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(54) Manufacture of elongate members such as strand and rope.

(57) Individual elongate elements (wires 2 or strands 4) are drawn off stationary coils (21) in such a manner that the element (2,4) is elastically twisted. The elements (2,4) are guided to a stationary closing means (23) in which a bundle of the elements is formed, the elements immediately before being formed into the bundle being substantially free from any curvature that will result in residual slackness in the elongate member (1,3) being manufactured. The bundle is withdrawn from the closing means (23) and is simultaneously rotated about its axis so as to form the elongate member (strand 1 or rope 3) and substantially untwist the elongate elements (2,4). The product can be at least 300 m long.

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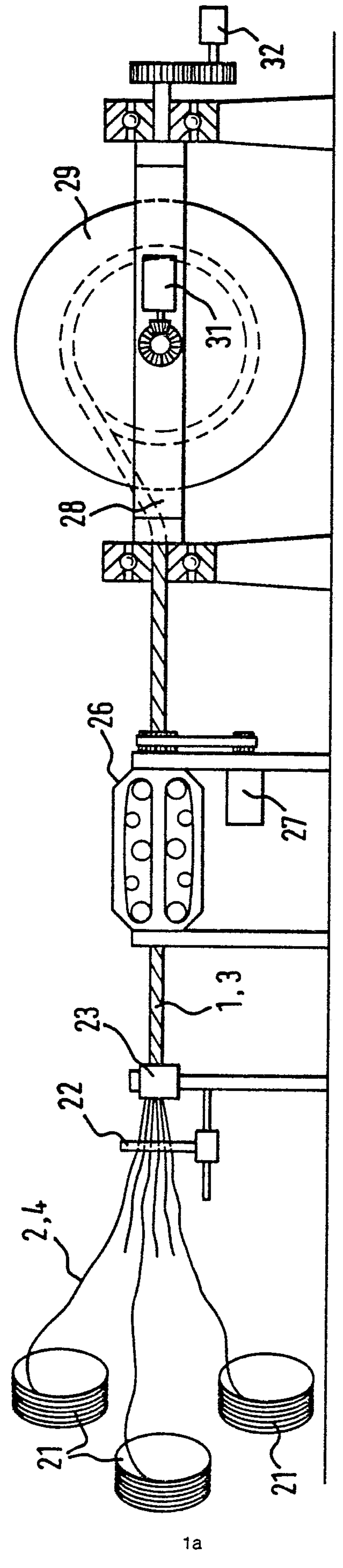

FIG.4.

Manufacture of Elongate Members such as Strand and Rope

This invention relates to the manufacture of an elongate member comprising a plurality of elongate elements. The elongate member may, for example, be a strand, a rope, or a cable. The elongate elements may, for example, be wires, strands, tubes, or filaments of metallic or non-metallic material, e.g. glass, carbon, or composite material. The elongate elements may surround a central core.

In conventional wire strand, for example, the component wires extend helically around the axis of the strand, generally with a helical lay length of 6 to 12 times the strand diameter. This helical arrangement keeps the wires together and allows the strand to be flexed and, therefore, coiled. However, there is a disadvantage in that the tensile strength of the strand is less than the sum of the tensile strengths of the wires. Furthermore, conventional stranding machines subject the wire to considerable bending, which is undesirable when strand is being produced for structural applications in which tensile strength and axial stiffness of the strand are of paramount importance.

In U.K. patent application GB-A-2 152 089 the present inventor has already proposed a method of forming a flexible tension member comprising bundling at least twenty high-strength elongate elements helically with a lay length of between 20 and 150 times the diameter of the member, the elements being introduced into the bundle without flexural stresses exceeding the yield point. Equipment has been devised which can be used for making a wire strand according to this method - (U.K. patent application GB-A-2 145 128). Equipment has also been devised for making large-size rope (U.K. patent application No. 8502557). The equipment in each case comprises: an elongate track; a rotatable clamp at one end of the track; anchoring means at the other end of the track, having rotatable tensioning spaced anchorages for wires or strands extending parallel to the track; a trolley movable along the track and carrying a closing die and guide means; drive means for moving the trolley and for rotating the clamp; and supports at intervals along the track.

Clearly, using such equipment it is only possible to produce a limited length of strand. The wires or strands have to be supported between the trolley and the anchoring means, and the track must of course be at least as long as the strand or rope to be produced. Thus any increase in length of strand or rope means additional capital expense, and possibly also an increase in the expense of manning and accommodating the equipment. A major problem with strands exceeding, say, 200 metres would be the difficulty of communication between operators at opposite ends of the track.

The present invention provides a method of making an elongate member comprising a plurality of elongate elements extending helically around the axis of the elongate member, the method comprising drawing individual elongate elements off a plurality of stationary coils, each elongate element being drawn off in such a manner that the element is elastically twisted, guiding the elongate element to a stationary closing means in which a bundle of the elements is formed, the elongate elements immediately before being formed into the bundle being substantially free from any curvature that will result in residual slackness in the elongate member, and withdrawing the bundle from the closing means and simultaneously rotating the bundle about its axis so as to form the elongate member and substantially untwist the elongate elements.

In this way an elongate member can be produced whose length is limited only by the length of a coil or is unlimited if a new coil can be connected to the trailing end of a used coil, which will usually be possible.

The twist in the element drawn off the coil and the untwisting of the element due to the rotation of the bundle being withdrawn from the closing means can be matched by ensuring that the turns of the coil are on average substantially equal in length to the lay length of the helix of the elongate member, assuming that the element in the coil has no twist. (Theoretically, the length of the elongate element in each turn of the coil should be equal to the length of the same elongate element on one complete helical turn of the coil, which length is slightly longer than the lay length and varies from the inside to the outside of the elongate member; however, an approximation to the lay length is sufficient in practice.) For the same diameter of coil, it may be possible to reduce the lay length by twisting the element as it is coiled, providing the element is not subject to torsional creep and provided the total twist of the element on drawing off is within the torsional elastic range of the element.

Thus, in general, a smaller lay length will require a smaller coil diameter and thus more bending of the element. Consequently, the method of the invention is best suited to elongate members of long lay length, viz. at least 12 times the diameter of the member (i.e. the diameter of a circle circumscribing the member), preferably 12 to 150 times the diameter, more preferably 20 to 75 times.

Since the amount of bending can be limited, the method can be used with stiff elements or with elements that cannot tolerate much bending.

Since it requires no movement of the coil, the method is also well suited to the production of elongate members in great lengths, preferably at least 300 m, more preferably at least 500 m.

The coil preferably has turns of substantially constant length, or at least cyclically or randomly varying length (within a limited range). However, if the coil has turns of decreasing or increasing length (e.g. if the coil has been reeled in layers), it is possible to decrease or increase the lay length of the elongate member correspondingly during manufacture, by progressively changing the rate of rotation of the bundle being withdrawn. This technique may be advantageously employed to produce a member which does not twist in the middle under the influence of its own weight when erected in a vertical plane but instead offers a substantially constant torque along its length.

Such modification of the rotation rate can also be carried out if excessive build up of differential twist is observed in the elements.

The elements may be applied to a central core supplied to the closing means while being rotated synchronously with the rotation of the bundle being withdrawn. The core may, of course, have been produced by the method of the invention.

The invention will be described further, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a cross-section of an elongate member in the form of a 73-wire strand;

Figures 2 and 3 are cross-sections of elongate members in the form of wire rope; and

Figure 4 is a schematic side view of apparatus for making such elongate members.

The strand 1 shown in Figure 1 comprises a bundle of 73 steel wires 2 extending helically around the strand axis. The rope 3 shown in Figure 2 has a bundle of 12 "Dyform" (Trade Mark) steel wire strands 4 extending helically around an independent wire rope core (IWRC) 6 which itself comprises six "Dyform" steel wire strands 7 wound on a central steel wire strand 8. The rope 9 shown in Figure 3 has a bundle of 12 conventional 19-wire steel strands 11 extending helically around an IWRC 12.

The method particularly described below is suitable for manufacturing such strand and rope with a very long pitch or lay in continuous lengths. Long lay strands and ropes are particularly attractive for structural applications where little bending is involved and where tensile strength and axial stiffness are of paramount importance.

The constituent wires 2 or strands 4 are provided in coils or spools 21 having a mean circumference equivalent to the length of wire or strand in a single lay length or pitch of the strand or rope bundle to be produced. The coils 21 are supported on separate fixed stands or pay-off frames (not shown) in such a way that one (360°) twist is introduced into the wire 2 or strand 4 for each lap pulled off. The number of coils 21 and stands available must be at least equal to the number of wires or strands required in the strand or rope bundle.

The ends of the wires 2 or strands 4 are led through straightening rollers (not shown), if necessary, and guided to a collector plate 22 where they are brought together in a predetermined pattern appropriate to the strand or rope construction. From here the wires 2 or strands 4 converge to form a bundle in a forming die 23 which may be a circular or shaped profile depending on the type of strand or rope cross-section.

Leaving the die 23, the strand 1 or rope 3 is led to a traction device 26, which is illustrated by way of example as a caterpillar haul-off and which is capable of being simultaneously rotated about the longitudinal axis of the strand 1 or rope 3 by a motor 26, the rotational and axial motions being interlinked, by mechanical or other means, to maintain a pre-set ratio.

From the traction device 23, the strand 1 or rope 3 is led to a take-up stand or cradle 28 which contains a large drum or reel 29, driven by a motor 31 (preferably via a torque converter to maintain a controlled tension in the strand or rope 24), and which is itself rotated by a motor 32 about the longitudinal axis of the strand 1 or rope 3 in synchronism with the rotation of the traction device 26. A traversing device (not shown) may be attached to the take-up stand 2B to control the coiling of the strand 1 or rope 3.

Additional lubrication, blocking, wrapping and/or sheathing equipment may be interposed at suitable locations between the collector plate 22 and the take-up stand 28 if required. Also rollers and preforming/postforming devices may be introduced to improve the formation of the strand or rope if desired.

In order to achieve a tight coherent strand or rope formation it is important that the wires or strands have a sufficient degree of straightness prior to stranding or closing. This may be defined in relation to the end product by requiring that any residual curvature of the wires or strands immediately prior to being formed into the strand or rope shall be always less than the curvature imparted to the same member when formed into the helical product.

Multi-layer strands or ropes are formed by feeding the core from a pay-off stand rotated synchronously with the take-up stand.

EXAMPLE

It is required to manufacture a strand 1 (Figure 1) of 48 mm diameter using 5 mm diameter wires 2, the strand having a lay length of 2.88 m (60 x strand diameter).

The wire is obtained in the form of coils 21 from a 915 mm (36 inch) diameter block (i.e. 2.88 m circumference); thus a given amount of twist is imparted to the wire during uncoiling from the stationary coil. The wires 2 are guided to the die 23 in the manner described above and are withdrawn by the traction device 26, which rotates so that the strand 1 acquires the prescribed lay length of 2.88 m and in such a direction that the wires 2 are untwisted, i.e. the wires in the strand 1 are free of twist and there is no build up of twist between the die 23 and the coils 21.

It may be calculated that the curvature of the outer wires in the strand will be $0.102 m^{-1}$, which is considerably less than the curvature of the wire in the coil ($0.694 m^{-1}$). If necessary the wires should therefore by straightened after uncoiling, to a curvature of less than $0.102 m^{-1}$, i.e. a deviation from straightness not exceeding 2.5 mm over a metre length; this can be done by conventional straightening rollers. Alternatively, if the material used has a yield strain in excess of the bending strain due to coiling (0.55%), then straightening equipment should not be required, since the wire will straighten by its own elasticity.

Although the method described above is especially advantageous for long lay strand, rope, etc., it is also applicable to shorter lays, in which case, however, the amount of twist which needs to be present in the elements drawn off the coils is increased. If too much twist is introduced, the torsional stress may exceed the elastic limit of the material of the elongate element; accordingly, the minimum lay length achievable will depend on the torsional elastic limit of the material.

By means of the above-described method, an advantageous product can be obtained comprising a bundle of elongate elements (with or without a central core), with a lay length 12 to 150 times - (preferably 20 to 75 times) the diameter of the bundle, and having a length of at least 300 m - (preferably at least 500 m). Such a product could not have been produced by the processes available hitherto.

Claims

1. A method of making an elongate member (1,3) comprising a plurality of elongate elements (2,4) extending helically around the axis of the elongate member (1,3), the method comprising drawing individual elongate members (2,4) off a plurality of stationary coils (21), each elongate element (2,4) being drawn off in such a manner that the element (2,4) is elastically twisted, guiding the elongate elements (2,4) to a stationary closing means (23) in which a bundle of the elements (2,4) is formed, the elongate elements (2,4) immediately before being formed into the bundle being substantially free from any curvature that will result in residual slackness in the elongate member (1,3), and withdrawing the bundle from the closing means and simultaneously rotating the bundle about its axis so as to form the elongate member (1,3) and substantially untwist the elongate elements (2,4).

2. A method as claimed in claim 1, in which the turns of the coil (21) are on average substantially equal in length to the lay length of the helix of the elongate member (1,3).

3. A method as claimed in claim 1 or 2, in which the lay length of the helix of the elongate member - (1,3) is at least 12 times the diameter of the bundle.

4. A method as claimed in claim 3, in which the lay length is at most 150 times the diameter.

5. A method as claimed in claim 4, in which the lay length is 20 to 75 times the diameter.

6. A method as claimed in any of claims 1 to 5, in which the length of the elongate member (1,3) produced is at least 300 m.

7. A method as claimed in claim 6, in which the length is at least 500 m.

8. A method as claimed in any of claims 1 to 7, in

which the coil (21) has turns of substantially constant length.

9. A method as claimed in any of claims 1 to 8, in which the elements (2,4) are applied to a central core supplied to the closing means (23) while being rotated synchronously with the rotation of the bundle being withdrawn.

10. An elongate member (1,3) comprising a bundle of elongate elements (2,4) extending helically around the axis of the elongate member (1,3), the lay length of the helix being 12 to 150 times, preferably 20 to 75 times, the diameter of the bundle, and the length of the elongate member being at least 300 m, preferably at least 500 m.

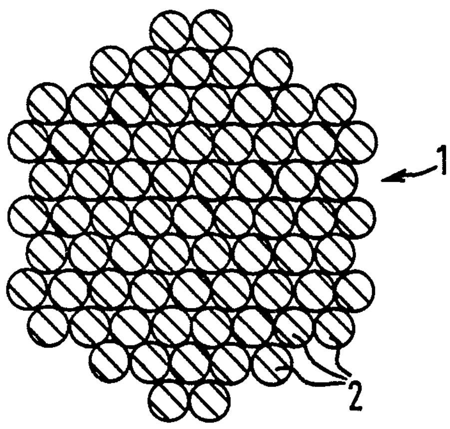

FIG.1.

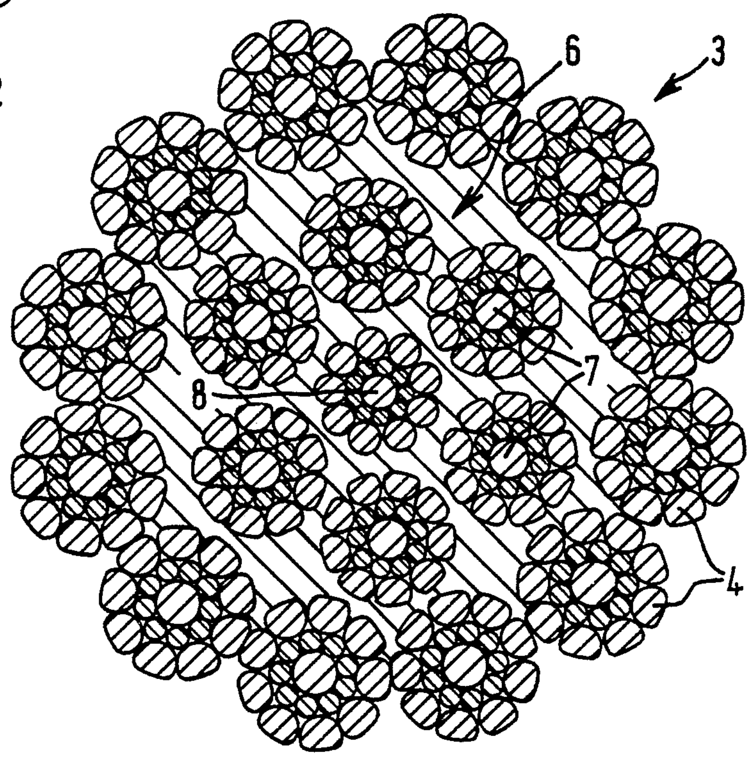

FIG.2.

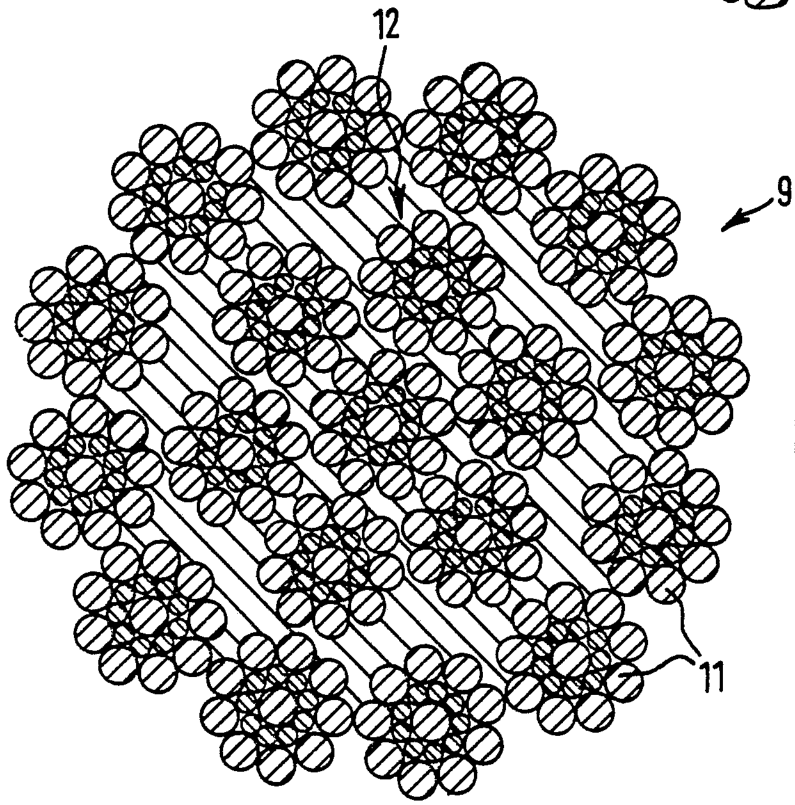

FIG.3.

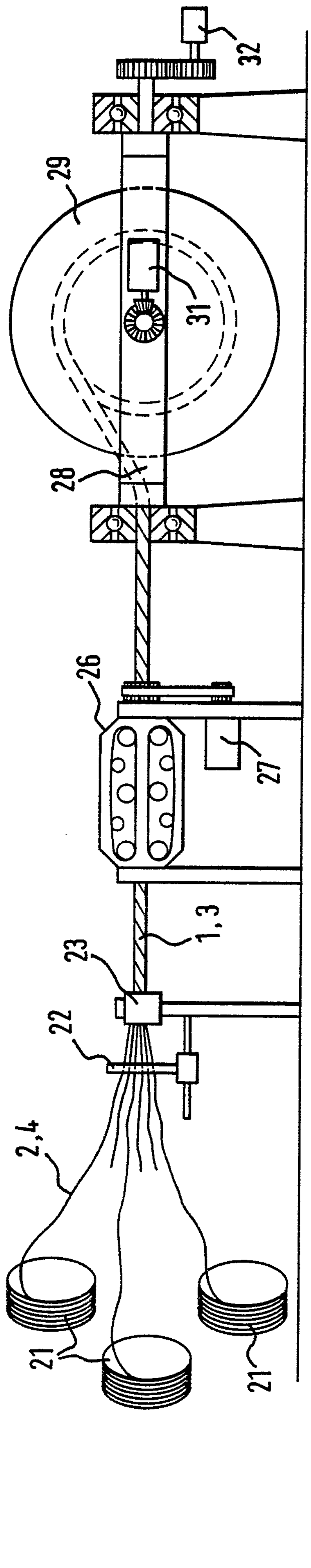

FIG.4.