**Title:** APPARATUS AND METHOD FOR MANUFACTURING A FIBER-REINFORCED TUBE

(57) **Abstract:** An apparatus for manufacturing a fiber-reinforced tube, comprising a carrier for carrying a tube core (4) and a head (5), wherein the head and tube core are arranged so as to be translatable with respect to each other, and wherein the head is provided with a feeding device for operatively feeding a strip (6) of fiber material to the outer surface of the tube core, wherein the feeding device is provided with a pressure body (9) arranged so as to be rotatable about the centerline of the tube core, which pressure body operatively applies the fiber material to the outer surface under radial pressing force. The invention further relates to a method for manufacturing a fiber-reinforced tube (2), wherein, with the aid of a pressure body arranged so as to be rotatable about the centerline of a tube core, a strip of fiber-reinforced material is applied to the outer surface of the translatably arranged tube core under radial pressing.
before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
Title: Apparatus and method for manufacturing a fiber-reinforced tube

The invention relates to an apparatus for manufacturing a fiber-reinforced tube, comprising a carrier for carrying a tube core and a head, wherein the head and carrier are arranged so as to be translatable with respect to each other and wherein the head is provided with a feeding device for operatively feeding a strip of fiber material to the outer surface of the tube core.

Such an apparatus is generally known and is used for manufacturing composite tubes.

In the known apparatus, the strip of fiber-reinforced material is tangentially fed to the outer surface.

What is disadvantageous thereof is that the pressing force depends on the winding angle at which the strip of material is applied to the outer surface.

During winding with a small winding angle, with the strip including an acute angle with the longitudinal axis of the tube core, a relatively large tensile stress is needed to press the strip on the outer surface of the tube core. In some cases, this makes it impossible to provide sufficient pressing force, while, in addition, a relatively large residual stress is left behind in the wound fiber material.

The invention contemplates an apparatus of the type stated in the opening paragraph, with which the drawbacks mentioned can be obviated while maintaining the advantages. In particular, the invention contemplates an apparatus which is suitable for manufacturing continuous tube lengths, i.e. tube lengths with relatively long lengths, in particular tube lengths of more than 20 m, preferably more than 50 m.
To this end, the apparatus according to the invention is characterized in that the feeding device is provided with a pressure body arranged so as to be rotatable about the centerline of the tube core, which pressure body operatively applies the strip of fiber material to the outer surface under radial pressing force.

Thus, it can be achieved that the pressing force can be chosen independently of the winding angle, so that the tensile stress on the strip of fiber material can be relatively low during winding.

Thus, the winding angle can even be set at 0°, so that the strips of fiber material extend parallel to the centerline of the tube core.

The invention further relates to a method for manufacturing a fiber-reinforced tube, where, with the aid of a pressure body arranged so as to be rotatable about the centerline of the tube core, a strip of fiber material is applied to the outer surface of the tube core arranged so as to be translatable.

Further advantageous embodiments of the invention are shown in the subclaims. The invention will now be explained in more detail on the basis of an exemplary embodiment shown in the drawing, in which:

Fig. 1 shows a schematic front view of the winding apparatus in axial direction of the tube core;

Fig. 2 shows a schematic cross-section of the winding apparatus in side elevational view; and

Fig. 3 shows a perspective partly cross-sectional view of the winding apparatus.

The drawing only shows a schematic representation of a preferred embodiment of the invention which is given here by way of non-limiting exemplary embodiment. In the Figures, same or corresponding parts are designated by same reference numerals.

Figs. 1-3 show a winding apparatus 1 for manufacturing a fiber-reinforced tube 2. The apparatus 1 comprises a carrier 3 for carrying a
tube core 4. In the Figures, for the sake of clarity, the carrier is not shown, but may, for instance, comprise a roller conveyor, a conveyor belt, bed or different supporting support device. The supporting support device is preferably interrupted at the location of the head to facilitate the application of the fibers. In this exemplary embodiment, the tube core is unwound from a reel and, after feed-through through the head, is wound on a reel as a tube. Of course, the carrier may also be designed as a spindle between which the tube core is clamped.

The apparatus further comprises a head 5. The tube core 4 is arranged with respect to the head 5 so as to be translatable in the direction of arrow P2. In this exemplary embodiment, the tube core 4 is designed as a prefabricated inner tube, for instance from plastic or steel. In this case, the inner tube forms a fluid-tight internal lining for the fiber-reinforced tube 2 to be formed, and is here manufactured from thermoplastic material. Of course, it is also possible for the tube core to be formed by a mandrel which is later detached from the fiber-reinforced tube formed or a supporting mandrel along which the tube to be formed moves.

The head 5 is provided with a feeding device 6 for operatively feeding a strip of fiber material 8 to the outer surface 7 of the tube core 4. The feeding device 6 is provided with a pressure body 9 arranged so as to be rotatable about the centerline H of the tube core 4, which pressure body 9 operatively applies the fiber material of the strip 8 to the outer surface 7 in the direction of the direction indicated by the arrow R under radial pressing force. It will be clear that, here, the pressing force can also contain a tangential component, for instance when, as a consequence of the relative translation, the resulting pressing force is somewhat oblique with respect to the outer surface.

The feeding device 6 is designed to feed the strip of fiber material 8 to the pressure body 9 in a feeding direction T which deviates from the tangent line K to the outer surface 7 at the location of the contact surface C between
pressure body 9 and outer surface 7. Such a contact surface C is also
referred to by the term "nip point" by a skilled person. Thus, with a feeding
direction deviating from the tangent line, the "nip point" forced with the
pressure body is located at a different position from where the natural "nip
point" would be located.

The feeding device 6 is designed to feed the strip 8 over at least a part
of the feed path B formed with the strip to the pressure body 9 in
substantially radial direction with respect to the centerline H of the tube
core 4.

The pressure body 9 is provided with a guide surface 11 for
reorienting the strip of fiber material 8 into a tangential feeding direction,
i.e. a feeding direction along the tangent line K.

Here, the pressure body 9 is designed as a pressure roller rolling
along the outer surface 7 of the tube core 4. In this embodiment, each time,
a part of the outer surface 12 of the pressure roller 9 forms the guide
surface 11. It will be clear that the pressure body may also be designed in a
different manner, for instance as a guide plate or a shoe.

The pressure body 9 is arranged so as to be non-translatabile with
respect to the fixed world. The tube core 4 is arranged so as to be axially
translatable with respect to the pressure body 9.

In the Figures, the rotation of the pressure body 9 about the
centerline H of the tube core is indicated by P1, while translation of the tube
core with respect to the pressure body 9 is indicated by the arrow P2.

The pressure body 9 is adjustable about a pivot Z which at least
partly coincides with the path B along which the strip of fiber material 8 is
fed to the pressure body 9. This allows the winding angle to be set. The
pressure body 9 is adjustable into a position in which it delivers the strip of
fiber material 8 substantially parallel to the centerline H. In such a case,
there is no rotation of the pressure body 9 about the centerline H.
Fig. 1 shows that the pressure body 9 is pivotable about a pivot Zw which extends substantially in radial direction with respect to the centerline H of the tube core 4. Preferably, the pivot Zw runs through the pressure body 9, and in particular the pivot Zw intersects the contact surface C. Thus, it can be achieved that the pressure body 9 can have a symmetrical design, and that it can have the largest pressing force in the center. Further, the path traveled by the strip of fiber material 8 does not depend or depends only to a small extent on the extent of pivotal movement of the pressure body about the pivot Zw, and therefore depends on the winding angle only to a small extent. Further, with the same pressure body 9, both positive and negative winding angles can be wound, which is an advantage when, in successive steps, strips of fiber material are applied to the outer surface of the tube with opposite winding angles.

As is shown in Fig. 2, the head 5 may be provided with a multiple number of feeding devices 6 each provided with a pressure body. By arranging at least a part of the pressure bodies 9 axially along the centerline H so as to be staggered with respect to one another, also with a small winding angle, the outer surface 7 of the tube core 4 can be covered in one step. Preferably, the fibers of the strips have the same winding angle per step.

As shown, the apparatus 1 may optionally be provided with heating means 13 stationarily arranged with respect to the fixed world. The stationarily arranged heating means 13 are designed for heating the space 10 tapering in feeding direction of the strip 8 towards the pressure body 9, which space has formed between the strip 8 and the outer surface 7. By, for instance, blowing hot gas into this gap 10, thermoplastic matrix material of the strip of fiber-reinforced thermoplastic material 8 can be melted during winding, so that it is welded onto the tube core 4. The hot gas may, for instance, be inert gas or air. As a result, in one process step, a consolidated tube can be obtained. With a thermosetting matrix material,
such a heating 13 is less important, and the tube formed may, for instance, be cured in an oven.

As shown, the apparatus may further optionally be provided with preheating means 14 which are arranged so as to rotate along about the centerline H of the tube core 4. Such preheating means 14 preferably comprise a ceramic heating plate or similar electric heating, preferably infrared heating, arranged along the feed path B of the strip 8. The main heating 13 preferably comprises a gas burner, but may of course also be any other type of heating.

About the heating means, in general, the following is noted.

The heating means may, for instance, be a gas burner, such as a propane or hydrogen burner. The heating means may also be electric, for instance electrically heated ceramic tiles or infrared radiators. The heating means may further be designed as lasers.

In an advantageous manner, the heating means are designed as gas burners with which gas is burnt in ceramic foam. With such burners, in addition to gases heated by the burning, the infrared radiation emitted by the ceramic foam can be used well.

For the sake of completeness, it is noted that it is also possible to heat the tube only after the fiber-reinforced material has been applied. However, it is preferred to heat during the application, so that a good weld is formed of the thermoplastic material.

In an advantageous manner, further, heating means may be provided which heat the bearing rollers of the prestressing mechanism 15 and/or in particular the pressure body 9 to heat the thermoplastic matrix material of the strip of fiber material. Preferably, such heating means are designed as inductive heating means which contactlessly heat the bearing rollers and/or the pressure body.

Fig. 2 shows that, in the feeding device 6, the strip of fiber material 8 is taken from a stock 18 received in a cassette, for instance a stock roll. The
feeding device 6 is provided in a prestressing mechanism 15 for stressing the strip 8 with a relatively low prestress. This is because the stress in the strip is not necessary for providing the radial pressing force R. This force is provided by the pressure body 9.

Further, it is well visible in Fig. 2 that the pressure roller 9 is pivotal about a pivot Z extending in radial direction with respect to the centerline H of the tube core 4, and that this pivot Z at least partly coincides with a part of the feed path B of the strip of fiber material 8. It is thus achieved that, during setting of the winding angle, the feeding of the tape 8 through the path B is disturbed as little as possible by torsion.

With the aid of a bearing 16, the head 5 is rotationally connected with the machine frame 17 via a drive. The tube core 4 is feed with its centerline H through the center of the annular head 5.

During use, the tube core 4 is axially translated through the head 5, here in the direction of the closed arrow P2, while the head rotates about the centerline H more or less rapidly depending on the winding angle.

In this exemplary embodiment, the strip of fiber material 8 comprises a bundle of long fibers substantially extending in feeding direction. The strip 8 is substantially flat with a substantially rectangular cross section. The fiber material is, for instance, a bundle of glass fibers included in a matrix from polyethene or a bundle of polypropylene fibers included in a matrix material from polypropylene having a lower melting point than the fibers. The strip of fiber material forms one whole with the matrix material, and is a prefabricated tape, also called prepreg tape.

The strip 8 forms a thermoplastic tape which is preheated with the aid of the preheating 14 and is then melted at the location of the pressure roller 9 with the aid of the main heating 13. By melting the thermoplastic matrix material and optionally the outer surface material of the inner tube or strips previously wound around the tube core 4, which then form the outer surface, the fibers of the strip 8 can be welded to the outer surface 10.
under the influence of the radial pressing force $R$ exerted by the pressure body 9.

Simultaneously melting and pressing the fiber-reinforced thermoplastic material during the application of the preimpregnated tapes on the outer surface allows the processing speed to be high, and allows a consolidated tube to be obtained in one processing step.

By heating the thermoplastic tape before application, the respective winding layer of tube 2 is ready shortly after application of the tape 8 and no additional processing step is needed, like with thermosetting material which still needs to cure after application. Also, thus, the winding process can be stopped and be started again at any moment, for instance for carrying out a quality inspection. Further, there is no limitation of the processing time, so that long products can be wound in one time, or multiple layers can be applied one shortly after the other.

As is well visible in Fig. 3, the strip of fiber material 8 is fed over at least a part of the feed path to the pressure body 9 in a substantially radial direction with respect to the centerline $H$ of the tube core 4. The strip of fiber material 8 is reoriented into a tangential direction with the aid of the pressure body 9.

The strip of fiber material 8 is pressed on the outer surface 7 with the aid of a pressure roller 9 rolling along the outer surface 7 of the tube core 4. When the carrier is designed as a bed or a conveyor belt, it can be achieved that a relatively long, thin tube does not bend during the processing.

The invention further relates to a tube, comprising a thermoplastic tube core with one or more prefabricated strips of fiber-reinforced thermoplastic tape material applied to the outer surface of the tube core, comprising a substantially flat bundle of substantially parallel running fibers included in thermoplastic matrix material, the fibers having a
winding angle of less than about 15°, in particular less than about 10°, with respect to the centerline of the tube core. In an advantageous manner, the winding angle of such a winding layer may even be about 0°. With such a relatively small winding angle, an optimal design can be realized for tubes which are loaded in axial direction. In addition, winding can take place rapidly. Also, in the case of a winding angle of about 0°, it is relatively simple to provide a tube with a non-round cross section.

Also, with the aid of the winding apparatus and winding method described hereinabove, winding can take place with relatively low tensile stress, for instance lower than about 8 N/mm or even lower than about 5 N/mm, so that the residual stress in the tube can be low. The thickness of the tape of fiber material is, for instance, less than 1 mm and preferably 0.5 mm or 0.2 mm. Such a tube can be wound on a reel, and can have a length of more than 1000 m.

The invention is not limited to the embodiment shown herein.

Thus, the carrier may, for instance, translate back and forth with respect to the head, so that multiple layers of fiber material can be applied. Further, the winding apparatus may comprise multiple heads.

Such variations will be readily apparent to a skilled person and are understood to be within the scope of the following claims.
CLAIMS

1. An apparatus for manufacturing a fiber-reinforced tube, comprising a carrier for carrying a tube core and a head, wherein the head and carrier are arranged so as to be translatable with respect to each other, and wherein the head is provided with a feeding device for operatively feeding a strip of fiber material to the outer surface of the tube core, wherein the feeding device is provided with a pressure body arranged so as to be rotatable about the centerline of the tube core, which pressure body operatively applies the strip of fiber material to the outer surface under radial pressing force.

2. An apparatus according to claim 1, wherein the pressure roller is arranged so as to be pivotable about a pivot which runs substantially in radial direction with respect to the centerline of the tube core.

3. An apparatus according to claim 1 or 2, wherein the pivot runs through the pressure body.

4. An apparatus according to any one of the preceding claims 1-3, wherein the pivot intersects the contact surface between pressure body and outer surface.

5. An apparatus according to any one of the preceding claims, wherein the pressure body is arranged so as to be non-translatable with respect to the fixed world and wherein the tube core is arranged so as to be axially translatable with respect to the pressure body.

6. An apparatus according to any one of the preceding claims, wherein the feeding device is designed to feed the strip of fiber material to the pressure body in a direction which deviates from the tangent line to the outer surface at the location of the contact surface between pressure body and outer surface.

7. An apparatus according to any one of claims 1-6, wherein the feeding device is designed to feed the strip of fiber material over at least a part of
the feed path to the pressure body in substantially radial direction with respect to the centerline of the tube core.

8. An apparatus according to any one of the preceding claims, wherein the pressure body is provided with a guide surface for reorienting the strip of fiber material into a tangential feeding direction.

9. An apparatus according to any one of the preceding claims, wherein the pressure body comprises a pressure roller rolling along the outer surface of the tube core.

10. An apparatus according to any one of the preceding claims, wherein the pressure body is adjustable about a pivot which at least partly coincides with the path in which the strip of fiber material is fed to the pressure body.

11. An apparatus according to any one of the preceding claims, wherein the pressure body is adjustable into a position in which it delivers the strip of fiber material substantially parallel to the centerline.

12. An apparatus according to any one of the preceding claims, wherein the head is provided with a multiple number of feeding devices provided with a pressure body.

13. An apparatus according to claim 12, wherein at least a number of the pressure bodies are axially staggered with respect to one another.

14. An apparatus according to any one of the preceding claims, wherein heating means arranged stationarily with respect to the fixed world are provided.

15. An apparatus according to claim 14, wherein the stationarily arranged heating means are designed for heating the space between strip and outer surface which tapers in the feeding direction of the strip towards the pressure body.

16. An apparatus according to any one of the preceding claims, wherein heating means arranged so as to rotate along with the pressure element with respect to the centerline of the tube core are provided, which heating means preferably form preheating means.
17. An apparatus according to claim 16, wherein the heating means comprise a ceramic heating plate arranged along the feed path of the strip.

18. An apparatus according to any one of the preceding claims, wherein, for the purpose of the translation of the tube core, a support for the tube is provided, in particular a roller conveyor.

19. An apparatus according to any one of the preceding claims, wherein heating means which heat the pressure body and/or the guide rollers are provided.

20. An apparatus according to claim 19, wherein the heating means comprise an induction heating.

21. A method for manufacturing a fiber-reinforced tube, wherein, with the aid of a pressure body arranged so as to be rotatable about the centerline of a tube core, under radial pressing, a strip of fiber material is applied to the outer surface of the tube core arranged so as to be translatable.

22. A method according to claim 21, wherein the strip of fiber material is fed to the pressure body in a direction which deviates from the tangent line to the outer surface of the tube core at the location of the contact with the pressure body.

23. A method according to claim 17 or 18, wherein the strip is fed to the pressure body in radial direction with respect to the centerline of the tube core.

24. A method according to any one of the preceding claims 21-23, wherein the strip of fiber material is reoriented into a tangential feeding direction with the aid of the pressure body.

25. A method according to any one of the preceding claims 21-24, wherein the strip of fiber material is pressed on the outer surface with the aid of a pressure roller rolling along the outer surface of the tube core.
26. A method according to any one of the preceding claims 21-25, wherein the pressure body stands still with respect to the fixed world and wherein the tube core translates with respect to the pressure body.

27. A method according to any one of the preceding claims 21-26, wherein the winding angle at which the strip of fiber material is delivered to the outer surface of the tube core is settable.

28. A method according to any one of the preceding claims 21-27, wherein the strip of fiber material is delivered to the outer surface of the tube core parallel to the centerline of the tube core.

29. A method according to any one of the preceding claims 21-28, wherein a multiple number of strips are simultaneously fed to the outer surface.

30. A method according to any one of the preceding claims 21-29, wherein the strip of fiber material comprises a bundle of long fibers substantially extending in feeding direction.

31. A method according to any one of the preceding claims 21-30, wherein the strip of fiber material is substantially flat with a substantially rectangular cross section.

32. A method according to any one of the preceding claims 21-31, wherein the fiber material is chosen from the group comprising carbon fiber, aramid fiber, glass fiber, steel fiber and synthetic fiber.

33. A method according to any one of the preceding claims 21-32, wherein the fiber material is included in a matrix material.

34. A method according to any one of the preceding claims 21-33, wherein the matrix material comprises synthetic material, preferably thermoplastic synthetic material.

35. A method according to any one of the preceding claims 21-34, wherein the strip of fiber material has been preimpregnated with synthetic material.

36. A method according to any one of the preceding claims 21-35, wherein, by heating the strip of fiber material during or before the
application thereof, in one processing step, a ready winding layer is formed on the outer surface.

37. A method according to any one of the preceding claims 21-36, wherein the tube core forms an inner tube.

38. A method according to any one of the preceding claims 21-37, wherein the tube core forms a mandrel which forms a winding mandrel of the fiber-reinforced tube.

39. A method according to any one of the preceding claims 21-38, wherein the inner tube is fed as a continuous length.

40. A method according to claim 39, wherein the inner tube is fed from a reel.

41. A method according to any one of the preceding claims 21-40, wherein the fiber-reinforced tube is wound on a reel.

42. A tube, comprising a thermoplastic tube core and one or more prefabricated strips of fiber-reinforced thermoplastic tape material with a flat bundle of substantially parallel running fibers, included in a thermoplastic matrix material, which strips have been applied to the outer surface of the tube core, wherein the fibers have a winding angle of less than about 15°, preferably less than about 10° with respect to the centerline of the tube core.

43. A tube according to claim 42, wherein the winding angle is less than about 5°, is in particular about 0°.

44. A tube according to claim 42 or 43, wherein the residual tensile stress in the fibers is less than about 8 N/mm, in particular less than about 5 N/mm.

45. A tube according to any one of claims 42-44, wherein the length of the tube is greater than about 20 m, in particular more than about 50 m.

46. A reel provided with a tube wound around it according to any one of the preceding claims 42-45.
### INTERNATIONAL SEARCH REPORT

**A. CLASSIFICATION OF SUBJECT MATTER**

INV.  B29C53/56  B29C53/68  B29C70/30
ADD.  B29L23/00  B29K101/12  B29K105/10

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

### B. FIELDS SEARCHED

Maximum documentation searched (classification system followed by classification symbols)

B29C  H01B

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

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tbody>
<tr>
<td>X</td>
<td>WO 2004/007179 A (SAINT-GOBAIN VETROTEX FRANCE S.A; ZANELLA, GUY; DUCRET, CHRISTOPHE; VO) 22 January 2004 (2004-01-22) page 11, lines 14-35; figure 1 page 12, line 9</td>
<td>1,21,42</td>
</tr>
<tr>
<td>X</td>
<td>EP 0 423 954 A (THIOLK CORP) 24 April 1991 (1991-04-24) column 2, line 1 - column 4, line 2; figures</td>
<td>1,21</td>
</tr>
<tr>
<td>X</td>
<td>FR 2 389 060 A (COURTAULDS LTD) 24 November 1978 (1978-11-24) page 3, line 23 - page 5, line 30; figures</td>
<td>1,21</td>
</tr>
</tbody>
</table>

**X** Further documents are listed in the continuation of Box C.

* Special categories of cited documents:
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Date of the actual completion of the international search

22 August 2006

Date of mailing of the international search report

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Cordenier, J

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<tr>
<th>Category</th>
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<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>US 4 790 898 A (WOODS ET AL) 13 December 1988 (1988-12-13) abstract; figure 11</td>
<td>1,21</td>
</tr>
<tr>
<td>X</td>
<td>US 4 058 427 A (WILSON ET AL) 15 November 1977 (1977-11-15) column 3, lines 53-59; figures 1,2</td>
<td>1</td>
</tr>
<tr>
<td>X,P</td>
<td>WO 2005/108046 A (VETCO AIBEL AS; HAANDE, OLA; JAHN; DAG, MORTEN) 17 November 2005 (2005-11-17) page 2, lines 14-17; figure 1</td>
<td>1,21</td>
</tr>
<tr>
<td>A</td>
<td>EP 0 198 744 A (AEROSPATIALE SOCIETE NATIONALE INDUSTRIELLE) 22 October 1986 (1986-10-22) figure 6</td>
<td>2</td>
</tr>
<tr>
<td>A</td>
<td>EP 0 355 308 A (CINCINNATI MILACRON INC) 28 February 1990 (1990-02-28) figure 2</td>
<td>2</td>
</tr>
<tr>
<td>A</td>
<td>EP 0 535 264 A (CINCINNATI MILACRON INC) 7 April 1993 (1993-04-07) figure 2</td>
<td>2</td>
</tr>
<tr>
<td>A</td>
<td>US 6 782 932 B1 (REYNOLDS, JR. HARRIS A ET AL) 31 August 2004 (2004-08-31) column 5, lines 26-29 column 6, lines 38,39</td>
<td>42</td>
</tr>
<tr>
<td>A</td>
<td>EP 0 154 321 A (CINCINNATI MILACRON INC) 11 September 1985 (1985-09-11) figure 2</td>
<td></td>
</tr>
<tr>
<td>Patent document cited in search report</td>
<td>Publication date</td>
<td>Patent family member(s)</td>
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<tr>
<td>WO 2004007179 A</td>
<td>22-01-2004</td>
<td>AU 2003264672 A1</td>
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<td>BR 0312310 A1</td>
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<td>CA 2491315 A1</td>
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<td>CN 1665672 A1</td>
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<td>EP 1519826 A1</td>
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<td>FR 2841816 A1</td>
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<td>MX PA04012682 A</td>
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<td>US 2005269017 A1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 5039368 A</td>
</tr>
<tr>
<td>FR 2389060 A</td>
<td>24-11-1978</td>
<td>DE 2818376 A1</td>
</tr>
<tr>
<td>US 4790898 A</td>
<td>13-12-1988</td>
<td>DE 3277865 D1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 8400351 A1</td>
</tr>
<tr>
<td>US 4058427 A</td>
<td>15-11-1977</td>
<td>NONE</td>
</tr>
<tr>
<td>WO 2005108046 A</td>
<td>17-11-2005</td>
<td>NONE</td>
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<tr>
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<td></td>
<td>WO 9955519 A1</td>
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<td>DE 3662348 D1</td>
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<td>JP 2139467 A</td>
</tr>
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<td>07-04-1993</td>
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<tr>
<td>US 5587041 A</td>
<td>24-12-1996</td>
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