April 28, 1942. J. A. HETZEL 2,281,036

ROPE STRUCTURE

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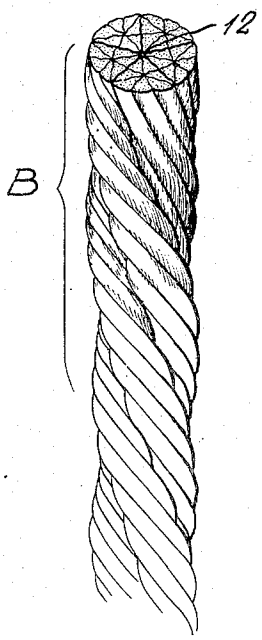


Fig. 1.

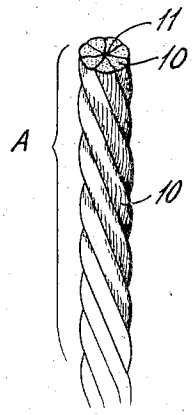
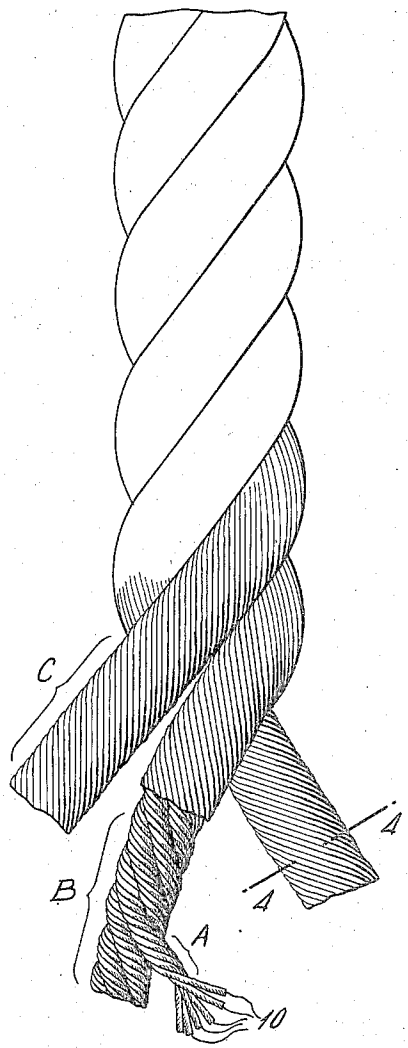


Fig. 2.

Fig. 3.



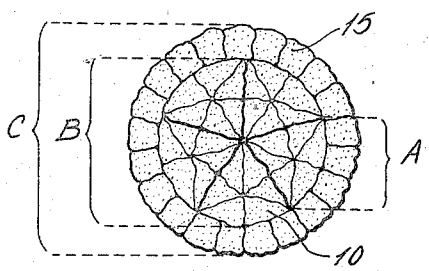


Fig. 4.

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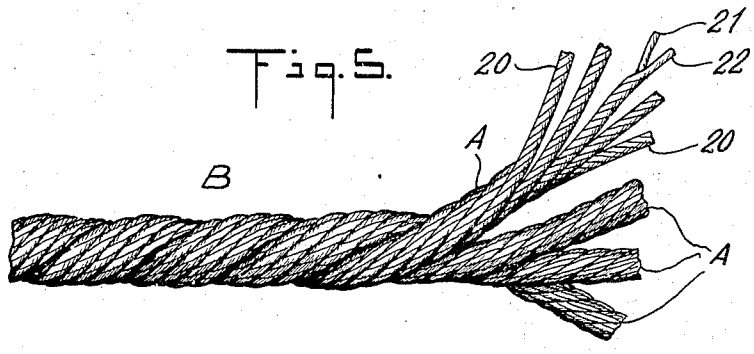
Fig. 5.



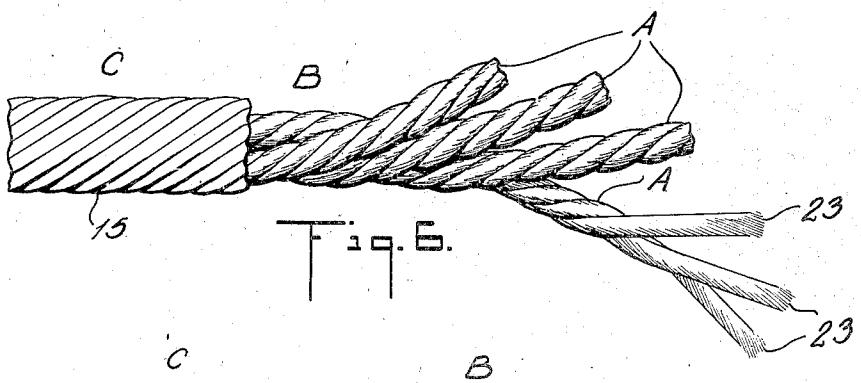


Fig. 6.

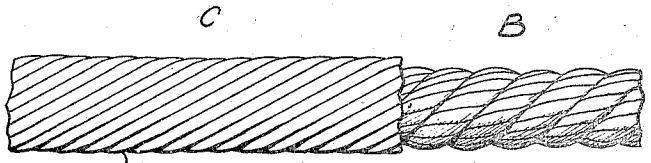


Fig. 7.

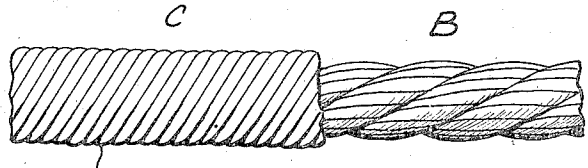


Fig. 8.

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ROPE STRUCTURE

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Application December 21, 1940, Serial No. 371,161

18 Claims. (Cl. 57—144)

This invention relates to rope structure or cordage and more particularly to the formation of rope strands of fibrous or filamentary material intended to be used as single units or laid or twisted together with corresponding strands to form ropes, hawsers, drilling cables, cable-laid ropes and the like, the principal object of my invention being to provide a rope structure in which the individual strands are made up of elements twisted together in such a way that the length of each element in a given length of strand is substantially equal to, or bears a predetermined relation to, the length of each other element, and all of the elements are twisted and arranged to produce a strand of maximum strength with improved durability and handling qualities.

In conventional all-yarn rope structures heretofore produced, the individual strands are formed by twisting together a predetermined number of yarns. Those lying at or near the surface of the finished strand may be called the cover yarns and those lying inside the cover yarns may be called the core yarns. In ordinary practice, each yarn in the strand, whether it be a cover yarn or a core yarn, forms substantially a helix about the axis of the strand. The diameters of the helices of the cover yarns are greater than those of the core yarns, and the diameters of the helices of the outer core yarns are greater than those of the inner core yarns at or near the axis of the strand. The lengths of the yarns in a given length of strand are therefore unequal, the inner core yarns being shortest and the outer cover yarns being longest. When the strand is put under longitudinal strain in use, the pull is not equally divided among the yarns. The inner yarns being shortest are subjected to the severest strain. The outer yarns being longest and being cushioned by compression of the inner yarns are subjected to the least strain. As a result, the inner yarns are subjected to greater strain than the outer yarns, and in case of excessive strain the inner yarns will break first and the rupturing will proceed outwardly through the core yarns to the cover yarns.

The problem of providing a strand structure that will impose equal strain simultaneously upon all of the yarns or elements of the strand and permit them all to exert simultaneously their full tensile strength, has long challenged the ingenuity of rope makers. A number of proposals have been made for solving the problem but without practical success.

The present invention is characterized by a strand structure which consists of a group of units that are symmetrically twisted together around the axis of the strand, each unit in turn consisting of a group of smaller elements or yarns that are symmetrically twisted around the axis of the unit. In a given length of such a structure, the units are all of equal length because they are arranged in helices of equal diameter around the axis of the strand; the smaller elements or yarns comprising each single unit are all of equal length because they are arranged in helices of equal diameter around the axis of that unit; in consequence, all of the elements or yarns, so arranged in any given length of strand, are of the same substantial length. The symmetry of the structure and the equal length of yarns or rope elements comprising it, enable all of the yarns or rope elements to pull together equally and simultaneously, and produce a strand structure of maximum tensile strength.

The units may be made of yarns or groups of yarns or slivers or groups of slivers or the like. The units may, if desired, be pretwisted in the same direction in which they are formed in the strand or in the opposite direction.

The strand may be supplied with cover yarns of any suitable size or other elements such as ply goods, and the pitch of the cover yarns or elements may be correlated to the compound twist of the core yarns or elements so as to make the length of the cover yarns or elements in a given length of strand substantially equal to, or a predetermined percentage of, that of the core yarns or elements in the same length of strand.

Other objects and advantages of this invention will appear from the following description and claims taken in connection with the accompanying drawings, in which—

Figure 1 illustrates diagrammatically a rope strand structure embodying the invention;

Fig. 2 illustrates a unit of said strand structure;

Fig. 3 shows a three-strand, all-yarn rope embodying the invention in modified form;

Fig. 4 is an enlarged sectional view on the line 4—4 of Fig. 3;

Fig. 5 shows a form of the invention in which the units are made of a group of ply-goods;

Fig. 6 shows a form of the invention in which the core units are made of a group of slivers; and

Figs. 7 and 8 illustrate strand structures embodying the invention in which the cover yarns have been given a pitch greater or less than that of the units comprising the core.

In the drawings and in the description that follows, the invention is illustrated by reference to a strand structure that is formed to the left and rope structure that is laid to the right. It will be understood, however, that right formed strands and left laid rope may be made in accordance with the invention by simply reversing the twists of the various elements of which the strand and rope are made.

Referring to Figs. 1 and 2, in which is shown one preferred form of the invention, a group of ordinary right turn yarns 10 are twisted together to the left to form the unit A shown in Fig. 2. The yarns are properly arranged or guided in the twisting operation so that they form substantially symmetrical helices about the axis 11 of the unit and are substantially in contact along the axis. The number of yarns that may be used in making such a unit is limited, but as many as eight or ten may be conveniently employed. A number of units A are then twisted or formed together to the left to produce the strand B shown in Fig. 1. The units A are properly arranged or guided in the strand forming operation so that they form substantially symmetrical helices about the axis 12 of the strand and are substantially in contact along the axis or are as close thereto as the conformation of the units A will permit. Good results have been secured by using five units A in forming strand B, but obviously a greater or smaller number may be employed within reasonable limits, having in mind that all of the units A are to be of substantially the same length in a given length of strand B. From this arrangement it results that all of the yarns 10 in a given length of strand are substantially equal in length, and a strand structure of maximum tensile strength is produced.

The strand B may then preferably be laid to the right with other corresponding strands to form a rope or hawser, in the usual manner, and, if desired, the resulting rope may be cable-laid with other corresponding ropes to form a cable. In each case, the resulting rope or cable will be formed of yarns, all of which are of substantially the same length in a given length of rope or cable, and the desired improvement in tensile strength thus obtained.

In Fig. 3 is shown a rope embodying another preferred form of the invention. In this embodiment, six right turn yarns 10 are first twisted together to the left to form a unit A, substantially as described above in connection with Fig. 2. Five units A are then twisted together or formed to the left, producing a core B, and at the same time cover yarns 15 are supplied and twisted about the core to produce a strand C, comprising a core B of units A and a cover of yarns 15. The units A are appropriately guided in the strand forming operation so that they form substantially symmetrical helices about the axis of the strand as described above in connection with Fig. 1. It follows that all of the core yarns in a given length of strand will be of substantially the same length.

Where it is desired that the cover yarns 15 shall contribute to the fullest extent to the tensile strength of the rope, it is possible by this invention to provide the desired relationship between the length of core and cover yarns in a given length of strand without using any difference in pitch as between the helices formed by the cover yarns in the strand and the helices formed by the units A in the core B. This may be accomplished by regulating the amount of twist of the yarns 10 in forming the units A, so that when units A are twisted or formed into the core unit B, the yarns 10 in a given length of strand will be of substantially the same length as the cover yarns 15 in that same length of strand, or of such greater or lesser length as is desired to produce the strongest rope structure.

It has been found by test that where the twist imparted to each unit A is such as to make the core yarns in a given length of strand slightly shorter, say one to three percent, shorter, than the cover yarns in the same length of strand, maximum tensile strength of the resultant rope is obtained.

A three-strand 5½ inch circumference, all-yarn rope may desirably be made in accordance with this invention, as follows: Seven regular right turn yarns, of about 270 feet per pound and 11½ turns per foot, are twisted together symmetrically to the left, with no center yarn, through a tube of suitable diameter, and given a pitch of about 5.1 inches. Five of the resulting units are then formed to the left, along with twenty-eight cover yarns, to produce a strand of five inch pitch, the cover yarns being of the same size and material as the core yarns and of substantially the same length in a given length of strand. Three strands are then laid into a rope in the customary manner. A finished rope so made, having a pitch of about 5.2 inches of the strands in the rope lay, a pitch of about 5.8 inches of the cover yarns and core units in each strand, and a pitch of about 2.9 inches of the yarns in each core unit, has a breaking strength that is in excess of that of conventional all-yarn rope of the same size and material.

In the rope structure made as just described, the length of the core yarns is substantially the same as the length of the cover yarns in a given length of strand, and the pitch of the cover yarns is the same as the pitch of the core units. When the core yarns are made slightly shorter than the cover yarns in a given length of strand, i. e., 97–99% as long, the maximum tensile strength is apparently achieved.

The desired predetermined ratio between core yarn length and cover yarn length in a given length of strand may be achieved, according to this invention, in either or both of two ways. Either the degree of twist used in making the units A may be increased or decreased, as described above, or the group of units A may be pretwisted to the right or left in making the core B before the core B is formed with the cover yarns to make the strand. In the latter case the pitch of the cover yarns in the strand is not equal to the pitch of the core units in the strand. Fig. 7 illustrates a strand in which the cover yarns have a longer pitch in the strand than the units A of the core B, achieved by pretwisting the group of units A to the left. Fig. 8 illustrates a strand in which the cover yarns have a shorter pitch in the strand than the units A of the core B, achieved by pretwisting the group of units A to the right before they are formed with the cover yarns to make the strand. Any desired degree of twist may be employed in making up the units A. The tighter the twist, the greater will be the length of the yarns in a given length of the unit. Any degree of pretwist of the group of units A may be employed in making up the core B. When the group is pretwisted in the same direction in which the strand is to be formed, i. e., to the left, the yarns will be longer in a given length of the core unit B and

strand C than in the absence of such pretwist. When the group is pretwisted in the opposite direction, i. e., to the right, the yarns will be shorter. According to the amount of right pretwist used, the group of units A may appear in the strand as of either right or left turn, because the right pretwist is partially lost or is reversed when making a left turn strand.

The desired length of core yarn in a given length of strand may be achieved by means alone of the twist imparted to the elements in making up the units or by means alone of the pretwist imparted to the group of units in making up the core or by combining and correlating the said twist and pretwist. In each case the core yarns will all be of equal length in a given length of strand, and all of them will bear a desired predetermined relation to the length of the cover yarns in the same length of strand.

In making all yarn rope, there are important practical advantages in using core yarns and cover yarns that are of the same size and material. By this invention, identical yarns may be employed throughout the rope structure, yet the tensile strain may be equalized on all yarns or varied as desired between the core and cover yarns. The invention likewise has the practical advantage of permitting the cover yarns to have the same pitch in the strand as the core units, while still subjecting the cover yarns to full tensile strain and producing a rope of maximum strength. And similarly, wherever it is desired to vary the relative tensile strains imposed upon the core and cover yarns, it may be accomplished, according to this invention, by varying the ratio of length of cover yarns to length of core yarns in a given length of strand, as described, with or without variation in the pitch of the cover yarns and core units in the strand.

Instead of making units A by twisting together ordinary yarns, as described, they may be made by twisting together slivers or groups of slivers, which may, if desired, have been previously twisted individually or in groups; or they may be made by twisting together ply-goods or groups of yarns; but to achieve the full benefits of the invention, care should be taken in making each unit to twist all of the elements in the group together into substantially symmetrical helices about the axis of that group and without center yarns or elements, and similarly to twist all the units together in symmetrical helices in forming the strand, so that the length of all elements in a given length of strand will be substantially equal and will have the desired relationship to the length of the cover yarns or elements, if any, in the same length of strand.

Fig. 5 illustrates a strand B made up of units A, each unit A being made up of a plurality of ply-goods elements 20 and each element 20 being made up of a plurality of yarns such as 21, 22 twisted together. The yarns may be right turn yarns plied or twisted together to the left or vice versa, or the twist of the ply may be in the same direction as the individual twist of the yarns.

Fig. 6 illustrates a strand C with cover yarns 15 in which the core B is made up of units A and each unit A is made up of a plurality of slivers 23 twisted together in helices of substantially equal diameter about the axis of the unit.

Figs. 7 and 8 show the difference in pitch of cover yarns and core units that may be achieved by pretwisting the group of units to the left or right before forming the same into a strand with cover yarns

Rope structures embodying the invention herein described are found to have advantages not only in strength, durability and handling, but also in elasticity, due perhaps to the absence of excess strain on individual yarns or elements before the full strength of the rope is reached. In cable-laid ropes such as drilling cables this feature of improved elasticity is of particular value and importance.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary limitations should be understood therefrom, but the appended claims are to be construed as broadly as permissible in view of the prior art. The use of the terms right and left in describing the twists of the various parts making up the rope structure is to be understood as having reference to the structure of a left formed strand or right laid rope, but where a right formed strand or left laid rope is desired the opposite twists are intended and covered. The term rope elements as used herein is intended to include elements such as yarns, slivers, ply-goods, filaments, etc., made of fibrous or filamentary materials appropriate for use in the manufacture of ropes, rope strands and the like. In rope strands used as single units the cover elements may be twisted around the core in the direction opposite to that in which the core elements are twisted, to give desired balance to the strand, and the length of the cover elements in a given length of strand may be made to bear a predetermined relation to the length of the core elements in the same length of strand as above described, while preserving equality of length of all of the core elements and such relation of pitch of the cover elements and core units as may be desired and predetermined.

I claim:

1. A rope strand comprising a plurality of units twisted together in helices of substantially identical diameter about the axis of the strand, each unit consisting of a plurality of rope elements twisted together in helices of substantially identical diameter about the axis of the unit without center elements so that all of the said rope elements in a given length of strand are of substantially equal length.

2. A rope strand comprising cover yarns and a core of rope elements, the core comprising a plurality of units twisted together in helices of substantially equal diameter about the axis of the strand, each unit comprising a plurality of rope elements twisted together in helices of substantially equal diameter about the axis of the unit without center elements, and the pitch of the cover yarns in the strand bearing a predetermined relation to the pitch of the units in the strand.

3. An all yarn rope strand comprising a plurality of units twisted together in helices of substantially equal diameter about the axis of the strand, each unit consisting of a plurality of yarns twisted together in helices of substantially equal diameter about the axis of the unit without center elements so that all of the yarns in a given length of strand are of substantially equal length.

4. An all yarn rope strand comprising core and cover yarns, the core comprising a plurality of units twisted together in helices of substantially equal diameter about the axis of the strand, each unit comprising a plurality of yarns twisted together in helices of substantially equal diameter about the axis of the unit, and the pitch of the

cover yarns in the stand bearing a predetermined relation to the pitch of the units in the strand.

5. An all yarn rope strand comprising core and cover yarns, the core comprising a plurality of units twisted together in helices of substantially equal diameter about the axis of the strand, each unit comprising a plurality of yarns twisted together in helices of substantially equal diameter about the axis of the unit, and the pitch of the cover yarns in the strand being substantially equal to the pitch of the units in the strand.

6. An all yarn rope strand comprising core and cover yarns, the core comprising a plurality of units twisted together in helices of substantially equal diameter about the axis of the strand, each unit comprising a plurality of yarns twisted together in helices of substantially equal diameter about the axis of the unit, and the length of the cover yarns in a given length of strand bearing a predetermined relation to the length of the core yarns in the same length of strand.

7. An all yarn rope strand comprising core and cover yarns, the core comprising a plurality of units twisted together in helices of substantially equal diameter about the axis of the strand, each unit comprising a plurality of yarns twisted together in helices of substantially equal diameter about the axis of the unit, and the length of the cover yarns in a given length of strand being substantially equal to the length of the core yarns in the same length of strand.

8. A rope strand comprising a cover of yarns and a core of rope elements, the core comprising a plurality of units twisted together in helices of substantially equal diameter about the axis of the strand, each unit comprising a plurality of rope elements twisted together in helices of substantially equal diameter about the axis of the unit, all of said rope elements in a given length of strand being of substantially equal length, and the pitch of the cover yarns in the strand bearing a predetermined relation to the pitch of the units in the strand.

9. A rope strand comprising a cover of yarns and a core of rope elements, the core comprising a plurality of units twisted together in helices of substantially equal diameter about the axis of the strand, each unit comprising a plurality of rope elements twisted together in helices of substantially equal diameter about the axis of the unit, all of said rope elements in a given length of strand being of substantially equal length, and such length bearing a predetermined relation to the length of the cover yarns in the same length of strand.

10. A rope strand comprising a cover of yarns and a core of rope elements, the core comprising a plurality of units twisted together in helices of substantially equal diameter about the axis of the strand, each unit comprising a plurality of rope elements twisted together in helices of substantially equal diameter about the axis of the unit, the pitch of the cover yarns in the strand bearing a predetermined relation to the pitch of the units in the strand and the length of the cover yarns in a given length of strand bearing a predetermined relation to the length of the said rope elements in the units in the same length of strand.

11. A rope strand comprising a cover of yarns and a core of rope elements, the core comprising a plurality of units twisted together in helices of substantially equal diameter about the axis of the strand, each unit comprising a plurality of rope elements twisted together in helices of substantially equal diameter about the axis of the units, the pitch of the cover yarns in the strand being substantially equal to the pitch of the units in the strand, and the length of the cover yarns being substantially equal to the length of the said rope elements in a given length of strand.

12. A rope strand containing a core and a cover made entirely of yarns of the same size and material, the core comprising a plurality of units twisted together to the left in helices of substantially equal diameter about the axis of the strand, each unit comprising a plurality of yarns twisted together to the left in helices of substantially equal diameter about the axis of the unit and without center yarns, the cover comprising yarns formed to the left about and enclosing the core, the pitch of the cover yarns in the strand bearing a predetermined relation to the pitch of the core units in the strand, all of the core yarns in a given length of strand being of substantially equal length, which length bears a predetermined relation to the length of the cover yarns in the same length of strand.

13. A rope strand containing a core and a cover made entirely of yarns of the same size and material, the core comprising a plurality of units twisted together to the left in helices of substantially equal diameter about the axis of the strand, each unit comprising a plurality of yarns twisted together to the left in helices of substantially equal diameter about the axis of the unit and without center yarns, the cover comprising yarns formed to the left about and enclosing the core, the pitch of the cover yarns in the strand being equal to the pitch of the core units in the strand, and all of the core yarns and cover yarns in a given length of strand being of substantially equal length.

14. An all yarn rope, each strand comprising a plurality of core units twisted to the left with cover yarns, the pitch of the cover yarns in the strand being the same as the pitch of the core units in the strand, the core units forming helices of equal diameter about the axis of the strand, each core unit comprising a plurality of yarns twisted together to the left in helices of equal diameter about the axis of the unit, all of the yarns, including both the core yarns and the cover yarns, being of substantially the same length in a given length of the rope.

15. A cable laid rope embodying strands, each strand comprising a plurality of units twisted together in helices of substantially identical diameter about the axis of the strand, each unit consisting of a plurality of rope elements twisted together in helices of substantially identical diameter about the axis of the unit without center elements so that all of the said rope elements in a given length of strand are of substantially equal length.

16. A cable laid rope as in claim 15 wherein each strand is provided with cover yarns the length of which in a given length of strand, is substantially equal to the length of the rope elements of the core units in the same length of strand.

17. A rope strand comprising a cover and a core, the core comprising a plurality of units twisted together in helices of substantially equal diameter about the axis of the strand, each unit comprising a plurality of rope elements twisted together in helices of substantially equal diameter about the axis of the unit, the cover com-

prising rope elements twisted around the core, and the length of all of the rope elements in the core units of a given length of strand being substantially equal and not more than three percent. shorter than the length of the rope elements in the cover of the same length of strand.

18. A rope strand comprising a cover of rope elements and a core of rope elements, the core comprising a plurality of units twisted together in helices of substantially equal diameter about the axis of the strand, each unit comprising a plurality of rope elements twisted together in helices of substantially equal diameter about the axis of the unit, all of said rope elements in the core of a given length of strand being of substantially equal length, and such length bearing a predetermined relation to the length of the rope elements in the cover in the same length of strand.

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