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TWISTING SPINDLE BALLOON CONTROL

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2 Sheets-Sheet 1

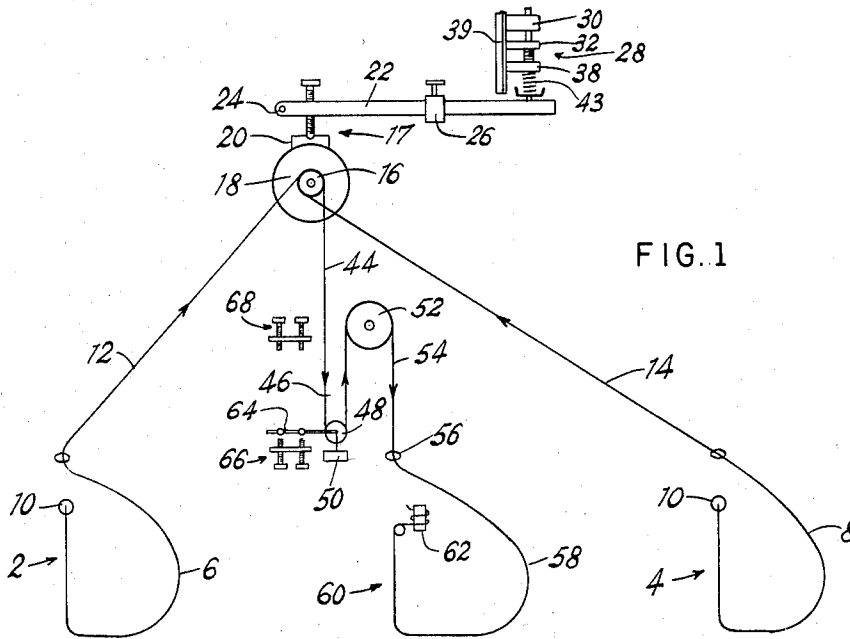


FIG. 1

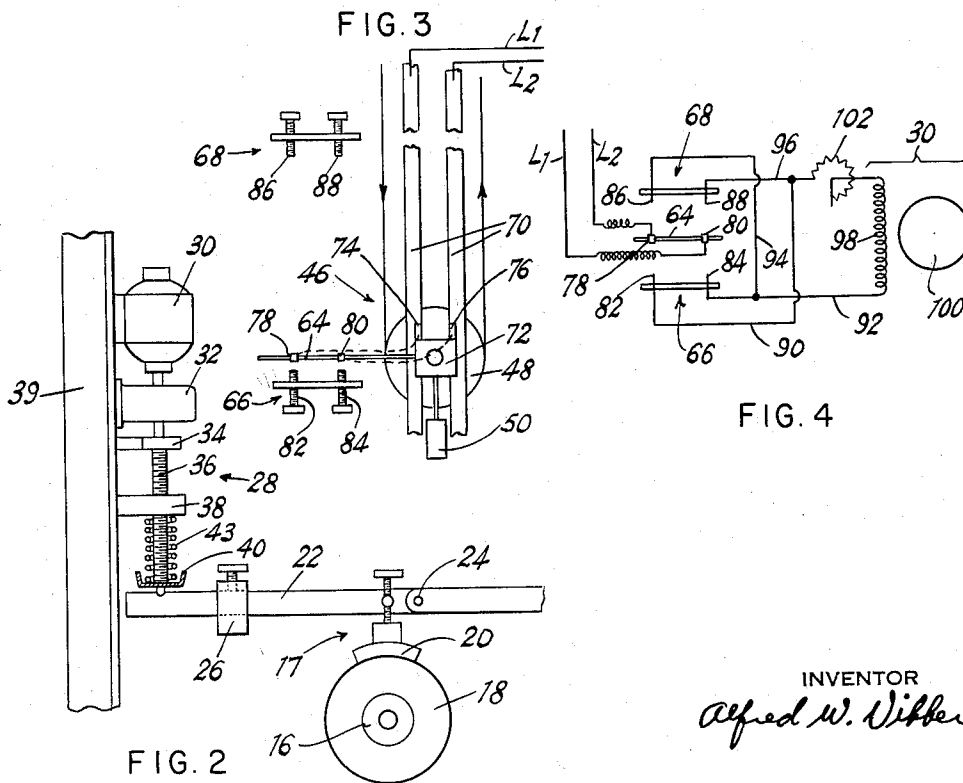


FIG. 3

FIG. 4

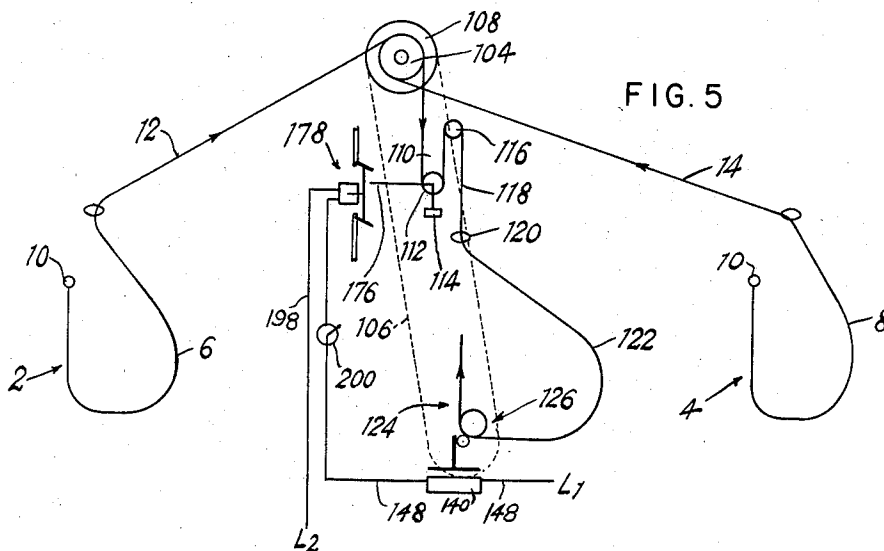
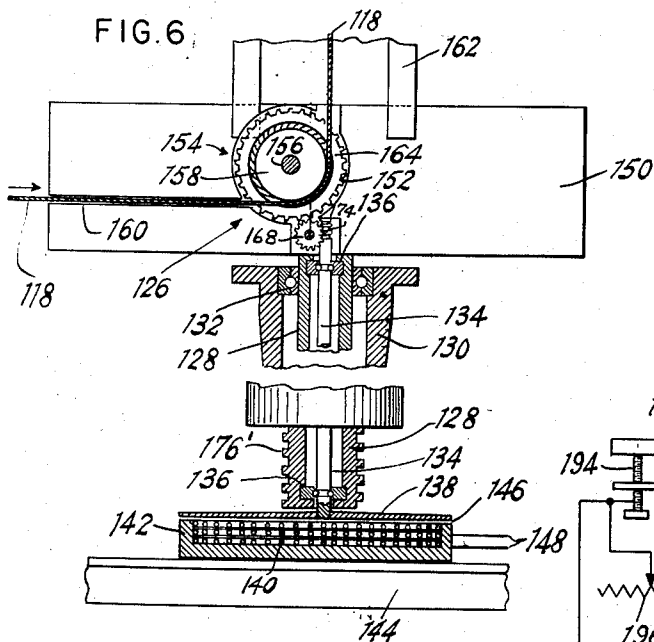
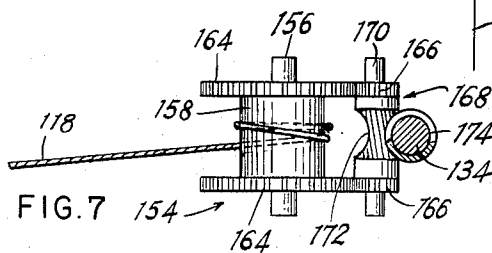
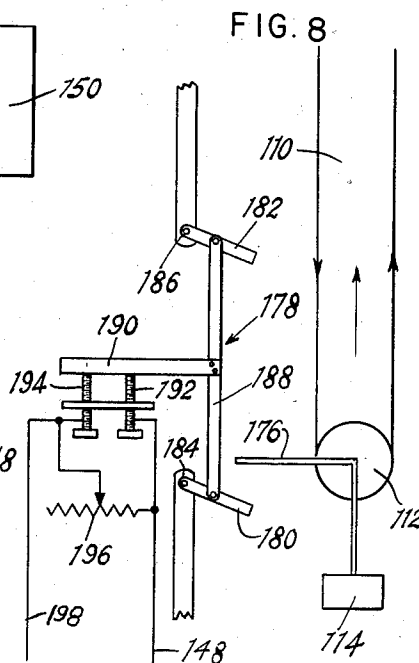
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2 Sheets-Sheet 2



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TWISTING SPINDLE BALLOON CONTROL

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19 Claims. (Cl. 57—58.55)

This invention relates to an improved twisting spindle and to the method of controlling the balloon of such spindle. Such spindle, in certain embodiments, may be employed as a singles twisting means of the supply type, which delivers the twisted material through a balloon at the spindle. In other embodiments the spindle may be employed as a downtwister, 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 drawing in elongated flexible material, such material proceeding from a source of supply into the spindle of the invention employed as a downtwister. 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 and twisting the separate strands fed thereto.

This application is a continuation-in-part of application Serial No. 238,215, filed July 24, 1951, now Patent No. 2,729,932, and of application Serial No. 274,401, filed March 1, 1952, now Patent No. 2,728,185, both bearing the same title.

In the twisting system wherein twisted strands are fed from a plurality of separate singles twisting spindles, are combined or doubled, and then fed into a further twisting means of the downtwister type, with which the present invention is illustrated, there has been employed a selectively braked gathering pulley from which the combined strands were fed directly to the doubles balloon. The tension in the material leading to the doubling and twisting means in such system is made up of the sum of the tensions of the balloons in the singles spindles plus the tension applied by the brake at the gathering pulley. In order to maintain the system in balance as to tensions, it has been proposed to control the brake at the gathering pulley by a tension-sensitive means engaging the combined but as-yet-untwisted-upon-each-other strands as they issue from the gathering pulley. Such apparatus has not been altogether satisfactory because of the fact that the tension-sensitive means has been rather insensitive to slight changes in tension in the material and also because of the instability of such control. The tension-sensitive means most commonly employed has been one which diverts the material from its straight run into a salient loop by means of a spring-biased pulley. It will be seen that such spring must, because it is acted upon by two run of material over the pulley, sustain at all times twice the weight or pull of the tension of the material in the doubles balloon. Consequently the small changes in the tension of the doubles balloon, which result in undue changes in the diameter of the balloon, represent but a small percentage of the total force which the spring is called upon to exert at all times. Thus the amount of travel which the pulley undergoes as a result of tension changes in the balloon are small and the measuring means and control incorporating such tension-

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sensitive means are inherently insensitive. Furthermore, the tension-sensitive means operates only when a tension change has taken place in the system, and thus inherently cannot maintain the balloon under constant tension.

It has also been proposed, in such multiple-spindle twisting system, to drive the gathering pulley in synchronism with the flyer of the gathering or doubles spindle and positively to drive the drawing-in capstan at the doubles spindle. The inevitable creep of the material on the gathering pulley and the capstan over the long period of operation necessary to fill a bobbin, during which time many miles of the material passes such means, makes it impossible to drive the gathering pulley and the capstan at fixed speeds relative to each other while maintaining between them a balloon of the desired diameter. Thus it has been proposed to control the speed of the material at the auxiliary capstan by causing such capstan to feed the material at selectively variable speeds in response to tension-sensitive means engaging the material and positioned near the capstan. Such device, like that discussed above, is insensitive, and thus fails to respond to small tension changes and to control the speed of material at the capstan accurately enough to insure the maintenance of the doubles balloon at the desired size. Furthermore, the device also inherently introduces tension changes into the system.

The present invention overcomes the problem of balloon size maintenance in both systems (a) in which the gathering pulley is braked as well as (b) that in which the gathering pulley is positively driven, by maintaining at all times a variable supply of material in tension-transmitting communication with the balloon being controlled, and by applying a predetermined substantially fixed tension on the portion of the material in the variable supply so that the balloon is subjected at all times to said predetermined substantially fixed tension. Variations in the length of material stored in said supply, shown specifically as a variable loop subjected to a freely hanging weight, are employed in the first disclosed embodiment selectively to vary the severity of application of the brake at the gathering pulley, and thus the speed of the gathering pulley relative to the drawing-in capstan, and in the second disclosed embodiment selectively to vary the material-forwarding speed of the drawing-in capstan relative to the driven gathering pulley. As a result of such variation in the relative speeds of feeding of the material toward and away from the balloon, material is ordinarily alternately first withdrawn from the balloon at a rate faster than it is fed into the variable supply, thus to decrease the variable supply and then the material is withdrawn from the balloon at a rate slower than it is fed into the variable supply, thus to increase the variable supply. In any event, whether or not such regular changes in the speeds of feeding of the material into and out of the balloon take place, the balloon is continually maintained under the said predetermined tension at all times with the apparatus of the invention.

The invention will be more readily understood by reference to the accompanying drawings forming a part of the specification.

In the drawings:

Fig. 1 is a diagrammatic view in side elevation of a twisting and doubling apparatus for forming cord from yarns, such apparatus employing a first preferred embodiment of the balloon control apparatus described as a means for controlling the diameter of the center, doubles balloon;

Fig. 2 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 adjustably apply said brake;

Fig. 3 is a fragmentary view in side elevation of the means for forming the loop in the material approaching the balloon and of the switch operated thereby;

Fig. 4 is a wiring diagram showing means whereby the motor in Fig. 2 is controlled by the variable loop forming apparatus of Fig. 3;

Fig. 5 is a diagrammatic view in side elevation of a second preferred embodiment of the three-spindle yarn twisting and doubling apparatus constructed generally along the lines of that shown in Fig. 1, the apparatus of Fig. 5, however, employing a positively driven gathering pulley and a driven drawing-in capstan which is selectively variable in speed in response to the length of the variable loop;

Fig. 6 is an enlarged view, partially in side elevation and partially in vertical axial section through the bottom of the central, cabling and twisting, spindle in the combination shown in Fig. 5;

Fig. 7 is a somewhat diagrammatic view in plan of the gearing driving the cord advancing roller 154, the worm, worm gear, and roller 154 being shown in plan in their connected driving relationship. In such view, for clarity of illustration of such driving relationship, the worm, worm gear, and roller are shown spread out laterally and projected on a horizontal plane;

Fig. 8 is a wiring diagram showing the means whereby the variable speed drawing-in capstan in the apparatus of Fig. 5 is controlled by the material storing loop of variable length.

The embodiment of the combination of apparatus, to which the mechanism of the invention is shown as being applied, is generally of the type shown and described in the patent to Uhlig No. 2,487,837, issued November 15, 1949. Such apparatus consists of three spindles, spindles 2 and 4 being of the two-for-one singles supply type, the yarn, which is subjected to tension devices 10 in each spindle being delivered therefrom in balloons 6 and 8, respectively, and being forwarded to combining, or doubling, and retarding tension imposing mechanism to be described, from which it is delivered as doubled cord 44 to the infedding end of balloon 58 of the central cabling and twisting spindle 60. Spindle 60 is likewise of the two-for-one twisting type, the combined threads receiving a first twist in their passage through the balloon 58 and a second twist in their upward travel vertically through the spindle. Upon emerging from the top of the spindle, the cord is engaged by the positively driven capstan 62 driven in synchronism with the central spindle 60 so as to supply the power to withdraw the cord from the balloon 58, to overcome the retarding tension of the tension-imposing means 10, and to withdraw the singles strands from their balloons 6 and 8. After leaving capstan 62 the cord is taken up by being wound upon a bobbin (not shown), being laid thereon by reciprocating traverse mechanism (not shown) conventional in the art.

It is with the control of the diameter of the balloon 58 of the system shown in Fig. 1 with which the present invention is concerned. Experience has shown that there is little, if any, difficulty in the control of the singles balloons when proper adjustment is made of the retarding tension imposing means at the top of each singles spindle. Difficulty has been experienced with control of the doubles balloon 58, wherein if the balloon is too tight, it rubs upon the upper rub ring (not shown) of the spindle to the consequent damage of the cord, and, if such balloon is too loose, it rubs upon the outer guard member if one is used, also to the damage of the cord. If no such guard is used, the balloon 58 very quickly becomes entangled with the balloons 6 and 8 of the singles spindles if it extends to overlap such balloons. The balloon control apparatus of the present invention is designed to hold the balloon 58 under constant tension, and thus to maintain its diameter within close limits, so that such balloon neither contacts the inner wear ring nor contacts the outer guard or housing member thereat.

In the embodiment of the apparatus shown in Fig. 1, the singles supply spindles 2 and 4 are driven at the same constant high speed and in the same direction by means of a belt (not shown) entrained over the drive pulley of a motor (not shown). The central cabling spindle 60 is driven in the opposite direction at a slightly slower but constant high speed by the same belt.

The twisted singles strands 12 and 14 proceed upwardly from the balloons of their respective spindles 2 and 4, and thence to the idle gathering pulley 16, from which the combined, generally parallel, but as yet untwisted-upon-each-other strands forming material 44 are led downwardly to the constant tension imposing means to be described and thence into the balloon 58 of the center, doubles spindle 60. The gathering pulley 16 is, in the embodiment shown, under the control of a retarding or braking means 17 shown more clearly in Fig. 2; the idle gathering pulley 16 and the braking means 17 therefor constitute a variable speed means for feeding the material into variable loop 46. The retarding or braking means 17 is designed to impose, once the machine has been placed in operation and adjusted, a controlled variable retarding torque upon the gathering pulley 16. Braking means 17 is designed to impose upon the gathering pulley 16, by a separately powered prime mover controlled by the variable loop 46, to be described, a first, smaller retarding torque when the loop has reached its minimum length, and to impose upon the gathering pulley 16 a second, larger retarding force when the loop has reached its maximum length, so that the gathering pulley 16 exerts upon the material 44 a force, varying within a narrow range, such that the material travels past the gathering pulley at speeds which are alternately slightly greater than and then slightly less than the speed of the material at the drawing-in capstan 62, which is driven at a constant speed. The loop 46, which is in direct, tension-transmitting relationship with the balloon 58, continually subjects such balloon to the same constant tension to which the material in the loop is subjected, as by a freely hanging weight. The sum of the tensions in the singles balloons plus the instantaneous retarding tension imposed by the brake substantially equals the tension in the doubles balloon but for the small amounts of unbalance deliberately introduced into the system by variation in the speed of rotation of the braked gathering pulley.

The construction of the regarding means 17 and of the separately powered means 28 for applying such retarding means is shown more clearly in Fig. 2. As there shown, there is secured to the shaft mounting the gathering pulley 16 a brake drum 18. Connected by pivot pin 24 to a portion of the machine frame, as shown, is a brake lever 22. A brake shoe 20 is held against the brake drum by a total force made up of that supplied by means of the mechanism 28, to be described, and that supplied by means of the weight 26 slidable along lever 22 and held thereon in adjusted position by a thumb screw, as shown.

The mechanism 28, under the control of the variable loop forming means to be described, consists of the small motor 30, the drive shaft of which is connected to the speed reducer 32, which in turn is connected to the vertical rotatable worm 36, mounted to rotate in bearing providing support member 34. Threadedly engaged with the worm 36 is the nut 38, one side of which is slidably and non-rotatably engaged with a vertical guideway on the frame member 39 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 40 is supported on the left-hand end of brake lever 22 by having a central projection thereon, such projection having a rounded bottom end, received within a seat on the lever. A coil spring 43 is telescoped around the lower end of worm 36 and is positioned between the lower surface of nut 38 and the spring seat 40. The

spring 43 is preferably so chosen that when the nut 38 lies substantially centrally in its range of vertical travel the spring will impose sufficient pressure upon the brake lever 22, taken with the force also imposed thereon by weight 26 when the latter is placed at a fixed predetermined location lengthwise of lever 22, to cause the retarding or braking means 17 to impose sufficient retardation upon the material 44 entering the doubles balloon to effect a balance in the system when the singles and doubles balloons have their preferred medial diameters.

The loop 46 in the material is formed immediately below the gathering pulley 16 by means of the freely vertically traveling pulley 48 which is pulled downwardly by the weight 50, which is selectively adjustable as by the addition of smaller weights thereto. The material 44 is fed into loop 46 by idle but braked gathering pulley 16, at a rate determined by the degree of braking applied to pulley 16 by braking means 17. When braking means 17 is applied with less force, that is, eased up on the brake drum 18, weight 50 causes material 44 to enter loop 46 at an increased rate past gathering pulley 16, the weight 50 thus then descending to lengthen variable supply loop 46. The material 44 rises from the pulley 48 over the fixed guide pulley 52, from which it travels downwardly through the eye 56 into the balloon 58 of the spindle 60. It will be apparent that the tension to which the material 44 in loop 46 is subjected by the combined weights of the pulley 48 and the weight 50 is transmitted directly to the material of the balloon 58. With a proper choice of the value of weight 50 the balloon 58 will be stable, under fixed conditions of flyer speed, yarn characteristics, and so forth, since the balloon 58, thus subjected to a constant suitable back tension, tends to seek and remain at a given diameter.

Connected to the pulley 48 is the horizontally extending switch arm 64, made of electrically insulating material, which travels therewith between its lower position, in which it engages the bottom contactor 66, to the top position, at which it cooperates with the top contactor 68, both such contactors being mounted on fixed portions on the frame on the machine (not shown). The guide pulley 48 has mounted on opposite ends of its shaft bearing chocks, one of which is shown at 72 in Fig. 3, such chocks travelling in guideways provided between two sets of two spaced parallel guide members 70, two of which are shown in Fig. 3. The weight 50 is of such shape as to slide freely in the space provided between such guide members 70. Preferably at least two of the members 70 are insulated from the machine frame and from each other so as to serve as bus bars, one side, L_1 , of a low tension current source being connected to one of such members 70 and the other side, L_2 , being connected to the other of such members. Connection between contacts 78 and 80, mounted upon the insulating switch arm 64, are effected through lead wires, shown in dotted lines, from such contacts to brush members 74 and 76 making connection with their respective members 70.

The contactor 66, which bears separate independently adjustable contacts 82 and 84, insulated from each other, and the contactor 68, which carries similar contacts 86 and 88, together with the switch arm 64 and the contacts 78 and 80 form parts of a reversing and controlling switch for the motor 30 of the brake means above described. The motor 30 is preferably 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. The rotor may be made, for example, of "Alnico," which is an alloy of aluminum, nickel, and cobalt, made and sold by the General Electric Company. 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 the weight 26, the motor 30 may

be of the very small fractional horse power type, and the spring 43 may be comparatively weak.

The motor 30 is connected to the current source L_1 , L_2 in the manner shown in Fig. 4. The circuit to the motor is such that when the switch arm 64 rises, with the shortening of the loop 46, so that the contacts 78 and 80, respectively, touch contacts 86 and 88, the field 98 of the motor 30 is energized through the thus described contacts and the wires 94 and 96 in such direction as to drive the motor to impel the nut 38 upwardly. The speed at which the motor rotates is adjustable through the manually adjustable rheostat 102 in the motor circuit. The amount of speed reduction afforded by means 32, and the speed with which the motor 30 is run are so chosen that when switch arm 64 cooperates with contactor 68 the motor 30 will have run sufficiently far, before the contact is broken by descent of pulley 48, for the material 44 to run past the gathering pulley 16 at a speed slightly in excess of the speed with which it is taken up at the drawing-in capstan 62. Such change of speed of material 44 at the gathering pulley 16 is relatively small, so that the speed at which the pulley 48 descends is relatively slow, thereby avoiding the imposition of mechanical shocks or material unbalances in the system due to marked acceleration or deceleration of masses.

When the pulley 48 has descended sufficiently for the contacts 78 and 80 on arm 64 to touch contacts 82 and 84, respectively, the motor 30 will again be started, this time in the reverse direction. The motor will, of course, remain rotating until the arm 64 is raised by the shortening of loop 46 to break the circuit through such contacts. During the time that the motor 30 remains running, with the arm 64 in its lower position, the nut 38 will have been lowered sufficiently by the motor to apply the brake shoe more forcibly to the brake drum 18. The material will thus be fed more slowly past the gathering pulley 16 so that the loop 46 will begin to shorten and pulley 48 will begin slowly to rise. Thereupon the contacts on switch arm 64 will move away from the contacts on means 66, thereby shutting off the motor. The loop 46 therefore will now continually shorten, since the material at this time will be running more slowly past the gathering pulley 16 than it will be drawn in from balloon 58 by the capstan 62. Such process of alternately first feeding the material into the loop at a rate slower than it is withdrawn therefrom by the capstan and then faster than such rate of withdrawal from the balloon therefore continues while the machine is in operation. All during such time the balloon 58 is subjected to the constant tension exerted thereon by the loop 46, the material in which is subjected to the constant gravity effect of the pulley 48 and the weight 50.

The above described manner of operation of the apparatus is that which will usually be carried out by it upon normal settings and adjustments of the parts. The apparatus will, however, continue to function to impose a constant tension on the balloon by maintaining a variable supply of material under constant tension and in tension-transmitting communication with the balloon even if occasionally the pulley 48 should not reach an end (first) point of its travel before again approaching the other (second) end point of its travel. In such case the switch arm 64 upon reaching the contactor at the second end point of travel will cooperate with the contactor at such point to cause the motor 30 to run so that the brake means 17 is adjusted to restore the system to a condition in which the pulley 48 once again has its full travel. In other words, the described pulley, switch arm, and contactors will function automatically to adjust the brake so that it imposes the proper higher and lower retarding torques to maintain the full travel of the pulley 48 in both directions. Thus the maintenance of the balloon under uniform tension at all times is assured.

The three-spindle system shown in Fig. 5 differs from

that described in connection with Fig. 1 in that the gathering pulley 104 is constantly driven at a speed synchronized with the speed of rotation of the center spindle 124. Parts of the singles spindles and strands delivered therefrom in Fig. 5 corresponding to those in Fig. 1 are designated by the same reference characters. The belt 106 entrained over the pulley 108 keyed to the shaft bearing gathering pulley 104 is driven in a manner conventional in the art and specifically described in application Serial No. 238,215. The twisted singles strands 12 and 14 are gathered at the pulley 104, being given a sufficient number of wraps around the pulley to have a substantially non-slipping engagement therewith, and are led downwardly to a loop 110 formed by the vertically travelling pulley 112 which has a selectively adjustable weight 114 attached thereto. The material rises from the loop over the fixed guide pulley 116 and descends as material 118 through the eye 120 and into the balloon 122 of the spindle 124. In this instance the speed at which the material is withdrawn from balloon 122 is under the control of the selectively variable speed draw-in means 126, specifically shown in Figs. 6 and 7. Means 126, in turn, is under the control of the loop 110 so that as the loop reaches a predetermined maximum length, means 126 is increased in speed and that as the loop reaches a predetermined minimum length, the means 126 is decreased in speed. As a result, the balloon 122 is continually subjected to the constant tension to which the loop 110 is subjected, such tension being substantially unaffected by the small variations in the relative speeds between the means 194 and 126.

Means 126, whereby the speed of withdrawal of the material from the balloon 122 may be varied, will be better understood by consideration of Figs. 6 and 7. As there shown, the main driving and supporting shaft 128 for spindle 124 is hollow, having an axial bore therethrough. Shaft 128 is mounted in a supporting member 130, member 130 being received in a portion of the machine frame, not shown. Shaft 128 is rotatably supported in supporting member 130 by bearings of which one is shown at 132. Supported within the bore in shaft 128 is the small axially located shaft 134, such shaft being journaled in shaft 128 through the medium of the bearings 136.

On the bottom of the small shaft 134 there is positioned the inductor disc 138 made of electrically conducting metal such as copper, aluminum, and the like. A wound field coil 140, positioned in shell 142, is supported on frame part 144 so as to lie parallel with the outer broad face of disc 138 with a small air gap 146 between them. The wound field coil 140 is selectively energized to varying degrees, by means to be explained, through the lead wires 148. The degree of attraction between inductor disc 138 and the wound field coil 140, and thus the force imposed upon shaft 134 retarding its rotation, may be varied by varying the degree of energization of coil 140.

Journalled within the flyer 150, in the recess 152 therein, is the cord engaging and advancing roller member generally designated 154. Member 154 is, as shown, so positioned that its axle 156 extends transverse to the axis of rotation of the flyer. The roller 154 is of such diameter and is so positioned that the longitudinal center of the inner side of its central cord engaging drum portion 158 lies tangent to the axis of the flyer, along which material 118 proceeds after leaving such roller. The cord 118, proceeding inwardly through the radial passage 160 in flyer 150, may be wrapped one or more times about such central portion 158 of the roller so as to have substantially non-slipping engagement therewith. As mentioned, the cord then leaves such portion 158 and travels upwardly through the bore in the enlarged portion 162 of the central shaft of the spindle, which in this instance is discontinuous, the flyer 150 being interposed

between the portions 128 and 162, both such parts 128 and 162 being fixedly connected to flyer 150.

Roller 154 is provided with end flanges, the outer portions of such flanges having gears 164 thereon. Gears 164 mesh with the gears 166 positioned on the ends of the intermediate gear member 168 which is also journaled in a recess in the flyer on axle 170, such axle being parallel to axle 156. Centrally of member 168 there is positioned the hour-glass worm gear 172 which meshes, as shown, with the small worm 174 fixedly attached to the top of the shaft 134. Shaft 134 is positioned coaxially of the flyer. Gears 172 and 174 are made of such hand, and gears 164, 166, 172, and 174, and drum 158 are made of such relative size, that, when the flyer 150 rotates with the disc 138, and thus the shaft 134 and the worm 174 are locked from rotation, material 118 will be drawn into the flyer at a speed at least slightly in excess of the speed required to maintain the balloon 122 at the desired medial diameter. Such driving of member 154 results, of course, from the rotation of members 154 and 168 as a unit with the flyer about the worm 174, and thus the driving of member 154 through the medium of the gears 174, 172, 166, and 164 from shaft 134, in that order.

During the preferred operation of the spindle, the wound field coil 140 is energized to a degree sufficient to retard the rotation of inductor disc 138 to a point at which the speed of rotation of shaft 134 and thus of worm 174 with respect to member 168 is such that the drum portion 158 of member 154 alternately has a peripheral speed such that it withdraws material from the balloon 122 at speeds which are first in excess of and then less than the speed at which the material 118 leaves the gathering pulley 104, which is driven at constant speed by the belt 106, driven by a pulley at the bottom of the spindle, not shown, such pulley in turn being driven by a worm gear, not shown, meshing with worm 176' on the spindle shaft 128.

Such energization of the inductor 140 is effected by the arm 176 secured to the pulley 112 which forms the variable loop 110. The arm 176, which rises and falls with the pulley 112, is employed to operate a switching mechanism 178 which alternately subjects inductor 140 to increased and then decreased energization. A pair of parallel dog members 180 and 182 are pivoted at 184 and 186, respectively, on parts of the machine frame. Such dog members are connected together by the vertical link member 188 to which is connected horizontal arm 190. The pivotal joints at 184 and 186 have enough friction to retain the dog, link, and switch arm (to be described) system in the position into which it is urged by arm 176. When the pulley 112 and thus the arm 176 rise so that the arm 176 pushes the top dog 182 upwardly, it also pulls the bottom dog 180 upwardly through the medium of link 188. Reverse operation of arm 176, that is, contact between such arm and the bottom dog 180 thrusts the dogs and link downwardly. The link 188, made of electrically insulating material, carries intermediate its length the horizontally extending electrically conducting switch arm 190 which extends across and selectively bridges the two adjustable contacts 192 and 194. Bridging contacts 192 and 194 is the manually adjustable resistance 196. It will be seen that when the switch arm 190 is retracted from the contacts 192 and 194 the resistance 196 is introduced into the feed circuit to the inductor 140, such feed circuit including the source L_2 , the wire 198, the manually adjustable rheostat 200, and the source L_1 .

We have seen above that when the inductor 140 is more highly energized, the material forwarding speed of the means 126 is increased, and that when means 140 is less highly energized, the material forwarding speed of means 126 is decreased. Accordingly, when the arm 176 trips the top dog 182 to remove the switch arm 190 from contacts 192 and 194, and to interpose resistance 196 in the circuit, the inductor 140 is less highly energized and

the material feeding speed of means 126 is decreased. The energization of means 140, and thus the speed at which means 126 forwards the material from the balloon, when the resistance 196 is by-passed by arm 190, may be adjusted by the rheostat 200. When resistance 196 is in the circuit to means 140 the material forwarding speed of means 126 is affected by the adjustment of both rheostat 200 and of resistance 196.

With the dogs 180 and 182 in the position shown in Fig. 8, the pulley 112 travels upwardly until the loop 110 has reached its minimum length. The tripping of dog 182 then causes the described decrease in speed of means 126 so that such means 126 withdraws material more slowly from the balloon than it is fed into the loop by the driven gathering pulley 104. Consequently the loop 110 is then replenished and continues to grow longer until the arm 176 trips the bottom dog 180. The bottom dog thereupon causes the switch arm 190 to descend, thereby by-passing the resistance 196 so that the inductor 140 is increasingly energized. The material forwarding speed of means 126 is then increased so that the loop 110 gradually decreases in size, since the material is now being withdrawn from balloon 122 at a rate faster than it is being fed into the loop 110 by the gathering pulley.

Suitable adjustment of the variable resistance 196 allows the choice of a selected degree of difference between the higher and the lower speeds at which the means 126 withdraws material from balloon 122, so that the frequency with which the loop 110 becomes filled and then depleted may be chosen. Ordinarily it is preferred, as with the embodiment of Fig. 1, that with this apparatus the variable loop shall become filled and depleted rather slowly, fast enough to insure the maintenance of a constant tension loop in tension-transmitting communication with the balloon but slowly enough to avoid the imposition of undue mechanical shocks to the system.

Whereas I have described preferred embodiments of the method of and apparatus for controlling the balloon of a twisting spindle, it will be understood that such embodiments are illustrative only. The invention is, therefore, to be defined by the scope of the claims appended hereto.

Thus, in the illustrative embodiments the tension is imposed on the variable supply of material by a freely hanging weight. In such embodiment the tension is virtually constant regardless of the length of the material in the variable supply. In the practice of the broad aspects of the invention, however, it is necessary only that the tension imposed on the variable supply and thus on the balloon remain substantially constant, that is, that it shall not vary beyond the range required to maintain the diameter of the balloon within a predetermined operative range. Accordingly means other than a weight may be employed to maintain the variable supply of material under the requisite substantially constant tension.

I claim as new the following:

1. The method of controlling the balloon of elongated flexible material at a twisting spindle having a balloon guiding eye which comprises advancing the material from a first feeding means toward the balloon, maintaining a variable supply of material outwardly of the eye in tension-transmitting communication with the balloon and between the first feeding means and the guiding eye for the balloon, applying a predetermined fixed tension on the portion of the material in the variable supply, withdrawing the material from the balloon by a second feeding means, and varying the relative speeds of feeding of the material toward and away from the balloon by varying the relative material advancing speeds of the first and second feeding means alternately first to withdraw the material from the balloon and thus from the variable supply at a rate faster than it is fed into the variable supply to decrease the variable supply by a predetermined amount and then to withdraw the material from the balloon and thus from the variable supply at a rate

slower than it is fed into the variable supply to increase the variable supply by a predetermined amount, so that the variable supply is continually maintained under the said predetermined fixed tension.

2. The method of controlling the balloon of elongated flexible material at a twisting spindle having a balloon guiding eye which comprises advancing the material from a first feeding means toward the balloon, maintaining a variable loop of material outwardly of the eye in tension-transmitting communication with the balloon, applying by a freely hanging weight a predetermined fixed tension on the portion of the material in the loop, withdrawing the material from the balloon by a second feeding means, and varying the relative speeds of the first and second material feeding means alternately first to withdraw the material from the balloon and thus from the variable loop at a rate faster than it is fed into the variable loop to decrease the variable loop by a predetermined amount and then to withdraw the material from the balloon and thus from the variable loop at a rate slower than it is fed into the variable loop to increase the variable loop by a predetermined amount, so that the loop is continually maintained under the said predetermined fixed tension.

3. The method of controlling the balloon of elongated flexible material at a twisting spindle which comprises advancing the material from a first feeding means toward the balloon, said first feeding means being of selectively variable speed, maintaining a variable supply of material in tension-transmitting communication with the balloon, applying a predetermined fixed tension on the portion of the material in the variable supply, withdrawing the material from the balloon by a second, fixed speed, feeding means, and varying the speed of the first material feeding means to alternately first withdraw the material from the balloon and thus from the variable supply at a rate faster than it is fed into the variable supply to decrease the variable supply by a predetermined amount and then to withdraw the material from the balloon and thus from the variable supply at a rate slower than it is fed into the variable supply to increase the variable supply by a predetermined amount, so that the balloon is continually maintained under the said predetermined fixed tension.

4. The method of controlling the balloon of elongated flexible material at a twisting spindle which comprises advancing the material from a first feeding means toward the balloon, said first feeding means being of selectively variable speed, maintaining a variable loop of material between the first feeding means and the balloon, said variable loop being in tension-transmitting communication with the balloon, applying by a freely hanging weight a predetermined fixed tension on the portion of the material in the loop, withdrawing the material from the balloon by a second, fixed speed, feeding means, and varying the speed of the first material feeding means to alternately first withdraw the material from the balloon and thus from the variable loop at a rate faster than it is fed into the variable loop to decrease the variable loop by a predetermined amount and then to withdraw the material from the balloon and thus from the variable loop at a rate slower than it is fed into the variable loop to increase the variable loop by a predetermined amount, so that the balloon is continually maintained under the said predetermined fixed tension.

5. The method of controlling the balloon of elongated flexible material at a twisting spindle which comprises advancing the material from a first feeding means toward the balloon, said first feeding means advancing the material with a fixed speed, forming a variable loop of material in tension-transmitting communication with the balloon, applying a predetermined fixed tension on the portion of the material in the loop, withdrawing the material from the balloon by a second, variable speed, feeding means, and varying the speed of said second material feeding means to alternately first withdraw the

material from the balloon and thus from the variable loop faster than it is fed into the variable loop to decrease the variable loop by a predetermined amount and then to withdraw the material from the balloon and thus from the variable loop at a rate slower than it is fed into the variable loop to increase the variable loop by a predetermined amount, so that the loop is continually maintained under the said predetermined fixed tension.

6. The method of controlling the balloon of elongated flexible material at a twisting spindle which comprises advancing the material from a first feeding means toward the balloon, said first feeding means advancing the material with a fixed speed, withdrawing the material from the balloon by a second, variable speed, feeding means, forming a variable loop of material as it travels between the first and second feeding means, the variable loop being in tension-transmitting communication with the balloon, applying by a freely hanging weight a predetermined fixed tension on the portion of the material in the loop, and varying the speed of said second material feeding means to alternately first withdraw the material from the balloon and thus from the variable loop faster than it is fed into the variable loop to decrease the length of the variable loop by a predetermined amount and then to withdraw the material from the balloon and thus from the variable loop at a rate slower than it is fed into the variable loop to increase the length of the variable loop by a predetermined amount, so that the loop is continually maintained under the said predetermined fixed tension.

7. Apparatus for twisting elongated flexible material which comprises a twisting spindle which creates and maintains a balloon thereat, said spindle having a balloon guiding eye, a first material feeding means for advancing the material toward the balloon of the spindle, means forming a variable supply of material outwardly of the eye in tension-transmitting communication with the balloon, means applying a predetermined substantially fixed tension on the portion of the material in the variable supply, and a second feeding means for withdrawing the material from the balloon.

8. Apparatus for twisting elongated flexible material which comprises a twisting spindle which creates and maintains a balloon thereat, said spindle having a balloon guiding eye, a first material feeding means for advancing the material toward the balloon of the spindle, a second feeding means for withdrawing the material from the balloon, means forming a variable loop of material in the material outwardly of the eye as the material travels between the first and second feeding means, said loop being in tension-transmitting communication with the balloon, and means applying a predetermined substantially fixed tension on the portion of the material in the variable loop.

9. Apparatus for twisting elongated flexible material which comprises a twisting spindle which creates and maintains a balloon thereat, said spindle having a balloon guiding eye, a first material feeding means for advancing the material toward the balloon of the spindle, means forming a variable supply of material outwardly of the balloon in tension-transmitting communication with the balloon, means applying a predetermined fixed tension on the portion of the material in the variable supply, a second feeding means for withdrawing the material from the balloon, and means responsive to variations in the length of material in the variable supply for varying the relative material advancing speeds of the first and second feeding means so as to maintain the length of material in the supply within predetermined limits.

10. Apparatus for twisting elongated flexible material which comprises a twisting spindle which creates and maintains a balloon thereat, said spindle having a balloon guiding eye, a first material feeding means for advancing the material toward the balloon of the spindle, a second

feeding means for withdrawing the material from the balloon, means forming a variable loop of material in the material outwardly of the eye as the material travels between the first and second feeding means, said loop being in tension-transmitting communication with the balloon, means applying a predetermined fixed tension on the portion of the material in the variable loop, and means responsive to the length of the variable loop for varying the relative material advancing speeds of the first and second feeding means so as to maintain the length of the loop within predetermined limits.

11. Apparatus for twisting elongated flexible material which comprises a twisting spindle which creates and maintains a balloon thereat, said spindle having a balloon guiding eye, a first material feeding means for advancing the material toward the balloon of the spindle, a second feeding means for withdrawing material from the balloon, means forming a variable loop of material in the material outwardly of the eye as the material travels between the first and second feeding means, said loop being in tension-transmitting communication with the balloon, said last named means including a freely hanging weight applying a predetermined fixed tension on the portion of the material in the variable loop, and means responsive to the length of the variable loop for varying the relative material advancing speeds of the first and second feeding means, such last named means being so constructed and arranged as to alternately first withdraw the material from the balloon and thus from the variable loop at a rate faster than it is fed into the variable loop to decrease the length of the variable loop by an amount in a predetermined range and then to withdraw the material from the balloon and thus from the variable loop at a rate slower than it is fed into the variable loop to increase the length of the variable loop by an amount in a predetermined range, so that the loop is continually maintained under the said predetermined fixed tension.

12. Apparatus for twisting elongated flexible material which comprises a twisting spindle which creates and maintains a balloon thereat, a first material feeding means for advancing the material at constant speed toward the balloon of the spindle, a second feeding means for withdrawing the material at a selectively variable rate from the balloon, means forming a variable supply of material in the material as it travels between the first and second feeding means, said supply being in tension-transmitting communication with the balloon, means applying a predetermined fixed tension on the portion of the material in the variable supply whereby the balloon is continually maintained under the said fixed tension, and means responsive to changes in the length of material in the variable supply for varying the material advancing speed of the second feeding means so as to maintain the length of material in the variable supply within predetermined limits.

13. Apparatus for twisting elongated flexible material which comprises a twisting spindle which creates and maintains a balloon thereat, a first material feeding means for advancing the material at constant speed toward the balloon of the spindle, a second feeding means for withdrawing material at a selectively variable rate from the balloon, means forming a variable loop of material in the material as it travels between the first and second feeding means, said loop being in tension-transmitting communication with the balloon, said last named means including a freely hanging weight applying a predetermined fixed tension on the portion of the material in the variable loop, and means responsive to changes in the length of the variable loop for varying the speed of the second material feeding means, such last named means being so constructed and arranged as to alternately first withdraw the material from the balloon and thus from the variable loop at a rate faster than it is fed into the variable loop to decrease the length of the variable loop by a predetermined amount and then to withdraw the material from the balloon and thus from the variable loop at a rate

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slower than it is fed into the variable loop to increase the length of the variable loop by a predetermined amount, so that the balloon is continually maintained under the said predetermined fixed tension.

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, strand speed regulating means acting upon the strands as they pass between the supplies and the take-up twister, said last named means being driven in synchronism with the take-up twister and engaging the strands substantially without slippage, means forming a variable supply of material in tension-transmitting communication with the balloon of the take-up twister, means applying a predetermined fixed tension on the portion of the material in the variable supply so that the balloon is continually maintained under the said fixed tension, and means responsive to variations in the length of material in the variable supply for varying the speed of driving of the means for drawing the cord through the balloon of the take-up twister.

15. A strand-forming machine comprising a plurality of singles twisters, means for doubling the strands issuing from the singles twisters into a plied strand, said singles twisters effecting a twisting operation in a first free-flying balloon, said doubling means effecting a twisting operation in a second free-flying balloon, means acting to counteract a difference between the tension of materials entering the second balloon and the sum of the tensions of materials leaving the first balloons, said last named means comprising means for imposing a predetermined retarding tension on the material at the entering end of the second balloon, means drawing the material into the balloon of the take-up twister at a constant speed, means forming a variable supply of material in tension-transmitting communication with the balloon of the take-up twister, means applying a predetermined fixed tension on the portion of the material in the variable supply so that the balloon is continually maintained under the said fixed tension, and means responsive to variations in the length of material in the variable supply to vary the retarding tension imposed on the material at the entering end of the second

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balloon to restore the balance of the first and second balloons.

16. Apparatus for twisting elongated flexible material which comprises a twisting spindle having rotatable means creating and maintaining a balloon of such material, and a guiding eye for the apex of the balloon spaced from said rotatable means, a first means for feeding the material into the balloon, a second means for feeding the material from the balloon, means positioned outside the balloon and between the eye and the respective feeding means for forming a supply of material of variable length in tension transmitting communication with the balloon, means applying a fixed tension on the material in the variable length supply over the entire range of length variation of the variable supply, the first and second feeding means operating to feed the strand at a substantially fixed speed ratio relative to each other over the intermediate part of the range of variation of the variable supply, and means operated by the variable length supply for varying the relative speeds of the first and second feeding means adjacent the ends of such range of variation so as to maintain the length of the variable supply of material within predetermined limits.

17. The apparatus defined in claim 16, wherein one of the feeding means is driven at constant speed and the other feeding means is variable in speed.

18. The apparatus defined in claim 17, wherein the variable supply of material is in the form of a salient path of material having two parallel runs, and comprising yieldable means forming the bight of the salient path.

19. The apparatus defined in claim 18, wherein the parallel runs of the material extend vertically, and the yieldable means is a freely hanging weight.

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