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PLYING AND TWISTING OF YARNS

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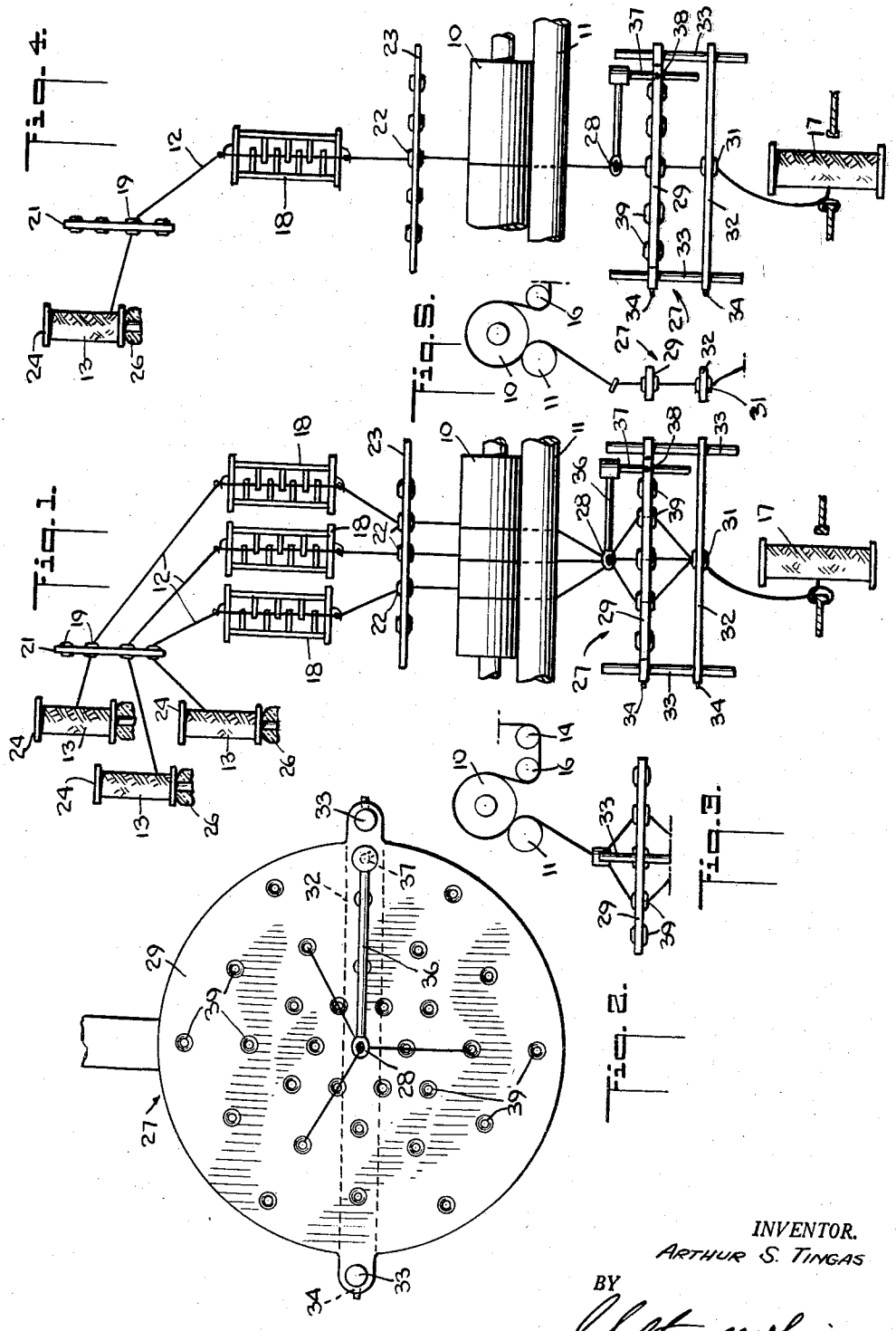


Fig. 4.

Fig. 5.

Fig. 1.

Fig. 3.

Fig. 2.

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PLYING AND TWISTING OF YARNS

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This invention relates to the processing of yarns and relates more particularly to the plying and twisting of yarns.

In the field of industrial yarns and fabrics, for example tire cords, a great deal of attention has been given to the development of fibers of very high tensile strength. Thus, for example, regenerated cellulose fibers having tensile strengths of 6 grams per denier or higher, e.g. 8 or 9 grams per denier, have been produced by the saponification of stretched cellulose acetate fibers. These very high tenacity regenerated cellulose fibers generally have elongations at break of less than 10%, e.g. about 5 to 7%, and show a high average initial modulus, generally about 200 grams per denier or higher, e.g. about 200 to 250 grams per denier. When yarns made up of continuous filaments of such materials are twisted and plied together to form tire cords in the conventional manner, it is observed that the strength of the resulting tire cords is substantially lower than the strength which would be expected from theoretical considerations. Also, the resistance of the resulting tire cord to tensile fatigue is not as high as desired.

It is therefore an important object of this invention to provide a novel process and apparatus for the twisting and plying of yarns and for the twisting of single yarns, which are free from the foregoing and other disadvantages.

Another object of this invention is the provision of new and improved process and apparatus for the production of tire cords of improved strength, better resistance to tensile fatigue, and greater uniformity of properties and of appearance.

One form of the apparatus of this invention is illustrated in the accompanying drawing, wherein

Fig. 1 is a front view of the apparatus, with supporting structure and other parts omitted,

Fig. 2 is a plan view of a portion of the guide structure shown in Fig. 1,

Fig. 3 is a side view of the apparatus of Fig. 1 showing the path of the yarns through the apparatus,

Fig. 4 is a front view showing the application of the apparatus of Fig. 1 to the twisting of a single yarn, and

Fig. 5 is a side view of a portion of Fig. 4.

Referring now to the drawing, the apparatus illustrated in Fig. 1 is a modification of a conventional plying and twisting device. Like the conventional device it comprises a plurality of feed rolls **10** and **11** for drawing spaced yarns **12** from supply packages **13** and around idler rolls **14**, **16** (Fig. 3), and for delivering the yarns at a constant rate to a driven rotatable bobbin **17**, the rotation of the bobbin **17** about its vertical axis serving to twist the yarns together and to wind the resultant composite yarn into package form. In order to traverse the composite yarn along the length of the bobbin **17** during the winding operation so as to form the yarn package in the desired configuration, the apparatus includes the conventional means comprising a ring rail, carrying

the usual ring and traveler. As illustrated, the composite yarn balloons out as it passes to the driven bobbin **17**.

As is customary, the upper feed roll **10** has a smooth metal surface while the lower feed roll **11** is surfaced with a softer material, such as rubber, having a high coefficient of friction with the yarns, the friction between the yarns and the rolls serving to maintain the spaced relation of said yarns as they pass between said rolls. One of the feed rolls is positively driven at a constant rate by any appropriate prime mover, while the other feed roll is pressed resiliently against the driven feed roll by any suitable means (not shown) and is caused to rotate by the frictional engagement of its surface with the surface of the driven feed roll.

It will be understood of course, that instead of using only two feed rolls a greater number may be employed. For example, the invention may be carried out by modifying, in the manner to be described, a conventional three-roll twister, wherein there are two lower feed rolls of equal diameter, each positively driven at the same speed. Each lower feed roll is in contact with a top feed roll which is mounted above and between said lower rolls and which is driven by contact therewith. The yarns are passed under the rear lower roll, up between the two lower rolls, around the top roll and down under the front lower roll. There may also be employed a conventional twister of the type which employs four feed rolls. With these three- and four-roll twisters the yarns make more contact with the feed rolls so that there is more friction between the yarns and the rolls; such twisters will therefore operate efficiently even when all of the feed rolls are metallic.

There are several important differences between the apparatus illustrated in the drawing and the conventional twisting and plying devices. Thus, in the apparatus illustrated the tension in the yarns passing to the feed rolls **10**, **11** is maintained at a substantially uniform value. For this purpose there are provided a plurality of adjustable tensioning devices, one for each yarn, which tensioning devices may be in the form of adjustable tension gates **18** of conventional construction. The yarns being unwound from the supply packages **13** pass through individual guides **19**, mounted in a frame **21**, to the tension gates **18** and then through other guides **22**, mounted in a lower frame **23**, to the feed rolls **10**, **11**. The spools **24** used for the supply packages **13** are mounted for rotation on suitable antifriction supports, which may be smooth porcelain bases **26**, so that there is very little tension, preferably only sufficient tension to keep the yarns from sagging and kinking, on the yarns passing from the supply packages **13** to the tension gates **18**. This arrangement is most suitable when the yarns on the supply packages **13** have a substantial amount of twist. When these yarns have little or no twist, it is more desirable to arrange the supply packages so that the yarns are drawn off over the ends of said packages to the guides **19**, in which case no rotation of said packages is necessary during the unwinding of the yarns.

The tension gates **18** are so adjusted at the beginning of the twisting and plying operation that the tensions in all of the yarns **12** passing to the feed rolls **10**, **11** are substantially equal (i.e. within 5%) and are at the desired predetermined value. Thereafter no further adjustment of these gates is necessary so long as the same yarns are employed and the other twisting and plying conditions are kept constant. Generally speaking, the tensions in the yarns passing to the feed rolls **10**, **11** are made up of the forces necessary to draw the yarns through the tension gates **18** and the forces necessary to draw the yarns from the supply packages **13** to the tension gates. Variations in the latter forces, that is, in the forces necessary to draw the yarns from the supply

packages, which variations are caused by changes in the size of the supply packages and in speed, will cause corresponding variations in the tensions in the yarns passing to the feed rolls. However, as explained above, in the apparatus of this invention the forces necessary to draw the yarns from the supply packages are comparatively negligible and therefore variations therein have no substantial effect on the constancy of the tension in the yarns passing to the feed rolls. If the supply arrangement is such that these variations are large and unequal, there should be employed tensioning devices, of known type, which will compensate for these variations and insure equality and uniformity of the tension in the yarn passing from the tensioning devices to the feed rolls.

In travelling from the feed rolls **10**, **11** to the rotating bobbin **17** the yarns **12** pass through a guide structure designated generally by reference numeral **27**. This guide structure comprises an upper eyeguide **28**, an apertured circular guide plate **29** and a lower eyeguide **31**, all mounted in adjustable relationship to one another. The guide plate **29** is supported on the frame (not shown) of the plying and twisting apparatus. The lower eyeguide **31** is mounted, on the prolongation of the vertical axis of the bobbin **17**, on a bar **32** which is joined to the guide plate **29** by means of a pair of rods **33**, along which rods the bar **32** may be moved relative to the plate **29** and fixed in any desired position by means of set screws **34** engaging said rods. The upper eyeguide **28** is mounted, also on the prolongation of the vertical axis of the bobbin **17**, at the end of an arm **36** carried on a rod **37** adjustably supported on plate **29**, being held in adjusted position by a set screw **38**.

Guide holes **39** are provided in the guide plate **29** and are arranged symmetrically along a series of concentric circles around the center of said plate, said center being situated on the prolongation of vertical axis of the bobbin **17**. One of the guide holes **39** is located at the center of the plate **29**. In normal usage only one group of symmetrically arranged guide holes **39** is actually used, the choice of guide holes for optimum results depending on the particular yarns being twisted, the number of yarns, the amount of twist to be inserted and the applied tension. However, a plurality of groups of guide holes **39** are provided in the guide plate **29** in order that the same guide plate may be employed for a wide variety of yarns and twisting conditions. Preferably all of the guide holes **39**, as well as all of the other guides **19**, **22**, **28**, **31**, are lined with inserts or ferrules of suitable antifriction material, such as smooth ceramic material.

In operation, the yarns to be twisted and plied are passed down, in converging relationship, to the upper eyeguide **28**, which is of a diameter large enough to accommodate the yarns passing therethrough without causing said yarns to be forced into contact with each other. From the upper eyeguide **28** the yarns diverge and pass through the plate **29** in symmetrical relationship through selected guide holes **39** which are situated at equal distances from the center of said plate, said selected guide holes being located symmetrically about said center. The yarns leaving said guide holes **39** converge again and pass into the lower eyeguide **31** where they are brought together and twisted and pass on to the rotating bobbin **17**. If observation shows that the twisting point, that is the point where the yarns meet and form the composite yarn, is not at the lower eyeguide **31** but at some point spaced therefrom, the bar **32** carrying the eyeguide should be adjusted vertically to bring the lower eyeguide **31** to the twisting point.

The apparatus of this invention can also be employed for twisting a single yarn, without plying, as illustrated in Fig. 4. The arrangement is essentially the same as that of Figs. 1, 2 and 3, except that only a single supply package **13** and a single tension gate **18** are employed and the yarn passes through the center hole of the guide plate **29**. Here also the yarn coming from the feed rolls **10**, **11** changes in direction as it passes through the upper eyeguide **28**, as indicated in Fig. 5. Preferably there is a change in direction of at least about 50°, e.g. 60°.

The following example is given to illustrate this invention further.

Example

A yarn of 812 denier composed of 1392 filaments of regenerated cellulose, produced by the saponification of stretched cellulose acetate, said yarn having a dry tenacity of 8.0 grams per denier and an elongation at break of 6.0% and having a twist of 0.82 turn per inch, is twisted on itself, 15.5 total turns per inch in the **Z** direction, using a Whitin "D" Heavy Duty three-roll twister modified in the manner described above and illustrated in Figs. 4 and 5. The tension in the yarn between the tensioning device and the feed rolls is maintained at 20 grams, the upper eyeguide is located at a distance of 3 inches measured along the path of the yarn from the feed rolls, and the yarn changes in direction by 50° as it passes through said upper eyeguide. The guide plate and lower eyeguide are 2 inches and 4.5 inches, respectively below the upper eyeguide. The yarn is delivered by the feed rolls at 24.7 feet per minute, while the take up bobbin is rotated at 3950 r.p.m. Three yarns, all twisted in the manner described above, are then plied together, using a Whitin "D" Heavy Duty three-roll twister modified in the manner described above and illustrated in Figs. 1, 2 and 3 of the drawing. The tension in each yarn between the tensioning device and the feed rolls is 25 grams. The positions of the upper eyeguide and guide plate are identical with those given above. The selected holes in the guide plate are about 1½ inches from the center of said plate and the yarns passing from the plate to the lower eyeguide make an angle of about 40° to the vertical, the lower eyeguide being positioned at about the twisting point of the yarns. The feed rolls deliver the yarn at 29.4 feet per minute and the take up bobbin rotates at 3700 r.p.m., so that the composite yarn, or cord, is given a twist of 10.5 turns per inch in the **S** direction. The resulting cord has a dry tenacity (measured on a cord conditioned at 70° F. and 65% relative humidity) of 5.27 grams per denier and resists failure, on a tensile fatigue test, for 150 minutes. In contrast, when the same yarns are given the same singles twist and ply twist but the conventional twisting and plying method is employed, using a standard Whitin "D" Heavy Duty three-roll twister, the resulting cord has a dry tenacity (measured on a cord conditioned at 70° F. and 65% relative humidity) of only 4.45 grams per denier and resists failure, on the same tensile fatigue test, for only 40 minutes. The cord produced by the conventional method is also rougher and less uniform in appearance.

In the tensile fatigue test mentioned above a weight of 17.5 pounds is suspended from the lower ends of a pair of cords to be tested. Each cord is 20 inches long. The upper ends of the cords, are fixed to a support which is vibrated at 1500 cycles per minute in such a manner that during each cycle first one cord and then the other carries substantially the entire weight, the amplitude of vibration being about ⅛ to ¼ inch. The test is conducted at a temperature of 130° C.

It is believed that the marked improvements obtained by the use of this invention may be explained, at least in part, by several factors. Thus, the establishment of uniform and constant tensions on all the yarns passing to the feed rolls causes all the components entering the composite yarn or cord to have substantially equal lengths. The importance of this factor may be understood by a consideration of a three-ply cord in which one of the ends is 1% shorter than the others due to its having been placed under higher tension in travelling to the feed rolls. Assume that the elongation at break of each end, taken separately, is 6%. If such a cord is placed under tension it will collapse when only one end

breaks, which will occur when the shortest end has been stretched 6%. At this instant the other two ends will be intact, having been stretched only 5% each, but they will cease to be of any utility. Thus the presence of components of uneven lengths will result in a loss in the overall strength of the cord.

Another advantage of the present invention is the avoidance of the ribbon-like structure which occurs when the yarns are twisted and plied in the conventional manner. The yarns passing between the feed rolls are compressed from a round shape to a flat ribbon-like shape. In the conventional way of twisting, the twist is inserted while the yarn is still in contact with the feed rolls so that the ribbon-like structure is set by the twist and maintained thereby in the final structure, the filaments being thus prevented from rearranging themselves within the yarn cross section. The result is reduced yarn strength. In the apparatus of this invention the yarns pass over and through various guides and holes before they are set into the final structure. This reduces the aforementioned ribbon effect by giving the yarn a chance to change from a flat to rounded shape.

Still another advantage of the present invention is the uniformity of the twist obtained. Thus, in the conventional process as pointed out above, there is no precise and uniform control of the tension of the yarn passing to the feed rolls and all the twist is inserted instantly at the nip of the rolls. Since there will be variations in the yarn length fed, due to the aforementioned variations in tension, and since the degree of twist is directly dependent on the linear speed of the yarn at the feed rolls, the twist inserted will be non-uniform. In the present invention the yarn tensions are maintained substantially constant and uniform as pointed out previously, and, in addition, the arrangement is such that the twisting point can move up and down and thus compensate for periodic short-length changes in tension and in amount of yarn fed. This results in a more uniform twist.

The uniform, predetermined tension and the symmetrical feeding of the yarns to the twisting point eliminate or reduce the defects known as "corkscrew" and "tendrilness" which are characteristic of yarns produced by the conventional twisting and plying method. "Corkscrew" is a variation with respect to length of the yarns in the cord, while "tendrilness" is a variation with respect to the angle these yarns form with the axis of the cord. As a result, in the yarns produced in accordance with this invention there is a better sharing of the forces within the cord by all the components thereof and the cord has a smoother appearance.

Another factor which it is believed enters into the greater uniformity and smoother appearance of cord produced according to the present invention is the avoidance of uneven untwisting of the yarns composing the cord. Thus, if two or more yarns are originally twisted in one direction, e.g. the Z direction, and then plied in the other direction, e.g. the S direction, there is a tendency for the component yarns to untwist somewhat. In the conventional twisting method the component yarns are pressed together during the ply twisting operation and are therefore not able to untwist evenly and smoothly before they are set by the twist into the ply or cord structure.

As has been discussed above in connection with Figs. 4 and 5, and as shown in the specific example above, it is desirable to carry out the twisting of each yarn before it is plied in a manner wherein the tension on the yarn passing to the feed roll is controlled and uniform and wherein the yarn changes direction considerably as it passes through the upper eyeguide. As a result of this considerable change of direction the twist is inserted over a greater length of yarn and for a longer time, resulting in a more uniform twist. Twisting the single yarns in this manner instead of using the conventional method for twisting singles results in a significant improvement in the strength of the final cord. However, the major improvement effected by the use of the present invention is attained in the plying operation.

This invention has shown its greatest value in the production of cords from filamentary material of very high tenacity and low elongation at break. It may, however be also employed for the twisting and plying of other filamentary materials such as the polyamides known as nylon, or the regenerated cellulose materials produced from viscose and having lower tenacity (e.g. 3 to 4.6 grams per denier) and greater elongation (e.g. 9 to 17%).

It is to be understood that the foregoing detailed description is merely given by way of illustration and that many variations may be made therein without departing from the spirit of my invention.

Having described my invention, what I desire to secure by Letters Patent is:

1. Apparatus for the twisting and plying of yarns, comprising a driven rotatable yarn package support, means for feeding a plurality of spaced yarns to said support so that said yarns are twisted and plied together to form a composite yarn and wound on said support by the rotation of said support, individual tensioning devices for individually restraining the yarns passing to said feeding means, said tensioning devices being constructed and arranged to impart predetermined equal tensions to the yarn passing to said feeding means, a guide at which said yarns converge, said guide being interposed in the paths of said yarns between said feeding means and said support, and a plurality of guides symmetrically arranged with respect to said first mentioned guide, each of said plurality of guides being interposed in the path of one of said yarns between said feeding means and said first mentioned guide.

2. Apparatus for the twisting and plying of yarns, comprising a driven rotatable yarn package support, means for feeding a plurality of spaced yarns to said support so that said yarns are twisted and plied together to form a composite yarn and wound on said support by the rotation of said support, individual tensioning devices for individually restraining the yarns passing to said feeding means, said tensioning devices being constructed and arranged to impart predetermined equal tensions to the yarns passing to said feeding means, a guide at which said yarns converge, said guide being interposed in the paths of said yarns between said feeding means and said support, a plurality of guides symmetrically arranged with respect to said first mentioned guide, each of said plurality of guides being interposed in the path of one of said yarns between said feeding means and said first mentioned guide, and further guide means interposed in the path of said yarns between said feeding means and said plurality of guides, said further guide being of sufficient size that the yarns remain out of contact with each other in passing therethrough.

3. Apparatus for the twisting and plying of yarns, comprising a driven rotatable yarn package support, feed rolls at least one of which is driven for feeding a plurality of spaced yarns to said support so that said yarns are twisted and plied together to form a composite yarn and wound on said support by the rotation of said support, individual tensioning devices for individually restraining the yarns passing to said feeding means, said tensioning devices being constructed and arranged to impart predetermined equal tensions to the yarns passing to said feeding means, means for supplying said yarns in spaced condition to said pair of feed rolls whereby the yarns will pass between the feed rolls in spaced conditions, a guide at which said yarns converge, said guide being interposed in the paths of said yarns between said feed rolls and said support, and a plurality of guides symmetrically arranged with respect to said first mentioned guide, each of said plurality of guides being interposed in the path of one of said yarns between said feed rolls and said first mentioned guide.

4. Apparatus for the twisting and plying of yarns, comprising a driven rotatable yarn package support, means for feeding a plurality of spaced yarns to said support so that said yarns are twisted and plied together to form a composite yarn and wound on said support by the rotation of said support, means for supplying all of said yarns to said feeding means at substantially equal predetermined tensions, a guide at which said yarns converge, said guide being interposed in the paths of said yarns between said feeding means and said support, and a plurality of guides symmetrically arranged with respect to said first mentioned guide in a plurality of concentric circles, each of said plurality of guides being adapted to be interposed in the path of one of said yarns between said feeding means and said first-mentioned guide.

5. Apparatus for the twisting and plying of yarns, comprising a driven yarn package support rotatable about a vertical axis, a pair of rolls at least one of which is driven, for feeding a plurality of spaced yarns to said support so that said yarns are twisted and plied together to form a composite yarn and wound on said support by the rotation of said support, means for supplying said yarns in spaced condition to said pair of feed rolls, said supplying means including individual tensioning devices for individually restraining the yarns passing to said feed rolls, and means for furnishing said yarns to said tensioning devices under low tension, said tensioning devices being constructed and arranged to impart predetermined equal tensions to the yarn passing to said feed rolls, an upper guide at which the yarns passing from said feed rolls converge, said guide being of sufficient size that the converging yarns remain out of contact with each other, a plate containing a plurality of guides to which said yarns diverge from said upper guide, each of said plurality of guides being interposed in the path of one of said yarns, and a lower guide at which the yarns passing from said plurality of guides to said driven support converge to form said composite yarn, each of said upper and lower guides being situated on the prolongation of the vertical axis of said support, said plurality of guides being disposed symmetrically about said vertical axis and between said upper and lower guides.

6. Process for the twisting and plying of yarns, comprising positively feeding a plurality of continuous filament spaced yarns having elongations at break of less than about 10% by passing the yarns, in spaced condition, in frictional engagement with at least one rotating feed roll, passing said positively fed yarns through a guide at which they converge and subsequently in spaced condition through spaced guides, the yarns in passing from said first-named guide to said spaced guides being caused to undergo a change in direction of at least about 50°, then bringing said yarn together to form a composite yarn and twisting said composite yarn.

7. Process for the twisting and plying of yarns comprising positively feeding a plurality of spaced yarns, individually tensioning the yarns passing to said feeding means so that the tensions on the yarns reaching said feeding means are substantially equal and uniform, passing said positively fed yarns in spaced condition through spaced guides, then bringing said yarns together to form a composite yarn and twisting the composite yarn.

8. Process for the twisting and plying of yarns, comprising providing a plurality of supply packages of yarn, drawing the yarns from said packages by passing the yarns, in spaced condition, in frictional engagement with at least one rotating feed roll, individually tensioning the yarns passing to said feed roll so that the tensions on the yarns reaching said roll are substantially equal and uniform, passing said positively fed yarns in spaced condition through spaced guides, then bringing said yarns together to form a composite yarn and twisting said composite yarn.

9. Process for the twisting and plying of yarns, comprising providing a plurality of supply packages of yarn, drawing the yarns from said packages by passing the yarns, in spaced condition, in frictional engagement with at least one rotating feed roll, individually tensioning the yarns passing to said feed roll so that the tensions on the yarns reaching said feed roll are substantially equal and uniform, passing said positively fed yarns in spaced condition through spaced guides, then converging said yarns to a guide, and twisting said yarns together to form a composite yarn and winding said composite yarn on a rotating yarn package support, said guide where said yarns converge being located on the prolongation of the axis of rotation of said yarn package support, and said spaced guides being symmetrically disposed about said axis.

10. Process as set forth in claim 8 in which each of said yarns is first twisted on itself by passing said yarn under uniform predetermined tension over at least one rotating feed roll, then successively through a plurality of spaced guides to a rotating yarn package support on which said yarn is wound, said guides being situated on the prolongation of the axis of rotation of said support.

11. Process as set forth in claim 10 in which, during the twisting of each of said yarns on itself, each of said yarns is fed to said feed roll at substantially the same predetermined tension as each of the other yarns making up said composite yarn and, each of said yarns is caused to change its direction by about 50° as it passes from its respective feed roll through said guides.

12. Process as set forth in claim 8, said yarns having elongations at break of less than 10%.

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