Sept. 23, 1969 C. L. HILDEBRAND 3,468,120

METHOD OF PRODUCING ALTERNATE TWIST YARN

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FIG. 1

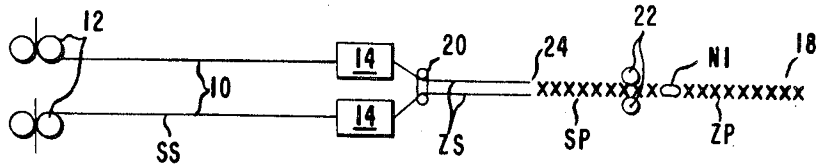

FIG. 2

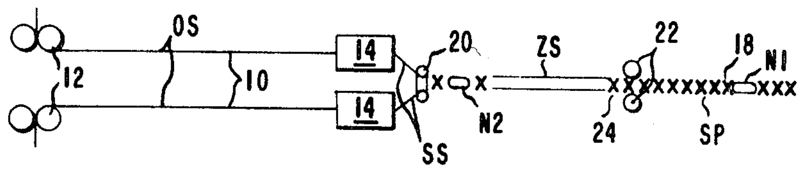

FIG. 3

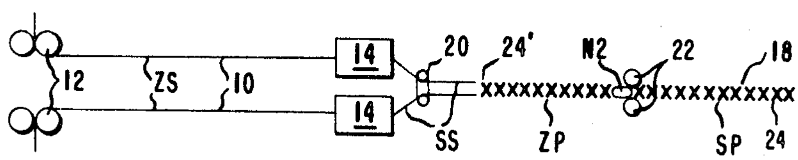

FIG. 4

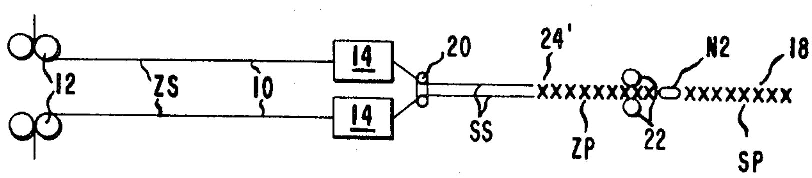

FIG. 5

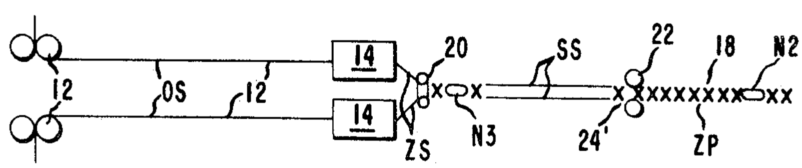

FIG. 6

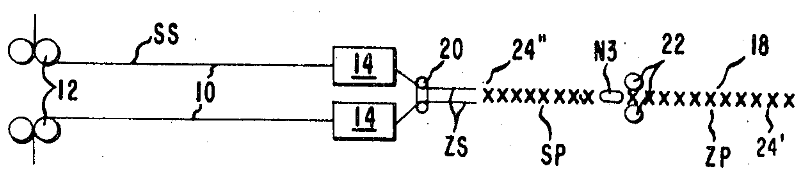

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FIG. 8

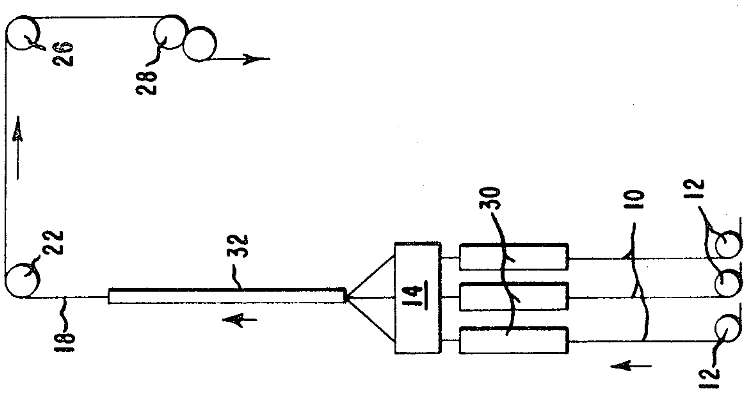


FIG. 7

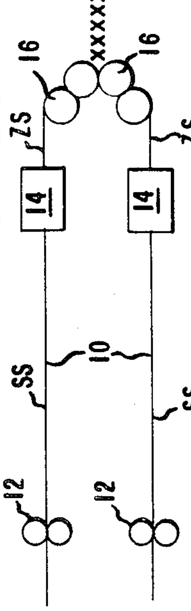


FIG. 9

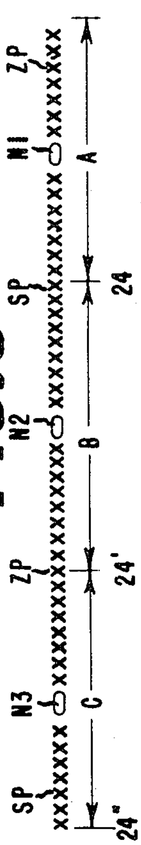


FIG. 10

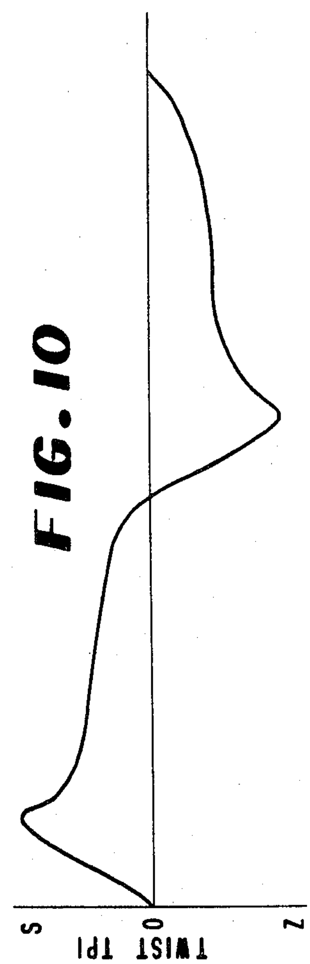
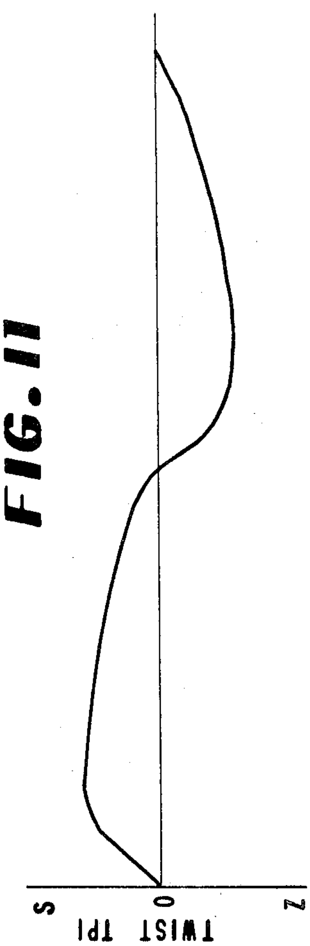


FIG. 11



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METHOD OF PRODUCING ALTERNATE TWIST YARN

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U.S. Cl. 57—157 4 Claims

ABSTRACT OF THE DISCLOSURE

Alternate-twist plied yarns are made by separately false twisting running textile strands alternately in opposite directions then converging the twisted strands and letting them partially untwist and thereby ply. An improvement in this method is provided by converging the twisted strands without snubbing, and snubbing at a point downstream of the twisting point a distance less than the distance between nodes and downstream of the convergence point a distance greater than ½ the distance between nodes.

Description of the prior art

British Patent 1,047,503 and United States Patent 3,225,533 disclose alternate-twist plied yarn structures and a method of making them. The method involves applying false twist to at least one of a plurality of parallel, separated, running textile strands, either intermittently in one direction or alternately in opposite directions, so as to produce in the strand(s) alternating zones of opposite twist separated by zones of zero twist referred to as nodes. The method further involves converging the strands downstream of the point where the false twist is applied, and permitting the twisted strand or strands to partially untwist. This untwisting action causes the strands to become alternate-twist plied about one another.

In the embodiments of this method disclosed in the above patents, the strands are converged at a snub point which stops the twist being inserted into the strand or strands. In other words, the twisting device does not apply torque to the strand or strands downstream of the convergence point. In the U.S. patent, the strands are converged in the nip of a pair of gears; in the British patent, they are converged on snubbing rolls. Consequently, the twisted strands are freed to begin untwisting as soon as they pass the convergence point, and the ply action thus begins to occur essentially continuously as the strands pass this point. In these prior art embodiments, then, the plying zone is positively separated or isolated from the twisting zone by the convergence point.

Summary of the invention

It has now been found that improvements in the quality of plied yarn produced by the above-described method wherein the direction of twisting is periodically reversed can be obtained by converging the strands, without snubbing, immediately downstream of the twisting point, and

snubbing at a point downstream of the twisting point a distance less than the distance between nodes, and downstream of the convergence point a distance greater than ½ the distance between nodes. As already implied, the word "snubbing" is used herein in a special sense to refer to applying sufficient constraint to the twisted strand or strands to prevent the torque produced by the false twisting from passing downstream or upstream of the point where such constraint is applied. The point where such constraint is applied is referred to as the "snub point."

As a consequence of this mode of operation, plying occurs intermittently in the zone between the convergence point and the snub point while a node, produced at the twisting point upon reversal of the direction of twist, moves through the plying zone and is free to rotate. During intermediate periods plying does not occur because the torque produced by the false twisting prevents the twisted strand or strands from untwisting and because there is no node in the plying zone which can rotate. When plying does occur, it occurs simultaneously on either side of a node as the node rotates with the untwisting of the strand.

In a preferred embodiment of the invention, false twist is applied to all the strands in phase, that is with nodes and like twist zones in register, and the strands are converged in phase, whereby the nodes in the plied yarn correspond to the nodes in the strands. Also in this embodiment, the direction of twisting is reversed at equal intervals whereby the node intervals (i.e. distances between nodes) are constant.

Improvements in yarn quality which are obtainable with practice of this invention include longer node intervals, shorter nodes, and higher level of twist adjacent nodes.

In a particularly preferred embodiment, the twisted strands are constrained in the plying zone (i.e. the zone between the convergence point and the snub point) sufficiently to slow down, but not prevent, untwisting. This permits production of a yarn with a very uniform ply twist profile.

Brief description of drawings

FIGS. 1 through 6 are schematic diagrams of the system used to practice the improvement of this invention, showing various phases of the operation through one complete cycle;

FIG. 7 is a schematic diagram of the system used to produce alternate-twist plied yarn structures as taught in the prior art, in particular FIG. 9 of U.S. 3,225,533;

FIG. 8 is a schematic diagram of a preferred equipment arrangement for practicing the invention;

FIG. 9 is a schematic representation of a portion of a plied yarn structure obtainable by the invention; and

FIGS. 10 and 11 are plots showing two types of ply twist profile obtainable by the invention.

Detailed description

Referring to FIGS. 1 through 6, the system used in practicing this invention comprises upstream nip rolls (or other snubbing means) **12**, false twisting means **14**, converging guide **20**, and driven nip rolls (or other snubbing and take-up means) **22**. In operation parallel, separated, running strands **10** are passed through twisting means **14** where they are individually false twisted alternately in opposite directions. Immediately downstream of the twisting means **14** the yarns are converged by passing them through guide **20**. Between guide **20** and nip rolls **22** the yarns ply, with the plying action occurring intermittently, to form stable alternate-twist plied yarn **18**. Twisted sections of plied yarn **18** are represented by *x*'s in the figures, and nodes are represented by ellipses.

The other symbols in FIGS. 1–6 have the following meanings: "ZS," "SS" and "OS" indicate, respectively, "Z" twist in strands **10**, "S" twist is strands **10**, and zero twist in strands **10**; "ZP" and "SP" indicate, respectively, "Z" twist in the plied yarn **18** and "S" twist in the plied yarn **18**; N1, N2 and N3 indicate three consecutive nodes.

FIG. 1 illustrates the condition of the system just at the end of an interval in which counterclockwise (as viewed in the direction of strand travel) twist has been applied to the strands **10**, thus producing S twist in the strands **10** upstream of twisting means **14** and Z twist downstream. The S twist in strands **10** backs up to nip rolls **12**, and the Z twist in strands **10** travels downstream to the point **24** where the strands are plied. Guide **20** converges but does not snub the strands **10**, i.e. it does not stop or block the twist introduced by twisting means **14**. Converged strands **10** between guide **20** and point **24** do not ply in this base of the operation because the action of twisting means **14** prevents them from untwisting, and also because there is no node in the plying zone between convergence point **20** and nip rolls **22** which can rotate. Rolls **22** provide the first snubbing point after the strands leave twister means **14**. Downstream of point **24** is a section of previously produced plied yarn **18** having a node N1 with S ply upstream of the node and Z ply downstream. Twist in the strands **10** downstream of point **24** is zero at the node N1 and is opposite to the direction of ply twist in the ply-twisted portions of yarn **18**.

FIG. 2 illustrates the condition of the system a short time later, after the twisting action has been stopped momentarily, then reversed to twist the strands **10** in the opposite (clockwise) direction. Momentary removal of the twisting torque at the time of reversal of twist direction is preferred, but not necessary. In either case, at the instant of removal and/or reversal, the nodes produced in strands **10** pass through twisting means **14** and begin to travel downstream. Also the strands downstream of twisting means **14** begin to rotate at the nodes, since they are now free to untwist. As a result the strands **10** begin to ply in the area between guide **20** and point **24**. When the nodes in the strands reach guide **20** plying begins to take place simultaneously on either side of the nodes, forming a node N2 in the ply which corresponds to the nodes in the singles. The untwisting and plying action travels downstream from node N2 toward point **24** at a high rate, much faster than the rate of yarn travel. High speed movies of the action shows waves travelling down the strand from the node N2 as the ply forms. Since the direction of twisting of strands **10** is clockwise, S twist is imparted to the strands downstream of twisting means **14** and Z twist is imparted upstream. However, at the moment of reversal, there will be from the previous interval some residual S twist upstream, and some S twist will have "slipped through" the twisting means **14**. Consequently, there is a time, illustrated in FIG. 2, when the S twist imparted to the strands upstream of twisting means **14** by counterclockwise rotation is just offset by Z twist imparted upstream by clockwise rotation, so that the net twist upstream is zero. Also, the upstream S twist which "slips through" twisting means **14** upon reversal from counterclockwise to clockwise is reinforced by the clockwise rotation during the phase shown in FIG. 2. It will be observed that the twisting means **14** assists the plying at this stage, since it causes the strands **10** to rotate downstream in the direction they want to go to untwist from the twist imparted during the previous interval.

FIG. 3 illustrates the condition of the system a short time later at the middle of an interval in which the strands are being twisted clockwise. Node N2 has traveled downstream, and plying on either side of that node has been completed downstream to point **24** and upstream to point **24'**. Downstream of node N2 there is S ply twist while upstream there is Z ply twist, in both cases, of course, opposite to the twist in the strands **10**. In the strands **10** which have not yet plied there is Z twist upstream and S twist downstream of twisting means **14**. Plying downstream in the area between guide **20** and point **24'** is prevented by the action of the twisting device **14** which prevents the strands from untwisting.

FIGS. 4, 5 and 6, illustrate the other half of the cycle and correspond respectively, to FIGS. 1, 2 and 3. FIG. 4 shows the system just at the end of an interval of clockwise twisting, FIG. 5 shows the system early in an interval of counterclockwise twisting, when plying has just begun, and FIG. 6 shows the system in the middle of an interval of counterclockwise twisting, when plying action has been completed. In FIG. 5 N3 represents the new node formed upon reversal of twisting from clockwise to counterclockwise, and in FIG. 6 **24"** identifies the new point where plying upstream of node N3 stops until the direction of twisting is again reversed.

The distance from the point within twisting means **14** where twist is applied to the first downstream snubbing point (take-up rolls **22**) should be less than one times the distance between nodes. This is to assure that, when direction of twist is reversed, the node produced by the previous reversal will have passed beyond the downstream snubbing point. Also, the distance from the convergence point (e.g., guide **20**) to the first downstream snubbing point must be greater than ½ times the distance between nodes, in order to assure that the end (**24, 24'** or **24"** in FIGS. 1–6) of the previous ply section is still in the plying zone at the time plying begins. Otherwise, the plying action will be stopped before it reaches the end of the previous ply. Due to a self-curing action, any non-plied section will tend to equilibrate beyond rolls **22**, but the section so cured will have a lower twist level.

It will be apparent from the above description that the improved process operates intermittently, or "batchwise." A "batch" can be considered as the plied yarn produced as a result of one complete interval of twisting in a given direction. It includes one ply node, one section of S ply and one section of Z ply. FIG. 9 shows three batches, A, B, and C, which can be related to FIGS. 1–6. Batch A had already been produced in FIG. 1. FIGS. 1, 2 and 3 show production of batch B, and FIGS. 4, 5, and 6 show production of batch C. As shown in FIG. 9, the plied yarn is made up of alternating zones of opposite twist. In the method of this invention, half of a given zone is produced in one batch, the other half in the preceding or succeeding batch.

In the previous discussions, the schematic diagrams and the explanations are idealized for clarity and understanding. It should be understood however that in actual operation, there may be variations from these idealized diagrams. For example, while it is useful in understanding the way this invention operates to think in terms of definite points **24, 24'**, and **24"**, it should be recognized that the twist on the upstream side of a node from a previous batch may back up toward guide **20**. Also, while it is apparent that at some time in the operation twist in the strands **10** upstream of twisting means **14** will be zero, this does not necessarily occur just at the instant that the node is at the position indicated in FIGS. 2 and

5. Other variations occur and the invention should not be limited to the idealized explanation.

For comparison, FIG. 7 illustrates the system and the method of operation employed in the prior art. Nip rolls **16** act not only to converge the strands **10** but also to block the twist inserted in the strands by false twisting means **14**. Thus the strands **10**, having been twisted in one direction by twisting means **14**, are free to begin untwisting by rotation in the opposite direction as soon as they pass snubbing and converging means **16**. As a result the strands are plied continuously (except of course where nodes in strands **10** correspond or where twists in adjacent strands **10** are opposite in direction and substantially the same in magnitude) as they leave rolls **16**. In the prior art mode of operation, therefore, the twist profile of the plied yarn is determined by the twist levels in the individual strands as they pass snubbing point **16**.

In the improved method of this invention ply twist profile depends upon factors other than twist level in the individual strands, and can be controlled, for example by constraining the strands in the plying zone sufficiently to slow down their rate of untwisting. FIG. 10 illustrates the type of twist profile which can be obtained if the strands are not constrained in the plying zone. As the curve indicates, the twist level rises rapidly to a maximum on one side of a node but rises gradually on the other side. The reason for this will be apparent from FIGS. 2 and 5; when plying begins the distance downstream from a node (N2 or N3) to the terminus of a previously plied section (**24** or **24'**) is much greater than the distance from the node upstream to the point of convergence **20**. Rotation of the node results in the same number of ply turns being inserted upstream and downstream of the node. Since the upstream distance for plying is less than the downstream distance initially, the twist level (t.p.i.) inserted immediately upstream must be greater. Another factor which contributes to the production of this type of profile is the high twist level in the strands just upstream of a node, which results from reinforcement of twist in the strands just downstream of the twisting means **14** immediately following reversal of the twisting direction.

FIG. 11 illustrates the type of twist profile which can be obtained by constraining the strands, and thereby slowing the plying action. Slowing the plying action provides time for the node (N2 or N3 in FIG. 2 or 5) to move downstream before a large number of ply turns have been inserted.

Another factor affecting the node length and the slope of the initial portion of the twist profile is the manner in which the twisting action is stopped and reversed. To have short nodes and high slopes it is necessary to maintain the twisting force at its maximum level as long as possible before reversing and have it achieve its maximum level rapidly in the opposite direction after reversal. Mechanical twisting devices are capable of doing this, but air jets as described in British 1,047,503 are preferred because they permit twisting at higher yarn speeds. With air jets fast-acting valves, e.g., a solenoid rather than rotary valves, should be used in the air supply lines to reverse direction of twisting to obtain short nodes and high slopes of the twist profile curves.

FIG. 8 shows a preferred apparatus arrangement for obtaining a 3-ply carpet yarn having a twist profile similar to that illustrated in FIG. 11. Individual strands **10** which may be, e.g., continuous multifilament synthetic yarns, are fed through tensioning devices (not shown) which assure a uniform tension on the strands, around rolls **12**, and through tubes **30**. Tubes **30** prevent the strands from contacting and plying upstream of twisting means **14**. The yarns then pass through twister **14** where the yarns are twisted separately, alternately in opposite directions, and in phase. Each twisting means **14** is a pair of air jets positioned next to each other; one jet twists the yarn in clockwise direction, the other twists the yarn in counterclockwise direction. A short distance downstream of twister **14** is confining tube **32** which serves to converge the strands and to constrain them sufficiently to slow the plying action. The plying action takes place within the tube **32** just as described for FIGS. 1–6. Downstream of the tube the plied yarn passes over snubbing roll **22**, then around guide roll **26**, thence to take-up rolls **28**, and finally to wind-up. Arrows in FIG. 8 indicate direction of yarn travel.

In a specifically preferred embodiment, which is cited for illustration only, strands **10** are multifilament crimped polyhexamethyleneadipamide yarn of 1300 denier each. Tension on the strands is 0.06 g.p.d., maintained by tension devices (not shown) upstream from snubbing rolls **12**. Yarn speed is 350 yards per minute. Tubes **30** are 9 inches long and $\frac{3}{32}$ inch in diameter. Tube **32** is 24 inches long and $\frac{1}{16}''$ in diameter. Distance from rolls **12** to twister **14** is 35 inches, distance from twister **14** to lower end of tube **32** is 3 inches, and distance from lower end of tube **32** to snub roll **22** is 32 inches. Air pressure to the torque jets **14** is 61 p.s.i.g. and the direction of twist is reversed 4 times per second. The resulting plied yarn has a node interval of 52.5 inches, an average node length of 1.8 inches, an average twist of 1.7 t.p.i., an average maximum twist of 2.3 t.p.i., and a uniformity index of 1.3. Shape of the twist profile curve is similar to the curve of FIG. 11. Node interval is the distance between two nodes in the plied yarn; maximum twist is the maximum twist level, in turns per inch (t.p.i.), encountered in an S or Z section, and average maximum twist is the average of the maximum twist levels in a representative number of S and Z sections; and uniformity index is the ratio of average maximum twist to average twist, where average twist is the absolute numerical average of twist per unit length, taken over a representative length of yarn (several node intervals), regardless of twist direction. A plied carpet yarn having a uniformity index between about 1.1 and 1.6 will provide a relatively uniform carpet, in the sense that there will not be areas of obviously much higher ply twist than others. Such yarns are generally preferred for carpets. However, for novelty effects in carpets, yarns having a uniformity index of about 2.5 or even higher and a twist profile similar to that illustrated in FIG. 10 are useful. An advantage of this invention is that it enables production of good quality alternate twist plied yarns with long node intervals, e.g. in excess of 30 inches.

While the invention has been illustrated in connection with the production of plied carpet yarn from three 1300 denier continuous multifilament nylon strands, it will be apparent that the invention is applicable to the production of yarns of both synthetic and natural origin and of both filament and staple variety, as well as yarns of a wide range of deniers. The denier of the individual strands may vary from 100 or less to 4000 or above. The number of strands plied also can be varied, e.g. 2 or 4 or more can be plied if desired. Also, yarns for other end uses, e.g. upholstery yarns, may be prepared by the improved process.

I claim:

1. In the method for making alternate-twist plied yarn which involves applying false twist alternately in opposite directions along the length of at least one of a plurality of parallel, separated, running strands so as to produce in the strand or strands alternating zones of opposite twist separated by nodes of zero twist, converging the strands, and permitting the twisted strand or strands to partially untwist, the improvement which comprises converging the strands, without snubbing, immediately downstream of the twisting point, and snubbing at a point downstream of the twisting point a distance less than the distance between nodes and downstream of the convergence point a distance greater than ½ the distance between nodes whereby plying occurs intermittently in the zone between the convergence point and snubbing point as a node, produced at the twisting point upon the reversal of the direction of twist, moves through the plying zone.

2. Method of claim 1 wherein the twisting is applied to all strands in phase, the strands are converged in phase, and the direction of twisting is reversed at equal intervals, whereby the nodes in the plied yarn correspond to the nodes in the strands and the node intervals are constant.

3. Method of claim 2 comprising the further improvement of constraining the strands in the plying zone sufficiently to slow down, but not prevent, untwisting and plying of the strands, whereby a plied yarn having a uniformity index in the range 1.1 to 1.6 is produced.

4. Method of claim 2 wherein the rate of yarn travel and rate of reversal of direction of twisting are such as to provide a node interval greater than 30 inches.

References Cited

UNITED STATES PATENTS

2,990,671	7/1961	Bunting et al.	57—34
3,025,656	3/1962	Cook	57—34
3,052,079	9/1962	Henning	57—34
3,116,588	1/1964	Breen et al.	57—157
3,225,533	12/1965	Henshaw	57—34

JOHN PETRAKES, Primary Examiner

U.S. Cl. X.R.

57—34, 77.3, 140