(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 010 815 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
21.06.2000 Bulletin 2000/25

(51) Int Cl.7: **E02D 5/52**, E21B 17/08, F16L 15/06

(21) Application number: **99660132.4**

(22) Date of filing: **23.08.1999**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **18.12.1998 FI 980570 U**

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(54) **Splice for a drilled pile**

(57) The invention relates to splices (1) between successive tube elements of a pile tube (2) driven into the ground and/or rock. The splice comprises a sleeve (3), inside of which the ends (15, 16) of two successive tube elements are found. The sleeve includes two female taper threads (5a and 5b) expanding towards the ends (7a, 7b) of the sleeve, and male taper threads (6) corresponding to the sleeve threads at the end of each tube element (4a, 4b, etc.) and tapering towards the end surface (8). In the splice, the tube elements are attached to the sleeve by reciprocal gripping of the taper threads (5a and 6;5b and 6) and they provide an extension for each other, the end surfaces (8) of the opposite tube parts (4a, 4b) being pressed against each other.

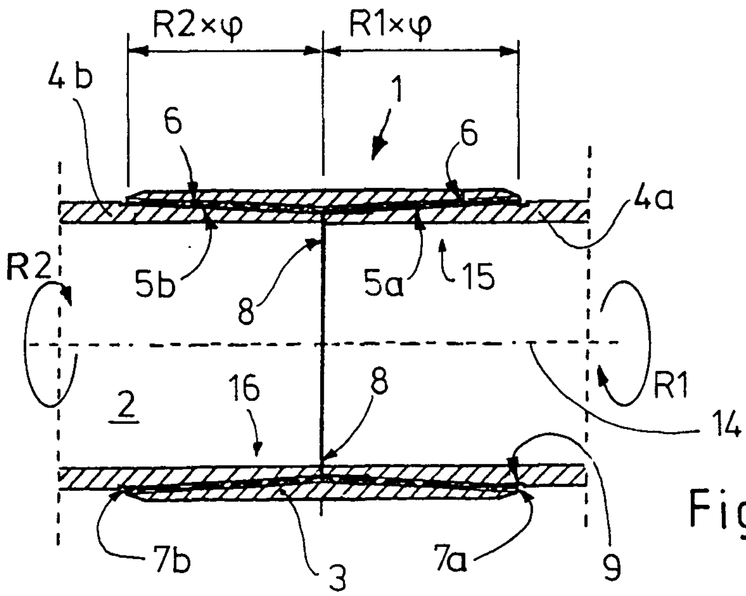

Fig. 3

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Description

[0001] The object of the present invention is a splice in the pile tube of a drilled pile to be driven into the ground and/or rock, comprising successive metal tube elements of a pile tube so that the splice comprises a principally straight metal sleeve inside which the ends of two tube elements acting as extensions for each other are situated.

[0002] In foundation work, the piles need to endure stresses due to mounting, i.e. penetration into the ground and/or rock, and meet, for example, the requirements in building regulations for compressive and tensile strength, bending stiffness and yield moment. Due to the strength and toughness of steel, steel tube piles endure big vertical and horizontal loads. This makes high requirements for the durability of splices for pile elements. It is usually required that the splice for the pile elements holds as well as the actual pile tube. When the overall length of a pile needed in the target site exceeds the manufacturing length of a single pile tube, driving into the ground is interrupted, the pile is extended, and mounting into the ground is resumed. These stages are repeated in order to provide a sufficient final length for the pile. An extension method for a tube pile generally used is to weld a new pile tube as a direct extension for the previous one so that, in principle, a strong and rigid joint is achieved. However, in the circumstances at a piling site, welding is a slow and difficult method, and it requires the presence of a professional welder at the site and that the quality is controlled and inspected. With less demanding pile splices, also a threaded joint between the pile tubes may be used, with a male thread at the one end of a tube element entering the joint, the other pile element end including a suitable female thread so that the ends of each pile element are different, and the elements of the pile tube have to be fastened directly to each other the right side up. A threaded splice otherwise works in a relatively satisfactory way, but the threads weaken the pile tube, and the splice tends to break at the point of the male thread, to which the pile tube with the female thread ends on top of the male thread. The said splices are disclosed in the below-mentioned publication by Sami Eronen and in the brochure of AB Sandvik.

[0003] Further, the patent US-3 796 057 discloses a sleeve joint which includes a straight sleeve element to be mounted on top of the elements of the pile tube, and a formed element to be placed inside in order to improve the gripping between the tube element and the sleeve. However, this is not suitable for situations in which, for example, dynamic alternating stress, i.e. both drawing and compression alternately, and possibly rotating force, i.e. torsion, are applied to the pile during drilling,. Further, this joint is problematic, as penetration into the ground causes the pile to bend due to various reasons, such as non-uniformities in the ground. Also the internal elements of the tube make it difficult to at least move the drill bit.

[0004] Extending the pile is problematic especially when piling in close spaces which poorly endure vibration; for example, when reinforcing foundations of an old building. In this case, several short pile tubes have to be used in each pile, and they have to be extended. As a mounting method for piles causing only slight vibration, ground tube drilling with a casing tube for the borehole is known; this method is used i.a. for well drilling so that, when penetrating soft soil layers, the casing tube is pressed into the ground after the drill bit, and the said casing tube is then left to later act as a pile. The drilling method is described both in patents, e.g. US-3 848 683; in literature, Sami Eronen: "Drilled Piles in Scandinavia", Tampere University of Technology, Geotechnical Laboratory, Publication 40, Tampere, 1997; and in brochures of equipment manufacturers. This kind of drilling method by AB Sandvik Rock Tools is known by the name of Tubex. Drilling may be accomplished by a pressure hammer lowered to the borehole on top of the drill bit; this is referred to as "down-the-hole hammer" (DTH) drilling, i.e. using down-the-hole drilling equipment; or by a surface pressure hammer as "top-hammer" drilling, i.e. using an overhead driving equipment. The casing tube for a borehole typically consists of casing tube elements 1 - 3.5 m long, but sometimes even 6 m long, tubes with thick walls which thus have to be extended almost in every case.

[0005] Thus, the first object of the present invention is to provide such a joint between successively mounted sections of tube piles that, besides stresses directed at the pile during operating conditions, it also endures well both dynamic stresses during mounting, such as pulsating stress or alternating stress, and torsion, if necessary. The second object of the invention is to provide such a joint which may be produced reliably and firmly under varying conditions on piling sites and, if possible, without requiring special qualifications from workers. The third object of the invention is to provide such a joint which is adapted to be used in ground tube drilling for extending the casing tube, and to be filled with hardening mortar after the drilling, and thus to be used as a concrete-filled tube pile.

[0006] The problems described above are solved and the objects are achieved by a splice of the invention, which is characterized in what is disclosed in the characterising part of claim 1.

[0007] Surprisingly enough, it has now been found that, when using an external jointing sleeve with the pile tube and a taper thread between the jointing sleeve and the tube element in the splice for drilled piles, a great tube wall thickness may be achieved at the base of the thread where the stresses are the highest. The sleeve may be manufactured to a desired thickness, and assembling the joint does not require, for example, welding qualifications from the personnel. The splice may be assembled firmly, and the correct way of mounting is easily and clearly detected with the help of a feature of the invention. The taper sleeve joint of the invention can endure approximately the same amount of stress as the pile tube.

[0008] The invention is next described in detail referring to the enclosed drawings.

[0009] **Fig. 1** presents in side view a finished tube pile achieved by the splices of the invention in the ground, for example in sandy soil, and at least partly surrounded by concrete so that a friction pile supporting itself to the ground is provided.

[0010] **Fig. 2** is a partly cutaway side view of a finished tube pile achieved by the splices of the invention in the ground, and for example, drilled into primary rock so that a pile supporting itself to the rock is provided. At this stage, the tube pile has not yet been filled with concrete.

[0011] **Fig. 3** is a longitudinal section of a splice through the middle line of pile tubes, corresponding to the cutaway section of Fig. 2. The splice of the figure comprises taper threads for the pile tube ends in accordance with Fig. 1, and a sleeve of Fig. 5 with taper threads.

[0012] **Fig. 4** shows at the top of the figure a longitudinal section of a male taper thread at the end of a pile tube entering the splice, as in Fig. 3, the bottom part presenting it in side view.

[0013] **Fig. 5** shows an extension sleeve for the splice of the invention, comprising two internal taper threads beginning at both ends of the sleeve, in longitudinal section as in Fig. 3. At the top part of the figure, the taper threads beginning at opposite ends of the sleeve extend uninterrupted through the sleeve and, at the bottom part of the figure, the taper threads beginning at opposite ends of the sleeve are separated by an opening of the thread bottom in the middle section of the sleeve.

[0014] The splice is used for connecting the successive tube elements 4a, 4b, 4c, etc. of metal, typically of steel, of a pile tube 2 for a drilled pile driven into the ground M and/or rock K, with each other. The splice 1 comprises a principally straight sleeve 3 of metal, typically of steel, inside which the ends 15, 16 of two tube elements acting as extensions for each other are situated. For a splice of the invention, the sleeve 3 is provided with two female taper threads 5a and 5b, which expand towards the ends 7a, 7b of the sleeve, i.e. the taper threads begin at the sleeve ends and taper towards the centre of the sleeve. Each end of the tube elements 4a, 4b, 4c, etc. includes a end surface 8 and male taper threads 6 corresponding to the sleeve threads, the taper threads 6 tapering towards the said end surface 8, i.e. these taper threads begin at the ends of the tube elements. The end surface 8 of every tube element advantageously extends essentially perpendicularly to the centre line 14 of the tube so that the end surfaces would press evenly against each other. In the splice 1, the tube elements adhere to the sleeve by reciprocal gripping of the taper threads 5a and 6; 5b and 6, and the end surfaces 8 of the opposite or successive tube elements 4a and 4b, 4b and 4 c, etc. providing extensions for each other are pressed against each other. In accordance with the invention, by using a taper thread in the tube elements, it is possible to maintain the wall thickness of the tube element big at the end edges 7a, 7b of the sleeve so that the tubes endure stress well also at these critical points.

[0015] Due to the tapered form of the threads 5a, 5b and 6, it is easy to align the threads of the splice upon mounting. The splice is tightened with the end surfaces 8 of the pile tube ends pressed end to end with such a moment that a tensile stress is provided in the sleeve. This is achieved so that the inside angles of rotation R1, R2 of the tube elements 4a and 4b, 4b and 4c, etc. inside the sleeve 3 are arranged big enough especially so that the inside angles of rotation R1, R2 times the pitch thread added together, i.e. $Le = R1\times\varphi + R2\times\varphi$, in which φ is the pitch angle, is bigger than the length L1 of the sleeve, or its predetermined portion in free space. With this arrangement, a tensile stress is provided in the sleeve at the same time as compression stress is generated to the taper thread of the tube. When drilling a pile into the ground, for example, the strokes of a pressure hammer are directed at the extension sleeve as load peaks so that tension in the sleeve varies while remaining on the drawing side all the time. Thus, the stress varying from tension to compression, which is dangerous for the fatigue durability, changes to less dangerous pulsating load. While making long pilings, the lowermost tubes are exposed to very high dynamic stresses, as the number of strokes of the pressure hammer may typically be 3000 strokes/minute, and the piling time e.g. 8 hours. When mounted, the piles carry the prevailing static load in the splice mainly with their end surfaces.

[0016] In accordance with the invention, the tensile stress to be generated to the sleeve may be accurately controlled on site by providing the tube elements 4a, 4b, 4c, etc. with a marking slot 9 along the external periphery within a distance L2 from the end surface 8 predetermined either by calculation and/or experiment, either edge 11a or 11b of the slot indicating the length Le for the inside angle of rotation times pitch determined in the previous paragraph. The predetermined portion of the sleeve 3 in free space is generated if, for example, the sleeve 3 includes an aperture for observing the marking slot 9 from the outside, and the length L1 of the sleeve is the applicable standard of comparison, if the end edge 7a, 7b of the sleeve is used for observing the marking slot. In practice, the correct tensile stress for the sleeve and the correct compression stress for the tube element are thus achieved so that the two tube elements and the sleeve connecting them are turned one within the other until, for example, the end edges 7a and 7b of the sleeve are at a certain predetermined point along the marking slot for the tube elements, such as at the edge 11a or 11b of the marking slot, or at a certain predetermined distance from the marking slot edge 11b farther away from the end surface 8 of the tube element. Due to its elasticity, the sleeve 3 has then stretched so that it is longer than its length L1 in free space, the bigger length generated by deformation corresponding to the said predetermined length Le. Depending on the desired accuracy, the reduction in the distance L2 between the end surface 8 and the marking slot 9 caused by the elasticity of the tube element and the compression directed at the tube element has to be taken into account, when necessary. When it further is seen to that the bottom diameter Dl of the marking slot is equivalent to or bigger than the biggest inner diameter D2 of the taper thread 6 of the tube element, the wall thickness of the tube material remains big enough at the point of the marking slot so that the tube element 4a, 4b, 4c, etc. is not vulnerable to fracture at this point, either. The large inner diameter D2 refers to the last bottom diameter of the thread found at the thick end of the thread before the end of the taper thread.

[0017] Between the end surface 8 of the tube element 4a, 4b, 4c, etc. and the taper thread 6 there is a principally cylindrical guide section 10, the outer diameter D3 of which is at most equivalent to the smallest inner diameter D4 of the taper thread 6 of the tube element, and further, there is a provided a transitional bevel 12 between the guide section 10 and the male thread. This design guides the external taper thread 6 of the tube element easily and accurately to the internal taper thread 5a and 5b, respectively, of the sleeve. In the pile tube, the taper thread thus begins from the short guide surface 10 at the end of the tube, the diameter of which is smaller than the thread, and ends to the shallow slot 9 on the surface. Upon mounting, the pile tube is turned to the sleeve as far as the surface slot so that it is then known that the end surfaces 8 of the tube element ends are in contact and pressed against each other, and that the afore-mentioned stress state exists in the elements.

[0018] The two female threads 5a, 5b of the sleeve 3 both extend to the middle area C of the sleeve length, or near the middle area C, in which the smallest inner diameter D4 of the sleeve is bigger than the outer diameter D3 of the guide section 10 of the tube element ends, making it thus possible for the end surfaces 8 to penetrate sufficiently deep through the sleeve and get into contact with each other. The taper threads 5a and 5b of the sleeve may extend through the sleeve as a continuous and unbroken thread, as is shown at the upper part of Fig. 5; or the taper threads 5a and 5b may be separated from each other by the bottom opening 17 of the thread, as is shown at the lower part of Fig. 5. Both ends of the sleeve are further provided with external peripheral bevels 13 which reduce the resistance of the pile tube as the tube is driven forward into the ground M and/or rock K.

[0019] The thread length L3 of the male taper thread 6 of the tube element from the end surface 8 to the edge 11a nearer the end surface of the marking slot 9 typically is smaller than half of the thread length of the female taper thread 5a, 5b of the sleeve, i.e. ½L1 from the end surface 7a and 7b to the middle C of the sleeve. The thread length L3 of the male taper thread 6 from the end surface 8 to the edge 11 farther away from the end surface of the marking slot 9 again is essentially as big as half the thread length of the female taper thread 5a, 5b of the sleeve, i.e. ½/L1 from the end surface 7a and 7b of the sleeve to the middle C of the sleeve.

[0020] Drilled pile tubes 2 driven into the ground M and/or rock K are usually filled with concrete B consisting of hydraulically hardening binding agent, water, filler material principally of rock material, and possible additives. In some cases, the drilled pile may also not be filled with concrete, as can be seen in Fig. 2. When necessary, auxiliary reinforcements are arranged inside the drilled pile tube 2, which adhere to the hardening concrete B and the tube elements 4a, 4b, 4c, etc. of the drilled pile tube. Concrete B may be injected through the pile tube so much that it rises up the outer surface to surround the pile, as is shown in Fig. 1. Alternatively concrete may also be fed through the pile and further to its outer surface during drilling.

[0021] The outer diameters of the drilled piles may be, for example, 75 - 300 mm, and typically the outer diameters of drilled pile tubes are 130 - 220 mm. Because of the method, it is difficult to drill very small tubes into the ground, and big drilled pile tubes again are expensive. The drilled pile tubes may be welded or seamless tubes. The minimum wall thickness is 5 mm, typically 6 - 12 mm. The wall thickness of the sleeve 3 is approximately the same as or slightly bigger than that of the tube elements 4a, 4b, etc. along the pile tube. The sleeves are made of seamless tube or similar material. The taper angle a of the taper threads 5a, 5b and 6 is 1° - 10°. For example, with a taper angle of 3°, the convergence is about 10 mm at a taper length of 100 mm.

[0022] A drill bit 20 with a larger diameter than the pile tube 2, or a similar working ring 20, may be left at the point of the pile tube. A stronger tube element without a ring may also be welded to the point of the tube.

Claims

1. Splice in a pile tube (2) of a drilled pile to be driven into the ground and/or rock, consisting of successive metal tube elements (4a, 4b, 4c...) of a pile tube, the splice (1) comprising a principally straight metal sleeve (3) inside which ends (15, 16) of two tube parts acting as extensions for each other are situated; **characterized** in that the sleeve (3) includes two female taper threads (5a and 5b) expanding towards the ends (7a, 7b) of the sleeve; that the end of each tube element (4a, 4b, 4c...) is provided with a end surface (8) and male taper threads (6) corresponding to the threads of the sleeve and tapering towards the said end surface (8); and that in the splice (1) the tube elements are attached to the sleeve by reciprocal gripping of the taper threads (5a and 6; 5b and 6), and the end sur-

faces (8) of the opposite tube elements (4a, 4b, 4c...) extending each other are pressed against each other.

2. Splice according to claim 1, **characterized** in that the inside turn angles (R1, R2) times the thread pitch (φ) added together (R1×φ + R2×φ) inside the sleeve 3 is bigger than the length (L1) of the sleeve, or its predetermined portion in free space, for generating tension stress to the sleeve.

3. Splice according to claim 1, **characterized** in that within a distance (L2) from the end surface 8, the tube part (4a, 4b, 4c...) is provided with an external peripheral marking slot (9), either edge of which (11a or 11b) indicating a predetermined length (Le) for the inside turn angle times the thread pitch of the tube element; and that the bottom diameter (D1) of the marking slot is equivalent to or bigger than the biggest inner diameter (D2) of the taper thread (6) of the tube element.

4. Splice according to claim 1, **characterized** in that between the end surface (8) of the tube element (4a, 4b, 4c...) and the taper thread (6) there is provided a principally cylindrical guide section (10), the outer diameter (D3) of which is at most equivalent to the smallest inner diameter (D4) of the taper thread (6) of the tube element; that the end surface (8) of each tube element is essentially perpendicular to the middle line (14) of the tube; and that between the guide section (10) and the male taper thread there is provided a transitional bevel (12).

5. Splice according to claim 1 or 4, **characterized** in that the two female taper threads (5a, 5b) of the sleeve (3) both extend essentially to the middle area C of the sleeve length, in which the inner diameter (D4) of the sleeve is bigger than the outer diameter (D3) of the guide section of the tube element end; and that the ends (7a and 7b) of the sleeve are provided with external peripheral bevels (13).

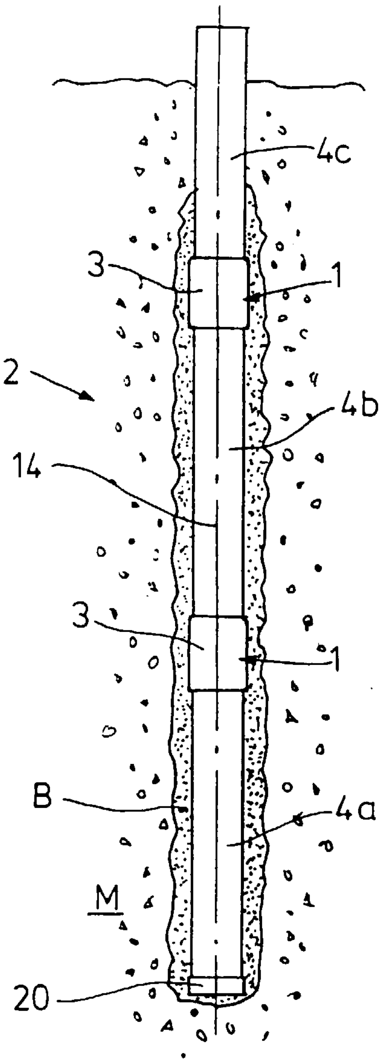

Fig. 1

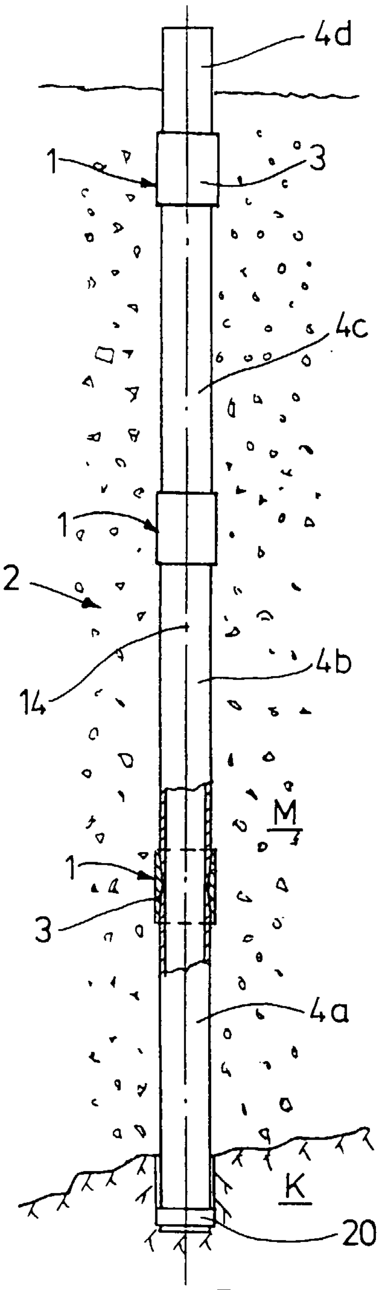

Fig. 2

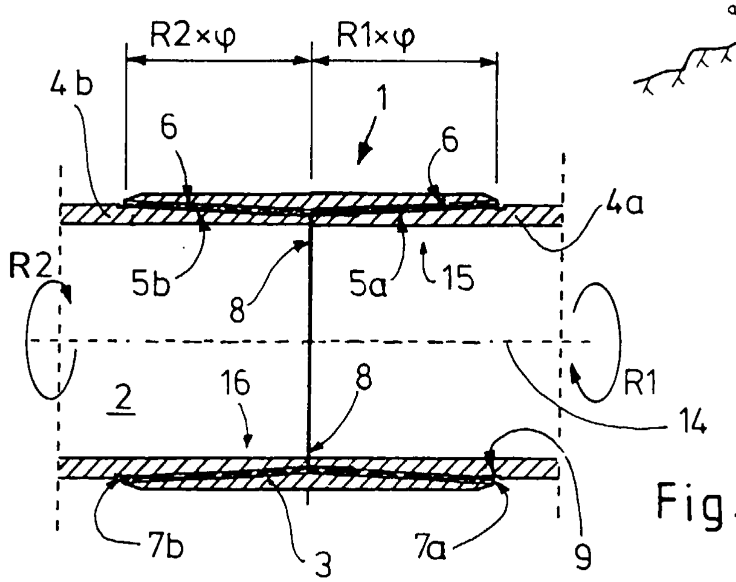

Fig. 3

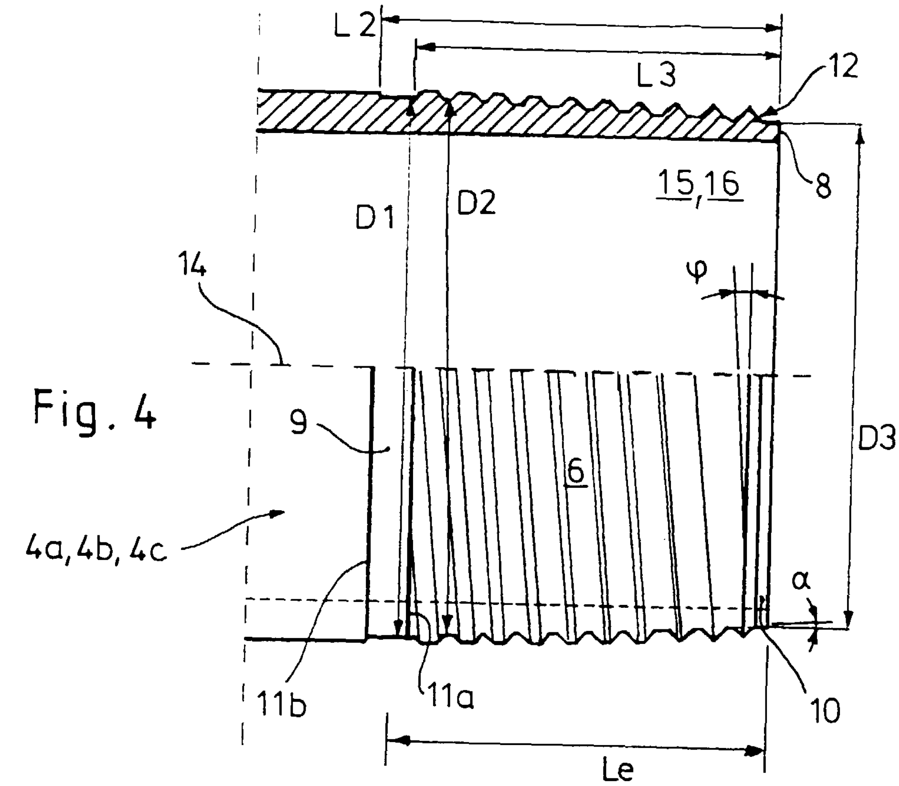
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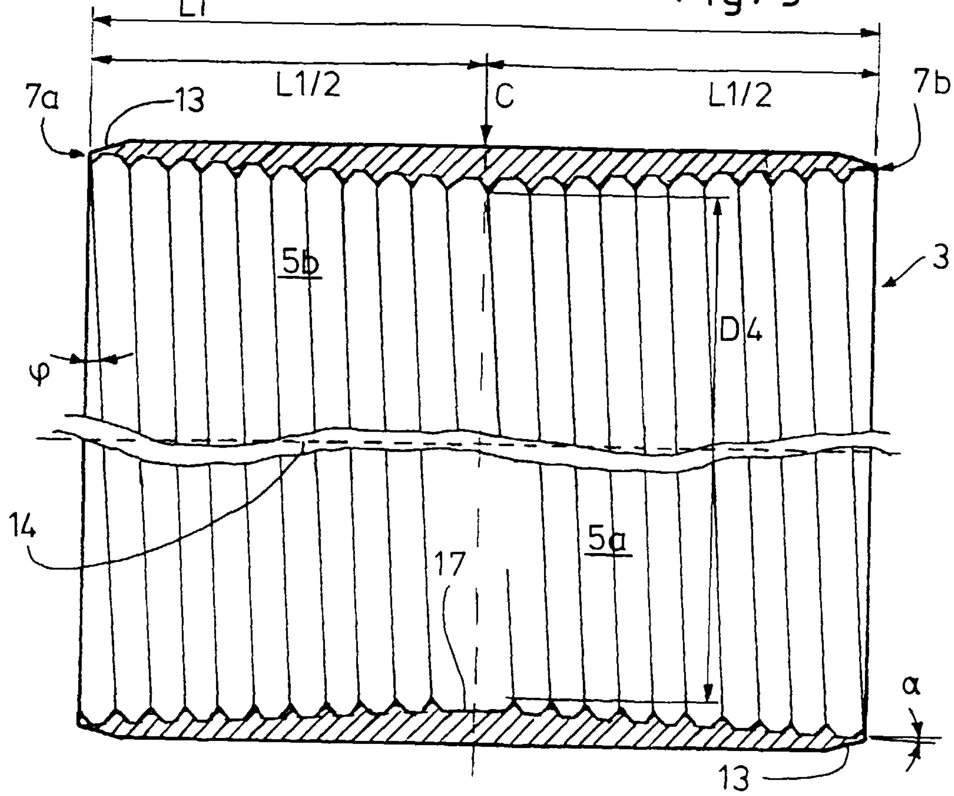
Fig. 4

Fig. 5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EUROPEAN SEARCH REPORT

Application Number
EP 99 66 0132

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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Y	US 4 962 579 A (MOYER) 16 October 1990 (1990-10-16) * column 4, line 4-61 * * column 6, line 54-65 * * figures 1-3 *	3	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

E02D
E21B
F16L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	23 March 2000	Kergueno, J

CATEGORY OF CITED DOCUMENTS

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