Jan. 3, 1956 A. W. VIBBER 2,729,052

TWISTING SPINDLE BALLOON CONTROL

Filed Feb. 16, 1953 3 Sheets-Sheet 1

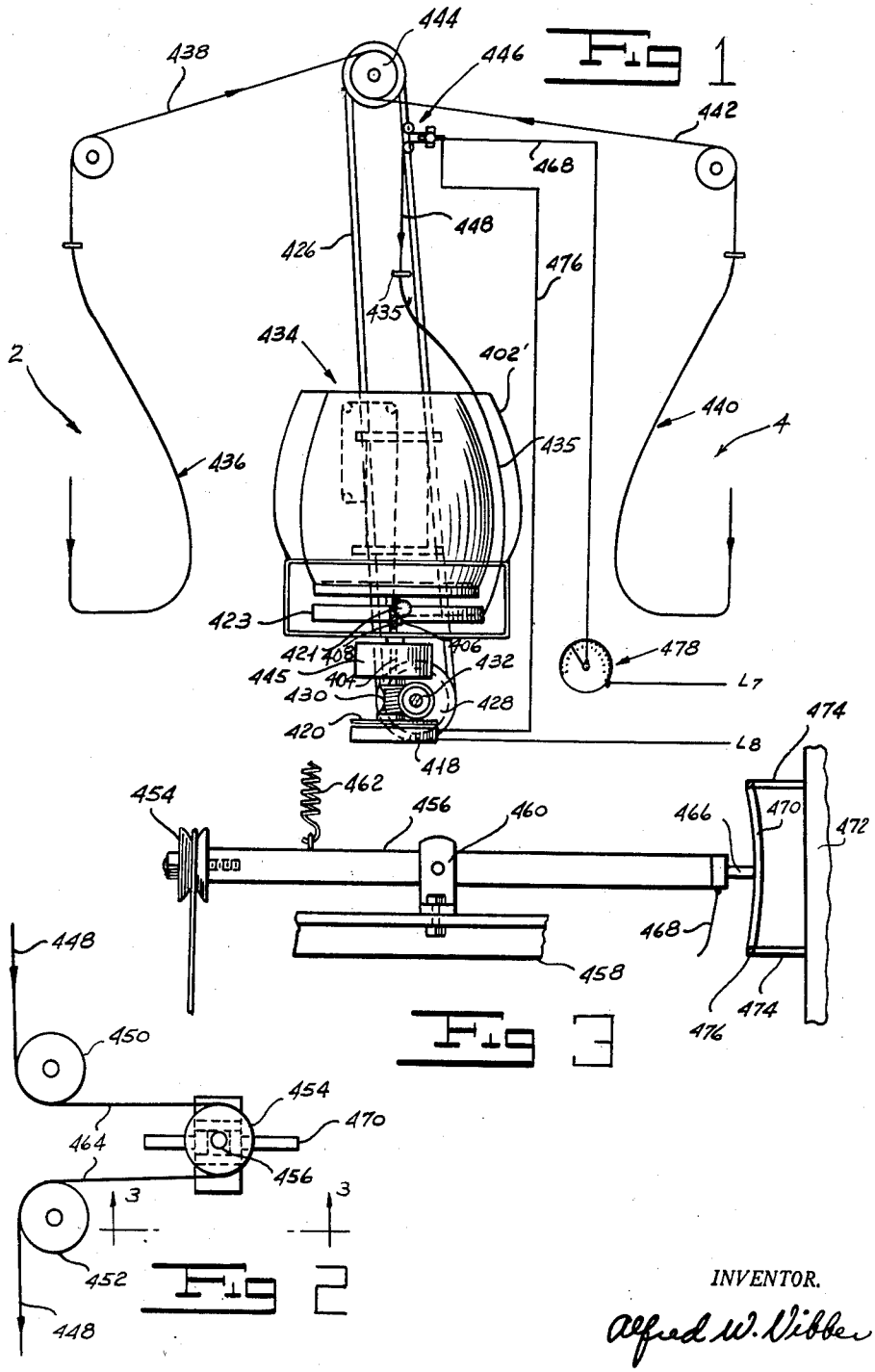


FIG 1

FIG 3

FIG 2

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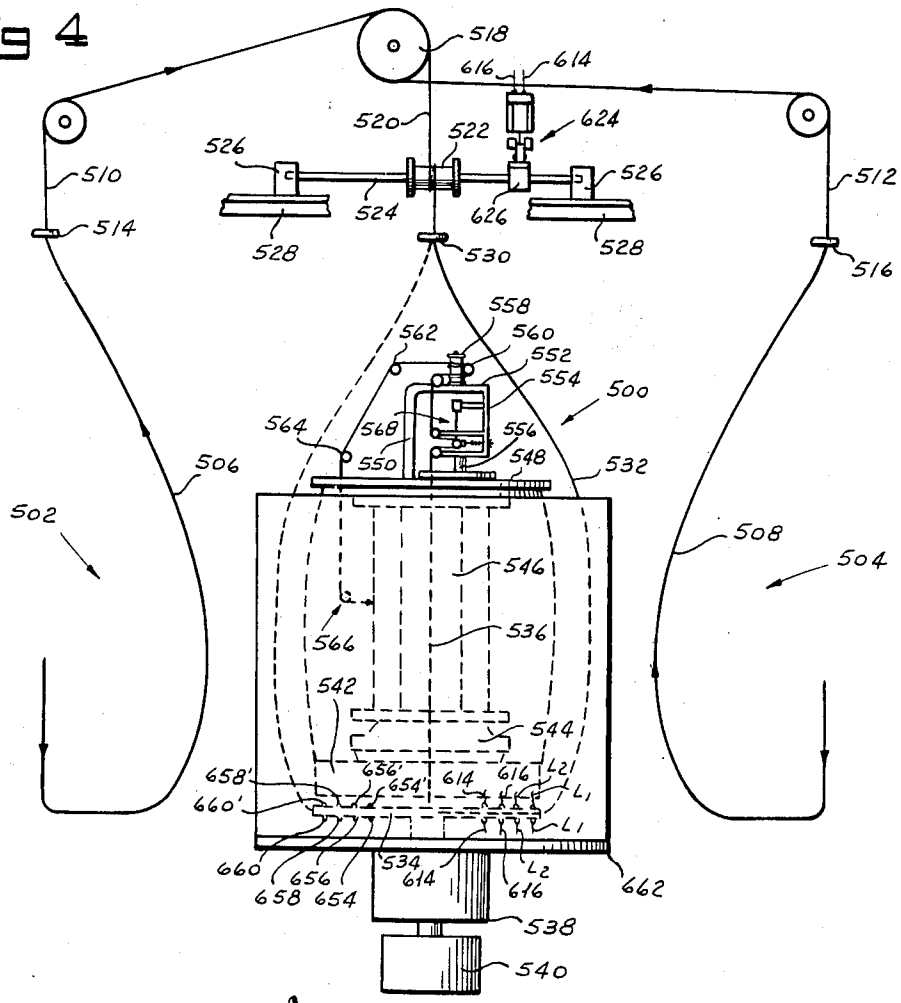
Alfred W. Vibber

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TWISTING SPINDLE BALLOON CONTROL

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Fig 4



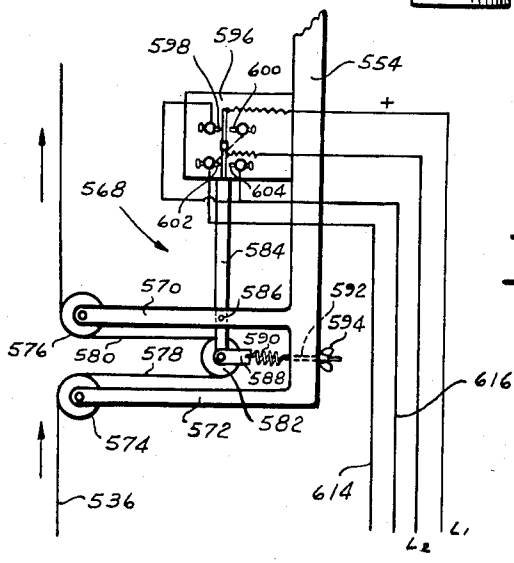


Fig 5

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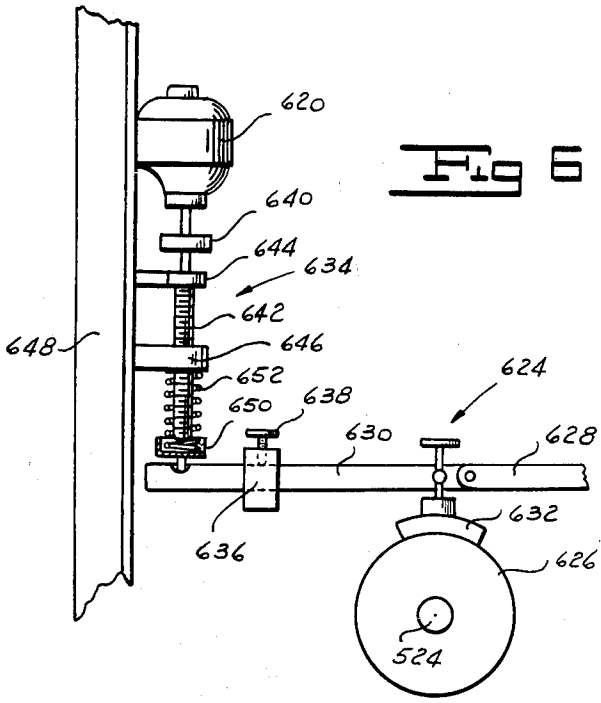


Fig 6

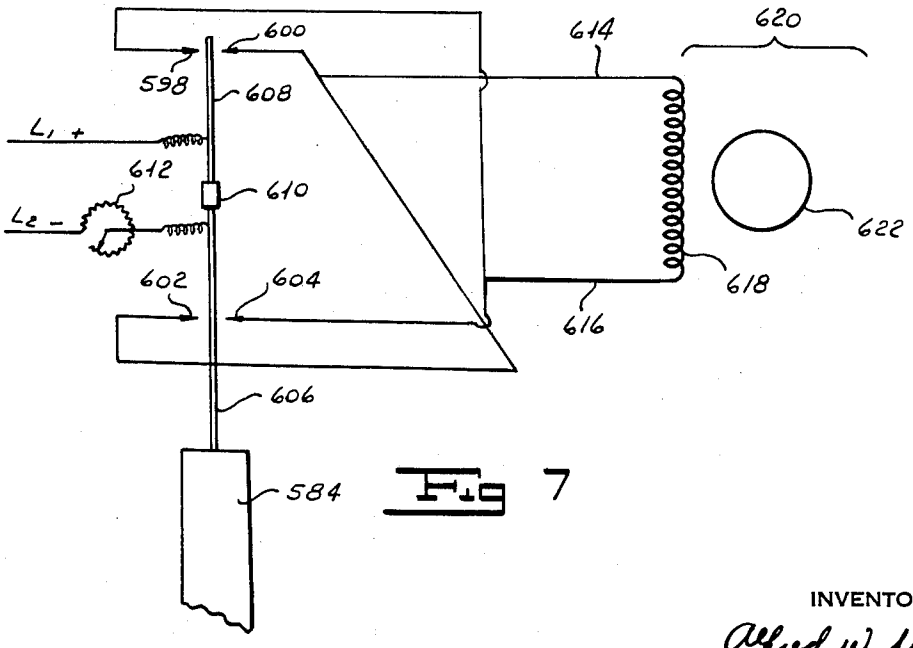


Fig 7

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TWISTING SPINDLE BALLOON CONTROL

Alfred W. Vibber, Ridgewood, N. J.

Application February 16, 1953, Serial No. 337,192

17 Claims. (Cl. 57—58.55)

This invention relates to an improved twisting spindle. Such spindle, in certain embodiments, may be employed as a singles twisting means of the supply containing up-twister type. In other embodiments the spindle may be employed as a cabling and twisting spindle of the down-twister type which receives the elongated flexible material in a balloon created and maintained by the spindle. The invention also relates to a system for continuously twisting and taking up elongated flexible material, such material proceeding from a source or from sources of supply into the spindle of the invention. In a preferred embodiment of the system of the invention there is employed apparatus forming cord from a plurality of yarn supplies, preferably twisting spindles, while the material is continuously in motion, such system incorporating the improved spindle of the invention for doubling the separate strands fed thereto.

This application is a continuation-in-part of applications Serial Nos. 238,215, filed July 24, 1951, 278,800, filed March 27, 1952, and now abandoned, and 337,191, filed February 16, 1953, all bearing the same title.

It has formerly been attempted, in apparatus in which the tension produced in a balloon at the take-up twisting spindle has been balanced against the one or more balloons of the one or more supply spindles, to position a fixed tension imposing device between such supply balloon or balloons and the take-up balloon. Since the tension in such balloons, and thus in the spans leading from them and to them, respectively, does not stay constant, due to minute variations in the gauge and moisture content of the elongated flexible materials such as yarn, and thus of the weight of the material in each balloon, it is not possible to maintain the diameter of the take-up balloon substantially constant by use of a tension compensating means which imposes a fixed retarding tension on such material.

It has also been attempted to employ a variable retarding means between the supply and take-up balloons, such retarding means being variable in response to the variations in tensions of the material traveling therepast. Such prior art variable retarding means positioned between the supply and take-up balloons have employed as a tension detecting means a resiliently mounted deflectable roll positioned above the cabling balloon eye, the combined, but as-yet-untwisted-upon-each-other, strands running over the deflectable roll in a salient path, whereby changes in tension in the strands are reflected in changes in the amount of deflection of the roll. Such changes in the amount of deflection of the roll are employed as the means for governing a variable strand retarding means, such as a braked gathering pulley, acting upon the strands in advance of the detecting roll, the tension-sensitive means incorporating the detecting roll engaging the material between the variable strand retarding means and the cabling balloon eye. Because the strands running over the detecting roll come from the singles balloons, pass the variable strand retarding means, and run into the doubles balloon, the instantaneous tension in the first portion of the salient run of the strands, that is, that approaching the tension detecting roll, reflects changes in the tension in the entire system prior to such roll, including the singles back tensions, the singles balloons, and the action of the variable strand retarding means, and the tension in the second portion of the salient run of the strands, that leaving the detecting roll, reflects changes in the tension in the doubles or cabling balloon. Consequently the detecting roll, being acted upon by both such portions of the salient run of the strands, measures the sum of the tensions in each of such portions of the salient run, and is subject to all the variables outlined above.

When the tension in the first portion of the run is not absolutely constant, and it almost never is for any appreciable length of time because of at least minute variations in tension in the singles back-tensions, in the singles balloons, in the system between the singles balloons and the first portion of the salient run, and in the action of the variable strand retarding means itself, the described prior art tension detecting means does not give a true measurement of the tension in the strands in the cabling balloon proper. Such device accordingly does not give a true measurement of balloon size, balloon diameter, or, by calibration starting with balloon tension as thus attempted to be measured, the length of the strands within the balloon.

In the described prior constructions employing a tension-sensitive means engaging the material adjacent one end of the balloon, one salient run of the material at the deflectable roll of the tension-sensitive means is located immediately adjacent to and directly communicating with the material engaging the variable speed, material speed controlling means. Thus a change in such material speed controlling means, which may, of course, be caused by the control thereof by the tension-sensitive means itself, is immediately operative upon the tension-sensitive means. Such action causes further change in the amount of retardation imposed on the material by the variable speed controlling means. Thus the described prior systems employing tension-sensitive means have been unstable in their operation, and have been unable to isolate, detect, or measure per se the tension of the material in the balloon to be controlled.

The present invention is particularly concerned with the control of the diameter of, and/or the length of the material in, a free-flying loop of elongated flexible material rotating about an axis, such as the balloon of the cabling and twisting spindle by the use of tension-sensitive means engaging the material at the spindle the balloon of which is to be controlled, such invention overcoming the above outlined difficulties experienced with prior constructions of balloon controlling apparatus employing tension-sensitive controlling means. Such control is effected by the continuous and instantaneous measurement of the tension per se of the material in tension-transmitting relation to the material in the balloon proper of the cabling and twisting spindle, and by the variation of the size of the balloon in response to such measurement. In both illustrative embodiments of the apparatus of the invention there is employed a tension-sensitive means engaging the material immediately adjacent one end of the balloon to be controlled. Both embodiments of the apparatus employ a constant speed material engaging means at one end of the balloon and a variable speed material engaging and material speed controlling means at the other end of the balloon, such last named means being under the control of the tension-sensitive means. It is of the essence of the present invention that the means for detecting the tension in the balloon to be controlled, such as a tension-sensitive material engaging means, shall detect the tension in that portion of the flexible material,

as by engaging it, between the balloon and the means for feeding the material at a substantially constant rate. With such construction the only significant variables affecting the tension detecting or tension-sensitive means are (1) the variation in tension in the material in the balloon proper to be controlled, and (2) changes in the tension transmitted from the balloon to the tension-sensitive means caused by attendant, determinable variations in the shape of the balloon and its orientation relative to the spindle. Consequently the tension detecting means of the invention truly reflects changes in tension in the balloon to be controlled and may be used as a means of accurate control of the tension of the material in such balloon and thus of the size of the balloon.

In the first described embodiment of the apparatus, shown in Figs. 1, 2, and 3, there is employed a constant speed gathering pulley for feeding material at a constant speed into the balloon of the doubles spindle. The tension-sensitive means is disposed between such constant speed feeding means and the upper end of the balloon, such tension-sensitive means controlling the speed of the variable speed means for withdrawing the material from the bottom end of the balloon. In the second described embodiment of the invention, that shown in Figs. 4, 5, and 6, a constant speed take-up means is employed at the inner end of the balloon, and a tension-sensitive means is disposed between such constant speed take-up means and the inner end of the balloon, such tension-sensitive means controlling the speed of a variable speed material feeding means, such as the gathering pulley of the three-spindle system, which feeds the material into the doubles balloon. In both such embodiments the tension in one salient run of the material in the tension-sensitive means, adjacent the constant speed material feeding means, has no significant variables introduced therein by the constant speed material feeding means or by anything in such system prior to such constant speed feeding means, since sufficient wraps of material are taken about the constant speed feeding means to give non-slipping engagement of the material therewith. The other salient run of the material at the tension-sensitive means, in immediate communication with the balloon to be controlled, accurately reflects changes in tension in the balloon, and so the response of the tension-sensitive means affords an accurate measurement of the instantaneous tension of the material in such balloon.

The invention will be more readily understood by reference to the accompanying drawings forming a part of the specification, in which:

Fig. 1 is a somewhat schematic view in side elevation of a three-spindle twisting and doubling apparatus for forming cord from yarns in accordance with the invention, the doubles spindle having a variable speed take-up means;

Fig. 2 is an enlarged view in side elevation of the tension-sensitive means engaging the doubled strands below the gathering pulley and prior to their entry into the eye of the cabling and twisting spindle;

Fig. 3 is an enlarged view in end elevation of such tension-sensitive means, the view being taken from a point of view along the line 3—3 in Fig. 2;

Fig. 4 is a somewhat schematic view in side elevation of a second embodiment of the three-spindle twisting and doubling apparatus for forming cord from yarns in accordance with the invention;

Fig. 5 is a detailed view in side elevation of the tension-sensitive means, and of the adjustable motor-reversing switch operated thereby;

Fig. 6 is a detailed view in side elevation of the brake operating upon the tension applying means at the in-feeding end of the doubles balloon and of the motor selectively to apply such brake with selectively variable force; and

Fig. 7 is a wiring diagram for the reversing switch of Fig. 5 and the motor shown in Fig. 6 controlled thereby.

In Figs. 1, 2, and 3 there is shown the first embodiment of the twisting apparatus of the invention. In the specific embodiment shown, such apparatus, which is designed for the making of cord such as the reinforcing cord for tires, incorporates two singles strand delivering spindles and a central cabling and twisting spindle, in accordance with the general combination shown in Uhlig Patent No. 2,487,837, November 15, 1949. In Fig. 1 the left-hand singles spindle, generally indicated at **2**, and the right-hand singles spindle, generally indicated at **4**, feed their strands **438** and **442**, respectively, from their respective balloons **436** and **440**, to a driven gathering pulley **444** which is driven at constant speed, from which they are fed and gathered, in as-yet-untwisted-upon-each-other condition, to the central, cabling and twisting spindle **434** through the balloon guiding eye **435'** thereof. Preferably sufficient wraps of the threads **438** and **442** are taken upon the driven gathering pulley so that substantially no slippage between such threads and the pulley occurs. Under such conditions, the gathering pulley acts as a tension isolating means, whereby tension conditions in the singles spindles and in the spans leading to the gathering pulley are isolated from tension conditions in the cabling and twisting spindle. Furthermore, under such conditions the gathered cord is withdrawn at an essentially constant speed from the singles spindles and is fed at an essentially constant speed into the cabling and twisting spindle. Spindles **2**, **4**, and **434** are supported upon a frame, not shown, and are driven by a common motor through belt means, also not shown, the pulley of the doubling and twisting spindle **434** being indicated at **445**.

As is well known, the spindles **2** and **4** are both of the two-for-one uptwisting type, the doubly twisted threads therefrom being combined at pulley **444** and being led downwardly through the tension-sensitive means **446**, to be described, through the upper guiding eye of the balloon **435** at the spindle **434**. The lower end of such balloon is led radially inwardly through the balloon creating and maintaining flyer **423** and thence rises axially of the spindle, as shown, to be coiled upon the bobbin carried by the spindle. The described driven gathering pulley **444** acts, in this embodiment, as a speed determining member for the strands being processed and thus as a twist governor. Pulley **444** is mounted on a driven horizontal shaft, such shaft having thereon a V belt receiving pulley, as shown. Entrained over such pulley is the driving V belt **426**, which is driven in synchronism with the main upright shaft carrying the flyer **423** of the spindle **434**, such driving being accomplished by the provision of worm **430** on the bottom of the main shaft and the worm gear **432** keyed to a horizontal shaft at the bottom of the spindle, the worm gear **432** meshing with worm **430**. The V belt receiving pulley **428**, on the bottom horizontal shaft, receives belt **426** at the bottom of the run of the latter.

The variable speed means for engaging the cord **448** at the inner end of the balloon **435** is the same as that shown in detail in Figs. 5 and 6 of application Serial No. 238,215 and described at length in such application. As indicated in such prior application the main driving and supporting shaft for the spindle **434** is hollow, having an axial bore therethrough. Supported within the bore in the main shaft of the spindle is the small axially located shaft **404**, such shaft being journalled in the main shaft of the spindle by anti-friction bearings.

On the bottom end of the small shaft **404** there is positioned the inductor disc **420** made of electrically conducting metal such as copper, aluminum, and the like. A wound field coil **418**, positioned so as to lie parallel with the outer broad surface of disc **420** with a small air gap between them, is selectively energized from the alternating current source L_7 and L_8. The degree of attraction between the inductor disc **420** and the wound field coil **418**, and thus the force imposed upon shaft

404 retarding its rotation, may be varied by varying the degree of energization of coil 418.

Journalled within the flyer 423 is the cord engaging and advancing roller member generally designated 421. Member 421 is, as shown, so positioned that its axis lies transverse to the axis of rotation of the flyer 423. The roller 421 is of such diameter and is so positioned that the longitudinal center of the inner side of its central cord engaging drum portion lies tangent to the axis of the flyer along which the material 448 proceeds after leaving such roller. Such cord, proceeding inwardly through the radial passage in the flyer, may be wrapped one or more times about the central drum portion of the roller 421, so as to have substantially non-slipping engagement therewith. As set out in application Serial No. 238,215, roller 421 carries gears on its outer flanges, such gears meshing with gears on the small interposed gear member 406. Centrally thereof such small gear member carries an hour glass worm gear which meshes with the worm 408 on the upper end of the small vertical shaft 404. Members 421 and 406 are made of such size, the aforementioned worm and worm gear are made of such hand, and the drum of roller member 421 is made of such size, that, when the flyer 423 rotates, and with the disc 420, and thus the shaft 404 and the worm 408, locked from rotation, material 448 will be drawn into the flyer at a speed at least slightly in excess of the speed required to maintain the balloon 435 at the desired medial diameter. Such driving of roller 421 results, of course, from the rotation of members 421 and 406 as a unit with the flyer 423 about the worm 408 and thus the driving of member 421 through the medium of the gears thereon meshing with the gears on the small interposed member 406 and also the worm and worm gear above described.

During operation of the doubles spindle 434 and of the three-spindle system shown, the wound field coil 418 is energized to a degree sufficient to retard the rotation of inductor disc 420 to a point at which the speed of rotation of shaft 404 and thus of worm 408 with respect to member 406 is such that the drum portion of member 421 has the proper peripheral speed to withdraw material 448 at the requisite speed from its balloon to maintain balloon 435 of constant diameter. The material leaving the positive cord withdrawing means 421 rises, as explained, through the central axial bore in the main shaft of the spindle 434, thence proceeding, over guide pulleys as shown, directly to the traverse mechanism generally shown, whereby it is laid on the bobbin. In such mechanism it is generally preferred to employ a compensating magnetic clutch drive between the main spindle shaft of the spindle and the bobbin, as shown in Agresti Patent No. 2,534,496, December 19, 1950, the bobbin being yieldingly rotated with a gradually increasing torque as the diameter of material upon the bobbin builds up, whereto to maintain a substantially constant winding tension upon the material as it enters upon the bobbin.

In this embodiment of the invention, the diameter of balloon 435 is maintained substantially constant by feeding the doubles strands 448 thereinto at a substantially constant speed by reason of their substantial non-slipping engagement with the driven gathering pulley 444, by withdrawing the material from the doubles balloon at a selectively variable rate by the mechanism above described, and by governing such rate of withdrawal by a tension-sensitive means engaging the doubled strands at a point between the constant speed gathering pulley and the guiding eye of the doubles balloon.

From the driven gathering pulley 444 the gathered strands 448 enter the ballon 435, being drawn into the flyer 423 by the driven cord engaging roller 421, as described. The speed of driving of roller 421 is under the control of the tension-sensitive means 446, which is shown in Fig. 1 engaging the run of doubled strands 448 above the eye 435' of the spindle 434.

The character of means 446 will be more readily apparent from a consideration of Figs. 2 and 3. As shown in Fig. 2, the doubled strands 448 proceed downwardly and 90° around the first fixed guide pulley 450, thence around the movable tension detecting pulley 454, back into engagement with the second fixed guide pulley 452, and then resume their travel into the balloon 435. The runs of material 448 approaching and leaving pulley 454 are designated 464. The movable, tension detecting, pulley 454 is mounted, as shown in Fig. 3, on the outer end of the first-class lever 456. Such lever is journalled for oscillation in a horizontal plane (Fig. 1) between the ears of the U-shaped bracket 460 mounted on the frame part 458. Deflection of roller 454 in such direction as to shorten runs 464 is opposed by the spring 462, the bottom end of which (as shown in Fig. 3) is attached to the forward end of the lever, the upper end, not shown, being attached to a fixed part of the machine frame.

It will be apparent that increased tension in run 448 of the doubled strands will result in travel of roller 454 in a direction to the left in Fig. 2 and downward in Fig. 3. It has been found that, within the desirable range of balloon size, tension in the portion of the strands above the balloon guiding eye of a downtwister decreases as the balloon diameter increases and that the tension thus measured increases as the balloon diameter decreases. Accordingly, the tension-sensitive means 446 is so connected as to cause the means for controlling the speed of roller 421 to withdraw material from the balloon at a greater rate when the tension measured by means 446 decreases, and to withdraw material from the balloon at a lesser rate when the tension as measured by means 446 increases. The means for controlling the speed of roller 421 therefore operates to vary the speed of withdrawal of the material from the balloon in inverse proportion to the deflection of the roller 454 of the tension-sensitive means, such deflection of the roller 454 being directly proportional to the tension in the material at the tension-sensitive means.

The means for accomplishing this result take the form of a brush 466 mounted in an insulating holder on the rear end of lever 456, such brush holder being provided with a flexible lead wire 468. Brush 466 slidingly cooperates with a curved linear resistor member 470 mounted, as shown, on the machine frame part 472 through the medium of the insulating brackets 474. A lead wire 476 is attached to the bottom of resistor 470, as the device is shown in Fig. 3. As a result of such construction, upon a decrease in diameter of balloon 435 roller 454 is increasingly deflected and the effective resistance between wires 468 and 470 increases, thereby resulting in decreased energization of means 418, since the effective length of the resistance 470 is in series with means 418, being positioned in line L_7. Thus, there then results a lesser speed of driving of roller 421 and a smaller rate of feeding of the material out of the balloon. Accordingly, the balloon is then restored to its medial diameter. Should, however, the balloon increase unduly in diameter, there will be less tension in the portion of the strands above the balloon guiding eye and thus the roller 454 will move to lengthen runs 464. Accordingly, less resistance will be inserted in the circuit feeding means 418 by resistance 470, the speed of feeding of roller 421 will be increased, and the material will be withdrawn from the balloon at a greater rate, thereby restoring the balloon to its medial diameter. Material feeding capstan 421, therefore, is governed by means 446 so that the speed at which the material is withdrawn from balloon 435 varies in inverse proportion to the response of tension-sensitive means 446. For the purpose of allowing initial adjustments of the device to attain such medial diameter of the balloon, there is inserted in the lead wire 468 between the source L_7 and resistance 470 the manually adjustable rheostat 478.

As pointed out above, the gathering pulley 444, driven

at constant speed and in synchronism with the speeds of rotation of the flyers of the respective spindles, effectively isolates tension conditions present in the singles balloons and in the spans leading to the gathering pulley, when sufficient wraps of the material are taken about the gathering pulley, from the system beyond the gathering pulley and in the doubling and twisting spindle area. Thus in the upper salient run 464 of the material at the tension-sensitive means, as shown in Fig. 2, no variables are introduced by the gathering pulley 444. Since the lower salient run 464 of the material at the tension-sensitive means is in immediate communication with the run of material 448 adjacent the balloon 435, the only significant variable imposed upon the tension-sensitive means is that of the tension in the material above the guiding eye of balloon 435. The thus measured tension, for each diameter of the balloon, bears a fixed determinable relationship to the tension in the balloon proper. Accordingly, the tension-sensitive means in the above described embodiment of the apparatus, measuring per se the tension and tension changes in the portion of the strands above the guiding eye of the doubles balloon, may be employed as a means of accurate control of the variable speed take-up means for withdrawing material from the bottom end of the balloon, thereby to control the size of the balloon.

The apparatus of the present invention is also characterized by the essential fact that the entity to be controlled, the doubles balloon, is interposed between the tension-sensitive means and the variable speed, material speed controlling means, in the first described embodiment such last named means being the take-up means. Thus a change in the action, that is, the speed of withdrawal of the material by the variable speed take-up means is felt or reflected at the tension-sensitive means only through the doubles balloon which is being controlled, and is thus felt or reflected only after the desired change in speed of driving of the take-up means has been effected. Consequently the described system is stable in operation and will accurately and effectively control the tension of the doubles balloon, and thus its size, to maintain them within narrow predetermined limits so that the three-spindle system, thus controlled, will operate for long periods of time free of operator attention.

The second embodiment of the apparatus shown in the drawings, that of Figs. 4–7, inclusive, is to some extent a reversal of that shown in Figs. 1, 2 and 3 and above described. In the apparatus of the second embodiment the material is withdrawn from the cabling and twisting balloon at a substantially constant rate by a take-up capstan, the material entering the balloon being variably retarded by a selectively operable adjustable retarding means. In this instance, the tension-sensitive means is mounted within the cabling and twisting spindle and between the inner end of the balloon and the constant speed take-up capstan, the response of such tension-sensitive means being transmitted outside the spindle by means of electric circuits including brushes, and slip rings on the flyer, whereby to govern the selectively adjustable retarding means at the entering end of the balloon.

In the three-spindle apparatus shown in Fig. 4, which generally resembles that shown in Fig. 1, the center, cabling and twisting spindle is designated 500, the two singles spindles feeding their twisted threads thereto being designated 502 and 504. The balloons of the singles spindles are designated, respectively, 506 and 508, the upper ends of such balloons being guided by the respective eyes 514 and 516. The twisted material or strands from such singles spindles, designated respectively 510 and 512, run upwardly as shown to be gathered at the idle gathering pulley 518, from which they travel downwardly, as the combined but as-yet-untwisted-upon-each-other, strands 520. After leaving the gathering pulley 518 the strands 520 proceed downwardly to be wrapped several times about the retarding drum 522 so as to preclude their slippage thereon. The retarding drum is mounted upon the horizontal shaft 524, which as shown, is journalled in the pillow blocks 526 mounted upon a frame part 528 of the machine.

Upon leaving the drum 522 the strands pass through the eye 530 of the spindle 500 and enter the balloon 532 thereof. The balloon 532 is created and maintained by the rotatable flyer 534, through the radial passage in which the material in the balloon enters at its bottom end, traveling inwardly to the center to rise in the straight axial path 536 within the spindle. Spindle 500 is mounted in a conventional manner upon the frame of the machine (not shown) by the supporting means 538. The flyer, the auxiliary take-up capstan to be described, and the bobbin rotating mechanism are driven through the medium of the pulley 540 affixed to the bottom end of the main shaft of the spindle, spindles 502 and 504 being similarly driven by means (not shown) at high speed in synchronism with spindle 500.

As in the first embodiment of the apparatus above described the cabling and twisting spindle 500 is provided with a rockably mounted support, here designated 542, and with a cage member, not shown, mounted on support 542 and enclosing the bobbin 546. A compensating magnetic clutch drive, generally designated 544, is interposed between the main spindle shaft of the spindle 500 and the bobbin. Such drive may be that shown in Agresti Patent No. 2,534,496, above referred to.

The above referred to cage of the spindle, supported on member 542, is provided with the top plate, rub ring supporting, structure 548 as shown in Fig. 4. To the top of plate 548 there is secured the supporting bracket having the main vertical portion 550, the horizontal top portion 552, the depending vertical portion 554, and as more clearly shown in Fig. 5, the inwardly directed parallel arms 570 and 572 secured to the bottom of portion 554. Such described bracket forms the upper bearing for the vertical shaft 556, to the top of which is secured the auxiliary take-up capstan 558. The shaft 556 and the capstan 558 carried thereby are driven in synchronism with the main shaft of the spindle 500 by means of a reducing belt drive between a hollow extension connected to the upper portion of the main spindle shaft and the bottom end of the shaft 556. The double twisted cord 536 in the straight axial run thereof within the spindle rises to pass through and cooperate with a tension-sensitive means, to be described, from which it passes to the capstan 558, first being wrapped several times around the bottom step thereof, being removed from such first step by the idle pulley 560, and being returned to the top step of the capstan, where it passes around it several times in non-slipping relationship. The cord leaves the capstan 558 passing over the two idle guiding pulleys 562 and 564 in that order to the vertically traversing cord laying mechanism generally indicated at 566, such mechanism laying the cord upon the rotating bobbin 546.

The tension-sensitive means and the reversing switch operated thereby are shown more specifically in Fig. 5, where they are designated generally by the reference character 568. As there shown, there is journalled on the left-hand end of arm 572 the idle cord guiding roll 574 and on the corresponding end of the arm 570 the similar roll 576. The cord 536 rises, as shown, passes partially around the roll 574, and is forced into the salient parallel runs 578 and 580 by the deflectable tensioning roller 582. The response of roller 582, which is spring pressed in a direction constantly to tend to lengthen runs 578 and 580, is employed as a measure of the tension of the material in balloon 532, and by connection with the tension imposing means, appropriately controls the retarding torque imposed upon the drum 522.

The deflectable tension-sensitive roller 582 is rotatably mounted on the lower end of the lever 584, which in turn is pivotally mounted on the arm 570 of the bracket by means of the pivot pin 586. A U-shaped yoke 588

straddles roller 582 and is connected to lever 584 at its lower end, as shown. To such yoke there is attached the tension coil spring 590, the right-hand end of which is attached to the left-hand end of the threaded rod 592 which extends through an opening in the portion 554 of the bracket. A wing nut 594 threadedly engages the outer end of the rod 592, whereby the tension in the direction to the right in Fig. 5 imposed upon the yoke 588 and thus upon the lower end of the lever 584 by the spring may be adjusted.

The upper end of the lever 584 carries contactor means cooperating with fixed contacts to form a sensitive reversing switch whereby the braking means may be controlled. It is obvious that with judicious selection of the respective lengths of the arms of the lever 584 on both sides of the pivot pin 586, the reversing switch, to be described, may be made responsive to minute variation in length of the salient runs 578 and 580 of the cord whose tension is to be measured, and thus to tension variations which are very small parts of the total tension to which the tension-sensitive means is subjected.

As set out above, with the apparatus of Figs. 1, 2, and 3 use is made of the fact that the tension in the material above the balloon guiding eye of a downtwister decreases as the balloon expands and increases as the balloon contracts. This is caused by the substantial sidewise force which the material in the balloon exerts upon the balloon guiding eye, such sidewise force increasing as the balloon diameter increases. Thus even though tension in the material in the balloon proper increases with increase in balloon diameter, the vertical component of such total tension, which is the tension in the material above the eye, decreases with increase in balloon diameter.

When the tension in the run 536 of the material within the spindle 500 and below take-up capstan 558 is measured, however, it is found that such tension increases with increase in diameter of the balloon 532 and that it decreases with decrease in diameter of such balloon. This is caused by the fact that, in feeding the material upwardly, capstan 558 must overcome the tension in the balloon proper and the frictional forces exerted on the material in both the radial run thereof through the passage in the flyer and the vertical run through the axial passage in the spindle. Such frictional forces, particularly in the outer portion of the radial run through the flyer, increase with increase in balloon diameter by reason of the increased wrap-around of the balloon with increase of balloon diameter and thus the increased force between the material and the outer end of the radial passage in the flyer in the direction which is opposite the instantaneous direction of rotation of such outer end of the radial passage. Thus the tension sensitive means and the switch operated thereby (Fig. 4) are so connected to the motor 620 by the circuit shown in Fig. 7 that upon deflection of the roller 582 to the left in Fig. 5 sufficiently to close the circuits through the switch, retarding means 624 acts to cause means 522 to feed the material into the balloon more slowly. When roller 582 travels to the right in Fig. 5 sufficiently to cause the contacts 606 and 608 to engage the opposite set of fixed contacts of the switch, means 624 will cause feeding means 522 to feed material into the balloon at a faster rate. Thus means 624 and 522 vary the speed of feeding of the material into the balloon in inverse proportion to the tension of the material at the tension sensitive means.

Fixedly mounted upon the portion 554 of the bracket member is the insulating panel member 596. Such panel member carries opposed sets of adjustable contacts 598, 600 and 602 and 604. The upper end of the lever 584 carries, as more clearly shown in Fig. 7, the two blade-like contactor members 606 and 608, such members being connected by the insulating block 610. Contactor 606 is connected to a source of low voltage direct current L_2 through the medium of a flexible lead wire, the manually adjustable rheostat 612 being interposed in such line. Contactor 608 is connected to the other side, L_1, of such current source. Contacts 600 and 602 are connected together, as shown, and are then connected to a common lead wire 614. Contacts 598 and 604 are similarly connected together and to a common lead wire 616. When the arm 584 swings clockwise sufficiently the circuit is completed through member 608 and contact 600 and through member 606 and contact 604 to cause the motor 620 to rotate in one direction. When the arm 584 swings counter-clockwise sufficiently the circuit is completed through member 608 and contact 598 and through member 606 and contact 602 to cause the motor 620 to rotate in the opposite direction. When lever arm 584 occupies the mid-position shown in Figs. 5 and 7 the circuit is broken and the motor 620 is at rest.

The wires L_1, L_2, 614, and 616, shown leading to the reversing switch in Fig. 5, are, in effect, continued outside the spindle through the medium of brushes and slip rings, shown in Fig. 4 and more fully to be described. The tension-sensitive means, the reversing switch operated thereby, and the means whereby the circuits are completed from the inside to the outside of the spindle make possible the control of the brake operating motor 620 which is located, as shown in Fig. 4, outside the balloon 532 and in proximity to the retarding drum 522.

The construction of the retarding means 624 and of the separately powered means 634 for applying such retarding means is shown more clearly in Fig. 6. As there shown, there is secured to the shaft 524 a brake drum 626. Pivoted to a portion 628 of the machine frame is a brake lever 630. Pivoted to such brake lever at a position above brake drum 626 is a brake shoe 632, the brake shoe being held against the brake drum by means of the mechanism 634, to be described, and by means of the weight 636 slidable along lever 630 and held thereon in adjusted position by thumb screw 638.

The mechanism 634, under the control of the tension-sensitive means and the reversing switch actuated thereby, shown at 568 and previously described, consists of the small motor 620 the drive shaft of which is connected by the medium of coupling 640 to the vertical rotatable worm 642 which is mounted to rotate in bearing providing support member 644. Threadedly engaged with the worm 642 is the nut 646, one side of which is slidably and non-rotatably engaged with a vertical guideway on the frame member 648 so that as the worm rotates the nut will rise and fall depending upon the direction of rotation of the worm. As shown, a spring seat providing member 650 is supported on the left-hand end of brake lever 630 by having a central projection thereon, such projection having a rounded bottom end received within a seat on the lever. A coil spring 652 is telescoped around the lower end of worm 642 and is positioned between the lower surface of nut 646 and the spring seat 650. The spring 652 is preferably so chosen that when the nut 646 lies substantially centrally in its range of vertical travel the spring will impose sufficient pressure upon the brake lever 630, taken with the force also imposed thereon by weight 636 when the latter is placed at a fixed predetermined location lengthwise of lever 630, to cause the retarding or braking means 634 to impose sufficient retardation upon the material entering the doubles balloon 532 to effect a balance in the system when the singles and doubles balloons have their preferred medial diameters. When the diameter of the doubles balloon increases, the motor 620, in response to the swinging of the upper end of the lever 584 to the right and thus the effecting of a circuit through means 600 and 608 and through means 604 and 606, will rotate to cause the worm 642 to lower the nut 646, thereby increasing the counter-clockwise retarding torque imposed by means 634 upon the brake lever 630. The doubles balloon will thereupon contract to its preferred medial diameter. Should, however, the doubles balloon contract unduly, the motor 620 will be impelled to rotate in a reverse direction by reason of the

swinging of the upper end of lever 584 to the left, whereby contact is effected between members 598 and 608 and between members 602 and 606. Under such conditions the nut 646 will be impelled upwardly, thus to impose a smaller counterclockwise torque upon brake lever 630 and to feed material into the balloon at a greater rate. When the doubles balloon is at the preferred medial diameter, and thus the material in such balloon is under the desired tension, the upper end of the lever 584 occupies the central position shown in Fig. 7, so that motor 620 remains at rest so as to hold nut 646 in its then correct position.

The motor 620 is preferably of the type energized by a low potential direct current source, the field being the stator and the rotor being of the fixed high permeability magnet type made, for example, of Alnico. Such motor requires low current feed, thereby minimizing contact difficulties at the reversing switch. Furthermore, because of the permanent magnet rotor, the problem of reversing the motor is a simple one. Because by far the greater part of the necessary retarding torque is contributed by weight 636, the motor 620 may be of the very small fractional horsepower type.

The circuits in the wires L_1, L_2, 614, and 616 are completed from the outside of the spindle to the inside thereof by means of the brush and slip ring means shown in Fig. 4. As there indicated, four brushes, spaced radially of the relatively fixed member 542 of the spindle 500 and supported thereon by appropriate insulating means, cooperate with the respective upper slip rings 654', 656', 658', and 660'. Such upper slip rings are supported in appropriate insulating channel members secured to the upper surface of the flyer 534. To the bottom of the flyer member, in locations confronting the upper slip rings, there are similarly secured similar slip rings 654, 656, 658, and 660, the upper and lower corresponding slip rings being connected together by insulated wires extending through the flyer. Brush members are provided on the fixed member 662 which is attached to the support 538. The lines L_1, L_2, and 614, 616 are then continued to the outer power source, and to the leads to the motor, respectively.

It will be understood that the present invention is not restricted in its broader aspects to the above two described embodiments thereof. Thus, for example, the tension-sensitive means and the reversing switch operated thereby may, instead of being mounted inside the spindle, be employed in a system such as that shown in Fig. 1 of the present application wherein the gathering pulley is positively driven and renders the speed of the cord entering the doubles balloon substantially constant. The alternative construction presently being described employs at the lower inner end of the balloon a variable speed means for taking up material from the balloon at a selectively variable rate governed by the tension-sensitive means. Such variable speed take-up means may be that shown in Fig. 1 of the present application, or it may be that shown in Figs. 1–3, inclusive, of my previous application Serial No. 238,215. In the alternative construction here being described the tension-sensitive means and the reversing switch operated thereby control a motor similar to motor 620 herein, such motor driving a worm having a traveling nut similar to the nut 646 thereon. Such nut carries a brush which cooperates with a linear resistor member, whereby the resistance interposed in the controlling circuit for either the variable speed driving means of Fig. 1 of the present application or for the variable speed auxiliary pulley driving means of Figs. 1, 2, and 3 of application Serial No. 238,215, is of such value at any instant as to maintain the speed of withdrawal of the cord from the balloon appropriate to maintain the balloon at substantially a constant diameter. Such described variable speed take-up means, under the control of the tension-sensitive means, acts to withdraw the material at a faster rate when the balloon expands unduly, and to withdraw the material at a slower rate when the balloon contracts unduly.

Whereas for purposes of illustration I have shown and described preferred embodiments of the apparatus for controlling the size of the cabling or take-up balloon in a system wherein a plurality of singles spindles feed into a take-up spindle, it is to be understood that such embodiments are illustrative only and that 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 controlling the balloon of an elongated flexible material balloon creating twisting spindle, comprising means at one end of the balloon for feeding material at an essentially constant rate, means at the other end of the balloon for feeding material in the same direction relative to the material at a selectively variable rate, means for detecting the tension in that zone of the flexible material located between the balloon and the first recited feeding means, and means responsive to the last named means operative upon the second recited material feeding means to vary its speed of feeding of the material.

2. Apparatus for controlling the balloon of an elongated flexible material balloon creating twisting spindle, comprising means at one end of the balloon for feeding material into the balloon, means at the other end of the balloon for feeding material out of the balloon, one of such above recited means feeding the material at an essentially constant rate, the other of such means feeding the material at a selectively variable rate, means for detecting the tension in that zone of the flexible material extending between the balloon and the essentially constant speed feeding means, and means responsive to the last named means operative upon the variable speed material feeding means to vary its speed of feeding of the material.

3. Apparatus for controlling the balloon of an elongated flexible material balloon creating twisting spindle, comprising means at one end of the balloon for feeding material into the balloon at an essentially constant rate, means at the other end of the balloon for feeding material out of the balloon at a selectively variable rate, means for detecting the tension in that zone of the flexible material extending between the balloon and the first recited feeding means, and means responsive to the last named means operative upon the second recited material feeding means to vary its speed of feeding of the material.

4. Apparatus for controlling the balloon of an elongated flexible material balloon creating twisting spindle, comprising means at one end of the balloon for feeding material into the balloon at a selectively variable rate, means at the other end of the balloon for feeding material out of the balloon at an essentially constant rate, means acting upon the length of the flexible material extending between the balloon and the second recited feeding means to determine the tension in such length of material, and means responsive to the last named means operative upon the first recited material feeding means to vary its speed of feeding of the material.

5. Apparatus for controlling the balloon of an elongated flexible material balloon creating twisting spindle, comprising means at one end of the balloon for feeding material at an essentially constant rate, means at the other end of the balloon for feeding material in the same direction relative to the material at a selectively variable rate, tension-sensitive means engaging the flexible material between the balloon and the first recited feeding means, and means responsive to the last named means operative upon the second recited material feeding means to vary its speed of feeding of the material.

6. Apparatus for controlling the balloon of an elongated flexible material balloon creating twisting spindle, comprising means at one end of the balloon for feeding material into the balloon, means at the other end of the balloon for feeding material out of the balloon, one of such above recited means feeding the material at an

essentially constant rate, the other of such means feeding the material at a selectively variable rate, tension-sensitive means engaging the flexible material between the balloon and the essentially constant speed feeding means, and means responsive to the last named means operative upon the variable speed material feeding means to vary its speed of feeding of the material.

7. Apparatus for controlling the balloon of an elongated flexible material balloon creating twisting spindle, comprising means at one end of the balloon for feeding material into the balloon at an essentially constant rate, means at the other end of the balloon for feeding material out of the balloon at a selectively variable rate, tension-sensitive means engaging the flexible material between the balloon and the first recited feeding means, and means responsive to the last named means operative upon the second recited material feeding means to vary its speed of feeding of the material.

8. Apparatus for controlling the balloon of an elongated flexible material balloon creating twisting spindle, comprising means at one end of the balloon for feeding material into the balloon at a selectively variable rate, means at the other end of the balloon for feeding material out of the balloon at an essentially constant rate, tension-sensitive means engaging the flexible material between the balloon and the second recited feeding means, and means responsive to the last named means operative upon the first recited material feeding means to vary its speed of feeding of the material.

9. Apparatus for controlling the balloon of an elongated flexible material twisting spindle of the downtwister type which creates and receives material from a balloon in free flight through the air, comprising a flyer, means for continuously feeding material into the balloon at an essentially constant rate, means for continuously withdrawing material from the balloon and thence in through the flyer, tension-sensitive means engaging the flexible material prior to its entry into the balloon, and means responsive to the last named means operative upon the means for withdrawing material from the balloon to vary the speed at which the material is withdrawn from the balloon.

10. Apparatus for controlling the balloon of an elongated flexible material twisting spindle of the downtwister type which creates and receives material from a balloon in free flight through the air, comprising a flyer, means for continuously feeding material into the balloon at an essentially constant rate, means for continuously withdrawing material from the balloon and thence in through the flyer, tension-sensitive means engaging the flexible material prior to its entry into the balloon, and control means responsive to the last named means for controlling the means for withdrawing the material from the balloon, said control means being so constructed and arranged that it varies the speed of withdrawal of the material from the balloon in inverse proportion to the tension of the material at the tension-sensitive means.

11. A balloon creating and maintaining spindle for twisting elongated flexible material which comprises a flyer, means for rotating the flyer, a balloon guiding eye located axially of and spaced from the flyer, means for continuously feeding material into the balloon, means for continuously withdrawing material from the balloon, one of such feeding means feeding the material at an essentially constant rate, the other of such feeding means feeding the material at a selectively variable rate, tension-sensitive means engaging the flexible material between the balloon and the essentially constant speed feeding mans, and means responsive to the last named means operative upon the selectively variable speed feeding means to vary its speed of feeding of the material.

12. A balloon creating and maintaining spindle for twisting elongated flexible material which comprises a flyer, means for rotating the flyer, a balloon guiding eye located axially of and spaced from the flyer, means for continuously feeding material into the balloon at an essentially constant rate, selectively variable speed means for continuously withdrawing material from the balloon and thence in through the flyer, tension-sensitive means engaging the flexible material prior to its entry into the balloon, and control means responsive to the last named means for controlling the means for withdrawing the material from the balloon, said control means being so constructed and arranged that it varies the speed of withdrawal of the material from the balloon in inverse proportion to the tension of the material at the tension-sensitive means.

13. A balloon creating and maintaining spindle for twisting elongated flexible material which comprises a flyer, means for rotating the flyer, a balloon guiding eye located axially of and spaced from the flyer, means for continuously feeding material into the balloon at a selectively variable rate, means for continuously withdrawing material from the balloon and thence in through the flyer at an essentially constant rate, tension-sensitive means engaging the flexible material between the balloon and the last named feeding means, and control means responsive to the last named means for controlling the means for feeding the material into the balloon, said last named means being so constructed and arranged that it varies the speed of feeding the material into the balloon in inverse proportion to the tension of the material at the tension-sensitive means.

14. A system for doubling a plurality of strands into a cord comprising a plurality of strand supplies, a multiple-twist type of take-up balloon creating twister for doubling the strands and collecting the cord, means mounted on the take-up twister for drawing the cord through the balloon of the take-up twister, means for driving the last named means at a selectively variable speed, a strand speed regulating device engaging the strands between the supplies and the take-up twister, said device comprising a member driven in synchronism with the take-up twister around which the strands pass and are discharged as a group, tension-sensitive means for engaging the strand group, means connected with the tension-sensitive means for controlling the speed of driving of the means for drawing the cord through the balloon of the take-up twister so that such speed varies in inverse proportion to the response of the tension-sensitive means to the tension in the group of strands between the strand speed regulating device and the take-up twister.

15. A system for doubling a plurality of strands into a cord comprising a plurality of strand singles supplies, a multiple-twist type of take-up balloon creating twister for doubling the strands and collecting the cord, means mounted on the take-up twister engaging the cord beyond the inner end of the balloon for drawing the cord through the balloon of the take-up twister at a substantially constant speed, means engaging the strands between the strand supplies and the outer end of the balloon at the doubling and cabling spindle for gathering the singles strands and for feeding them to the doubling and cabling spindle, said last named means including means to impose a selectively variable retarding tension on the strands, tension-sensitive means engaging the doubled and twisted strands at a location between the constant speed doubled strand withdrawing means and the inner end of the balloon, and means operated by and responsive to the last named means for controlling the means which imposes a selectively variable retarding tension on the strands entering the balloon of the spindle.

16. A system for the formation of cord comprising a plurality of singles twisters of the balloon creating uptwister type, a doubling and cabling spindle receiving the twisted elongated flexible strands from the singles twisters, said spindle being of the downtwister type receiving the doubled strands at the outer end of a balloon created and maintained by the spindle, means at the spindle for drawing in the doubled twisted strands from

the other, inner, end of the balloon at a substantially constant rate, means engaging the strands between the singles twisters and the doubling and cabling spindle for gathering the singles strands and for feeding them to the doubling and cabling spindle, said last named means including means to impose a selectively variable retarding tension on the strands, tension-sensitive means engaging the doubled and twisted strands at a location between the constant speed doubled strand withdrawing means and the inner end of the balloon, and means operated by and responsive to the last named means for controlling the means which imposes a selectively variable retarding tension on the strands entering the balloon of the spindle.

17. Apparatus for controlling a free-flying loop of elongated flexible material rotating about an axis comprising means at one end of the loop for feeding material at an essentially constant rate, means at the other end of the loop for feeding material in the same direction relative to the material at a selectively variable rate, tension-sensitive means engaging the flexible material between the loop and the first recited feeding means, and means responsive to the last named means operative upon the second recited material feeding means to vary its speed of feeding of the material.

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