Jan. 27, 1959 A. W. VIBBER 2,870,596

TWISTING SPINDLE BALLOON CONTROL

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FIG. 1.

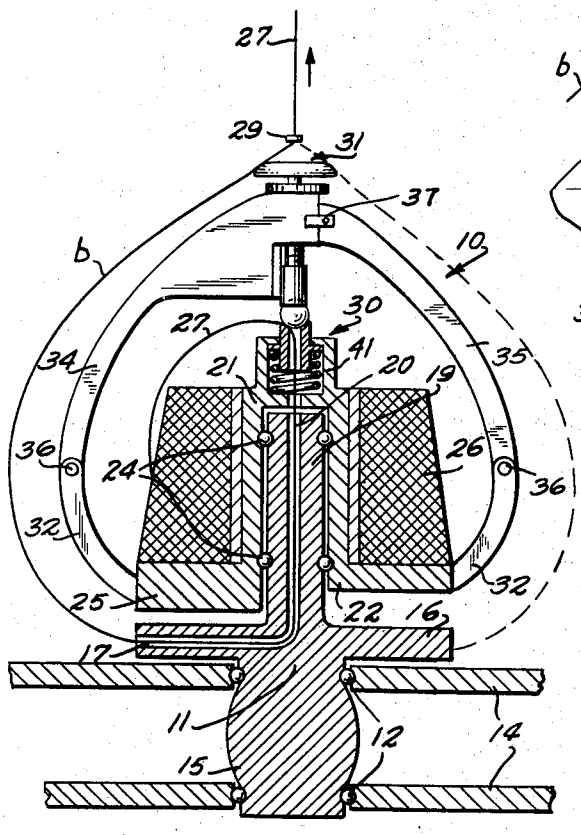
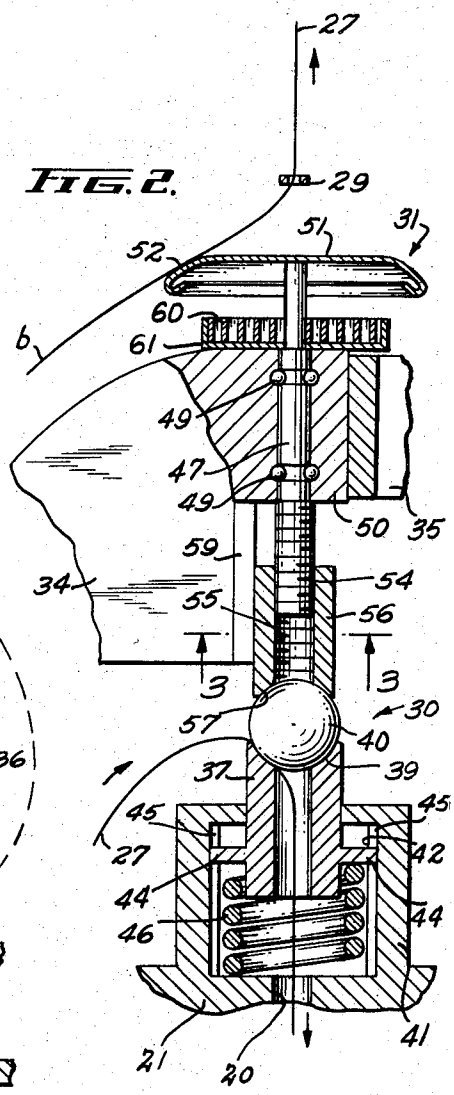


FIG. 2.



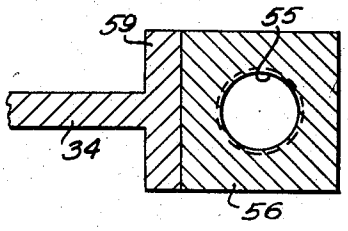


FIG. 3.

INVENTOR.

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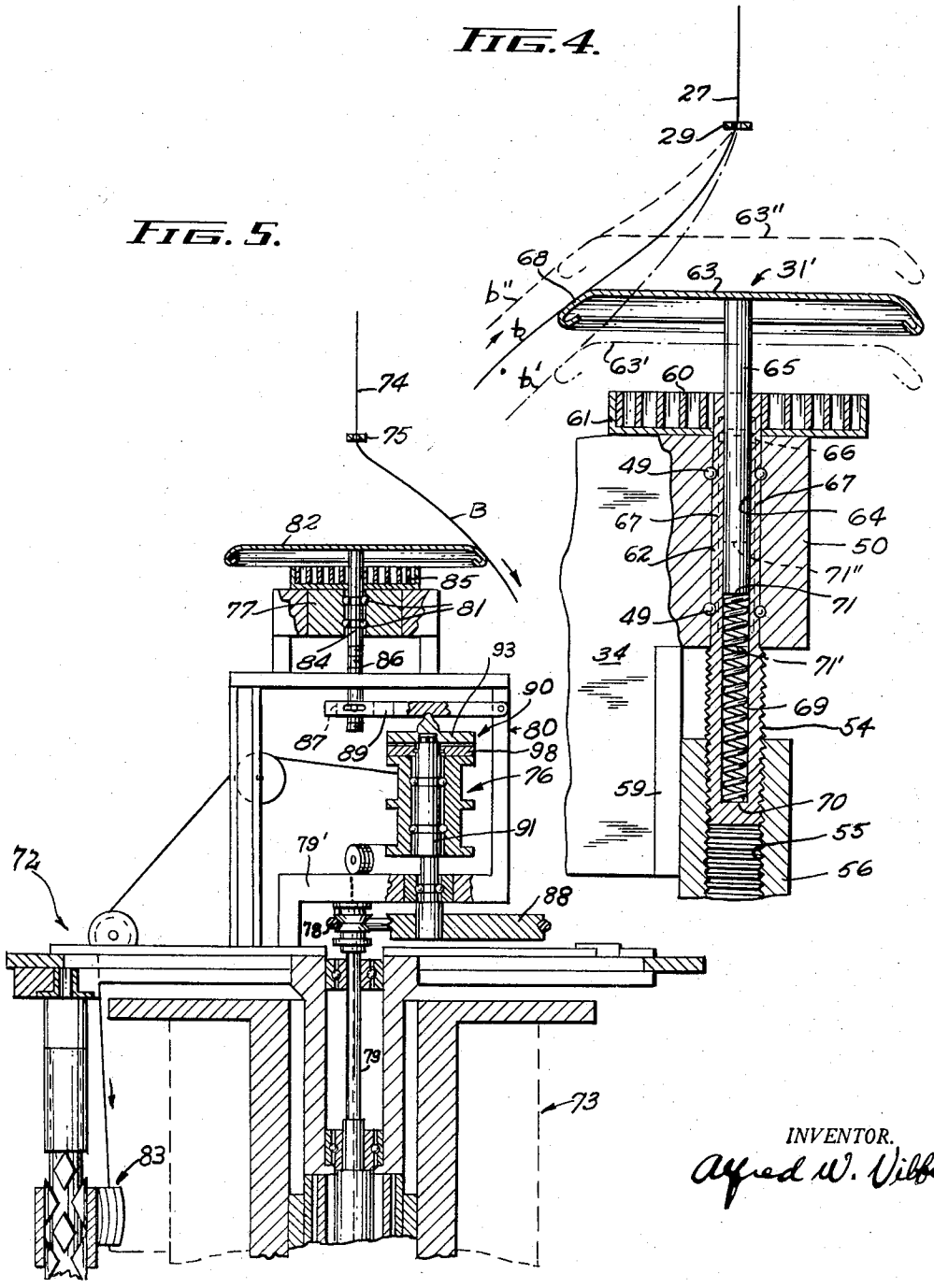
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TWISTING SPINDLE BALLOON CONTROL

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FIG. 4.

FIG. 5.



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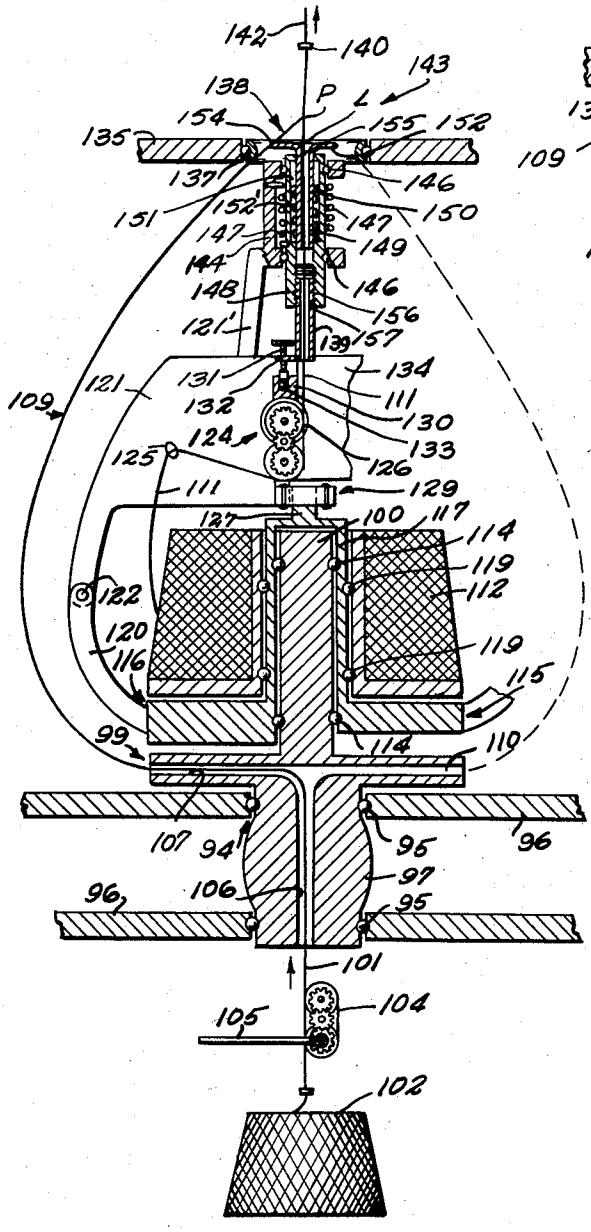
Alfred W. Vibber

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TWISTING SPINDLE BALLOON CONTROL

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FIG. 6.



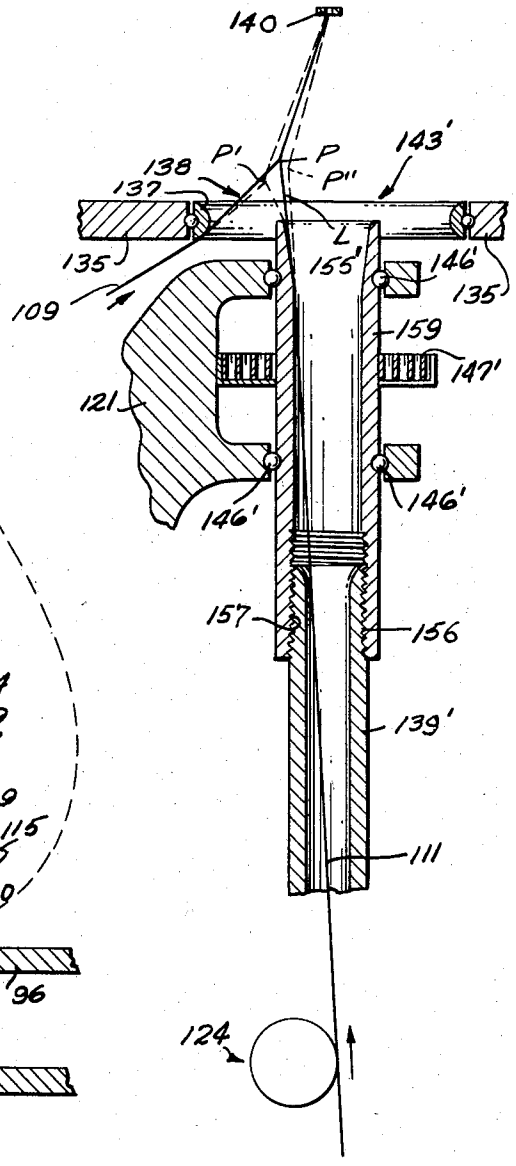


FIG. 1.

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TWISTING SPINDLE BALLOON CONTROL

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FIG. 8.

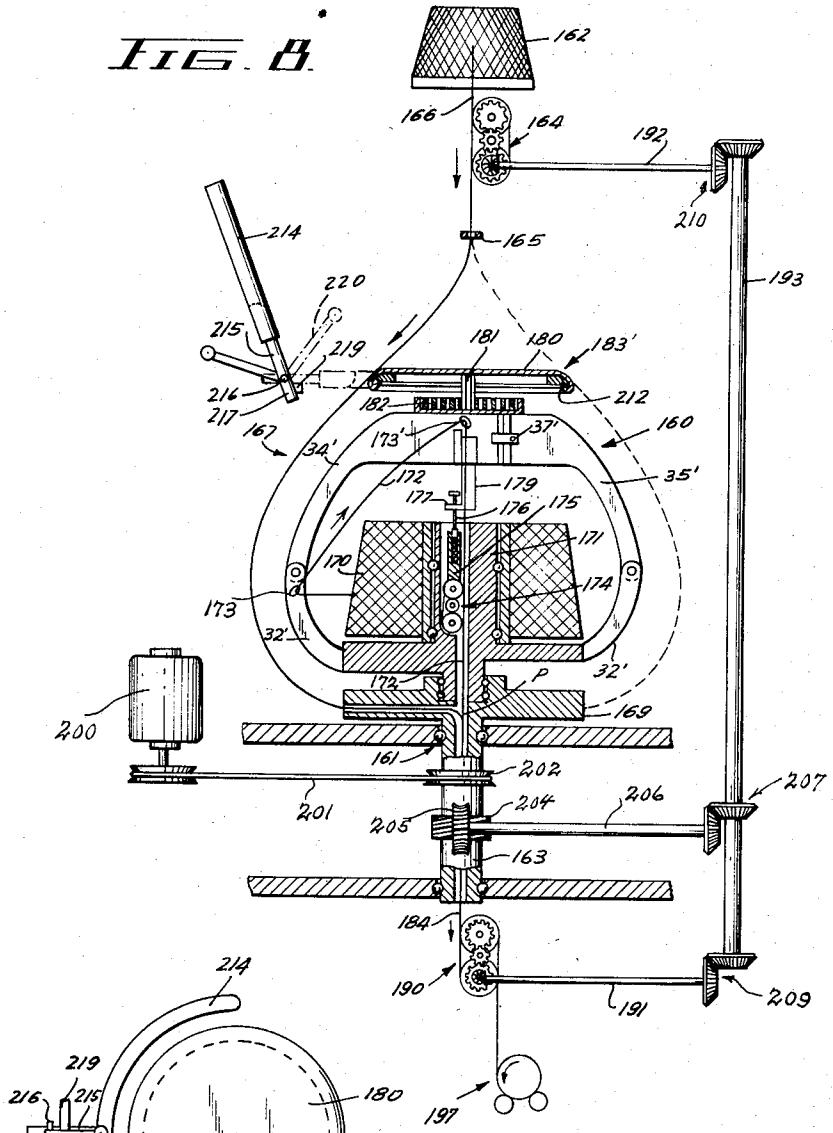


FIG. 9.

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United States Patent Office

2,870,596

Patented Jan. 27, 1959

2,870,596

TWISTING SPINDLE BALLOON CONTROL

Alfred W. Vibber, Ridgewood, N. J.

Application September 4, 1957, Serial No. 682,066

35 Claims. (Cl. 57—58.83)

This invention relates to apparatus for controlling the size and shape of a rotating bulging loop of elongated flexible material such as occurs at a twisting and/or plying spindle. The rotating bulging loop may be a large flying loop, ordinarily termed a balloon, concentric with a loop-creating shaft or flyer, or it may be a relatively shorter smaller loop, such as that caused by cyclically turning forces acting on a length of the material, for instance within the spindle itself, as will appear hereinafter.

With any twisting spindle employing a free flying balloon the size of the balloon is of importance. With such spindles, the diameter of the balloon can not exceed a certain dimension because of the economy of space required. Further, as is well known, the diameter of a balloon has a vital bearing on the tension at which the material is twisted. When a twisting spindle feeds directly into, or is fed from, another spindle or spindles, the control of the tension of the material at such first spindle, and thus the control of the size of the balloon of that spindle within certain limits, becomes especially important.

With plying spindles, particularly of the type wherein one strand balloons about the source of another strand and the two strands are then plied together, accurate control of the size of the balloon is necessary, since balloon size has a direct bearing upon the relative tensions of the two strands in the runs thereof immediately approaching the plying point. Ordinarily, as in the making of cord for the reinforcing of tires and V-belts by this method, equal lengths of the two strands are desired in the finished plied strand. Thus it is important that the two strands, the one ballooned and the other not, shall be and remain under substantially the same tension as they approach the plying point.

Various different types of apparatus have been proposed to detect variations in the size and shape of a balloon or free flying loop of flexible material, and to control the apparatus to restore the balloon to its optimum size. One type of such prior apparatus is that in which a rotatable annular balloon-contacting member is employed outside the balloon, rotation of such annular member being employed to control the size of the balloon. Apparatus of this type is shown in applicant's prior applications Serial Nos. 261,704, filed Dec. 14, 1951, and 317,406, filed October 29, 1952, now Patent No. 2,851,848. Another type of prior apparatus for detecting changes in the balloon and for restoring the balloon to the desired size is that wherein means is employed on the flyer to detect changes in the angle of approach and/or the tension of the material in the balloon. One such type of apparatus is shown in applicant's prior application Serial No. 361,999, filed June 16, 1953, now Patent No. 2,736,160. The present application is a continuation-in-part of each of applicant's above recited three prior applications, and is also a continuation-in-part of application Serial No. 541,222, filed October 18, 1955, now abandoned.

The prior devices, disclosed in the first three above identified applications, are satisfactory and work well. All, however, engage the loop or balloon by means supported outwardly thereof, and thus the control of the strand-tensioning means, that is, variable strand take-up or retarding means, positioned on the spindle within the balloon is difficult from the stand-point of design. The means connecting or linking the balloon size-detecting means and the means within the balloon to be controlled thereby may be of an electrical nature, operating through slip rings, or, if it is mechanical, it must effect its entry into the balloon essentially centrally of the spindle-supporting shaft.

In certain of the illustrative embodiments of apparatus according to the present invention, a means for detecting variations in the size or shape of the balloon or loop is positioned inwardly of such balloon or loop, or at least inwardly of an associated balloon or loop, and engages the inner surface of the balloon or loop. The balloon shape or size detecting apparatus may thus be located adjacent the variable strand tensioning means to be controlled, and both the detecting means and the controlling means are located within such balloon or loop, so that simple and direct operating connections may be employed between the balloon or loop size detecting and the balloon or loop size varying means operated thereby.

The invention has among its objects the provision of improved, simplified apparatus for detecting changes in the size or shape of a balloon or rotating bulging loop in a strand.

A further object of the invention, in certain embodiments thereof, lies in the provision, in apparatus of the type indicated in the preceding paragraph, of balloon or loop contacting means located inwardly of the balloon or loop.

Another object of the invention resides in the provision of a balloon or loop size or shape detecting means including balloon or loop contacting means, which is rotatable and which controls the balloon by reason of such rotation. In a preferred embodiment of the apparatus there is employed resilient means opposing rotation of the balloon contacting means in the direction of rotation of the balloon or loop.

Still another object of the invention resides in the provision, in some embodiments thereof, of an improved combination of a twisting spindle and a balloon or loop size detecting means wherein the balloon size detecting means includes means contacting the balloon and controlling a tension varying means such as a variable take-up or a retarding means which acts upon the same strand as that which is in the said balloon or loop.

In yet further embodiments of the invention, the balloon shape or size detecting means includes means engaging one ballooning strand or rotating bulging loop in a strand which is one of a related system of strands, the strands of the system leading to a common plying point. The balloon diameter detecting means of the invention, in this embodiment, controls the tension in a strand of the system other than that particular strand whose balloon or loop is engaged by the device, thereby varying the relative tensions of the strands leading to the plying point, and, through the resulting change in the rate of absorption of the strands into the plied product, varying the tension and the size and shape of the particular balloon or free flying loop itself.

The above and further objects of the invention relating to economies of use and manufacture will more fully appear in the following description of preferred embodiments thereof.

In the drawings accompanying the specification, and forming a part thereof;

Fig. 1 is a somewhat diagrammatic view of a first embodiment of the apparatus of the invention, certain parts of the apparatus being shown in vertical axial section and other parts thereof being shown in elevation.

Fig. 2 is an enlarged fragmentary view of the portion of the apparatus of Fig. 1 which is located within the balloon and contacts the balloon for detecting variations in size thereof, and of the means under the control of such balloon contacting means for applying retarding tension to the strand.

Fig. 3 is a fragmentary view in section through the apparatus of Fig. 2, the section being taken along the line 3—3 of Fig. 2.

Fig. 4 is a fragmentary view of an alternative device which may be employed in the spindle of Fig. 1 in place of that shown in Fig. 2, such device contacting the balloon to detect variations in the size thereof, certain of the parts being shown in vertical axial section and other parts being shown in elevation.

Fig. 5 is a fragmentary view of a second embodiment of yarn twisting spindle in accordance with the invention, the spindle being of the down-twister, two-for-one spindle type, certain of the parts being shown in vertical axial section and others of the parts being shown in elevation.

Fig. 6 is a somewhat schematic view of a third type of twisting spindle in accordance with the invention, the spindle being of the type which plies two strands together by ballooning one about a source of supply of the other, the spindle incorporating a balloon contacting means in accordance with the invention to control the relative tensions of the strands approaching the plying point, certain of the parts being shown in vertical axial section and others of the parts being shown in elevation.

Fig. 7 is a fragmentary view of an alternative balloon contacting means for detecting variations in the size of the balloon which may be used in the apparatus of Fig. 6, certain of the parts being shown in vertical axial section and others of the parts being shown in elevation.

Fig. 8 is a somewhat schematic view of a fourth embodiment of twisting spindle in accordance with the invention, the spindle also being of the type which plies two strands together by ballooning a first strand about a source of supply of a second strand, certain of the parts being shown in vertical axial section and others of the parts being shown in elevation.

Fig. 9 is a fragmentary view in plan of the device associated with the spindle of Fig. 8 for selectively retaining the means for imposing tension on the second strand in an adjusted position.

As is evident from the above, there are shown herein four embodiments of yarn twisting and/or plying spindles in accordance with the invention. The first such embodiment is shown in Figs. 1, 2, and 3, Fig. 4 showing an alternative strand contacting means for detecting changes in the size of the balloon. In such first embodiment the spindle shown is of the so-called two-for-one up-twister type. In Fig. 5 there is shown a down-twister of the two-for-one type incorporating a balloon control device in accordance with the invention. In Fig. 6 there is shown a third embodiment of the spindle of the invention, the spindle being a twisting and plying spindle generally of the type disclosed and claimed in applicant's prior application Ser. No. 469,481, filed Nov. 17, 1954. Fig. 7 shows an alternative device in accordance with the invention for controlling the size of the balloon at the spindle of Fig. 6. Fig. 8 shows a fourth embodiment of a spindle in accordance with the invention, the spindle shown being a twisting and plying spindle generally of the type disclosed and claimed in applicant's prior application Ser. No. 361,999, filed June 16, 1953.

The spindles disclosed are characterized by the location within a balloon of balloon or loop contacting means for detecting changes in the size and/or shape of the contacted balloon or of an associated balloon or loop.

In Figs. 1–5, inclusive, the balloon-contacting means contacts the balloon, and controls a means for applying a variable retarding force (Figs. 1–4) or a variable take-up force (Fig. 5) directly upon the strand which runs into or from the balloon. In the apparatus of (*a*) Figs. 6 and 7, and (*b*) Fig. 8, the balloon- or loop-contacting means of the spindle detects variations in the size and/or shape of a balloon or loop at such spindle, the strand in the balloon in these latter embodiments being one of a set of related strands which are fed forward to a plying point.

The spindle of the first embodiment, shown in Figs. 1, 2 and 3, is designated as a whole by the character **10**. The spindle has a main shaft **11** journaled in ball bearings **12** mounted in the frame parts **14**, and is driven by a belt (not shown) which runs over the crowned pulley **15**. Shaft **11** has mounted thereon a disc-like flyer **16** which has a radial, strand-conducting passage **17** therein. Above the flyer the shaft **11** is provided with a smaller diametered portion **19** having an axial passage **20** therein communicating with the radial passage **17**. A vertical sleeve member **21**, having a horizontally extending platform member **22** at the bottom thereof, is journalled on the sleeve **19** by ball bearings **24**. Although the shaft **11** and the parts **19** and **21** have been described as vertical, it will be understood that the spindle as a whole is disposed at an appreciable angle to the vertical, the sleeve **21** being held substantially from rotation by the provision of a heavier section **25** on the platform **22**. A package **26** providing yarn **27** is mounted on sleeve **21** so that it likewise remains substantially non-rotatable.

Strand **27** from package **26** progresses upwardly as shown, down through the variable retarding tension device **30**, through the passages **20** and **17** in that order and outwardly into the rotating bulging loop or balloon *b*. The upper end of the balloon is guided in a conventional fixed eye **29**, through which it proceeds in to further strand processing apparatus (not shown) such as a take-up, a further twisting spindle, plying means, or the like. The apparatus of the invention maintains the balloon *b* within substantially a limited range of variation of diameter or girth, whereby to maintain the tension in the strand **27** as delivered above the eye **29** within a desired narrow range of values.

The balloon-contacting means, generally designated **31**, is located within the balloon *b* and below the eye **29**. Means **31** is supported on an over-arm structure composed of two diametrically opposed lower arms **32** extending outwardly and upwardly from opposite sides of the platform **22**, the upper arm **34**, carrying the means **31**, and the steadying and bracing member **35** latched thereto by means **37**. Arms **34** and **35** are pivotally connected to the lower arms **32** by pivot means **36**, whereby the arms **34** and **35** may be swung sidewardly, when the spindle is at rest, to allow the replacement of the package **26**.

The structure of the balloon-contacting means **31**, and of the variable tension means **30** controlled thereby, will be more readily understood by consideration of Figs. 2 and 3. The tension device **30** is composed of a central sleeve member **37** having a broad partially spherical seat **39** in the upper end thereof rotatably supporting a strand tensioning ball **40** therein. As shown, the strand **27** from the package **26** runs upwardly to the tensioning device, between the ball **40** and its seat **39**, and then downwardly into the central passage **20** in member **19**. Sleeve **37** is vertically reciprocably mounted in an extension **41** at the top of member **19**, the sleeve **37** reciprocating in bore **42** in member **41**, but being prevented from rotation with respect thereto by the oppositely disposed key members **44** on the sleeve which project into longitudinally extending key-ways **45** in bore **42** of member **41**. Sleeve **37** is constantly urged toward its upper terminal position by a coil compression spring **46**

which acts between a shoulder at the lower end of the bore 42 in member 41 and the bottoms of the keys 44.

The back tension exerted upon the strand 27 by means 30 depends upon the force with which the ball 40 is urged toward its seat 39. Such force is varied by the means 31, now to be described. The device 31 includes a shaft 47 coaxial with the main shaft 11 of the flyer and of the balloon *b*, the shaft 47 being rotatably mounted in bearings 49 in an enlarged end 50 of the over-arm 34. The shaft 47 is thus fixed against axial movement with respect to the arm 34 and the balloon *b*. Mounted upon the upper end of the shaft 47 is a disc 51, which is coaxial of the shaft, and which has a smoothly downwardly bent curved outer edge 52 adapted to contact the strand in the balloon *b*. The lower end of the shaft 47 is threaded at 54, and is received within an axial threaded bore 55 in the square sleeve 56. Sleeve 56 is thus vertically reciprocated upon the turning of shaft 47 in reverse directions, the sleeve being held from rotation by engagement between one of its flat faces and the flat plate-like guide portion 59 on over-arm 34. The bottom end of sleeve 56 has a seat 57 which is partially spherical in form and which receives the upper surface of the ball 40.

When the shaft 47 turns in one direction it thrusts the sleeve 56 downwardly more forcibly upon the ball 40, thereby compressing the strand 27 more tightly between the lower surface of ball 40 and the seat 30. The coil spring 46 in the device 30 is progressively compressed as the sleeve 56 travels downwardly, so to impose a progressively greater retarding force upon the strand 27. When the shaft 47 rotates in the other direction the sleeve 56 rises, thereby allowing the sleeve 37 to rise so that coil spring 46 imposes progressively less strand retarding force upon the strand engaged between it and the ball 40. In Fig. 2 the sleeve 37 is shown substantially in a mid-position, wherein a desired intermediate value of retardation upon the strand is normally imposed to maintain the balloon *b* at a desired diameter.

Rotation of the disc 51 and thus the shaft 47 in the direction of rotation of the balloon *b*, as the result of frictional engagement between the balloon and the rim 52 of the disc, is opposed by a coil spring 60 contained in a spring barrel 61 fixed to the arm 34, one end of the spring being attached to the barrel and the other end being attached to the shaft 47, as shown. The coil spring 60 is so arranged, and the threads upon the threaded lower end of shaft 47 and the sleeve 56 are of such hand, that the coil spring 60 tends to lower the sleeve 56, thereby imposing an increased retardation upon strand 27, and rotation of the disc 51 by the balloon *b* tends to raise the sleeve 46, in opposition to the action of spring 60, thereby tending to decrease the retardation of the strand 27 by means 30.

The springs 60 and 46 are so related that when they are, in effect, in balance with each other the retardation imposed upon strand 27 by means 30 will normally maintain the balloon *b* at the desired diameter. If, however, the balloon *b* should increase undesirably in diameter, strand 27 in the balloon tends to pull away from the edge of disc 51, the friction between strand 27 and rim 52 of the disc 51 will decrease, so that the spring 60 will then rotate the shaft 47 to impose a greater retarding effect upon the strand 27, thereby to restore the balloon *b* to its desired diameter. If the balloon *b* should decrease undesirably in diameter, on the other hand, the frictional force between strand 27 in the balloon and rim 52 of disc 51 will increase, thereby raising the sleeve 56. Thereupon the yarn retarding effect of means 30 will be decreased, so that the strand 27 may feed into the balloon at a greater rate, and thus restoring the balloon to its desired diameter.

Although the torque exerted on disc 51 by the balloon *b* tends to turn platform 22 about its axis, the amount of unbalance of the platform produced by portion 25, taken with the described tipping of the spindle axis, is sufficient in most cases to maintain the platform against an unobjectionable degree of oscillation. In most instances some oscillation of the platform is not objectionable, nor does it disadvantageously affect the operation of the balloon diameter detecting means 31 nor of the strand tensioning means 30.

Where it is desired to hold platform 22 against any substantial oscillation, however, the platform may be held by a known device having cooperating inner and outer magnetic rings spaced to define between them a path in which the strand of the balloon may revolve. The inner ring is attached to the platform, whereas the outer ring is attached to the fixed frame of the spindle, as shown, for example, in Clarkson Patent No. 2,550,136. The magnetic ring device for holding the platform from rotation may be used instead of the described tipping of the spindle axis and the weighted portion 25 of the platform, or it may, if desired, be employed in addition to such eccentric weighting of the platform and tipping of the spindle axis.

In Fig. 4 there is shown a balloon-contacting device, generally designated 31', which may be employed in the apparatus of Figs. 1, 2, and 3 instead of the above described device 31, the portion of the device of Fig. 4 replacing the corresponding, upper, portion of the device of Fig. 2. In the device of Fig. 4, the balloon-contacting disc rather than being fixed vertically in the spindle is of such construction that it may rise and fall and seek a position at which there is a balance between the force urging it upwardly and the downward thrust exerted on the disc by the balloon *b*. In the apparatus of Fig. 4 a sleeve 62 is rotatably and non-reciprocably mounted in the enlarged portion 50 of arm 34 by bearings 49. A balloon-contacting disc 63 is mounted on the upper end of a vertical shaft 65 coaxial therewith, the lower end of the shaft being reciprocably mounted in axial bore 64 of the sleeve 62. Shaft 65 has keys 66 thereon projecting into the longitudinally extending key ways 67 in the bore 64 of sleeve 62. As a result of such construction, the shaft 65 may reciprocate with respect to the sleeve 62, but transmits its rotation to the sleeve.

A coil compression spring 69 is disposed between the lower end 71 of shaft 65 and the bottom 70 of the bore in the sleeve 62, thereby constantly to urge the shaft 65 and the disc 63 upwardly. The spring 69 is of such character that it has a relatively long range of compressive travel, and so that when the disc 63 is held in a mean position it does not markedly distort the contour of the balloon *b*. The mechanism of Fig. 4 is of advantage because of the smoothness of its action, the rim 68 of disc 63 contacting the strand 27 in the balloon at all times.

The hands of screw 54 thread on the lower end of sleeve 62 and of screw thread 55 in sleeve 56 are the same, relative to the direction of rotation of the balloon, as in Fig. 2, that is, rotation of the shaft 65 in the direction of rotation of the balloon tends to raise the sleeve 56 thereby to decrease the amount of retarding tension exerted on the strand 27 by ball 40 (Fig. 2), and rotation of the shaft 65 in the reverse direction by the coil spring 60 tends to lower the sleeve 65, thereby to impose more retarding tension upon the strand. The characteristics of the coil spring 60, which constantly urges sleeve 62 in such direction as to drive the sleeve 56 downwardly, and the coil spring 46, which constantly urges the sleeve 37 (Fig. 2) upwardly, are such that these springs are approximately midway in their winding and compressive travels, respectively, when the balloon *b* has substantially its desired medial diameter. The characteristics of coil spring 69 are so chosen that when the rim 68 of disc 63 contacts the balloon when it has the desired medial diameter, the spring 69 is compressed to an intermediate length, for example, two-thirds of its free, unstressed length. In the solid line position of the disc 63 the strand

of the balloon presses upon its rim with a predetermined force, determined by the degree of compression of the spring **69**, and thereby exerts a known predetermined torque upon the shaft **65**. If the balloon should decrease in diameter, and occupy a position indicated by *b'*, the disc **63** would then be forced downwardly into the position **63'**, thereby depressing the lower end of shaft **65** to the position **71'**. The increased pressure between the rim of the disc and the strand in the balloon, as a result of increased compression of spring **69**, would produce an increased torque on shaft **65**, thereby tending to raise the sleeve **56**, thereby lessening the pressure upon ball **40** and decreasing the retarding tension on strand **27**.

If, on the other hand, the balloon should increase in diameter past the position *b*, it would, for example, occupy the position *b''*. With the balloon in this condition, the disc **63** would rise to the position **63''**, and the lower end of shaft **65** would then occupy the position **71''**. The resulting decrease in pressure between the rim of the disc and the strand in the balloon would produce a decreased torque upon the shaft **65** so that the torque exerted on the shaft by spring **60** would overbalance the torque thereon produced by the balloon. The sleeve **56** would then tend to travel downwardly to impose an increased retarding torque upon the strand, thereby to restore the balloon to its desired predetermined diameter.

In Fig. 5 there is fragmentarily shown a down-twister of the two-for-one type incorporating a balloon controlling device in accordance with the present invention. The spindle, generally designated **72**, is generally similar to that shown in the Bogdanffy et al. Patent No. 2,654,210, and in Fig. 2 of applicant's prior pending application Ser. No. 238,215, filed July 24, 1951, now Patent No. 2,729,932. In the apparatus of Fig. 5 herein, the take-up capstan of the spindle is under the control of balloon diameter detecting means in accordance with the present invention.

The strand **74**, proceeding from a source not shown, travels downwardly through the fixed balloon guiding eye **75** into the balloon B, created and maintained by a flyer or similar device, not shown. A variable speed driven take-up capstan **76**, which pulls the strand inwardly from the balloon and forwards it to a traversing device **83** for laying it upon bobbin **73**, is rotatably mounted upon shaft **91**, journalled in support **79'**. Shaft **91** is driven from hollow extension **79** of the central shaft of the capstan through the medium of a belt **78** entrained over a small pulley on shaft **79** and over a large pulley **88** on the end of the shaft **91** carrying the capstan.

A supporting member **77**, affixed to framework **80**, carries bearings **81** coaxial of the spindle in which is mounted a shaft **84** carrying balloon-contacting disc **82** on its upper end. Rotation of the disc **82** in the direction of rotation of the strand in the balloon B is opposed by the coil spring **85**. The shaft **84** has a screw thread **86** on its lower end, such screw thread being engaged with a pivotally and slidably mounted nut **87** on the free end of lever arm **89**. The opposite end of the lever **89** is pivoted on the framework **80**. As indicated in Fig. 5, the take-up capstan **76** is freely rotatably mounted upon the shaft **91**. The capstan is drivingly connected to the shaft **91**, with varying degrees of slip therebetween, by means of clutch **90**, the driven upper movable plate element **93** of which is pressed downwardly by an intermediate portion of lever **89**, so that as the lever **89** presses the plate **93** downwardly against friction disc **98** affixed to the upper end of capstan **76** the driving connection between the shaft **91** and the capstan **76** is progressively tightened. The upper end of shaft **91** is squared, as shown, and fits within a central square socket in the underside of plate **93**, so that the plate may reciprocate vertically to a limited extent while preserving its driving connection with shaft **91**.

The hands of the screw **86** and that of the nut **87** are such that when the disc **82** is rotated in the same direction as the strand in the balloon the lever arm **89** tends to rise to loosen the clutch, and that when the disc is driven in the reverse direction, by the coil spring **85**, the lever arm **89** tends to travel downwardly to tighten the clutch. When, therefore, a balance is effected between the torque exerted on the disc **82** by the balloon and that exerted on the shaft **84** by the coil spring **85**, the rate of slippage in the drive through the clutch to the take-up capstan remains constant. When, however, the balloon contracts undesirably in diameter, the disc **82** is turned in the same direction as the balloon, thereby to loosen the driving connection between the parts of the clutch, so that yarn is drawn in from the balloon by the capstan at a decreased rate, thereby restoring the balloon to its desired diameter. On the reverse action, that is, undesirable expansion of the balloon, the balloon contacts disc **82** more lightly or even pulls free of the disc **82**, and thus the coil spring **85** drives the screw **84** in such direction as to tighten the clutch connection between the take-up capstan and the driven shaft **91**.

In Fig. 6, a balloon controlling device in accordance with the present invention is shown applied to a strand plying apparatus of the type shown in applicant's prior application, Serial No. 469,481, filed November 17, 1954. In such apparatus a rotary driven shaft generally designated **94** is mounted on bearings **95** supported in frame parts **96**. Shaft **94** is driven at a high speed by a belt (not shown) engaging the crowned portion **97** of the shaft between the frame parts. Above the upper frame part **96** shaft **94** is provided with an enlarged flange portion or flyer **99** which functions as a balloon generating means. Above the flyer **99** shaft **94** is provided with the upper extension **100**.

A first strand **101**, to be ballooned by the spindle, is fed upwardly from a first package **102** by the driven constant speed strand feeding means **104**. Means **104** consists of two multigrooved capstans geared together by an intermediate idler gear and driven at a constant speed by the shaft **105** connected to a driving means (not shown) synchronized in speed with the rotation of the shaft **94**. Shaft **105** drives means **104** through the medium of bevel gears, as shown.

Strand **101**, after leaving means **104**, progresses upwardly into the axial bore **106** of shaft **94** and thence radially through a connecting bore **107** in the flyer so as to be formed into the free flying loop or balloon **109** about the axis of shaft **94**. To insure dynamic balance of the shaft the flyer is provided with an inactive or dummy passage **110** opposite passage **107**. The strand **101** travels upwardly through the balloon toward fixed guiding eye **140**, below which it meets a second strand **111** fed upwardly from a second strand package **112** within the balloon. As a result of the rotation of the strand in the balloon **109** about the run of the strand **111** the two strands are plied together. Because the apparatus imposes only a momentary false twist on the strand **101** the two strands in the plied cord are given no twist additional to that which they had in their packages.

Mounted on the extension **100** of the shaft **94** through the medium of bearings **114** is a platform **115**. Platform **115** is eccentrically weighted on one side, as shown at **116**, so that when the shaft **94** is tilted at a small angle to the vertical, in its operative position, the platform **115** remains substantially non-rotating. The package **112** is mounted on sleeve **117**, which is integral with the platform **115**, by means of bearings **119** so that the package is able to turn slowly about its axis as required by the paying off of the strand **111** therefrom.

The platform **115**, at the location of the eccentric weight **116**, is provided with an extension arm **120** which rises generally vertically from the edge of the platform. Arm **120** serves as the support for a frame member **121** which is hingedly connected thereto at **122**. Carried on frame member **121** is a variably retarded strand-feeding capstan means **124** which comprises two multi-grooved

capstans geared together by an intermediate idle gear, the central grooves of the capstans lying along the axis of the shaft **94**.

The frame member **121**, which may be turned counterclockwise about pivot means **122** to allow the replacement of the package **112**, is accurately held in position by means of a split bearing **129** mounted on the inner lower edge of frame member **121**. Bearing **129** has its two halves hinged to the frame, the two bearing halves being held in position to embrace shaft portion **127**, when the frame is in operative position, by a removable pin holding the outer ends of the bearing halves together. If desired, the over-arm structure may be further braced and strengthened by a diametrically opposed pivotally jointed arm similar to arm **32**, **35** of Fig. 1, rising from platform **115** and terminating in an upper end fragmentarily shown at **134**. Portion **134** may be latched to the confronting end of arm **121** by means (not shown) similar to means **37** of Fig. 1.

The second strand **111**, fed upwardly from package **112**, passes through the eye **125** on frame part **121** and into a radially outer groove on the lower grooved capstan of means **124**. The strand **111** then progresses radially inwardly from groove to groove on the capstans until it reaches the center groove from which it then rises toward the plying point P, and generally axially through a balloon compressing member **137**.

The balloon compressing member **137** is an annular member having a bore therethrough smoothly rounded in section, member **137** being mounted on frame member **135** through the medium of a ball bearing, as shown, so as to rotate freely with the balloon. Such arrangement markedly decreases the friction imposed on the strand of the balloon by the strand compressing means. In some instances, however, the annular balloon compressing member may be fixed from rotation.

The member **137** which, as shown, is positioned in a plane parallel to the flyer **99** and coaxial thereof, compresses or constricts the balloon markedly inwardly from the position which the balloon otherwise would have in the absence of the strand **111** and in the absence of the balloon compressing member. If neither the strand nor member **137** were present, the balloon would have its apex on a cord-guiding roller (not shown) positioned above and tangential to the axis of the balloon, or more properly speaking, at the small eye **140**, preferably employed, and positioned coaxial of the balloon a short distance below such roller to facilitate guiding of the plied cord to the roller. The balloon compressing member **137** has the functions of markedly decreasing the tension at the portion of the balloon above member **137**, thereby allowing the two strands to be plied together under reduced tension, of automatically confining the location of the plying point P to a relatively narrow range between the member **137** and the eye **140**, and of automatically varying the rate of absorption of the strand from the balloon into the plied cord to maintain the balloon substantially within desired operative diameters.

The plied cord **142** after rising through the eye **140**, may pass around the above-mentioned idle guiding roller into an automatic cord tension controlling means from which it is fed under substantially constant tension onto a take-up bobbin. The tension controlling means may be of a conventional type, such as that shown in the patent to Clarkson No. 2,503,242. The idle guiding roller for the plied strand, the automatic tension controlling means and the take-up bobbin may be similar to those shown in Fig. 1 of application Ser. No. 469,481.

In some instances, it has been found desirable to supplement the balloon-controlling function of the annular guide means **137** by a further means, in accordance with the present invention, whereby the strand **111**, rather than being fed by a constant speed feed means toward the plying point P, is fed thereto by a variable speed means under the control of a balloon-contacting means for detecting changes in the size of the balloon **109**. In the device shown, the upper grooved capstan of feeding means **124** is provided with a brake drum **126** which is acted upon by the brake shoe **130**. Brake shoe **130** is pressed downwardly against the brake drum with a variable force by means of the adjustable spindle **131** mounted on arm **132** of reciprocable sleeve **139**. Interposed between the brake shoe **130** and the lower end of the spindle **131** is a coil compression spring **133**.

Sleeve **139** is under the control of device **143**, which contacts the balloon **109** above the point at which it is contacted by the annular guiding member **137**. Such device is mounted, as shown, in the vertical sleeve portion **144** supported above the top of the arm **121** on member **121'** affixed to the arm. Rotatably mounted in sleeve **144**, through the medium of bearings **146**, is an inner sleeve **148** around which is disposed a coil torsion spring **147**, one end of the spring being secured to sleeve **144** and the other end of the spring being secured to sleeve **148**. Reciprocably mounted within the central bore in sleeve **148** is a second inner sleeve member **149** having keys **150** projecting therefrom into the longitudinally disposed keyways **151** in the wall of the bore of member **148**. Inner sleeve **149** is constantly urged upwardly by a coil compression spring **152'** acting between a lower shoulder in the sleeve **148** and the keys **150** on member **149**. Projecting radially outwardly from the upper end of sleeve **149** is an annular disc-like flange **152** having a smoothly rounded upper and outer edge **154** which contacts the upper portion **138** of the balloon.

Sleeve **139** is retained from rotation, as by sliding contact between part **132** attached thereto and a part of arm **121**. The upper end of sleeve **139** has an external thread **156** which is received in internal thread **157** at the lower end of sleeve **148**. The hands of the threads **156** and **157** on members **139** and **148**, respectively, are such that when member **152** is rotated by the balloon in the same direction as the balloon the sleeve **139** is driven downwardly to apply an increased braking force upon the capstan **124**, thereby more forcibly retarding the second strand **111**. The torsion spring **147** is so disposed as to oppose rotation of member **152** by the balloon, and so as constantly to urge the member **139** upwardly, thereby to decrease the retarding tension upon the strand **111**.

As has been set forth in application Ser. No. 469,481, when the plying point P travels downwardly unduly, thereby bringing the portion **138** into a relatively shallow angle with respect to the horizontal, the tension in strand **101** of balloon **109** is unduly high with respect to the tension in strand **111**. The annular guiding member **137** functions automatically to maintain the location of plying point P within certain limits. The device **143** still further limits the vertical travel of the plying point. As the plying point P travels downwardly, the upper portion **138** of the ballooning strand contacts the rim **154** of member **152** more forcibly, thereby to drive sleeve **139** downwardly to increase the braking action on capstan **124**. As a result, the tension in strand **111** rises relative to that in strand **101**, so that the rate of absorption of strand **101** into the plied product **142** increases, thereby to raise the plying point P and to decrease the tension in the upper portion **138** of the ballooning strand. When the plying point P rises unduly, the disc-like member **152** rises with it and continues to contact portion **138** of the balloon, with, however, decreased force, because of the expansion of spring **152**. The torsion spring **147** then over-balances the driving effect of the balloon upon member **152**, so that the sleeve **139** rises to cause capstan **124** to decrease the tension upon the strand **111**. Thereupon, the tension in portion **138** of the ballooning strand **101** increases relative to that in strand **111**, the rate of absorption of the strand **101** into the plied product decreases, the plying point P then falls to its desired medial range.

It will be understood that the strand 111 does not remain along the axis of the spindle in its travel to the plying point, but that it is outwardly bulged into a rotating loop L by reason of the tension thereon exerted by portion 138 of the strand 101, which approaches such axis at an acute angle. Under certain conditions of tension imposed upon the strands 101 and 111, and with certain diameters of the central bore through the inner sleeve member 149, the rotating bulging loop L may be made to impose a torque upon the inner surface 155 of member 149 which is additive to that imposed upon member 152 by portion 138 of the outer ballooning strand. Thus, in the apparatus of Fig. 6, the inner sleeve member 149 is subjected to forces which tend to rotate it in the same direction as the balloon 109, both by reason of its contact with such balloon and also by reason of its contact with the inner rotating bulging loop L of strand 111. The inner sleeve member 149, including surface 155 and disc 152, thus constitutes a means which is responsive to changes in the degree of eccentricity of plying point P with respect to the axis of the spindle.

It will be seen from the above that the annular guiding member 137 constitutes a first guide spaced radially from the axis from the main shaft of the spindle for directing the first strand in a rotating free bulging run in space approaching the flying junction. The inner surface 155 of member 149 terminates an appreciable distance short of the flying junction and directs the second strand in a rotating free bulging run in space approaching the flying junction and extending generally axial of the main shaft of the spindle. The guiding eye 140 is positioned on the axis of the main shaft of the spindle and is appreciably spaced axially of the shaft from the first and second guides so as to guide the plied strand away from the plying junction.

In Fig. 7 there is fragmentarily shown an apparatus similar to that in Fig. 6, but differing therefrom in that the device 143′ for controlling the braking of capstan 124, is acted upon only by the rotating bulging loop L in the strand 111. In Fig. 7 parts of the device which are the same as those in Fig. 6 are designated by the same reference characters as in Fig. 6. Other parts differing somewhat in structure but having essentially the same function, are designated by the same reference characters with an added prime. A sleeve 159 is rotatably supported in bearings 146′ in the supporting arm 121. Rotation of sleeve 159 in the direction of rotation of the balloon 109 and thus of the rotating bulging loop L is opposed by a coil compression spring 147′. A brake applying sleeve 139′ is connected to the lower end of sleeve 159 by means of interengaging threads 156 and 157 on parts 139′ and 159, respectively.

The degree of sidewise deflection of the plying point P from the axis of the spindle and thus the axis of sleeve 159 is a measure of the relative tensions in the portion 138 of strand 101 and in the portion of strand 111 approaching the plying point. When the tensions in such two strands approaching the plying point are equal, the plying point P lies somewhat eccentric of the axis of sleeve 159. When the tension in the portion 138 exceeds that in the strand 111 the plying point will be pulled further sidewardly to a position P′ as shown, and when the tension in the strand 111 exceeds that in portion 138 of the ballooning strand, the plying point will move inwardly somewhat to a position P″.

It will be seen that the sleeve 159, with its inner, strand contacting surface 155′, constitutes a means for detecting, or responsive to, changes in the degree of eccentricity of the plying point with respect to the axis of the spindle.

The characteristics and torque values of spring 147′, the contour of the inner upper flared surface 155′ of member 159, and the adjustment of the threaded spindle 131 and thus of the spring 133 of the brake means (Fig. 6) with which device 143′ is employed are such that the plying point normally occupies the poistion P. In such position of the plying point the torque exerted upon the sleeve 159 by contact between its surface 155′ and the rotating bulging loop L in strand 111 equals that exerted on sleeve 159 by spring 147′, the tensions in strand portion 138 and in the bulging loop L are equal, and, as a consequence, equal lengths of the two strands are continually absorbed into the plied strand. If, however, the tension in strand portion 138 should exceed that in loop L, the plying point would move further radially outwardly, for example, to the position P′, thereby causing the loop L to engage surface 155′ more forcibly. This causes the sleeve 159 to rotate in such direction as to raise sleeve 139′, thereby decreasing the braking effect upon capstan 124, shown schematically in Fig. 7, and thus restoring the two strands to a state of equal tension. If, conversely, the tension in the loop L should exceed that in portion 138 of the ballooning strand 101, the plying point would move radially inwardly, for example, to the position P″, in which the loop L contacts the portion 155′ of sleeve 159 more lightly. As a consequence, the torque exerted on member 159 by coil spring 147′ will momentarily overcome that exerted thereon by the loop L, so that the member 159 rotates to drive sleeve 139′ downwardly, thereby to apply the braking means more forcibly to capstan 124. This results in an increase in tension in strand 111, so that such tension once more equals that in portion 138 of the ballooning strand 101.

In Figs. 8 and 9 there is shown a strand plying spindle generally of the same type as that disclosed in Fig. 7 of applicant's Patent No. 2,736,160. Such spindle has a driven constant speed means for feeding at substantially constant speed a first, outer strand into a balloon which rotates about a strand package for a second, inner strand. The second strand is fed to the plying point by a variable speed strand-speed controlling means. The plied strand is taken up by a constant speed means driven in synchronism with the rotation of the balloon forming spindle and pulling the plied strand away from the plying point at a substantially constant speed. The variable speed means for controlling the speed of feeding of the second strand is under the control of means within the balloon which senses, or is responsive to, changes in balloon diameter, and which varies the variable speed strand feeding means so as to maintain the diameter of the balloon within predetermined narrow limits.

The spindle of Figs. 8 and 9 is advantageous because the plied strand is pulled away from the plying point by a constant speed means driven in synchronism with the flyer of the spindle. Thus the number of twists per inch of the product may be held to very close tolerances. Further, it eliminates the necessity of a variable speed take-up device with its consequent expense. Also, it reduces the significant variables in the system to one, the relationship between the tensions in the strands as they approach the plying point. Such relationship is at all times under the control of the balloon diameter sensing means, which not only maintains the balloon of substantially constant diameter and thus the two strands under substantially equal tension at all times as they approach the plying point, but only compensates for any small inherent creep of the strands which may occur at any or all of the three strand feeding means.

Proceeding now to a detailed description of the device of Figs. 8 and 9, there is there shown a spindle, generally designated 160, having a main shaft 163 rotatably mounted in bearings in a frame, fragments of which are shown. One such bearing is generally designated 161. A disc-like flyer 169 is integrally connected to shaft 163, as shown. A first strand 166, supplied by an outer package 162, is fed therefrom by a constant speed driven capstan 164 downwardly through a fixed eye 165 into a balloon 167 created and maintained by the flyer 169.

Centrally within the flyer, at plying point P, strand

166 meets strand 172 fed from inner package 170 through fixed guiding eyes 173 and 173'; in that order, and thence downwardly through a central axial bore in upper extension 171 of shaft 163. Extension 171 is mounted in bearings on shaft 163 above the flyer, as shown, and may be held from rotation by using an eccentrically weighted platform on extension 171, also as shown, and by tipping the spindle axis from the vertical. Alternatively or additionally, as set forth in connection with the first-described embodiment, extension 171 may be held from rotation by magnet means (not shown). The resulting plied strand 184 is pulled outwardly through the lower end of shaft 163 by constant speed driven capstan 190, from which it is taken up on a bobbin at take-up means 197.

Within the shaft extension portion 171 of the spindle there is located an idle strand-engaging capstan means 174 having a brake drum thereon variably engaged by a brake shoe 175. The brake shoe is engaged and pressed downwardly by the adjustable threaded spindle 176 through the medium of an interposed coil spring, as shown. Spindle 176 is mounted in a lateral arm 177 on the lower end of a vertically reciprocable sleeve 179. The sleeve 179, its manner of mounting, and the balloon-contacting means controlling it may be similar to any of those illustrated in Figs. 2, 4, and 5, but it is preferred that such elements be constructed and arranged in the manner shown in Fig. 5, wherein the balloon-contacting disc is mounted at a fixed distance from flyer 169.

The balloon-contacting disc 180 has a central shaft 181 similar to shaft 84 of Fig. 5. Rotation of the shaft 181 by engagement of the balloon with the outer edge of disc 180 is opposed by a coil spring 182. The mechanism 183' for detecting changes in balloon diameter is mounted on an over-arm device consisting of lower arms 32' attached to a package-supporting platform on extension 171, and upper arms 34' and 35' pivotally connected thereto. The main upper arm portion 34', carrying device 183, is latched to bracing arm 35' by means 37'.

Shaft 163 is driven by a motor 200 through the medium of a belt 201 entrained about a pulley on the motor shaft and pulley 202 on shaft 163. Capstans 164 and 190 are positively driven in synchronism with each other and with spindle shaft 163 by means of a shaft 193, which is connected to capstan 164 by a bevel gear set 210 and shaft 192 and is connected to capstan 190 by a bevel gear set 209 and shaft 191. Shaft 193 is driven by spindle shaft 163 through the medium of a worm 204 on shaft 163, such worm meshing with a worm gear 205. Gear 205 is keyed to cross shaft 206, which drives shaft 193 through bevel gear set 207.

It has been found that when the capstan rolls of capstan means 164 and 190 are of suitable dimensions and the ratios of the various gear sets 204, 205; 207, 209, and 210 are properly chosen, the shaft 163 and capstans 164 and 190 may have fixed speed ratios between them, as illustrated. In some instances, however, particularly where the spindle is designed for use with a variety of different types of strands, and to produce a variety of plied products having different twists per unit length, it may be preferred to interpose change speed mechanisms in one or both shafts 191 and 192. It is to be understood that such change speed mechanisms are of the type which may be adjusted to rotate the driven shaft thereof at a speed having a selected definite speed ratio with respect to the driving shaft. It is also to be understood that after such adjustment for any given plying operation, such change speed mechanism will not ordinarily thereafter be adjusted during such plying operation.

The manner of operation of the mechanism of Figs. 8 and 9 in maintaining the balloon of substantially constant diameter and in producing a plied strand of substantially uniform properties including number of twists per unit length will be apparent from the above. Briefly, when the balloon diameter becomes smaller than its desired optimum diameter the pressure between the outer ballooning strand 166 and the rim of disc 180 increases. This turns the disc in the direction of rotation of the balloon, thereby reducing the retarding tension imposed upon the inner strand 172 by means 174. The mechanism is such that a small decrease in diameter of the balloon causes the retarding means 174 to decrease its retarding effect so that now the inner strand 172 approaches the plying point under less tension than does the outer strand 166. Consequently the inner strand is now absorbed into the plied strand at a greater rate than the outer strand, and the balloon is soon restored to its optimum medial diameter. The mechanism is so arranged and adjusted that at such medial diameter of the balloon, retarding means 174 exerts a retarding force on strand 172 which is equal to the tension in strand 166 as it approaches the plying point. Consequently under such conditions, equal lengths of the two strands tend to be absorbed into the plied strand.

When the balloon increases in diameter from the optimum medial diameter, the lessened friction between the strand 166 of the balloon and the rim of disc 180 allows retarding means 174 to be adjusted by spring 182 to increase the tension of strand 172 so that it is now greater than the tension in strand 166 as the latter approaches the plying point. Consequently, more of strand 166 than of strand 172 is now absorbed into the plied strand, and the balloon is soon restored to its optimum medial diameter. The system is thus stable; in operation there is little tendency of disc 180 and retarding means 174 to "hunt," and the plied strand in any given length will contain substantially the same lengths of strands 166 and 172.

It will be understood that although the adjustable retarding means 174 is shown as being the sole means for imposing tension upon strand 172 in advance of the plying point, such adjustable retarding means may, instead, be employed with a fixed retarding means acting upon strand 172 either in advance of or following the adjustable retarding means. When a fixed and an adjustable retarding means are thus employed, it will be understood that the instantaneous total retarding tension which they exert on strand 172 will have the same relationship with respect to the diameter of the balloon of strand 166 as that described above for the apparatus employing only an adjustable retarding means 172.

In the illustrative embodiment, the shaft 181 mounting disc 180 is shown as being connected directly to brake shoe 175 directly through an interposed screw thread and nut arrangement. It is to be understood that if desired there may be employed a suitable speed reducing gearing interposed between shaft 181 and the mechanism operating to adjust the position of brake shoe 175. With such arrangement, the disc 180 makes several turns before the screw mechanism for adjusting brake shoe 175 makes one turn. Consequently such mechanism tends to be smoother in its operation. Thus the magnets and/or eccentric weights holding such platform fixed in space may be smaller.

Briefly, the device of Fig. 8 functions as follows: When the balloon 167 is of medial diameter, it contacts the disc 180 with sufficient force to apply the brake to the capstan 174 so as to maintain the tension in the two strands 166 and 172 approaching the plying point P substantially equal. When, however, the balloon 167 expands unduly, thereby causing the strand 166 to be under a higher tension as it approaches the plying point than is strand 172, the coil spring 182 rotates the shaft 181 to drive sleeve 179 downwardly, thereby to impose a greater braking effect on capstan 174 and thus restoring the tension of the two strands 166 and 172 to substantial equality. Conversely, when the balloon 167 contracts unduly, so that the tension in strand 172 as it approaches the plying point appreciably exceeds that in

strand 166, the resulting more forceful contact between the balloon 167 and the disc 180 results in the driving upwardly of the sleeve 179, thereby decreasing the braking effect upon the capstan 174, so that the tension in the portion of strand 172 approaching the plying point becomes equal to that in the portion of the strand 166 approaching the plying point.

Disc 180 may be initially positioned, at the start of the operation of the spindle, by winding spring 182 to the desired tension and quickly letting it go when the spindle is started. After a short period of adjustment, the strand in balloon 167 will interact with disc 180 to bring the back tension imposed upon strand 172 to the correct value. Alternatively, after the initial winding of disc 180, the disc may be preliminarily held by mechanical means such as a stick held against the disc with sufficient force to hold the disc from rotation but lightly enough to permit strand 166 to pass between it and the disc at each revolution of the strand balloon.

In Figs. 8 and 9 there is shown a device which is presently preferred for such preliminary holding of disc 180. As there shown, a ring magnet 212 is fixedly mounted on disc 180 by being clinched under the depending rim thereof. Disc 180 in this instance is made of non-magnetic metal such as non-magnetic stainless steel. Positioned outwardly of balloon 167, in a location selectively to cooperate with magnet 212, is a magnet 214 in the form of a half-ring. Magnet 214, in the illustrative embodiment, is mounted on a central arm 215 which is pivoted on a horizontal pin 216 supported on a fixed frame member (not shown). Arm 215 has a rear end portion 217. A fixed stop member 219 likewise supported on a fixed frame part (not shown) holds half-ring magnet 214 in either a horizontal, operative position, shown in full lines in Fig. 9 and in dotted lines in Fig. 8, or in tilted, inoperative position, shown in full lines in Fig. 8. Member 214 may be conveniently moved between such two positions by an angularly directed handle 220.

The spacing between magnets 212 and 214 when the latter is in operative position and the attraction between such magnets are such that disc 180 is held with spring 182 in properly wound condition when the spindle is at rest. After the spindle is started, and balloon 167 has assumed a regular formation so as to cooperate with disc 180, half-ring member 214 is moved into inoperative position. Immediately before the spindle is to be shut down, the half-ring member may be moved into operative position, whereby disc 180 will be held in the correctly wound position to cooperate immediately with balloon 167 when the spindle is again started and member 124 again shifted into inoperative position. Although one member 214 has been shown, it will be obvious that, if desired, a second such member, positioned on the opposite side of the spindle from that shown, may be provided. If two members 214 are used, both will be simultaneously selectively placed in operative or inoperative position.

Whereas for purposes of illustration I have shown and described herein preferred embodiments of the twisting spindle balloon control and/or means for controlling the size and shape of a rotating bulging loop in a strand, it will be understood that such embodiments are illustrative only, since the invention is capable of considerable variation as to details. The invention is, therefore, to be defined by the scope of the claims appended hereto,

I claim as new the following:

1. Apparatus for handling elongated flexible material advancing under tension in a zone in which it forms a rotating bulging loop in flight through the air, comprising means mounted within the loop and interacting with a portion of the loop intermediate its ends for detecting changes in the size of the loop, and means responsive to the last named means for varying the size of the loop.

2. Apparatus for handling elongated flexible material advancing under tension through a zone in which it forms a rotating bulging loop in flight through the air, comprising a loop-contacting member rotatably mounted within the loop and adapted to be turned in the direction of rotation of the loop by contact therewith for detecting changes in the size of the loop, and means responsive to the rotation of the loop contacting member for varying the tension of the material in the loop.

3. Apparatus for handling elongated flexible material advancing under tension through a zone in which it forms a rotating bulging loop in flight through the air, comprising a circular loop-contacting member rotatably mounted within the loop on an axis substantially coincident with the axis of the loop and adapted to be turned in the direction of rotation of the loop by contact therewith for detecting changes in the size of the loop, and means responsive to rotation of the circular member for varying the tension of the material in the loop.

4. Apparatus for handling elongated flexible material advancing under tension through a zone in which it forms a rotating bulging loop in flight through the air, comprising a circular loop-contacting member rotatably mounted within the loop on an axis substantially coincident with the axis of the loop and adapted to be turned in the direction of rotation of the loop by frictional contact therewith for detecting changes in the size of the loop, means for yieldingly turning said circular member in the direction opposite from the direction of rotation of the balloon, and means controlled by rotation of the circular member for varying the tension of the material in the loop.

5. Apparatus for handling elongated flexible material advancing under tension through a zone in which it forms a rotating bulging free-flying loop, comprising means mounted within the loop and contacting a portion of the loop intermediate its ends for detecting changes in the size of the loop, and a variable strand-tensioning means responsive to the first-named means acting directly upon the material for varying the tension of the material in the loop.

6. A spindle for twisting a strand advancing under tension through a balloon, comprising means mounted within the balloon and contacting a portion of the balloon intermediate its ends for detecting changes in the size of the balloon, and a variable strand-retarding means responsive to the first-named means acting directly upon the material in advance of its entry into the balloon for varying the tension of the strand in the balloon.

7. A spindle for twisting a strand advancing under tension through a balloon, comprising means mounted within the balloon and contacting a portion of the balloon intermediate its ends for detecting changes in the size of the balloon, and a variable speed means responsive to the first-named means acting directly upon the strand to pull the strand from the balloon, whereby to vary the tension of the strand in the balloon.

8. Apparatus for handling elongated flexible material advancing under tension through a zone in which it forms a rotating bulging free-flying loop having at least one end at a fixed location, comprising means mounted within the loop and contacting a portion of the loop intermediate its ends at a fixed distance from said one end of the loop for detecting changes in the size of the balloon, and means responsive to the last named means for varying the tension of the material in the loop.

9. Apparatus for handling elongated flexible material advancing under tension through a zone in which it forms a rotating bulging free-flying loop having at least one end at a fixed location, comprising means reciprocable along the axis of the loop mounted within the loop and contacting a portion of the loop intermediate its ends at varying distances from said one end of the loop for detecting changes in the size of the loop, and means

responsive to the last named means for varying the tension of the material in the loop.

10. Apparatus for handling elongated flexible material advancing under tension through a zone in which it forms a bulging free-flying loop rotating about an axis, the loop having at least one end at a fixed location, comprising a circular member coaxial of the loop and reciprocable along the axis of the loop mounted within the loop and contacting a portion of the loop intermediate its ends at varying distances from said one end of the loop for detecting changes in the size of the loop, the circular member being adapted to be moved by contact with the loop, means resiliently urging the circular member into contact with the loop, and means responsive to movement of the circular member by the loop for varying the tension of the material in the loop.

11. Mechanism for twisting together two strands so as to form a two-ply strand, comprising a source of supply of a first strand and a support carrying a let-off strand package for a second strand, a rotatable shaft operable to rotate a balloon of the first strand about the let-off package and also to ply the two strands together at a plying junction, a first means for feeding the first strand into the balloon, a second means for feeding the second strand to the junction where they are plied together, means mounted within the balloon and interacting with a portion of the balloon intermediate its ends for detecting changes in the size of the balloon, and means responsive to the last named means to vary the relationship between the tensions in the runs of the first and second strands approaching the plying junction.

12. Mechanism for twisting together two strands so as to form a two-ply strand, comprising a source of supply of a first strand and a support carrying a let-off strand package for a second strand, a rotatable shaft operable to rotate a balloon of the first strand about the let-off package and also to ply the two strands together at a plying junction, a first, substantially positive means for feeding the first strand into the balloon at a substantially constant speed, a second means for feeding the second strand at a variable speed to the plying junction, means mounted within the balloon and adapted to be contacted by a portion of the balloon intermediate its ends for detecting changes in the size of the balloon, and means responsive to the last named means to vary the speed of the second strand feeding means whereby to vary the relationship between the tensions in the runs of the first and second strands approaching the plying junction.

13. Mechanism for twisting two strands together at a floating plying point so as to form a plied strand, comprising means for tensioning and feeding a first strand forward in generally a straight path to the plying point, a guide for guiding the plied strand away from the plying point, said guide being positioned beyond the plying point on an axis passing close to the tensioning and feeding means for the first strand, means for tensioning a second strand and feeding it to the plying point at an acute angle relative to said axis, means for rotating the run of the second strand approaching the plying point about said axis, means for detecting changes in the degree of spacing of the plying point with respect to said axis, and means responsive to the last named means to vary feeding the relationship between the tensions in the runs of the first and second strands approaching the plying point.

14. Mechanism for twisting together two strands so as to form a two-ply strand, comprising a source of supply of a first strand and a support carrying a let-off strand package for a second strand, a rotatable shaft operable to rotate a balloon of the first strand about the let-off package and also to ply the two strands together at a floating plying junction which is eccentric of the axis of the shaft and which rotates about the axis of the shaft, a first means for feeding the first strand into the balloon, a second means for feeding the second strand to the junction where they are plied together, means for detecting changes in the degree of eccentricity of the plying junction, and means responsive to the last named means to vary the relative speeds of the first and second strand feeding means whereby to vary the relationship between the tensions in the runs of the first and second strands approachiing the plying junction.

15. Mechanism for twisting together two strands so as to form a plied strand, comprising a source of supply of a first strand and a support carrying a let-off strand package for a second strand, a rotatable shaft operable to rotate a balloon of the first strand about the let-off package and also to ply the two strands together at a floating junction, a first means for feeding the first strand into the balloon, a first guide for directing the run of the first strand approaching the plying junction generally radially inward toward the axis of the shaft, a second means for feeding the second strand to the plying junction, a second guide for directing the run of the second strand approaching the plying junction generally axial of the shaft, a third guide for directing the plied strand away from the plying junction generally axially of the shaft, means for detecting changes in the degree of eccentricity of the plying junction with respect to the shaft, and means responsive to the last-named means to vary the relative speeds of the first and second strand feeding means whereby to vary the relationship between the tension in the runs of the first and second strands approaching the plying junction.

16. Mechanism for twisting together two strands so as to form a plied strand, comprising a source of supply of a first strand and a support carrying a let-off strand package for a second strand, a rotatable shaft operable to rotate a balloon of the first strand about the let-off package and also to ply the two strands together at a floating plying junction, a first means for feeding the first strand into the balloon, a first, annular, guide spaced radially from the axis of the shaft for directing the first strand in a rotating free bulging run in space approaching the plying junction and extending generally radially inwardly toward the axis of the shaft, a second means for feeding the second strand to the plying junction, a second guide terminating an appreciable distance short of the plying junction for directing the second strand in a rotating free bulging run in space approaching the plying junction and extending generally axial of the shaft, a third guide on the axis of the shaft and appreciably spaced axially of the shaft from the first and second guides for leading the plied strand away from the plying junction, means for detecting changes in the degree of eccentricity of the plying junction with respect to the shaft, and means responsive to the last named means to vary the relative speeds of the first and second strand-feeding means whereby to vary the relationship between the tensions in the runs of the first and second strands approaching the plying junction.

17. Mechanism as claimed in claim 16, in which the first strand-feeding means substantially positively feeds the first strand at a constant speed, the second strand-feeding means variably retards the second strand, and the means for detecting the degree of eccentricity of the plying junction varies the degree of retardation of the second strand by the second strand-feeding means.

18. Mechanism for twisting together two strands so as to form a plied strand, comprising a source of supply of a first strand and a support carrying a let-off strand package for a second strand, a rotatable shaft operable to rotate a balloon of the first strand about the let-off package and also to ply the two strands together at a floating plying junction, a first means for feeding the first strand into the balloon, a first guide for directing the run of the first strand approaching the plying junction generally radially inward toward the axis of the shaft, a second means for feeding the second strand to the plying junction, a second guide for directing the run of the sec-

ond strand approaching the plying junction generally axial of the shaft, a third guide for directing the plied strand away from the plying junction generally axially of the shaft, means contacting at least one of the runs of two strands approaching the floating plying junction for detecting the degree of eccentricity of the plying junction with respect to the shaft, and means responsive to the last named means to vary the relative speeds of the first and second strand feeding means whereby to vary the relationship between the tension in the runs of the first and second strands approaching the plying junction.

19. Mechanism for twisting together two strands so as to form a plied strand, comprising a source of supply of a first strand and a support carrying a let-off strand package for a second strand, a rotatable shaft operable to rotate a balloon of the first strand about the let-off package and also to ply the two strands together at a floating plying junction, a first means for feeding the first strand into the balloon, a first guide spaced radially from the axis of the shaft for directing the first strand in a rotating free bulging run in space approaching the plying junction and extending generally radially inward toward the axis of the shaft, a second means for feeding the second strand to the plying junction, a second guide terminating an appreciable distance short of the plying junction for directing the second strand in a rotating free bulging run in space approaching the plying junction and extending generally axial of the shaft, a third guide located on the axis of the shaft and appreciably spaced axially of the shaft from the first and second guides for leading the plied strand away from the plying junction, means contacting at least one of the runs of the two strands between their respective guides and the plying junction for detecting the degree of eccentricity of the plying junction with respect to the shaft, and means responsive to the last named means to vary the relative speeds of the first and second strand feeding means whereby to vary the relationship between the tensions in the runs of the first and second strands approaching the plying junction.

20. Mechanism for twisting together two strands so as to form a plied strand, comprising a source of supply of a first strand and a support carrying a let-off strand package for a second strand, a rotatable shaft operable to rotate a balloon of the first strand about the let-off package and also to ply the two strands together at a flotaing plying junction, a first means for feeding the first strand into the balloon, a first guide spaced radially from the axis of the shaft for directing the first strand in a rotating free bulging run in space approaching the plying junction and extending generally radially inward toward the axis of the shaft, a second means for feeding the second strand to the plying junction, a second guide terminating an appreciable distance short of the plying junction for directing the second strand in a rotating free bulging run in space approaching the plying junction and extending generally axial of the shaft, a third guide on the axis of the shaft and appreciably spaced axially of the shaft from the first and second guides for leading the plied strand away from the plying junction, means contacting the run of the first strand between its guide and the plying junction for detecting the degree of eccentricity of the plying junction with respect to the shaft, and means responsive to the last named means to vary the relative speeds of the first and second strand feeding means whereby to vary the relationship between the tensions in the runs of the first and second strands approaching the plying junction.

21. Mechanism for twisting together two strands so as to form a plied strand, comprising a source of supply of a first strand and a support carrying a let-off strand package for a second strand, a rotatable shaft operable to rotate a balloon of the first strand about the let-off package and also to ply the two strands together at a floating plying junction, a first means for feeding the first strand into the balloon, a first guide spaced radially from the axis of the shaft for directing the first strand in a rotating free bulging run in space approaching the plying junction and extending generally radially inward toward the axis of the shaft, a second means for feeding the second strand to the plying junction, a second guide terminating an appreciable distance short of the plying junction for directing the second strand in a rotating free bulging run in space approaching the plying junction and extending generally axial of the shaft, a third guide on the axis of the shaft and appreciably spaced axially of the shaft from the first and second guides for leading the plied strand away from the plying junction, means contacting the run of the second strand between its guide and the plying junction for detecting the degree of eccentricity of the plying junction with respect to the shaft, and means responsive to the last named means to vary the relative speeds of the first and second strand feeding means whereby to vary the relationship between the tensions in the runs of the first and second strands approaching the plying junction.

22. Mechanism for twisting together two strands so as to form a plied strand, comprising a source of supply of a first strand and a support carrying a let-off strand package for a second strand, a rotatable shaft operable to rotate a balloon of the first strand about the let-off package and also to ply the two strands together at a floating plying junction, a first means for feeding the first strand into the balloon, a first guide spaced radially from the axis of the shaft for directing the first strand in a rotating free bulging run in space approaching the plying junction and extending generally radially inward toward the axis of the shaft, a second means for feeding the second strand to the plying junction, a second guide terminating an appreciable distance short of the plying junction for directing the second strand in a rotating free bulging run in space approaching the plying junction and extending generally axial of the shaft, a third guide on the axis of the shaft and appreciably spaced axially of the shaft from the first and second guides for leading the plied strand away from the plying junction, means contacting the run of the second strand between its guide and the plying junction for detecting the degree of eccentricity of the plying junction with respect to the shaft, and means responsive to the last named means to vary the relative speeds of the first and second strand feeding means whereby to vary the relationship between the tensions in the runs of the first and second strands approaching the plying junction.

23. Mechanism for twisting together two strands so as to form a plied strand, comprising a source of supply of a first strand and a support carrying a let-off strand package for a second strand, a rotatable shaft operable to rotate a balloon of the first strand about the let-off package and also to ply the two strands together at a floating plying junction, a first means for feeding the first strand into the balloon, a first guide spaced radially from the axis of the shaft for directing the first strand in a rotating free bulging run in space approaching the plying junction and extending generally radially inward toward the axis of the shaft, a second means for feeding the second strand to the plying junction, a second guide terminating an appreciable distance short of the plying junction for directing the second strand in a rotating free bulging run in space approaching the plying junction and extending generally axial of the shaft, a third guide on the axis of the shaft and appreciably spaced axially of the shaft from the first and second guides for leading the plied strand away from the plying junction, annular rotatable means mounted coaxial of the shaft, the run of the first strand between its guide and the plying junction contacting the outer rim of the member,

the run of the second strand between its guide and the plying junction contacting the inner surface of the member, means yieldingly opposing rotation of the member, and means responsive to rotation of the member by the runs of the strands to vary the relative speeds of the first and second strand feeding means whereby to vary the relationship between the tensions in the runs of the strands approaching the plying junction.

24. In a twisting spindle which forms a rotating strand balloon, a strand tensioning device comprising variable strand tensioning means, means mounted within the balloon and adapted to interact with a portion of the balloon intermediate its ends for detecting changes in the diameter of the balloon, and means mounted within the balloon and responsive to the last named means to control the strand tensioning means.

25. Mechanism for twisting together two strands so as to form a two-ply strand, comprising a source of supply of a first strand and a support carrying a let-off strand package for a second strand, a rotatable shaft operable to rotate a balloon of the first strand about the let-off package and also to ply the two strands together at a plying junction, a first means for feeding the first strand into the balloon, a second means for feeding the second strand to the junction where they are plied together, means mounted within the balloon for detecting changes in the size of the balloon, and means responsive to the last named means to vary the relationship between the tensions in the runs of the first and second strands approaching the plying junction.

26. Mechanism for twisting together two strands so as to form a two-ply strand, comprising a source of supply of a first strand and a support carrying a let-off strand package for a second strand, a rotatable shaft operable to rotate a balloon of the first strand about the let-off package and also to ply the two strands together, a first means for feeding the first strand into the balloon, a second means for feeding the second strand to the point where they are plied together, one of said feeding means being driven at a constant speed and another of said feeding means feeding its strand therepast at a variable speed, the two feeding means controlling the speeds at which their respective strands travel to the plying point, means mounted within the balloon to detect changes in size of the balloon, and means responsive to the last named means to vary the strand feeding speed of the said variable feeding means to vary the relative rates of absorption of the first and second strands into the plied strand.

27. The mechanism defined in claim 26 wherein the first strand feeding means is driven at constant speed and the second feeding means feeds its strand therepast at a variable speed.

28. The mechanism defined in claim 27, comprising a constant speed driven strand feeding means for pulling the plied strand away from the plying point.

29. Apparatus for handling elongated flexible material advancing under tension through a zone, means for rotating the material in a bulging loop in such zone, the loop having its ends spaced apart and lying generally on the axis of rotation of the loop, and means for detecting changes in the diameter of the loop, said last named means comprising means mounted inside the loop and adapted to be contacted by the material in the loop as the loop rotates with respect thereto, said means contacted by the material being responsive to changes in engagement therewith by the material in the loop.

30. The apparatus defined in claim 29 wherein the means adapted to be contacted by the material in the loop is a member having a circular material-contacting portion positioned coaxial with the loop.

31. The apparatus defined in claim 30 wherein the member is rotatable about its axis, and comprising means yieldably opposing rotation of the member by the loop.

32. The apparatus defined in claim 30 wherein the member is disc-like and the outer rim of the member forms the material-contacting portion of the member, and wherein the member is rotatable about its axis.

33. The apparatus defined in claim 32 which comprises means yieldably opposing rotation of the member by the loop.

34. A strand tensioning device for a spindle which has a rotatable shaft carrying a strand storage means, said shaft having means for rotating a strand balloon about the strand storage means said tensioning device comprising adjustable means to engage and variably tension the run of the strand extending from the strand storage means, means to adjust the tensioning means, a rotatable disc adapted to be mounted within the balloon coaxially of the shaft in position for the rim of the disc to be engaged by a zone of the strand in the balloon as such strand rotates thereabout, yieldable means connected to the disc and adapted to oppose rotation of the disc by the balloon, and means connecting the disc to the adjusting means so that rotation of the disc adjusts the strand tensioning means.

35. A strand tensioning and retarding device for a two-for-one uptwister spindle which has a rotatable shaft carrying a strand supply package, said shaft having means for rotating the strand from the package in a balloon about the strand package, said tensioning device comprising adjustable means to engage and variably tension the run of the strand between the package and the balloon, means to adjust the tensioning means, a rotatable disc adapted to be mounted within the balloon coaxially of the shaft in position for the rim of the disc to be engaged by a zone of the strand in the balloon as such strand rotates thereabout, yieldable means connected to the disc and adapted to oppose rotation of the disc by the balloon, and means connecting the disc to the adjusting means so that rotation of the disc adjusts the strand tensioning means.

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