

- [54] **METHODS OF AND APPARATUS FOR CONTINUOUSLY REELING STRAND MATERIAL**
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- [73] Assignee: **Western Electric Company, Incorporated**, New York, N.Y.
- [22] Filed: **Aug. 14, 1972**
- [21] Appl. No.: **280,368**
- Related U.S. Application Data**
- [62] Division of Ser. No. 150,283, June 7, 1971, Pat. No. 3,701,491.
- [52] U.S. Cl. **242/158.2, 242/25 A, 242/158.4 R**
- [51] Int. Cl. **B65h 57/28**
- [58] Field of Search **242/25 A, 158.2, 242/158.3, 158.4**

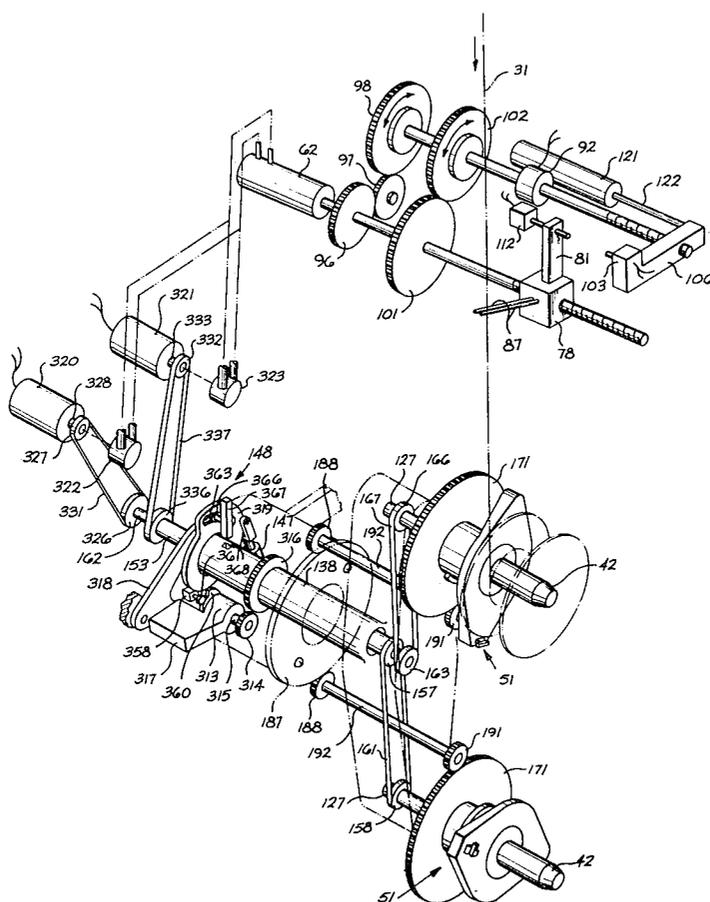
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Primary Examiner—Stanley N. Gilreath
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- [57] **ABSTRACT**
- A pair of transversely aligned arbors are rotatably cantilevered at opposite ends of a vertically disposed rotatable turret. Each arbor is provided with a plurality of internally floating, cam-operated mechanisms for

locking a take-up reel thereon. Independent drive mechanisms drive the reels separately at varying speeds. A snagger device is cantedly mounted on the cantilevered end of each arbor for rotation therewith and extends a radial distance slightly greater than the adjacent flange of the reel thereon to oscillate between two points coplanar with respect to the inner and outer surfaces of the flange, respectively. A distributor adjacent to one of the reels actively taking up the strand is provided with a reversible drive screw for driving a traversable strand guide controlled alternately by a stationary limit switch adjacent to the reel flange associated with the snagger and a rectilinearly movable limit switch mounted on a second drive screw and normally positioned adjacent to the opposite reel flange. Prior to cutover from a full reel to an empty reel, when a footage counter indicates that a length of strand approximating one layer of convolutions thereof remains to be taken up: (a) the turret is rotated 180° to position an empty reel between the distributor and the nearly full reel; and (b) the second drive screw is actuated to move the movable limit switch toward the stationary limit switch at the traverse speed of the strand guide. The limit switches continue to control the reversal of the first drive screw. When the remaining length of strand is taken up and the advancing strand is traveling close to the inside flange of the empty reel, the snagger associated therewith is thrust into the path of the strand to grip and sever its connection to the full reel and to commence winding thereof upon the empty reel. The full reel is replaced by an empty reel to await the next cutover operation.

10 Claims, 27 Drawing Figures



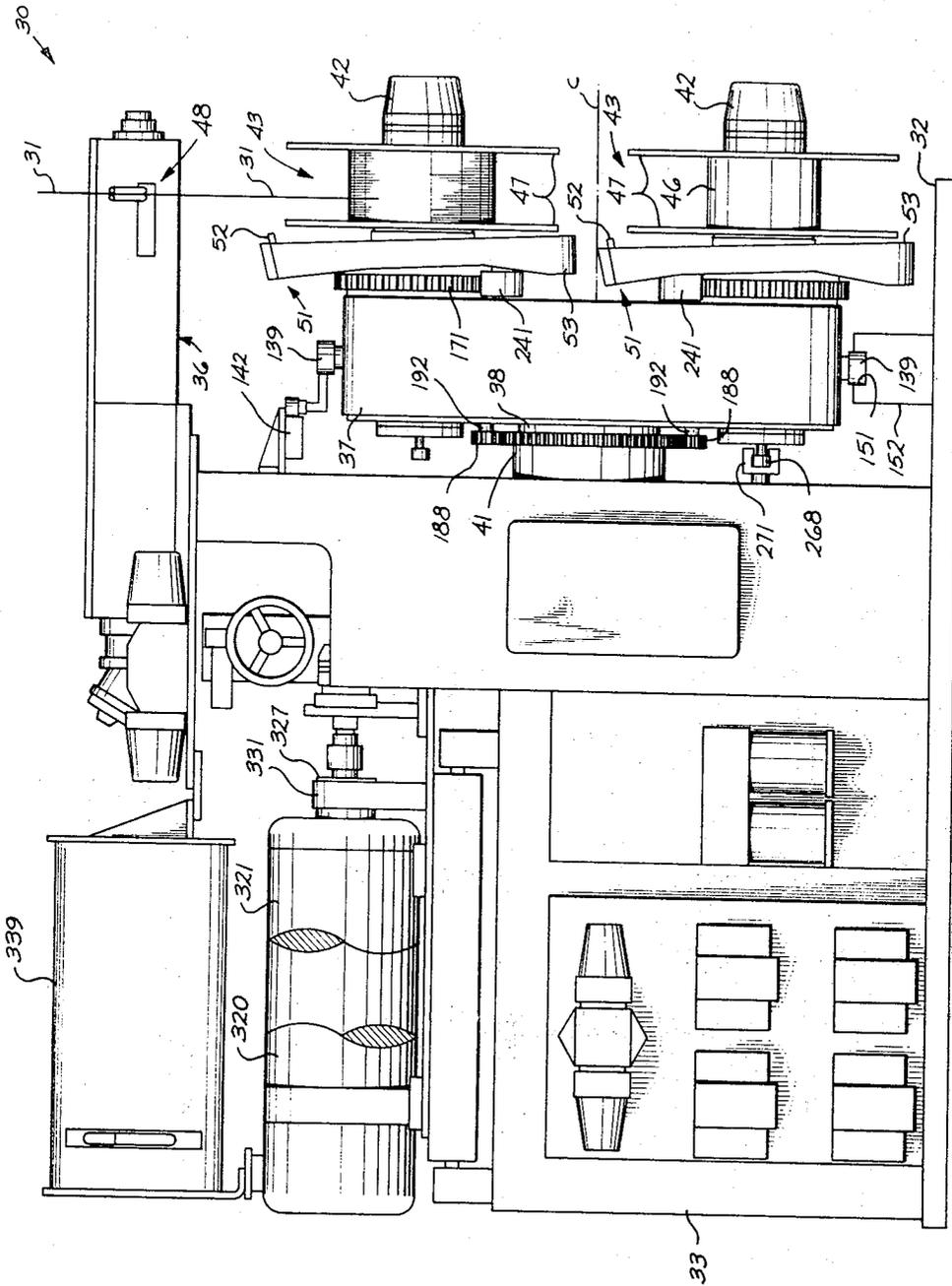


FIG. 1

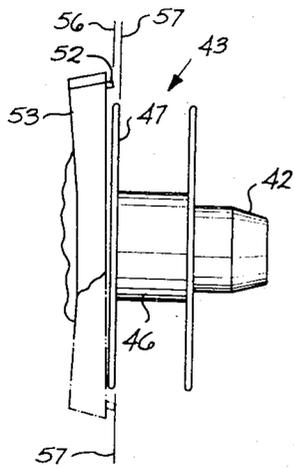


FIG. 4

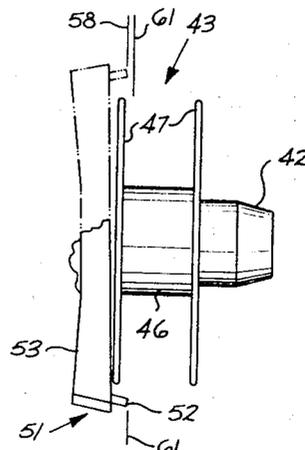


FIG. 5

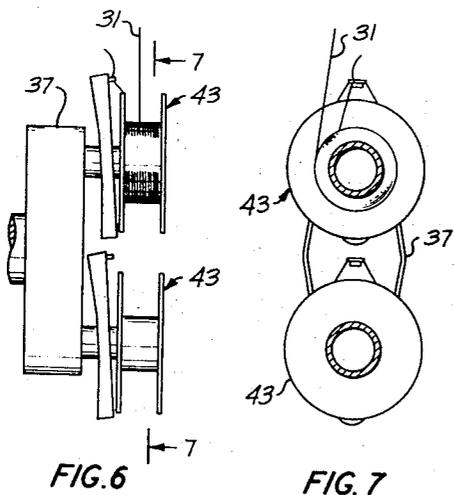


FIG. 6

FIG. 7

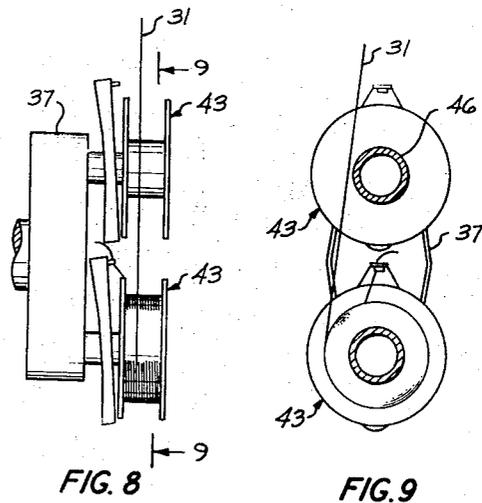


FIG. 8

FIG. 9

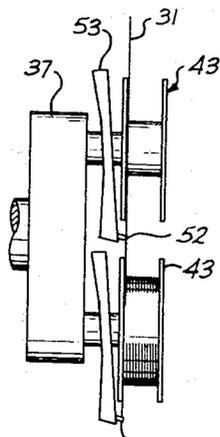


FIG. 10

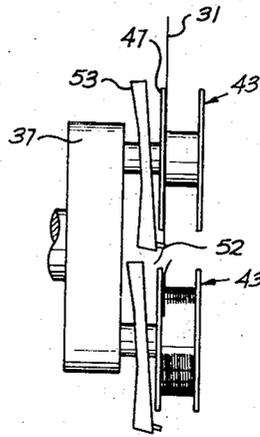


FIG. 11

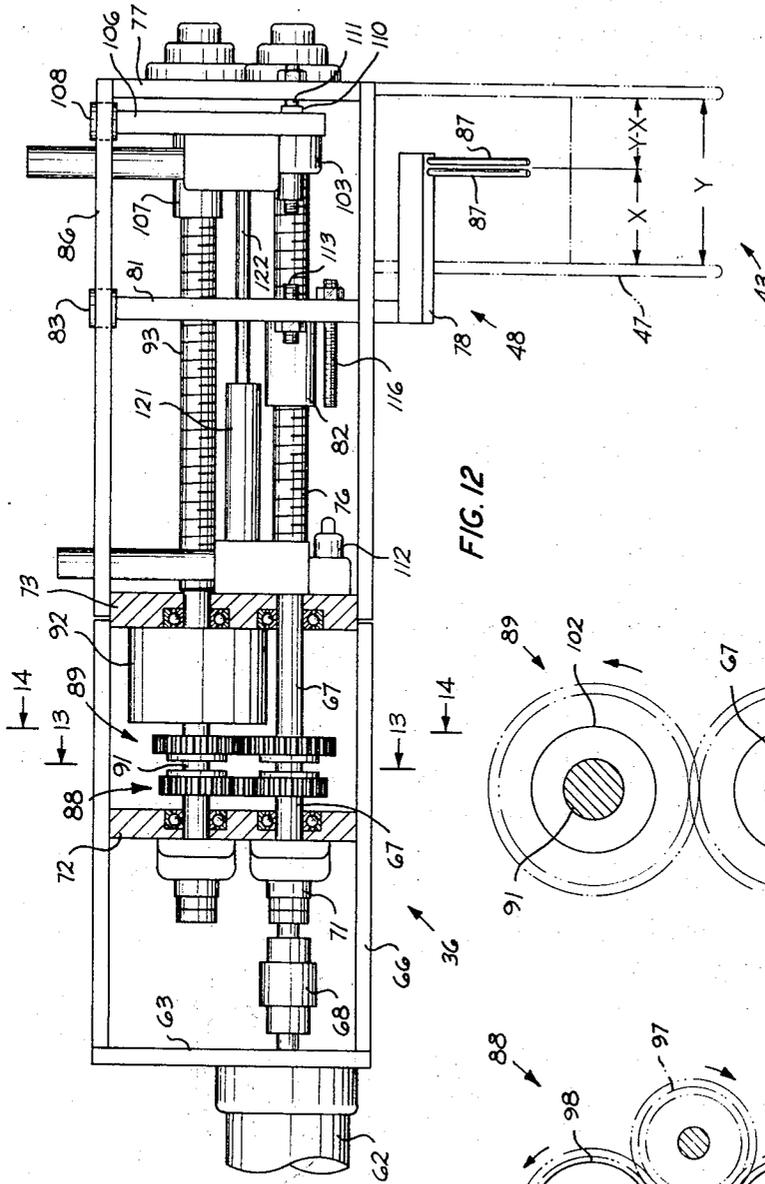


FIG. 12

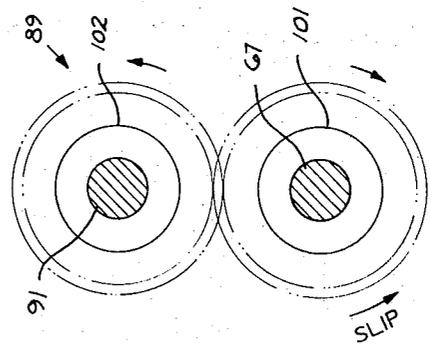


FIG. 14

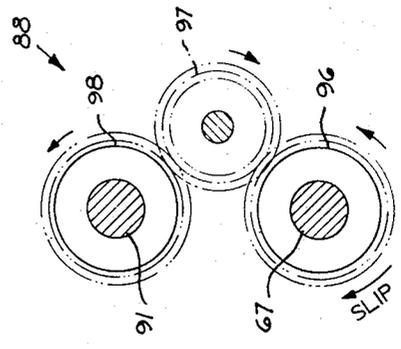


FIG. 13

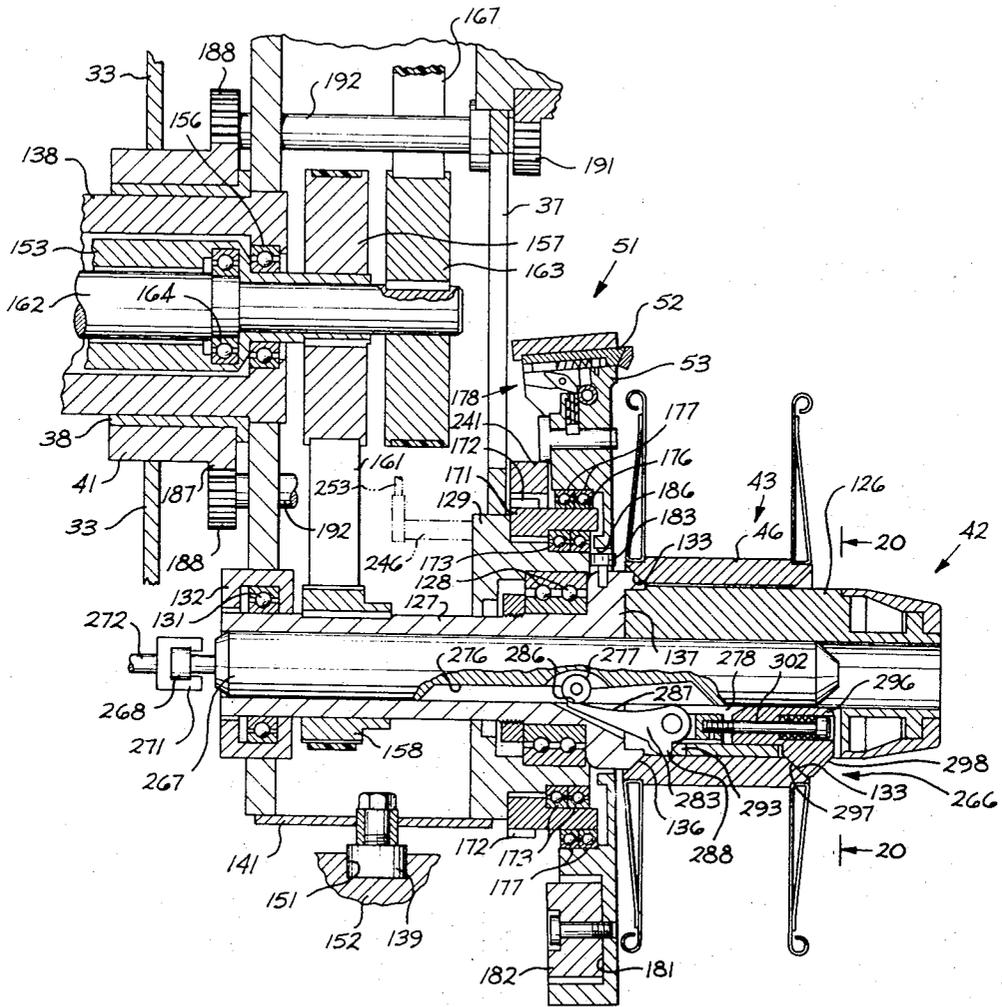


FIG. 15

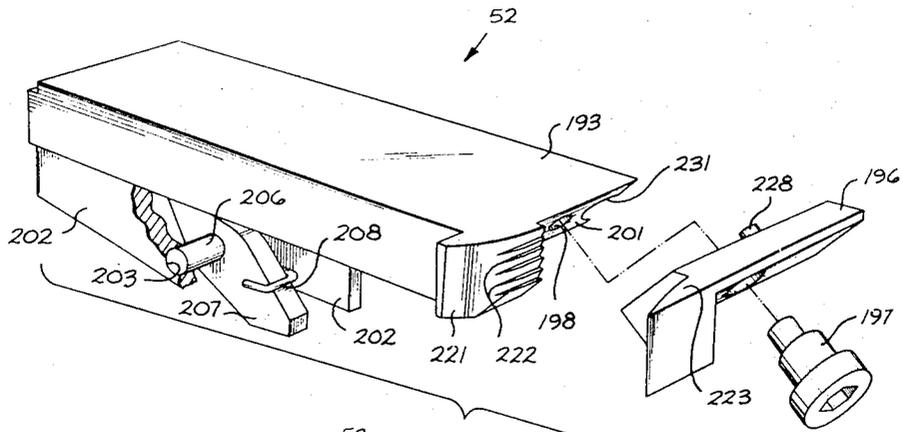


FIG. 16

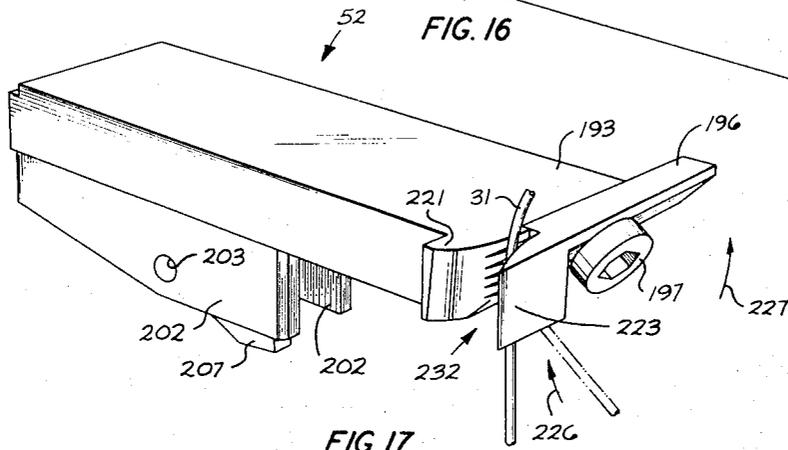


FIG. 17

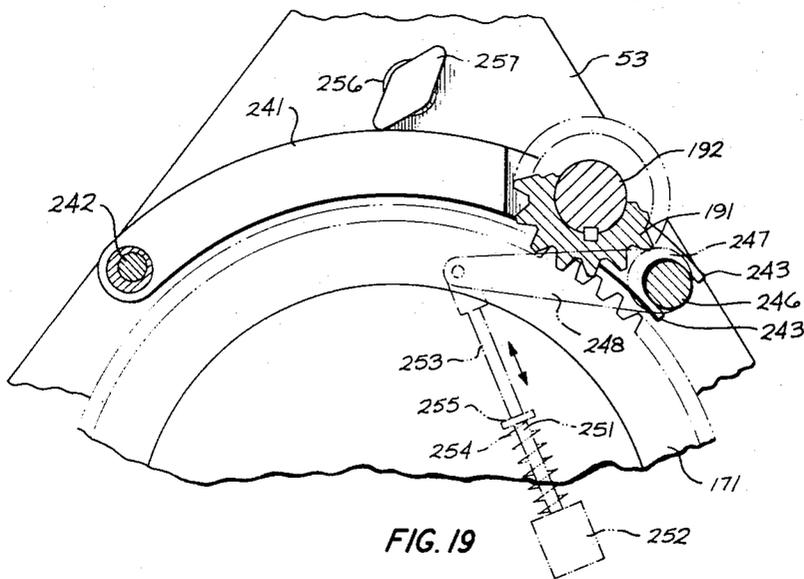


FIG. 19

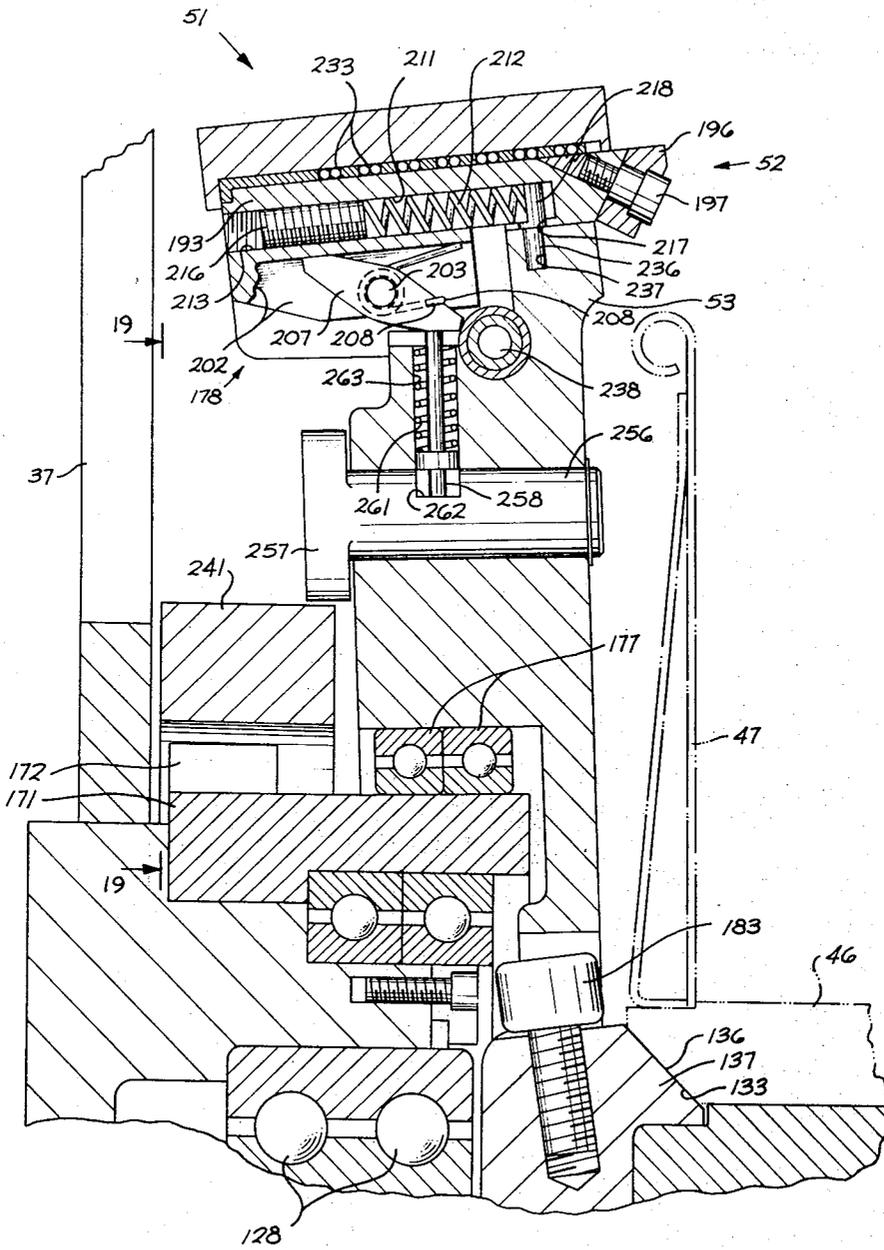


FIG. 18

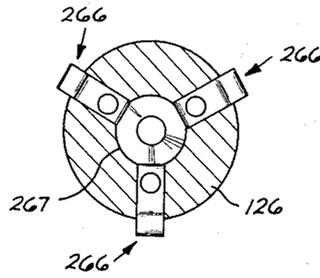


FIG. 20

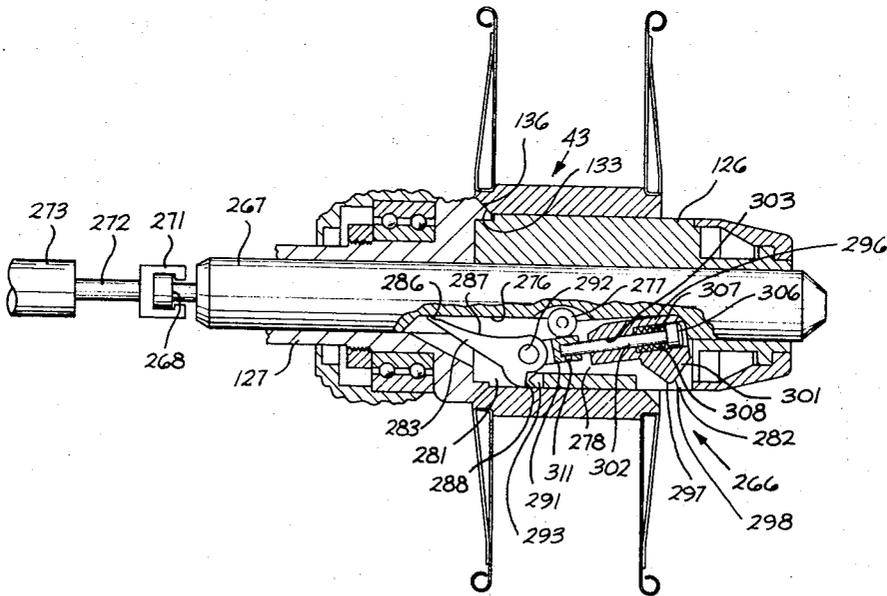


FIG. 21

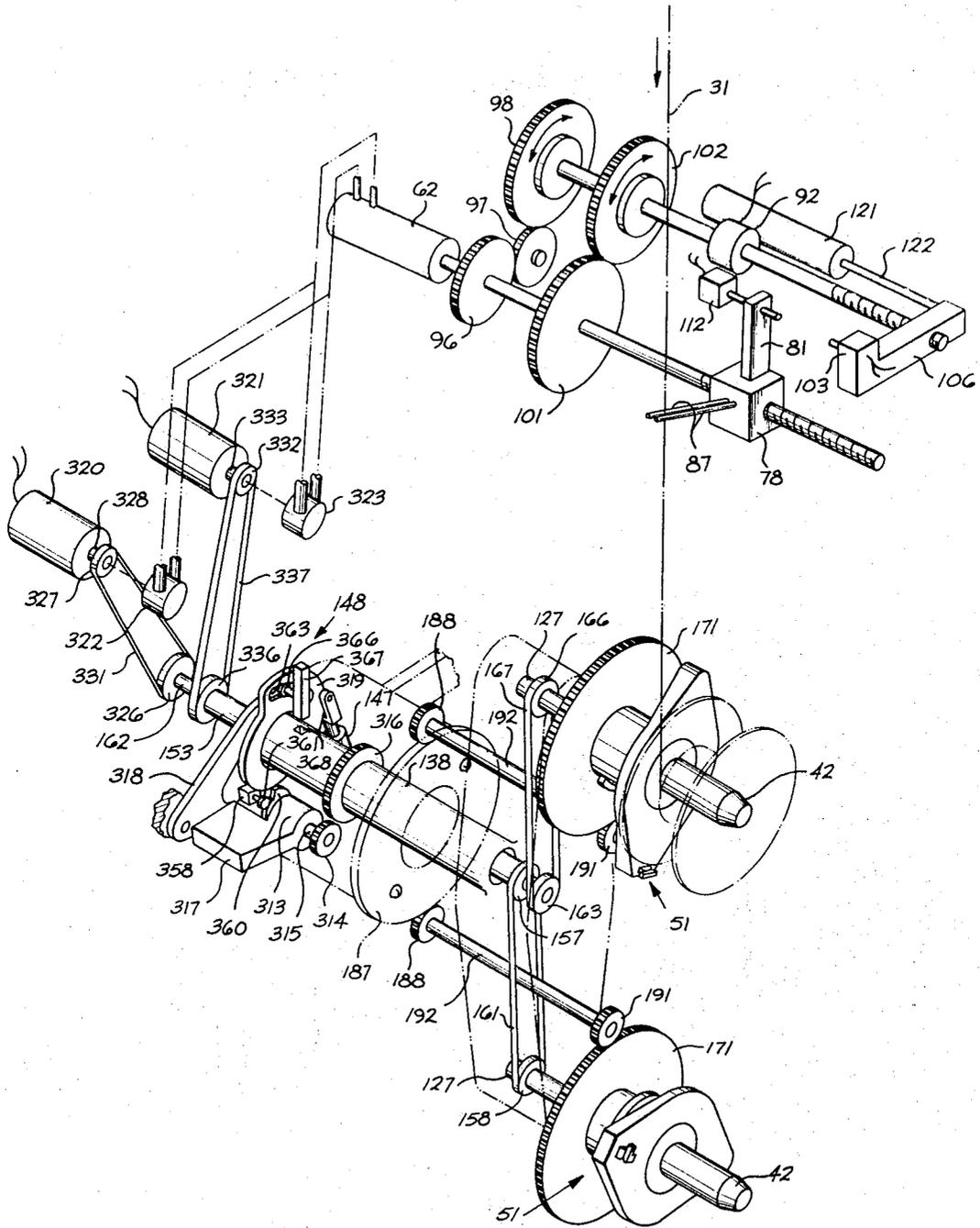


FIG. 22

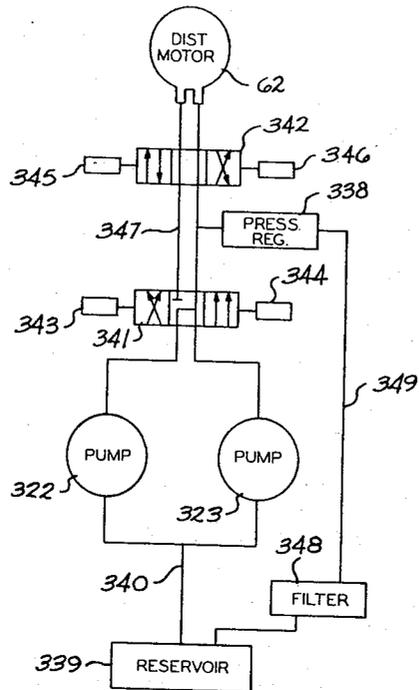


FIG. 23

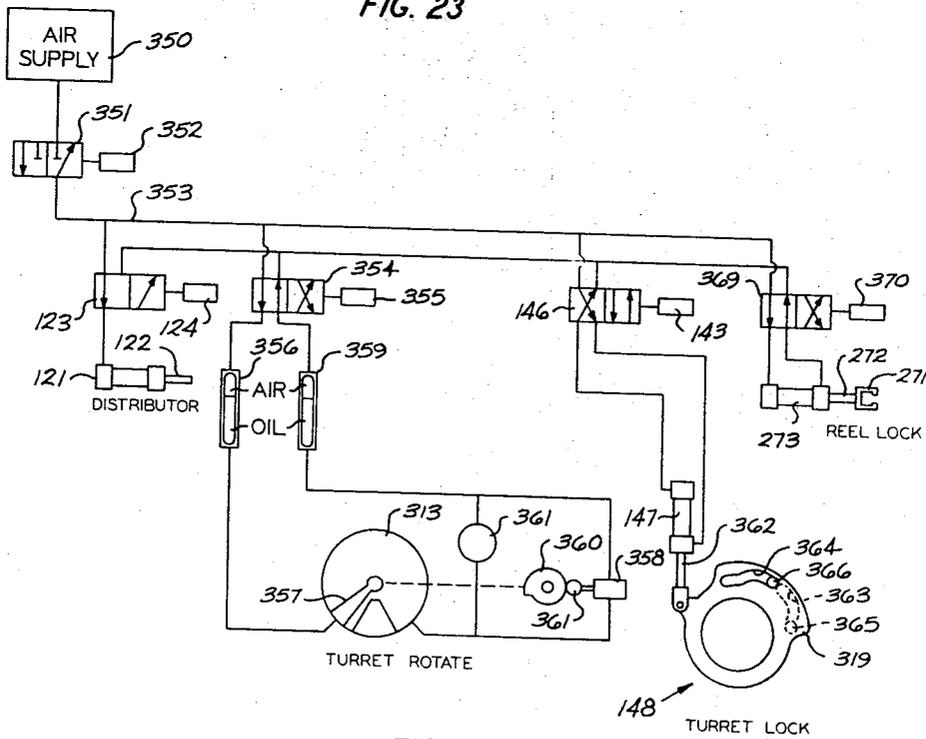


FIG. 24

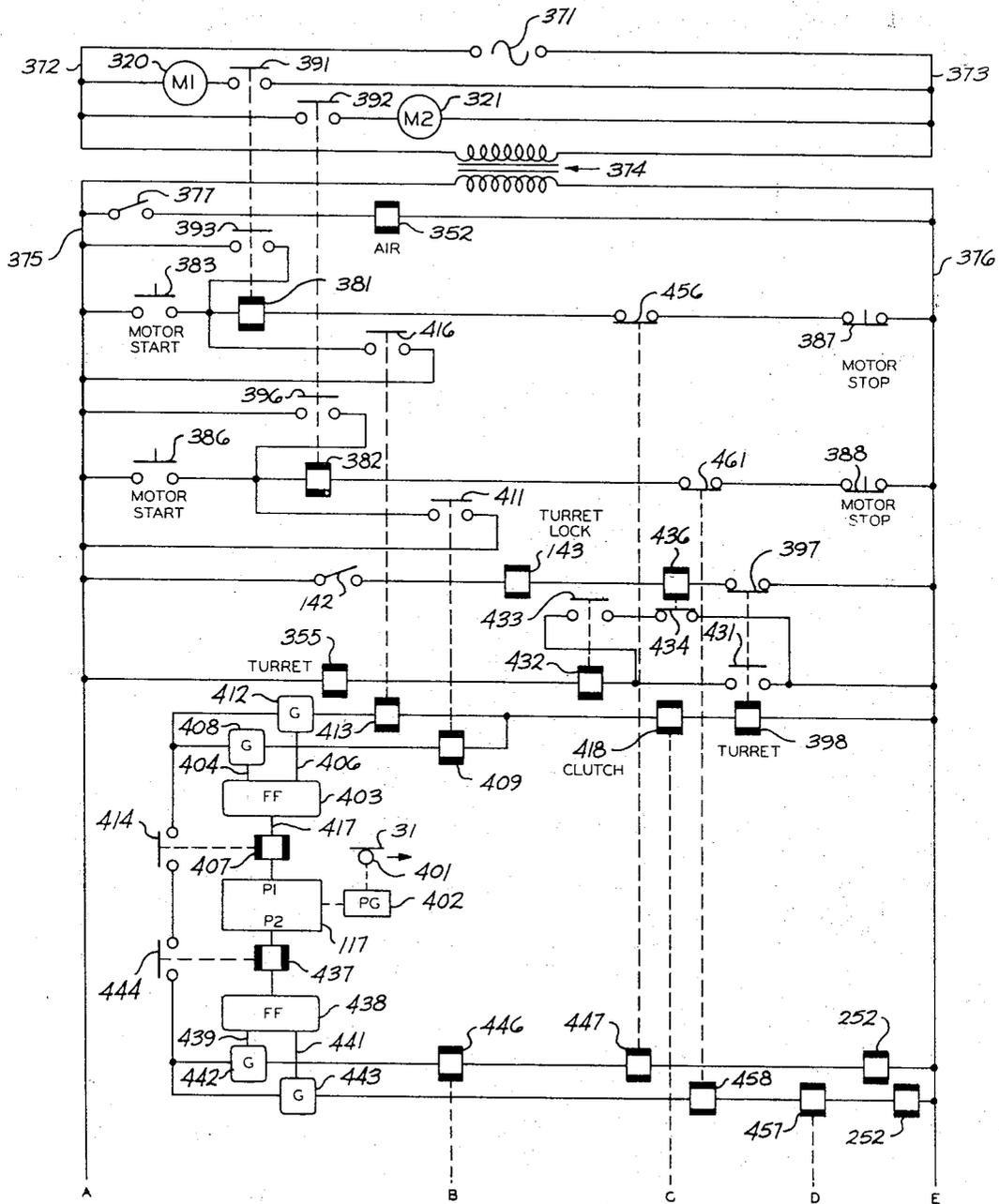


FIG. 25

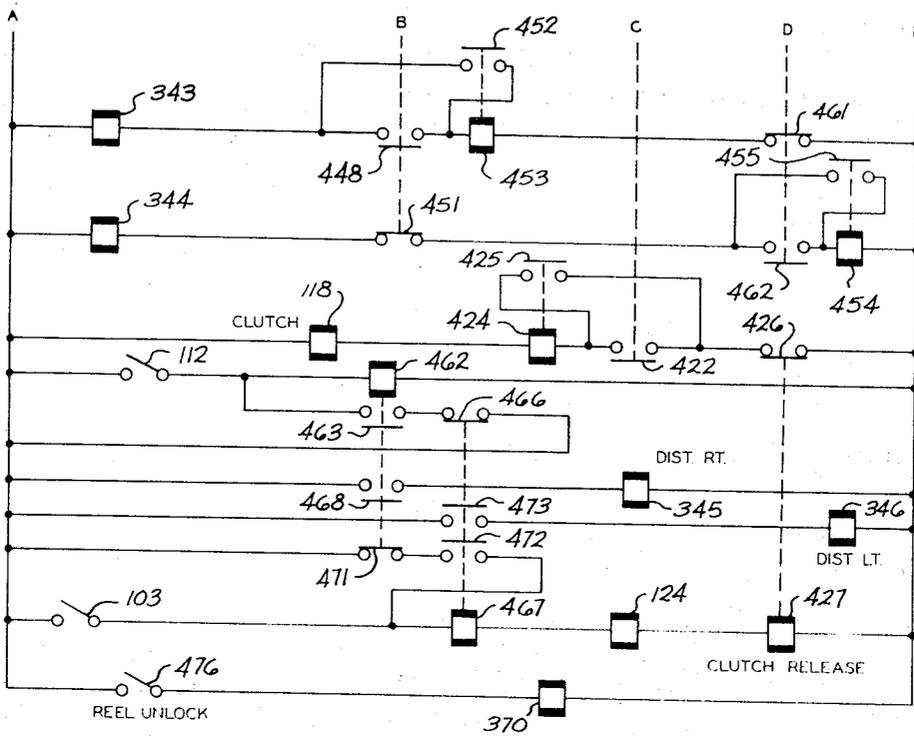


FIG. 26

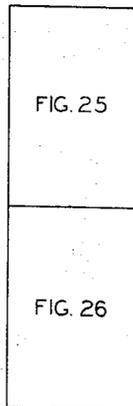


FIG. 27

METHODS OF AND APPARATUS FOR CONTINUOUSLY REELING STRAND MATERIAL

This is a division, of application Ser. No. 150,283 filed June 7, 1971, now U.S. Pat. No. 3,701,471.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to methods of and apparatus for continuously reeling strand material and more particularly to methods of and apparatus for taking up a continuously advancing strand automatically onto a pair of take-up reels releasably secured to a pair of transversely aligned arbors rotatably mounted in cantilever fashion on a centrally pivotable turret.

2. Description of the Prior Art

In the manufacture of strand material, for example, plastic insulated conductor wire, a finished insulated wire is directed continuously from an extruding process at a substantially constant linear speed. In order that the extrusion process may continue without interruption, it is common practice to take up the finished wire onto successive or alternate reels of a strand-reeling apparatus.

When a predetermined length of insulated wire has been wound upon one of the take-up reels, the advancing wire is transferred to an empty take-up reel without interrupting the advancement of the wire emerging from the extruding apparatus. When the reels are aligned transversely, i.e., for rotation about spaced parallel axes, a snagger device may be mounted for rotation adjacent to a flange of each reel. To accomplish transfer of the wire from a full reel to an empty reel or cutover, as it is called, relative movement must occur between the snagger associated with the empty reel and the insulated wire for the former to intercept, sever and capture the latter for subsequent take-up on the empty reel. During this cutover operation it is desirable to avoid a sudden diversion of the path of the wire into the snagger since the stress produced in the wire, especially if it is being advanced at high speed, may be sufficient to cause the wire to break before snagging occurs. For the same reason it is desirable to avoid subsequent contact between a later advanced section of the wire and the snagger after cutover to the empty reel has occurred. In this connection the relative movement between the advancing insulated wire and the snagger must be kept to a minimum. It follows, therefore, that cutover should occur when the wire is closest to the flange of the empty reel adjacent to the snagger. This has been considered the most favorable position for transfer of the wire.

One method of assuring that a wire will be in a favorable position for transfer is to cause the distributor to remain in a fixed position adjacent to the flange of the reel associated with the snagger when the reel taking up the wire is almost full. The use of this method, however, involves the risk of wire tangling and breakage due to the occurrence of wire pile-up at the flange.

Another method of assuring that a wire will be in a favorable position for transfer is to cause the stroke of the wire distributor to be shortened to a path lying towards the flange adjacent to the snagger at a time immediately prior to cutover. The use of this method, however, does not carry an assurance that transfer of the wire will take place when the distance between the

wire and the flange adjacent to the snagger is at a minimum.

It is also desirable to design a take-up apparatus to be compatible with various types of automatic loading and unloading facilities which may be utilized to minimize handling of the reels or the apparatus by an operator and thus avoid the risk of injury to the operator or damage to the reels, the wire or the apparatus.

Finally, it is desirable to provide automatic means for positively locking the rotatable reels in place during the operation of the apparatus and for unlocking the reels to permit easy removal thereof as they are filled.

SUMMARY OF THE INVENTION

One object of the present invention is to provide new and improved methods of and apparatus for reeling strand material.

Another object of the present invention is to provide new and improved methods of and apparatus for taking up a continuously advancing strand onto transversely aligned, rotatable take-up reels.

Another object of the present invention is to provide new and improved methods of and apparatus for distributing strand material onto a take-up reel.

Another object of the present invention is to provide new and improved methods of and apparatus for distributing and winding strand material, such as, for example, insulated conductor wire, on successive reels without stopping the distributing and winding of the material.

Another object of the present invention is to provide new and improved methods of and apparatus for controlling the distribution of strand material onto a take-up reel just prior to and during the time in which the strand is transferred from a full reel to an empty reel.

Another object of the present invention is to provide new and improved methods of and apparatus for distributing a predetermined amount of advancing strand in superimposed layers of convolutions between first and second axial limits on the winding surface of a take-up reel.

Another object of the present invention is to provide new and improved methods of and apparatus for distributing a length of strand substantially equal to one final layer of convolutions thereof between first and second boundaries on the winding surface of a rotating take-up reel.

Another object of the present invention is to provide new and improved methods of and apparatus for gripping an advancing strand.

Another object of the present invention is to provide a new and improved snagging device for a continuous take-up unit.

Another object of the present invention is to provide new and improved methods of and apparatus for snagging an advancing strand guided past a take-up element and in proximity to the periphery thereof.

Another object of the present invention is to provide new and improved methods of and apparatus for effecting the transfer of a moving strand from a first driven reel to a second driven reel aligned transversely with the first reel.

Another object of the present invention is to provide new and improved methods of and apparatus for snagging an advancing strand being distributed onto a take-up reel when a predetermined amount of strand has been taken up on the reel and for winding the snagged

strand onto an empty reel without subsequent risk of breaking the wire.

Another object of the present invention is to provide new and improved apparatus for supporting a hollow cylindrical article.

Another object of the present invention is to provide new and improved apparatus for releasably supporting a reel.

A method of taking up a continuously advancing strand onto first and second transversely aligned take-up reels mounted for rotation about spaced, parallel axes, embodying certain features of the invention, may include driving the first reel, distributing the advancing strand onto the first reel by guiding the strand back and forth across the winding surface of the first reel to wind successive layers of convolutions thereon, driving the second reel, interchanging the positions of the reels to position the second reel along the path of the strand being distributed onto the first reel, altering the distribution of strand onto the first reel in a predetermined sequence wherein the equivalent of the final layer of convolutions of strand is guided onto a part of the winding surface of the first reel, the end of the sequence occurring when the strand is being guided past a predetermined end of the second reel, and transferring the distributed strand from the first reel to the second reel at a time coincident with the end of the sequence.

An apparatus for taking up a continuously advancing strand onto first and second transversely aligned take-up reels mounted for rotation about spaced, parallel axes, embodying certain features of the invention, may include means for driving the first reel, means for distributing the advancing strand onto the first reel by guiding the strand back and forth across the winding surface of the first reel to wind successive layers of convolutions thereon, means for driving the second reel, means for interchanging the positions of the reels to position the second reel along the path of the strand being distributed onto the first reel, means for altering the distribution of the strand onto the first reel in a predetermined sequence wherein the equivalent of the final layer of convolutions of strand is guided onto a part of the winding surface of the first reel, the end of the sequence occurring when the strand is being guided past a predetermined end of the second reel, and means for transferring the distributed strand from the first reel to the second reel at a time coincident with the end of the sequence.

A method of controlling the distribution of a predetermined length of continuously advancing strand onto and traversing the winding surface of a rotating take-up reel reversibly between first and second longitudinally spaced limits, embodying certain features of the invention, may include moving the second limit linearly toward the first limit at a speed substantially equal to the speed of traverse of the strand, reversing the direction of traverse of the strand when it reaches the moving second limit, and terminating the advancement of the strand onto the reel at a time subsequent to the reversal of the strand at the moving second limit when the strand is next adjacent to the first limit.

An apparatus for controlling the distribution of a predetermined amount of continuously advancing strand onto and traversing the winding surface of a rotating take-up reel reversibly between first and second longitudinally spaced limits, embodying certain features of

the invention, may include means for moving the second limit linearly toward the first limit at a speed substantially equal to the speed of traverse of the advancing strand, means for reversing the direction of traverse of the advancing strand when it reaches the moving second limit, and means for terminating the advancement of the strand onto the reel at a time subsequent to the reversal of the strand at the moving second limit when the strand is next adjacent to the first limit.

A method of gripping an advancing strand embodying certain features of the invention may include revolving a snagger about a first axis in an annular path having an axis intersecting the first axis at an angle to oscillate the snagger between a pair of spaced planes perpendicular to the first axis, and imparting relative movement between the advancing strand and the snagger to position the strand in a path between the spaced planes intersecting the path of the revolving snagger to cause the snagger to intercept and grip the strand.

An apparatus for gripping an advancing strand, embodying certain features of the invention, may include a snagger mounted for revolution about a first axis in an annular path having an axis intersecting the first axis at an angle, means driving the snagger for oscillating the snagger between a pair of spaced parallel planes perpendicular to the first axis, means for imparting relative movement between the advancing strand and the snagger to position the strand in a path between the spaced planes intersecting the path of the revolving snagger whereby the snagger intercepts and grips the strand.

An apparatus for supporting a hollow, cylindrical article, embodying certain features of the invention, may include a hollow, generally cylindrical hub having a peripheral article mounting surface formed with an aperture therethrough adjacent to the article mounting surface, means on the hub, longitudinally spaced from the aperture, for abutting an annular edge of the article, a member having a transverse projection formed on a longitudinal body, the member being loosely disposed longitudinally within the hub and confined for limited longitudinal and lateral movement therein with the projection thereon adjacent to the aperture, resilient means associated with the elongated member for urging the member pivotally toward the axis of the hub to urge the projection thereon away from the aperture aligned therewith, an actuator disposed within the hub for axial movement, and means for rendering the actuator operable to move axially within the hub into engagement with the member to pivot the member against the effect of the resilient means away from the axis of the hub to cause the projection to protrude through the aperture to engage a section of an opposite annular edge on the article frictionally to secure the article onto the hub.

BRIEF DESCRIPTION OF THE DRAWINGS

The objects and various features of the invention will be more readily understood from the following detailed description of a specific embodiment thereof when read in conjunction with the accompanying drawings wherein:

FIG. 1 is a front elevational view of a strand take-up apparatus embodying the principles of the present invention;

FIG. 2 is a fragmentary, side elevational view of the apparatus of FIG. 1;

FIG. 3 is a perspective view of part of the apparatus of FIGS. 1 and 2, showing an advancing strand being guided by a distributor and wound upon one of a pair of take-up reels mounted on a pair of arbors supported on a rotational turret;

FIG. 4 is a schematic illustration of the closest and remotest points at which an orbiting snagger, retracted into a rotating snagger support, is proximate to a flange on a take-up reel adjacent to and rotating with the snagger support;

FIG. 5 is a schematic illustration similar to FIG. 4, illustrating the proximity of the orbiting snagger to the flange on the take-up reel after the snagger is moved from a retracted position within the support to an extended position partially without the support;

FIG. 6 is a front elevational schematic illustration of the relative positions of the turret, the take-up reels and a pair of snagger devices during the normal take-up operation;

FIG. 7 is a sectional view of the turret, the take-up reels and the snagger devices taken along lines 7—7 of FIG. 6;

FIG. 8 is a front elevational schematic illustration of the relative positions of the turret, the take-up reels and the snagger devices at a time just prior to cutover from a full reel to an empty reel when the turret has been rotated 180° from the position shown in FIG. 6;

FIG. 9 is a sectional view of the turret, the take-up reels and the snagger devices, taken along the lines 9—9 of FIG. 8;

FIG. 10 is a front elevational schematic illustration of the take-up reels and snagger devices at the instant of cutover;

FIG. 11 is a front elevational schematic illustration of the take-up reels and snagger devices at a time immediately subsequent to cutover;

FIG. 12 is a plan view, partly in section, of the distributor shown in FIGS. 1 to 3, illustrating the manner in which a strand is controlled to assure cutover of the apparatus at the proper time;

FIG. 13 is a sectional view of a first one-way clutch, taken along the lines 13—13 of FIG. 12;

FIG. 14 is a sectional view of a second one-way clutch, taken along the lines 14—14 of FIG. 12;

FIG. 15 is a sectional view of a supporting arrangement for the turret and a rotatable reel mounting arbor of the apparatus of FIG. 1, taken along lines 15—15 of FIG. 2;

FIG. 16 is an exploded perspective view of a snagger associated with the take-up apparatus;

FIG. 17 is a perspective view of the snagger of FIG. 14 in an assembled condition illustrating the manner in which a strand may be gripped thereby or removed therefrom;

FIG. 18 is a sectional view of one of the rotatable snagger devices illustrating a portion of a mechanism for actuating a snagger;

FIG. 19 is a sectional view of the remainder of the snagger actuating mechanism taken along the lines 19—19 of FIG. 18;

FIG. 20 is a sectional view of three mechanisms for locking a reel onto an arbor taken along the lines 20—20 of FIG. 15;

FIG. 21 is a sectional view of an arbor illustrating the manner in which one of the locking mechanisms is actuated for releasing a reel from an arbor;

FIG. 22 is a perspective view of the drive system for the distributor, the turret and the arbors associated with the take-up apparatus of the invention;

FIG. 23 is a schematic representation of a hydraulic control system for a strand-reeling apparatus in accordance with the principles of the invention;

FIG. 24 is a schematic representation of a pneumatic system for a strand-reeling apparatus in accordance with the principles of the invention;

FIGS. 25 and 26, taken together, represent a schematic representation of an electrical control system for a strand-reeling apparatus in accordance with the principles of the invention, and

FIG. 27 illustrates the manner in which FIGS. 25 and 26 are to be combined.

DETAILED DESCRIPTION

1. General Description of the Take-up Operation

Referring now to FIGS. 1, 2 and 3, there is shown a take-up apparatus, generally indicated at 30 for taking up an advancing strand 31 continuously. The strand 31 may be, for example, an insulated wire, advanced at a substantially constant relatively high speed from an insulation extruder (not shown) by a conventional motor drive (not shown).

The apparatus 30 includes a flat, rigid base plate 32 for supporting a frame 33 upon which is mounted a wire distributor 36 and a centrally pivotable support arm or turret 37. The turret 37 is journaled in a sleeve bearing 38 mounted in a hub 41 secured to the frame 33, for rotation about a central axis C. A pair of transversely aligned, reel-supporting spindles or arbors 42—42 are mounted in cantilever fashion on turret 37 for rotation about spaced axes which are parallel to the axis C of the turret 37.

A pair of identical take-up reels 43—43, each comprising a cylindrical winding surface or drum 46 and a pair of flanges 47—47 secured fixedly at opposite ends of the drum 46, are mounted on arbors 42—42 and are rotatable therewith. As will become more apparent from the following description, locking means associated with each arbor 42 releasably secure each reel 43 thereon.

The distributor 36 includes a traversible strand guide 48 which is reciprocated horizontally to guide the advancing insulated wire 31 across the drum 46 of the reel 43 in the upper position on the turret 37 adjacent to the distributor 36 to distribute successively advanced sections of insulated wire 31 in superimposed layers of convolutions on the upper reel 43.

A triggerable snagger device 51 is mounted at a supported end of each arbor 42 and is rotatable therewith. Each snagger device 51 includes a snagger clamp or snagger 52 normally maintained in a retracted position within a snagger support 53 which rotates with its associated arbor. Each snagger support 53 is mounted at a predetermined angle with respect to the axis of each arbor 42 (see FIGS. 4 and 5) to orbit each snagger 52 about an axis of revolution which intersects the axis of the arbor 42 but is not axially coincident therewith. The snagger 52 is positioned at a slightly greater radial distance from the axis of arbor 42 than the peripheral edge of the flange 47 on the reel 43 adjacent thereto.

As seen from FIG. 4, during its orbital movement the retracted snagger 52 traverses from a point in a plane 56 approximately flush with the outside face of flange 47 to a point in a plane 57 approximately flush with the

inside face of the flange 47. Similarly, as seen from FIG. 5, the snagger 52 may be triggered to move out of the support 53 from its retracted position therein into an extended position, to traverse, while it orbits, from a point in a plane 58 approximately flush with the inside face of reel flange 47 to a point in a plane 61 spaced from the inside face of flange 47.

FIGS. 6 to 11, inclusive, illustrate schematically a series of steps in an exemplary cutover operation wherein the advancing insulated wire 31 is transferred from a full reel to an empty reel to continue taking up wire 31. During normal operation (FIGS. 6 and 7) one reel 43 is in an active condition on the upper part of turret 37, taking up wire 31. When the active reel 43 is nearly full, e.g. when an amount of accumulated strand equal to a predetermined amount of wire less than the amount desired to constitute a full reel is detected by a footage counting system, turret 37 is rotated 180° to revolve the active reel 43 to a lower loading and unloading position (FIGS. 8 and 9) 180° away from its former position. At the same time a passive or empty reel 43 is revolved from the lower loading and unloading position into the upper position formerly occupied by the active reel 43. At this time the active reel 43 continues to rotate in the lower position on turret 37 to continue taking up insulated wire 31, now passing across drum 46 of the empty reel 43, which is acceleratedly driven to ultimate take-up speed.

As set forth in detail in the following description, when a predetermined amount of wire 31, representative of a full reel, has been taken up on the active reel 43 a footage counter detects this condition and triggers the snagger 52 associated with the empty reel 43 to extend the snagger 52 outwardly into the path of the wire 31 passing in proximity to the reel flange 47 adjacent to the snagger device 51 to intercept, grip and break the connection of the wire 31 to the full reel 43 at a point between the reels 43-43 (FIGS. 10 and 11).

The distributor 36 is operated to alter the movement of the strand guide 48 to position the path of travel of the wire 31 near the flange 47 of the empty reel 43 adjacent to the snagger 52 just prior to the time that the latter is triggered to insure that cutover occurs at the moment when the predetermined amount of wire 31 is taken up on the full reel 43.

After cutover takes place, subsequently advanced sections of wire 31 are wound onto the newly activated formerly empty reel 43 in the upper position on turret 37. Since the wire 31 only approaches the newly activated reel 43 from a side thereof opposite the side on which the snagger 52 caught the wire 31, i.e., from the side of the reel nearest to the distributor 36, and since the snagger 52 is traversed away from adjacent flange 47 when it is orbited to that side of the reel, there is no need to retract the snagger 52 after it is triggered to prevent it from re-snagging the oncoming wire. The full reel 43 in the lower position on turret 37 is then stopped from rotating and removed from the arbor 42 and a new empty reel is loaded thereon to await the next cutover cycle. Since the loading and unloading of the reels 43-43 on arbors 42-42 takes place in the lower position on turret 37, the arrangement may be used with various types of automatic reel loading and unloading facilities.

2. Automatic Take-up Apparatus

A. Distributor Assembly

Referring now to FIG. 12, the distributor 36 includes a reversible fluid-operated motor 62 secured to a left end support 63 of a housing 66. The motor 62 is coupled to a drive shaft 67 through sleeve couplings 68 and 71. The drive shaft 67 is rotatably supported in suitable bearings mounted in a pair of cross braces 72 and 73 and is coupled to one end of a first device screw 76 rotatably supported at its other end in a suitable bearing mounted in a right end support 77 of housing 66. The strand guide 48 includes a roller support plate 78 secured to a movable support arm 81 fastened to a threaded sleeve 82, threadedly mounted for reciprocating movement along drive screw 76. A roller 83 on arm 81 engages the underside of a side brace 86 on housing 66. A pair of spaced guide rollers 87-87 are rotatably mounted on the support plate 78 for guiding the advancing insulated wire 31 therebetween and reciprocally onto the winding drum 46 of a rotating take-up reel 43.

A pair of spaced, gear-driven first and second one-way clutches, generally indicated at 88 and 89 respectively, are mounted adjacent to one another on drive shaft 67. Clutches 88 and 89 are operatively coupled to a second drive shaft 91 rotatably supported at one end in suitable bearings in cross brace 72 and coupled at the other end through a selectively actuatable third clutch 92 to a second drive screw 93, rotatably mounted in suitable bearings in cross brace 73 and the right end support 77 of housing 66. The one-way clutches 88 and 89 function to convert the reversible rotary movement of the shaft 67 by the motor 62 to substantially continuous, unidirectional, rotary movement of the shaft 91 such that the shaft 91 always rotates in the same direction, regardless of the direction of rotation of shaft 67.

The conversion of the reversible movement of the shaft 67 into unidirectional movement of the shaft 91 is accomplished by arranging each of the one-way clutches 88 and 89 to slip when shaft 67 is rotated in a first direction and to rotate shaft 91 counterclockwise when shaft 67 is rotated in a second opposite direction. As illustrated in FIGS. 13 and 14, a gear 96 of clutch 88 is arranged to slip in response to clockwise rotation of shaft 67 and to couple shaft 67 to shaft 91 through gears 97 and 98 to rotate shaft 91 counterclockwise in response to counterclockwise rotation of shaft 67. Conversely, a gear 101 of clutch 89 is arranged to slip in response to counterclockwise rotation of shaft 67 and to couple shaft 67 to shaft 91 through a gear 102 to rotate shaft 91 counterclockwise in response to clockwise rotation of shaft 67. Thus clutches 88 and 89 function to rotate shaft 91 counterclockwise in response to any rotational movement of shaft 67.

A first control limit switch 103 is mounted on an arm 106 secured to a threaded sleeve 107 threadedly mounted for movement along the drive screw 93. Threaded sleeve 107 and drive screw 93 are formed with the same pitch or lead per revolution as threaded sleeve 82 and drive screw 76, respectively. Arm 106, having a roller 108 thereon which engages the underside of brace 86, is formed with a pad 110 thereon normally engaging a stop 111 in right end support 77. Limit switch 103 is normally positioned adjacent to the right end support 77 of housing 66 at a spaced distance from a second control limit switch 112 fixedly mounted on the cross brace 73. During normal operation of the distributor 36, the support arm 81 is driven along and

by the drive screw 76 until either of two switch actuators 113 or 116 fastened on opposite sides of arm 81 actuates control limit switch 103 or 112, respectively aligned therewith, alternately to reverse the direction of distributor motor 62 and thus reverse drive screw 76 to impart conventional reciprocating movement to the strand guide 48 to guide an advancing wire 31 through guide rollers 87-87 to distribute wire 31 evenly onto the winding drum 46 of a take-up reel 43 between flanges 47-57 thereof.

The third clutch 92 is normally disengaged to maintain the drive screw 93 in a nondriven condition to maintain the limit switch 103 in a nonmoving position adjacent to the right end support 77.

As mentioned previously, in order to initiate the snagging operation, the insulated wire 31 must be in a position immediately adjacent to the leftmost flange 47 of the take-up reel 43 adjacent to the snagger device 51. To insure the timely occurrence of this condition, a footage counting system or counter 117 (FIG. 25) is actuated when a predetermined length of wire representing one final layer of convolutions thereof remains to be taken up by the reel 43 in the upper active position on turret 37. The counter 117 continuously monitors the length in feet of the wire 31 wound upon the active take-up reel 43. At a time when the count on the counter 117 indicates that a predetermined amount of insulated wire 31 remains to be taken up to make a full reel, a first preset signal is generated on an output P1 of the counter 117 which alters the operation of the distributor 36 to insure that the wire 31 is in a position near to the reel flange 47 associated with the snagger device 51 at the time the snagging operation is to occur.

To illustrate the operation of the distributor 36, it is assumed that the strand guide 48 is being reciprocated normally in reverse directions along a rectilinear path having a length Y equal to the width of a reel 43 between flanges 47-47, if lead angles are neglected, when counter 117 generates a signal on output P1. At this time the support arm 78 can be traveling either to the right or to the left in FIG. 12 and the turret 37 is rotated 180° to position the almost full reel below the empty reel.

For the purpose of this illustration it is assumed that 1,000 feet of wire remains to be taken up when the counter 117 generates a signal on output P1 and that one complete layer of convolutions of wire 31 in substantially the last full layer thereof is substantially equal to 1,000 feet. It is desired to complete the take-up of this final 1,000 feet of wire 31 at the leftmost flange 47 of the empty reel 43. Since the reels 43-43 are transversely aligned, passage of wire 31 near the left flange of either reel occurs at the same time. The advancing wire 31 therefore, and thus the strand guide 48, must be traversed a distance Y across the reel 43 and end up at the leftmost flange 47.

If strand guide 48 is traveling to the right when the counting system 117 indicates that an additional 1,000 feet of wire is needed to complete the almost full reel 43, a signal on output P1 of counter 117 energizes a solenoid 118 (FIG. 26) to actuate the clutch 92 to drive the second drive screw 93 through driven shaft 67, clutch 88 and shaft 91 to move the limit switch 103 toward the limit switch 112. Since the relationship between drive screw 93 and sleeve 107 is identical to the relationship between drive screw 76 and sleeve 82, the

arm 106 is driven by drive screw 93 at the same rate of speed with which the arm 81 is driven by drive screw 76. If, as shown, the distance between the guide rollers 87-87 on the support plate 78 to the left flange 47 of reel 43 is X, the strand guide 48 will continue to be moved to the right until it has traveled a distance

$$Y-X/2$$

when the actuator 113 on arm 81 engages the moving limit switch 103 to reverse drive screw 76. The strand guide 48 is then moved to the left through a distance

$$Y-X/2 + X$$

to a position immediately adjacent to the left flange 47. At this time the strand guide 48 has traveled a total distance of

$$Y-X/2 + Y-X/2 + X$$

which is equal to Y from the time the clutch 92 was actuated by the counter 117, representing substantially one complete layer of convolutions of wire 31 on the reel 43. Since this layer of convolutions is assumed to equal 1,000 feet, the occurrence of a completed reel takes place precisely adjacent to the leftmost reel flange 47. At this time the counter 117 generates a signal on a second preset output P2 thereof to initiate the snagging operation, described in detail below.

When the actuator 113 on the support arm 81 engages the moving limit switch 103, the clutch 92 is deactuated to cease coupling the shaft 91 to the second drive screw 93 and a pneumatic cylinder 121, having a movable piston 122 in engagement with the limit switch 103 is actuated to return the limit switch 103 to its normal position adjacent to the end support 77. Since clutch 92 is disengaged, the actuating screw 93 is free to be rotated clockwise by the return movement of the movable limit switch 103 under the control of cylinder 121.

As will become more apparent from the description below with respect to FIGS. 24, 25 and 26, cylinder 121 is actuated by a spring-return solenoid-operated control valve 123 under the control of a solenoid 124 energized each time limit switch 103 is actuated by switch actuator 116. The actuation of cylinder 121, however, is effective to move switch 103 only at those times when switch 103 is away from end support 77.

If the first present signal output P1 is energized when the strand guide 48 is moving to the left, with the guide rollers 87-87 at a distance X from the left reel flange 47, the clutch 92 is actuated to rotate the second drive screw 93 and move arm 106 and the limit switch 103 thereon toward the limit switch 112 at the same rate of speed with which the support arm 81 and strand guide 48 is moved by drive screw 76. In this case the strand guide 48 continues to travel to the left until the actuator 116 on support arm 81 engages the fixed limit switch 112 to reverse the direction of drive screw 76. At this time the strand guide 48 and the moving limit switch 103 both have traveled a distance

$$X.$$

The strand guide 48, thereafter, is caused to move to the right through a distance

$$Y-X/2$$

when the actuator 113 engages the moving limit switch 103 to cause the drive screw 76 to be reversed to re-

verse the direction of the strand guide 48 which then is driven to the left. As previously mentioned, the actuation of the moving limit switch 103 causes the clutch 92 to be deactuated to cease driving the second drive screw 93 and the cylinder 121 is actuated to return the limit switch 103 to its normal position adjacent to the end support 77. The strand guide 48 continues moving to the left, until the wire 31 is in a position immediately adjacent to the leftmost flange 47 of reel 43, traveling through a distance

$$Y-X/2$$

The total distance thus traveled by the strand guide 48 from the time the clutch 92 was actuated by the counter 117 is

$$X + Y - X/2 + Y - X/2$$

which is equal to Y, representing substantially one complete layer of convolutions of wire 31 on the reel 43. In this case, as in the one previously mentioned, the occurrence of the completed reel occurs when the path of the wire 31 is precisely adjacent to the leftmost flanges 47—47 of reels 43—43. At this time a signal is generated on the second preset counter output P2 to initiate the operation of the snagger device 51.

Thus it is seen that the distributor 36 may be controlled to insure that the path of the wire 31 being taken up is adjacent to the left flange 47 of the reel 43 adjacent to the snagger device 51 at the time of cut-over.

B. Turret and Arbor Assembly

Referring to FIG. 15, each arbor 42 includes a hub 126 secured to a hollow shaft 127 mounted for rotation in bearings 128—128 in a hub 129 and bearings 131 mounted in a sleeve 132, both aligned with one another and formed in turret 37. A reel 43 may be mounted on hub 126 with a bevelled interior face 133 of drum 46 in frictional engagement with a chamfered edge 136 of a flange 137 formed on the hollow shaft 127.

A central hub 138 formed in the turret 37 is journaled in the sleeve bearing 38 disposed in the hub 41 on the frame 33. Each end of the turret 37 is provided with a roller bearing 139 fastened to a plate 141 secured to each end of the turret 37. Each bearing 139 is designed to perform one of two functions, dependent upon the position of the turret end associated therewith. The bearing 139 at the end of the turret 37 in the upper position engages a microswitch 142 when the turret is vertically aligned as shown in FIGS. 1 to 3. Microswitch 142 controls a solenoid 143 (FIGS. 24 and 25) which selectively operates a valve 146 to actuate a pneumatic cylinder 147 which causes a turret lock 148 (FIGS. 22 and 24) to lock turret 37 from rotational movement and to disengage the driving means therefor. The bearing 139 in the lower position on vertically aligned turret 37 is received in a slot 151 on a support 152 secured to base plate 32 to prevent lateral movement or cambering of turret 37.

A hollow shaft 153 is journaled in a set of bearings 156 mounted in central hub 138. A pulley 157 keyed to hollow shaft 153 is drivably connected to a pulley 158 keyed to hollow shaft 127 through a timing belt 161. Rotational movement of shaft 153 is imparted to arbor 42 through pulley 157, pulley 158 and shaft 127.

A solid shaft 162, coaxial with shaft 153, is journaled in bearings 164 mounted in hollow shaft 153. A pulley

163 keyed to solid shaft 162 is drivably connected to a pulley 166 (FIG. 22), similar to pulley 158 and keyed to the shaft 127 associated with the oppositely aligned arbor 42, through a timing belt 167. Rotational movement of shaft 162 is imparted to arbor 42 through pulley 163, pulley 166 and shaft 127.

C. Snagger Assembly

FIG. 15 shows a snagger support gear 171, having circumferentially spaced teeth 172—172, and mounted for rotation on bearings 173—173 on hub 129 of turret 37. Gear 171 is formed with an eccentric peripheral bearing seat 176 having a circumferential surface canted with respect to the circumferential surface defined by the spaced teeth 172—172. More specifically, the centerline or central axis of the bearing seat 176 on gear 171 intersects the central axis of the teeth 172—172 thereof at an approximate angle of 1° counterclockwise from a horizontal reference in FIG. 15. One gear 171 is associated with each arbor 42 but is not drivably connected thereto. Though each gear 171 is rotatable about an axis through its associated arbor 42, and the central axis of bearing seat 176 on gear 171 generates a right circular conical locus about an axis through arbor 42, the rotation of gear 171 is independent of the rotational movement of arbor 42.

Snagger support 53 is rotatably mounted on bearings 177—177 mounted on the eccentric bearing seat 176 of gear 171. Snagger support 53 therefore assumes a canted orientation with respect to a plane normal to the central axis of arbor 42 and the central axis of turret 37. More specifically, the principal plane of snagger support 53 is tilted counterclockwise at an angle of approximately 1° from a vertical reference in FIG. 15.

One end of snagger support 53 is formed with an opening 178 for receiving the snagger 52. An opposite end of snagger support 53 is formed with a slot 181 for receiving a weight 182 fastened therein to counterbalance the snagger 52. A roller 183 rotatably mounted on a peripheral section of the flange 137 on shaft 127 extends into an aperture 186 formed in snagger support 53. Rotation of hollow shaft 127 causes roller 183 to bear against an adjacent edge of the aperture 186 to rotate snagger support 53 with the arbor 42. As previously mentioned, the snagger support 53 rotates with arbor 42 and at an angle with respect to the axis thereof to oscillate the snagger 52 toward the reel 43 on arbor 42 when snagger 52 is below a horizontal plane through the axis of arbor 42 and away from reel 43 when the snagger 52 is above a horizontal plane through the axis of arbor 42.

In order to maintain the canted orientation of the snagger device 51, the central axis of the bearing seat 176 on gear 171 must be maintained at a constant angle to a horizontal reference plane; otherwise a 180° rotation of the turret 37 will position the gear 171 in an inverted position from that shown in FIG. 15 with the result that the orbiting snagger 52 will oscillate toward the reel 43 on arbor 42 when the snagger 52 is in a position above a horizontal plane through the axis of arbor 42. The occurrence of the foregoing condition would create the risk of interference with or re-snagging of the wire 31 being distributed onto the reel 43 at a time subsequent to cutover. To prevent the foregoing condition from occurring, the apparatus must be arranged such that for each increment of rotation of the turret 37, gear 171 must be rotated an equal increment in the

opposite direction to compensate for the rotation of turret 37. Stated otherwise, each gear 171 must be arranged for resultant translational movement with respect to the remainder of the apparatus. The compensation for each gear 171 is accomplished by connecting 5 a sun gear 187 (FIGS. 15 and 22), fixedly secured to frame 33, to each gear 171 through a planetary gear 188 and a connecting gear 191 mounted on a shaft 192 extending through and journaled in the sides of turret 37. The gears 187, 188, 191 and 171 are arranged to provide a 1:1 ratio between gears 187 and 171. 10

As seen most clearly in FIG. 22, any rotary movement of turret 37 about central axis C will cause planetary gears 188—188 to undergo epicycloidal movement with respect to sun gear 187, thus rotating connecting gears 191—191 and the snagger support gears 171—171 connected thereto. Thus for every increment of rotation of turret 37 about central axis C, there is a corresponding increment of rotation in the opposite direction of gears 171—171 to keep the snagger devices 51—51 properly canted with respect to arbors 42—42 and reels 43—43 thereon. 20

The structure of each snagger 52 is illustrated in FIGS. 16 and 17. The snagger 52 includes a block 193 and a clamp 196, pivotally secured to the block 193 by a partially threaded shoulder screw 197 fastened in a threaded aperture 198 formed in a bevelled surface 201 formed on block 193. The block 193 is formed on its underside with a pair of spaced retaining members 202—202 each formed with an aperture 203 there- 25 through for receiving a pivot pin 206 which supports a pivot element 207. The pivot element 207 is normally biased clockwise by a torsion spring 208 with one end of the element 207 in abutting engagement with the underside of block 193. As shown in FIG. 18, block 193 is also formed with a bore 211 for receiving a compression spring 212 and a threaded counterbore 213 for receiving a removable stop 216 threaded therein and engaging spring 212. A slot 217 is formed in the underside of the block 193 communicating with the bore 211 for receiving a pin 218 press-fitted therein. 30

Referring once again to FIGS. 16 and 17, one end of the block 193 is formed with a laterally projecting, semiarcuate gripping jaw 221 having a series of serrations 222 formed on the arcuate portion thereof. The clamp 196 is formed with a corresponding semiarcuate gripping jaw 223 having a relatively smooth arcuate surface. When the snagger 52 is not being removed, the clamp 196 assumes an offset, pivoted position clockwise about the axis of screw 197 in the direction of arrow 226 shown in FIG. 17. When the snagger 52 is being revolved due to rotation of the snagger support 53, centrifugal force causes the clamp 196 to pivot counterclockwise in the direction of arrow 227 until a pin 228 mounted therein engages an arcuate notch 231 in the block 193 to prevent further pivoting. At this time the jaws 221 and 223 are aligned to form a strand-receiving opening 232. 40

The snagger 52 is constructed to be moved into the path of the wire 31 to receive it in opening 232 to grip the wire 31 securely between the jaws 221 and 223. When it is desired to remove the wire 31 from the snagger 52, it is merely necessary to remove the reel 43 upon which the wire is wound by sliding the reel off of the arbor 42 supporting the reel. Removal of the reel will cause a force to be exerted on the wire 31, as shown in phantom in FIG. 17, to separate the jaws 221 45

and 223 to pull the wire 31 free from the opening 232 between the jaws and around the smooth arcuate surface of the jaw 223. Thus the snagger 52 is provided with a self-cleaning capability which automatically releases the gripped section of the wire 31 without operator assistance in the release operation.

Referring to FIG. 18, each snagger 52 is slidably disposed in bearings 233-233 mounted in the opening 178 formed in the snagger support 53. The snagger 52 is normally biased into a retracted position within the support 53 by the action of the spring 212 against pin 218 which has a shank portion 236 disposed in a bore 237 formed in support 53. The pivot element 207, aided by torsion spring 208, normally abuts a steel roll 238 to lock the snagger 52 in its retracted position. 15

An arcuate cam lever 241 (FIGS. 18 and 19) is one of a pair thereof, pivotally mounted at each end of the turret 37 by a pivot pin 242. The opposite end of the lever 241 is formed with bifurcations 243—243 for receiving a revoluble eccentric disc 246. As shown in FIG. 19, the disc 246 is secured eccentrically to a shaft 247 coupled to a linkage member 248 connected to a movable armature 251 of a solenoid 252 by a connecting rod 253. The solenoid 252 may be secured to the inside wall of turret 37. A tension spring 254 disposed between the solenoid 252 and a stop 255 on rod 253 normally acts to bias the rod 253 upward and to the left (FIG. 19) to pivot linkage member. The solenoid 252, associated with each snagger device 51, may be energized selectively to rotate shaft 247 partially about its axis to rotate eccentric disc 246, to pivot the lever 241 about pin 242. When the solenoid 252 is de-energized the lever 241 is automatically returned to its normal unpivoted position by the action of spring 254. 20

During normal operation when the snagger support 53 is rotated, it passes, for a portion of its path, adjacent to the cam lever 241. As shown in FIGS. 18 and 19, a detent member 256, having a flanged end 257, is rotatably supported in the snagger support 53. The lower part of the flanged end 257 is spaced from the arcuate surface of lever 241 when the snagger support 53 passes adjacent to lever 241. When the counting system 117 generates a signal on output P2 thereof indicating that an amount of wire representative of a full reel thereof has been taken up onto the active reel 43, the solenoid 252 is energized to pivot the lever 241 to engage flanged end 257 of the revolving detent member 256. Upon engagement with the pivoted lever 241, the detent member 256 partially rotates causing a pin 258, biased by a compression spring 261 into an arcuate notch 262 formed in detent member 256, to move upward within a bore 263 in the snagger support 53 against the action of spring 261 into engagement with pivot element 207 to move it against the action of torsion spring 208 out of abutting engagement with the roll 238 to unlock or trigger the snagger 51. 45

A centrifugal force component acts to drive the unlocked snagger 52 slidably outward from the support 53 into an extended position to grip, sever and clamp a section of the wire 31 at a portion thereof adjacent to the leftmost flanges 47—47 of reels 43—43 when the extended snagger 52 is revolved into position between the supported take-up reels. Thereafter the wire 31 is wound onto the upper empty take-up reel associated with the extended snagger 52, which continues to revolve in its extended position, retaining the gripped wire 31 therein. The wire 31 is retained in the snagger 50

52 until the reel 43 associated therewith is removed from its arbor 42 at which time the absence of centrifugal force allows the clamp 196 to assume its offset, pivoted position to facilitate removal of the section of the wire 31 held between the jaws 221 and 223 as previously described. The absence of centrifugal force also permits the snagger 52 to be self-retracted into the snagger support 53 by the spring 212 to cause the pivot member 207 to ride back over the roll 238 to assume the initial locked position shown in FIG. 18. Thus the triggering mechanism for each snagger device 51 is automatically reset when its associated arbor 42 stops rotating.

D. Reel Locking Assembly

FIG. 15, taken in conjunction with FIGS. 20 and 21, illustrates the arrangement and operation of three reel locking mechanisms 266—266 associated with each arbor 42 for releasably retaining a reel 43 thereon. An elongated member or shaft 267 having a head 268 formed on one end thereof is slidably disposed axially within the hollow shaft 127 and the hub 126 of the arbor 42. A yoke 271 on a piston 272 connected to a pneumatic cylinder 273 mounted in the frame 33 is designed to receive the head 268 on the shaft 267 associated with the arbor 42 positioned adjacent to the base 32 whenever the turret 37 is rotated to interchange the vertical positions of the aligned arbors 42—42.

The shaft 267 is formed along an intermediate section thereof with three circumferentially spaced longitudinal slots 276—276, one of which is shown in FIGS. 15 and 21. A roller 277 is mounted in an intermediate portion of each slot 276.

Each hub 126 is formed with three circumferentially spaced cavities 278—278 therein, each of which communicates with the hollow interior thereof. The locking mechanisms 266—266 are freely or floatably disposed within cavities 278—278 but are confined therein by the walls thereof to prevent substantial longitudinal and lateral movement. Each of a pair of aligned apertures 281 and 282 formed in the periphery of hub 126 communicates with each cavity 278. Each locking mechanism 266 cooperates with an associated roller 277 in the slot 276 of shaft 267 to lock and release a reel 43 on an arbor 42 at selected times during the handling thereof.

Each mechanism 266 includes an arm 283 having first and second arcuate cam surfaces 286 and 287, respectively, and a shoulder 288 formed thereon. When the reel 43 is locked to the arbor 42, roller 277 in shaft 267 engages cam surface 286. Arm 283 is pivotally connected to a yoke 291 by a pivot pin 292. The shoulder 288 projects into the aperture 281 and engages a lug 293 on hub 126. A clamping block 296 having bevelled surfaces 297 and 298 on a projection 301 thereof extending through aperture 282, is coupled to yoke 291 by a pin 302 threaded therein. Pin 302 extends through a bore 303 in block 296, and is formed with a head 306 disposed in a counterbore 307 for retaining a plurality of washer-type springs 308—308 therein. The threaded end of pin 302 is prevented from becoming unthreaded from yoke 291 by a set screw 311.

As illustrated in FIG. 15, with the shaft 267 positioned as shown, wherein a slot 276 in shaft 267 is offset from a cavity 278 in hub 126, a reel 43 may be clamped onto arbor 42 with the bevelled surfaces 133—133 on drum 46 of the reel 43 retained between

the bevelled surface 136 of hollow shaft 127 and surfaces 297—297 of clamping blocks 296—296, respectively. This clamping action is accomplished by the rollers 277—277 acting against cam surfaces 286—286 of arms 283—283 pushing arms 283—283 downward into a locked position, urging shoulders 288—288 against lugs 293—293, and the leading peripheral portion of shaft 267 acting against the clamping blocks 296—296. This action is aided by the elastic force exerted by springs 308—308 which tend to urge clamping blocks 296—296 leftward resiliently to retain reel 43 on arbor 42 and to compensate for variances in reel hub lengths.

When it is desired to remove the reel 43 from the arbor 42, the pneumatic cylinder 273 is actuated to slide shaft 267 axially to the right until each slot 276 is moved from its offset position with respect to each cavity 291 to a position subtending the cavity 291 as shown in FIG. 21. As the shaft 267 is moved to the right, each roller 277 moves from engagement with an aligned cam surface 286 horizontally, unlocking arm 283. Each unlocked arm 283 pivots about pin 292 moving the cam surface 287 into engagement with roller 277. When slot 276 ultimately clears the clamping block 296, the latter is permitted to be pivoted about pin 292 upwardly into slot 276. It is of minor consequence whether or not the clamping block 296 actually pivots upwardly since if it does not, the only force which prohibits removal of the reel 43 slidably to the right in the weight of the adjacent portions of clamping blocks 296—296 which are small when compared to the weight of the reel 43 especially if the reel is wound with a full accumulation of strand thereon.

E. Drive System

Referring to FIG. 22, the drive system for the take-up apparatus 30 is shown. A hydraulic dashpot or motor 313 drives the turret 37 through a gear 314, mounted on an output shaft 315, which engages a gear 316 secured to the hub 138 on the turret 37. The ratio of gear 314 to gear 316 is chosen to such that gear 316, and therefore the turret 37, rotates 180° for a 270° rotation of gear 314 by motor 313. Motor 313 is mounted on a plate 317 secured to a rocker arm 318 controlled by a face cam 319 of turret lock 148. As discussed in detail below in connection with the pneumatic system of FIG. 24, the turret lock 148 may be actuated to bolt-lock the turret 37 from movement and to disengage gear 314 from gear 316 after the positions of the reels 43—43 are interchanged.

Each arbor 42 and its associated snagger device 51 is driven independently by one of a pair of identical electrically energized speed-controlled motors 320 and 321. As explained in more detail in connection with the hydraulic system of FIG. 23, the motors 320 and 321 are coupled to a pair of pumps 322 and 323, respectively, to vary the speed of distributor motor 62 in accordance with the speed of the motor driving the reel taking up the wire 31 to control the rate of distribution of the wire 31 onto the reels 43—43. The motor 320 drives the arbor 42, shown in the upper vertical position on turret 37, through a pulley 326 keyed to solid shaft 162 and coupled to a pulley 327 on an output shaft 328 of motor 320 through a timing belt 331. As previously explained, rotation of shaft 162 drives the hollow shaft 127 secured to upper arbor 42 through pulley 163 on shaft 162 and pulley 166 on shaft 127, drivably coupled to one another by timing belt 167.

The motor 321 drives the arbor 42, shown in the lower vertical position on turret 37, through a pulley 332 on a motor output shaft 333 coupled to a pulley 336 keyed to hollow shaft 153 by a timing belt 337 to drive shaft 127 secured to lower arbor 42 through pulley 157 on shaft 153 and pulley 158 on shaft 127, drivably coupled to one another by timing belt 161.

As previously mentioned, every increment of rotation of turret 37 about central axis C by the energization of motor 313 produces a similar opposite increment of rotation of snagger support gears 171—171, through sun gear 187, planetary gears 188—188 and connecting gears 191—191, to compensate gears 171—171 for the rotation of the turret 37 to keep snagger devices 51—51 properly oriented with respect to their associated arbors 42—42 and the reels 43—43 thereon.

Further, as previously mentioned, the distributor 36 is operated by a reversibly driven hydraulic motor 62, under the control of reel motors 320 and 321 and pumps 322 and 323. Motor 62 is directly coupled to drive screw 76 and is selectively coupled to drive screw 93 through clutches 88, 89 and 92.

F. Control Systems

Referring to FIGS. 23, 24, 25 and 26, the hydraulic control system, the pneumatic control system and the electrical control system, respectively, for the take-up apparatus 30 are shown.

As illustrated in FIG. 23, a hydraulic system for controlling the distributor motor 62 includes a reservoir 339 containing hydraulic fluid at atmospheric pressure. Fluid is pumped from reservoir 339, containing hydraulic fluid at atmospheric pressure, through a supply line 340 connected to the reel-motor-driven fluid pumps 322 and 323 through a pair of spring-centered, double-solenoid operated valves 341 and 342 under the control of two sets of solenoids 343 and 344 and 345 and 346, respectively, to the motor 62. Pumps 322 and 323 and valve 341 determine the speed of motor 62, while valve 342 determines the direction of rotation of motor 62. Though both valve 341 and valve 342 are shown in their spring-centered neutral positions, it should be understood that one solenoid associated with each valve will be energized when the take-up apparatus 30 is being operated.

When either solenoid 343 or solenoid 344 is energized, valve 341 is operated to direct fluid to motor 62 through a high fluid pressure line 347 and valve 342. Solenoids 343 and 344 are alternately operated in response to the cutover signal represented by the pulse on output P2 of counter 117.

Solenoids 345 and 346 are operated upon the actuation of control limit switches 112 and 103, respectively, by the movement of strand guide 48, to direct fluid reversibly to motor 62 to reverse the direction of drive screw 76 and strand guide 48. Fluid is returned to the reservoir 339 through a pressure regulator 338 which insures smooth operation of motor 62 and a filter 348 both connected in a return line 349.

As illustrated in FIG. 24, pressurized air for the pneumatic control system is directed from an air supply 350 through a four-way, spring return, solenoid-operated valve 351 operated by a solenoid 352, to a supply line 353. As mentioned previously, the movable limit switch return cylinder 121 is controlled through a four-way, spring return, solenoid-operated valve 123, operated by the solenoid 124 to direct air from the supply line

353 to cylinder 121 to force piston 122 outward to move arm 106, and switch 103 thereon, to its normal position abutting the stop 111 on end support 77 of the distributor 36.

The driving means for the turret motor 313 includes a four-way, spring-return, solenoid-operated valve 354 operated by a solenoid 355 to direct air from supply line 353 to a first air-oil tank 356 where the air pressure forces oil from the tank 356 into the left side of the motor 313 to rotate a vane 357 therein 270°. The vane 357 is coupled to shaft 315 to rotate gear 314 through an angle of 270°, thereby rotating gear 316 on hub 138 and the turret 37 through an angle of 180°, to interchange the positions of the reels 43—43 (FIG. 22). Oil exits from the right side of motor 313 and passes through a cam-controlled valve 358 into a second air-oil tank 359. The vane 357 in motor 313 is coupled to a cam 360 which rotates therewith to move a cam follower 361 on valve 358 to close valve 358 gradually as the turret 37 completes the latter portion of its 180° rotation. This is necessary to insure a controlled rotation of the turret 37 since the weight of the full reel in the upper position on turret 37 might otherwise cause the turret 37 to whip around two quickly after its initial movement creating the risk of damage to or misalignment of the apparatus due to the stresses involved.

As previously mentioned, operation of the turret lock 148, discussed in detail below, causes the gears 314 and 316 to disengage to permit motor 313 to be reset upon the de-energization of solenoid 355, operating valve 354 to direct air into tank 359, forcing oil through a one-way check valve 361 into the right side of motor 313 to move vane 357 back to its original position. The oil then exits the left side of motor 313 and enters the tank 356 to await the next cycle of operation.

The turret lock 148 is controlled by the four-way, spring-return, solenoid-operated valve 146 under the control of solenoid 143. When solenoid 143 is energized, valve 146 is operated to direct air from line 353 into cylinder 147 to retract a piston 362, partially rotating face cam 319 which is coupled thereto. The face cam 319 is formed on opposite sides with a pair of complementary cam slots 363 and 364 for receiving a pair of cam followers 365 and 366, respectively. The cam follower 365 is coupled to a bolt 367 (FIG. 22) while the cam follower 366 is coupled to the rocker arm 318. Each of the cam slots 363 and 364 are formed for approximately half their lengths with arcuate portions having a center of curvature which coincides with the center of face cam 319.

During the first half of the movement of face cam 319, the cam follower 365 is moved outwardly to move bolt 367 into a notch 368 in the hub 138 to lock the turret 37 from movement, while the cam follower 366 rides in the slot 364 without movement. During the second half of the movement of face cam 319, the cam follower 365 rides in the slot 363 without further movement, holding bolt 367 in locked position while the cam follower 366 is moved inwardly to pivot rocker arm 318 and plate 317 connected thereto to disengage gear 314 on motor 313 from gear 316 on hub 138, thus allowing motor 313 to be reset.

The reel locking and unlocking cylinder 273 is actuated through a four-way, spring-return, solenoid-operated valve 369 under the control of a solenoid 370, shown energized, selectively to lock the locking mecha-

nisms 266—266 in the arbor 42 aligned with the cylinder 273.

As shown in FIGS. 25 and 26 arranged as shown in FIG. 27, power is supplied to the electrical system from a suitable 220 volt 60hz source of E.M.F. connected at terminals 371—371 to lines 372 and 373 and through a suitable step-down transformer 374 to lines 375 and 376. The solenoid 352 for operating valve 351 to direct air to the pneumatic control system of FIG. 24 may be energized by an operator closing a switch 377 which connects solenoid 352 across lines 375 and 376.

Connected across lines 375 and 376 are a pair of motor starting relays 381 and 382 in series with a pair of push-button start switches 383 and 386 and a pair of emergency-stop push-button switches 387 and 388, respectively. When one of the motor start buttons 383 or 386 is depressed, the associated relay 381 or 382 is energized to close a contact 391 or 392 connecting a reel driving motor 320 or 321, respectively, across lines 372 and 373 to energize the associated motor. Energization of motor start relay 381 or 382 also closes a contact 393 or 396, respectively, to complete a holding circuit for keeping relay 381 or 382 energized to permit the operator to release either depressed motor start button without stopping its associated motor.

Both motor 320 and motor 321 are provided with suitable speed-control systems (not shown) to match the constant linear speed of the advanced wire 31 by reducing the rotational speed of each arbor 42 as the winding diameter of reel 43 thereon increases. The speed-control systems may be, for example, of the type disclosed in Hauck et al. U.S. Pat. No. 3,408,013, assigned to the assignee of the present invention.

Closure of microswitch 142 by the bearing 139 on turret 37 in the upper position energizes the solenoid 143 through a normally closed contact 397 of a relay 398 to operate valve 146 to actuate cylinder 147 to engage the turret lock 148.

The counting system includes a follower sheave 401 in rolling contact with the advancing wire 31. Sheave 401 is mechanically coupled to and drives a pulse generator 402 which indicates the length of wire advanced past sheave 401 by feeding pulses to counter 117, for example, one pulse for every two feet of wire advanced. As previously mentioned, counter 117 is provided with two preset outputs P1 and P2.

A pulse is generated on output P1 of the counter 117 when the total number of pulses from the pulse generator 402 is representative of a total length of wire 31 wound upon a reel 43 equal to a predetermined length of wire less than the desired length of wire on a full reel. For example, if it is desired to have 26,000 feet of 24 gauge insulated wire on each reel, preset output P1 may be adjusted to render an output pulse when the total number of pulses fed to counter 117 indicates that 25,000 feet, or 1000 feet less than the desired amount of wire has been taken up by the active reel 43.

Similarly, a pulse is generated on output P2 of the counter 117 when the total number of pulses fed to counter 117 from the pulse generator 402 is representative of a total length of wire 31 wound upon a reel 43 equal to the desired amount. In the chosen example, an output pulse would be rendered on output P2 when the total number of pulses fed to counter 117 indicates that 26,000 feet of insulated wire has been taken up on the active reel 43.

The output P1 of counter 117 is coupled to a first toggle or flip-flop 403 having complementary d.c. voltage level outputs 404 and 406 through a relay 407. Output 404 of flip-flop 403 is coupled to the enabling input of a gate 408 serially connected to a relay 409 having a contact 411 which closes when relay 409 is energized to energize motor starting relay 382 to energize motor 321. Output 406 of flip-flop 403 is coupled to the enabling input of a gate 412 serially connected to a relay 413 having a contact 416 which closes when relay 413 is energized to energize motor starting relay 381 to energize motor 320. The flip-flop 403 responds to pulses at its input 417 by changing the state of the output voltage levels at outputs 404 and 406. Thus, flip-flop 403 changes state after each received pulse generated on output P1 of counter 117. Each of the gates 408 and 412 is designed to respond to a high d.c. voltage level from the flip-flop output associated therewith.

When an output pulse is generated on counter output P1, a contact 414 of relay 407 closes momentarily to connect the gates 408 and 412 to line 375. When either gate 408 or 412 is enabled by a high d.c. voltage level on its associated flip-flop output, a circuit is completed across lines 375 and 376 to energize a relay 418 and the relay 398. When relay 418 is energized, a contact 422 thereof is closed to energize the clutch-actuating solenoid 118 and a relay 424, closing a make contact 425 thereof, to establish a holding circuit for solenoid 118 through a break contact 426 of a clutch-release relay 427. Solenoid 118, when energized, actuates clutch 92 to drive the second drive screw 93, moving the arm 106, and the limit switch 103 thereon, away from its normal position adjacent to the right end support 77 toward the fixed limit switch 112 (FIG. 12), moving piston 122 into the air cylinder 121. When limit switch 103 is subsequently closed by actuator 113 carried by support arm 81, the clutch-release relay 427 and solenoid 124 are energized. When relay 427 is energized, the normally closed contact 426 thereof opens to de-energize clutch solenoid 118 to disengage clutch 92 so that the drive screw 93 is no longer being driven. Energization of solenoid 124 operates valve 123 which actuates cylinder 121 to move piston 122 to the right to return the arm 106 to its position adjacent to end support 77.

When relay 398 is energized, a contact 431 thereon closes to energize solenoid 355 and a relay 432. Energization of solenoid 355 operates valve 354 to force oil from air-oil tank 356 into turret motor 313 to rotate vane 357 clockwise (FIG. 24) 270° to rotate turret 37 through gears 314 and 316 through an angle of 180° to interchange the positions of the arbors 42—42. Energization of relay 432 closes a make contact 433 to set up a holding circuit therefor through a break contact 434 of relay 436. Contact 397 of relay 398 opens to de-energize solenoid 143 to permit valve 146 to reverse the fluid through cylinder 147 to unlock the turret 37.

When contact 397 is opened, the relay 436 de-energizes to close contact 434, completing the holding circuit for relay 432. As the turret 37 rotates to interchange the positions of the reels 43—43, the bearing 139 associated with the upper reel moves out of engagement with microswitch 142 opening the latter. When the bearing 139 associated with the now-revolving lower reel subsequently engages microswitch 142, relay 436 is energized to open the holding circuit

for relay 432 to de-energize relay 432 and solenoid 355 to cease driving the turret motor 313. At this time solenoid 143 is again energized to operate valve 146 to actuate turret lock 148.

The output P2 of counter 117 is coupled through a relay 437 to a second flip-flop 438 having complementary d.c. voltage level outputs 439 and 441 coupled to the enabling inputs of a gate 442 and a gate 443, respectively. The operation of flip-flop 438 and gates 442 and 443 by a pulse on output P2 of counter 117 is identical in all respects to the operation of the flip-flop 403 and the gates 408 and 412 at counter output P1. Each of the gates 442 and 443 is designed to respond to a high d.c. voltage output level from the flip-flop output associated therewith.

When a pulse is generated on counter output P2 a contact 444 of relay 437 momentarily closes and a high d.c. voltage level on output 439 enables gate 442 to energize a relay 446, a relay 447 and the solenoid 252 associated with the snagger device 51 adjacent to the arbor 42 driven by the motor 321.

Energization of relay 446 closes a make contact 448 thereof and opens a break contact 451 thereof. Closure of contact 448 energizes solenoid 343 to operate valve 341 to direct fluid from pump 323, driven by motor 321, to distributor motor 62, through valve 342, to control the rate thereof. The solenoid 343 is held operated by a holding circuit through a contact 452 on a relay 453 which is also energized upon closure of contact 448. Solenoid 344 is simultaneously de-energized since the opening of contact 451 of relay 446 causes a relay 454 to become de-energized, opening a holding circuit therefor through a contact 455. Energization of relay 447 opens a break contact 456 to open the circuit to motor start relay 381, opening contact 391 thereof to cease supplying current to reel motor 320. Energization of the snagger solenoid 252, associated with the snagger device 51 adjacent to the arbor 42 driven by motor 321, pivots the lever 241 associated therewith to trigger the associated snagger 52.

Similarly, a high d.c. voltage level on output 441 of flip-flop 438 enables the gate 443 to energize a relay 457, a relay 458 and the solenoid 252 associated with the snagger device 51 adjacent to the arbor 42 driven by the motor 320.

Energization of relay 457 opens a break contact 461 and closes a make contact 462 thereof. When contact 461 opens, solenoid 343 and relay 453 are de-energized, opening the holding circuit through contact 452. Closure of contact 462 energizes solenoid 344 and relay 454 through contact 451 of relay 446. Solenoid 344 and relay 454 are held energized through holding contact 455. As previously mentioned, the energized solenoid 344 operates valve 341 to direct fluid from pump 322, driven by motor 320, to distributor motor 62, through valve 342, to control the rate thereof. Energization of relay 458 opens a break contact 461 to open the circuit to motor start relay 382, opening contact 392 thereof to cease supplying current to reel motor 321. Energization of the snagger solenoid 252, associated with the snagger device 51 adjacent to the arbor 42 driven by motor 320, pivots the lever 241 associated therewith to trigger the associated snagger 52.

Closure of fixed limit switch 112 by actuator 116 on support arm 81 energizes a relay 462 which closes a contact 463 thereof to establish a holding circuit therefor through a break contact 466 of relay 467. A contact

468 of relay 462 closes to energize distributor solenoid 345 to operate valve 342 to direct fluid through distributor motor 62 to rotate drive screw 76 in a first direction to move the support arm 81 and the strand guide 48 to the right (FIG. 12). A contact 471 of relay 462 opens to open a holding circuit for the relay 467. When the actuator 113 on arm 81 closes movable limit switch 103, the relay 467 is energized to open break contact 466 thereof to open the holding circuit for relay 462 to set up the holding circuit for relay 467. Contact 472 of relay 467 closes to complete the holding circuit therefor and contact 473 closes to energize distributor solenoid 346. When the distributor solenoid 346 is energized the valve 342 is operated to reverse the direction of rotation of motor 62 to drive screw 76 in a second reverse direction to move the support arm 81 and the strand guide 48 to the left.

The unlocking of the normally locked reel locking mechanisms 266—266 is controlled by an operator closing a switch 476 which energizes the solenoid 370 to operate valve 369 to reverse the fluid in cylinder 273 to move piston 272 therein and the shaft 267 to the right, as shown in FIG. 21, to permit the clamping members 301—301 to pivot upward so that a full reel 43 can be removed and replaced with an empty reel. If automatic loading and unloading facilities are utilized with the apparatus 30, the unlocking of the reel locks would also be automatic, the solenoid 370 being energized in response to the operating signal for the unloading facility.

3. Operation

With the take-up apparatus 30 having the turret 37 positioned to orient the reels 43—43 as shown in FIGS. 1 to 3, with the reel in the upper position on turret 37 drivably connected to motor 320, and the leading end of wire 31 being gripped by a snagger 52, an operator depresses the reel motor start push button 383 and closes air supply switch 377 (FIG. 25).

Depression of push button 383 energizes motor start relay 381 through contact 456 of relay 447 and emergency-stop push-button switch 387, closing contact 391 to energize reel drive motor 320 and contact 393 to hold relay 381 energized. Energized motor 320 rotates to drive the reel 43 in the upper position on turret 37 through pulleys 326 and 327, shaft 162, pulleys 163 and 166 and the shaft 127 associated with upper reel 43 (FIG. 22). The rotary movement of motor 320 is imparted to pump 322 to supply hydraulic fluid from reservoir 339 to control the rate of distributor motor 62 through valve 341, operated by energized solenoid 343 (FIG. 23).

Closure of switch 377 energizes solenoid 352, operating valve 351 to direct air from air supply 350 to the pneumatic system of FIG. 24.

Assuming that the strand guide 48 is in its leftmost position as shown in FIG. 12 with actuator 116 on arm 81 engaging the fixed limit switch 112, relay 462 will be energized closing contact 468 thereon, energizing solenoid 345 to operate valve 356 to direct fluid through distributor motor 62 to rotate drive screw 76 and move arm 81 and strand guide 48 thereon to the right. As the strand guide 48 moves to the right, the insulated wire 31 is advanced at a constant linear speed from an extruding process through guide rollers 87—87 and onto the winding surface of the rotating take-up

reel 43 where the wire 31 is coiled thereon. Upon reaching the rightmost flange 47 of reel 43, actuator 113 on arm 81 engages and closes limit switch 103. Closure of limit switch 103 energizes relays 427 and 467. Energization of relay 427 opens contact 426 thereof which has no effect at this time since it is in electrical series with normally open contact 422 of relay 418. Energization of relay 467 closes contacts 472 and 473 thereof and opens contact 466 to open the holding circuit for relay 462. Since limit switch 112 is open at this time, relay 462 de-energizes opening contact 468 to de-energize solenoid 345 to permit valve 342 to be neutralized momentarily in its spring-centered position, and closing contact 471 to complete the holding circuit for relay 467 through contact 472 thereof. Solenoid 346 is energized through now-closed contact 473 of relay 467 to operate valve 342 to reverse the direction of distributor motor 62 to reverse drive screw 76, driving strand guide 48 to the left.

The strand guide 48 continues to be reciprocated to guide the wire 31 between the flanges 47—47 of the upper take-up reel 43 under the control of limit switches 112 and 103 and distributor motor 62 to distribute superimposed layers of convolutions of insulated wire 31 upon the winding drum 46 of the upper take-up reel 43. When pulse generator 402 has fed a total number of pulses to counter 117 representative of an amount of accumulated wire on upper reel 43 equal to a predetermined amount of wire less than the amount of wire desired to make a full reel, a pulse is generated on preset output P1 of counter 117.

The output pulse on preset output P1 of counter 117 changes the state of flip-flop 403 to establish a high d.c. voltage level on output 404 to enable gate 408. The output pulse on P1 also energizes relay 407 to close momentarily contact 414 to energize relay 409, clutch relay 418 and turret relay 398. Energization of relay 409 closes contact 411 to energize motor start relay 382 which closes contact 396 in the holding circuit therefor and closes contact 392 to energize the other reel drive motor 321 which rotates the empty reel, which occupies the lower position on turret 37, through pulleys 332 and 336, shaft 153, pulleys 157 and 158 and the shaft 127 associated with the lower reel 43 (FIG. 22). Energization of relay 418 closes contact 422, energizing relay 424 which holds energized through now-closed contact 425 thereof energizing clutch solenoid 118 to engage clutch 92 and rotate the second drive screw 93 through shaft 67 and one of the clutches 88 or 89 depending upon the direction of drive screw 76 (FIGS. 12 and 22). Rotation of drive screw 93 causes arm 106 and switch 103 to move to the left along drive screw 93 toward limit switch 112, driving piston 122 to the left into cylinder 121.

Energization of relay 398 closes contact 431 energizing relay 432, closing contact 433 thereof to set up a holding circuit therefor through contact 434 of relay 436, energized through closed microswitch 142, and energizing solenoid 355. Contact 397 of relay 398 opens to de-energize solenoid 143 which operates valve 146 to deactivate the turret lock 148 (FIGS. 22 and 24). Relay 436 is also de-energized by the opening of contact 397 to close contact 434 to establish the holding circuit for relay 432 and solenoid 355. Energization of solenoid 355 operates valve 354 to actuate turret motor 313 to rotate turret 37 and revolve the arbors 42—42 and the reels 43—43 thereon. When turret 37

has rotated 180°, now-open microswitch 142 is closed by the bearing 139 at the end of the turret 37 which has been rotated from the lower position adjacent to the base 32 to the upper position. Upon closure of microswitch 142, relay 436 is energized to break the holding circuit for relay 432 to de-energize solenoid 355 to operate valve 354 to reset the vane 357 of turret motor 313. At this time the solenoid 143 is again energized to operate valve 146 to lock turret 37 from movement and disengage gears 314 and 316. The reel 43 taking up the wire 31 is now in the lower position on turret 37. The empty reel 43 now occupies the upper position on turret 37 and is being driven by motor 321 as the wire 31 is advanced past the empty reel toward the full reel.

When the moving limit switch 103 is subsequently engaged by the actuator 113 on arm 81, relays 427 and 467 and solenoid 124 are energized. Energization of relay 427 opens contact 426 to de-energize clutch solenoid 118 to disengage clutch 92 to cease driving drive screw 93. Relay 424 in series with solenoid 423 is also de-energized to open contact 425 in the holding circuit for solenoid 118. Energization of solenoid 124 operates valve 123 to actuate piston 122 of cylinder 121 to move arm 106 to its normal position adjacent end support 77.

As mentioned previously, the energization of relay 467 causes distributor solenoid 345 to be de-energized and causes distributor solenoid 346 to be energized to operate valve 356 to reverse distributor motor 62 to rotate drive screw 76 to move the strand guide 48 toward the left flange 47 of the empty reel 43 adjacent to the snagger device 51 associated therewith. At this time an output pulse is generated on preset output P2 of counter 117.

The output pulse generated on counter output P2 energizes relay 437 to close contact 444 and changes the state of the flip-flop 438 to generate a high voltage level on output 439 to enable gate 442 energizing snagger solenoid 252 and relays 446 and 447 through contact 444. The energization of the solenoid 252 pivots cam lever 241, associated with the empty reel 43, to rotate flange 257 of detent member 256 causing pin 258 to move pivot member 207 on snagger 52 upward to ride over roll 238. At this time centrifugal force thrusts the snagger 52 outwardly to catch and sever the wire 31 therein and remain in an extended or trigger position. The advancing wire 31 is now wound upon the empty reel in the upper position of turret 37.

Energization of relay 446 opens contact 451 to de-energize solenoid 344 and relay 454 breaking the holding circuit therefor through contact 455. When solenoid 344 is de-energized, valve 341 (FIG. 23) is momentarily rendered neutral. Contact 448 of relay 446 closes to energize solenoid 343 and relay 453, closing contact 452 to complete the holding circuit therefor. When solenoid 343 is energized, valve 341 is operated to direct fluid to distributor motor 62 from reservoir 339 through pump 323 driven by the motor 321 which drives the arbor 42 in the upper position on turret 37 to increase the distribution rate of the wire 31 on the newly positioned reel 43 now taking up the wire 31.

Energization of relay 447 opens contact 456 thereof to de-energize motor relay 381 which causes contact 391 thereof to open the supply circuit to motor 320 to stop the latter from rotating the now-full reel 43 in the lower position on turret 37. The operator may now close switch 476 to energize solenoid 370 to operate valve 369 to actuate cylinder 273 to move piston 272

and shaft 267 to the right, as shown in FIG. 21, to permit the locking mechanisms 266—266 to release the reel 43 from the lower arbor.

The operator or an automatic unloading apparatus may then act to pull the full reel 43 from the arbor 42 5 associated therewith, pulling the wire 31 from the jaws 221 and 223 of snagger 52. A new empty reel may be loaded onto the arbor 42 and the solenoid 370 may be de-energized to permit valve 369 to be positioned to retract piston 272 into cylinder 273, moving the shaft 267 into locking engagement with the reel locking mechanisms 266—266 in hub 126.

Upon the subsequent generation of a pulse on output P1 of counter 117, indicating that a predetermined amount of strand less than that desired to make a full reel 15 has been taken up on the formerly empty reel, relay 407 is again energized to close contact 414 and flip-flop 402 is caused to change state, this time generating a high voltage level on output 406 to enable gate 412. When gate 412 is enabled relays 413, 418 and 398 are energized through contact 414. Energization of relay 413 closes contact 416 thereof to energize motor relay 381 which closes contact 391 to energize reel motor 320 which rotates the new empty reel 43 in the lower 20 position on turret 37. The relays 418 and 398 operate as previously explained to unlock the turret 37, rotate the turret 180°, stop, lock, disengage and reset the turret drive motor 313, and cause the distributor to direct the advancing wire 31 past the left flange 47 of the empty reel 43 now in the upper position on turret 37. 30

At this time a pulse is again generated on the counter output P2 to energize relay 437, closing contact 444 thereof and changing the state of flip-flop 438, this time generating a high voltage level on output 441 to enable 35 gate 443. When gate 443 is enabled, solenoid 252 and relays 457 and 458 are energized through contact 444. Energization of the solenoid 252, associated with the empty reel 43 triggers the snagger 52 associated with the empty reel 43 in the upper position on turret 37, to catch, sever and grip the wire 31 to begin winding the wire 31 thereon. 40

Energization of relay 457 opens contact 461 to de-energize solenoid 343 and the relay 353, breaking the holding circuit therefor through contact 452. When solenoid 343 is de-energized, valve 341 (FIG. 23) is momentarily rendered neutral. Contact 462 of relay 457 45 closes to energize solenoid 344 and relay 454, closing contact 455 to complete the holding circuit therefor. When solenoid 344 is energized, valve 341 is operated to direct fluid to distributor motor 62 from reservoir 339 through pump 322, driven by the motor 320, which drives the arbor 42 in the upper position on turret 37 to increase the distribution rate of the wire 31 on the newly positioned reel 43 now taking up the wire 31. 50 Energization of relay 458 opens contact 461 thereof to de-energize motor relay 382 opening contact 392 thereof to cease supplying electrical energy to the motor 321 driving the full reel 43 now in the lower position on turret 37 to stop the reel 43. Once again the full reel may be unlocked, removed and replaced either by an operator or suitable automatic apparatus. 60

The apparatus will thereafter continuously operate as described above, with each full reel 43 being removed and replaced with an empty reel in the lower position on turret 37. 65

It will be understood that the above-described arrangements are simply illustrative of the applications of

the principles of the invention. Other arrangements may be devised by those skilled in the art which will embody the principles of the invention without departing from the spirit and scope thereof.

What is claimed is:

1. A method of controlling the distribution of a predetermined length of continuously advancing strand onto and traversing the winding surface of a rotating take-up reel reversibly between first and second longitudinally spaced limits, which comprises the steps of:
 - moving the second limit linearly toward the first limit at a speed substantially equal to the speed of traverse of the advancing strand;
 - reversing the direction of traverse of the advancing strand when it reaches the moving second limit, and
 - terminating the advancement of the strand onto the reel at a time subsequent to the reversal thereof at said moving second limit when the strand is next adjacent to the first limit.
2. A method of controlling the distribution of a predetermined length of continuously advancing strand as set forth in claim 1 including the additional step of:
 - measuring the length of strand accumulated on the reel from the time the second limit is moved until the measured length is equal to the predetermined length, and wherein the termination of advancement of the strand occurs in response to the accumulation of the predetermined length.
3. A method of controlling the distribution of a length of strand material equal to one final layer of convolutions thereof between first and second boundaries on the winding surface of a rotating take-up element at a time when the advancing strand is being directed toward the first boundary, which comprises the steps of:
 - reversing the direction of the strand when it is adjacent to the first boundary to direct it toward the second boundary;
 - reversing the direction of the strand when it has traveled toward the second boundary a distance equal to one-half the distance it was originally positioned from said second boundary when the strand was adjacent to the first boundary to direct it toward said first boundary, and
 - terminating the advancement of the strand when it is again adjacent the first boundary.
4. A method of distributing a predetermined amount of advancing strand in superimposed layers of convolutions between first and second axially spaced limits on the winding surface of a rotating take-up reel, comprising the steps of:
 - guiding the advancing strand transversely across the surface of the take-up reel in timed relation to the peripheral speed of the reel;
 - reversing the direction of traverse of the advancing strand each time it reaches an axial limit;
 - detecting a first accumulation of strand on the reel indicative of an amount of strand substantially equal to one layer of convolutions of strand less than the predetermined amount;
 - moving the second axial limit axially toward said first axial limit at a speed equal to the speed of traverse of the advancing strand in response to the detection of the first accumulation;
 - detecting a second accumulation of strand on the reel indicative of the predetermined amount, and

terminating the advancement of the strand onto said winding surface when the strand is in the vicinity of the first limit subsequent to a reversal at the moving second limit in response to the detection of the second accumulation, whereby the accumulation of the predetermined amount of strand on the reel occurs near the first axial limit.

5. Apparatus for controlling the distribution of a predetermined amount of continuously advancing strand onto and traversing the winding surface of a rotating take-up reel reversibly between first and second longitudinally spaced limits, comprising:

means for moving the second limit linearly toward the first limit at a speed substantially equal to the speed of traverse of the advancing strand;

means for reversing the direction of traverse of the advancing strand when it reaches the moving second limit, and

means for terminating the advancement of the strand onto the reel at a time subsequent to the reversal thereof at said moving second limit when the strand is next adjacent to said first limit.

6. An apparatus for controlling the distribution of a predetermined amount of continuously advancing strand onto the winding surface of a rotating take-up reel as set forth in claim 5, including:

means for measuring the length of strand accumulated on the reel from the time the second limit is moved until the measured length equals a predetermined length, and

means for rendering said terminating means operable in response to the accumulation of said predetermined length on the reel.

7. An apparatus for distributing a predetermined amount of advancing strand as set forth in claim 6, wherein said measuring means includes:

means for detecting a first accumulation of strand on the reel indicative of an amount of strand substantially equal to one layer of convolutions of strand less than the predetermined amount;

means responsive to the detection of said first accumulation for rendering said second limit moving means operable, and

means for detecting a second accumulation of strand on the reel indicative of a length of strand equal to the predetermined length.

8. An apparatus for controlling the distribution of a length of a strand material equal to one final layer of convolutions thereof between first and second boundaries on the winding surface of a rotating take-up element at a time when the advancing strand is being directed toward the first boundary, which comprises:

means for reversing the direction of the strand at the first boundary to direct it toward the second boundary;

means for reversing the direction of the strand when it has travelled toward the second boundary a distance equal to one-half the distance it was originally positioned from said second boundary when the strand was adjacent to the first boundary to direct it toward said first boundary, and

means for terminating the advancement of the strand when it is again adjacent the first boundary.

9. Distributing apparatus for guiding strand material onto a take-up reel, which comprises:

a first drive screw mounted parallel to the longitudinal axis of the take-up reel;

reversible means coupled to said first drive screw for driving said first drive screw in timed relation to the peripheral speed of the winding surface of the reel; guide means threadedly engaging and motivated by said first drive screw for transverse movement along the winding surface of said reel for forming superimposed layers of convolutions of strand material on the reel;

first control means adjacent to a first axial end of the reel and actuated by the transverse movement of said guide means in a first direction along the winding surface of the reel for causing said reversible means to reverse the drive of said first drive screw to cause transverse movement of said guide means in a second reverse direction along the winding surface of said reel;

a second drive screw mounted parallel to the longitudinal axis of said reel and spaced from said first drive screw;

clutch means selectively actuable to couple said reversible means to said second drive screw for driving said second drive screw nonreversibly;

second control means threadedly engaging and normally located at an end of said second drive screw adjacent to an opposite end of the reel and actuated by the transverse movement of said guide means in said second direction for causing said reversible means to reverse the drive of said first drive screw to cause transverse movement of said guide means in said first direction along the winding surface of said reel whereby said guide means is caused to reciprocate along the winding surface of said reel to distribute successively formed superimposed layers of strand material on the reel;

means responsive to the accumulation of an amount of strand material representative of substantially the last desired layer of convolutions on the reel for actuating said clutch means to drive said second drive screw to move said second control means therealong toward said first control means at the same speed as said guide means is moved along the winding surface of the reel;

means responsive to the subsequent actuation of said second control means by the transverse movement of said guide means for deactuating said clutch means and for causing said reversible means to reverse the drive of said first drive screw to move said guide means toward said first control means, and

means responsive to the accumulation of a second amount of strand material representative of an ultimately desired amount on the reel for terminating the advancement of the strand onto the reel.

10. An apparatus as set forth in claim 9, wherein said clutch means comprises:

a rotatable drive shaft; selectively actuable motion transmitting means for coupling said drive shaft to said second drive screw;

a first one-way clutch coupling said drive shaft to said reversible means for rotating said shaft in a predetermined direction when said reversible means is operated in a normal mode and for slipping with respect to said drive shaft when said reversible means operates in a reverse mode, and

a second one-way clutch coupling said drive shaft to said reversible means for rotating said shaft in said same predetermined direction when said reversible means is operated in a reverse mode and for slipping with respect to said drive shaft when said reversible means is operated in a normal mode.

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