May 17, 1960 D. S. ADAMS ET AL 2,936,877

STRAND PROCESSING

Filed Sept. 10, 1954 4 Sheets-Sheet 1

FIG. 1

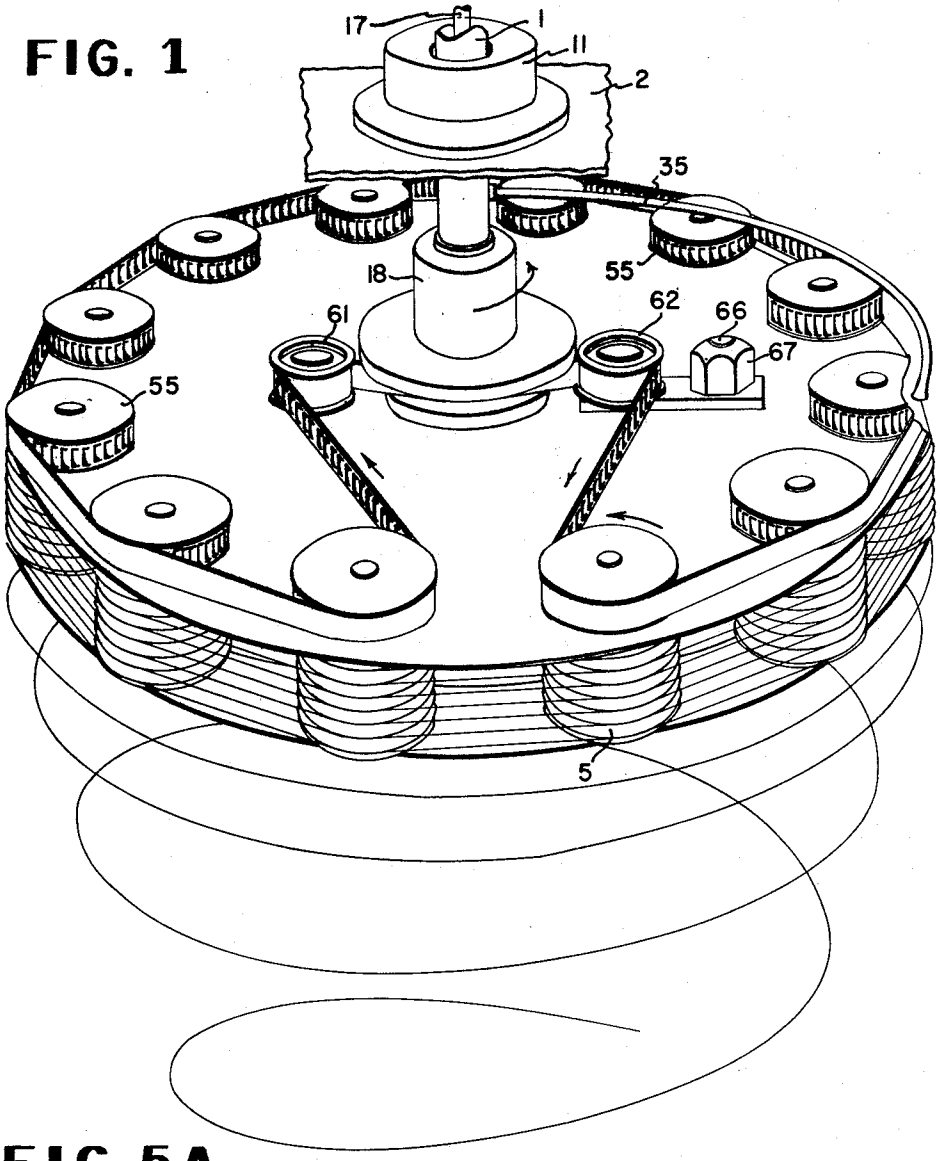
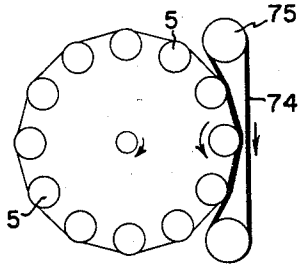


FIG. 5A



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STRAND PROCESSING

Filed Sept. 10, 1954 4 Sheets-Sheet 2

FIG. 2

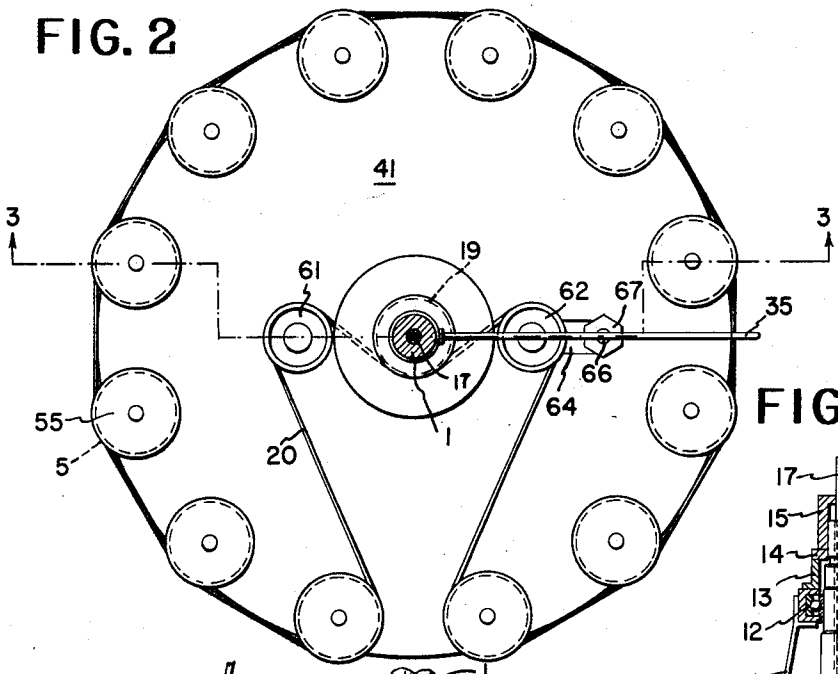


FIG. 4

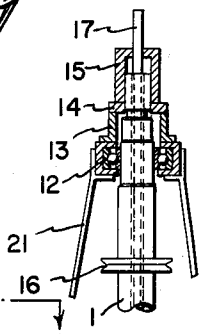


FIG. 3

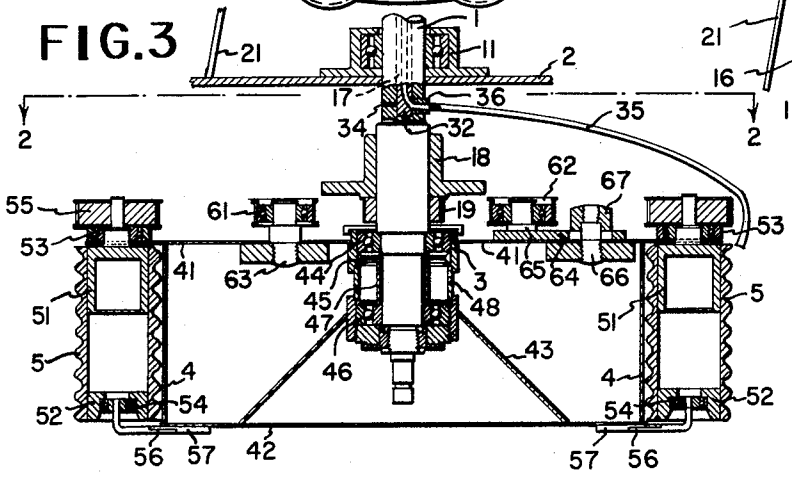
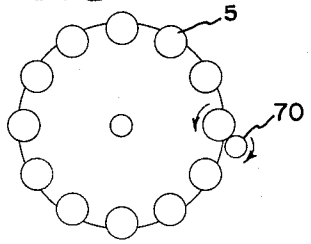


FIG. 5



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May 17, 1960 D. S. ADAMS ET AL 2,936,877

STRAND PROCESSING

Filed Sept. 10, 1954 4 Sheets-Sheet 3

FIG. 6

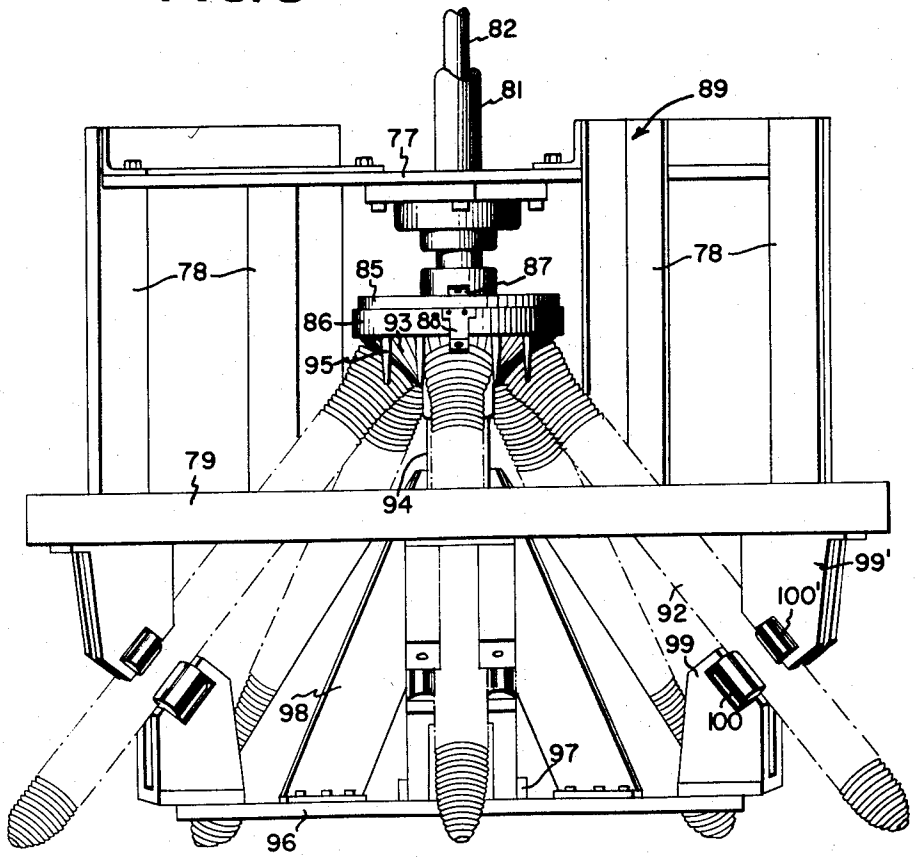
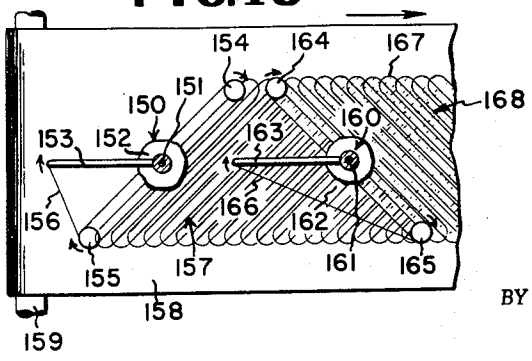


FIG. 10



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May 17, 1960 D. S. ADAMS ET AL 2,936,877

STRAND PROCESSING

Filed Sept. 10, 1954 4 Sheets-Sheet 4

FIG. 8

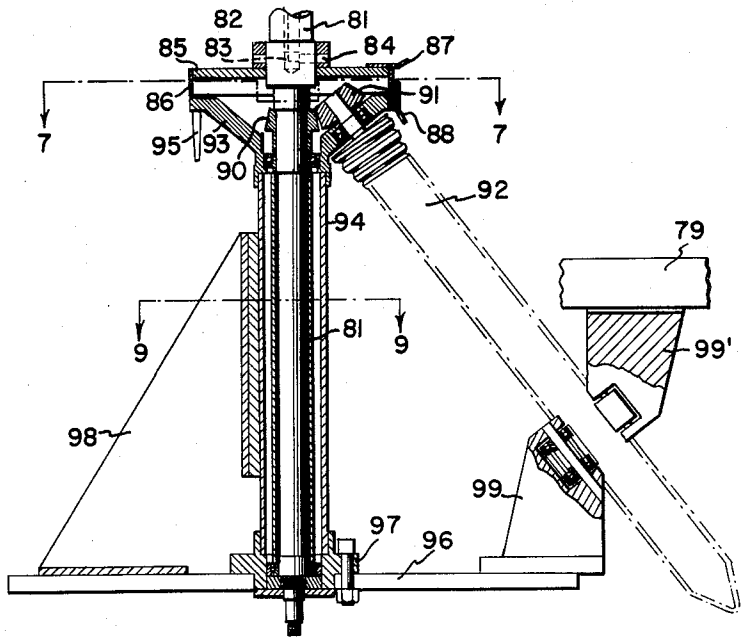


FIG. 7

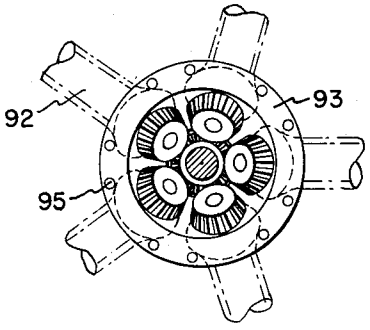
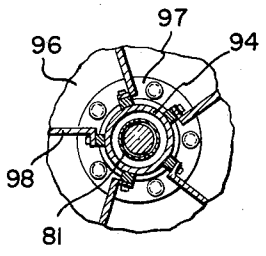


FIG. 9



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United States Patent Office 2,936,877 Patented May 17, 1960

2,936,877

STRAND PROCESSING

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Application September 10, 1954, Serial No. 455,192

21 Claims. (Cl. 203—1)

This invention relates to the processing of strand materials, particularly to their drawing-off and deposition in novel manner, being especially useful in textile processing.

In recent years rates of production and treatment of synthetic filaments have increased to well above one thousand yards per minute. However, winding speeds attainable on existing equipment are limiting the rise in production speeds. Conventional systems suffer from abrasion, ballooning, misalignment, snagging, splitting, and wrapping of the strand of textile being processed. Attempts to increase the operating speeds of present equipment lead to excessive wear and impose severe stress inequalities leading to unever dyeing and other nonuniformities in the product. Air jets have proved helpful in drawing off or forwarding light-weight strands, but the problem of collecting these and similar heavy strand materials in compact, orderly form for convenient backwinding or other use remains.

The present invention is directed toward the processing of all forms of strand material as here defined. The term "strand" herein means monofilament, multifilaments, tow, sliver, staple yarn, thread, ribbon, rope, and other articles capable of being handled as described, regardless of their composition, cross-sectional appearance, or method of construction and despite exemplification by such textile material as tow (a bundle of substantially continuous filaments).

A primary object of this invention is compact, orderly deposition of a strand drawn off rapidly from a source of supply. Another object is helical coiling of a strand being supplied at high speed. An object is deposition of a strand originally traveling at high speed in the form of coils or loops traveling at much lower speed. A further object is tensioning of a strand so as to forward it against a restraining force. Another object is controlled extension of a traveling strand. Other objects, including provision of means for attaining the above and related objects, will be apparent from the explanatory text and the accompanying diagrams.

Figure 1 is a perspective view of one form of apparatus useful according to this invention. Figure 2 is a plan view of the apparatus of Figure 1. Figure 3 is a vertical section of a portion of the same apparatus through the central axis at 3—3 of Figure 2. Figure 4 is a vertical section of a different portion of the same apparatus. Figures 5 and 5A are fragmentary plan views of the apparatus of Figure 1 in conjunction with accessory apparatus. Figure 6 is a side elevation of another form of apparatus useful according to this invention. Figure 7 is a horizontal section through the apparatus as 7—7 of Figure 8. Figure 8 is a vertical section of the same apparatus through the central axis and normal to the view of Figure 6. Figure 9 is a different horizontal section through the same apparatus at 9—9 of Figure 8. Figure 10 is a plan view of other apparatus used according to this invention.

In general, the objects of this invention are brought

about by imparting to a traveling strand a helical configuration having an axis substantially parallel to the original direction of travel. In an apparatus embodiment this is achieved by passing a rapidly traveling strand through a guide making the circuit of a plurality of supporting elements adapted to receive the strand and advance it in substantially helical form for deposition onto a collecting surface. The rate of travel of the guide with respect to fixed external coordinates is of the same order of magnitude as the rate of travel of the strand with respect to the guide, and the resulting helical configuration of the strand on the supporting elements moves axially therealong at a speed that is exceeded greatly by the original strand travel rate. The collecting surface receives the strand from off the ends of the supporting elements at reduced speed in the form of coils or loops that adapt themselves readily to the configuration of the collecting surface; the collapsed configuration of the strand on the collecting surface may be controlled by movement of the collecting surface with respect to the apparatus, as well as by the relative spacing of the elements themselves. Thus, the strand is drawn off from the source of supply in a direction substantially in line with the axis of the helical configuration, and the rapid rate of travel in that direction is converted to slow advancement of the helical configuration therealong; while the lengthwise component (now in a direction substantially perpendicular to the original direction), if any, is greatly reduced and may be zero or even negative as will appear below. While being advanced in helical form, the strand may be extended, heated, or otherwise treated as may be convenient and desirable, depending upon its chemical and physical composition and its desired characteristics and intended use.

Figures 1 through 4 show one apparatus embodiment of this invention. Main drive shaft **1** carries frame **3** suspended below support **2**. A circular hole cut in this support permits the shaft to extend therethrough and be supported from above by bearings **11** and **12** and thrust bearing **13**. Support legs **21** extend from the housing of bearing **13** to the upper surface of the support. Near the upper end of the shaft **1** is thrust collar **14** secured to the shaft by screw lock nut **15**. Between bearings **11** and **12** is a V-belt driving pulley **16** affixed to the shaft for belt drive from a suitably located motor (not shown). Below the support the shaft carries hub **18** pinned through the center of the shaft to insure rotation therewith. In a centrally located cylindrical bore of the shaft is tube **17** for guiding a strand to be processed. The tube extends beyond the upper end of the shaft through a hole in lock nut **15** to facilitate introduction of the strand. At the lower end of the tube, which may conveniently be of ceramic, metal, or the like, fitting **32** fastened in place by means of set screw **34** leads the yarn into the bore of radial fitting **36**. Into this radial opening is brought the end of a tube **35**, such as of stainless steel, and this is held in place by means of a tight-fitting sleeve. This tube extends more or less radially outward and downward and then bends abruptly downward to terminate in an opening near the top of screw-threaded cylindrical rolls **5**.

The lower part of shaft **1** carries frame **3** by means of bearings **44** and **46**, which are in suitable housings constituting part of the suspended frame. This frame consists of a number of parts welded together. Cylindrical member **4** is welded to an upper plate **41** and a lower plate **42**, and conical stiffener **43** joins the lower plate with the housing for lower bearing **46**. To further support bearings **44** and **46**, cylindrical sleevelike member **48** is welded to the outer part of their housings. Cylindrical member **47**, only slightly larger in internal diameter than

the shaft at this point, floats between the two bearings, keeping them spaced apart, while "Belleville" spring 45 exerts an upward pressure against bearing 44 to relieve the end pressure on spacer sleeve 47.

The frame thus formed supports a plurality of cylindrical worm rolls 5, twelve being shown equally spaced around the periphery of the frame and grooved or threaded alike. Into the upper end of each worm roll is press-fitted a gudgeon 51, which extends through bearing 53 supported in suitable housings. The gudgeon extends through and is keyed to "Gilmer" pulley 55, which is toothed with a series of transverse rectangular slots. The lower end of each worm roll is supported for rotation by a press-fitted insert 52 on bearing 54, which in turn is supported by a bent rod 56 welded to a plate 57 screwed to bottom plate 42 of the frame.

To shaft 1 is keyed a "Gilmer" pulley 19 of the same peripheral size and sprocket pitch as pulleys 55. The twelve worm drive pulleys and the driving pulley 19 are joined by a "Gilmer" timing belt 20 with the aid of two idler pulleys 61 and 62, which are smooth-surfaced for contact with the back or smooth side of the timing belt. The belt passes outside each worm drive pulley, back over an idler pulley about the drive pulley on the shaft, against the other idler pulley, and onto the first worm drive pulley. The idler pulleys are mounted in the top plate of the frame, which has been reinforced at these points by welding to the underside of the plate a substantial thickness of metal. The support for pulley 61 is shouldered bolt 63 threaded into one of the reinforced sections of the top plate. Pulley 62 is mounted on adjustable arm 64 by means of shouldered post 65 welded to the arm. The arm is slotted and is adjustably held in position by means of stud bolt 66 threaded into the other reinforced section of the top plate. The arm and the pulley carried thereby are held in position by means of nut 67 threaded onto the upper end of the stud bolt. This arrangement for driving the worm rolls causes all of them to rotate once with each rotation of the shaft and the attached guide.

During operation of the apparatus, the frame supporting the worms may be held stationary or may be counter-rotated by suitable "snubber" means to reduce the component of rotation of the strand about the axis of the helix. Rotatable snubber roll 70, shown in Figure 5, accomplishes this by bearing on the tips of some of the threads forming the surface of one of the worms. Such a snubber roll is mounted on a suitable arm (not shown) which may depend from support 2, even as an extension of leg 21, if desired. While a lone snubber roll should be satisfactory, it may be convenient to use two, three, or more. The roll, which should have a resilient surface, is so positioned as not to contact the yarn passing thereunder in the grooves of the worm. Figure 5A shows another snubbing arrangement, which utilizes belt 74 passing in non-slipping contact over pulleys 75, whose axes are parallel to the axes of the worm rolls. Arrows indicate the directions of rotation and suggest the relative speeds of the belt and the rolls; contact of the belt with several of the rolls which have a considerably greater surface velocity in the same direction, moves the entire group opposite to the individual worm rotation, the small resultant being indicated by the central arrow. This imposed counter-rotation can afford substantially complete cancellation of the component of rotation that the apparatus otherwise imparts to the strand being processed; a stationary belt actually would bring the component to a small negative value. For example, when the belt is held stationary, the rotation of the worm rollers against the belt surface in a counter-clockwise direction will cause the rotatable frame to which the worm rollers are attached to rotate about its central axis in a clockwise direction. When the worm rollers are not rotating and the belt is moved in a clock-wise direction, the rotatable frame will be driven in a counter-clockwise direction. When the belt is moved in a clockwise direction at the same surface speed as the rotating worm rollers rotating in a counter-clockwise direction, the frame will be held stationary. When the belt is moving in a counter-clockwise direction, the rotatable frame will be driven in a clockwise direction. By controlling the direction and rate of rotation of the belt, the rotation of the frame and the configuration of the loops which fall from it may be controlled to any desirable degree. Magnets may be used to prevent rotation also, as is apparent without necessity for illustration.

This apparatus calls for no unusual articles or construction materials. With the exception of the drive belt, the entire apparatus may be steel or similar material. The guide for the strand, or portions of it, may consist of ceramic material. The various parts that are fastened together may be joined by usual methods, such as welding, bolting, or riveting. The surface of the rolls may be blasted, pebbled, or slitted to aid in preventing wrapping of a strand or parts thereof about the individual rolls.

Details of operation of the apparatus just described follow. A strand end is introduced into the top of tube 17 and brought out at the lower end of the tube. Depending upon the physical characteristics of the strand, it may pass through the tube more easily by being pushed manually at the entering end or merely by the pull of gravity, or the lower end of the tube may be connected temporarily to an evacuated line so that the flow of air into the top of the tube will carry the strand along with it. Similarly, the entrance of a "sucker-gun" apparatus such as that of Miller Patent No. 2,667,964 may be juxtaposed to the bottom end of the tube for this purpose and then withdrawn with the strand traveling through it to continue with the stringing up. After securing the end of the strand from the exit of the tube, the person stringing up the apparatus then starts the motor to begin rotation of the guide and the rolls. The guide passes about the group of worm rolls, paying off the strand about the rolls into the outermost portion of the topmost groove of each. The number of turns required to ensure collection and advancement of the strand by the apparatus depends upon various physical characteristics of the strand; usually several turns will suffice and the strand may be cut at the entrance to the sucker-gun, with the end then left hanging down from the side of a groove in one of the rolls. Rotation of the rolls carries the end of the strand downward to the bottom of a roll, after which the outermost thirty degrees of each groove in each roll is occupied by the strand. Rotation of the rolls themselves also carries the strand around the group of rolls, a component of motion that may be nullified in whole or part, as mentioned above. The configuration of the strand as it falls after leaving the bottom of the worm rolls appears in Figure 1.

Assuming thirty inches as the diameter of the helix formed by the strand in passing from roll to roll, an operating speed of slightly over 2000 r.p.m. draws the strand off from its source at a rate of about 5500 yards per minute (neglecting rotation of the entire helical configuration, which may be made nil if desired). When rotating at the above rate, rolls having a groove length of 6 inches for one complete turn (a thread-root diameter of about 2 inches) impart a speed of about 330 yards per minute to the strand, less than 1/16 of its original rate of travel. If the guide and the rolls rotate in the same direction, as shown, the draw-off speed of the strand is the difference of the two rates; it is the sum of the two when these elements are counter-rotating. The smaller the roll diameter, the smaller the peripheral speed of the strand, and the rolls may be tapered to reduced diameter at the bottom to reduce this speed component to the desired level. A residual rotational component favors maintenance of a circular shape to the loops of the falling strand. The advancing of the yarn along the axis

of the helical configuration is a function of the peripheral speed and screw pitch of the rolls. With one-half inch pitch to the grooves in the above rolls, the rate of advance is about 30 yards per minute or only a few thousandths of the supply speed of the strand. If the apparatus is an appreciable distance above the collecting surface, the intervening free fall of the strand may increase the impact somewhat, but the reduction from the supply rate will remain very substantial.

The orderly collection patterns that may be formed on a moving collecting surface according to this invention are highly desirable; the evenness of deposition ensures compactness of the pattern. Backwinding or withdrawal of the strand from the surface is much easier than in conventional systems where the strand is allowed to fall at random with high impact speed and consequent frequent wedging of one length of the strand among others or separation of the components of the strand along portions of its length. Too, where the strand is to be processed further on the collecting surface, the regular configurations permitted by this apparatus facilitate uniformity. The collecting surface may be rotated, oscillated, or moved in a complex manner to provide the desired pattern of collected strand. Simple rotation of the surface about a center eccentric to that of the apparatus permits buildup of a toroidal "package" of the strand. Two or more of these machines may be operated in juxtaposition so as to interleave their respective strands as they fall on the collecting surface, and other patterning arrangements will come readily to mind.

Apparatus embodiments besides that just described also are useful in practicing the process of this invention. Obviously, the number of supporting elements for the strand may be reduced (or increased) or their relative locations, sizes, or shapes varied, with attendant change in the shape of the strand configuration, at least two elements being required for the desired processing of the strand. Instead of producing substantially circular loops, such apparatus may be designed to supply triangular, square, semi-circular or other shapes of loops by omission of some of the worm rolls or change in their locations. Reduction of the rotational component about the axis of the configuration is desirable to preserve these loop shapes. Rhombic or more elongated patterns, which may also be interleaved from a plurality of machines, are especially useful when the collected material is to be processed into non-woven articles as taught by Lauterbach in patent application Serial No. 312,067 filed September 29, 1952, now abandoned.

Figure 10 shows one such arrangement in plan view, including two identical two-roll modifications **150** and **160** of the apparatus of this invention suspended by suitable means (omitted from the drawing for clarity) attached to supports **152** and **162** above collecting belt **158** supported and moved by horizontal cylindrical rolls **159** (of which only one is shown). Visible in the center of respective shafts **151** and **161** are bores into which strands **156** and **166**, represented therein as solid dots, are passing from suitable sources of supply not shown in the drawing. The first apparatus comprises vertical worm rolls **154** and **155** located upper right and lower left with respect to shaft **151**. Tube **153**, which extends to the left from the shaft, is hollow to receive the yarn from the bore of the shaft. Strand **156** passes from inside the hollow shaft into the tube and thence out of the tube onto the rolls. Rotation of the shaft sweeps the tube clockwise and lays the strand onto each of the rolls in turn to form a configuration (here termed for convenience an "elongated oval") having sides parallel to each other and to a line joining the roll axis and closed at each end by semi-circular arcs. From the bottom of the rolls, the strand drops continuously in this elongated oval form onto the belt moving underneath to the right. Resulting overlapping pattern configuration **157** is clearly visible between the two pieces of apparatus. The structure of the second apparatus is like that just described except for orientation of rolls **164** and **165** at the upper left and lower right of shaft **161**, from which tube **163** extends to the left. This tube sweeps clockwise at the same rate as the other tube, the phasing shown being effective to prevent collision. Pattern **157** laid down by this apparatus is like that of the first but perpendicular thereto; in resultant composite pattern **168**, the superimposed straight lengths of strand from each apparatus form opposite angles of 45° with the edge of the belt. Additional layers of strand may be deposited similarly in criss-cross fashion on top of those shown. Non-woven structures formed from batts so constructed are notable for their uniformity of strength and other physical characteristics in all azimuthal directions.

The screw type of advancing may be accomplished by having a minimum of one threaded roll for the strand to move over in non-slipping contact, the strand rolling or slipping sideways over the surface of the other supporting elements, which may be smooth to facilitate the advancing. Alternatively, the element for advancing the strand may be threaded over only part of its surface or otherwise fragmentary, instead of cylindrical; this modification necessitates slipping contact of the strand over the advancing element, while contact between the strand and at least one other supporting element should be non-slipping (although intermittent as the advancing element passes by). Such a moving advancing element conveniently may perform also the function of the guide in encoiling the strand about a cylinder or other type of supporting element.

Movement of a supporting element transverse to the strand may replace or supplement screw advancing, and in simplest form such an element might constitute an annular or toroidal surface capable of continuous eversion; of course, this surface may be fragmented also, as into a substantially parallel group of conveyer belts clustered about a vertical axis. Gears or chains could be substituted for the belts, but in any event the outer or supporting surface would move undirectionally to advance the strand, the inner surface merely returning to the initial strand-supporting position. When this type of advancing and supporting element is used, the component of movement of the strand about the axis of the helical configuration depends upon the relative orientation of the belts and the common axis, which if parallel—with the supporting elements fixed in azimuth—would render the rotational component nil. If desired to promote circularity of the loops leaving the traveling belts, rotation of the strand-supporting elements as a group about the central shaft may be attained by a suitable planetary drive, as by two sun sheaves or gears affixed respectively to the supporting member through which the shaft passes and to the framework for the strand-supporting elements and interconnecting planetary pulleys or gears revolving about the shaft axis in fixed relationship to the rotating shaft.

Regardless of variations in kind or location of strand-supporting elements, the resulting configuration of strand so supported is comprehended herein by the general term "helical," signifying primarily the non-contiguous coiling of the strand about a rectilinear axis regardless of the cross section of the configuration perpendicular thereto and despite rotation or periodic change of orientation of the configuration.

The direction of rotation of the worm rolls of this apparatus may be opposite to the travel of the guide, an arrangement that increases the draw-off rate somewhat. Increasing the number of turns of the strand about the group of supporting elements permits the forwarding of the strand against relatively great restraining forces. In processes for making synthetic yarn, this type of apparatus may withdraw it directly from the spinneret, and stretching may occur at that time, if desired. An important feature of the present invention is the positive supporting

and advancing of the strand, as distinguished from systems where a coiled strand is merely allowed to slip against an inscribed or a circumscribed surface or allowed to fall freely. The helical configuration here described has a controlled extent and the strand describes an arc substantially greater than a complete circle throughout that extent. In fact, strands of many synthetic textile materials may be drawn to increased length by suitable orientation and shape of the rolls or other supporting elements when the configuration contains several complete turns of the supported strand.

Figure 6 and subsequent figures show a form of apparatus constructed according to this invention with the particular object of extending or "drawing" a strand by means of worm rolls of substantially constant cross-section oriented outwardly from one another, i.e., splayed, in the direction of advance. Drive shaft **81** is supported and driven in substantially the same way as shaft **1** shown in earlier figures. Frame **89** comprises top plate **77** supporting vertical angle irons **78**, to the bottom of which is attached annular member **79**. The upper part of the shaft has a similar bore containing guide tube **82**. Lower on the shaft is hollow fitting **83** connecting the vertical bore of the shaft to radial bore **84** and held in place by a set screw. Around this part of the shaft and secured to plate **85** is a collar having radial openings matching the radial bore **84** and the set-screw tapping. Also at ninety degrees to these radial openings is a set-screw to secure the collar to the shaft. Suspended from plate **85** and secured thereto are cylindrical shield members **86**. Near the periphery of plate **85** is located guide **87**, and dependent from the lower shield member **86** is guide **88**.

Keyed to shaft **81** below top plate **85** is beveled drive gear **90** meshing with each of five beveled driven gears **91**, each driven gear being fastened in turn to one of worm rolls **92**. The gear arrangement, as viewed from above, appears in Figure 7. A bearing housing and support for the upper shaft bearing and for the five bearings of the worm rolls is support member **93**, which is rigidly fastened to support sleeve **94** of the stationary frame. Relative positions of the upper ends of the worm rolls, the central drive shaft, and the auxiliary support pins **95** appear clearly in Figure 6. The pins are provided to make the path nearly circular for the first few loops of the strand. The extensive supports shown are necessary because the worm rolls splay out toward the bottom in order to provide the desired degree of drawing.

Sleeve **94** fastened to bottom plate **96** by welding to flanged lower shaft bearing-housing **97**, which in turn is bolted to the bottom plate, is further supported by five evenly spaced plate braces **98** bolted to the bottom plate and to ribs affixed to sleeve **94**. This bracing ties the bottom plate rigidly to the sleeve, thus providing excellent anchorage in the bottom plate for supporting the lower ends of the worm rolls. Figure 9 is a detail of this superstructure. Suitably shaped angled supports **99** bolted to the bottom plate carry two ball-bearing rollers **100** on parallel axes for each worm roll, serving to support the lower part on a fixed axis of rotation. Similar supports **99'** depending from annular member **79** carry like rollers **100'**.

The radial cross-section of each worm roll varies, tapering near the top to a smaller section that remains constant until near the other end, where the roll decreases in radius. While an apex at the discharge ends of the worm rolls may be effective to slow or stop rotation of the strand about the vertical axis, it also ensures no slippage back into the drawing zone. The tapering at the upper end of the rolls is so designed as to permit several turns to be laid down on the worm rolls at constant tension, preventing drawing or extension of the strand as well as slippage between strand and rolls. The taper angle of the shoulder with the parallel sides of the rolls approximates one half the angle by which the worm axis deviates from the vertical or central axis of the apparatus.

Generally, the construction should be rigid and precise in order to gain the maximum benefits of smooth uniform operation. Greater or less draw is possible by increasing or decreasing the splay angle of the worm rolls or the over-all length of the rolls may be chosen to provide the desired amount of draw, which for synthetic fibers often lies within the range of about three to six times the original length. This apparatus can be strung up and operated similarly to the apparatus described earlier, with the strand here passing also about the set of pins as well as the rolls. The guide rotates counter to the direction of rotation of the rolls, as is apparent from the construction shown. The advantages of the apparatus shown and described above are combined in the apparatus just considered plus the feature of extending the strand to increased length. The advantages of doing so are obvious.

Other shapes and orientations of worm rolls may be employed to draw a strand passing over them. Change in length of the strand is generally a function of the inclination of the roll axes to the axis of the group, direction of rotation of the rolls as compared with that of the guide, and change in roll diameter from the entering location of the strand to the discharge location. Counter-rotation of guide and rolls is favored over rotation in the same direction because of the attendant increased draw. As noted above, no draw occurs in like apparatus whose roll elements are conical and are oriented with apex downward and axis inclined down and outward from the apex of the entire group if the apex angle (axial plane) of the element equals the angle of inclination of the element axis to the common axis; greater inclination of such an element provides positive draw. Rolls may be made of varying section to vary initial and final draw rates, as well as total amount of draw. The drawing action may be spread over a considerable length of strand with exact control in location, a notable advantage over existing equipment. The drawn strand passing from apparatus of the type described may be fed to another similar apparatus for further drawing, and so on, in a cascade arrangement. Additional ways of utilizing the apparatus considered here without departing from the invention will be evident. For example, the apparatus may be heated internally or externally and may be wholly or partly enclosed, and the strand may be heat-set by such apparatus.

The claimed invention:

1. Novel process of delivering strand material in the form of loops comprising the steps of initially directing the strand in a substantially vertical downward direction, imparting to said strand a helical configuration having an axis substantially parallel to the initial direction of said strand, impelling the strand lengthwise of itself to impart a component of movement thereto along its length while advancing it in the helical configuration, and releasing said strand at the terminus thereof in the form of loops, said loops forming a helical configuration, the strand retaining sufficient component of movement that the helical configuration is retained as said strand falls under the influence of gravity at a rate substantially less than the speed of the strand in its initial downward direction.

2. The process of claim 1 wherein the strand is positively supported as the helical configuration is imparted and as the strand is impelled lengthwise while advancing it in the helical configuration.

3. The process of claim 1 wherein the rate of advance of the strand in the helical configuration is less than $\frac{1}{16}$ of the rate of supply of the strand.

4. The process of claim 1 in which the diameter of the helical configuration varies in controlled manner with distance along the axis thereof.

5. The process of claim 1 in which the pitch of the

helical configuration is substantially fixed throughout and the strand is advanced axially along the configuration to the terminus thereof.

6. Process of collecting the falling strand of claim 5 in patterned overlapping arrangement.

7. Apparatus comprising a plurality of elements mounted on a rotatable frame and grouped to support a strand making a circuit of the elements in a substantially helical configuration having a substantially vertical axis, including at least one rotatable supporting element adapted to advance the strand lengthwise of itself along the configuration and one supporting guide element rotating in a circle perpendicular to the helix axis concentric therewith near one end of the group of elements to receive the strand from a source of supply.

8. The apparatus of claim 7 in which an advancing element is threaded and is adapted to rotate on an axis substantially parallel to the axis of the helical configuration and fixed with respect thereto.

9. The apparatus of claim 7 adapted for travel of the strand with respect to the supporting elements, whereupon the respective supporting elements successively contact each portion of the strand.

10. The apparatus of claim 9 in which each of the supporting elements is also a lengthwise advancing element.

11. The apparatus of claim 10 in which all of the supporting and advancing elements are threaded externally and are adapted to rotate on axes of their own fixed with respect to the axis of the helical configuration.

12. The apparatus of claim 11 in which all the axes are parallel to one another.

13. The apparatus of claim 7 in combination with a collecting surface moving underneath, adapted to receive the strand as it is released from the apparatus in the form of loops.

14. The apparatus of claim 7 further comprising guide means for initially directing the strand substantially parallel to the center of rotation of the supporting element rotating in a circle perpendicular to the helix axis.

15. Apparatus comprising a plurality of similar helically grooved cylinders rotatable at the same rate and mounted on a rotatable frame, and guide means movable about the group of cylinders in synchronism with the rotation of the cylinders so as to encoil a strand helically about the plurality of cylinders for advancing in the grooves.

16. The apparatus of claim 15 in which shape and orientation of the cylinders are effective to extend a strand in non-slipping contact therewith as the cylinders rotate.

17. The apparatus of claim 16 in which the axes of the respective cylinders are splayed outwardly in the direction of advance of a strand therealong.

18. Apparatus comprising a plurality of similar helically grooved cylinders rotatable at the same rate and mounted on a rotatable frame, means to direct a strand in a substantially vertical direction into a tubular guide member movable about the cylinders in synchronism with the rotation of the cylinders so as to encoil a strand helically about the cylinders and advancing in the grooves, snubber means in bearing contact with at least one of the cylinders to regulate the rotational component of the frame, in combination with a collecting surface moving underneath to collect the strand as it is released in loop form from the apparatus.

19. Apparatus comprising a plurality of yarn-processing units, each said unit comprising at least two similar helically grooved cylinders and guide means movable about the group of cylinders in synchronism with the rotation of the cylinders to encoil a strand helically about the cylinders for advancing in the grooves, said cylinders of each unit being rotatable at the same rate and located with their axes parallel to each other and to a vertical axis of rotation of the guide means and at opposite sides thereof in a line perpendicular to the corresponding line of like units of apparatus immediately adjacent thereto; a collecting surface moving underneath said plurality of units in a substantially horizontal plane and in a direction therein making an angle of about forty-five degrees with the lines connecting the axes of at least two of the helically grooved cylinders.

20. Apparatus of claim 19 wherein the snubber means comprises a roller in contact with the tips of at least one said threaded element.

21. Apparatus comprising a plurality of elements mounted on a rotatable frame and grouped to support a strand making a circuit of the elements in a substantially helical configuration having a substantially vertical axis, including a supporting guide means rotating in a circle perpendicular to the helix axis concentric therewith near one end of a group of elements to receive the strand from a source of supply, and snubber means to regulate the component of rotation of the frame.

References Cited in the file of this patent

UNITED STATES PATENTS

1,960,743	Junkers	May 29, 1934
2,424,490	Henry	July 22, 1947
2,605,536	Litzler	Aug. 5, 1952
2,691,852	Slayter	Oct. 19, 1954
2,742,737	McElroy	Apr. 24, 1956

FOREIGN PATENTS

539,200	Great Britain	Sept. 1, 1941