

June 17, 1958

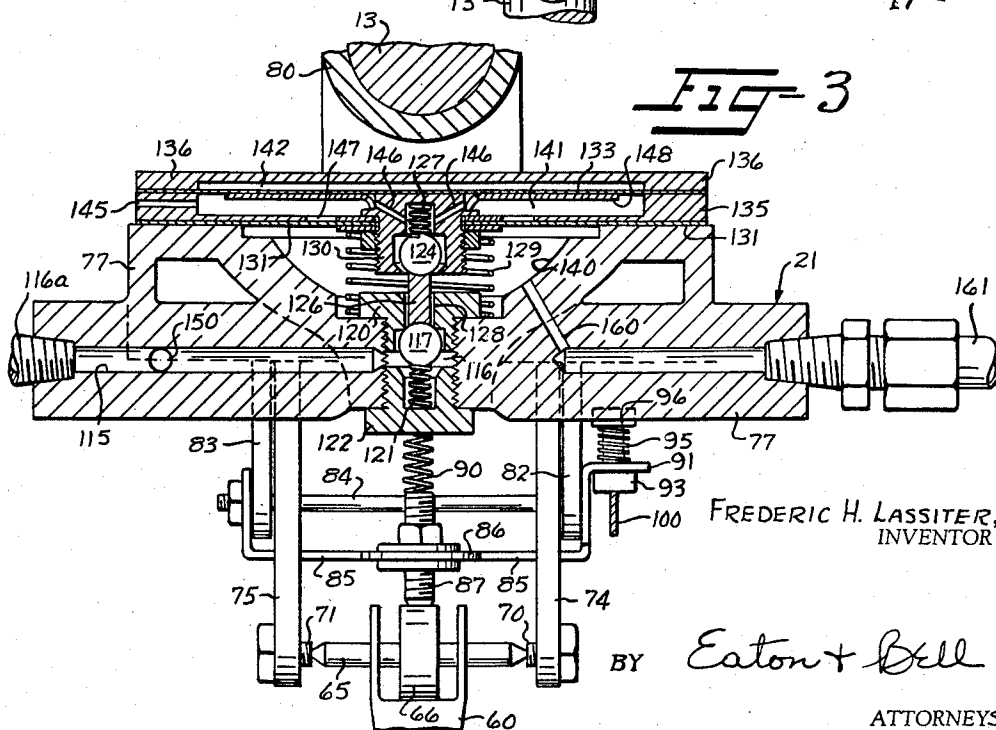
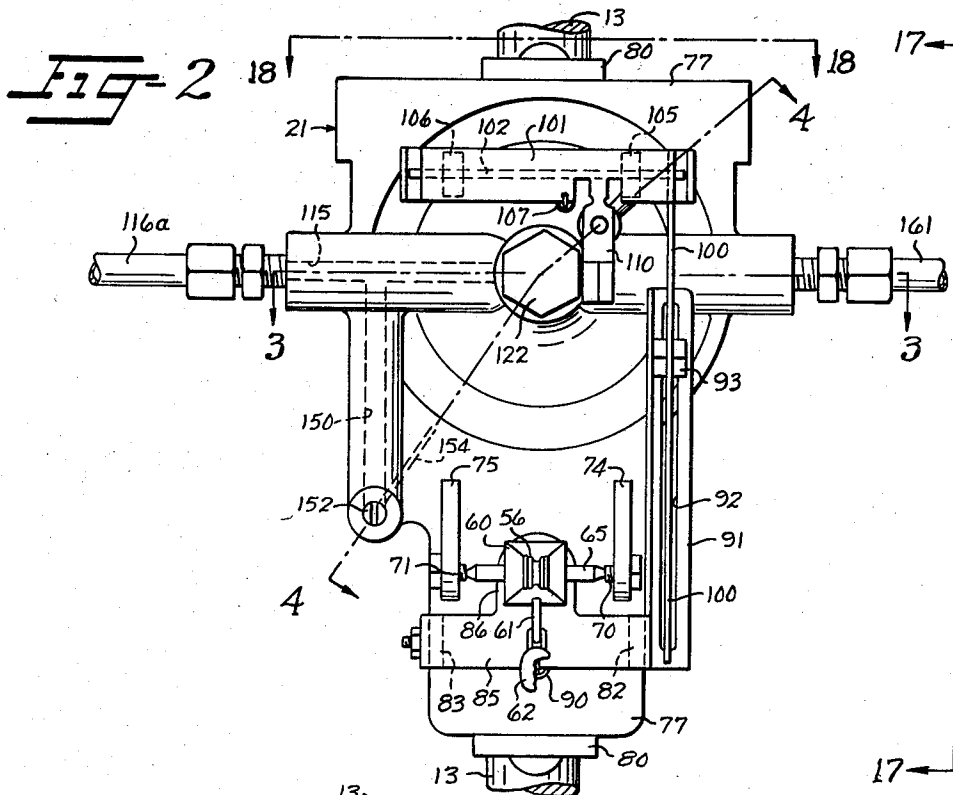
F. H. LASSITER

2,838,923

YARN TENSION CONTROLLED YARN FEEDING APPARATUS

Filed Feb. 7, 1955

6 Sheets-Sheet 2



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YARN TENSION CONTROLLED YARN FEEDING APPARATUS

Filed Feb. 7, 1955

6 Sheets-Sheet 3

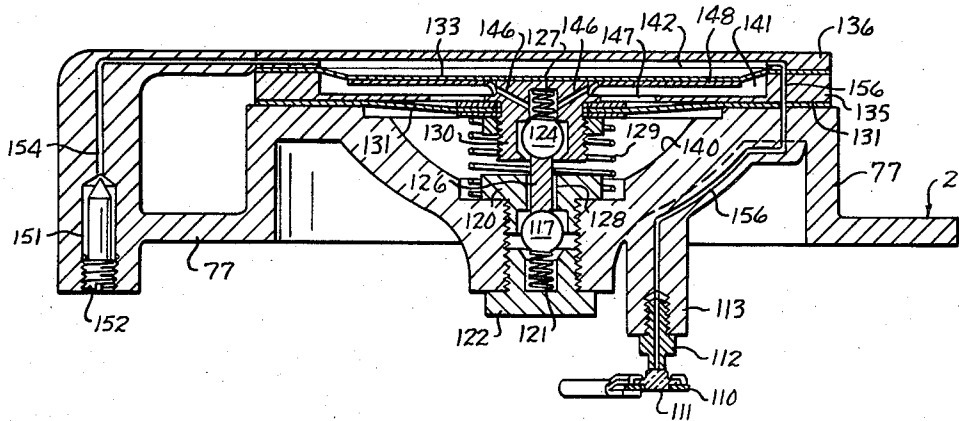


FIG-4

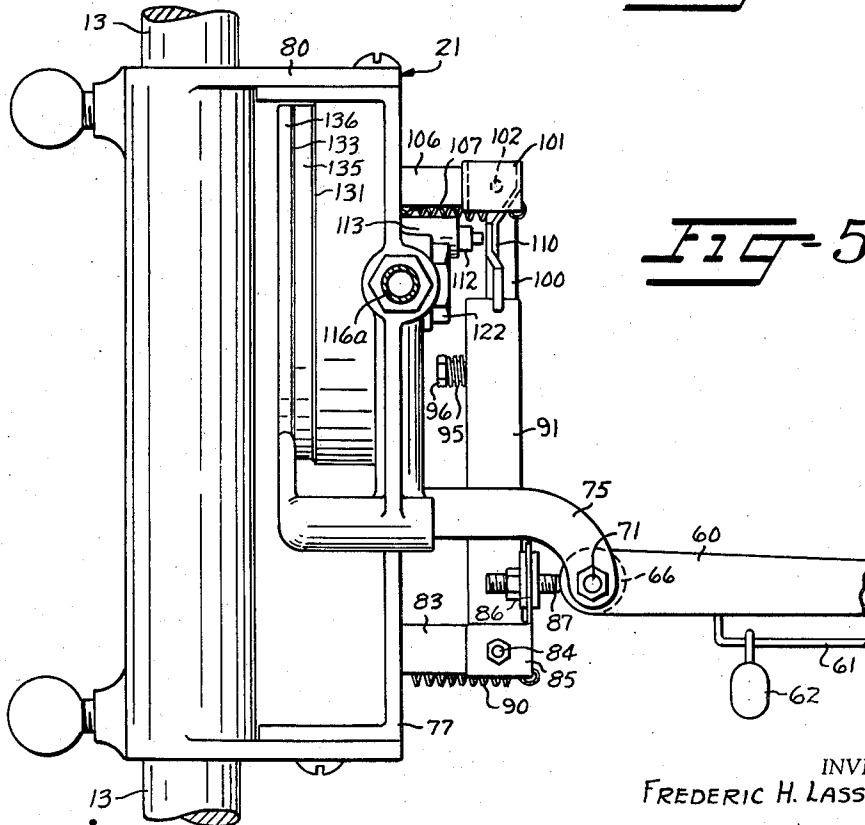


FIG-5

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June 17, 1958

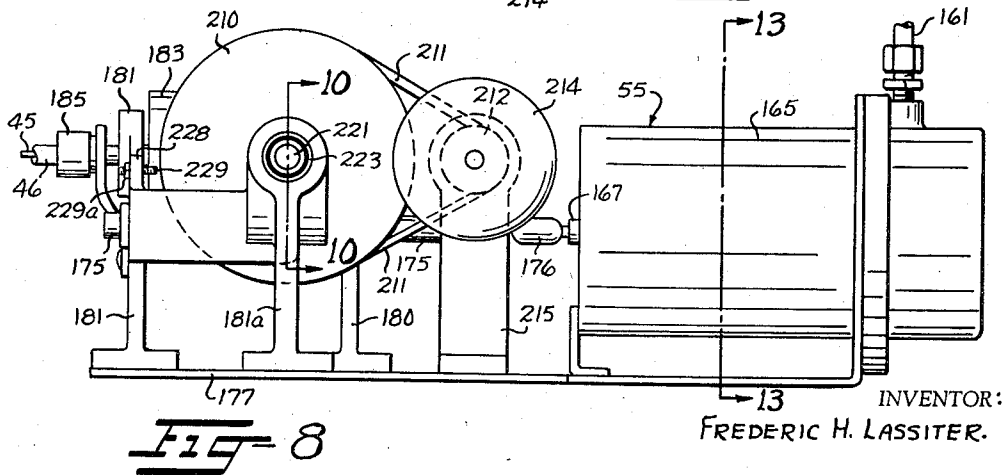
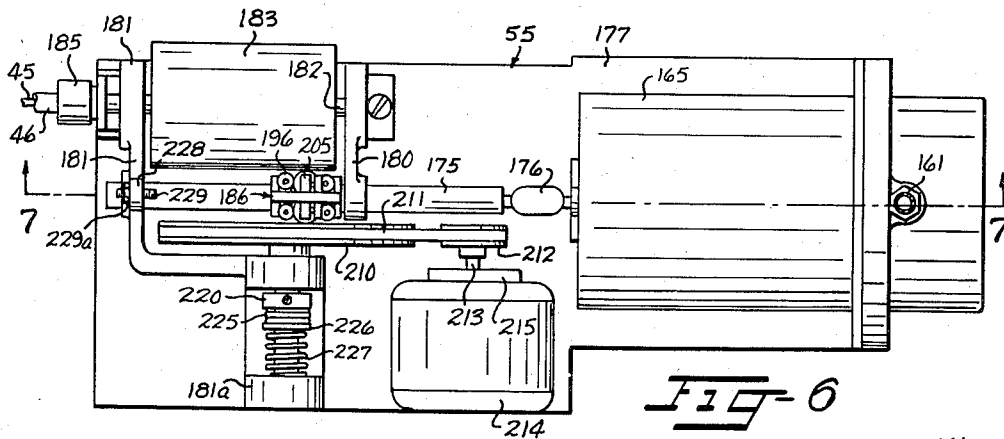
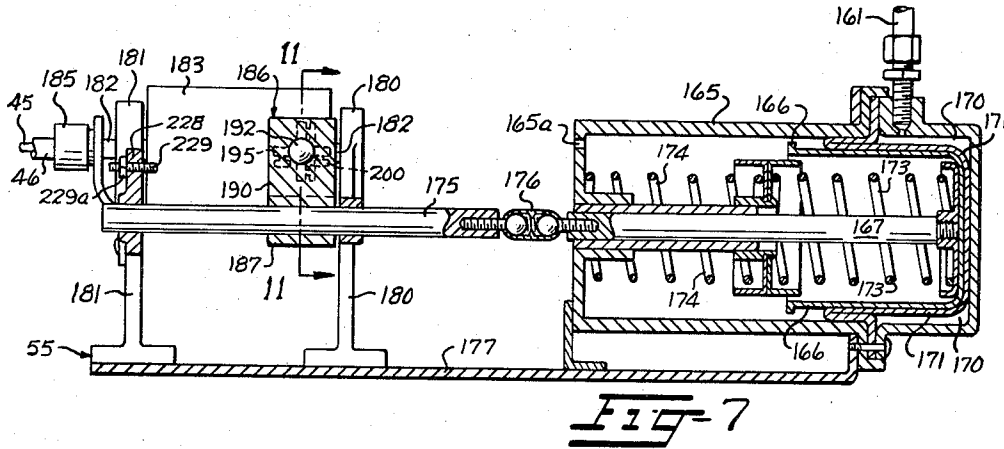
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YARN TENSION CONTROLLED YARN FEEDING APPARATUS

Filed Feb. 7, 1955

6 Sheets-Sheet 4



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2,838,923

YARN TENSION CONTROLLED YARN FEEDING APPARATUS

Filed Feb. 7, 1955

6 Sheets-Sheet 5

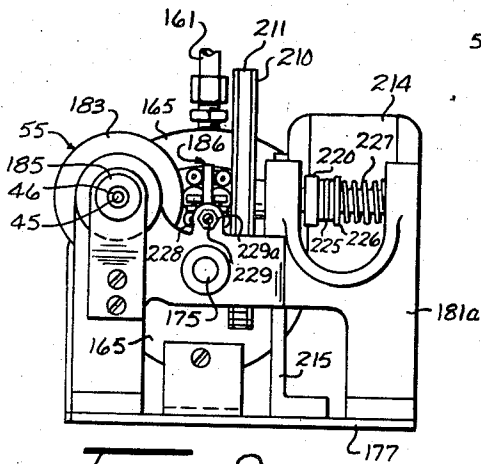


FIG-9

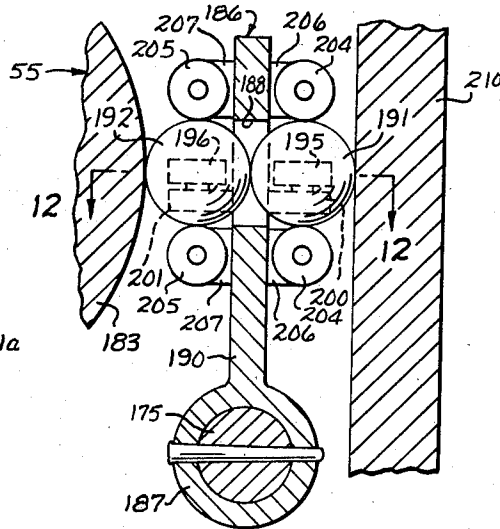


FIG-11

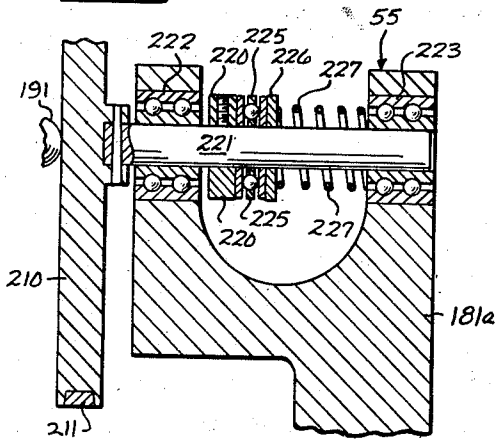


FIG-10

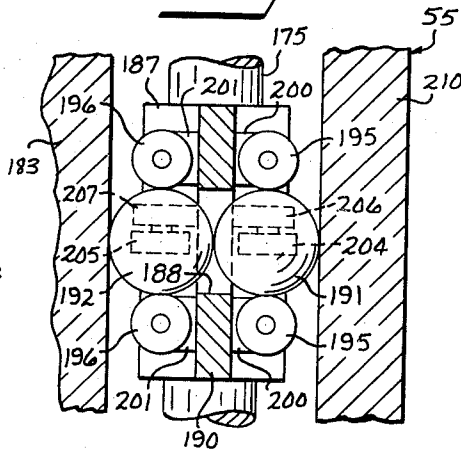


FIG-12

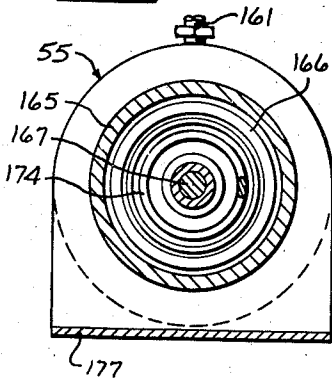


FIG-13

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YARN TENSION CONTROLLED YARN FEEDING APPARATUS

Filed Feb. 7, 1955

6 Sheets-Sheet 6

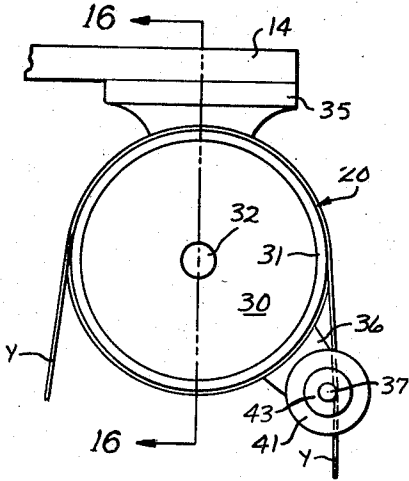
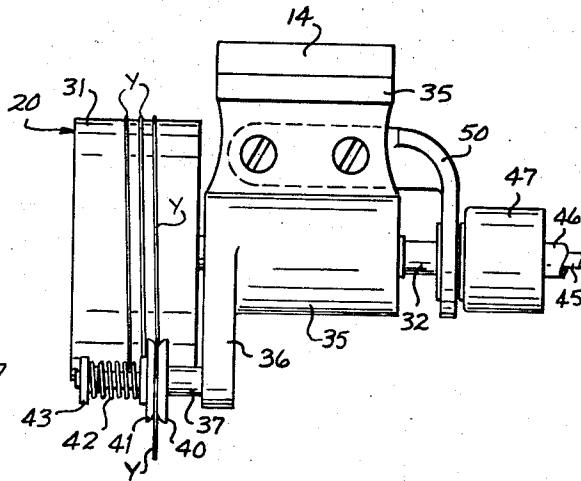


FIG-14



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2,838,923

YARN TENSION CONTROLLED YARN FEEDING APPARATUS

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Application February 7, 1955, Serial No. 486,530

10 Claims. (Cl. 66—132)

This invention relates to yarn tension devices and more especially to an improved method and means for maintaining a constant stress in a strand of yarn drawn from a randomly tensioned source.

This invention is particularly adapted for use in maintaining a constant tension on nylon yarn such as is used in the manufacture of ladies' hosiery and the like, but it is understood that the present invention might as readily be used for maintaining uniform tension in yarns made from natural fibers or in any other types of synthetic yarn. Although the improved yarn tension device is shown in association with a seamless knitting machine, it may be used for delivering yarn under constant tension while withdrawing it from a non-rotating spool or pirn on which the yarn has previously been wound in such a manner that varying tensions are required to withdraw it from the non-rotating pirn, or from which spool or pirn several convolutions of yarn may slide off simultaneously.

It is an object of this invention to provide a yarn tensioning device for feeding yarn under uniform tension irrespective of the type of yarn fed and irrespective of the speed at which the yarn being fed is taken up. The rate at which the yarn leaving the yarn tensioning device is taken up may be either constant or variable and it is an important feature of this invention to feed the yarn at a speed determined by the demand for it. The tension on the yarn being fed by this yarn tensioning device may be varied from a very light tension to a considerable tension as desired.

It is another object of this invention to provide a yarn tensioning device comprising a driven feed roll interposed between a yarn source and a take-up means and about which roll the yarn passes. A strand length or feed velocity detector or sensing means interposed between the driven roll and the take-up means operates a control unit for controlling a drive for the feed roll in such a manner that the peripheral speed of the feed roll is commensurate with the speed at which the yarn is taken up while maintaining the yarn under tension. The drive means may also reverse the feed roll in the event of the yarn having a tendency to become slackened so the feed roll actually takes up the yarn to still maintain the yarn under predetermined uniform tension.

It is still another object of this invention to provide an improved method of maintaining uniform tension in a strand which comprises feeding the strand from a rotating element while taking up the strand, sensing the length of that portion of the strand between the rotating element and the taking-up means and varying the speed of the rotating element in response to the sensing of variations in the length of said portion of the strand.

The yarn length or feed velocity detector or sensing means is movable by the yarn in accordance with variations in yarn length and this movement is measured by a sensitive pneumatic device including a diaphragm and the pneumatic device is connected to the drive roll in such a manner as to cause compensatory variations in

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the speed of the driven feed roll. The pneumatic device permits prompt and sensitive response without lagging or overcorrecting.

Some of the objects of the invention having been stated, other objects will appear as the description proceeds, when taken in connection with the accompanying drawings, in which—

Figure 1 is a schematic illustration of the improved yarn feeding and tensioning device as applied to a seamless knitting machine;

Figure 2 is an enlarged elevation of the roll drive control unit taken substantially along line 2—2 in Figure 1;

Figure 3 is an enlarged sectional plan view of the control unit taken substantially along line 3—3 in Figure 2;

Figure 4 is an enlarged sectional view taken substantially along line 4—4 in Figure 2;

Figure 5 is an enlarged side elevation of the control unit shown in the central portion of Figure 1;

Figure 6 is an enlarged plan view of the roll drive or regulator unit shown in the lower right-hand portion of Figure 1;

Figure 7 is a longitudinal vertical sectional view taken substantially along line 7—7 in Figure 6;

Figure 8 is a side elevation of the regulator unit looking up at the lower side of Figure 6;

Figure 9 is an end view of the regulator unit looking at the left-hand side of Figure 8;

Figure 10 is an enlarged vertical sectional view taken substantially along line 10—10 in Figure 8;

Figure 11 is an enlarged vertical sectional view taken substantially along line 11—11 in Figure 7;

Figure 12 is a fragmentary sectional plan view taken substantially along line 12—12 in Figure 11;

Figure 13 is a transverse vertical section view taken substantially along line 13—13 in Figure 8;

Figure 14 is an enlarged elevation of the strand or yarn feed roll shown in the upper right-hand portion of Figure 1;

Figure 15 is an elevation looking at the right-hand side of Figure 14;

Figure 16 is a transverse vertical sectional view taken substantially along line 16—16 in Figure 14;

Figure 17 is a fragmentary elevation looking substantially along line 17—17 in Figure 2;

Figure 18 is a fragmentary plan view looking along line 18—18 in Figure 2.

Referring more specifically to the drawings, the numeral 10 designates a source of yarn Y such as a pirn mounted on a pirn-holding or package-holding bracket or rack 11 extending rearwardly from a circular knitting machine indicated broadly at 12. The bracket 11 supports the lower end of a post 13 which has a yarn guiding rack 14 fixed on the upper end thereof.

It might be stated that the pirn 10 shown in Figure 1 is of the usual type received directly from the manufacturer of the yarn Y. The yarn Y may be nylon or the like as wound on the pirn 10 by the manufacturer with little or no regard for the manner in which the yarn is "laid" onto the pirn or the shape of the yarn package on the pirn. Various convolutions of the yarn lay across others, the shape of the package is not uniform and the tension in adjacent convolutions may vary considerably. Heretofore, the yarn Y on the pirn 10 had to be rewound, under uniform tension, onto a cone before it could be used with circular knitting machines such as the type illustrated in Figure 1. Many knitting plants are not equipped with winding machinery, so the rewinding of the yarn would have to be done at other plants and then forwarded to the knitting plant. The improved method of applying tension to the yarn, as embodied in the improved yarn tensioning device, eliminates rewinding of the yarn so the yarn may be drawn directly from the

pirn, on which it was wound by the manufacturer, into the knitting machine.

The yarn Y extends upwardly from the pirn 10 in Figure 1 and is wound about a feed roll, broadly designated at 20, one or more times. The yarn Y then passes downwardly to engage a yarn length detector in the form of a roller 56 on the outwardly extending arm 60 of a controller or control unit broadly designated at 21. The yarn Y may then pass upwardly, to form a loop, and over an idler roller or guide roller 22 journaled on a bracket 23 supported on the post 13.

However, in order to minimize vertical oscillation of arm 60 as it "hunts" its optimum position, in a manner to be later described, it may be desirable, but it is not essential, that the variations in the effective length of the yarn Y are reduced at the roller 56. Accordingly, there will be observed in Figure 1 an auxiliary roller 26 spaced above arm 60 and loosely journaled on the lower end of an arm 25 depending from the yarn guiding rack 14. Thus, in its course from the yarn feeding roll 20 to guide roller 22, the yarn passes downwardly from the feed roll 20, partially around the roller 56 and upwardly (see arrows), partially around the roller 26 and back downwardly partially around the roller 56 and then upwardly over the roller 22. The pulley 56 may be a multi-grooved type, if desired, one groove being provided for each pass of the yarn thereby, in order to prevent entanglement of the adjacent passes of yarn.

The yarn Y then extends downwardly through the usual yarn feed fingers 24 of the circular knitting machine 12. Thus, the amount of movement of arm 60 is greatly reduced so that a given amount of variation in the length of the yarn passing the roller 56 when the roll 26 is used will cause the roller 56 to move upwardly or downwardly in an arc only about one-half the distance the roller would move if the yarn extended directly from the roller 56 to the guide roll 22. The knitting machine 12 is representative of any type of yarn consuming or take-up means. The path of the yarn Y between feeding roll 20 and the take-up means or knitting machine may be termed as the yarn tensioning zone.

Yarn feeding roll

The yarn feeding roll 20 (Figures 1, 14, 15 and 16) comprises a body or drum 30, which has a peripheral resilient covering 31 thereon preferably made from leather, plastic or other material which will produce a minimum of static electricity and which has a coefficient of friction sufficient to prevent slippage of the yarn passing in engagement therewith. The drum of roll 20 is fixed on one end of a shaft 32 rotatably mounted intermediate its ends in suitable bearings 33 fixed in a bracket 35 fixedly secured to the yarn guide rack 14. The bracket 35 has an arm 36 integral therewith (Figures 14 and 15) to the lower end of which a stud 37 is secured. The stud 37 supports a suitable initial yarn tensioning device comprising a pair of yarn tension disks 40 and 41 loosely mounted on the reduced outer end of stud 37.

A compression spring 42, surrounding the reduced portion of the stud 37, resiliently urges disk 41 into engagement with the tension disk 40 as well as the yarn Y passing therebetween. The tension disk 40 is, in turn, urged into engagement with the shoulder on stud 37. The pressure exerted by spring 42 is varied by an adjustment nut 43 threadably mounted on the free end of the stud 37. The disks 40, 41 are preferably restrained from rotation on stud 37. To this end, rectangular holes may be provided in disks 40, 41 and the medial portion of stud 37 may be rectangular in cross-section to accommodate the holes in the disks 40, 41, as is conventional practice.

The end of the shaft 32 remote from drum 30 has one end of a driving cable or flexible shaft 45 fixed thereto. The cable 45 has a suitable housing or covering 46 surrounding the same and corresponding ends of the housing 46 and the cable 45 are supported in a coupling 47. The

coupling 47 is fixedly secured in a bracket 50 which extends upwardly and is suitably secured to the bracket 35 on the yarn guide rack 14 (Figure 16). The cable 45 and the housing 46 extend downwardly in Figure 1 to one end of a novel variable speed drive or regulator unit broadly designated at 55, to be later described in detail.

Controller unit

The yarn feed velocity detector or sensing means comprises the free-rolling grooved roller 56 (Figures 1 and 2) which is rotatably mounted on the free outer end of the control arm or detector lever 60. The arm 60 carries a rack or weight guide 61 which extends longitudinally of the arm 60 and is adapted to receive a sliding weight member 62, the size of which may vary to provide the desired amount of tension to be maintained on the yarn Y as it passes from the feeding roller 20 to one of the yarn feeding fingers 24 of the knitting machine 12. The bifurcated inner or forward end of the control arm 60 is fixed on the medial portion of a pivot shaft 65 which also has an eccentric cam 66 fixed thereon (Figures 3 and 5).

Opposite ends of the pivot shaft 65 are pointed and are pivotally mounted in studs 70, 71 adjustably secured in the rear free ends of a pair of support arms 74, 75 whose front or inner ends are integral with a housing 77 of the roll drive controller 21 (Figures 1 to 5, inclusive). The housing 77 is suitably secured to a control unit support bracket 80 adjustably secured on the post 13. The housing 77 also has a pair of laterally spaced, outwardly extending lower support arms 82, 83 thereon whose outer ends support a pivot shaft 84, on opposite ends of which a bracket 85 is pivotally mounted. The central portion of bracket 85 has an upwardly extending portion 86 thereon (Figures 2, 3, 5 and 17) in which an adjustment bunter or screw 87 is adjustably mounted. The outer or rear end of screw 87 is urged into engagement with the cam 66 by a tension spring 90, one end of which is connected to the lower edge of bracket 85 and the other end of which is connected to the housing 77.

The bracket 85 has an upwardly extending arm 91 thereon which is L-shaped in plan and is provided with a longitudinal slot 92 in the lateral flange thereof. Slot 92 is provided to accommodate a wedge-shaped fulcrum 93 (Figures 2, 3, 5 and 17) which has a reduced end portion of stem extending through the slot 92. The fulcrum 93 is resiliently urged against arm 91, by a compression spring 95 surrounding the reduced stem thereof, and is adjustable by means of a nut 96 threadably mounted on said stem. The fulcrum 93 is engaged by one edge of a lever arm 100, the upper end of which is integral with one leg of a bracket 101 which is substantially U-shaped in plan (Figure 18). Opposite legs of bracket 101 are oscillatably mounted on a pivot rod 102 fixed in the outer or rear ends of a pair of upper support arms 105, 106 (Figures 2, 5, 17 and 18) whose inner or front ends are fixed to or integral with the housing 77.

The arm 100 is urged into engagement with the fulcrum 93 by a tension spring 107, one end of which is connected to the lower end of the bracket 101 and the other end of which is connected to the housing 77. The elongated web or lateral portion of bracket 101 has a downwardly extending arm 110 integral therewith which has a throttling valve closure member 111 mounted therein (Figure 4) which is preferably made from glass or other smooth material and which, at times, mates with and closes the open outer end of a tubular throttling valve or nozzle 112 fixed in an outwardly extending boss 113 integral with the housing 77. One side of the controller 21 is provided with a lateral main compressed air intake passageway 115 (Figures 2 and 3) into which compressed air, preferably at fifteen pounds per square inch is introduced by a lead-in pipe 116a connected to a suitable source of compressed air, not shown.

The intake passageway 115 extends inwardly substantially to the center of the housing 77 and communicates

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with an axial bore or main valve chamber 116 in which a main or primary valve in the form of a ball 117 is movably mounted. The ball 117 is normally urged into engagement with the seat of a tubular main or primary valve housing 120 by a compression spring 121 (Figures 3 and 4). The outer end of spring 121 bears against a chamber closure or cap 122 threadably secured in the bore 116. The valve housing 120 is also fixed in the chamber or bore 116 and establishes communication between chamber 116 and a main air transmission chamber 140 in housing 77.

The ball 117 is spaced from a secondary valve or ball 124 by a spacing member 126. Valve 124 may also be termed as an exhaust valve. The ball 124 is loosely mounted in an exhaust valve housing 130 which is fixed to and penetrates an inner or auxiliary flexible diaphragm 131. A spring 127 in housing 130, which is substantially weaker than spring 121, maintains ball 124 in contact with rod or spacer 126. A relatively light compression spring 129 also normally urges the exhaust valve housing 130 away from the main valve housing 120.

It is particularly important to note that, when the parts of controller 21 occupy "normal" or relaxed positions as shown in Figure 3, spring 21 maintains the main or primary valve 117 in closed position. However, the length of spacer 126 and the diameters of balls 117, 124 relative to the distance between the seats in the main and exhaust valve housing 120, 130 are such that the spring 127 then maintains valve 124 in open position.

It should be noted that the main valve housing 130 has a passageway 128 therein through which spacer 126 loosely extends to permit air to pass through passageway 128. The diaphragm 131 and an outer or main diaphragm 133 are fixedly secured to the main housing 77, in spaced relationship, by rigid diaphragm holding members or disks 135, 136, respectively, suitably secured to housing 77. The front surface of housing 77 has the second, inner or air transmission chamber 140 therein.

The diaphragms 131, 133 define an intermediate, third or latent air chamber 141 therebetween and the diaphragm 133 and the front plate 136 define a front, fourth or pilot air chamber 142 therebetween. The ridge on disk 135, which defines the peripheral wall of the latent chamber 141, has an air exhaust port or opening 145 therein (Figure 3) which is open to the atmosphere. A plurality of passageways or ports 146 in the exhaust valve housing 130 connect the chamber 141 with the chamber in housing 130 which is normally closed by the exhaust ball valve 124.

The central portion of the inner disk 135 has a hole 147 therein which is large enough to permit free movement of the front portion of the exhaust valve housing 130 therethrough, but which is substantially smaller than the corresponding peripheral wall of latent chamber 141 so that a positive pressure relationship may be maintained between diaphragms 133, 131 when air under pressure is directed against the opposite sides of each. Also a relatively light and thin pressure-distributing disk 148 is provided on the outer or front end of the exhaust valve housing 130 for evenly distributing the pressure placed on the exhaust valve housing 130 over a substantial portion of the face of the diaphragm 133 when the spring 129 tends to overcome the air pressure in pilot chamber 142. Of course, the disk 148 also prevents the diaphragm 133 from bulging around valve housing 130 during an increase of pressure in chamber 142.

The main air intake or ingress passageway 115 has a branch passageway 150 leading downwardly therefrom (Figure 2) to a metering valve chamber 151 (Figure 4) in which is adjustably mounted a needle valve or metering valve 152 for reducing the volume of air passing by the needle valve into a reduced auxiliary main air input passageway 154 communicating with the fourth front or pilot chamber 142 (Figures 2 and 4). An output or bleed-off passageway 156 communicates with chamber 142 and extends through the ribbed peripheral portions of the

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disks 135, 136 and the corresponding portions of diaphragms 131, 133, through the housing 77 and its boss member 113 thereon where it communicates with the tubular throttling valve 112. The housing 77 has an output passageway 160 therein leading from chamber 140 to one end of an output or air egress pipe 161 connected to the housing 77 of the controller 21 (Figure 3). The output pipe 161 extends from the controller 21 to the intake side of the roll drive unit or speed regulator unit 55 (Figures 1, 6, 7 and 8).

Feed roll drive or speed regulator unit

The feed roll speed regulator unit 55 comprises an air cylinder or housing 165 in which a cup-shaped piston 166 is loosely mounted. A piston rod 167 is fixed to the bottom or end wall of the piston 166 and is mounted for sliding movement in the housing or cylinder 165. The input pipe 161, which extends from the controller 21, is connected to the rear end of the cylinder 165 for communication with a chamber 170 defined by a rolling diaphragm or pliable seal 171 (Figure 7). The piston 166 is normally urged rearwardly or to the right in Figure 7 by a pair of compression springs 173, 174 which surround the piston rod 167 to cause the piston and the rolling seal 171 to occupy the position shown in Figure 7 when there is zero air pressure in the chamber 170. The front end of piston rod 167 is connected to a control rod 175 by a suitable universal or swivel joint 176. The head end of cylinder 165 has a vent aperture 165a therein. The cylinder 165 and piston structure need not be specifically as disclosed, this structure being preferred in order to minimize friction between the relatively movable parts thereof. The cylinder 165 is fixed on a base plate 177 (Figures 1, 6, 7 and 8).

The control rod 175 is slidably mounted in a pair of standards or frame members 180, 181 fixed on the base plate 177. A shaft 182 is journaled in standards 180, 181 and has fixedly secured thereon a cylindrical driving member 183. The left-hand end of the shaft 182 (Figures 1, 6 and 7) has the corresponding end of driving cable 45 fixedly secured thereto and the corresponding end of cable housing 46 is fixed to standard 181, as by a coupling 185.

Fixedly mounted on the rod 175 between the standards 180, 181 is an enlarged lower portion 187 of a plate 190 which is a part of a novel variable speed power transmission unit broadly designated at 186 (Figures 6, 7, 9, 11 and 12). The plate 190 has an opening 188 therein into which the proximal portions of a pair of interengaging balls 191, 192 loosely extend. The portion of the ball 192 remote from ball 191 engages the cylindrical member 183. The balls 191, 192 are mounted for rotation about respective vertical axes between rollers 195 on one side of the plate 190 and rollers 196 on the opposite side of the plate 190.

The rollers 195, 196 are journaled on outwardly extending arms 200, 201 whose inner ends are fixedly secured to the upstanding plate 190. The balls 191, 192 are also mounted for rotation about respective horizontal axes between respective pairs of rollers 204, 205 journaled on corresponding arms 206, 207 fixed on opposite sides of the plate 190. The ball 191 is engaged by the flat end surface of a disk or pulley 210 which is grooved for reception of an endless belt 211 which is continuously driven, preferably, by a pulley 212 fixed on the shaft 213 of an electric motor or other prime mover 214. The motor 214 is carried by a standard 215 fixed on base plate 177. The pulley 210 is fixed on one end of a shaft 221 slidably and rotatably mounted in a pair of bearings 222, 223 fixedly secured in the bifurcated upper end of a bracket 181a. The bracket 181a extends to the left in Figure 6 and then past the pulley 210 where it is formed integral with standard 181. A collar 220 is adjustably secured on the shaft 221 and is engaged by a thrust bearing 225 which surrounds the shaft 221.

The end of bearing 225 remote from the collar 220 engages a thrust washer 226 engaged by one end of a compression spring 227. The other end of spring 227 engages the bearing 223 in the upper end of the bracket 181a. It is thus seen that the shaft 221 and the pulley 210 are urged from right to left in Figures 9 and 10 by the compression spring 227 and the amount of pressure under which the pulley 210 is urged into engagement with the ball 191 depends upon the position of the collar 220 along the shaft 221. It is apparent that spring 227 resiliently urges the pulley 210 into engagement with the ball 191, the ball 191 into engagement with the ball 192 and the ball 192 into engagement with the cylindrical member 183 to thus transmit rotation from the pulley 210 to the cylindrical member 183 whenever the ball 191 is not in contact with the dead center of pulley 210.

Since the rollers 195, 196 204, 205 insure that the balls 191, 192 remain in alinement with each other and since the electric motor 214 is continuously driven to rotate the pulley 210, as long as the ball 191 is not in contact with the dead center of the pulley 210, rotation will be imparted thereto which, in turn, drives drum 183. Of course, when rotation is transmitted to the cylindrical member 183, the cylindrical member 183 drives the yarn feed roll 20 through the intervening cable 45. The standard 181, directly above the shaft 175 (Figures 6 to 9, inclusive) has an upwardly extending projection 228 thereon in which an adjustment screw 229 is threadably mounted and held in position by a lock nut 229a. Screw 229 serves as a stop to limit travel of the shaft 175 from right to left in Figures 6 and 7 for purposes to be later described.

In operation, assuming the knitting machine or other take-up means is not operating, the parts of the yarn tension device may occupy substantially the position shown in Figure 1. As the yarn Y is fed to the knitting machine and as the knitting machine is started, the roller 56 along with arm 60 is raised or moved in a counterclockwise direction in Figures 1 and 5 as the yarn Y tends to straighten out as it is consumed by the knitting machine. As the arm 60 moves upwardly in Figures 1 and 5, the rise of eccentric cam 66 causes adjustment screw 87 and the bracket 85 to move about pivot shaft 84, stretching spring 90, to move the L-shaped arm 91 (which may be termed a primary sensitivity lever) in a counterclockwise direction in Figure 5 or a clockwise direction in Figure 17. This causes the second sensitivity lever or arm 100, the bracket 101 and the arm 110 extending downwardly therefrom to be moved in a clockwise direction (Figure 5) about pivot shaft 102 by the tension spring 107, so the glass closure member 111 closes the throttling valve 112 (Figure 4).

The pressure of the main air entering pipe 116 is constant at, say, fifteen pounds per square inch. Thus, when valve 112 is throttled by valve closure 111, this causes an increase of pressure in chamber 142 (Figure 3), since air flows from pipe 116 through the passageway 150, past the needle valve 152 (Figure 4) through the passageway 154 and into the chamber 142. Since chamber 141 is vented to atmosphere through port 145 and the exhaust valve 124 is normally held open by springs 127 and 129, the diaphragm 133 moves from the position shown in Figure 3 to the position shown in Figure 4.

As the diaphragm 133 moves to the position shown in Figure 4, the pressure of spring 127 is overcome by spring 121 to seat the ball 124 and the intervening bar or spacer 126 moves the ball 117 away from its seat to thereby permit main air to flow from the pipe 116 through passageway 115, through the chamber 116, past the spacing member 126 in passageway 128 and into the main air transmission chamber 140. Main air then passes from chamber 140 through passageway 160 and through the egress pipe 161 into the chamber 170 in the cylinder 165 of the regulator unit 55 (Figure 7).

When no yarn Y is being used up by the knitting machine, as when the knitting machine is standing still, the yarn Y between feed roll 20 and the knitting machine is under predetermined optimum tension, the electric motor 214 will be driving the pulley or disk 210, but the transmission balls 191, 192 will be in the dead center of the pulley 210 or axially alined with pulley 210 so the cylinder 183 is stationary. However, it will be observed in Figures 6 and 7 that the transmission balls 191, 192 are disposed rearwardly of the axis of disk or pulley 210 or in negative drive or reverse position. It is apparent therefore that a relatively low pressure or a relatively small amount of compressed air is present in the chamber 170 whenever the transmission balls are in neutral or dead-center position relative to disk 210. In this instance, the glass throttling valve plate 111 would be minutely spaced from the throttling valve 112 so the air pressures in the chambers 140, 142 are such that substantially the same balancing force exists on diaphragms 133 and 131, notwithstanding the main air pressure in chamber 116, the pressure of spring 121 against the primary ball valve 117 and the pressure of spring 129 against the exhaust valve housing 130. Thus, both the primary ball valve 117 and the exhaust valve 127 would then be closed.

Upon additional air pressure being introduced into the chamber 170 in the cylinder 165, due to upward movement of arm 60 and resultant closing of throttling valve 112, the piston rod 167 and the shaft 175 are moved forwardly or from right to left in Figures 6 and 7 to thus move the balls 191, 192 outwardly on the positive side of the dead center of the pulley 210. Thus, pulley 210 imparts positive rotation to the cylindrical member 183 through the transmission balls 191, 192. Depending upon the amount of air pressure entering the cylinder chamber 170, the ball 191 will move along the face of the pulley 210 a predetermined distance to thus control the speed at which the cylindrical member 183 is driven. It is apparent that the further the transmission balls 191, 192 move radially outwardly on the positive side of dead center of the disk or pulley 210, the faster the positive rate of rotation imparted to the cylindrical member 183 and the yarn feeding roll 20. Of course, this forward movement of the transmission unit 186 occurs quite rapidly so the movement of the yarn Y promptly accelerates to permit the detector arm 60 to return to optimum position as the rate of movement of yarn being fed by the feeding roll 20 conforms to the rate at which the yarn is taken up by the knitting machine 12.

As the detector arm 60 moves downwardly to said optimum position, the throttling valve closure member 111 moves a minute distance away from the open end of the throttling valve 112 sufficient only to permit enough of the compressed air to escape from the pilot chamber 142 to permit the spring 129 and the force delivered to the lower side of diaphragm 131 (Figure 4) by the pressure in chamber 140 to move the exhaust valve housing 130 away from the main valve housing 120 a sufficient amount to permit the valve 117 to close and to also cause the exhaust valve 124 to remain closed. Since air cannot then escape from the chamber 170 in cylinder 165 (Figure 7) it is apparent that the yarn feeding roll 20 will continue to rotate at the desired optimum rate.

In the event that the transmission unit 186 initially moves forwardly to such an extent as to impart rotation to the yarn feeding roll 20 at a speed exceeding the desired optimum speed, the detector arm 60 then moves downwardly beyond the optimum position to correspondingly open the throttling valve 112 an excessive amount to permit an excessive amount of compressed air to escape from the pilot chamber 142. Thus, the spring 129 will move the exhaust valve housing 130 to where the valve 117 is closed and the exhaust valve 124

is opened so the compressed air will escape from the chamber 170 in cylinder 165 through the conduit 161, passageway 160, main air transmission chamber 140, exhaust valve housing 130, latent chamber 141 and through the exhaust port 145 until the detector arm 60 has again moved upwardly to the desired optimum position to where both of the valves 117, 124 (Figures 3 and 4) are again closed.

It is apparent that any time the tension in the yarn Y between the feeding roll 20 and knitting machine 12 has a tendency to increase above the desired optimum, which correspondingly decreases the effective length of the portion of the yarn between roll 20 and the machine 12, the detector arm 60 moves upwardly a corresponding amount to further restrict or completely stop the egress of air from pilot chamber 142 and to thereby proportionately increase the effective pressure in the pilot chamber 142. Thus, the rate of positive rotation of the feeding roll 20 is momentarily increased, in the manner heretofore described, as the length of the yarn in the tension zone tends to decrease. On the other hand, any time the length of the yarn Y between feed roll 20 and the knitting machine 12 has a tendency to increase above the desired optimum, the detector arm 60 moves downwardly to move the throttling valve plate 111 further away from valve 112, or to fully open the throttling valve 112 and to permit a proportionate decrease of the effective pressure in the pilot chamber 142. Accordingly, this will either close both of valves 117, 124, or it will close the valve 117 and open valve 124 to either maintain a constant pressure in the chamber 170 of cylinder 165 or to release a proportionate amount of the air pressure from the chamber 170, as the case may be.

There are several factors which determine the sensitivity of the relay or controller 21, including the length and weight of the detector arm 60, the pressure of the main compressed air entering pipe 116, the position of the metering valve or needle valve 152 (Figure 4), the proportionate sizes of the various chambers 140, 141, 142 and the corresponding diaphragms 131, 133, the proportionate sizes of the springs 121, 127, 129, the sizes of the valve balls 117, 124 and the spacer 126 influenced by said springs, the adjusted positions of the abutment or set screw 87 and the fulcrum 93 as well as the amount of rise and fall in the eccentric cam 66 on the inner or front end of the detector arm 60. Although the description heretofore specifically defines nylon yarn as it is withdrawn from pirns onto which the yarn is wound by the manufacturer, it is apparent that tension may be maintained in other types of yarns, including so-called synthetic stretch yarns, elastic yarns or natural fiber yarns, by the improved apparatus.

It may be desirable to counterbalance the detector arm 60 to some extent, depending upon the character of the material from which the detector arm 60 is made and the length of the detector arm 60. However, it is apparent that the detector arm 60 should be sufficiently heavy at its free end, that is, where the yarn Y passes beneath the roller 56 thereon, to move downwardly in the event of the tendency of the yarn feeding roll 20 to feed the yarn Y at an excessive speed which would tend to decrease the tension in the yarn.

It may occasionally happen that the yarn Y is being taken up by the knitting machine 12 at a relatively high rate of speed while the yarn feeding roll 20 is rotating at a correspondingly high rate of speed and, suddenly, the tension in the yarn has a tendency to be excessively decreased so the detector arm 60 would suddenly move downwardly excessively for a relatively short period of time before returning to optimum position. The tension in the yarn may suddenly tend to decrease for many reasons. For example, the yarn feed finger 24 may suddenly rise out of operating position according to a predetermined pattern. The machine may stop suddenly as a result of actuation of its usual stop motion, etc.

With such sudden excessive downward movement of arm 60, the throttling valve 112 would then suddenly be fully opened as the throttling valve plate 111 moved away from the same and this permits the compressed air in the pilot chamber 142 to rapidly escape therefrom to the extent permitted by the size of the passageway 156 and the internal diameter of the throttling valve 112. Of course, the exhaust valve 124 would then become fully opened to permit relatively rapid escapement of the compressed air from the chamber 170 of the cylinder 165 (Figure 7). The sudden escapement of air from the chamber 170 combined with the sudden relaxing of the pressure on the springs 173, 174 in the cylinder 165 would then cause the transmission unit 186 to move rearwardly to substantially the position shown in Figures 6 and 7 or, in other words, to negative position relative to the axis of the pulley or disk 210.

Although this would tend to cause the yarn feeding roll 20 to rotate in a reverse direction, the disk 212 and the transmission balls 191, 192 would merely apply a braking action against the cylindrical member 183 and, unless the yarn Y had actually become parted between the feeding roll 20 and the knitting machine 12, it is likely that the excess yarn Y will have been taken up by the time the cylindrical member 183 has ceased rotation in one direction and before it has started rotation in the other direction, particularly in view of the fact that the transmission unit 186 would then be disposed only a relatively short distance rearwardly of the axis of the pulley or disk 210. Accordingly, since the yarn is taken up by the knitting machine 12 with a sudden decrease in speed or stopping of the yarn feeding roll 20, the detector arm 60 will be moved upwardly by the yarn Y to again cause the transmission unit 186 to return to substantially its original position and the arm 60 will then return to its normal or optimum position as the positive rate of rotation of the yarn feeding roll 20 again equals the rate at which the yarn Y is taken up by the knitting machine 12, while maintaining the yarn under the optimum predetermined tension.

It is apparent that the amount of tension in the yarn Y may be predetermined by adjusting the weight member 62 longitudinally of the guide 61 depending from the detector arm 60. It is also apparent that any changes in the speed at which the yarn Y is taken up by the knitting machine 12, or by any other means, are accurately compensated for by the detector arm 60 which, in turn, controls the rate of rotation of the yarn feeding roll 20 through the intervening connections heretofore described. It is well known that most circular knitting machines operate at a relatively high speed during rotary knitting, such as in knitting the leg and foot of a stocking, and the speed of the knitting machine is substantially decreased during reciprocatory knitting, such as in knitting the heel and toe of a stocking. Even during such drastic changes in the rate at which the yarn is taken up, upon a sudden change in speed of the machine 12 from high speed to slow speed, the detector lever 60 and roller 56 move downwardly momentarily and then upwardly above optimum position and then return to optimum operating position to correspondingly decrease the rate of rotation of the yarn feeding roll 20 substantially simultaneously with the decreased speed of the knitting machine 12. This rapid reaction of the yarn feeding roll 20 is also promptly effected when the knitting machine 12 suddenly changes from relatively slow speed to relatively high speed, since the detector arm 60 and roller 56 merely suddenly move upwardly and then move downwardly below optimum operating position and then return to normal optimum operating position to correspondingly increase the rate of rotation of the yarn feeding roll 20 so it feeds the yarn Y at the proper rate of speed substantially simultaneously with the increase in speed of the knitting machine 12 in the manner heretofore described.

At times, the detector arm 60 may tend to swing up

and down as it "hunts" its optimum operating position because of the fact that the signal from the arm 60 is transmitted to the cylinder 165 and, at times, tends to move the transmission balls 191, 192 too far forwardly or outwardly of the center of the pulley 210. Of course, this causes the arm 60 and roller 56 to drop excessively, since the yarn Y is momentarily fed at too fast a rate of speed. This difficulty may be overcome in many different ways. One way of reducing the "hunting" tendency of arm 60 is to provide means to adjustably limit the speed-increasing stroke of the transmission unit 186. To this end, an adjustable stop is shown in Figures 6, 7, 8 and 9 in the form of the adjustment screw or bunter 229 which threadably penetrates projection 225 on standard 181 and is locked in adjusted position by lock nut 227. The screw 229 is adapted to engage the leading edge of the plate 190 of the transmission unit 186 to thus limit movement thereof from right to left in Figures 6 and 7 after the usual operating range has been determined. This assists in preventing overriding or hunting by the shaft 175 and the plate 190 when a speed-increasing signal is received from the control arm 60 to thus insure that the balls 191, 192 are not moved too far out of the range of normal operation of the yarn tension device during normal operating speeds.

It is thus seen that I have provided a novel method of feeding and tensioning yarn which is carried out by means of a yarn feeding device and a yarn length signaling device interposed between the feeding device and the yarn take-up means, said feeding device being variable as to the speed at which it feeds the yarn to the take-up means and at a speed which is equal to the demand of the take-up means while maintaining the yarn under uniform tension although the demand of the take-up means may vary the rate of travel of the yarn considerably. The yarn tension device is also provided with a regulator unit which is adapted to drive the yarn feeding device and which is controlled by a length sensing means embodied in the signaling device or controller 21 interposed between the yarn feeding device 20 and the yarn take-up means 12 for instantly changing the speed of the yarn feeding device upon a signal being received from the controller to thus maintain the yarn Y extending from the yarn feeding roller 20 to the take-up device 12 at a substantially constant length and under a constant uniform tension which may be varied, if desired, by adjustably varying the weight of the detector arm of the controller.

In the drawings and specification, there has been set forth a preferred embodiment of the invention and, although specific terms are employed, they are used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention being defined in the claims.

I claim:

1. Apparatus for feeding yarn to a variable-speed take-up means comprising a rotatable element about which at least a portion of said yarn is moved and from which said yarn extends to said take-up means, a sensing element resting upon the yarn at a point between the rotatable element and the take-up means, and means responsive to variations in the position of the sensing element caused by variations in the effective length of the portion of the yarn extending between the rotatable element and the take-up means, for automatically driving the rotatable element at a speed corresponding to the speed at which the yarn is taken up while maintaining the yarn under a predetermined tension, said means for automatically driving the rotatable element comprising a rotatable cylindrical member, driving connections between the cylindrical member and said rotatable element, a constantly driven disk mounted on an axis substantially radially of the axis of the said cylindrical member and spaced from said cylindrical member, a power transmission unit disposed between the cylindrical member and said disk, said

transmission unit being movable substantially parallel to the axis of said cylindrical member and having means for transmitting rotation from the disk to the cylindrical member, and means responsive to variations in the movement of said sensing element either side of a predetermined position for imparting corresponding movement to the transmission unit to correspondingly vary the rate of rotation transmitted to the cylindrical member from the disk by said transmission unit and to correspondingly vary the rate of rotation of the rotatable element.

2. A structure according to claim 1, wherein said means for moving the transmission unit comprises a piston rod, means connecting said transmission unit with said piston rod, a piston, a cylinder surrounding said piston, resilient means normally urging said piston in one direction to correspondingly urge the transmission unit in the same direction, means for introducing compressed air into and releasing compressed air from said cylinder, and means responsive to variations in the position of the sensing element for proportionately varying the amount of compressed air in the cylinder to correspondingly vary the position of the transmission unit.

3. In a structure according to claim 2, said means for varying the amount of compressed air in said cylinder comprising a controller having a pilot chamber and a main air transmission chamber therein, said pilot chamber communicating with a source of compressed air pressure, communicative means extending from said main air transmission chamber to said cylinder, a throttling valve on said controller communicating with said pilot chamber, means responsive to variations in the position of said sensing element for opening and closing said pilot valve with respect to the atmosphere, a normally closed main valve interposed between said source of compressed air and said transmission chamber, an exhaust valve for exhausting air from said transmission chamber when opened, means responsive to a relative increase of air pressure in said pilot chamber as a result of the throttling valve being closed for closing said exhaust valve and opening said main valve substantially simultaneously whereby the transmission chamber receives compressed air and transmits the same to said cylinder, means responsive to a relatively slight reduction in air pressure in said pilot chamber as a result of partially opening said throttling valve for closing said main valve and said exhaust valve to correspondingly maintain constant pressure in the main transmission chamber and the cylinder, and means responsive to further reduction in the pressure in said pilot chamber resulting from further opening of the throttling valve to cause the main valve to remain closed while opening the exhaust valve thereby permitting compressed air to escape from said cylinder through the transmission chamber and the exhaust valve.

4. Apparatus for feeding yarn to a variable speed take-up means comprising a rotatable yarn feeding element about which at least a portion of yarn is wound, a member pressing against and forming a loop in said yarn at a point between the rotatable element and said take-up means and applying predetermined tension to said yarn, said member being movable by the yarn in accordance with variations in yarn length, compensating means responsive to movement of said member in one direction for driving said rotatable element at a relatively slow speed to decrease yarn length, and means responsive to movement of said member in the other direction for automatically driving said rotatable element at a relatively faster speed to increase yarn length whereby said member maintains a predetermined tension in the yarn.

5. Apparatus for feeding a strand from a randomly tensioned source to a take-up means comprising a rotatable element interposed between the source and the take-up means and about which the yarn is coiled and from whence the yarn extends to said take-up means, the length of yarn between the rotatable element and the

take-up means defining a tension zone, a length detecting member engaging said yarn and about which said yarn is at least partially looped at a point spaced intermediate the rotatable element and the take-up means, pneumatically controlled means responsive to a tendency of the length of the yarn to decrease in said zone, and impart movement to the member in one direction, for imparting rotation to said rotatable element at a speed proportionate to the amount of displacement of said member from its original position to thereby return said member to its original position and said pneumatically controlled means being responsive to a tendency in the length of the yarn to increase in said zone, and move the member in the opposite direction, for proportionately retarding the rate of rotation of said rotatable element.

6. Apparatus for feeding yarn to a take-up means for maintaining constant predetermined tension in said yarn comprising a yarn feeding roll having the yarn coiled thereon and from whence the yarn extends to said take-up means, a detecting member bearing against said yarn under predetermined pressure at a point between the yarn feeding roll and the take-up means, means to drive said yarn feeding roll at a predetermined speed proportionate to the speed at which the yarn is taken up while said detecting member occupies a predetermined position, said detecting member being movable either side of said predetermined position in response to corresponding variations in the amount of yarn extending between the yarn feeding roll and the take-up means, and fluid pressure operated means responsive to movement of the detecting member either side of said predetermined position for varying the speed of said driving means for the feeding roll to cause said detecting member to return to said predetermined position and to thereby maintain a predetermined length of yarn between the feeding roll and the take-up means while maintaining the yarn under predetermined tension.

7. A structure according to claim 6 wherein said driving means comprises a rotatable drum, a driving connection between the drum and said feeding roll, a constantly driven disk mounted on an axis substantially radially of the axis of the said drum, a power transmission unit having first and second interengaging balls disposed between the drum and said disk, means maintaining the disk in engagement with the first ball, the first ball in engagement with the second ball and the second ball in engagement with the periphery of the drum, and means responsive to variations in the movement of said detecting member either side of said predetermined position for imparting corresponding movement to the transmission unit substantially parallel to the axis of said drum to correspondingly vary the rate of rotation transmitted to the drum by the disk and to correspondingly vary the rate of rotation of the yarn feeding roll.

8. A structure according to claim 7 wherein said means for moving the transmission unit comprises a piston rod, means connecting said transmission unit with said piston rod, a piston connected to said rod, a cylinder surrounding said piston, resilient means normally urging said piston in one direction, to correspondingly urge the transmission unit in the same direction, means for introducing fluid pressure into and releasing fluid pressure from said cylinder and means responsive to variations in the position of the detecting member for proportionately con-

trolling the amount of fluid pressure present in the cylinder to correspondingly vary the position of the transmission unit.

9. In a structure according to claim 8, said means for controlling the amount of fluid pressure in said cylinder comprising a controller connected to a source of fluid pressure, said controller having a pilot chamber and a main chamber therein, said pilot chamber communicating with said source of fluid pressure, communicative means extending from said main chamber to said cylinder, a throttling valve on said controller communicating with said pilot chamber, means responsive to variations in the position of said detecting member for opening and closing said pilot valve to respectively decrease and increase the amount of fluid pressure in the pilot chamber, a normally closed main valve for controlling the flow of fluid pressure from said source into said main chamber, a normally closed exhaust valve for exhausting pressure from said main chamber when opened, means responsive to a relative increase of pressure in said pilot chamber as a result of the throttling valve being closed for closing said exhaust valve and opening said main valve substantially simultaneously whereby the main chamber receives fluid pressure and transmits the same to said cylinder, means responsive to a slight reduction in pressure in said pilot chamber as a result of partially opening said throttling valve for closing said main valve and said exhaust valve to maintain a constant amount of fluid pressure in said cylinder, and means responsive to further reduction in the pressure in said pilot chamber resulting from further opening of the throttling valve to cause the main valve to remain closed and to open the exhaust valve to permit fluid pressure to escape from the cylinder through the main chamber.

10. Apparatus for maintaining a uniform tension in a yarn being fed to a variable speed take-up means comprising a positively driven rotatable yarn feeding element positioned in frictional engagement with the yarn between a yarn source and a variable speed take-up means, a freely movable sensing pressing against and forming a loop in said yarn at a point between the rotatable feeding element and the variable speed take-up means and applying predetermined tension to said yarn, said sensing element being movable by the yarn in accordance with variations in yarn length, a pneumatic compensating means including an air cylinder, means for supplying air to said cylinder, a discharge valve permitting air to escape from said cylinder, means operable by the sensing element for at least partially restricting the discharge valve to vary the air pressure within said cylinder in accordance with the position of the sensing element, and a positive connection between the air cylinder and the driven rotatable yarn feeding element for substantially instantaneously varying the speed of rotation of said feeding element in response to variation in air pressure in said cylinder.

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