May 12, 1970 C. W. BROUWER ET AL 3,511,448

YARN INSPECTION APPARATUS

Filed March 13, 1968 3 Sheets-Sheet 1

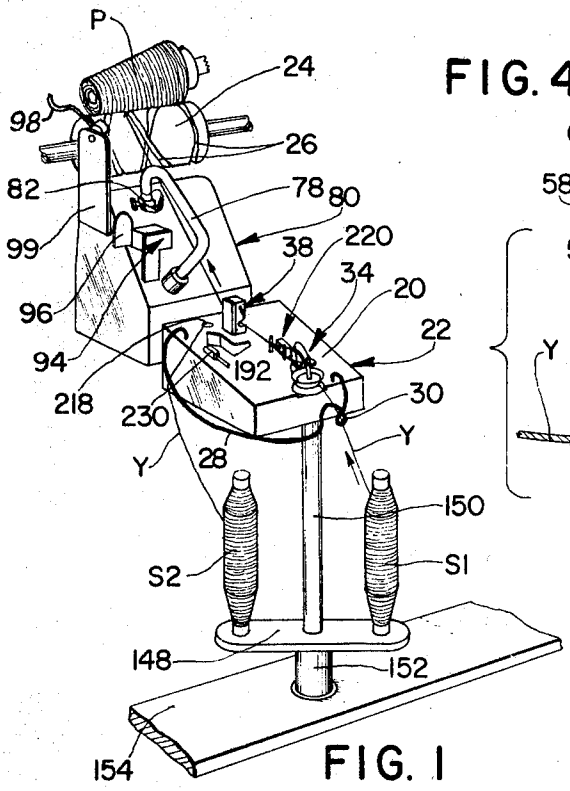


FIG. 1

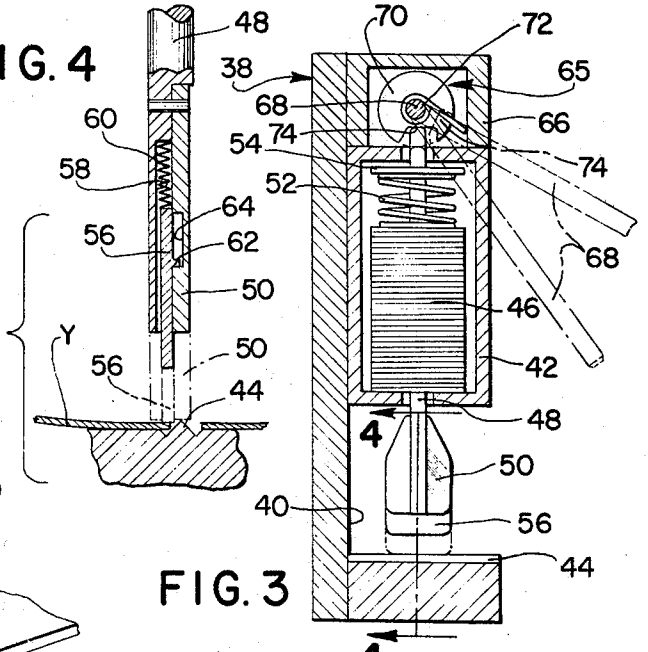


FIG. 3

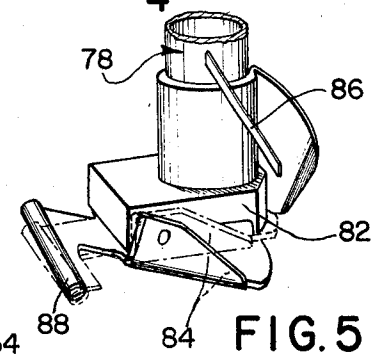


FIG. 5

FIG. 2

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YARN INSPECTION APPARATUS

Filed March 13, 1968 3 Sheets-Sheet 2

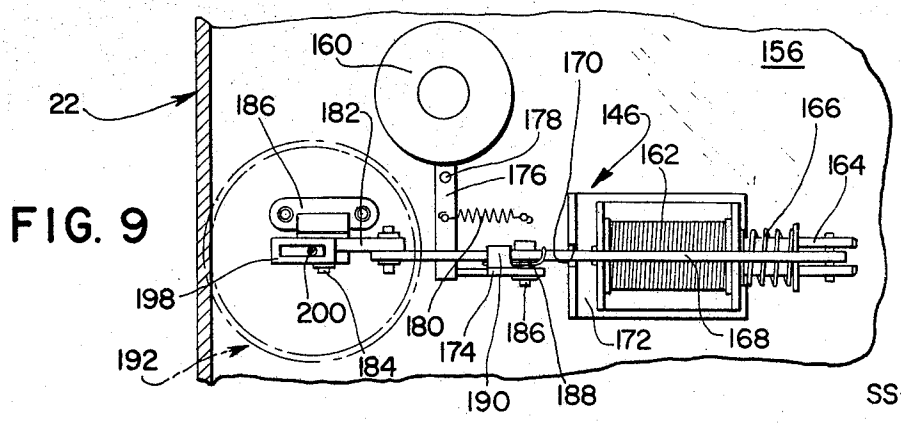


FIG. 9

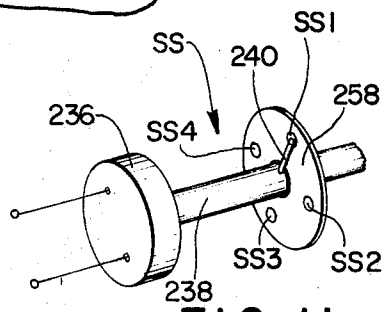


FIG. 11

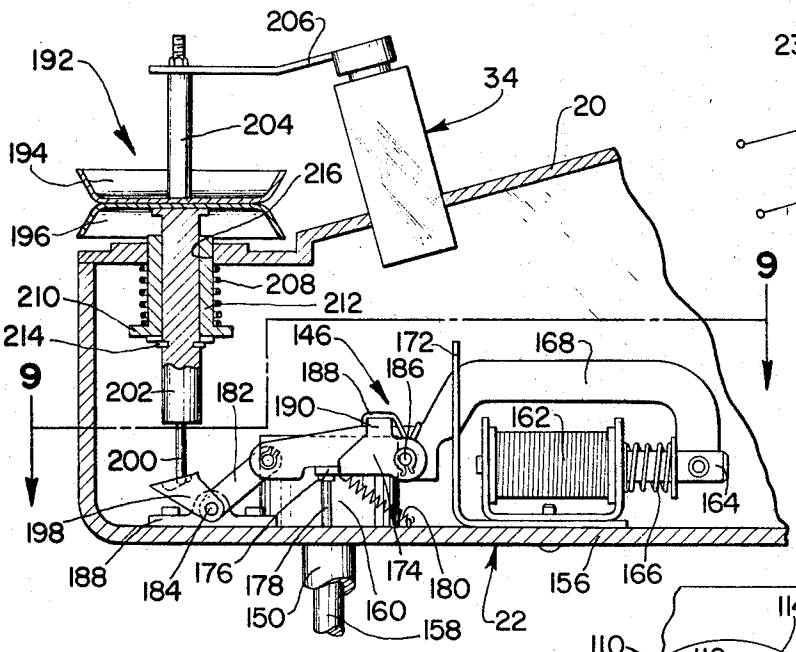


FIG. 8

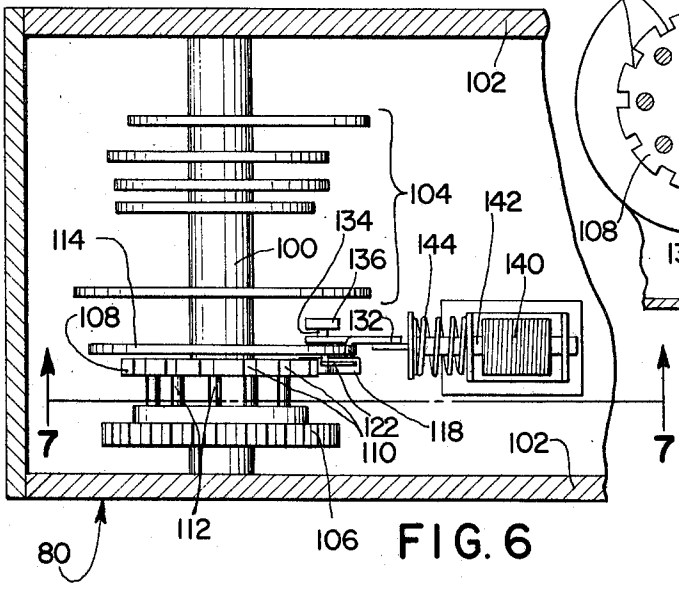


FIG. 6

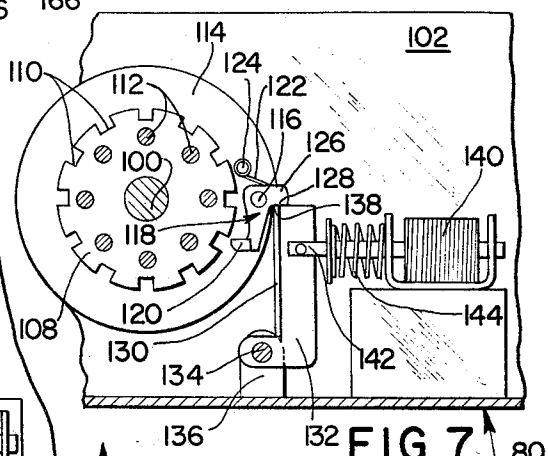


FIG. 7

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YARN INSPECTION APPARATUS

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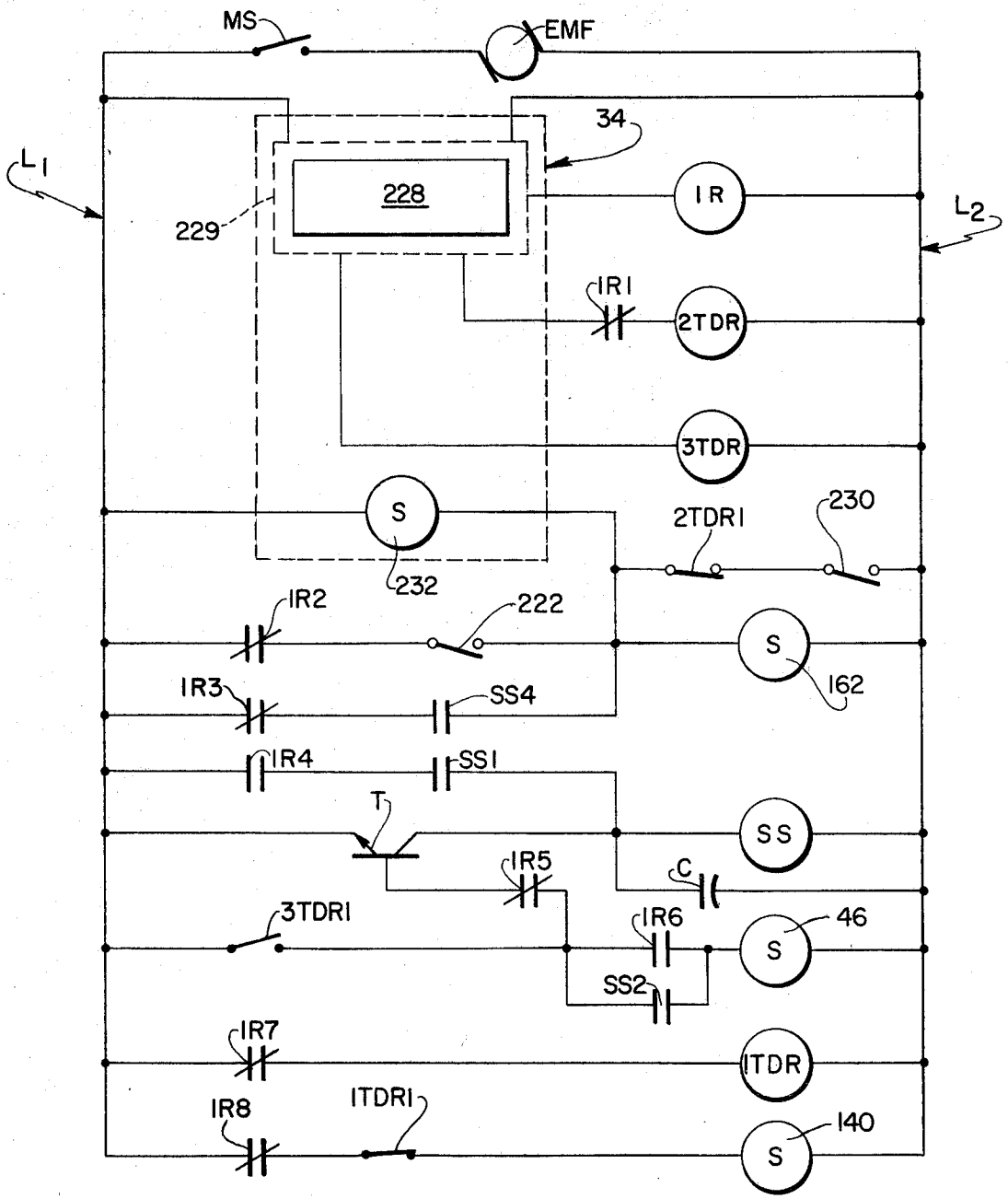


FIG. 10

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3,511,448

YARN INSPECTION APPARATUS

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Filed Mar. 13, 1968, Ser. No. 712,864
Int. Cl. B65h 63/04, 63/06
U.S. Cl. 242—36 8 Claims

ABSTRACT OF THE DISCLOSURE

Inspection apparatus for an automatic winding machine to inspect yarn for unacceptable defects before the yarn is wound onto a take-up package. Such defects detected during winding are eliminated and winding is resumed. In the event of a second yarn defect immediately following a first defect, or in the event of excessive yarn tension during thread-up of the winding machine, the yarn supply is replaced with a fresh supply.

The present invention relates generally to inspection apparatus for an automatic winding machine and particularly to such apparatus for inspecting the condition of yarn before it is wound onto a take-up package and responsive to the condition of yarn for controlling operation of the winding machine.

In the following specification the term "yarn" is employed in a general sense to denote various kinds of strand material, either textile or otherwise, and the term "package" denotes the product of a winding machine, whatever its form.

The commonly assigned U.S. Pat. No. 2,764,362 to W. V. Goodhue et al., discloses an automatic winding machine which mechanically inspects an advancing strand of supply yarn. When a yarn defect is detected, the supply yarn is cut and a portion of the yarn containing the defect is removed. When an interruption in the yarn is detected, the free ends of yarn from a supply package and a take-up package are retrieved and joined to reinstate the winding operation. The previously mentioned U.S. patent, and a commonly assigned U.S. Pat. No. 3,081,045 to T. E. Pitts et al., discloses such machines and Lesona Model 644 automatic cone winder manufactured by Leesona Corporation, Warwick, R.I., are examples of such machines.

The present invention is an improvement over the constructions disclosed in the referenced patent and cone winder in that the yarn is inspected for defects or faults as well as for excess tension. According to the invention, an automatic winding machine is provided with a yarn inspection unit located in the path of the supply yarn. If a yarn defect is detected while the yarn is advancing, the inspection unit signals for removal of the defect through operation of a first knife to cut the yarn at a location between the inspection unit and the take-up package and for operation of a mechanism for retrieving and joining the free end from the supply to the free end from the take-up package. If during the end retrieving and joining operation, tension in the supply yarn is excessive, or if a second successive defect is detected, the inspection unit signals for operation a second knife to cut the yarn at a location between the first knife and the supply package, for introduction of a fresh supply package, and for operation of the mechanism for retrieving and joining the free ends of yarn.

Therefore, a primary object of the invention is to provide new and improved yarn inspection apparatus.

Another object of the invention is to provide new and improved yarn inspection apparatus for a winding machine. A related object is the provision of such apparatus

for continuously inspecting the condition of yarn. Another related object is provision of such apparatus responsive to a predetermined yarn condition to signal for the performance of an ensuing operation.

Another object of the invention is to provide an inspection unit disposed in the path of an advancing strand of yarn adapted to identify a plurality of predetermined yarn conditions, and responsive to a certain predetermined yarn conditions to signal for cutting of the yarn at a first location and responsive to certain other predetermined yarn conditions to signal for cutting of the yarn at a second location spaced from the first location.

A further object of the invention is to provide new and improved apparatus for inspecting the condition of yarn and adapted, in the event of a yarn defect, to sever yarn between a supply and a take-up package and to signal, during an ensuing end finding and joining operation, for introduction of a fresh supply package in response to excessive yarn tension.

Other and further objects and advantages of the invention will be apparent from the following specification taken together with the accompanying drawings.

In the drawings:

FIG. 1 is a fragmentary, perspective view schematically illustrating normal winding operation of an automatic winding machine embodying the invention;

FIG. 2 is an enlarged, fragmentary view, in perspective, of parts illustrated in FIG. 1;

FIG. 3 is an enlarged section view taken substantially along the line 3—3 in FIG. 2;

FIG. 4 is a fragmentary section view taken substantially along line 4—4 in FIG. 3;

FIG. 5 is an enlarged fragmentary view, in perspective, of parts illustrated in FIG. 1;

FIG. 6 is a fragmentary top plan view of a mechanism illustrated in FIG. 1, adapted to control an end finding and joining operation, certain parts being cut away and in section for increased clarity;

FIG. 7 is a fragmentary section view taken substantially along line 7—7 in FIG. 6;

FIG. 8 is a fragmentary elevation view looking from the right of FIG. 2, with parts cut away and in section for increased clarity;

FIG. 9 is a section view taken substantially along the line 9—9 in FIG. 8;

FIG. 10 is an electrical schematic diagram illustrating a control system for the winding machine;

FIG. 11 is a perspective view schematically illustrating a component of the control system illustrated in FIG. 10.

Referring now to the drawings and initially to FIG. 1 illustrated a winding machine during the normal operation of which yarn Y is drawn from an active supply bobbin package S_1, across a top panel **20** of a housing **22**, and proceeds to a rotating take-up package P. The package P is in surface engagement with a drive roll **24** which may be of the type having a continuous helical groove **26** for guiding the yarn onto the package.

INSPECTION UNIT

Between the supply package S_1 and the take-up package P, the yarn is directed, by a suitable guide **28** having a pigtail portion **30**, into a path aligned with a passage **32** (FIG. 2) extending through an inspection unit **34**. The inspection unit **34** is a commercially available device such as Electronic Yarn Clearer, Type FR–3, manufactured by Loepfe Brothers, Limited, of Zurich, Switzerland, and operates in a suitable manner to examine the yarn Y as it advances through the passage **32** and is effective to operate a knife **36** (FIG. 2) for cutting the yarn under certain prescribed conditions. Sensitive to yarn movement, the inspection unit **34** is operable to detect whether the

yarn Y is running at a normal winding speed or below such speed. The normal winding speed may vary and may arbitrarily be defined for the purpose of this description as any yarn speed in excess of a predetermined particular speed, as for example, 200 yards per minute. This particular speed is suitably preset into the control of the inspection unit **34**. Also, deviations in the yarn Y are compared with a predetermined standard, the sensitivity level of the inspection unit **34** being adjustable, and the inspection unit signals for the elimination of all portions of yarn which exceed this level. For example, an excessive deviation may take the form of a defect having a diameter considerably greater than a nominal yarn diameter, possibly for a relatively short duration. Another example of an excessive deviation may be a defect having a diameter which may be smaller than that just described, but continuing for a considerably longer duration as in the instance of a torpedo, a spinner's double, or a double end.

CUTTING-CLAMPING ASSEMBLY

When the yarn Y is in the running condition, and the inspection unit **34** senses an unacceptable defect in the yarn, it signals for the operation of a cutting-clamping assembly **38** adapted to cut the yarn at a location between the inspection unit **34** and the take-up package P and to releasably hold a resultant end of the yarn extending from the supply package S_1. The cutting-clamping assembly **38** is suitably mounted on the top panel **20** (FIG. 2) in the normal winding path of the yarn such that the yarn advances through a passage **40** (FIGS. 2 and 3) in an enclosure **42** of the assembly. Integral with a lower surface of the passage **40** is a fixed cutting edge **44** (FIGS. 3 and 4). To sever the yarn Y, a solenoid **46** is suitably supported within the enclosure **42** and serves to operate an armature **48** at a free end of which is fixed a blunt-edged anvil **50**. When the solenoid **46** is de-energized, the anvil **50** is held distant from the cutting edge **44** by a compression spring **52** encircling the armature **48** and extending between the solenoid **46** and a retainer ring **54** fixed to the armature. In this way, the yarn is able to advance unhindered through the passage **40** during winding. However, when the solenoid **46** is energized in response to a signal from the inspection unit **34**, the armature **48** is projected against the force of the spring **52** such that the anvil **50** moves from a retracted, solid line position (FIG. 4) to an extended phantom line position against the cutting edge **44** to sever the yarn.

Yieldably but firmly holding the free end of yarn extending from the supply package S_1 against a lower surface of the passage **40** adjacent the cutting edge **44** after the yarn has been severed is a yarn clamp **56** adjacent the anvil **50**. As seen in FIG. 4, the free end of the armature **48** has a suitable recess **58** adapted to slidably receive the yarn clamp **56** and a compression spring **60** located in the recess bears against the upper end of the yarn clamp and serves to normally hold the yarn clamp in an extended position in which its lowermost edge reaches beyond the anvil **50**. In order to define the extended position to which the yarn clamp **56** is moved by the spring, a knob **62** on a surface of the yarn clamp **56** cooperates with a depression **64** in a surface of the anvil **50** to permit the axial movement of the yarn clamp from an extended position (FIG. 4) to a retracted position when the anvil **50** engages the cutting edge **44**. With an end of the yarn from the supply package S_1 firmly gripped between the lower surface of the passage **40** and the yarn clamp **56**, the free end of the yarn from the take-up package P drops away from the assembly **38** and is wound onto the take-up package P.

A releasable holding mechanism **65** responds automatically to operation of the solenoid **46** to releasably maintain the armature **48** in a partially extended position at which the yarn clamp **56** is effective to continue holding the free end of yarn. Specifically, at the top of the enclosure **42** is suitably mounted a cover **66** adapted to pivotally support an L-shaped lever **68**. A cam **70** is fixed to the lever **68** within the cover **66**, and a torsion spring **72** fixed to the cam **70** at one end is coiled about the lever **68** and at its other end engages the cover **66** thereby urging the lever **68** in a counterclockwise direction (FIG. 3). The periphery of the cam **70** includes a recess **74** adapted to receive, under certain conditions when the solenoid **46** is de-energized, the upper end of the armature **48** which is biased upwardly by the compression spring **52**. When the solenoid **46** is momentarily energized, the armature **48** is drawn downwardly and clears the recess **74** permitting the lever **68** to pivot under the urging of the spring **72** from a depressed position to a raised position, both positions being shown by phantom lines in FIG. 3. The raised position is defined when the lever **68** strikes a stop **76** which is fixed to and extends outwardly from the cover **66** (FIG. 2). When the solenoid **46** is de-energized, the spring **52** urges the armature **48** upwardly, until its upper end engages the outer periphery of the cam **70**, the recess **74** having moved to a phantom line position (FIG. 3) when the lever **68** moved to the raised position. At this stage of the operation, the anvil **50** is separated from the cutting edge **44** but the yarn clamp **56** firmly engages the lower surface of the passage **40** to hold the free end of yarn extending through the passage.

END FINDING AND JOINING MECHANISM

After the inspection unit **34** has signaled for the operation of the cutting-clamping assembly **38**, an end finding and joining mechanism is actuated to retrieve the respective ends of yarn from the supply package S_1 and from the take-up package P, one suitable mechanism being that disclosed in the U.S. Pat. No. 2,764,362. Only so much of the conventional mechanism is described herein as is necessary to provide sufficient background for a complete understanding of the present invention.

To retrieve the free end of yarn from the supply package S_1, a tension nozzle **78** (FIG. 1) comprising a substantially inverted U-shaped tube having its lower end portion rotatably mounted in a forward wall of a housing **80** and suitably connected to a source of vacuum (not shown) is swung downwardly in a clockwise direction (FIG. 1). At its open or free end, the tension nozzle **78** is provided with a downwardly opening yarn receiving mouth **82** (FIG. 5) having a hinged closure cap **84** movable between an open position, shown in solid lines, for receiving and releasing a yarn end, and a closed position, shown in phantom lines, to hold the yarn end. As the mouth of the tension nozzle is moved downwardly and forwardly across the top panel **20** and then travels across the path of the yarn extending between the inspection unit **34** and the cutting-clamping assembly **38**, a flexible reed **86** fixed to the tension nozzle **78** adjacent the mouth **82** and extending in an outward direction brushes against the lever **68**. In this way, the lever **68** is swung in a clockwise direction (FIG. 3) against the urging of the spring **72** from the raised position to the depressed position. With the lever **68** in the depressed position, the recess **74** is again oriented to receive the upper end of the armature **48** under the urging of the spring **52** and the yarn held between the yarn clamp **56** and the lower surface of the passage **40** is released for immediate entry into the mouth **82** under the influence of the vacuum in the tension nozzle **78**.

Viewing especially FIG. 5, a substantially rigid finger **88** projects laterally from the closure cap **84** and engages with a cam **90** fixed to the top panel **20** and having a contoured lower edge **92** adapted to pivot the closure cap **84** to the closed position to firmly seize and hold the yarn at the mouth **82**. Movement of the tension nozzle **78** is then suitably reversed so that, with the free end of the supply yarn held at its mouth **82**, the tension nozzle **78** swings upwardly in a counterclockwise direction (FIG. 1) to carry the yarn to a suitable knotter **94**. An opening cam **96** is fixed to the frame of the knotter **94** and

so positioned that when the tension nozzle **78** approaches the knotter, the finger **88** rides across a cam **96** to pivot the closure cap **84** to the open position thereby releasing the end of yarn from the active bobbin S_1 for engagement by the knotter **94**.

To retrieve the free end of yarn from the take-up package during an end finding and joining operation, a suitable mechanism (not shown) is operated to rotate the package P for a brief period in an unwinding direction and to draw off the free end of yarn from the package P, whereupon the end passes into vacuum passage. A yarn pick-up finger **98**, pivotally mounted on a bracket **99** on the housing **80** is then swung upwardly and forwardly (FIG. 1) and being upturned at its free end picks up a bight of the yarn being drawn off the package and carries the yarn to the knotter **94**. As the knotter **94** is operated to join the free ends, the defect is discarded along with free ends of the knotted yarn, and the pick-up finger **98** and the tension nozzle **78** are returned to their respective rest positions (FIG. 1) and the winding operation is reinstated and proceeds in the customary fashion.

Turning to FIG. 6, illustrating a drive mechanism for selectively operating the end finding and joining mechanism just described, a cam shaft **100** is rotatably supported in opposed sidewalls **102** of the housing **80**. Fixed to the cam shaft **100** are a plurality of plate cams **104** adapted to suitably operate the tension nozzle **78**, the pick-up finger **98**, the knotter **94**, and other instrumentalities which assist in performing the end finding and joining operation. The cam shaft **100** remains stationary during the normal winding operation and is operated only in response to an interruption in the supply yarn when it is necessary to join the respective ends from the supply and take-up packages. A continuously driven spur gear **106** is journaled on the cam shaft **100**. Similarly journaled on the cam shaft **100** is a drive plate **108** having a plurality of circumferentially, equally spaced notches **110** and fixed to the spur gear **106** by a plurality of axially extending drive pins **112** having their ends respectively fixed to the spur gear **106** and to the drive plate **108**.

Fixed on the cam shaft **100** at a location spaced slightly from the drive plate **108** in a direction away from the observer in FIG. 6 is an actuator disc **114** which bears a pivot pin **116** (FIG. 7) at a position spaced slightly inwardly of its periphery. A drive pawl **118** is swingably mounted on the pivot pin adjacent the actuator disc **114** and at a lower end of the pawl **118** is a laterally directed lug **120** arranged to engage with one of the notches **110**. An upper end of the pawl **118** is engaged by one end of a torsion spring **122**, the other end of which is anchored on a post **124** on the actuator disc **114**, so that the spring **122** urges the pawl **118** to swing in a clockwise direction (FIG. 7) about the pivot pin **116**. Thus, when the pawl **118** is free to rotate, the lug **120** is urged by the spring **122** into engagement with one of the notches **110** to couple the drive plate **108** to the actuator disc **114** for rotating the cam shaft **100**.

In order to hold the lug **120** out of engagement with one of the peripheral notches **110**, the upper end of the pawl **118** includes an outwardly projecting beak **126** having a straight lower edge which is adapted to engage a shoulder **128** at an upper end of a laterally directed flange **130** on a cam cycle lever **132**. The cam cycle lever **132** is free to rock with a shaft **134** rotatably mounted at its ends in a pair of spaced apart bearing blocks **136** fixed to the housing **80**. Lying in approximately the same radial plane as the axial of the pivot pin **116**, a substantially circular peripheral edge of the actuator disc **114** is formed with a radial shoulder **138** which is also adapted to engage the shouler **128**. As long as the beak **126** and the radial shoulder **138** are engaged with the shoulder **128**, the lug **120** is held removed from the periphery of the drive plate **108** and the cam shaft **100** remains stationary.

When a solenoid **140** is actuated, an armature **142** is drawn to the right (FIG. 7) against the urging of a spring **144** to swing the cam cycle lever **132**, pivotally connected to the armature **142**, on the shaft **134** in a clockwise direction. Thus, the shoulder **128** is momentarily moved out from beneath the beak **126** and the radial shoulder **138** releasing the actuator disc **114** for rotation and allowing the pawl **118** to pivot under the influence of the spring **122** to engage the lug **120** with the first notch **110** which approaches the lug.

When the solenoid **140** is de-energized so that the spring **144** returns the armature **142** and the cam cycle lever **132** to their original positions, the cam shaft **100** continues rotating but only for the remainder of its current revolution. This follows from the fact that as the pawl **118** swings to couple the actuator disc **114** and the drive plate **108** together, the beak **126** is projected into leading relationship with the radial shoulder **138** and as the ensuing revolution is completed, the beak **126** engages the shoulder **128** slightly in advance of the radial shoulder **138**. When this occurs, the actuator disc **114**, still coupled to the drive plate **108**, continues to rotate to bring its radial shoulder **138** into engagement with the shoulder **128**. Because the beak **126** on the pawl **118** is no longer free to move, the pawl swings against the force of the spring **122** and disengages the lug **120** from the peripheral notch **110** of the drive plate **108**, stopping rotation of the actuator disc **114** and of the cam shaft **100**.

When the yarn is running below the particular speed previously discussed, and the inspection unit **34** senses a defect in the yarn, as during threading of a new or reserve bobbin, as S_2, which has been moved to the active position and becomes the active bobbin or package S_1, the sensing unit signals for operation of the cutting-clamping assembly **38** and for operation of the solenoid **140** to commence a succeeding end finding and joining operation to eliminate the defect. If, however, a defect is again detected in the course of the succeeding operation, the inspection unit **34** signals for operation of the blade **36** and for operation of a suitable mechanism to replace the current active supply package S_1 with a fresh supply package S_2 (FIG. 1). It should be explained that it is desirable to remove the current supply bobbin S_1 from the active unwinding position when a yarn doubling is encountered and to replace it with a fresh supply package S_2. From experience, it is known that a doubling would probably cause a down spindle in that the tension nozzle **78** would perform a number of successive end finding attempts without locating a single end of yarn. As the yarn is drawn through the passage **32** upon the counterclockwise rotation (FIG. 1) of the tension nozzle **78**, a yarn defect detected by the inspection unit may be an ordinary slub or it may be the beginning of a doubling. In the former event, it is merely necessary to eliminate the slub from the yarn while retaining the current supply package S_1 in the active unwinding position. However, should the defect in the yarn be a doubling it is desirable to entirely remove the supply package S_1 and replace it with a fresh supply package S_2. To differentiate between a mere slub and a doubling, it is desirable first to remove the defect and then to reinspect the yarn. If the defect remains, the improbability of the second defect being a mere slub is so great that the doubling is substantially identified and the current supply package S_1 is removed and replaced with a fresh supply package S_2. This follows from the fact that slubs are relatively rare in occurrence such that the presence of two slubs in a short length of yarn, that is, the length of yarn which advances during the inherent delay period between detection of a defect and the actuation of the solenoid **46**, strongly suggests a defect having a length longer than an ordinary slub.

SUPPLY REPLENISHING MECHANISM

When operated, a replenishing mechanism **146** (FIGS. 8 and 9) within the housing **22** initiates a sequence of

events as the result of which the supply package S_1 is replaced with a fresh supply package S_2. The supply packages S_1 and S_2 are suitably mounted at opposite ends of a creel in the form of a spider **148** (FIG. 1) which is fixed to a tubular shaft **150** rotatably supported in a pedestal bearing **152** fixed to a rail **154** constituting a part of the frame of the winding machine. At its upper end, the tubular shaft **150** projects through a floor **156** (FIG. 8) of the housing **22** and an inner shaft **158** extends through the tubular shaft **150** and is appropriately held in a concentric relationship so as to be rotatable independently of the tubular shaft.

The inner shaft **158** is continuously rotated in a suitable manner and when a suitable semi-revolution clutch **160** mounted on the floor **156** within the housing **22** is actuated, the tubular shaft **150** is coupled to the internal shaft **158** to effect movement of the supply spider **148** to bring the fresh supply package S_2 into unwinding position and to remove the supply package S_1 to the inactive position, that is, reversing the respective positions shown in FIG. 1.

When a solenoid **162** of the replenishing mechanism **146** is energized, an armature **164** is drawn leftwardly (FIGS. 8 and 9) against the urging of a spring **166**. As a lever **168**, pivotally connected to an end of the armature **164** and guided through a slot **170** in an upstanding portion of an L-shaped base plate **172**, moves to the left (FIGS. 8 and 9), it carries with it a latch **174** which engages a clutch operating finger **176**. The operating finger **176** is pivotally mounted about a vertically disposed pin **178** (FIGS. 8 and 9) and, biased in a counterclockwise direction by a tension spring **180** having one end connected to the finger and the other end connected to the floor **156**, extends in a substantially radial manner beyond the enclosure of the clutch **160**. Thus, the finger **176** is pivoted in a clockwise direction (FIG. 9) about the pin **178** and against the urging of the spring **180** until the clutch **160** is actuated to couple the shaft **150** to the shaft **158**. As the armature **164** continues to be drawn to the left (FIGS. 8 and 9) by the solenoid **162**, an extreme end of the lever **168** pinned to a link **182** follows an ascending arc as it swings the link **182** in a counterclockwise direction (FIG. 8) about a stub shaft **184** journaled in a pillow block **186** mounted on the floor **156**. When the extreme end of the lever **168** reaches an appropriate height, the finger **176** slides off the latch **174**, and under the bias of the spring **180**, returns to its normal inoperative position. After the solenoid **162** is de-energized, the lever follows a descending arc under the urging of the spring **166** and returns to the normal inoperative position (FIGS. 8 and 9).

A pin **186** serves to pivotally mount the latch **174** on the lever **168**. The latch **174** is urged in a counterclockwise direction (FIG. 8) by a torsion spring **188** coiled around the pin **186** so that one end bears against the lever **168** and the other end against the latch **174** to normally hold a bent-over tab **190** on the latch against an upper edge of the lever **168**. As the lever **168** approaches the inoperative position, the latch **174** engages and slides across the upper surface of the finger **176**, rocking the latch **174** in a clockwise direction (FIG. 8) against the urging of the spring **188**. Rocking of the latch **174** continues until the latch moves beyond the finger **176** and is returned by the spring **188** to its inoperative position.

TENSION MECHANISM

Operation of the blade **36** always precedes operation of the solenoid **162** so that the free end from the supply, if any, is cut at the inspection unit **34** before the current supply package S_1 is removed from the active unwinding position (FIG. 1). A tension mechanism **192**, positioned in the normal yarn path intermediate the active supply package S_1 and the inspection unit **34** for controlling tension in the yarn as it advances across the top panel **20**, includes an upper tension disc **194** and a lower tension disc **196** between which the yarn advances. The discs **194** and **196** are suitably urged into mutual engagement and when a partially unwound supply package is to be removed, it is desirable to separate the discs after cutting the yarn at the inspection unit **34** in order to release the free end of yarn and to allow for insertion of yarn from the fresh supply package S_2.

Upon actuation of the solenoid **162** to operate the clutch **160**, a crank **198** integral with the link **182** swings downwardly in the counterclockwise direction (FIG. 8) about the stub shaft **184**. The crank **198** is suitably recessed to receive the free end of an axially extending pin **200** fixed to a lower end of a plunger **202**. Fixed to the upper end of the plunger **202** is the lower tension disc **196** positioned substantially beneath the upper tension disc **194**. The upper tension disc **194** is fixed to the lower end of a rod **204** which is suitably suspended from one end of a cantilever **206**. At its other end, the cantilever is suitably fixed to the top of the inspection unit **34**. As the crank **198** swings downwardly, a compression spring **208** is effective to cause the lower tension disc **196** to recede from the upper tension disc **194**. To this end, the spring **208** is coiled about the plunger **202** and extends between the underside of the top panel **20** and an annular flange **210** on a bushing **212** fixed to the plunger. The bushing **212** is seated on a retainer **214** also fixed to the plunger **202** and is axially movable in a bore **216** through the top panel **20**.

An aperture **218** in the top panel **20** communicates with a suitable source of vacuum (not shown) and serves to receive and retain the free end of yarn from the reserve supply package S_2 in the inactive position (FIG. 1). From the aperture **218**, the reserve end of yarn stretches over the guide **28**, then downwardly to the reserve supply package S_2, and as the reserve package S_2 is moved from the reserve to the active unwinding position, the yarn follows along the guide until it is received in the pigtail portion **30**. Simultaneously, the lower tension disc **196** recedes from the upper tension disc **194** for a sufficient period to receive yarn from the fresh supply package S_2 and by the time the fresh supply package S_2 reaches the active, unwinding position, the solenoid **162** is de-energized and the lower tension disc **196** returns to its normal yarn engaging position (FIG. 8).

TENSION SENSOR

Also located in the path of the supply yarn is a tension sensor **220** fixed to the top panel **20** intermediate the inspection unit **34** and the cutting-clamping assembly **38**. The tension sensor **220** operates only during the end finding and joining operation and serves to detect excessive tension in the supply yarn as the tension nozzle **78** swings upwardly to deliver the free end of supply yarn to the knotter **94**. In the course of an end finding and joining operation, the yarn is guided, generally as shown by dotted lines in FIG. 2, adjacent a switch **222** by a pair of angularly disposed guide pins **224** fixed to and extending downwardly from the enclosure for the switch **222** and a switch actuating arm **226** which extends outwardly and upwardly from the switch **222** and overlies the yarn. Under normal conditions, the yarn has no effect on the actuating arm **226**, but when yarn tension becomes excessive and the yarn becomes taut, as for example, when the yarn no longer unwinds freely from the supply package S_1, the yarn slides upwardly along the guide pins **224** and when a predetermined force has been applied to the actuating arm **226** by the yarn, the tension sensor **220** is effective to signal for operation of the blade **36** to cut the yarn extending from the supply package S_1 and for operation of the solenoid **162** to move a fresh supply package S_2 into the active unwinding position.

CONTROL CIRCUIT

Turn now to the electrical diagram, FIG. 10, all components are shown in positions assumed when the winding machine is inoperative. A continuous source of electric

potential EMF is provided across supply lines L_1 and L_2 and activates the control circuit when a master switch MS is closed.

Upon closure of the master switch MS, the solenoid **140** is energized initiating rotation of the cam shaft **100**. Because a suitable detector **228** within the inspection unit **34** senses that the yarn is currently running below the particular speed. The detector **228** is a photo-electric cell connected in a suitable circuit, indicated by the box **229**, of the previously mentioned Loepfe inspection device **34**, to provide various signals utilized and described hereinafter. Thus, a relay 1R remains de-energized such that its contacts (**1R1–1R8**) assume the positions indicated in FIG. 10. Thus, a time delay relay 1TDR is energized and its normally closed contact 1TDR1 remains closed until a predetermined period preset into the relay has lapsed, at which time it opens.

The relay 1TDR permits a plurality of successive end finding and joining attempts in the event a first or a succeeding attempt fails, and for this purpose operates to hold the solenoid **140** energized for an arbitrarily preset period of time. Specifically, the contact 1TDR1 normally assumes a closed position, but when the preset period in the relay 1TDR has lapsed, the contact 1TDR1 opens and remains open until the relay 1TDR is de-energized. Thus, as long as the contact 1TDR1 remains closed, the solenoid **140** remains energized, the cam cycle lever **132** (FIGS. 6 and 7) is held withdrawn from the actuator disc **114** so that the drive plate **108** and the actuator disc **114** remain coupled together, and the cam shaft **100** continues to rotate. When the contact 1TDR1 opens after the preset period of time has lapsed, the solenoid **140** is de-energized and the cam shaft **100** continues rotating only to complete the cycle which has already commenced.

Consider now the instance in which a fully or partially wound supply package or bobbin S_1 (FIG. 1) is in the unwinding position such that yarn Y extends through the passage **32** (FIG. 2) of the sensing unit **34** and is held at the cutting-clamping assembly **38**. In that event, the tension nozzle **78** is effective to draw the yarn Y laterally out of the passage **32**. The yarn slides off the angularly disposed guide pins **224** of the tension sensor **220** and away from the yarn clamp **56** which is released by the flexible reed **86** (FIG. 5) engaging the lever **68** as the tension nozzle **78** swings in the clockwise direction (FIG. 1). As the tension nozzle **78** approaches its extreme position, the rigid finger **88** brushes against and momentarily closes contacts of a switch **230** (FIGS. 1, 2 and 10) suitably mounted on the top panel **20** adjacent the closure cam **90**. However, removal of the yarn from the passage **32** generates a signal within the inspection unit **34** which operates to energize a relay 2TDR to open its normally closed contact 2TDR1 for a preset period of time lasting at least until the rigid finger **88** has moved to close the contacts of the switch **230**. Therefore, it is apparent that when yarn is present in the passage **32** and is subsequently removed, a solenoid **232** (FIG. 10) for operating the knife **36** is unaffected and remains inactive.

After the yarn ends from the bobbin S_1 and the package P have been tied by the knotter **94** and winding is reinstated, the yarn movement detector **228** signals the relay 1R accordingly, cause its contacts (1R1, etc.) to assume positions opposite those indicated in FIG. 10. With the opening of the contacts 1R7 and 1R8, the relay 1TDR is a de-energized and the solenoid **140** is de-energized to terminate rotation of the cam shaft **100** when it has completed its current cycle. A sufficient dwell period is suitably provided in the operation of the winding machine to assure that the yarn will have attained a linear speed in excess of the minimum value so that the solenoid **140** will have been de-energized prior to the beginning of a subsequent end finding and joining operation.

Should the knotter **94** fail to join the ends of yarn, the contacts of the relay 1R remain in the positions indicated in FIG. 10 such that the relay TDR and the solenoid **140** remain energized. The end finding and joining operation is then repeated until such time that the yarn is successfully joined and winding is commenced or until the relay 1TDR finally operates to open the contact 1TDR1. If the yarn is not joined when sufficient time has elapsed for the contact 1TDR1 to open, the winding machine becomes inactive until an attendant corrects the malfunction.

If for any reason yarn Y does not extend in a path suitable for seizure by the tension nozzle **78**, no signal is generated by the inspection unit **34**, the relay 2TDR remains de-energized, and the contact 2TDR1 remains closed. When the tension nozzle **78** reaches its extreme position and momentarily closes the switch **230**, the solenoid **232** is energized to sever any yarn which may yet remain in the passage **32** and the solenoid **162** is energized to actuate the clutch **160**, replacing the current supply package S_1 with a fresh supply package S_2. Movement of the fresh supply package S_2 into the active unwinding position is performed in a sufficiently rapid manner that the yarn from the package S_2 is moved laterally into the open jaws of the closure cap **84** before the mouth **82** reaches the cam **90**. If the yarn is successfully joined and winding reinstated, the yarn movement detector **228** energizes the relay 1R to move its contacts (1R1 etc.) to positions reversed from those indicated in FIG. 10. Thus, with the opening of the contact 1R8, the solenoid **140** is de-energized and rotation of the cam shaft **100** terminates after it completes its current revolution.

Consider now that yarn is running in the normal manner such that the relay 1R is energized and its contacts (1R1 etc.) are moved to positions opposite those indicated in FIG. 10. If in this condition a defect is detected in the yarn Y by the detector **228** within the inspection unit **34**, a time delay relay 3TDR is mometnarily energized thus closing its normally open contact 3TDR1 for a preset period of time. Because the contact 1R6 had previously been closed by the relay 1R, the solenoid **46** is energized to cut the yarn and to hold at the assembly **38** the free end of yarn extending from the supply package S_1. The resulting condition of the yarn running below the particular speed is sensed by the detector **228** de-energizes the relay 1R to return its contacts to the positions indicated in FIG. 10. With the closure of the contact 1TDR1, the solenoid **140** is energized and the cam shaft **100** commences rotation.

Consider the instance in which the detector **228** senses a yarn defect when the yarn is running below the particular speed, as during the end finding and joining operation. When this occurs, the relay 3TDR is momentarily energized by a signal from the detector **228** and its contact 3TDR1 is closed. Because the movement detector **228** senses that the yarn running below the particular speed, the relay 1R is de-energized and all of its contacts (1R1 etc.) assume the positions indicated in FIG. 10. Thus, the contact 1R5 is closed, switching a normally cut-off transistor T to drive it into conduction so as to energize a suitable stepping switch SS. One instance of a suitable stepping switch SS is a device designated Rotary Solenoid Switch, part No. 250–124–256, manufactured by Ledex Inc. of Dayton, Ohio, and is schematically shown in FIG. 11. When the stepping switch SS is energized, a suitable drive motor **236** is effective to rotate a shaft **238** on which is fixed a radially extending wiper element **240**. A free end of the wiper element **240** is adapted to successively engage a plurality of stationary contacts SS1, SS2, SS3, and SS4 fixed on a stationary disc **242**. A capacitor C (FIG. 10) in parallel with the stepping SS serves to sufficiently retard rotation of the shatf **238** (FIG. 11) to assure that positive engagement is made between the wiper element **240** and each of the contacts. The wiper element **240** is initially positioned (FIG. 11) to hold the contact SS1 open. The time period preset into the relay 3TDR is of sufficient duration to

swing the wiper element **240** across at least two of the contacts ont he disc **242**. Thus, when the motor **236** is energized, the wiper element **240** is rotated through a second position at which it momentarily closes the contact SS2 and continues to a dead position at a contact SS3. Although the contact SS1 is held open initially by the wiper element **240**, it remains closed during the subsequent operation of the stepping switch SS.

Should a yarn defect be detected as the yarn Y is drawn through the passage **32** in the course of the counterclockwise movement of the tension nozzle **78** (FIG. 1), the detector **228** signals the relay **3TDR** to close its contact **3TDR1** thus energizing the solenoid **46** to cut the yarn and hold the free end at the assembly **38**. The end finding and joiining operation is repeated and if no defect is detected this time, the relay **3TDR1** receives no signal from the detector **228** and the contact **3TDR1** remains open. When winding resumes and detector **228** energizes the relay **1R** to move its contacts to assume positions opposite those indicated in FIG. 10, closure of the contact **1R4** causes the stepping switch SS to be energized, because the contact SS1 is closed in all intermediate positions of the stepping switch SS, and to remain energized until the wiper element **240** moves to its initial position, opening the contact SS1. The stepping switch SS is thereupon de-energized.

If, however, the detector **228** again detects a yarn defect, it again signals the relay **3TDR** to close its contact **3TDR1** so that the stepping switch SS is energized through the normally non-conducting transistor T and its wiper element **240** continues from the dead position SS3 through a position in which the contact SS4 is momentarily closed. Because the movement detector **228** senses that the yarn is running below the particular speed, the contact **1R3** is closed and, upon closure of the contact SS4, energizes the solenoids **162** and **232** to cut the yarn at the inspection unit **34** and to index a fresh supply bobbin S_2 into the active unwinding position. An end finding and joining operation is commenced and when winding is resumed, the stepping switch SS is de-energized with its wiper element **240** in its initial position, opening the contact SS1.

Should yarn tension be excessive during the end finding and joining operation so as to effect closure of the switch **222**, the solenoids **162** and **232** are energized because the contact **2TDR1** is closed. In this manner, the yarn is severed by the knife **36** and a fresh supply bobbin S_2 is indexed into unwinding position thus removing the defective supply package S_1 and its associated yarn.

OVERALL OPERATION

When yarn is running above the previously described predetermined particular speed and the inspection unit **34** detects an unacceptable yarn defect, the assembly **38** is operated to cut the yarn and in the course of the subsequent end finding and joining operation the defect is eliminated, and winding is resumed. The yarn thus removed is at most a few feet and if in movement of this particular span of a few feet, an unacceptable yarn defect is detected, the solenoid **46** at the assembly **38** is initially operated and an end finding and joining operation is commenced. Should another defect be detected during movement of the particular span of a few feet through the assembly **34** during the end finding and joining operation, the knife **36** is operated and the active supply package S_1 is replaced with a fresh, reserve supply package S_2. Also should excessive yarn tension be detected during the end finding and joining operation, the knife **36** is operated and a fresh supply package S_2 is moved into unwinding position.

If yarn from an active supply bobbin S_1 does not lie in a path enabling the tension nozzle **78** to seize the yarn in the course of an end finding and joining operation, or if the supply package S_1 has become exhausted, a fresh supply package S_2 is moved into the active unwinding position.

For the reason that the invention is capable of numerous forms other than those disclosed without departing from the scope of the invention, it is intended that the embodiment disclosed be deemed illustrative and not restrictive.

What is claimed is:

1. Yarn winding apparatus comprising supply means for operatively positioning an active source of supply of yarn to be wound onto a package and operable for replacing said active source with a reserve source of supply of yarn, means operable for threading yarn from said supply means to said package, and control means for sensing yarn tension and operating said supply means for replacing said active source only during operation of the threading means and responsive to yarn tension above a predetermined value.

2. Apparatus as set forth in claim **1** in which said control means is operable for sensing the tension of yarn extending from said supply means toward said package to so operate said supply means.

3. Yarn winding apparatus comprising supply means for positioning an active source of supply of yarn to be wound onto a package and operable for replacing said active source with a reserve source of supply of yarn, means for winding the yarn from said active source onto said package, means operable for removing a fault from said yarn, and control means for sensing yarn tension and responsive to yarn tension above a predetermined value and to the fault removing means operating more than once within a predetermined span for operating said supply means to replace said active source with said reserve source.

4. Yarn winding apparatus comprising supply means for positioning an active source of supply of yarn to be wound onto a package and operable for replacing said active source with a reserve source of supply of yarn, means for winding the yarn from said active source onto said package at a rate above a particular winding speed during normal winding operation, fault removing means for removing a fault from said yarn and for reducing the yarn speed below said particular winding speed while removing a fault, and control means responsive to the fault removing means operating more than once within a predetermined span which terminates when the yarn speed rises above said particular speed following operation of said fault removing means for operating said supply means to replace said active source with said reserve source.

5. Apparatus as set forth in claim **4** including means operable for threading yarn from said supply means to said package, and in which said control means is operable for sensing the tension of yarn extending from said supply means toward said package and for operating said supply means to replace said active source with said reserve source responsive to said yarn tension being above a predetermined value only during operation of the threading means.

6. Apparatus as set forth in claim **5** wherein the sources of supply of yarn are bobbins, said supply means includes a holder for supporting said bobbins, means movably mounting said holder for replacing an active bobbin with a reserve bobbin, drive means, and clutch means operable to couple said holder to said drive means for movement of said holder to replace said active bobbin with said reserve bobbin, and said control means is operable for operating said clutch.

7. Apparatus for winding yarn from a supply to a take-up package, comprising first and second spaced apart cutting means operable to cut the yarn, and inspection means for detecting a predetermined yarn condition and upon detecting such condition responsive to yarn speed above a predetermined rate for operating said first cutting means and responsive to yarn speed below said pre-

determined rate for operating said second cutting means.

8. Apparatus as set forth in claim 7 wherein said first cutting means includes a cutting member operable for movement between a retracted, inoperative position and an extended position for cutting the yarn, and a clamping member for yieldably holding the yarn concurrently with operation of said cutting member.

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