient to melt the thermoplastic resin 34 completely and bond a layer 33 of composite material on said core 22 or on the preceding layer.

In the context of the invention, in order to accelerate the cooling of the resulting reinforced elongate element, cooling means 70 may be provided downstream from the heater means 50, as is readily understandable for a person skill in the art. The control means 60 are also advantageously designed to control the cooling means 70 via an appropriate connection 72.

In an advantageous embodiment of an apparatus of the invention, the apparatus 10 may be designed to enable the operation to be restarted in order to deposit an additional layer or a plurality of layers using tapes 32 of different kinds. In this context, it is possible to provide at least one second assembly 38 having at least one cassette 30 and advantageously a plurality of cassettes 30 for storing tapes 32 either of identical kind or of different kinds.

It can thus readily be understood that in an advantageous embodiment of the apparatus of the invention, a plurality of successive devices 38 or turntables are provided for supporting cassettes 30 for storing tapes 32 so that an element 12 of elongate shape can be made during a single movement in translation with a plurality of layers of composite material being deposited thereon, whether the layers are identical in kind or of different kinds.

In yet another advantageous embodiment of the apparatus of the invention, provision can be made for
means such as 80, 82 for adjusting tension to a predetermined tension value in the reel of each tape 32, e.g. by providing tension adjustment means 80, 82 enabling an adjustment to be made on a traction force of about 1 decanewton (1 kilogram) per tape 32, such that when the thermoplastic resin 34 melts, the threads or fibers embedded in the resin of each tape 32 are automatically shifted towards the center and thus towards the core by an internal tension effect, thereby pressing them against the core or the preceding layer. The turntable 38 may also have a frustoconical portion 46 supporting the means 82, together with a disk-forming element 48 supporting the means 40 for guiding the tapes 32, e.g. comprising rods 42 and studs 44 (see Figure 3).

In yet another advantageous embodiment of the invention, each heater device 50 for heating the thermoplastic resin 34 is so oriented as to avoid heating the core or the preceding layer, so as to avoid degrading it.

In yet another advantageous embodiment of the apparatus of the invention, provision can be made for each heater device 50 to comprise nozzles 52 delivering hot air at a minimum temperature greater than the melting temperature of the thermoplastic resin 34 used. These nozzles 52 may naturally be made so as to be steerable, thereby enabling them to be directed at an appropriate angle of orientation for diffusing the hot air under the best heating conditions.

Various embodiments of the elongate element 12 and in particular of the core 22 and of the tapes 32 are described in the introductory portion of the description.

It can thus be understood that the invention makes it possible to solve the above-specified technical problems and consequently it presents a solution that is novel and not obvious to a person skilled in the art. The invention, as described above for the apparatus, also enables the method of fabricating the elongate element 12
reinforced by at least one layer 33 to be implemented in the manner described above in the introductory portion of the present description.

As specified above, the invention also covers any means constituting technical equivalents of the means described and shown in the accompanying figures which form integral portions of the invention.
CLAIMS

1. A reinforced elongate element (12) comprising a core (22) of elongate shape coated with at least one layer (33) of composite material comprising a plurality of tapes (32) wound around said core (22), each of the tapes (32) being made from reinforcing threads or fibers (35), e.g. glass or carbon threads or fibers, embedded in a matrix (34) of thermoplastic resin.

2. An elongate element according to 1, characterized in that said core (22) of elongate shape is made of a metal or a metal alloy, in particular steel, preferably stainless steel.

3. An elongate element according to claim 1, characterized in that the core (22) is made of a thermoplastic material, in particular "nylon", preferably of the same kind as the thermoplastic resin used for making the matrix (34) of the tape (32).

4. An elongate element according to any one of claims 1 to 3, characterized in that the thermoplastic resin includes or is constituted by polyamide 11 or polyamide 12.

5. An elongate element according to any one of claims 1 to 4, characterized in that the core (22) presents a shape that is essentially convex.

6. An elongate element according to any one of claims 1 to 5, characterized in that the tapes are wound around the core at a predetermined angle relative to the longitudinal axis of the elongate element, depending on the mechanical strength desired for the intended application.
7. An elongate element according to claim 6, characterized in that said angle lies in the range from 20° to 70°.

8. An elongate element according to claim 6 or claim 7, characterized in that for applications of the "off-shore" type the intended angle presently lies in the range from 30° to 60°.

9. An elongate element according to claim 6 or claim 7, characterized in that for "wind-turbine blade" type applications, the intended angle presently lies in the range from 20° to 70°.

10. An elongate element according to any one of claims 1 to 9, characterized in that it can be provided at least one and preferably a plurality of layers of composite material of the same kind or of different kinds, in particular tapes that are different or that are disposed at different winding angles.

11. An elongate element according to any one of claims 1 to 10, characterized in that it can be provided at least one layer made of a composite material comprising a thermoplastic resin and using threads or fibers (35), e.g. glass threads or fibers, as reinforcement, it being possible to wind said threads or fibers (35) at predetermined winding angles about the preceding layer.

12. An elongate element according to any one of claims 1 to 11, characterized in that provision is made for the outermost layer on the elongate element to be made of composite material comprising a plurality of tapes also wound around the preceding layer, said tapes comprising a matrix of thermoplastic resin and reinforcement in the form of threads or fibers, e.g. glass or carbon threads or fibers.
13. A method of fabricating reinforced elongate elements (12), the method being characterized in that it comprises:

a. providing a support element (20) for supporting a core (22) of elongate shape, the support element including displacement means for moving the core (22) of elongate shape in translation;

b. providing at least one cassette (30), and advantageously a plurality of cassettes (30), for storing tapes (32) made of composite material comprising a matrix (34) of thermoplastic resin having embedded therein threads or fibers (35), e.g. threads or fibers of glass or carbon;

c. providing rotary drive means (36) for setting each cassette (30) into rotation;

d. providing synchronization means for synchronizing the displacement (20) in translation of the core (20) of elongate shape and the means (38) for setting each tape-containing cassette (30) into rotation;

e. providing at least one heater device (50) for heating thermoplastic resin (34) to a temperature greater than its melting temperature during a period of time that is sufficient to ensure complete melting of the thermoplastic resin and bonding of the layer (33) of composite material on said core (22) or on the preceding layer;

f. implementing synchronized displacement in translation of the core (22) of elongate shape and winding at a predetermined angle of at least one tape (32) by setting at least one cassette (30) for storing tape (32) into rotation;

g. causing a layer (33) to be formed either by unreeling a sufficient number of tapes (32) to form said layer (33), or by implementing a plurality of passes in translation of said core (22) to enable said tapes (32) to be wound; and
h. after said heating, cooling or allowing to cool, thus obtaining the reinforced elongate element (12).

14. A method according to claim 13, characterized in that means (80, 82) are provided for adjusting the winding angle of each tape (32) about said core (22).

15. A method according to claim 13 or claim 14, characterized in that, a plurality of successive devices (38) are provided for supporting cassettes (30) of said tapes (32) in order to deposit a plurality of layers (33) of composite material during a single movement in translation of the element (12) of elongate shape.

16. A method according to any one of claims 13 to 15, characterized in that each tape (32) is wound with predetermined tension, e.g. a traction force of about 1 decanewton (1 kilogram) per tape so that when the thermoplastic resin (34) is melted, the threads or fibers (35) embedded in the resin (34) of each tape (32) are caused to automatically shift towards the center and thus towards the core (22) by an internal tension effect, thereby obtaining a pressing effect against the core (22) or the preceding layer (33).

17. A method according to any one of claims 13 to 16, characterized in that the heater device (50) for heating the thermoplastic resin (34) is so oriented as to avoid heating the core (22) or the preceding layer (33) in order to avoid degrading it.

18. A method according to any one of claims 13 to 17, characterized in that the heating is implemented with the help of nozzles (52) delivering hot air at a temperature that is not less than the melting temperature of the thermoplastic resin (34) used.
19. Apparatus for fabricating reinforced elongate elements (12), the apparatus being characterized in that it comprises:
   a. providing a support element (20) for supporting a core (22) of elongate shape, the support element including displacement means for moving the core (22) of elongate shape in translation;
   b. providing at least one cassette (30), and advantageously a plurality of cassettes (30), for storing tapes (32) made of composite material comprising a matrix (34) of thermoplastic resin having embedded therein threads or fibers (35), in particular threads or fibers of glass or carbon;
   c. providing rotary drive means (36) for setting each cassette (30) into rotation;
   d. providing synchronization means for synchronizing the displacement (20) in translation of the core (20) of elongate shape and the means (36) for setting each tape-containing cassette (30) into rotation;
   e. providing at least one heater device (50) for heating thermoplastic resin (34) to a temperature greater than its melting temperature during a period of time that is sufficient to ensure complete melting of the thermoplastic resin and bonding of the layer (33) of composite material on said core (22) or on the preceding layer;
   f. providing control means (60) for synchronized control of synchronization means (61) for synchronizing the movement in translation of the core (22) of elongate shape and of the means (38) for setting each tape storage cassette (30) into rotation; the control means (60) being provided either to wind a number of tapes (32) that is sufficient to form at least one layer (33) of composite material comprising a plurality of tapes (32) wound around the core (22) of elongate shape, or to perform a plurality of passes in translation of said core (22) in order to wind said tapes (32); and
g. said control means (60) being provided to control each heater device (50, 52) to heat to a temperature greater than a melting temperature of the thermoplastic resin during a period of time that is sufficient to melt completely the thermoplastic resin and bond a layer of composite material on said core (22) or on the preceding layer (33).

20. Apparatus according to claim 19, characterized in that in order to accelerate cooling of the resulting reinforced elongate element (12), cooling means (70) are provided downstream from the heater device(s) (50).

21. Apparatus according to claim 19 or claim 20, characterized in that the apparatus comprises a plurality of successive devices (38) for supporting cassettes (30) for storing tapes (32) either of identical kind or of different kinds, so as to deposit a plurality of layers of composite materials in a single movement in translation of a core (22) or an element (12) of elongate shape.

22. Apparatus according to any one of claims 19 to 21, characterized in that the apparatus (10) includes tension adjustment means (80, 82) for adjusting the winding tension of each tape (32) to a predetermined value, e.g. by providing for said tension adjustment means (80, 82) to provide adjustment on a traction force of about 1 decanewton (1 kilogram).

23. Apparatus according to any one of claims 19 to 22, characterized in that the heater device (50, 52) for heating the thermoplastic resin is so oriented as to avoid heating the core (22) or the preceding layer (33) in order to avoid degrading it.
24. Apparatus according to any one of claims 19 to 23, characterized in that the heater device (50) comprises nozzles (52) delivering hot air at a temperature that is not less than the melting temperature of the thermoplastic resin (34) used.

25. The use of reinforced elongate elements as defined in any one of claims 1 to 12, in particular as obtained by the method according to any one of claims 13 to 18, or from the fabrication apparatus according to any one of claims 19 to 24 for fabricating pipes for burying in the ground or for use off-shore, in particular on the sea bed.
A. CLASSIFICATION OF SUBJECT MATTER
F16L9/12  B29C53/64  B29C70/38

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)
B29C  F16L

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>US 6 605 171 B1 (DEBALME JEAN-PAUL ET AL)</td>
<td>1,3,5-7, 10-12,25</td>
</tr>
<tr>
<td></td>
<td>12 August 2003 (2003-08-12) column 1, line 4 - line 14</td>
<td></td>
</tr>
<tr>
<td></td>
<td>column 2, line 58 - line 64</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>column 7, line 1 - line 63; figures 1a,2a</td>
<td>17,18, 23,24</td>
</tr>
</tbody>
</table>

X PATENT ABSTRACTS OF JAPAN

X Further documents are listed in the continuation of box C.

X Patent family members are listed in 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 doubt on priority claim(s) or which is cited to establish the publication date of another document 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.

*"A" document member of the same patent family

Date of the actual completion of the international search: 13 December 2005

Date of mailing of the international search report: 19/12/2005

Name and mailing address of the ISA:
European Patent Office, P.B. 5816 Patentlaan 2
NL - 2280 HJ RIJKWIJK
Tel: (+31-70) 340-2040, Tx: 31 651 epo nl, Fax: (+31-70) 340-2016

Authorized officer:
Pierre, N
<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>US 5 122 211 A (ROACH ET AL) 16 June 1992 (1992-06-16) column 1, line 24 - line 32 column 2, line 47 - line 59; figure 1 column 3, line 28 - line 35 column 3, line 41 - line 51; figure 2</td>
<td>1,2,5,12</td>
</tr>
<tr>
<td>A</td>
<td>FR 2 031 719 A (VERRE TEXTILE STE) 20 November 1970 (1970-11-20) cited in the application page 1, line 1 - line 3 page 2, line 4 - line 22</td>
<td>4</td>
</tr>
<tr>
<td>A</td>
<td>US 4 990 213 A (BROWN ET AL) 5 February 1991 (1991-02-05) column 5, line 24 - line 30 column 7, line 67 - column 8, line 42; figures 10a-10f column 7, line 17 - line 42</td>
<td>17,18,23,24</td>
</tr>
<tr>
<td>A</td>
<td>RU 2 055 734 C1 (URALSKIJ NAUCHNO-ISSLEDOVATELSKII INSTITUT KOMPOZITSIUNYKH MATERIALOV) 10 March 1996 (1996-03-10) figure 1</td>
<td>1-25</td>
</tr>
<tr>
<td>A</td>
<td>US 5 755 266 A (AANONSEN ET AL) 26 May 1998 (1998-05-26) claims 1,3; figure 2</td>
<td>1-25</td>
</tr>
<tr>
<td>A</td>
<td>US 5 700 347 A (MCCONIN ET AL) 23 December 1997 (1997-12-23) column 4, line 43 - line 52 column 4, line 64 - column 5, line 4; figure 1 column 5, line 39 - line 48 column 8, line 24 - line 29</td>
<td>1-25</td>
</tr>
<tr>
<td>Patent document cited in search report</td>
<td>Publication date</td>
<td>Patent family member(s)</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>-----------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AU 6208799 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BR 9914693 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CA 2347147 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CN 1118364 C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CZ 20011443 A3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 69904742 D1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EP 1123194 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ES 2189496 T3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FR 2784930 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 0024566 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HU 0104232 A2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 2002528295 T</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MX PA01003269 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NO 20011971 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PL 347926 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SK 5432001 A3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TR 200101133 T2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ZA 200102212 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 7004875 B</td>
</tr>
<tr>
<td>US 5122211 A</td>
<td>16-06-1992</td>
<td>NONE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CH 527248 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DE 2004555 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DK 138168 B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ES 376196 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FI 55622 B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GB 1259085 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LU 60304 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NL 7001823 A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NO 130864 B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SE 394898 B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 3703396 A</td>
</tr>
<tr>
<td>EP 0122884 A</td>
<td>24-10-1984</td>
<td>IT 1161116 B</td>
</tr>
<tr>
<td>US 4990213 A</td>
<td>05-02-1991</td>
<td>NONE</td>
</tr>
<tr>
<td>RU 2055734 C1</td>
<td>10-03-1996</td>
<td>NONE</td>
</tr>
<tr>
<td>US 5755266 A</td>
<td>26-05-1998</td>
<td>NONE</td>
</tr>
<tr>
<td>US 5700347 A</td>
<td>23-12-1997</td>
<td>NONE</td>
</tr>
</tbody>
</table>