

Aug. 24, 1965

J. STIRLING

3,201,930

ROPE STRAND AND METHOD FOR MAKING SAME

Filed May 13, 1963

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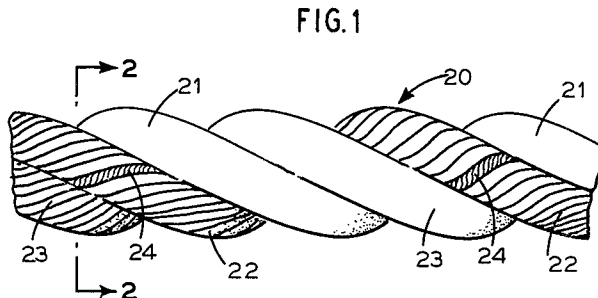
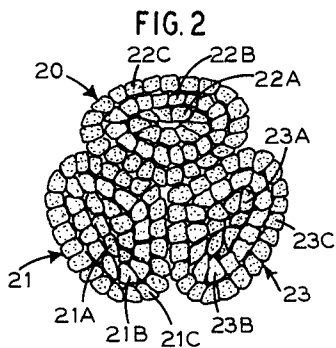
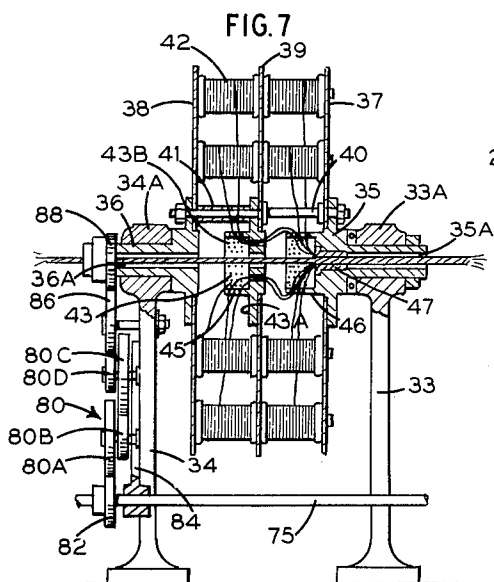
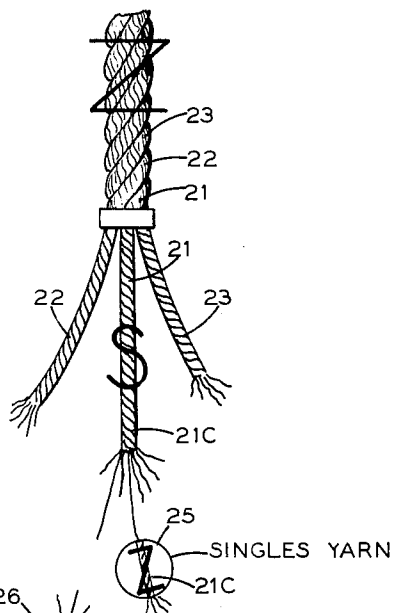
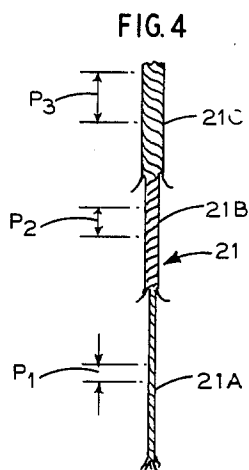


FIG. 3



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2 Sheets-Sheet 2

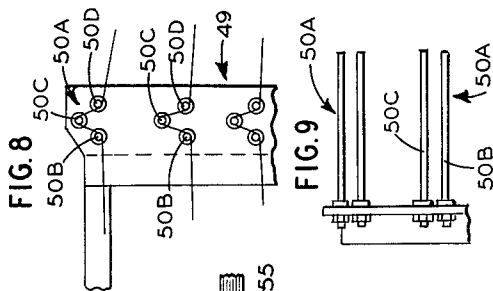


FIG. 6

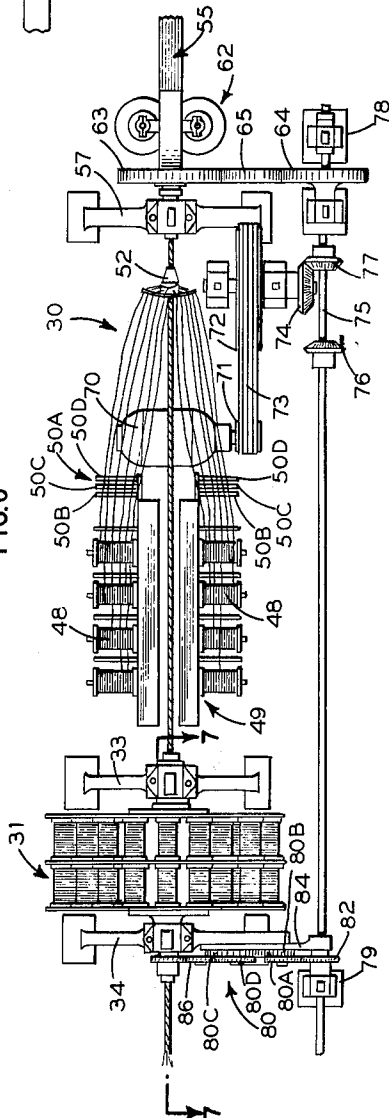
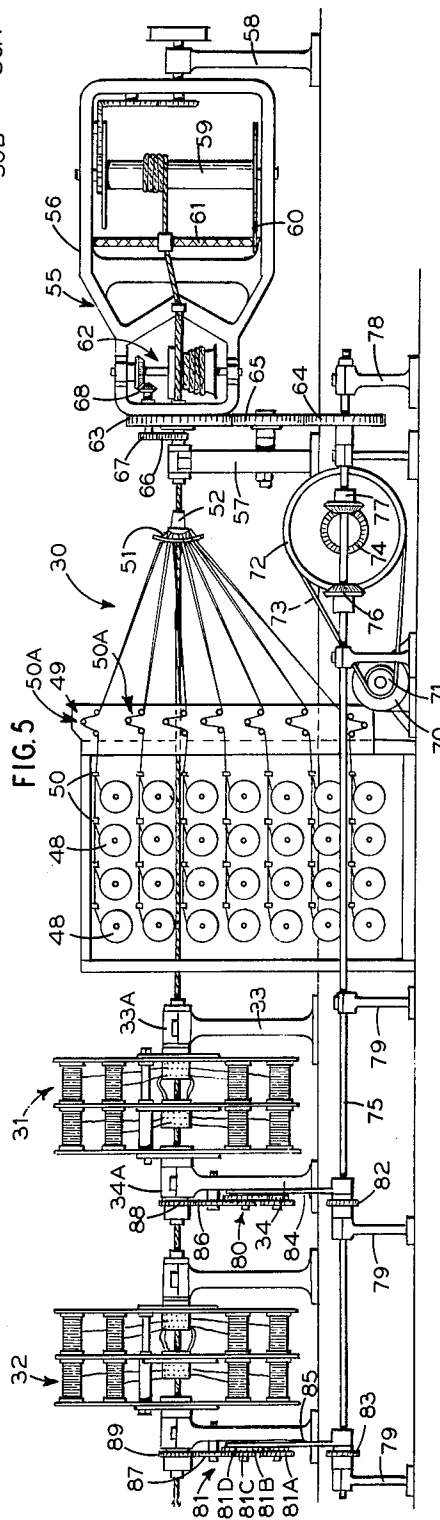


FIG. 5



1

3,201,930
**ROPE STRAND AND METHOD FOR
MAKING SAME**
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Long Island, N.Y.
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18 Claims. (Cl. 57—144)

This application constitutes a continuation-in-part application of my pending application S.N. 827,515, filed July 16, 1959, now Patent 3,097,472.

This invention relates in general to a rope strand construction, and to a method and apparatus for making the same. More particularly the invention relates to an improved rope strand made of either natural or synthetic fibers specifically constructed so as to insure that each of the individual fibers in the finished strand is substantially equal in length per unit length of strand when the same material is used so that each fiber is uniformly stressed when loaded, and including the method and apparatus for making the same. The invention further contemplates an improved strand construction as described wherein dissimilar materials either natural and/or synthetic are used wherein the length of the individual fibers is controlled by taking into consideration the known elastomeric properties of the different materials used so that the individual fibers will be more uniformly stressed under load.

It has been observed upon many observations and close examinations that ropes of conventional construction fail for the most part in one strand which is broken to destruction while the other strands usually have several of the inside or core yarns pulled out to destruction, with the cover yarns showing no signs of any appreciable damage. The extent of damage resulting from such breaks of course depends on the specific construction of the rope, e.g., with regard to the twist of the yarn, the lay of the strand, the lay of the rope, the fore-haul, and the tension during manufacture. However, the indications are evident that failure of the present day rope construction is due to the load being unevenly distributed over each strand, and over each of the individual ends or yarns therein.

In considering for example a three strand manila rope of 5" circumference, such rope normally requires 50 ends or fibers of #18 yarn (270 ft./lb.) in each strand. If 290 lbs. is taken as the breaking strain for this size yarn, it will be noted that 3 strands $\times$ 50 ends $\times$ 290 lbs. per end equals 43,500 lbs., or the theoretical breaking strain for such rope. However, the required minimum break for such 5" circumference 3 strand manila rope according to Federal Specification TR 605 is 22,500 lbs. or approximately 48% less than the 43,500 lbs. These facts are well-known to ropemakers, but very little has been done to reduce this loss in strength. It is possible to achieve relative equality of yarns in a strand structure by using groups of twisted yarns in the form of a strand structure or even a rope structure and using these in finished strand construction. But this method and the other known methods have the disadvantage of necessitating additional operations with the resultant increase in cost or decrease in production. This disadvantage is serious enough to offset any improvement that might result in achieving equal yarn lengths in the strand structure. Furthermore, the twisting of groups of yarn to form units for the strand

2

structure will result in increased shear stresses which will also offset the advantage that should be obtained by making the yarns in the strand substantially equal.

A further examination of a piece of finished 5" circumference manila rope of standard lay and conventional construction will reveal that the individual yarns in the strand vary in length over the length of the finished rope approximately as follows:

The outside cover yarns, plus 32.3%;
The second cover yarns, plus 26.2%;
The core cover yarns, plus 24.1%;
And the core yarns, plus 23%.

As a result of the variance in the lengths of the yarns in the respective layers of a rope strand, the maximum pull on the strand is taken by the inside or core yarn when a load is applied to the strand.

The above percentages of length of course will vary with the different materials used, but in all cases where the rope strand is made in accordance with known constructions, there will be a considerable variance in the length of the fibers in the respective layers of the strand, i.e., the cover yarns will be longer than the core yarns. Usually a piece of such rope when broken in a test machine will break in one strand. If the rope strand is made of natural fibers, e.g., manila or sisal, examination of the remaining unbroken strands will show several of the core yarns broken into short powdery lengths while the cover yarns show very little signs of damage, indicating that the core yarns, being shorter, are carrying more than their share of the load.

If synthetic fibers make up the rope strand, there will be evidence of fusing in the core yarns.

Such inherent latent weakness in a rope of conventional or heretofore known construction can and has resulted in serious situations. For example, such ropes when used as ship mooring lines are repeatedly subjected in rough weather to stresses which are just under the breaking stress of the rope, and therefore become internally weakened. With the exception of a little external fusing and chafing at the chocks, capstan and other points of contact, the very real damage to the core yarns can not be readily noticed. The results attributed to such rope failure thus become obvious.

Therefore, an object of this invention is to provide a rope construction employing either natural or synthetic fibers in which the lengths of the respective individual fibers, yarns, cords, or ends making up the rope strand are rendered substantially equal in length when the same material is used throughout the construction so that each yarn will be uniformly stressed under a given load condition.

Another object is to provide an improved rope strand construction formed of dissimilar synthetic fibers, ends, or yarns in which the physical properties of the respective synthetic fibers are utilized together with the controlled lengths of the fibers in the core and the respective layers of the strand to effect the necessary stretch or elongation to compensate for any variations in the lengths of the respective individual synthetic yarn making up the rope strand.

Another object is to provide an improved method of forming a rope element in which all the individual fibers, yarns, cords or ends are twisted and layed with respect to one another so as to assure that the respective lengths

of the individual yarns are substantially equal per unit length of strand when the same material is used.

Another object is to provide an apparatus for controlling and varying the twist of the respective layers of yarn making up a strand of rope so as to assure that the lengths of the individual yarns in each of the layers are made to the correct length to assure a more equitable distribution of load when similar or dissimilar materials are used.

Another object is to provide a rope making machine which controls the pitch at which the fibers of the same material are twisted per unit length of rope whereby the twist of the respective layers of fibers from the core to the outermost layer of the strand is progressively decreased so that in a finished strand the respective fibers of the core and of each of the succeeding layers are substantially equal in length for insuring uniform stressing of the respective fibers under given load conditions.

Still another object of the invention is to provide a machine in which the loss in strength of all types of ropes of either natural or man-made fibers made thereby is reduced to a minimum.

Still another object is to provide an apparatus for making an improved strand of rope that is relatively simple in construction, relatively inexpensive to fabricate and positive in operation.

A further object is to provide a machine for achieving a balanced rope strand construction.

The above objects, features and other advantages are attained by a rope strand or rope element which may be constructed of either natural and/or synthetic fiber, yarns, cords or ends. In accordance with this invention the improved rope strand or rope element is specifically constructed so that the respective ends, fibers, yarns or cords which make up the same are maintained at a controlled length per unit length of finished strand or element so as to result in each of the respective fibers or yarns being able to take its equal share of the load when the rope strand is subjected to a stress for obtaining either maximum strength or for achieving maximum service at whatever load applied. In general the rope strand or rope element construction comprises a core, and at least one or more concentrically disposed layers of yarns or fibers respectively twisted in successive layers onto the core. The arrangement is such that the core and each of the succeeding layers of yarn or fibers laid thereon are twisted either all in the same direction, or the respective layers may be alternately twisted in opposite directions. In either event the specific construction is such that the pitch of the respective layers is varied so that the pitch of each layer including the core is progressively adjusted from the core to the outermost layer of strand. Accordingly for optimum strength, the yarns of the strand structure and the fibers of the respective yarns in said strand structure are similarly laid into their respective element.

In a modified strand or yarn construction formed entirely of synthetic fibers, the core and the one or more layers twisted about the core are respectively formed of dissimilar synthetic material. In accordance with this invention the synthetic fiber material having the greatest working elasticity is utilized for the core, and other dissimilar synthetic material or materials having preferably progressively less working elasticity are utilized for the respective succeeding layers twisted about the core. The arrangement of this modification is such that the physical properties of the respective dissimilar material are utilized to effect the necessary relative stretch or elongation, when the strand so constructed is stressed, to compensate for any variations in the lengths of the respective individual synthetic yarn or fibers that make up the strand or element. For greater effect, the twist of the respective layers of synthetic yarn or fibers may likewise be varied so that the pitch of the respective layers of synthetic fibers is progressively adjusted or controlled from the core

layer to the outermost layer so that all fibers are more uniformly stressed at a given load.

The method for forming the rope strand in accordance with this invention comprises essentially twisting a plurality of yarn, either of natural or synthetic fibers, to form a core, and twisting other like or dissimilar yarns about the core layer to form thereon one or more succeeding concentrically disposed layers, and progressively adjusting the pitch of the yarn in each of the layers from the core to the outermost layer so that the fibers in each of the respective layers will be more equally stressed under a given load. Each succeeding layer may be twisted either all in the same direction or in opposite direction.

A machine for constructing a rope strand in accordance with this invention comprises in general a plurality of bobbin carrying table units rotatably journaled about a horizontal axis. The respective table units are disposed in axial alignment so that the yarn drawn from the bobbins of one of the table units may be pulled co-axially through the center of the next succeeding table unit whereby the yarns drawn from the bobbins of the latter table unit are twisted onto the yarn drawn from the former unit. The arrangement is preferably such that the number of table units co-axially arranged is equal to one less than the number of layers which make up the finished strand. Accordingly the yarns for the outermost or covering layer are drawn from bobbins carried by a stationary support or creel. The means for drawing the yarns from the respective bobbins and for forming the same onto the strand formed by the table units comprises a flyer of conventional construction.

In accordance with this invention means are provided for independently controlling and varying the speed and direction of rotation of the respective table means and flyer with respect to one another so as to give the correct number of turns or pitch to each of the respective yarn layers so that in the finished strand the yarns of the respective layers are rendered substantially equal in length when the same material is used or adjusted to the correct length in relation to the known elastomeric properties of the dissimilar materials used. As a consequence the finished strand comes very close to having each yarn or cord therein assume an equal share of the load applied thereto. If desired, by suitable gearing in the drive means, the respective table means may be rotated all in the same direction, or alternate table means may be rotated in opposite direction, or in any desired combination thereof.

A feature of this invention resides in the provision wherein the respective bobbin carrying table means and the flyer are independently controlled to vary the twist of the respective yarns accordingly in each of the layers making up the rope strand so that the respective lengths of the fibers or yarns, per unit length of finished strand, are rendered substantially equal in length when the same material is used, or adjusted to the correct length in relation to the known elastomeric properties of the dissimilar materials used.

Other features and advantages will become more readily apparent when considered in view of the drawings and description in which:

FIG. 1 shows a piece of three strand rope with one strand marked off to show the general pattern of an individual cover yarn.

FIG. 2 is an enlarged cross-section of the rope taken along line 2—2 of FIG. 1.

FIG. 3 illustrates a piece of three strand rope in which the lays of the respective individual components thereof are emphasized.

FIG. 3A is a modified showing of a strand formed with 3 ply yarn with Z twist made of 3 singles of S twist.

FIG. 4 illustrates an individual rope strand as made in accordance with this invention with the yarns or ends removed to show the core of the strand, one layer of cover yarn for the core, and an outside cover yarn. P₁, P₂, P₃ identify the pitch or lay of each layer to illustrate

5

the progressive increase in the twist per unit length of the respective layers from the outermost layer to the core so as to equalize the respective lengths of all the yarns when the strand is laid into finished rope.

FIG. 5 illustrates a side elevation view of a machine 5 for making the rope strand of this invention.

FIG. 6 is a partial plane view of FIG. 5.

FIG. 7 is a partial vertical sectional view taken along line 7—7 of FIG. 6.

FIG. 8 is an enlarged detail view of the yarn tensioning means.

FIG. 9 is a side view of FIG. 8.

Referring to the drawings, FIG. 1 illustrates a length of rope 20 embodying the improved rope strand construction of this invention. The illustrated length of rope 20 is made up of three strands 21, 22, 23. The individual strands of rope 20 can be readily produced on the machine illustrated in FIGS. 5 to 7, which will be hereinafter described. The rope 20 of FIG. 1 is shown with strand 22 marked off as indicated at 24 to show the general pattern of the individual cover yarns. Accordingly the outside cover yarn 24 is shaded darker to illustrate how it shows up on the outside and travels in a spiral around the outside of the strand going to the inside of the rope and reappearing on the outside again in a distance approximately equal to the lay of the rope.

FIG. 2 illustrates the cross section of the rope 20. It will be noted that each of the respective strands 21, 22 and 23 comprises a core 21A, 22A, 23A and a plurality of concentrically disposed layers which includes an intermediate layer 21B, 22B, 23B and an outermost cover layer 21C, 22C, 23C. Each of the respective layers are formed of several ends, fibers or yarns. While only one intermediate layer is shown, it will be understood that more than one intermediate layer may be provided depending upon the size of rope desired.

FIG. 3 illustrates, for an example, a rope construction in which the respective direction of twist of the individual rope components, making up the rope, are emphasized. In the example it will be noted that the three strands 21, 22, 23 are twisted so that they slope upwardly and to the right to define a right or Z twist as it is normally referred to in the art. For illustrative purposes a Z is superposed on the lay of the strands 21, 22, 23. Accordingly the yarns in the cover or outermost layer of each of the respective strands are layed so that they slope upwardly and to the left with a left or S twist or lay. This is indicated by the S formed in strand 21. It will be noted that if the respective layers are formed of single yarns, then the respective single yarns are twisted or layed with a twist which is opposite to that of the layer which includes it. For example if the outer cover is formed of single yarns and individual ends therein are layed with a left twist, the twist of the individual single yarns making up the outer cover layer is to the right or Z twisted. This is shown in FIG. 3 at 25 where cover yarn 21C of strand 21 is magnified.

If the respective layers of the strand are formed of plied yarn as indicated at 26, FIG. 3A, and as disclosed in a U.S. patent to D. Himmelfarb et al. #2,971,321, then the plied yarn 26 which makes up the respective layers is twisted in a direction opposite to that which the yarn in the given layer is layed, with the singles of plied yarn 27 being twisted in the direction opposite to the twist or lay of the plied yarn. For example, if the cover layer 21C was formed of a plurality of plied yarns, and the cover yarns were twisted with a left or S lay, as shown in FIG. 3, then the individual plied yarns 26 are plied to the right with a Z twist, whereas the individual singles of said plied yarn 27 are formed with a left or S twist. Thus it will be noted that the twist of the individual yarns in each of the respective layers of the strand is always opposite that of the layer which includes the same.

6

FIG. 4 illustrates a further detail of construction. In accordance with this invention the twist, i.e. number of turns per unit length, of the yarn which make up the respective layers of each strand is varied in a particular relationship so as to insure that in a finished strand the respective yarns of each layer are rendered substantially uniform in length. Referring again to FIG. 4, portions of the yarns or ends are removed to show the core layer 21A of the strand 21, the core cover yarn 21B, and the outside cover yarn 21C. P_1 , P_2 and P_3 illustrate the pitch or lay of the yarns in the respective layers which make up the strand, and thus it is evident the twist per unit length of the successive layers is progressively increased toward core 21A. The arrangement thus described will serve to balance the respective lengths of all the yarns when the strand is laid into a finished rope.

The method of making an improved strand or rope in accordance with this invention comprises the steps of progressively twisting a plurality of threads, cords or ends to form a core layer with a predetermined pitch or number of turns per unit length, and successively twisting of a plurality of other cords or ends in concentric layers about the core layer so that the pitch of the next core covering layer is greater than the pitch of the core layer and so on, so that in a finished strand of unit length the cords or ends in each of the respective layers are substantially equal in length when the same material is used whereby each end may be uniformly stressed when a load is applied thereto. In accordance with this method two or more layers of fibers may be concentrically twisted one layer upon the other wherein the twist or number of turns per unit length of each succeeding layers from the outermost layer to the core layer is progressively increased. Also, it is contemplated that the respective succeeding layers may be twisted either in the same direction or opposite direction. It is also noted that the method described is equally applicable to making rope strand of synthetic fibers, as well as of natural fibers.

In the making of rope of synthetic fibers, this invention further contemplates the utilization of the physical properties of the respective synthetic fibers, making up the rope strand, to effect the relative proportional elongation of the rope yarns or fibers so that each is the correct length in relationship to the known elastomeric properties of the dissimilar materials used so that each fiber will be more evenly stressed under a given load. The above concept may be utilized either separately or in conjunction with the method above described.

The common synthetics used in rope making are polyamide fibers—"nylon," polyester fibers—"Dacron," polyethylene, polypropylene multi-filament—Prolene, polypropylene, mono-filament. These materials have distinct physical properties, i.e. each has distinct rates of permanent elongation, working elasticity, melting temperatures, and relative strength. For example, assuming a normal load of 30% of ultimate breaking stress and a conventional rope construction the synthetic fiber material listed below evidenced the following characteristic:

Material	Permanent elongation, percent	Working elasticity, percent	Melting temp., °F.
Polyamide fibers—nylon....	13	23	About 430
Polyester fibers—Dacron....	12	9	About 500
Polypropylene (multi-filament—Prolene)....	15	14	About 350
Polypropylene (mono-fil)....	11	13	About 350
Polyethylene.....	9	10	About 265

The relative strength of the above material for a 6" circumferential rope based on average breaking strength in pounds is

Polyamide fiber—"nylon"	91,000
Polyester fiber—"Dacron"	61,300
Polypropylene multi-filament Prolene	59,000
Polypropylene mono-filament	53,000

In accordance with this invention an improved rope strand is formed by using a combination of these different synthetic fibers. The necessary stretch to compensate for the variation in lengths of the individual yarns which make up the rope construction is attained by special arrangement of the relative synthetic fibers. For example, an improved synthetic rope construction is attained by forming a core of polyamide fibers—nylon, making the core cover of polypropylene (multi-filament)—Prolene, making the next layer of polypropylene monofilament, and the cover of polyester fibers—Dacron. Nylon or polyamide fibers in the core will, because of the inherent characteristics thereof, take on more twist without any serious reduction in its strength, and will stretch more than the other synthetic fibers listed. Prolene, a trade name for a very fine multi-filament polypropylene, will also take considerable twist and stretch. Polypropylene mono-filament will not take as much twist as Prolene, but it will take more twist than Dacron. For this reason polypropylene mono-filament is used in the second cover layer where an intermediate amount of twisting is required in accordance with this invention. Also polypropylene mono-filament will stretch more than the polyester fiber or Dacron. Dacron or polyester fiber which should take less twist and less stretch is employed in the outermost or cover layer where the requirement for twist and stretch are least required in a rope construction of this invention.

In the synthetic rope construction using a combination of the different synthetic fibers discussed above, it will be noted that the melting point and resistance to fusing of the respective fibers is also taken into consideration to result in the rope construction capable of obtaining the most optimum results. In accordance with this invention, for example, polyester fibers or "Dacron" which has a melting point of about 500° F., when coupled with its relatively low percentage of working elasticity forms an optimum cover for the rope as it can take greater stress and pressure at the hilts. Thus it has the wear qualities, i.e. its resistance to abrasion and fusion, which will materially enhance the useful life of such rope construction. From the foregoing it will be readily apparent that the concept hereinbefore described of maintaining the stresses and ultimate length of the individual fibers of the same material substantially equal when loaded can be also closely approached by a proper selection of the synthetic fibers and placing them in accordance to their physical properties relative to one another so as to obtain the optimum results. If desired the same considerations can be applied when making rope strand utilizing a combination of natural and synthetic fibers. For optimum results it is necessary to adjust the pitch of the core and the respective layers in the strand structure in relationship to the known elastomeric properties of the different materials used in the core and the respective layers so that the individual fibers will be more evenly stressed under a given load.

While the respective rope construction and method of making the same hereinbefore described can be performed by hand, it is preferred that the same be automatically performed at relative high speed by the following described apparatus.

Referring to FIGS. 5 to 7, the apparatus 30 for making rope strand as above described comprises a plurality of rotatably journaled bobbin carrying table means 31, 32. Each of the table means 31, 32 are substantially similar in construction and therefore the detailed description of one is considered sufficient to understand the arrangement thereof. Each table means 31, 32 includes a pair of spaced apart upright stanchions 33, 34 provided with a bearing boss 33A, 34A at the upper ends thereof. A flanged bearing 35, 36 having a bore 35A, 36A extending therethrough is rotatably journaled in each of the bearing bosses 33A, 34A. Connected to the flange of the respective bearings 35, 36 is a table plate 37, 38, respectively, which is preferably of circular configuration. In the illus-

trated embodiment an intermediate table plate 39 is spaced in co-axial relationship to plates 37 and 38. The respective plates are maintained in spaced relationship by the bolts 40 extended through suitable sleeve spacers 41 disposed between adjacent table plates. Bobbins 42 supplying yarn for making the rope strand are mounted between adjacent pairs of plates. As seen the bobbins 42 are circumferentially spaced around the table plates. In the illustrated example each table plate is sized to take 48 8x10 bobbins, 24 between each of spaced adjacent plates 37, 39 and 39, 38. While the table unit illustrated is made up of three spaced plates 37, 38 and 39, it will be understood that the same may be made with more or less numbers of spaced plates, the number of spaced plates being determined by the number of bobbins to be carried by the table unit. With the specific table unit construction described, it will be noted that the physical dimensions of the table plates can be controlled within practical considerations by varying the number of table plates.

In accordance with this invention, if an intermediate table plate 39 is utilized, it is provided at its center with a yarn guide 43. As shown the yarn guide 43 comprises a flanged hub 43A formed with a connected cylinder portion 43B. Accordingly guide holes 44, 45 are formed both in the cylinder portion 43B and in the hub of guide 43 respectively, to guide the yarn drawn from the bobbins disposed between plates 38, 39. The outermost table plate 37, in the direction in which the yarn is being drawn is also provided with a similar constructed guide 46. However, guide 46 is formed integral with bearing 35. Located centrally of the guide 46 is a compacting tube 47 which serves to compact the yarns being drawn from the respective bobbins 42 carried by the table unit. It will be noted that the size or diameter of the respective compacting tubes 47 in each of the table units is varied so as to accommodate the yarn or ends being drawn therethrough.

In the illustrated embodiment only two table means 31, 32 as above described are shown. However, it will be understood that the number of table means can be varied depending upon the number of layers and size of the rope strand which is to be formed. It will be also noted that in accordance with this invention the number of table means provided is preferably one less than the number of yarn layers required to make a given rope strand. This is because in accordance with this invention the outermost or cover layer of a given rope strand is provided by bobbins 48 which are carried on a stationary creel means 49.

The creel means 49 comprises essentially a stationary frame on which are mounted the several bobbins 48 from which the yarn for the covering layer is drawn. Accordingly the covering yarns from bobbins 48 are threaded through suitable creel yarn guide means 50 and tensioning means 50A to guide plate 51 from whence the covering yarn is passed through the compacting tube 52 and twisted onto the strand portions being drawn from the table units 31 and 32. As best shown in FIGS. 8 and 9, the tensioning means 50A comprise a series of tensioning rods 50B, 50C, 50D which extend laterally of the creel part or frame. The respective tensioning rods 50B, 50C, and 50D of each tensioning means 50A are fixed relative to one another, and to the creel frame, as shown. Thus the respective yarn, cord, or fibers are guided under rod 50B, over rod 50C and under rod 50D in passing from the guides 50 to the guide plate 51. In this manner the tensioning means serve to straighten out any cockles in the yarns passing thereover so that it will appear smooth and regular in the cover. The amount of tension used is that amount sufficient to keep the cover yarn straight.

As it will be seen in FIG. 5, the means for drawing the yarn from the respective bobbins comprises a flyer 55 of well known construction to those skilled in the art. Essentially it comprises a frame 56 which is rotatably journaled between supports 57 and 58. A take-up reel 59 for receiving the finished rope strand is journaled between the sides of the frame. Associated in driving relationship

with the reel by a gear train 60 is a traverse screw means 61 for properly positioning the strand on the reel 59.

The flyer also includes a gear and capstan assembly 62 about which the finished strand is wound. As shown the flyer 55 is rotated through a flyer gear 63 which is driven by a spur gear 64, which is connected to the main drive shaft 75 through an idler gear 65. A gear train including gears 66, 67 and 68 serve to drive the capstan assembly 62 as the flyer 15 is rotated.

In accordance with this invention a feature resides in a drive means for individually controlling the speed and the direction of rotation of the respective table units 31, 32 and the flyer 55 with respect to one another so that the twist or pitch of the yarn making up the respective layers of the rope strand can be controlled with a relatively high degree of accuracy. Thus by varying the pitch or lay of the respective layers in a predetermined manner, the respective yarn or ends in each layer of the rope strand are maintained substantially equal in length when stressed.

In accordance with this invention the drive means comprise a motor 70 which is connected in driving relationship through V pulleys 71, 72, belt 73 and connected driving bevel gear 74 to a shaft 75. As seen in FIG. 6, the driving gear 74 is coupled to the pulley 72. The drive shaft 75 has connected thereto a pair of gears 76, 77 which are arranged to selectively mesh with the bevel driving gear, depending on the direction of rotation desired. As shown the main drive shaft 75 is rotatably journaled in suitable bearings 78 and 79. It will be noted that gears 76 and 77 are longitudinally splined and adjustable along the driving shaft 75 so that when gear 76 is meshing with bevel gear 74 the shaft rotates in one direction, and when gear 76 is disengaged and gear 77 engaged with gear 74, the shaft is rotated in the opposite direction.

Connected to one end of shaft 75 is the spur gear 64 which drives the flyer 55 in a given direction through an idler gear 63. The respective table units are individually controlled by respective gear trains 70 and 81 as to direction and speed of rotation, the respective gear trains being driven by shaft 75. For reasons of clarity of showing, the drive shaft has been shown at a lower elevation. Therefore, in practice spur gears 82, 83 keyed to shaft 75 are disposed in engaging or meshing relationship with gear trains 80, 81 respectively. The respective gear trains 80, 81 comprise meshing gears 80A, 80B, 80C, 80D and 81A, 81B, 81C, 81D which are respectively mounted on swing arms 84, 85. The arrangement is such that the last gear in the respective gear train 80D, 81D meshes with an idler gear 86, 87, respectively, which in turn meshes with a spur gear 88, 89, respectively, keyed to the flanged bearing 36 of the respective table units.

According to this invention the ratio of the respective gear train 80, 81 is such that the speed and direction of the table rotation can be varied relative to each other and to that of the flyer 55. Thus by suitable gearing ratios the speed and direction of the respective table means and that of the flyer can be individually controlled and established. Thus the relative angular speed of the respective table means and that of the flyer attains a result in which the ends or yarns in the finished strand are maintained substantially uniform or equal in length, which is required when the same material is used. The gear ratio can be changed to give the correct twist to the respective stages of the strand structure when dissimilar materials are used so that the pitch of the core and the respective layers in the strand structure is adjusted in relationship to the elastomeric properties of the respective materials used.

If desired gears of the respective gear trains may include a change gear which can be readily interchanged so as to vary the angular speeds of a given table unit controlled thereby at will. Therefore, from the foregoing description it will be readily apparent that the twist, i.e. number of turns per given unit length of the respective strand layers will vary in accordance with the relative angular rotation of the respective table units and the

flyer. In the illustrated embodiment the ratios of the gear trains are calculated so that the pitch of the respective layers increase progressively from the core to the outermost layer, as best seen in FIG. 4, i.e. twist per unit length of the respective layers of yarn from the core to the outermost layer of the strand is progressively decreased so that in the finished strand the individual yarn of the same material of the respective layers are substantially equal in length, and thereby each yarn is able to carry substantially its equal share of the load when stressed. By changing the gear ratio, the necessary adjustment to the lengths of the yarns in the core and in the respective layers of the strand structure can also be achieved to utilize the respective known elastomeric properties of the different material used so that the respective fibers will be more uniformly stressed at a given load. From the results of tests made for singles yarn and for strand and for rope where the singles yarn and the strand were made as herein described all elements in the rope structure showed increased strength, less stretch, longer life and also increased productivity. In accordance with this invention, the pitch of the cover layer of yarn in the strand is longer than the pitch of the cover layer of an equally sized strand conventionally made even though both strands are equally well compacted. This will hold true also in regard to the fibers in the singles yarn or the singles of plied yarn so that the end result in increased production in addition to the other improvements in the physical characteristics thereof.

While the instant invention has been disclosed with reference to a particular embodiment thereof, it is to be appreciated that the invention is not to be taken as limited to all of the details thereof as modifications and variations thereof may be made without departing from the spirit or scope of the invention.

What is claimed is:

1. A rope strand comprising a core, said core including a plurality of yarns twisted about a common axis at a predetermined pitch per unit length, a layer of individual yarn elements twisted about said common axis onto and about said core whereby the pitch per said unit length of said layer of yarn is greater than the pitch per unit length of said core measured along said common axis, so that each yarn in said core and the yarns of said core covering layer reach their maximum elongation at the breaking stress to insure each of said yarns being uniformly stressed under a given load.

2. The invention as defined in claim 1 wherein the yarns forming the core are twisted about said axis in one direction and the yarns layed onto the core being twisted about said axis in the opposite direction.

3. A rope strand comprising a core including a plurality of yarns twisted about a common axis at a predetermined pitch per unit length, a plurality of concentrically disposed layers of individual yarn elements twisted successively about said axis and about said core and each other whereby the pitch of the yarn in said core and each of said succeeding layers is progressively increased along said axis from the core to the outermost layers thereof, said yarns having substantially similar properties of stretch, so that in the finished strand the respective yarns in the core and in each of the concentrically disposed layers are rendered substantially equal in length to attain maximum strength with minimum twist so that each of the yarns may be uniformly stressed under a given load condition.

4. The invention as defined in claim 3 wherein yarns forming the core are twisted in one direction, and the yarns in each of the other succeeding layers are twisted in a direction relative to said core in a manner such that the outermost layer of the strand is twisted opposite to the lay of a rope including said strand.

5. The invention as defined in claim 3 wherein said plurality of yarns in the core and in each of the succeeding layers are twisted in the same direction.

6. The invention as defined in claim 3 wherein said plurality of yarns in the core and in each of the layers are twisted with an S twist.

7. The invention as defined in claim 3 wherein said plurality of yarns in the core and in each of the layers are twisted with a Z twist.

8. An element of a rope strand comprising a core of fibers twisted at a predetermined pitch per unit length, a core cover layer of individual fibers twisted concentrically about the axis of said core whereby the pitch of the fibers in said core cover layer is progressively increased over that of the core, and a first cover layer of individual fibers twisted concentrically about said axis of said core cover layer whereby the pitch of said first cover layer is greater than the pitch of said core cover layer, said fibers each having substantially similar elastomeric properties so that in the finished strand the respective fibers in the core and in the concentrically disposed layers about the axis of said core are rendered substantially equal in length to insure that each of the fibers in said core and concentrically disposed layers is uniformly stressed under a given load condition.

9. A strand of rope comprising a core of yarns twisted at a predetermined pitch per unit length, a layer of individual yarn elements having different elastomeric properties from the yarns in said core twisted about said core yarns to form a covering layer for said core yarns whereby the pitch per unit length of the yarns in said core and in said covering layer for said core yarns is governed by the known elastomeric properties of the respective yarns in said core and said covering layer so that each of said yarns is substantially uniformly stressed at a given maximum load.

10. A method of making a multiple layer rope strand comprising the steps of drawing a plurality of yarn from a source, twisting said yarns as they are drawn from the source to form the core of said rope strand, forming said twist so as to have a predeterminate pitch per unit length of said core, simultaneously pulling another plurality of yarn having substantially similar elastomeric properties as the yarn forming said core from another source, twisting said second mentioned yarns about said core to form a covering layer therefor as said core is formed, and forming the twist of said covering layer so as to have a pitch per said unit length which is greater than the pitch of said core in one continuing operation so that the respective yarns of said core and covering layer attain substantial equality in length to insure that each of said yarns is uniformly loaded when stressed.

11. A method of making a rope strand in one continuing operation comprising the steps of progressively twisting a plurality of yarn to form a core, simultaneously twisting other individual yarn elements about said core as said core is formed to form an intermediate layer, and simultaneously twisting still other individual yarn elements about said intermediate layer as said intermediate layer is formed onto said core to form an outer covering layer, the yarns in said core and in each of said layers having substantially similar elastomeric properties, and progressively increasing the pitch of each layer and said core per unit length from said core to said outer covering layer simultaneously so that the respective lengths of each yarn in each of said layers and said core is substantially equal in length to insure each of said yarns being uniformly stressed under a given load.

12. A method of making a rope element of synthetic fibers in one continuous operation comprising the steps of twisting a plurality of synthetic fibers to form a core, and simultaneously twisting a layer of individual dissimilar synthetic fibers onto said core whereby physical properties of the respective synthetic fibers are utilized to effect the necessary stretch to compensate for any variations in the length of the respective fibers making up the rope element and simultaneously varying the pitch of the core and the said layer of fibers about said core whereby the pitch

from the core to the outermost layer is progressively controlled in accordance to the elastomeric properties of the respective fibers in said core and said layer so that said fibers are uniformly stressed under a given load.

13. A method of making a rope strand of yarns comprising the steps of twisting a plurality of yarns to form a core, simultaneously twisting a plurality of yarns formed of a different material having a different working elasticity than that of the yarns of said core onto said core as said core is being formed, and simultaneously varying the pitch of said core and said layer covering said core whereby the pitch of said covering layer and the pitch of said core is governed by the difference in the working elasticity of the respective dissimilar yarns used so that each yarn in said core and said layer will be more equally stressed under a given load.

14. The invention as defined in claim 13 wherein each of said yarns are formed of dissimilar synthetic materials.

15. A strand construction having a plurality of yarn elements twisted to define a core and at least one layer of individual yarn elements twisted onto said core wherein the pitch at which the yarn elements in the core and in each of the layers are twisted so that the pitch is controlled from the core to the outer most layer in accordance with the known elastomeric properties of the yarn elements in the core and layer twisted thereon in such a manner that the yarn elements in said core and layer are uniformly loaded when stressed, and wherein the respective yarn elements making up the core and the layers of said strand include a plurality of fibers, a portion of which are twisted to define the core of said respective yarn elements, and with other portions of said fibers twisted in a layer about the core of said yarn elements wherein the pitch at which the fibers in the yarn core and in each of the yarn layers are twisted so that the pitch is progressively increased from the yarn core to the outer most yarn layer thereof in such a manner that the twisted fibers in the respective core of said yarn elements and the covering yarn layers thereof are rendered substantially equal in length.

16. A rope strand comprising a core, said core including a plurality of yarns twisted about a common axis at a predetermined pitch per unit length measured along said axis, a layer of individual yarns twisted about said common axis onto and about said core whereby the pitch per unit length of the respective yarns in said layer is greater than the pitch per unit length of the yarns in said core measured along said common axis so that in the finished strand the yarns of said core and the yarns of said core covering layer are rendered substantially equal in length to assure each of said yarns being uniformly stressed under a given load, and wherein the yarns in said core and in said layer are similarly constructed materials having similar elastomeric properties.

17. The invention as defined in claim 16 wherein the yarn in said core and in said layer comprise a plurality of fibers a portion of which are twisted to define the core for said yarn and with other portions of said fibers twisted in a layer about the core of said yarn wherein the pitch at which the fibers in the yarn core and in the yarn layer are progressively increased from the yarn core to the outer most yarn layer thereof in such a manner that the twisted fibers in the yarn core and the covering yarn layer thereof are rendered substantially equal in length so that the fibers in the respective yarn when laid into the core and covering layer of said strand are rendered substantially equal throughout said strand.

18. A yarn construction comprising a core, said core including a plurality of fibers twisted about a common axis at a predetermined pitch per unit length, a layer of individual fibers twisted about said common axis onto and about said core whereby the pitch per unit length of said layer of fibers is greater than the pitch per unit length of said core measured along said common axis, so that each fiber in said core and said layer reach their maximum

elongation at the breaking stress to insure each of said
yarns being uniformly stressed under a given load.

References Cited by the Examiner

UNITED STATES PATENTS

5

271,548 1/83 Trott et al.
1,896,084 2/33 Hill ----- 57—15
1,907,744 5/33 Craig ----- 57—15
2,022,683 12/35 MacKinnon et al. ----- 57—144
2,055,037 9/36 MacKinnon ----- 57—144

2,281,036 4/42 Hetzel ----- 57—144
2,438,864 3/48 Reed ----- 57—144
3,026,669 3/62 Stanton ----- 57—140
3,055,167 9/62 Gaston ----- 57—144

FOREIGN PATENTS

605,994 9/60 Canada.
811,501 4/59 Great Britain.
833,387 4/60 Great Britain.

10 MERVIN STEIN, *Primary Examiner.*