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F. HONIG

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APPARATUS FOR AND METHOD OF PREPARING TEXTILE STRANDS
BY TWISTING, TWINING, WRAPPING AND COVERING
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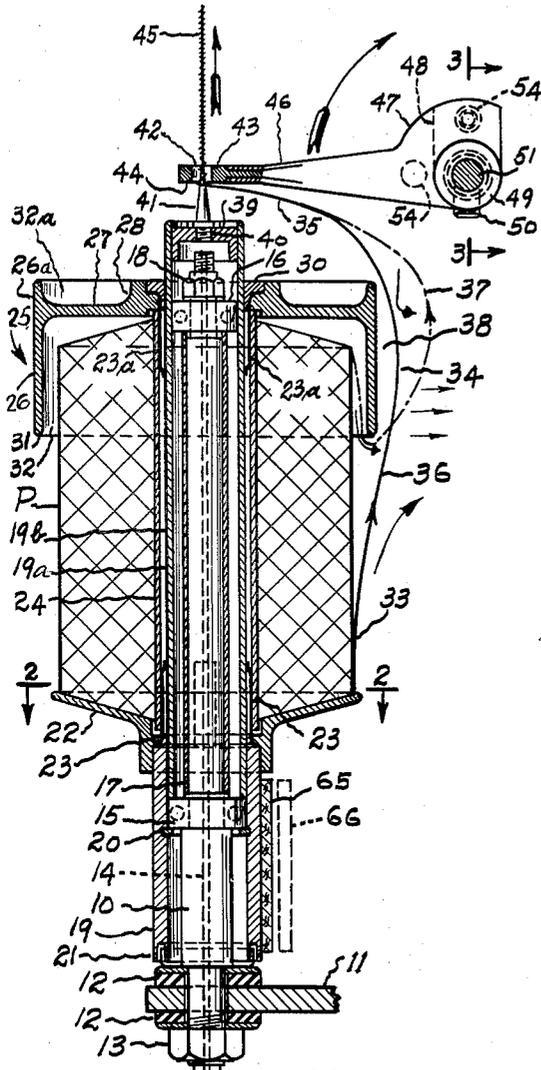


Fig. 1

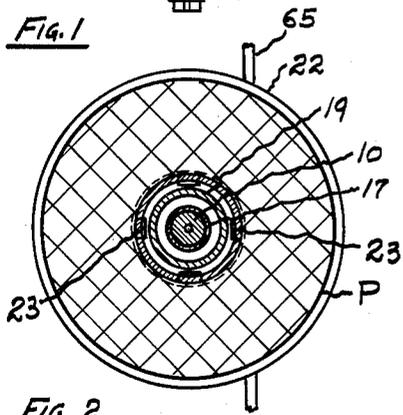


Fig. 2

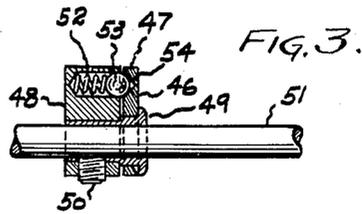


FIG. 3.

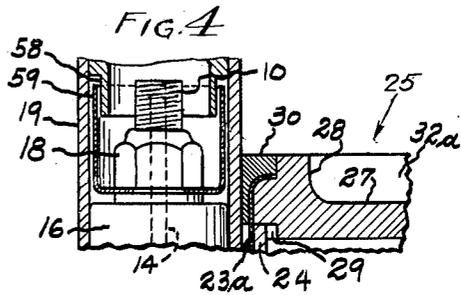


FIG. 4

INVENTOR.

FRANK HONIG

BY

Robert Cushman & Co.

Att'ys.

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2,729,050

**APPARATUS FOR AND METHOD OF PREPARING
TEXTILE STRANDS BY TWISTING, TWINING,
WRAPPING, AND COVERING**

Frank Honig, Edgewood, R. I.

Application October 9, 1951, Serial No. 250,532

9 Claims. (Cl. 57—18)

This invention relates to the preparation of textile strands by twisting, twining, wrapping, covering, etc., and relates more especially to novel apparatus for performing the above or similar operations and to a novel method of controlling one or more of the yarns or filaments employed in the process, thereby to insure uniform tension. The improved apparatus of the present invention is thus useful for example in twisting, coiling, covering, plying, bunching or similar operations performed on a yarn or filament or on a plurality of yarns or filaments for the purpose of imparting twist to filamentous material comprising continuous or staple fibers; for increasing the number of twists in a strand; for twisting a plurality of filaments or yarns to form a cord or strand; for covering a core with a spirally wound covering; and in general for the performance of such and similar operations relating to the general art of twisting or twining.

One object of the present invention is to provide apparatus for and a method of producing a strand comprising a plurality of constituent yarns or filaments, which is substantially uniform as to size and as to the number of twists or convolutions per unit of length. A further object is to utilize the yarn, ballooning from an unwinding supply spool or package, as a tension control for the winding-on yarn which will not harm, by abrasion or otherwise, the most delicate yarn or filament. A further object is to provide apparatus of the above type having provision for maintaining, at substantially constant length, that portion of the yarn or filament which is actually being twisted or wound on, as distinct from that portion of the yarn which forms the balloon proper. A further object is to provide apparatus of the above type comprising means operative automatically to maintain a uniform tension in the winding on or twisting portion of the yarn or filament regardless of the varying resistance to unwinding characteristic of the ordinary supply package and regardless of varying lengths of the balloon. A further object is to provide, in apparatus of the above type, means operative to create an air swirl coaxial with the unwinding yarn mass and which is operative to insure a constant velocity of revolution of the balloon formed by the unwinding yarn regardless of balloon diameter. A further object is to provide, in apparatus of the above type, means for creating an air flow in a direction such as to reduce the normal air resistance to motion of the balloon of unwinding yarn thereby to decrease the tension of the yarn at the winding-on point.

Another object of the invention is the employment of a pneumatically applied force for applying uniform tension to a portion of the filament being operated on.

Another object of this invention is the provision of means to control the movement of a portion of the filament through the various air velocities and directions of flow, from time to time, as may be required to produce a uniform static tension in the twisted filament.

Still another object of the invention is the automatic control of the stress-velocity or kinetic energy input into the planetary balloon portion of the filament.

Another object is to provide stress or twist-blocking means to maintain a uniform length in the twisting section of the filament and to prevent the twist from entering into the high velocity variable length portion of the filament where the kinetic stress-velocity is controlled.

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A further object is to produce a twisted strand, by unwinding yarn or tow over-end from a supply package, whereby the number of twists per unit of length in the completed strand will be more uniform than is customarily attainable by prior apparatus or methods. A further object is to provide for the production of a twisted strand, by unwinding yarn or tow over-end from a supply package, whereby the number of twists per unit of length in the completed strand will not vary by more than 0.2% from the desired number of twists. A further object is to provide apparatus for twisting delicate or tender yarn or tow at a very high speed but under so low a tension as to minimize breakage, thus increasing the production per spindle.

Other objects, not specially mentioned, will be clear or become evident to those experienced in the related arts as the description of the invention proceeds.

As is common in apparatus of the class to which the invention pertains, one at least of the yarns or filaments which is to take part in the twisting, wrapping or covering operation is supplied as a closely wound mass, preferably a self-sustaining mass on a headless tube or core, although other forms of supply package may be employed. When the operation to be performed involves pure twisting, the several yarns or filaments which are to be twisted together may conveniently be ply-wound to form the supply mass or package. When the operation to be performed involves the wrapping of one or more yarns or filaments about another, the yarn to be covered (that is to say the core yarn) passes through an axial bore in the spindle of the machine and the yarn which is to be wrapped about the core yarn is provided in the form of a wound mass or package such as above referred to and which is mounted for rotation about the axis of the spindle. After the twisting, wrapping or covering operation has been performed, the resultant strand is wound to form the finished package which may be of any usual or desired type. That portion of the yarn intermediate the supply package and the finished package is herein referred to as the "working" portion.

The yarn or filament from the rotating supply package unwinds to form a balloon which revolves at high velocity about the package. One end of this balloon is joined to the unwinding convolution on the supply package and its other end is joined to that portion of the yarn which is undergoing twist or which is being wrapped about the core and which is herein referred to as the "twisting" portion. In accordance with the present invention mechanical means is provided for de-limiting the length of the unwinding portion so that the latter (which is substantially straight) remains of constant length. This length-limiting means is also effective in preventing the twist from traveling back into the ballooning portion of the yarn. This twist-limiting means or "twist-block" may be a capstan, belaying stud, opposed tension disks or any equivalent device. It may be attached to and rotate with the part on which the yarn package is mounted or it may be rotatable with but independent of said part. On the other hand it may be stationary and suitably supported by any convenient part of the machine frame. The "twist-block" is the point at which the planetary balloon part of the working portion ends and the twisting begins. The purpose of this twist-block is to prevent both the forward or backward movement of the terminal point of the planetary ballooning section of the yarn being worked on. At this fixed point or block is where the actual twisting operation begins.

When the yarn is unwound from the supply package (prepared according to customary procedures) the force necessary to separate the unwinding convolution from the yarn mass varies constantly. This is due in part to varia-

tions in tension imparted during the preparation of the package; in part to the pinching of the convolutions between adjacent convolutions and in part to the inherent tendency of the convolutions to adhere to each other, etc. The necessary force to separate the unwinding convolution from the supply package is herein referred to as the "static stress."

The twisting portion of the strand is substantially straight and remains uniform in length throughout the operating period.

The high velocity planetary ballooning section will change in length. The diameter and the shape of the balloon will also change, as the length of this section is shortened or lengthened, automatically, to produce the desired kinetic stress variation in order to provide a uniform static tension in the twisting section of the yarn.

That is to say, according to the present invention, there is produced an annular disk-like body of air at a point intermediate the ends of the yarn package, and this disk-like body of air rotates at a velocity which is substantially greater than the velocity of rotation of the air adjacent the ends of the yarn package.

In effect, this high velocity rotating air current, located between the ends of the package, operates to rotatively carry the balloon or to reduce or to increase the air resistance offered to the balloon as the balloon diameter changes and moves through the various transverse rotative velocities.

According to the present invention, variable static stresses are equalized with variable kinetic stresses so that the net result is a very uniform tension in the twisting yarn.

This action may be compared to the balancing of a scale beam to maintain a uniform load at one end with a variable load at the other end, by shifting the central pivot point so as to increase or decrease the leverage and thus maintain a uniform load at one end with a variable load at the other end. In this comparison the load at one end and the leverage is changed to maintain a uniform load at the other end.

In the comparison, the variable load at one end may represent the variable unwinding tension, the variable air resistance, the variable balloon weight, etc., and the change of leverage may represent the variable diameter of the balloon.

For example, when the static stress increases on the package, it will hold back the planetary balloon and thus reduce its length and diameter and the weight of the yarn constituting the balloon and consequently reducing its linear velocity at a smaller radius, the rotative speed of the spindle and balloon remaining constant, and thus the kinetic stresses in the ballooning section will be reduced so that the static stresses of unwinding and the kinetic stresses of the balloon will equal a predetermined total. On the other hand, when the unwinding static stress is reduced, the ballooning section will increase in length, adding more weight to the balloon, and increasing the balloon diameter, thus producing higher linear velocity. The higher weight, larger diameter and consequent higher velocity will produce an increase in the kinetic stresses, and thus the total of static plus kinetic stresses will equal that in the example just above stated.

As will be seen from the following description, the variable unwinding tension or static stress in the yarn is automatically and exactly counter-balanced by the variable kinetic stress so that the net result, in the yarn, will be uniform tension and twist (practically speaking).

It may be stated here that, using continuous filament tow, such as rayon or nylon for example, and operating at speeds between 15,000 and 30,000 R. P. M., I have been able to maintain a uniform tension on the yarn, with this invention, within 0.01 gram/denier, and a uniform number of twists of coils per inch within 0.2% of the desired and predetermined unit.

The kinetic stresses are controlled in part by an im-

PELLER forming a part of the spindle and rotating therewith. This impeller operates to produce a materially higher peripheral speed for a ring-like portion of the air surrounding the yarn package at a suitable longitudinal location between the ends of the package. It is, usually, made of hollow cylindrical form, overhanging the delivery end of the package of yarn being operated on. This overhang, is usually, about $\frac{1}{4}$ of the length of the package, more or less, depending on the spindle speed. One of the objects of this impeller is to produce a higher air speed velocity near the delivery end of the package than prevails at the other end of the package, and thus cause the air to flow spirally from both ends of the package toward its middle section and thus to eject, as by centrifugal force, the balloon portion of the yarn into the high velocity air ring if and when the static unwinding tension is decreased as the yarn or strand is withdrawn from the package over the delivery end.

Under normal operating conditions, the yarn does not come in contact with the impeller, except, perhaps, momentarily when the adhesion of the convolutions on the package greatly exceeds the centrifugal force inherent in the weight of the balloon. If when winding the starting package, reasonable care is exercised, the variation in the unwinding tension will come within the centrifugal force of the balloon weight and, under such conditions, the yarn will not contact the impeller.

The twist block is located at a point where the planetary balloon ends, and the twisting, coiling, covering, etc., begins, the planetary balloon acting like a crank to twist, etc., a straight section of the strand.

I prefer to use a reasonably sharp angle of turn in the yarn flow path to produce the desired tension gradient. I find that a sharp bend between the axis of the spindle and the upper part of the planetary balloon portion will serve for most sizes of yarn and spindle speeds.

The twist block may be a capstan, attached to the rotating part of the spindle for positive rotation therewith, or it may be rotatively mounted on the spindle so as to have free rotation relative to the spindle. In some cases the delivery end of the spindle itself may act as the twist block or capstan. If substantial tension is desired as in working heavy yarn, the twist block may consist of a pair of rotatably mounted discs. In the plying or covering type of twisting, the twist block may be a stationary belaying stud, as will hereinafter be described. That is to say, the twist block operates to form a comparatively sharp angular turn at the terminal end of the planetary ballooning section and restricts the longitudinal movement of this sharp angular bending point to a vertically narrow zone so that it cannot move forward with the pull of the yarn being twisted and cannot fall behind due to any lessening in the kinetic stresses or leverage of balloon shape or diameter.

It may be explained here that this invention is best suited for high speed rotation of the spindles, that is in the 30,000 R. P. M. speed range, and I find the most desirable speed range to be between 15,000 and 35,000 R. P. M. However, higher or lower spindle speeds may be employed if desired.

I also prefer to use large size packages with windings of the self-supporting type, that is, a package that is wound on a tubular core without head. Spools, bobbins, or any other suitable yarn package may be employed. For 100 denier or finer nylon or rayon continuous filament, I prefer to use a package of about 2 to 3 pounds capacity and rotate the spindle at 20,000 to 25,000 R. P. M. Larger or smaller packages and higher or lower speeds, however, may be used.

I prefer to use a spindle construction formed of a stationary inner stud and provided with a rotative outer sleeve, with suitable bearings interposed between the stud and the sleeve in such a way that the package is supported between the axially spaced bearings or so that the bearings are located intermediate the ends of the

package. One of such spindles is shown in my Patent No. 2,080,918 issued May 18, 1937, and another in my Patent No. 2,163,789 issued June 27, 1939. In such spindles, the center of kinetic gravity of the rotating yarn package and attendant parts, as a unit, is located between the supporting bearings or within the limits of the bearing if a long single bearing is used.

In the present application a spindle with two anti-friction bearings is illustrated, and the stationary stud is shown as provided with an axial bore for the passage of a core. This construction permits general use of the particular embodiment of the invention for various classes of twisting operations. However, for certain work, the bore in the stationary stud may be dispensed with and a solid stud used, if so desired, for economy of manufacture.

When the device of the invention is used to twist together a plurality of strands to form a twisted yarn, it may be desired to ply-wind the strands to form a single package, which is used as the supply package on the spindle. In such ply-winding operation, the conventional winding and tensioning devices produce unequal tension in the several strands being wound side by side, and this results in localized length variation between the several adjoining strands on the package.

When such length differences occur the impeller will automatically segregate the ballooning portion of the yarns into several independent planetary balloons and each individual balloon will be thrown out to the desired diameter to equalize the kinetic stresses between the several adjacent yarns in the strand. These segregated balloons may take a position either ahead or behind the main balloon along the periphery of the impeller, depending on the tension difference between the yarns.

It is very important in twisting a yarn body to have a uniform tension on all of its component fibers. For example, in the manufacture of continuous filaments, such as nylon tow for example, a say 100 denier tow may comprise say 40 filaments, each 2.5 denier, a total of 100 denier. Each of these 40 filaments may and do have different stresses, in parts, so that the tensile strength of the tow as a whole will be substantially less than the tensile strength of the 40 individual filaments as such added together. The several variations are in fact a part of the total kinetic stress control.

When such is the case, the tow twisted with this invention, may have 40 separate planetary balloons, at times, providing 40 different degrees of kinetic stresses for the 40 separate filaments in the tow so that each individual filament will have substantially the same total stress units as the other filaments. This will result in a very substantial increase in the tensile strength of the twisted strand as a whole when produced with this invention, as will be clear to those experienced in the related arts.

It has been stated that the working portion of the tow or strand is divided, so to speak, into two sections and that the twist block serves to limit the twist to one section only and that this twisting section remains uniform in length. The other section, that is to say the balloon, constantly changes its length. Some of this change in length is due to the kinetic stress control, as has been explained, and some is due to the fact that the tow or strand is unwound from various positions on the package length. When the tow issues from the bottom of the package this variable length section will tend to become longer, and when the tow issues from the top of the package, it tends to become shorter, assuming the top to be the delivery end.

The impeller is so proportioned as to cause the air currents to flow from both ends of the package toward its middle and the yarn will remain close to the package at both ends before ballooning out, as will be clear from the illustration.

However, since there is variation in the length of the ballooning section only and the twist is prevented from entering into this variable length section by the twist

block, the twist-block thus cooperates with the impeller in eliminating "cyclic" twist variation in the twisted yarn, which results in a very uniform number of twists in any fractional part of the strand, as has been stated.

Further objects and features of my invention will best be understood from a detailed description of the mechanical embodiment, selected for purposes of illustration and shown in the accompanying drawings in which:

Fig. 1 is a vertical section of a single twist per revolution spindle embodying the invention;

Fig. 2 is a section taken as indicated at line 2—2 of Fig. 1;

Fig. 3 is a section taken as indicated at line 3—3 of Fig. 1; and

Fig. 4 is an enlarged fragmental vertical section to larger scale, showing in more detail the connections between the impeller and the spindle.

The invention may be adapted for spindles producing a single twist per spindle revolution, as shown in the drawings, or to spindles producing two or more twists per spindle revolution, as indicated in the patents above identified.

Referring to Fig. 1, the invention shown comprises a stationary stud 10 resiliently fastened to a standard 11 by means of resilient pads 12—12 and a nut 13. When the embodiment is to be used for general purposes, the stud 10 may be provided with a bore 14. When the embodiment is to be used for some specific type of twisting, for economy of manufacture, the bore 14 may be dispensed with and the stud 10 made solid.

The stud 10 is provided with anti-friction bearings of any desired type. In the selected embodiment, two bearings are shown, the lower bearing 15 and the upper bearing 16. Between these bearings is a tubular spacer 17 by means of which the bearings are properly positioned, the parts being held in place by a nut 18 engaging the upper end of the stud 10.

The stationary stud 10 is provided with a rotatable sleeve 19 supported by the bearings 15 and 16. As illustrated, the sleeve 19 comprises a pulley portion 19a and a tubular package supporting portion 19b. The sleeve portion 19b is press fitted into a bore in the pulley portion 19a, the end of sleeve 19b constituting a shoulder within the bore of pulley portion 19a. The bearing 15 is clamped against this shoulder by a conventional spring snap-ring 20. The lower end of the pulley portion 19a of the sleeve is provided with the conventional groove and cup dust-seal indicated at 21.

A package supporting base 22 has a hub portion provided with an axial bore which is press fitted onto the outside of the pulley portion 19a of the sleeve 19. The base 22 has a plurality of upstanding spring fingers 23 which are positively clamped at their lower ends between the sleeve portion 19a and the wall of an enlarged portion of the axial bore in part 22. (See also Fig. 2.)

The yarn package is indicated at P. Any desired form of package may be used. In the particular illustration selected to describe the invention, a package is a self-supporting winding, with tapering ends, wound on a tubular core 24. The lower tapering end of package P fits the contour of the base 22 and, in practical effect, the base 22 forms a protective shield for the package. The lower end of core 24, which conventionally projects beyond the winding, fits loosely into an annular cavity in the base 22 as will be clear from the drawing.

The spring fingers 23 yieldingly centralize and clamp the package P to the rotating sleeve 19 so that the package will rotate therewith. This arrangement yieldingly permits the rotating package to find its own axis of rotation, which may or may not be the axis of the stud 10. The spring fingers 23 also permit the longitudinal removal of the empty core 24 and the mounting of a new package P on the sleeve 19.

The impeller 25 is slidably mounted near the top end of the sleeve 19. It comprises a substantial cylindrical

portion 26, of an internal diameter exceeding the diameter of the full package P, a web portion 27 and a hub portion 28 (Figs. 1 and 4). The hub portion 28 is provided with an annular recess 29 (Fig. 4) which loosely receives the upper projecting end of the tubular core 24. The hub portion 28 has an axial bore into which a plug 30 is press fitted. Between the plug 30 and the bore of the hub portion 28 are clamped fast the upper ends of a plurality of spring fingers 23a, which extend down along the outer surface of the sleeve portion 19a and serve to hold and centralize the upper end of the package.

The impeller 25, springs 23a and plug 30 form a single assembly unit which may be slid off the end of sleeve 19 when a new package is to be mounted on the rotating sleeve 19. The springs 23a also act yieldingly to clamp the impeller assembly to the sleeve 19 so that it will rotate therewith.

For most purposes the cylindrical form of impeller, as shown in Fig. 1, will produce the desired aero-dynamic action inside the balloon perimeter to bring about the automatic change in the kinetic stresses with which the static stresses are balanced in the twisting yarn body. However, for some materials, sizes of yarn or tow package, spindle speed, etc., other forms of impellers may be used.

Whatever form of impeller may be used, it should be provided with a smooth, preferably rounded unbroken lower periphery 31 which should project below the top of the package P a distance which, for optimum results and as here illustrated, may be of the order of one-third the length of the package, so as to form an annular chamber 32 between the package P and the impeller 25. The cylindrical portion 26 of the impeller preferably projects above the level of the web 27 so as to form a shallow annular channel 32a between the hub portion 28 and the cylindrical portion 26 of the impeller. The web 27 may be provided with an opening or openings to afford communication between chambers 32 and 32a if desired.

In other words, there may be two separate chambers formed, one on each side of the web 27, separated from each other by the web 27, or there may be communication between these chambers by means of perforations (not shown) in the web 27. For some sizes of packages and spindle speeds only the lower chamber 32 may be used.

The impeller, rotating with the spindle, frictionally drags the air along with it, creating a revolving shell or ring of air and complex air currents which sweep about the periphery of the yarn package P and within the inside periphery of the ballooning portion of the yarn. Since the outer surface of the part 26 is of a constant diameter larger than the maximum diameter of the package P, its effect is substantially independent of the effective diameter of the package, and the velocity of the revolving shell or ring of air is greater than that which is normally created by the rotating package itself. Some of these air currents apparently follow a spiral path along the surface of the package, starting from the ends and moving toward the center, apparently right and left-hand spirals, respectively.

The axially moving portions of the air current tend to cause the ballooning yarn unwinding from the respective end portions of the package to remain close to the peripheral surface of the package, but in the region adjacent to the edge 31 the upwardly and downwardly moving air currents merge and tend to sweep radially outward, thus causing the balloon to form a bulge outwardly of the cylinder 26 such that the portion 35 of the balloon which approaches the twisting or winding on point always lies in a plane which makes substantially the same angle with the axis of the spindle.

Normally, in the region outwardly from the cylinder 26, the revolving annular mass of air, frictionally entrained by the action of the impeller and whose linear velocity exceeds that of the air contacting the package itself, provides a driving force for the balloon such as substantially to neutralize air resistance, thus reducing substantially to zero the tension ordinarily resultant from air drag. The

centrifugal force due, in part, to the weight of the balloon tends to expand the balloon to a larger diameter so that it comes within the influence of the high velocity rotating air ring. The apparent right and left-hand spiral air movement causes a part of the balloon to cling, so to speak, to the package, as indicated, for example, at 33. Whatever the exact form of these currents, the composite net result is to bring the yarn, whether ballooning from one or the other end of the package, towards the edge 31 and to cause the balloon to bulge out, diametrically, immediately above the edge 31, as indicated at 34, so that the strand approaches the twisting or wrapping point at a constant angle of from 60° and preferably approximately 80° to the axis of the spindle (dependent upon rotational speed and the character of the material). This is effective or cooperative in blocking the twists or coils from running back into the ballooning section of the yarn.

It may here be stated that actual test has shown that air currents do flow from both ends of the package toward the intermediate point where the edge 31 of the impeller is located. Air current indicators show a very sharply defined high velocity, ring-shaped air current centered at approximately the horizontal plane of the lower edge 31 of the impeller. Using a medium-sized spindle operating within the 20,000 to 25,000 R. P. M. speed range, this rapidly rotating ring of air is about one inch thick, coaxial with the spindle, and with about half of its thickness above and the other half below the horizontal plane of the edge 31.

The shape of the balloon when the strand is unwinding from the bottom of the package is shown by solid line 36, and its shape, when the strand is unwinding from the top end of the package, is shown by dot and dash line 37.

As has been stated, the balloon 36 or 37 does not contact the impeller 25 during normal operation of the invention, being spaced from the impeller as indicated at 38. However, when starting or stopping the spindle, there is momentary contact between the balloon and the edge 31 of the impeller.

It may be explained here that using spindle speeds between 15,000 and 30,000 R. P. M., a balloon diameter of 7 inches for the balloon shown by line 37, and twisting 100 denier continuous filament nylon, it is possible to maintain a uniform tension on the strand, between the balloon size shown at 36 and that shown at 37, within 0.5 gram, and to reduce the total tension on the strand to from 2 to 8 grams, depending on the speed used.

With such low total tension on the twisting yarn and low tension variation from position to position of the balloon, at the speed indicated, a package of yarn may be twisted from end to end in a period of about 100 consecutive hours without a single break, thus eliminating labor cost in attending to the knotting of the broken strand.

The top end of sleeve 19 (Fig. 1) is closed by a plug 39 press fitted into the bore of the sleeve. Plug 39 is provided with a central screw hole 40 adapted to receive the desired type of twist block which may be used.

The twist block member 41, shown in Fig. 1, comprises a right conical capstan partly projecting into a smooth hole 42 provided in a ring 43. The lower surface 44 of the ring 43 provides an unbroken raceway to prevent the section 35 of the balloon from rising above the winding-on or twisting point, and thus to maintain the desired angle between the part 35 of the balloon and the axis of the spindle.

A conventional transverse oblique threading slot (not shown) may be provided in ring 43 to permit rapid threading of the apparatus when a new or full package is placed on the spindle.

Ring 43 is carried by a swinging arm 46 to which it is removably attached, by means of screws (not shown). Arm 46 is provided with a segmental hub portion 47 and is rotatably fastened to a supporting block 48 by means of a stud 49 and set screw 50 (Figs. 1 and 3).

The screw 50 also holds fast the assembly, just above described, to the horizontal supporting bar 51. Bar 51 is conventionally supported, for example, by attachments to the main standard 11, and, if desired, is adjustable up or down for spacing the surface 44 of ring 43 from the upper end of the rotating sleeve 19. For clearness of illustration, the member 43 is shown separated by a considerable space from the end of sleeve 19, in actual practice, this space may be substantially less than that shown. When the ring 43 is properly set its lower surface 44 prevents the terminal point of the ballooning yarn from advancing in the direction in which the twisted strand is being drawn off while the end of the spindle sleeve 19 prevents the terminal point of the ballooning yarn from running back. Thus the twisting point is limited to a zone which is very narrow in the axial direction of the spindle and is prevented from moving out of this zone in either direction.

The block 48 is provided with a socket to receive a compression spring 52 and a ball 53. The hub portion 47 of swing arm 46 is provided with sockets 54 into which the ball 53 is pressed by the spring 52 and thus yieldingly holds the arm 46 in a horizontal or in a vertical position, respectively, as desired, during the operation of the apparatus or when a new or full package is placed on the spindle.

When very fine yarn is to be twisted, the arrangement shown in Fig. 1 is used, except that the capstan 41 is removed from the plug 39 and the upper raceway ring 43 lowered to bring the surface 44 closer to the end of the sleeve 19. By removing the capstan 41 and lowering the raceway member 43, the tension in the twisted straight portion 45 may be reduced to a small fraction of 1 gram at the speeds above indicated. Fine yarns, say from about 15 to 75 denier, are usually twisted with such tension.

It may be explained here that in the operation of the apparatus (Fig. 1) the section 35 of the balloon winds about the upper part of capstan 41 forming turritella-like coils which slide off the end of capstan 41 and become a straight but axially twisted strand. The number of coils on the capstan will vary from time to time during the operation. At times this variation in the number of coils is quite rapid, say from second to second, at other times a uniform number of coils will remain on the capstan for several minutes, and, at times, the capstan is entirely free of all coils. It is believed that the coil formation on the capstan is a function of the variable kinetic stress control and has its origin in the static tension variation with which the yarn is unwound from the package.

The number of coils on the capstan is small, 2 to 4 coils are commonly observed on capstan 41 (Fig. 1) and 3 to 12 coils on capstan 55 (Fig. 6). The coil change on capstan 19 is more regular in time periods and more rapid. The rotating motion of assembly 62 is more of an oscillating motion as the assembly accommodates its movement to the coil formation on the capstan.

In the prior art devices, the twist per unit length will vary "cyclically" as the yarn changes its point of issue from one end of the package to the other end of the package as it is unwound during the twisting operation. In the prior art devices this "cyclic" twist variation is, usually, about 10% of the predetermined number of twists per unit, and results in visually observable surface variation in the cloth made from such yarn.

The twist per unit length produced in the yarn made by the use of this invention, as has been stated, may be held so uniform that the variation will not exceed 0.2% of the predetermined total. The cloth made from yarn produced by the use of this invention is so uniform that no surface variations can be visually detected.

Also, the tension on the yarn being twisted is reduced to such a low unit that even the most delicate yarn may be twisted at substantially higher speed than possible

with the prior art devices. Due to such low and uniform tension the yarn will not break during the twisting operation, thus reducing labor cost, eliminating knots and increasing the production per spindle since the spindle need not be stopped to tie up the broken ends.

As has been explained, the static tension in the twisted yarn is regulated by the kinetic stresses as the balloon rotates in the variable speed air currents produced by the impeller. That is, in this invention the yarn tensioning element is the air in which the spindle rotates, and thus, the delicate individual filaments of which a yarn or tow comprises, will not be marred, as by chafing, which is unavoidable with the prior art tension devices having solid frictional tension members. Furthermore, this kinetic stress control will automatically adjust itself to any variation in any of the stress producing units so that the total tension will always be substantially the same predetermined total.

The driving belt, when it is in driving contact with the pulley part of the spindle, is indicated at 65. When the spindle has been stopped the driving belt is out of contact with the pulley, as indicated with dash lines at 66.

In operating the apparatus, assuming the spindle to be stationary and the raceway arm in a vertical position, a package is placed on the spindle so that the yarn will properly unwind in producing either Z or S twist, as desired, and the impeller placed on top of the package with the gripping spring fingers inside of the tubular core and the upper raceway is then moved into horizontal position. The starting end of the yarn to be twisted is conducted over the outer periphery of the impeller and through the opening in the upper raceway, thence to any conventional winding device (not shown) and a few turns of thread wound on the wind-up core (not shown) by hand. After this is done the operator actuates the driving belt (by any conventional device not shown) to bring it into driving contact with the pulley and thus the package and spindle will rotate in the desired direction.

The coil formation about the particular twist block capstan used is automatic and regulated by the impeller. The operator need not start any coil to form, the coils will form automatically as and when needed to produce the uniform tension and twist in the yarn. If, from time to time, no coils about the twist block capstan are needed to maintain uniformity, the apparatus will automatically discontinue the coil formation and if coils are needed the apparatus will start forming the needed coils about the capstan.

While certain embodiments of the invention have been described in detail, in order to illustrate the principles of the invention, it is to be understood that the invention may have various embodiments within the limits of the prior art and the scope of the appended claims.

I claim:

1. That method of preparing twisted strand by unwinding yarn or tow overend from a rapidly rotating supply package, which comprises as steps creating a rotating body of air coaxial with the package, a portion of said rotating body of air, relatively narrow as compared with the length of the package and located near the discharge end of the package, flowing radially outward in response to centrifugal action, and another portion of said rotating body of air flowing helically toward the discharge end of the package from the opposite end of the latter and acting to compress the starting end of the balloon formed by the unwinding yarn, and so compressing the terminal portion of the balloon as to maintain the maximum diameter of the balloon within said radially flowing portion of the revolving body of air.

2. That method of producing twisted strand, wherein the yarn or tow to be twisted is unwound overend from a supply package which is rotated at a high angular velocity and thereby forms a balloon, which comprises as steps causing air to flow helically along the peripheral surface of the package toward its discharge end from

the region of its opposite end, thereby compressing the starting end portion in the balloon as the yarn or tow unwinds from said last-named end portion of the package, and compressing the balloon lengthwise of the package by positively fixing the twisting point so near to the discharge end of the package that the maximum diameter of the balloon is always within a zone extending downwardly from the vicinity of its discharge end a distance of the order of one-third the length of the package.

3. The method of preparing a twisted textile strand wherein the material to be twisted is unwound overend from a supply package and in so unwinding, while the package is turning at normal operative angular velocity, forms a balloon coaxial with the package and which terminates at a twisting point coaxial with the package and spaced from the discharge end of the package, and wherein the rotating balloon is not subjected to drag imposed by a rotating mechanical part through which the ballooning material passes on its way to the twisting point and wherein the material is continuously pulled away from the twisting point by force exerted in an axial direction and away from the discharge end of the package, characterized in that the twisting point is fixedly located so close to the discharge end of the package and upwardly and downwardly moving air currents are so created, which currents follow right and left spirals in moving toward the center of length of the package and merge, between its center of length and its discharge end, to sweep radially outwardly, that the resultant balloon shape is different from that which it tends to take in response to centrifugal force only and is such as to maintain a substantially uniform tension in the material as it approaches the twisting point, regardless of the point on the package from which the material at any given instant is unwinding.

4. In apparatus for use in preparing twisted strand material which forms a balloon in unwinding overend from a supply package, a spindle and a rotary support for the supply package which is coaxial with the spindle, a stationary part spaced from the discharge end of the package operative to locate the terminal end of the balloon close to the discharge end of the package, and means operative to create a flow of air along the lower part of the periphery of the package toward the discharge end of the package, whereby the maximum radius of the balloon is kept within a zone extending from the discharge end of the package to a distance not substantially exceeding one-third the length of the package from said discharge end.

5. In apparatus for use in preparing twisted strand material which forms a balloon in unwinding overend from a supply package, a spindle and a rotary support for the supply package which is coaxial with the spindle, a stationary part spaced from the discharge end of the package and which is operative to locate the terminal end of the balloon at a point which is so near to the discharge end of the package that the included angle between the terminal portion of the balloon and the axis of the package is at least 80°, and a rotary impeller coaxial with the package, said impeller having a cylindrical peripheral surface operative to create a rotating body of air, substantially all of whose particles move in planes perpendicular to the axis of the package.

6. In apparatus for use in preparing twisted strand material and which includes a rotary support for an unwinding package of the material to be twisted, in combination a part having a right cylindrical surface coaxial with the package and which rotates in time with the latter, one end of said cylindrical surface being adjacent to the discharge end of the package and the other end being in a plane, perpendicular to the axis of the package, which is located not more than one-third the length of the package from the discharge end of the latter, and a normally fixed part operative to locate the terminal end of the balloon close to the discharge end of the package, said parts being

so constructed and arranged that the maximum diameter of the balloon is always within a zone located between the opposite ends of the cylindrical surface of said first mentioned part.

7. In apparatus for use in preparing twisted strand material which forms a balloon in unwinding overend from a supply package, a spindle and a rotary support for the supply package which is coaxial with the spindle, a rotary part having a cylindrical surface of uniform diameter from end to end which is coaxial with the package, one end of said cylindrical surface being adjacent to that end of the package which is closest to the twisting point and the other end of said cylindrical surface being in a plane perpendicular to the axis of the package which is spaced from the first-mentioned end of the package a distance not substantially exceeding one-third the length of the package, and a normally stationary part operative so to control the path of approach of the terminal portion of the balloon to the axis of the package that the included angle between said terminal portion and the axis of the package is not substantially less than 80°, the parts being so constructed and arranged as to maintain the maximum diameter of the balloon always between the horizontal planes of the opposite ends of said rotary part.

8. In apparatus for use in preparing twisted strand material and which includes a rotary support for an unwinding package of the material to be twisted, in combination an impeller comprising an annular shell whose peripheral surface is cylindrical from end to end and which is coaxial with the package and rotates in time with the latter, the impeller having an imperforate web which supports the shell and which is in a plane perpendicular to the axis of the package and closely adjacent to the discharge end of the package, the cylindrical, peripheral surface of the shell extending at least from the plane of said web to a plane parallel thereto which is located not more than one-third the length of the package from the discharge end of the latter, said shell being of such internal diameter as to be free from contact with the package, and means defining a twisting point coaxial with the package, said means being so located that the included angle between the terminal portion of the balloon and the axis of the package exceeds 60°.

9. In apparatus for use in preparing twisted strand material which forms a balloon in unwinding overend from a supply package, a spindle and a rotary support for the supply package which is coaxial with the spindle and normally fixed thereto, an annular shell having a cylindrical wall, of an axial length approximately equalling its radius, which is coaxial with the package, the upper end of said cylindrical surface being adjacent to that end of the package which is nearer to the twisting point, and a normally stationary part operative so to control the path of approach of the terminal portion of the balloon to the axis of the package that the included angle between said terminal portion and the axis of the package is not substantially less than 80°, the parts being so constructed and arranged as to maintain the maximum diameter of the balloon always between the horizontal planes of the opposite ends of the cylindrical surface of said rotary part.

References Cited in the file of this patent

UNITED STATES PATENTS

1,872,971	Kingman	Aug. 23, 1932
2,129,956	Pastor	Sept. 13, 1938
2,237,062	Schlums	Apr. 1, 1941
2,331,240	Selvig	Oct. 5, 1943
2,338,656	McNally et al.	Jan. 4, 1944
2,432,935	Rhodes	Dec. 16, 1947
2,466,797	EGGE	Apr. 12, 1949
2,488,970	EGGE	Nov. 22, 1949

FOREIGN PATENTS

634,830	Germany	Sept. 4, 1936
905,738	France	Apr. 30, 1945