Re. 24662

Jan. 31, 1956 A. W. VIBBER 2,732,680

METHOD OF AND APPARATUS FOR PLYING STRANDS

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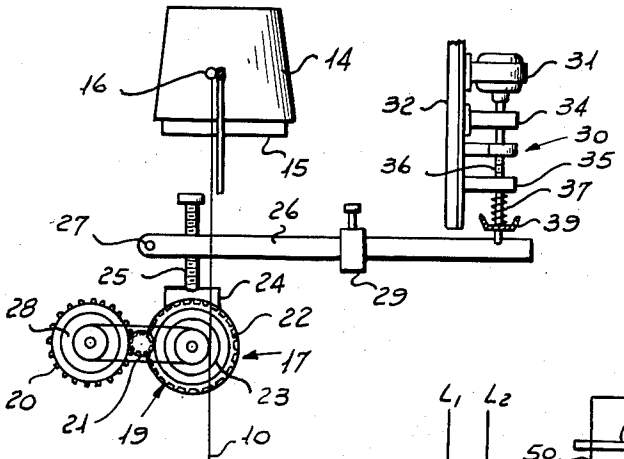
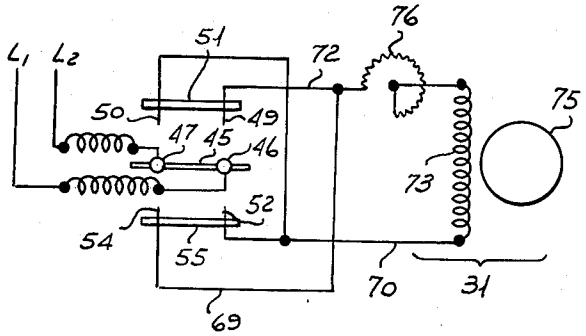
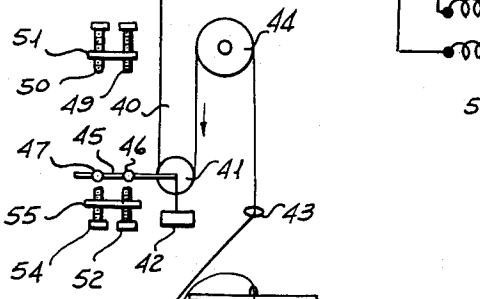


Fig 3





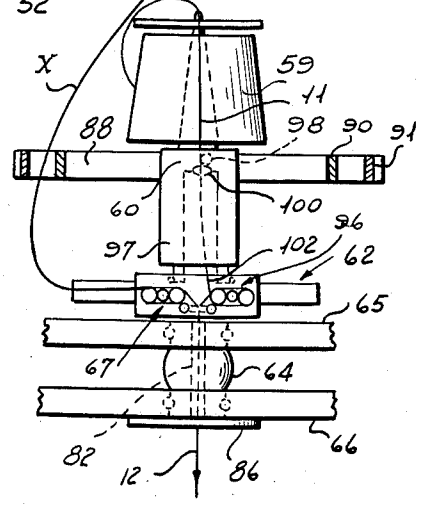


Fig 1

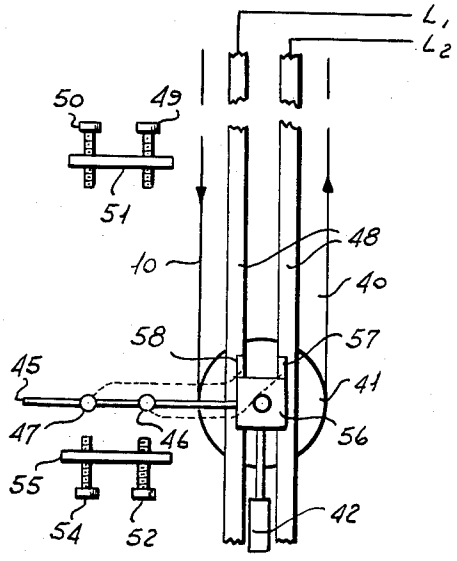


Fig 2

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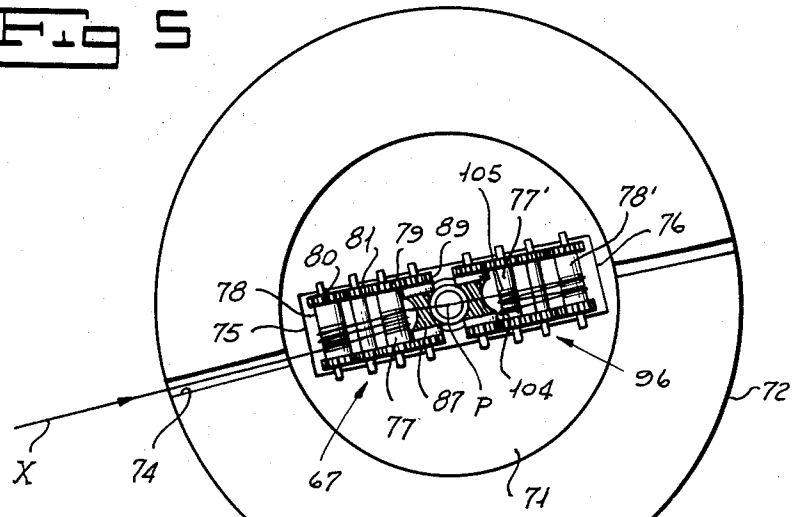
Alfred W. Vibber

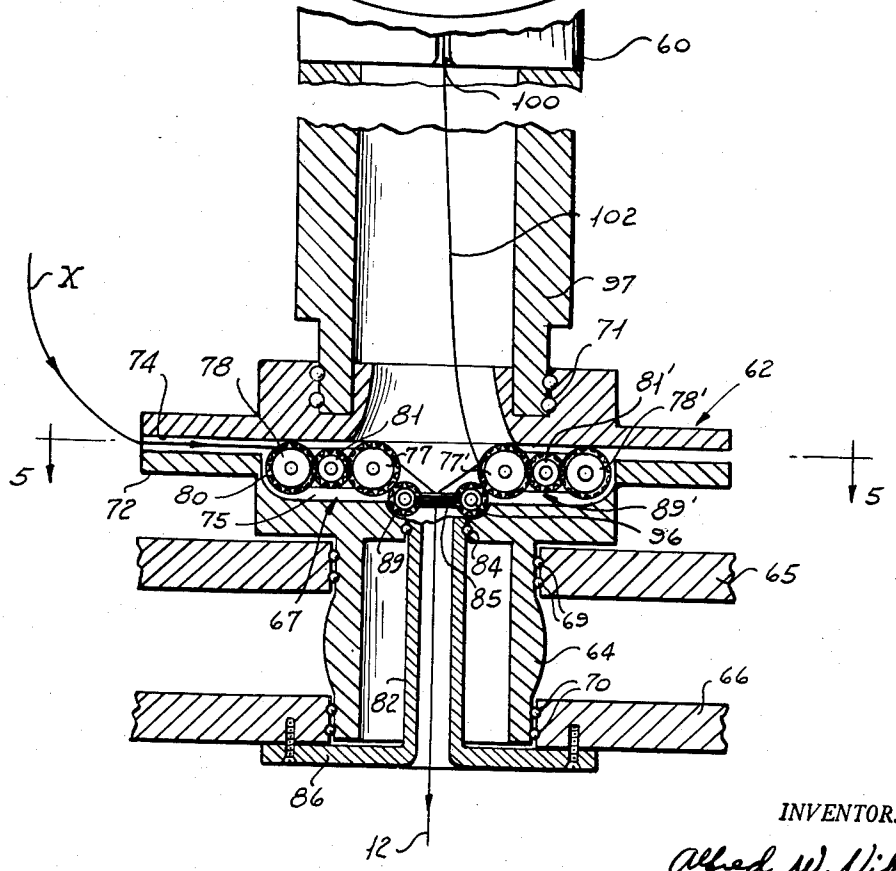
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Fig 5





INVENTOR.

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Fig 4

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Fig 6

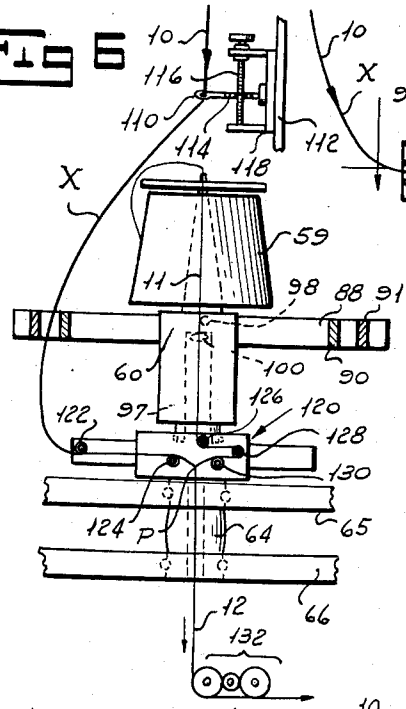


Fig 8

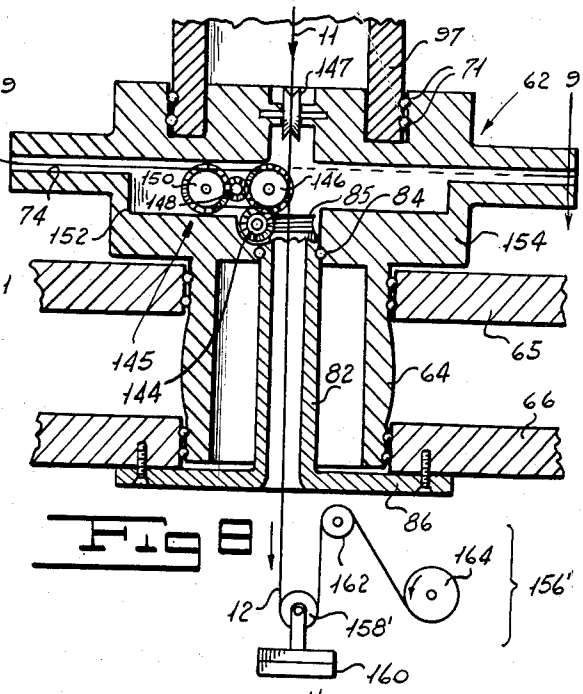
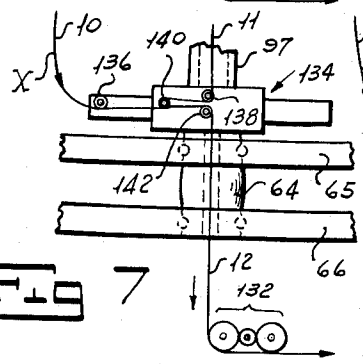


Fig 7



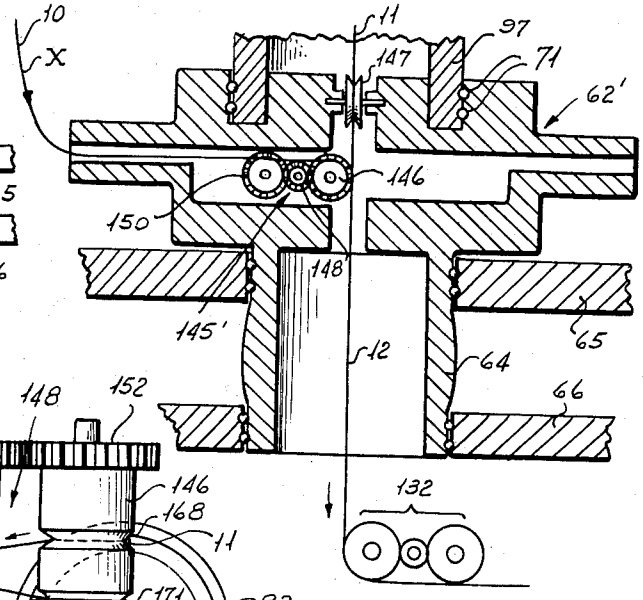


Fig 9

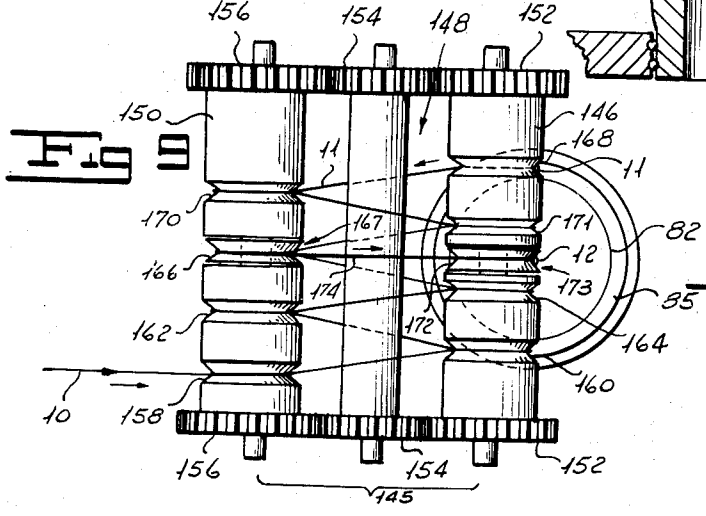


Fig 10

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United States Patent Office

2,732,680

Patented Jan. 31, 1956

2,732,680

METHOD OF AND APPARATUS FOR PLYING STRANDS

Alfred W. Vibber, Ridgewood, N. J.

Application March 12, 1953, Serial No. 341,865

24 Claims. (Cl. 57—58.3)

This invention relates to a method of and an apparatus for plying strands together to form cords. More particularly, the invention relates to the control of the speeds of feeding of the component strands to the point of plying them together, to the control of the attitude of the strands at such point with respect to each other and to the plied cord, and to the control of the tension condition of the strands as they approach the plying point, thereby producing a cord having optimum desired characteristics. The invention further relates to a plying device for carrying out the above method which will operate for long periods free from operator attention.

This application is a continuation-in-part of application Serial No. 333,242, filed January 26, 1953, bearing the same title. As does the said prior application, this application relates to a system such as that shown in the patent to Clarkson, No. 2,503,242. The present invention provides an apparatus and a method of plying two strands together to form a cord in generally the same manner as in the above Clarkson patent and as in my prior application.

The drawings depict several embodiments of the method and apparatus of the invention. In all such embodiments a two-ply cord is formed by creating and maintaining a first false twisting loop in a first strand leading from a source of supply such as a let-off package, by creating and maintaining a second false twisting loop in a second strand leading from a second let-off package, the axes of the two loops coinciding, rotating the first loop about the second source of supply, and by leading the two strands from their loops generally radially inwardly into contact with each other at at least the axis of rotation of the loop to ply the strands together. In all embodiments of the invention the attitude of the strands with respect to each other and with respect to the plied cord is controlled. In certain embodiments of the invention the strands meet for the first time on the axis of the loop creating flyer and approach such axis and each other symmetrically. In other embodiments the strands are combined in parallel relationship prior to reaching the axis of the flyer where they are plied together.

In accordance with the broader aspects of the invention, the strand conducting or feeding means in the flyer may be either idle or driven. When two strand feeding means are incorporated in the flyer, they may be placed opposite each other symmetrically with respect to the axis of the flyer. When such two strand feeding means are incorporated in the flyer, they may driven in synchronization with each other, if desired, in a simple, positive manner. In other embodiments of the invention there may be only one feeding means in the flyer, driven or idle if desired, the two strands entering such feeding means, usually at different points therein, and progressing therethrough, being combined therein in parallel relationship before emerging into the twisting zone on the axis of the flyer.

When the attitude of the strands with respect to each other and with respect to the plied cord is controlled in

accordance with one embodiment of the idle, strand feeding and attitude controlling, means of the present invention, the pull imposed upon the plied cord by the take-up means tends to even out the pull imposed on the two strands prior to their being twisted together, so that each sustains substantially one-half the pull of the take-up means. With such embodiment the plied cord will have substantially the same length of each strand therein, even though the feeding means below the package or source of each strand is permissive rather than positive in character.

The invention has among its objects the provision of an improved method of and an apparatus for plying together a plurality of strands to form a cord.

The invention has as a further object the provision of a method of and an apparatus for plying together strands wherein the speeds of feeding of the strands immediately adjacent the point of plying are positively synchronized by feeding means incorporated in the flyer and acting upon the respective strands.

A further object of the invention lies in the provision, in a cord-forming system wherein the strands are given no additional twist about their own axes but are merely plied together, of apparatus in which both strands are formed into false twisting loops, one such loop rotating about the source of the strand in the other loop, the two strands being led from their loops generally radially inwardly into contact with each other at at least the axis of rotation of the loops to ply them together. In certain embodiments of the invention the strands first meet at such axis. In other embodiments the strands are brought into parallel side-by-side relationship prior to their reaching the axis of the loops.

Yet another object of the invention resides in the provision, in the cord-forming system set out above, of positive feeding means for the two strands being plied, such feeding means being symmetrically located in the flyer of the twisting spindle, the two feeding means bringing each of the strands to the plying point at substantially the same angle with respect to the axis of the plied strand.

A still further object of the invention resides in the provision of an apparatus for and a method of plying together strands wherein each of the strands is treated in substantially the same manner, including its subjection to tension and its formation into a loop at the feeding means, whereby the resulting plied strand has its components in substantially the same condition and substantially symmetrically placed in the cord.

The above and further objects of the invention will be more readily apparent upon consideration of the drawings accompanying the specification, in which:

Fig. 1 is a somewhat diagrammatic over-all view in side elevation of the complete system of a first embodiment of the invention;

Fig. 2 is a fragmentary view in side elevation of details of the loop forming mechanism forming a part of the means for controlling the rate of feeding of the first strand into the balloon;

Fig. 3 is a wiring diagram for the motor controlling the speed of feeding of the first strand into the balloon;

Fig. 4 is an enlarged view generally in axial section of the flyer of the spindle in Fig. 1;

Fig. 5 is a view in horizontal section through the flyer of Fig. 4, the section being taken along the line 5—5 in Fig. 4;

Fig. 6 is a fragmentary, somewhat diagrammatic view in vertical axial section of a first modified system and flyer in accordance with the invention, the strand guiding means in the flyer being idle;

Fig. 7 is a fragmentary, somewhat diagrammatic view in vertical axial section of a second modified system and

flyer in accordance with the invention, the strand guiding means in the flyer being idle;

Fig. 8 is a fragmentary, somewhat diagrammatic view in vertical axial section of a third modified system and flyer in accordance with the invention, the single strand feeding means in the flyer engaging both strands and being driven;

Fig. 9 is a view in plan of the strand feeding capstans in the feeding means in the flyer of Fig. 8, the view being taken generally along the line 9—9 of Fig. 8; and

Fig. 10 is a view similar to Fig. 8 of a fourth modified system and flyer in accordance with the invention, the single strand feeding means in the flyer positively engaging both strands but being undriven except by the strands.

In the system shown in Fig. 1 two oppositely disposed positively driven strand feeding means are incorporated in the flyer. In such system the first strand, designated **10**, proceeds from the first let-off package **14** downwardly through tension control apparatus, to be described, into the balloon *x* created by the flyer **62**. The strand **10** is drawn in through the flyer by the first feeding mechanism **67** therein, to be described, and meets the second strand **11** fed from the second let-off package **59** and positively fed by the second feeding means **96** in the flyer at the point P on the axis of the flyer, the two strands being plied together so as to emerge as the plied strands or cord **12**. The cord **12** is taken up by a conventional take-up mechanism. Preferably one such as shown in Clarkson Patent No. 2,503,242, withdrawing the cord under constant tension, is employed.

Taking up now the instrumentalities which operate upon the strand **10** in succession, the first let-off package **14** is preferably rotatably mounted upon the support **15** so as to present strand **10** opposite the feed-off eye **16**. Strand **10** proceeds downwardly from the eye into the strand feeding capstan system generally designated **17**. Means **17** is made up of a first multi-grooved capstan **23** and a second multi-grooved capstan **28** spaced therefrom, the two capstans being positively geared together, so as to rotate at the same speed and in the same direction, by means of the gear **19** on capstan **23**, the gear **20** on capstan **28**, and the intermediate idle gear **21** meshing with gears **23** and **20**, all of such mechanism being carried on fixed framework (not shown). A brake drum **22** is provided on capstan **23** so as variably to retard the two capstans **23** and **28**. A brake shoe **24** is thrust against the brake drum **22** by means of the thrust pin **25** mounted on the brake lever **26**, such lever being pivotally mounted on a fixed part of the machine (not shown) by the pivot pin **27**. The primary braking effort is contributed by the collar shaped weight **29** slidable along lever **26** and positionable thereon by the set screw on top of the weight.

The brake means is variably energized by means of control mechanism, to be described, through the medium of the brake applying device **30**. Device **30**, mounted upon the frame part **32**, includes the small low voltage direct current motor **31** which drives a worm **36** through the speed reducing mechanism **34**. Mounted on the worm is the nut **35** which is non-rotatably guided so as to rise and fall as the motor is energized selectively to rotate in reverse directions. A compression coil spring **37** is disposed about the worm **36** below the nut **35**, the lower end of such spring fitting within the spring seat **39** which is supported in a seat on the top of the outer end of the lever **26**. The mechanism **30** is more fully described and shown in my application Serial No. 274,401.

In Fig. 1 the balloon *x* in the strand **10** is under the control of the mechanism which is the subject of the embodiment shown in Figs. 1–4, inclusive, of my application Serial No. 315,871. It is to be understood, however, that the variable speed mechanism for feeding the strand **10** into the balloon *x* may, if desired, be controlled by other devices for measuring the balloon diameter, the length of material in the balloon, or the tension in the material above the eye of the balloon which are the subjects of my prior pending applications including application Serial No. 238,215.

The mechanism shown forms a loop **40** in the strand **10** immediately below the capstan **23** by means of the freely vertically travelling pulley **41** which is pulled downwardly by the weight **42**, such weight being selectively adjustable as by the addition or subtraction of smaller weights (not shown) thereto or therefrom, respectively. The strand **10** rises from the pulley **41** over the fixed guide pulley **44**, from which it travels downwardly through the eye **43** into the balloon *x*. It will be apparent that the tension to which the material **10** in loop **40** is subjected by the combined weights of the pulley **41** and the weight **42** is transmitted directly to the material in the balloon *x*. With a proper choice of the value of weight **42** the balloon *x* will be stable under fixed conditions of flyer speeds, yarn characteristics, etc., since the balloon *x*, thus subjected to a constant suitable back tension, tends to seek and remain at a given diameter.

Connected to the pulley **41** is the horizontally extending switch arm **45**, made of electrically insulating material, which travels therewith between its lower position, in which it engages the bottom contactor **55**, to the top position, at which it cooperates with the top contactor **51**, both such contactors being mounted on fixed portions of the frame of the machine (not shown). The guide pulley **41** is mounted on opposite ends of its shaft in bearing chocks, of which one is shown at **56** in Fig. 2, such chocks travelling in guide ways provided between two sets of two spaced parallel guide members **48**, two of which are shown in Fig. 2. The weight **42** is of such shape as to slide freely in the space provided between such guide members **48**. Preferably at least two of the members **48** 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 direct current source being connected to one of such members **48** and the other side, L_2, being connected to the other of such members. Connection between the contacts **46** and **47**, mounted upon the insulating switch arm **45**, is effected through lead wires, shown in dotted lines in Fig. 2, from such contacts to brush members **57** and **58** making connection with their respective members **48**.

The contactor **51**, which bears separate independently adjustable contacts **49** and **50** insulated from each other, and the contactor **55**, which carries similar contacts **52** and **54**, together with the switch arm **45** and the contacts **46** and **47**, form parts of a reversing and controlling switch for the motor **31** of the brake means **30** above described. The motor **31** is preferably of the type energized by a low potential direct current source, the field **73** being the stator and the rotor **75** 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 the weight **29**, the motor **31** may be of the very small fractional horse power type, and the spring **37** may be comparatively weak.

The motor **31** is connected to the current source L_1, L_2 in the manner shown in Fig. 3. The circuit to the motor is such that when the switch arm **45** rises, with the shortening of the loop **40**, so that the contacts **46** and **47**, respectively, touch contacts **49** and **50**, the field **73** of the motor **31** is energized through the thus described contacts and the wires **72** and **71**, **70** in such direction as to drive the motor to impel the nut **35** upwardly. The speed at which the motor rotates is adjustable through the manually adjustable rheostat **76** in the motor circuit. The amount of speed reduction afforded by means **34**, and the speed with which the motor **31** is run are so chosen that when switch arm **45** cooperates with contactor **51** the motor **31** will have run sufficiently far, before the contact

is broken by descent of pulley **41**, for the material **10** to run past the capstan **23** at a speed slightly in excess of the speed with which it is taken up at the feeding means **67** in the flyer **62**. Such change of speed of material **10** at the feeding means **17** is relatively small; thus the speed at which the pulley **41** 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 **41** has descended sufficiently for the contacts **46** and **47** on arm **45** to touch contacts **52** and **54**, respectively, the motor **31** will again be started, this time in the reverse direction. The motor will, of course, remain rotating until the arm **45** is raised by the shortening of loop **40** to break the circuit through the contacts. During the time that the motor **31** remains running, with the arm **45** in its lower position, the nut **35** will have been lowered sufficiently by the motor to apply the brake shoe **24** more forcibly to the brake drum **22**. The material **10** will thus be fed more slowly past the capstan **23** so that the loop **40** will begin to shorten and pulley **41** will begin slowly to rise. Thereupon the contacts on switch arm **45** will move away from the contacts on means **55**, thereby shutting off the motor. The loop **40** therefore will now continually shorten, since the material at this time will be running more slowly past the capstan **23** than it will be drawn in from balloon *x* by the feeding means **67**. Such process of alternately first paying the material into the loop at a rate slower than it is withdrawn therefrom by the feeding means and then faster than such rate of withdrawal from the balloon continues while the machine is in operation.

The above described manner of operation of the apparatus is that which will usually be carried out by it upon normal settings and adjustment of the parts. The apparatus will, however, continue to function to impose a constant tension on the balloon *x* by maintaining a variable supply of material **10** under constant tension and in tension-transmitting communication with the balloon even if occasionally the pulley **41** 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 **45** upon reaching the contactor at the second end point of travel will cooperate with the contactor at such point to cause the motor **31** to run so that the brake means **30** is adjusted to restore the system to a condition in which the pulley **41** 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 higher and lower retarding torques on the strand being led into the balloon to maintain the pull travel of the pulley **41** in both directions. Thus the maintenance of the balloon under uniform tension at all times is assured.

The structure of the loop creating and maintaining means, and of the means **67** and **96** for withdrawing strand **10** from the balloon *x* and for withdrawing strand **11** from package **59**, respectively, will be more readily understood by a consideration of Figs. 4 and 5. The driving and supporting shaft **64** has the flyer **62**, in the nature of an enlarged head, thereon. Shaft **64** has its outer surface crowned to engage a driving belt (not shown) and is journalled in the bearings **69** and **70** in the upper and lower frame parts **65** and **66**, respectively. The head of the shaft, that is, the flyer **62**, has a central thickened hub portion **71** with an outer disc-like portion **72** affixed thereto. A generally radially disposed passage **74** extends through member **72** into the cavity **75** in hub **71**, the cavity **75** containing the first feeding means **67**. A similar cavity **76** on the diametrically opposite side of the hub contains the second feeding means **96**, the parts of which are similar to those of means **67** and are designated by the same reference characters as those employed with means **67** with an added prime.

The strand feeding means **67** is composed of an opposed spaced pair of multi-grooved capstans **77** and **78** journalled in the side walls of the cavity **75**, as more clearly indicated in Fig. 5. Such capstans have on the ends thereof the gears **79** and **80** which mesh with the gears on the interposed idler gear member **81**, so that the two capstans rotate in the same direction. The strand **10** is led in from the balloon *x* through the passage **74** and around the capstans **77** and **78** in the manner shown in Fig. 5, progressing from groove to groove of the opposed capstans so that it can finally be led off, in a radial direction, to the plying point P where it meets the strand **11** fed thereto from the second let-off package **59**. The capstans **77** and **78** derive their drive from rotation of the flyer **62**, at a speed fixedly synchronized therewith, by means of the worm **85** fixedly held in space coaxial of the flyer and the worm gear and pinion member **87** interposed between the worm and the gears in the train **79**, **81** and **80** connecting the capstans of the feeding means **67**. The worm **85** is positioned within the flyer and is made integral with the vertical tube **82** which is held from rotation by the flange **86** on the bottom thereof, such flange being attached to the frame member **66**. A ball bearing **84** is interposed between the bottom of the flyer and the top of the tube **82**. The central hourglass worm gear of member **87** meshes with the worm **85**, as shown more clearly in Fig. 5. Member **87** has the pinions **89** on the ends thereof meshing with the pinions **79** on capstan **77**. It will be apparent that when the pitch and hand of the worm **85** and the worm gear **87**, their relative diameters, and the relative diameters of the gears **89** and **79** are properly correlated the capstans **77** and **78** will be rotated in the proper direction and through a desired angle for each rotation of the flyer **62**, in other words, that the feeding means **67** will withdraw the material or strand **10** from the balloon *x* at the proper speed.

The two spaced capstans and the gear intermediate therebetween as well as the hourglass worm gear **87'** of the feeding means **96** are the same as those of previously described feeding means **67**. Means **96** withdraws strand **11** from the package **59** at the desired speed, usually the same speed as means **67**. Package **59** is held from rotation above the flyer on the axis thereof by the supporting member **60**, mounted on the tube **97** which is journalled in the bearing **99** in the top of the flyer **62**. Strand **11** is unwound from package **59**, and passes upwardly outside the guard ring shown above the package and then downwardly into an axial passage in the central tapered package support which forms an extension of member **60**. Member **60** is held from rotation by means of a horizontal spider member **88** attached thereto, as shown in Fig. 1, such spider member having on its periphery the annular magnet **90**. Surrounding the magnet **90** and spaced therefrom to provide an annular passage receiving balloon *x* is a larger annular magnet **91** held on fixed structure of the machine (not shown). Incorporated in the support **60** is the tensioning roller means, generally designated **98**, about which the strand **11**, in its travel downwardly into member **60**, is wrapped a sufficient number of times to provide non-slipping engagement therewith. Roller **98** may be retarded from rotation by means of an adjustably spring pressed brake shoe (not shown) attached thereto, as is conventional in the art.

Upon leaving the tensioning roller **98** the strand **11** runs downwardly through an opening in the bottom of the support **60** providing the guiding eye **100**. Strand **11** is brought to the capstan **77'** at a side groove **104** thereof, as more clearly shown in Fig. 5. As a result, upon rotation of the flyer **62** there is formed a small balloon **102** between eye **100** and groove **104** of capstan **77'**. The central top portion of the flyer **62** is cut away as shown in Fig. 4 so that the balloon **102** need not contact it nor the supporting tube **97**. The tension in balloon **102** is preferably made substantially the same as that in balloon *x*, by suitable adjustment of the means retarding rotation of tension

roll 98. Thus in the stranded cord 12 the two plies are in substantially the same physical condition, having been subjected to the same tension before, during, and after plying. Such adjustment of tension means 98 holds the balloon 102 in very tightly, because of the shortness of such balloon 102. Accordingly there is no difficulty in the control of balloon 102 during operation of the system.

The strand 11 at feeding means 96 is run successively from the outer groove 104 in capstan 77 back and forth between the grooves of such capstan and those in capstan 78 until it is finally presented to a central groove 105 in capstan 77'. The capstans 77 and 77' are at the same level transverse to the axis of the flyer, as shown in Fig. 4, and present their respective strands to the plying point P along diametrically opposed radii, as shown in Fig. 5. Thus not only do the feeding means 67 and 96, when made identical, insure the delivery of equal lengths of strands 10 and 11 to the plying point P, but they deliver them to such point with identical orientations relative to the axis of the spindle. Thus the resulting plied strand assumes substantially its final set at the plying point, there being no necessity for readjustment of the strands relative to each other upon their downward travel from the spindle.

It will be apparent cord 12 is one wherein the two components themselves have only the initial twist on their own axes which they had before treatment in the mechanism of the invention, the two strands being twisted about each other. Such cord is that which is particularly useful as the reinforcing means in automobile tires and V belts and the like. The lack of the modification of any twist in the singles components of the strands is caused by the fact that each strand undergoes a treatment wherein it is given a first twist in one direction and is then reversely twisted at the point P where the strands are plied together. Such similarity of treatment of the two strands before plying aids in the production of a symmetrical cord.

Thus the loop formed in strand 10, the balloon x being a part of such loop, subjects strand 10 to a first twist (1) in one direction in the balloon and to another twist (2) in the same amount but opposite in direction when strand 10 reaches the axis of the flyer after passing therethrough. The loop formed in strand 10 is therefore a false twisting loop. The same is true of the loop formed in strand 11, such latter loop rotating about the same axis as the loop in strand 10. Strand 11 is given a first twist (1) in balloon 102 in the same direction as twist (1) in strand 10, and is given a second twist (2) of the same amount but in the opposite direction as it comes in to the axis of the flyer after emerging from feeding means 96.

In Fig. 6 there is fragmentarily shown a cord-forming system wherein the enlargement 120 on the head of shaft 64, such enlargement forming a flyer, is provided with idle strand conducting means which forms a part of the rotating loop in strand 10, forms the rotating loop in strand 11, and conducts the strands to the plying point P. The parts of such system which are the same as those shown in Figs. 1–5, inclusive, are designated by the same reference characters. The strand 10 is fed from a source of supply such as a package through a balloon diameter regulating means (neither of these being shown in Fig. 6) such as that shown in Fig. 1. Strand 10 is guided by the upper balloon guiding eye 110 formed on the end of the vertically adjustable arm 114, whereby the height of the balloon x may be varied as desired. A U-shaped support 118 secured to the frame part 112 carries thereon the rotatable vertical worm 116 threadedly engaged with the arm 114. Suitable adjustment of eye 110, and the suitable addition or subtraction of small weights to the weight 42 on the pulley 41, if the means 17, 40, etc. of Fig. 1 for feeding strand 10 into balloon x is employed, will produce a stable balloon x having a predetermined inherent tension therein. The tension producing retarded roll 98 is suitably adjusted so as to impose a tension in the strand 11 as it is presented to the plying point P which is approximately equal to that in the strand 10 as presented to such point. Strand 10 is fed to the point P through a radially positioned passage in the flyer, there being an idle roll 122 at the end of the flyer and a roll 124 adjacent the point P. The strand 11 after passing roll 98 is fed downwardly to the idle roll 126 which engages it on the axis of the flyer. The strand 11 is then fed outwardly around the outer roll 128 and then inwardly over the idle pulley 130, which is positioned symmetrically to the pulley 124 as regards radial distance from point P and its height above point P. The two strands are thus symmetrically presented to the plying point P with symmetrical orientation to each other and to the plied strand. Further, since such strands are subjected to substantially the same tension in approaching such plying point, the resulting plied strand 12 is symmetrical. Such plied strand is taken up by the driven constant speed take-up capstan 132, which may have a structure similar to means 17 in Fig. 1 except that it is driven by a constant speed motor.

The false twist given the strand 10 in the balloon x is the same as that above discussed in connection with Fig. 1. The strand 11 is given a similar false twist by reason of its passage between roller 98 and roller 126, in which first passage it is given a first twist about its axis in one direction, and its passage from roll 130 to the plying point P, in which latter passage it is given a second twist about its axis in the reverse direction. The strand 11 may thus be said to pass through a false twisting loop, since the first twist therein, between means 98 and 126, occurs by reason of the rotation of the run of the strand between rollers 126 and 128 with respect to the roller 98, the second, reverse, twist taking place by reason of the rotation of the run of strand 11 between rollers 128 and 130 about the axis of the plied strand 12. In the embodiment of Figs. 1–5, inclusive, as well as those in Figs. 7–10, inclusive, to be described, both strands may also be said to pass through false twisting loops.

In Fig. 7 there is shown a fragment of a further embodiment of the cord-forming machine of the invention. In such machine, which is the same as that of Fig. 6 except for the substitution of the novel flyer 134, the strands 10 and 11 are plied about each other by being fed through the flyer to the axis thereof, the paths of feeding of the two strands in the flyer coinciding for a part of their runs inwardly to the axis, whereby the strands are combined into parallel relationship before reaching the axis and being plied together. The strand 10 emerges from the balloon x into the flyer under the idle roll 136 on the outer end thereof and over idle roll 142 which presents such strand at the axis of the flyer. The strand 11 travels downwardly along the axis of the flyer, around the upper idle roll 138 on the axis thereof and thence outwardly into a loop formed about the roll 140. The portion of the run of strand 11 from the bottom of the roll 140 to the top of roll 142 coincides with the radially inner portion of the path of travel of strand 10. The combined strands then travel downwardly from the idle roller 142, which rotates with the flyer about the axis of the latter, to the constant speed take-up capstan 132, the plying of the strands about each other to form the plied strand 12 taking place in the plying zone between roller 142 and take-up means 132.

In the embodiment of Fig. 7, as in that of Fig. 6, there is advantageously employed the balloon diameter control means for the strand 10 shown in Fig. 1, and the adjustable tension roll 98 shown in Fig. 6 for the strand 11. The tension in the two strands 10 and 11 approaching the roll 140 may thus be made substantially equal. The two strands 10 and 11 do not begin to twist appreciably about each other until they pass over the roll 142 into the downward run between it and means 132. The tension applied to plied strand 12 by means 132 is divided between the two strands 10 and 11, the two such strands, particularly in that portion in which they travel in combined relationship between the rolls 140 and 142 having an

opportunity to readjust their longitudinal positions with respect to each other before they pass into the zone of plying about each other. Thus the device of Fig. 7 is particularly advantageous in that it provides by simple apparatus a cord in which the components are substantially symmetrically plied and in which almost identically equal lengths of the two strands are present in a given length of the plied cord.

In Figs. 8 and 9 there is shown a further embodiment of the cord-forming device of the invention, such device employing a single driven strand feeding means, positively engaging both strands, such strand feeding means being incorporated in the flyer of the device and forwarding the strands to the zone of plying them together. The spindle, shaft, and flyer thereon in Figs. 8 and 9 are substantially the same as those of the embodiment of Figs. 1–5, inclusive, except that the second strand feeding means **96** is omitted therefrom. Consequently the same reference characters for the same parts are employed in Figs. 8 and 9 as those employed with Figs. 1–5, inclusive.

In this embodiment, the strand feeding means **145** has the first capstan **146**, the intermediate geared roller **148**, and the second grooved capstan **150** connected together as shown. The capstan **146** is so positioned that the roots of its grooves **160, 164, 172,** and **168** lie in a vertical plane through the axis of the shaft **64**. The capstans **146** and **150** are driven, as before, by a member **144** having a central hour-glass worm gear engaging the worm **85** on top of the fixed shaft **82** and pinions on the ends thereof meshing with the pinions **152** on the capstan member **146**. Pinions **152** in turn mesh with pinions **154** on member **148** which are meshed with pinions **156** on capstan **150**.

The strand **10** enters the feeding means **145**, as more clearly shown in Fig. 9, by passing through the substantially radial passage **74** in the flyer into contact with the groove **158** on capstan member **150**. Strand **10** then contacts in succession grooves **160, 162, 164,** and **166**, the first and third of such grooves being on member **146** and the second and fourth grooves being on member **150**. Groove **166** is located on the idle roller **167**, centrally mounted upon and freely rotatable with respect to member **150**. Strand **11** enters feeding means **145** by progressing downwardly partially around the idle guiding roll **147**, positioned to maintain the run of cord approaching it substantially axial of shaft **64**, and thence laterally into the groove **168** on the capstan member **146**. Strand **11** then travels successively into contact with groove **170** on member **150**, groove **171** on member **146**, then proceeding to the groove **166** on the idle center roller **167** on member **150**. The two strands **10** and **11** are thus first gathered into parallel relationship at the groove **160**, progressing to the right as shown in Fig. 9 in the run **174** to pass into groove **172** in the idle central pulley **173** mounted on member **146** so as to present plied strand **12** at the axis of the flyer.

As apparent from the above, the feeding means **145** is driven, as are the feeding means **67** and **96** in Fig. 1, at a fixed speed with relation to the flyer **62**. Each of strands **10** and **11** has sufficient frictional contact with the capstans **146** and **150** as to be substantially non-slipping with respect thereto. It is to be understood that a larger number of grooves on capstans **146** and **150** may be provided if necessary to provide a larger number of runs of the strands between them to attain such substantially non-slipping feed of the strands. Consequently, an almost identical length of each of the strands is presented at the idle pulley **167**. The run **174**, between the pulleys **166** and **173**, in which the two strands are in parallel, as-yet-untwisted-upon-each-other relation, while being subjected to the tension of the constant tension take-up **156** allows the two strands to readjust their longitudinal positions with respect to each other, so that when they pass over the pulley **173** into the vertical twisting zone between such pulley and take-up means **156** substantially equal lengths of the two strands are presented for plying about each other. The constant tension take-up means **156'**, shown schematically in Fig. 8, may be similar to that shown and described in the patent to Clarkson, No. 2,503,242. The plied strand **12** is subjected to the constant tensional force of the pulley **158'** acting on a loop thereof, augmented by the freely hanging adjustable weight **160**. The strand passes upwardly from the loop over the idle pulley **162** and downwardly to the take-up bobbin **164**.

The apparatus of Figs. 8 and 9 functions to produce a cord which is almost perfectly symmetrical, that is, in which the two strands are plied about each other in the same manner, and one in which substantially identical lengths of the two strands are present in the plied cord. These results follow from the fact that the positively driven feeding means **145** insures the presentation of almost identical lengths of the two strands to the strand combining run **174**, and that the two strands have an opportunity to readjust themselves longitudinally of each other so that each sustains its one-half of the total tension on the plied strand before they are fed into the plying zone.

The fifth embodiment of the cord-forming machine of the invention, shown in Fig. 10, employs a geared double capstan arrangement, generally designated **145'**. The parts of means **145'**, that is, the two capstans **146** and **150** and the intermediate gearing member **148**, are the same as those shown in Figs. 8 and 9. The feeding means differs from that shown in Figs. 8 and 9 only by the omission of the positive driving means for the feeding means. Consequently, tube **82**, worm **85**, and the hourglass worm containing member **144** are omitted in the structure of Fig. 10. Further, instead of employing a constant tension take-up means such as means **156**, the system of Fig. 10 employs a constant speed take-up capstan **132**.

Means **145'** is driven, in this embodiment, solely by the tension imposed on the plied strand **12** by means **132**, the plied strand in turn, through its components **10** and **11**, turning capstans **146** and **150**. The components **10** and **11** interchange energy between themselves at feeding means **145'** to equalize their rates of travel therepast. As before, the two components of the plied strand have an opportunity in run **174** to readjust themselves longitudinally with respect to each other before they are twisted upon each other. Further, because the strands **10** and **11** have substantially non-slipping engagement with capstans **146** and **150**, and because the two capstans are geared together, the delivery of almost identically equal lengths of strands **10** and **11** into the run **174** is insured.

Each of the described embodiments of the invention, whether it feeds the strands being plied into initial contact with each other at the axis of the plying shaft or flyer or combines the strands into parallel relationship prior to their being fed to the axis, is characterized by its accurate control of the attitude of the strands, with respect to each other and to the plied strand, before they are plied together. In those embodiments wherein the inner end of the outer loop or balloon is engaged by a positively driven feeding means, the size of the outer loop or balloon has no effect upon the plying action, since the tension in the balloon is isolated from that of the strand issuing from such balloon at the plying point or zone. The embodiment wherein the two strands are positively equalized, whether by one or two driven feeding means synchronized with the flyer or by an idle feeding means which interchanges energy between the strands, as in Fig. 10, are particularly advantageous because of the accuracy of the cord which they produce. With all the systems disclosed, however, the unavoidable minute differences in length of the two strands presented to the plying point or zone are continually uniformly absorbed in the plied product, so that such differences are not accumulated in any portion of either strand leading to the plying point or zone. The operation of plying devices

in accordance with the invention is, therefore, particularly free from the need of fine adjustment of the components or of frequent operator attention.

Whereas for purposes of illustration I have shown and described preferred embodiments of the method of and apparatus for plying strands together of my invention, it is to be understood that such embodiments are illustrative only and that the invention is to be defined by the scope of the claims appended hereto.

I claim as new the following:

1. The method of twisting together two strands so as to form a two-ply strand which comprises feeding a first strand from a first source of supply into a first false twisting loop, feeding a second strand from a second source of supply into a second false twisting loop, rotating the second loop in one direction in an orbit about an axis from which the second loop extends generally radially, rotating the first loop in an orbit at the same angular speed and in the same direction as the second loop about the axis of rotation of the second loop, about the orbit of the second loop, and about the second source of supply, and feeding both strands in generally radial runs from substantially diametrically opposite directions at positively equalized rates and in substantially the same plane transverse to the axis of rotation of the loops from their respective loops into initial contact with each other at a point of plying on the axis of rotation of the loops, the rotation of the loops serving to twist the strands about each other.

2. The method of twisting together two strands so as to form a two-ply strand which comprises feeding a first strand from a first source of supply into a first false twisting loop, feeding a second strand from a second source of supply into a second false twisting loop, rotating the second loop in one direction in an orbit about an axis from which the second loop extends generally radially, rotating the first loop in an orbit at the same angular speed and in the same direction as the second loop about the axis of rotation of the second loop, about the orbit of the second loop, and about the second source of supply, and positively feeding both strands at the same speed in generally radial runs from substantially diametrically opposite directions and in substantially the same plane transverse to the axis of rotation of the loops from their respective loops into initial contact with each other at a point of plying on the axis of rotation of the loops, the rotation of the loops serving to twist the strands about each other.

3. The method of twisting together two strands to form a two-ply cord which comprises creating and maintaining a first rotating loop in a first strand leading from a source of supply, creating and maintaining a second rotating loop in a second strand leading from a second source of supply, the axes of the two loops coinciding, the first loop rotating about the second source of supply, and leading the two strands from their loops generally radially inwardly toward the axis of rotation of the loops, bringing the strands into close parallel relationship generally radially of the flyer at a zone outwardly of such axis, positively equalizing the rates of travel of the strands, leading the thus gathered strands at equal rates of travel to the axis, and plying the strands together by rotation of the loops.

4. The method of twisting together two strands to form a two-ply cord which comprises creating and maintaining a first rotating loop in a first strand leading from a first source of supply, creating and maintaining a second rotating loop in a second strand leading from a second source of supply, the axes of the two loops coinciding, the first loop rotating about the second source of supply, and leading the two strands from their loops generally radially inwardly toward the axis of rotation of the loops, bringing the strands into close parallel relationship generally radially of the flyer at a zone outwardly of such axis, positively forwarding the thus combined strands, each at the same rate of travel, to the axis, and plying the strands together by rotation of the loops.

5. The method of twisting together two strands to form a two-ply cord which comprises creating and maintaining a first rotating radially extending loop in a first strand leading from a first let-off package, creating and maintaining a balloon in a second strand leading from a second let-off package, the axes of the loop and balloon coinciding, the balloon rotating about the second let-off package, and leading the two strands from the loop and balloon, respectively, generally radially inwardly toward their axis of rotation, bringing the strands into close parallel relationship generally radially of the flyer at a zone outwardly of such axis, leading the thus gathered strands of the axis, equalizing the rates of travel of the strands toward the axis, and plying the strands together by rotation of the loops.

6. The method of twisting together two strands to form a two-ply cord which comprises creating and maintaining a first rotating loop in a first strand leading from a first let-off package, creating and maintaining a second rotating loop in a second strand leading from a second let-off package, the axes of the two loops coinciding, the first loop rotating about the second let-off package, and leading the two strands from their loops in runs extending generally radially inwardly toward the axis of rotation of the loops, bringing the strands into close parallel relationship generally radially of the flyer at a zone outwardly of such axis, leading the thus gathered strands to the axis, equalizing the rates of travel of the two strands toward the axis by positively feeding at its radial run each of the strands to forward the strands at the same rate to a point of plying on the axes of the loops, and plying the strands together by rotation of the loops.

7. Mechanism for twisting together two strands so as to form a two-ply strand, comprising a source of a first strand and a support carrying a let-off package for a second strand, a revolving shaft operable to rotate a first loop, of the first strand, about the package, to rotate a second loop, of the strand of the package, about the axis of the first loop, and also to ply the two strands together, a first means mounted on the shaft for guiding the first strand from the first loop, and a second means mounted on the shaft for guiding the second strand from the package, said last named guiding means forming a loop in the second strand extending generally radially of the axis of rotation of the shaft, said first and second guiding means leading the strands from their respective loops in angularly spaced directions substantially radial of the shaft to the junction where they initially contact each other and are plied together.

8. Mechanism for twisting together two strands so as to form a two-ply strand, comprising a source of a first strand and a support carrying a let-off package for a second strand, a revolving shaft operable to rotate a first loop, of the first strand, about the package, to rotate a second loop, of the strand of the package, about the axis of the first loop, and also to ply the two strands together, a first means mounted on the shaft for guiding the first strand from the first loop, and a second means mounted on the shaft for guiding the second strand from the package, said last named guiding means forming a loop in the second strand extending generally radially of the axis of rotation of the shaft, said first and second guiding means leading the strands from their respective loops in directions generally radial of the shaft from generally diametrically opposite directions into initial contact at the junction where they are plied together.

9. Mechanism for twisting together two strands so as to form a two-ply strand, comprising a source of a first strand and a support carrying a let-off package for a second strand, a revolving shaft operable to rotate a first loop, of the first strand, about the package, to rotate a second loop, of the strand of the package, about the axis of the first loop, and also to ply the two strands to-

gether, a first means mounted on the shaft for positively feeding the first strand from the first loop, and a second means mounted on the shaft for positively feeding the second strand from the package, said last named feeding means forming a loop in the second strand extending generally radially of the axis of rotation of the shaft, said first and second feeding means leading the strands from their respective loops in angularly spaced directions substantially radial of the shaft to the junction where they are plied together.

10. Mechanism for twisting together two strands so as to form a two-ply strand, comprising a source of a first strand and a support carrying a let-off package for a second strand, a revolving flyer operable to rotate a first loop, of the first strand, about the package, to rotate a second loop, of the strand of the package, about the axis of the first loop, and also to ply the two strands together, a first feeding means driven at a speed synchronized with the speed of rotation of the flyer, said first feeding means being mounted on the flyer and positively feeding the first strand from the first loop, and a second feeding means driven at the same speed as the first feeding means, said second feeding means mounted on the flyer and positively feeding the second strand from the package, said last named feeding means forming a loop in the second strand extending generally radially of the axis of rotation of the flyer, said first and second feeding means leading the strands from their respective loops in angularly spaced directions substantially radial of the flyer to the junction where they are plied together.

11. Mechanism for twisting together two strands so as to form a two-ply strand, comprising a source of a first strand and a support carrying a let-off package for a second strand, a revolving flyer operable to rotate a first loop, of the first strand, about the package, to rotate a second loop, of the strand of the package, about the axis of the first loop, and also to ply the two strands together, a first means mounted on the flyer for positively feeding the first strand from the first loop, and a second means mounted on the flyer for positively feeding the second strand from the package, both said feeding means being driven at the same strand forwarding speed by rotation of the flyer, the second feeding means forming a loop in the second strand extending generally radially of the axis of rotation of the flyer, said first and second feeding means forwarding the strands from their respective loops in directions generally radial of the flyer from generally diametrically opposite directions to the junction where they are plied together.

12. Mechanism for twisting together two strands so as to form a two-ply strand, comprising a source of a first strand and a support carrying a let-off package for a second strand, a revolving shaft operable to rotate a first loop, of the first strand, about the package, to rotate a second loop, of the strand of the package, about the axis of the first loop, and also to ply the two strands together, and means mounted on the shaft for guiding the first and second strands from the first and second loops, respectively, said guiding means leading the strands generally radially of the shaft to the axis thereof along paths which coincide in at least that radial portion thereof adjacent the axis of the shaft, the rotation of the shaft plying the strands together.

13. Mechanism for twisting together two strands so as to form a two-ply strand, comprising a source of a first strand and a support carrying a let-off package for a second strand, a revolving flyer operable to rotate a first loop, of the first strand, about the package, to rotate a second loop, of the strand of the package, about the axis of the first loop, and also to ply the two strands together, and rotatable means mounted on the flyer for guiding the first and second strands from the first and second loops, respectively, said guiding means positively engaging both strands and equalizing the speeds of travel thereof, said guiding means leading the strands generally

radially of the flyer to the axis thereof, the rotation of the flyer plying the strands together.

14. Mechanism for twisting together two strands so as to form a two-ply strand, comprising a source of a first strand and a support carrying a let-off package for a second strand, a revolving shaft operable to rotate a first loop, of the first strand, about the package, to rotate a second loop, of the strand of the package, about the axis of the first loop, and also to ply the two strands together, and positively driven feeding means mounted on the shaft for positively feeding the first and second strands from the first and second loops, respectively, said feeding means being driven in synchronism with the rotation of the shaft, said feeding means leading the strands generally radially of the shaft to the axis thereof, the rotation of the shaft plying the strands together, and means for taking-up the plied strand under substantially constant tension.

15. Mechanism for twisting together two strands so as to form a two-ply strand, comprising a source of a first strand and a support carrying a let-off package for a second strand, a revolving flyer operable to rotate a first loop, of the first strand, about the package, to rotate a second loop, of the strand of the package, about the axis of the first loop, and also to ply the two strands together, and idle rotatable feeding means mounted on the flyer for guiding the first and second strands generally radially inwardly from the first and second loops, respectively, said feeding means positively engaging the two strands and interchanging energy between them to equalize their rates of travel, said feeding means leading the strands generally radially of the flyer to the axis thereof, the rotation of the flyer plying the strands together.

16. Mechanism for twisting together two strands so as to form a two-ply strand, comprising a source of a first strand and a support carrying a let-off package for a second strand, a revolving flyer operable to rotate a first loop, of the first strand, about the package, to rotate a second loop, of the strand of the package, about the axis of the first loop, and also to ply the two strands together, and positively driven rotatable feeding means mounted on the flyer for forwarding the first and second strands from the first and second loops, respectively, said feeding means being positively driven in synchronism with the rotation of the flyer, said feeding means positively engaging the first and second strands and leading them generally radially of the flyer to the axis thereof, the rotation of the flyer plying the strands together.

17. The method of twisting together two strands so as to form a two-ply strand which comprises feeding a first strand from a first source of supply into a first twisting loop, feeding a second strand from a second source of supply into a second twisting loop, rotating the second loop about an axis, rotating the first loop about the axis of rotation of the second loop and about the second source of supply, feeding both strands from their respective loops in runs extending generaly radially inwardly to a point of plying on the axis of rotation of the loops, and controlling at their radial runs the rate of passage of each of the strands to positively equalize such rates, the rotation of the loops serving to twist the strands about each other.

18. The method of twisting together two strands so as to form a two-ply strand which comprises feeding a first strand from a first source of supply into a first twisting loop, feeding a second strand from a second source of supply into a second twisting loop, rotating the second loop about an axis, rotating the first loop at the same angular speed and in the same direction as the second loop and about the axis of rotation of the second loop and about the second source of supply, feeding both strands from their respective loops in runs extending generally radially inwardly to a point of plying on the axis of rotation of the loops, and positively feeding at its radial run each of the strands to forward the strands at

the same rate to the point of plying, the rotation of the loops serving to twist the strands about each other.

19. The method of twisting together two strands so as to form a two-ply strand which comprises feeding a first strand from a first source of supply into a first twisting loop, feeding a second strand from a second source of supply into a second twisting loop, rotating the second loop about an axis, rotating the first loop at the same angular speed and in the same direction as the second loop and about the axis of rotation of the second loop and about the second source of supply, feeding both strands from their respective loops in runs extending generally radially inwardly and in directions substantially diametrically opposite each other into initial contact with each other at a point of plying on the axis of rotation of the loops.

20. Mechanism for twisting together two strands so as to form a two-ply strand, comprising a source of a first strand and a support carrying a let-off package for a second strand, a revolving flyer operable to rotate a first loop, of the first strand, about the package, to rotate a second loop, of the strand of the package, about the axis of the first loop, and also to ply the two strands together, and positively driven rotatable feeding means mounted on the flyer for forwarding the first and second strands from the first and second loops, respectively, said feeding means being positively driven in synchronism with the rotation of the flyer, said feeding means positively engaging the first and second strands and leading them generally radially of the flyer into initial contact at the axis of the flyer, the rotation of the flyer plying the strands together.

21. Mechanism for twisting together two strands so as to form a two-ply strand, comprising a source of a first stand and a support carrying a let-off package for a second strand, a revolving flyer operable to rotate a first loop, of the first strand, about the package, to rotate a second loop, of the strand of the package, about the axis of the first loop, and also to ply the two strands together, and positively driven rotatable feeding means mounted on the flyer for forwarding the first and second strands from the first and second loops, respectively, said feeding means being positively driven in synchronism with the rotation of the flyer, said feeding means positively engaging the first and second strands and leading them generally radially of the flyer, into close parallel relationship generally radially of the flyer at a zone outwardly of the axis of the flyer, and then in such parallel relationship to the axis of the flyer, the rotation of the flyer plying the strands together.

22. Mechanism for twisting together two strands so as to form a two-ply strand, comprising a source of a first strand and a support carrying a let-off package for a second strand, a revolving flyer operable to rotate a first loop, of the first strand, about the package, to rotate a second loop, of the strand of the package, about the axis of the first loop, and also to ply the two strands together, and a first and a second positively driven rotatable feeding means mounted on the flyer for forwarding the first and second strands from the first and second loops, respectively, said feeding means being located on the flyer diametrically opposite each other, both said feeding means being positively driven in synchronism with the rotation of the flyer, said first feeding means positively engaging the first strand and said second feeding means positively engaging the second strand, the feeding means forwarding the strand generally radially of the flyer and along diametrically opposite paths to a point of plying of the strands on the axis of the flyer, the rotation of the flyer plying the strands together.

23. Mechanism for twisting together two strands so as to form a two-ply strand, comprising a source of a first strand and a support carrying a let-off package for a second strand, a revolving flyer operable to rotate a first loop, of the first strand, about the package, to rotate a second loop, of the strand of the package, about the axis of the first loop, and also to ply the two strands together, and positively driven rotatable feeding means mounted on the flyer for forwarding the first and second strands from the first and second loops, respectively, said feeding means being positively driven in synchronism with the rotation of the flyer, said feeding means including means for rst separately positively engaging both the first and second strands and means for combining the strands into generally parallel unplied relationship generally radially of the flyer at a location radially displaced from the axis of the flyer and then leading them in such parallel unplied relationship generally radial of the flyer to a plying point on the axis of the flyer, the rotation of the flyer plying the strands together.

24. Mechanism for twisting together two strands so as to form a two-ply strand, comprising a source of a first strand and a support carrying a let-off package for a second strand, a revolving flyer operable to rotate a first loop, of the first strand, about the package, to rotate a second loop, of the strand of the package, about the axis of the first loop, and also to ply the two strands together, a rotatable driven shaft mounting the flyer, positively driven rotatable feeding means mounted on the shaft for forwarding the first and second strands from the first and second loops, respectively, means for positively driving the feeding means in synchronism with the rotation of the flyer, said feeding means positively engaging the first and second strands and impelling them generally radially of the flyer to the axis thereof, the rotation of the flyer plying the strands together.

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