April 3, 1962 H. KABELITZ 3,028,110

SYSTEM FOR THE REGULATION OF WINDING MACHINES PARTICULARLY FOR TEXTILE THREADS

Filed Dec. 18, 1956 4 Sheets-Sheet 1

FIG. 1

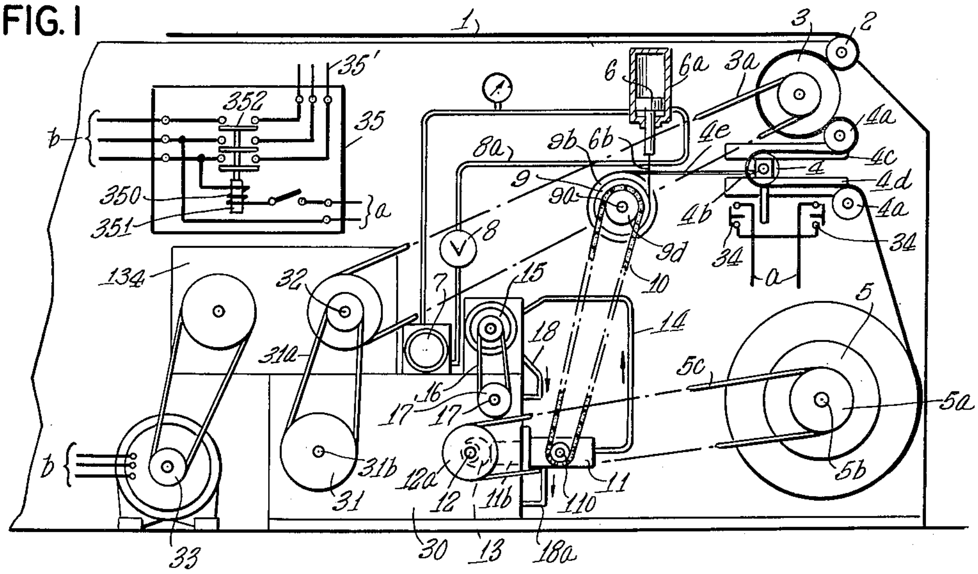


FIG. 3

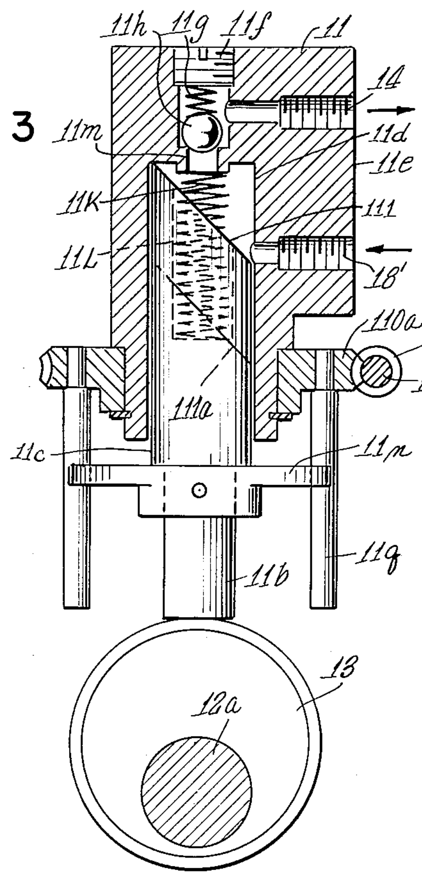


FIG. 2

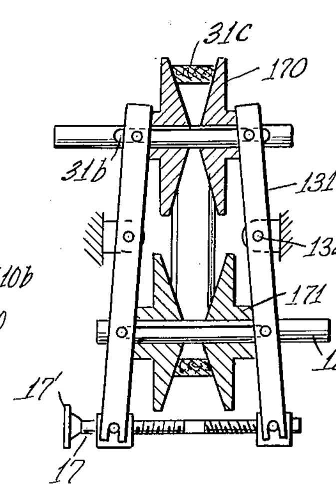


FIG. 4

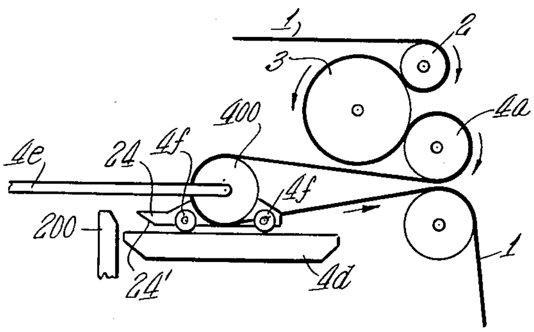


FIG. 5

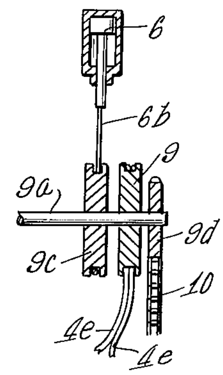


FIG. 8

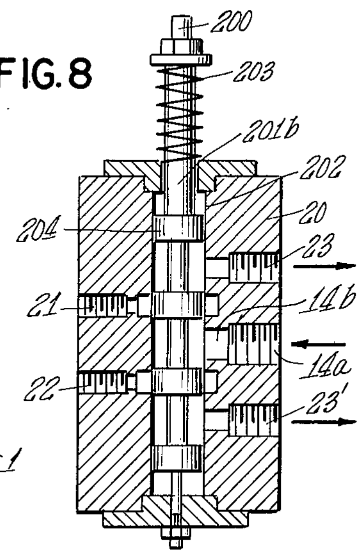


FIG. 6

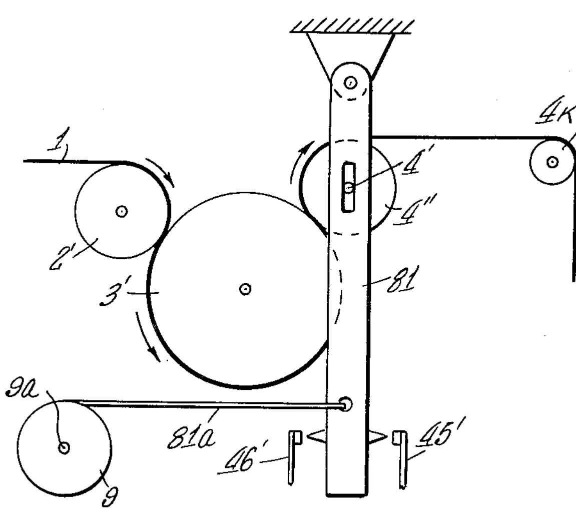


FIG. 7

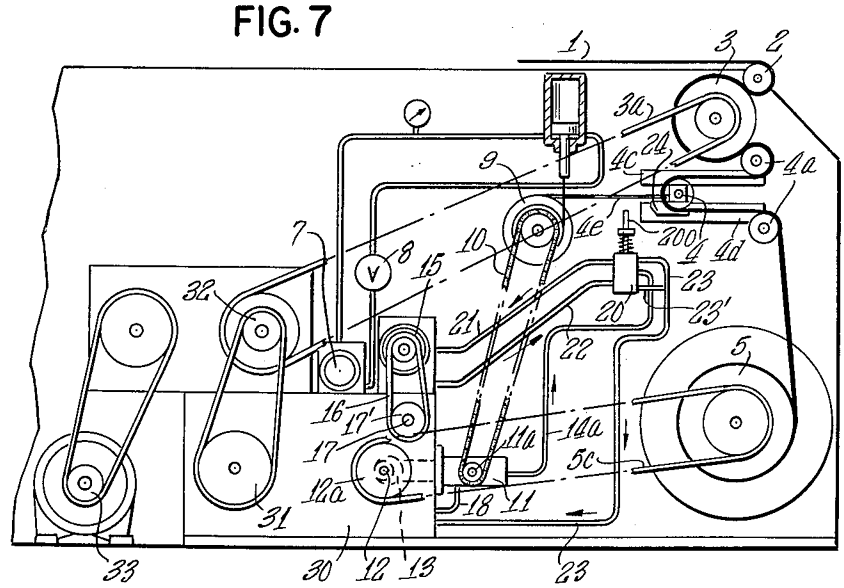
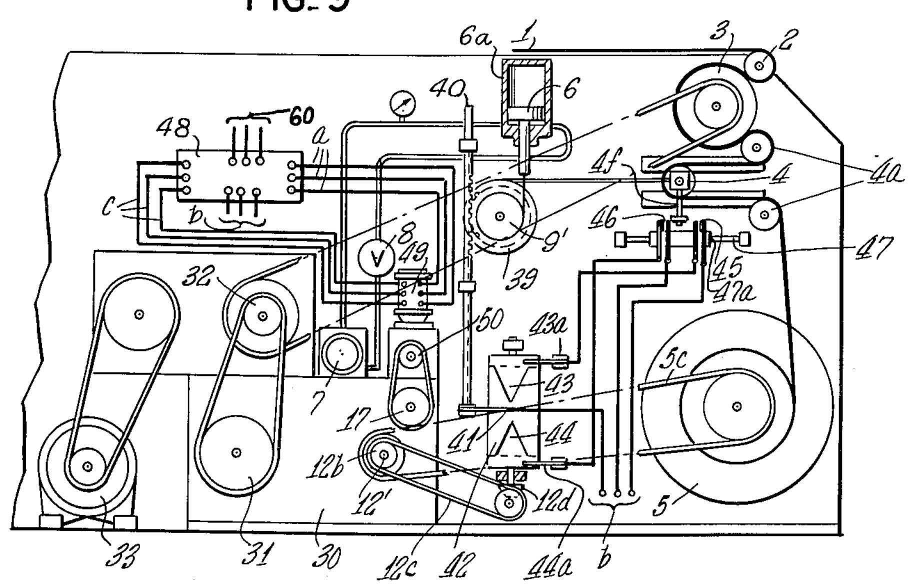


FIG. 9



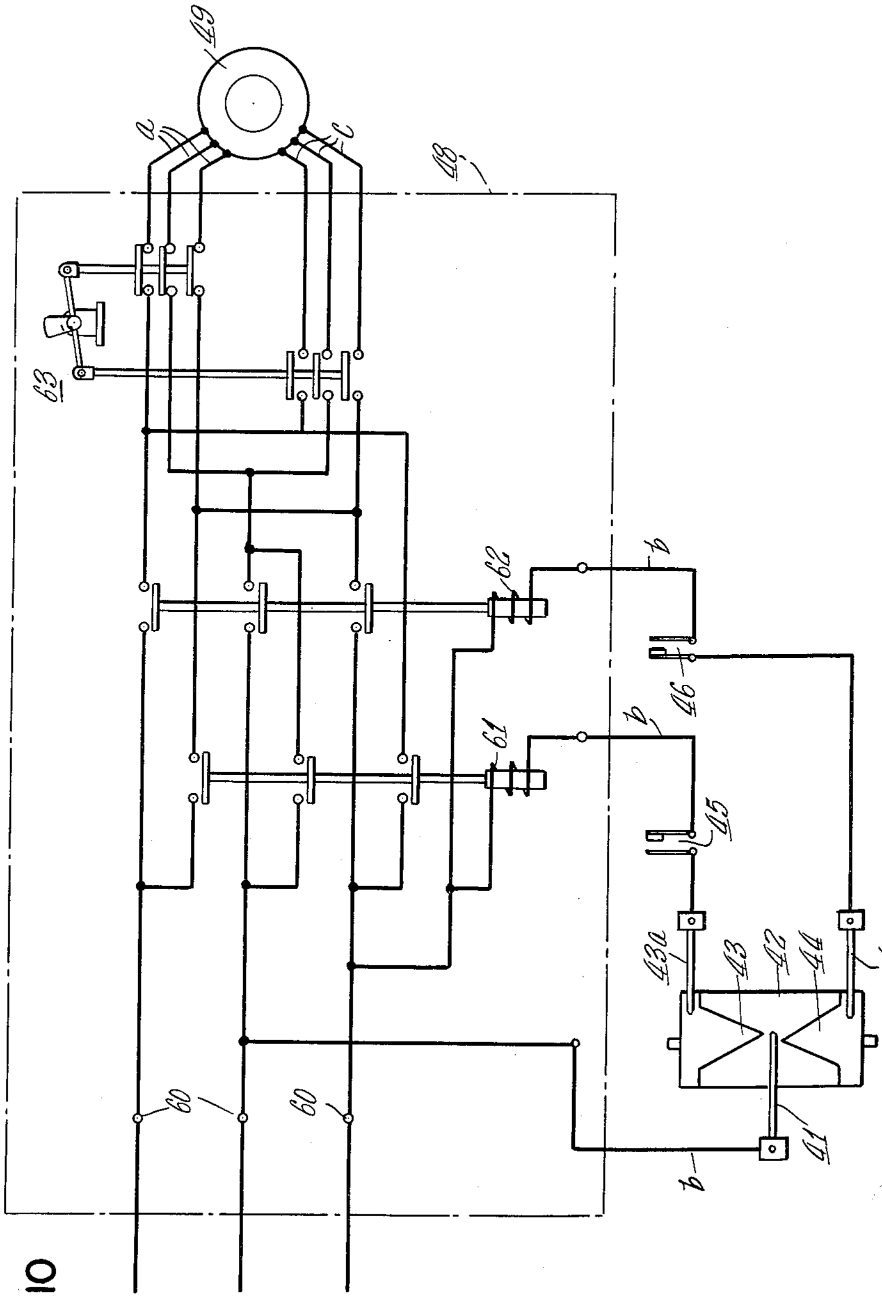


FIG. 10

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SYSTEM FOR THE REGULATION OF WINDING MACHINES PARTICULARLY FOR TEXTILE THREADS

Hans Kabelitz, Monchen-Gladbach, Germany, assignor to Gebruder Sucker G.m.b.H., Monchen-Gladbach, Rhineland, Germany, a corporation of Germany

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13 Claims. (Cl. 242—45)

My invention relates to the automatic regulation of the winding performance in winding machines, particularly for textile threads. It particularly relates to the regulation of thread tension and linear thread velocity in textile machines, particularly in coiling, warp beaming and other winding machines.

When winding stretchable material, particularly freshly sized arrays of textile threads, on winding beams or warp beams, care must be taken to maintain constant thread tension and linear thread velocity during the entire winding operation. However, since the diameter of the body of material being wound up upon the beam increases continuously, the speed of beam rotation must be gradually reduced correspondingly. Heretofore there were used for this purpose chiefly manually or automatically operated friction-disk transmissions, or regulating devices such as dancer rollers, or electric regulating devices, the regulation being in most cases controlled by means of feeler rollers that engage the material on the winding beam.

These prior expedients have inherent limitations. For example, the friction-disk drive must be designed to accommodate the smallest beam diameter, that is, for the greatest speed of beam rotation. The necessary reduction in rotational speed is obtained by braking, which involves dissipation of driving power. The friction losses thus occurring are considerable because the diameter of the winding that is being built up on the beam may increase up to five to ten times the initial diameter. The speed of beam rotation must not only be decreased in the same ratio but must also be adaptable to the quality of the thread and must also permit operation at creeping or threading speed. Consequently, the ratio of rotational speed must be varied to a much higher extent than corresponds to the increase in winding diameter only.

For maintaining constant thread tension and for equalizing the rotational winding speed, it is common to use compensators, such as dancer rollers, which rest against the bight of a long loop of the material and can perform lifting and lowering movements, the weight of these rollers being chosen, or varied, in accordance with the desired thread tension. Any change in the tension of the yarn or web forming the loop, as well as any change in the traveling speed of the material being processed in the machine, causes the dancer roller to become vertically displaced as the loop of material lengthens or shortens. This displacement is used for controlling the driving speed of the machine. Such dancer rollers, forming part of a compensator of the above-mentioned type, require a large height of construction when a large regulating range of the tension or traveling speed is required, or it is necessary to provide for a multiple loop similar to the roping of a multiple pulley which however involves large frictional losses and a reduced sensitivity of the regulating device. A sufficiently long length of the loop permits an increase in winding diameter within certain limits. However, it is not feasible to make the length of the loop so large, or to multiply the loops, so that the entire diameter range of the winding beam can thus be compensated for constant peripheral, that is linear, speed of the oncoming thread. In such cases therefore

the dancer rollers have been substituted by feeler rollers which are in engagement with, and driven by, the material running onto the winder core or winder beam and which travel away from the winding axis as the winding of material is being built up upon the core or beam. This outward displacement of the feeler rollers controls the regulation of the winder drive. The displacement of the rollers thus engaging the material on the winder beam is not always uniform and lacks the desired sensitivity because the feeler rollers are displaced also when the winding becomes somewhat non-circular. Hence the feeler rollers may signal a change in driving speed. Such slight irregularity in the shape of the winding does not vary the thread tension or the linear thread velocity to such an extent as to call for a change in driving speed or a change in the transmission ratio of the driving transmission.

The above-mentioned use of a dancer roller for varying the thread tension, or more generally in a compensator for the above-mentioned purposes, has the further disadvantage that, if the regulating device is adapted to respectively different thread qualities by the addition or removal of loading weights acting upon the dancer roller, a stepless adaptation to variations in thread quality is not feasible in this manner because the addition and removal of loading weights can be effected only in a relatively crude manner. On the other hand, if springs are used for setting the thread tension to the desired value, then these springs, although securing a stepless regulating characteristic, cannot readily be adapted with the desired accuracy to the various types and qualities of thread. The force-travel characteristic of a loading spring increases or decreases with each positional change of such a compensator. Furthermore, such an arrangement results in a static regulator and does not inherently offer the usually desired astatic regulating performance.

All of the known devices possess appreciable inertia which often causes trouble by loosening or excessively tensioning the warp threads. Or the devices may operate with insufficient sensitivity, and hence not in a completely stepless manner, so that during winding operation undesired variations in tension will occur to a significant extent. This is disadvantageous in the further fabrication of the thread material.

A beam-speed regulation operating with an electric motor of variable speed for driving the winder beam has an only slight overall efficiency and is comparatively very expensive, due to the necessity of using several motors, speed-regulating, speed-controlling and other switching components and the like. Such an electric regulation has the further disadvantage that, where rapid stopping or accelerating of the winding machine is frequently required, the regulating performance often occurs with too much delay, so that the array of threads becomes either too slack or is over-tensioned for short intervals of time, both such occurrences being detrimental because the threads become entangled by slightest slackening or tear at already slight increases in tension. Above all, electric drive motors do not have such a large range of speed regulation as to be capable of taking care of changes in winding diameter up to five to ten times the initial value, and of changes in transmission ratio up to about 30:1 for adaptation to the various occurring thread qualities and the sometimes necessary setting to creeping speed. In such cases, additional machines must be provided which not only greatly increase the investment cost, but also reduce the overall efficiency to a further extent, and impair the desired accuracy and reliability in maintenance of a constant thread tension.

It is an object of my invention to eliminate or greatly minimize the above-mentioned deficiencies of the known thread-winder compensator or regulating systems.

In one aspect, the invention involves a novel way of regulating the rotating speed of the winding beams. It is based upon the use of a driving transmission, preferably of the V-belt stepless type, which is controlled in dependence upon the change in diameter of the material wound up on the beam. The dependency of the beam rotating speed upon the winding diameter is determined by a program curve, or datum curve, whose time characteristic depends upon the properties of the material to be wound up, particularly the thickness. The variation of the transmission ratio is controlled by impulses of various types, for example hydraulic, electrical or mechanical. The magnitude, number or frequency, and/or duration of the pulses are dependent upon the traveling path of a regulating member which is moved directly or indirectly by the steadily increasing diameter of the material being wound. These impulses operate, preferably through a motor, upon the regulator shaft of the above-mentioned transmission ratio of the machine drive.

According to a more specific feature of the invention, the impulse transmitter which is diameter-dependently controlled consists of an oil pump of variable volumetric delivery. The pump is continuously driven so long as the winding machine is in active condition or operation, and the driving speed of the pump is preferably constant; or the pump is driven at a speed proportional to the rotating speed of the feed roller or the winding beam. By correspondingly varying the setting of the delivery regulator, the quantity of oil delivered by the pump can be varied from zero, continuously or stepwise, up to an oil quantity adapted to the regulating requirements to be satisfied at the time. The delivered oil quantity drives a hydraulic motor which serves for regulating the rotating speed, that is the transmission ratio, of the above-mentioned, preferably stepless, driving transmission. Such a regulation of the delivered oil quantity can be performed with any desired degree of sensitivity.

If a coarse regulation is sufficient, then the issuance of the impulses for regulating the winder speed can be effected by any of the known sensing members in response to displacement of these members, such as a feeler roller. Such members, however, are not satisfactory where a higher degree of reliability is required. This is so because the wound-up bodies of thread have non-uniform softness at different diameters and at different localities, depending upon the thread quality, so that the feeler roller is pressed into the winding sometimes to a larger and sometimes to a smaller depth. Therefore, in accordance with another feature of my invention, the oil delivery of the pump is regulated by means of a horizontally arranged compensator, which is adjustable to respectively different tension values depending upon the thread quality and which varies the volumetric delivery of the oil pump with each change in length of the loop of thread. Instead of the above-mentioned hydraulic impulses and hydraulic regulation, electric impulses can be used advantageously. In this case the sensing member responsive to changes in diameter of the winding on the beam controls the setting of an electric contact transmitter which issues current pulses to a regulating motor or directly to the regulator shaft of the variable-ratio transmission of the beam drive, the number or frequency, magnitude, or the duration, or several of these characteristics in combination, being adapted to the datum curve of the beam speed at increasing diameter of the winding.

According to another, more specific, feature of the invention, the electric contact transmitter is designed as a drum which is driven by the beam-driving transmission and is provided with contact segments or contact plates, the drum being axially displaceable relative to a stationarily mounted brush contact, or vice versa, such axial movement or relative displacement being effected or controlled by the above-mentioned sensing member.

In accordance with a further feature of my invention, I provide a compensator whose sensing member is a dancer roller that is displaceable along a short, substantially horizontal, path, the loop formed by the material to be processed being also guided in a substantially horizontal direction. The ends of the horizontally displaceable dancer roller or the displaceable means in which the roller is journaled, are connected by pulling means such as a rope, chain or strap, to a tensioning disc mounted on a revolvable but rigid, or torsionally stiff, shaft. The pulling member extends about the periphery of the tensioning disc, and the disc is subjected to a biasing force tending to pull the dancer roller toward the tensioning disc. With such a unilateral loading force acting upon the dancer roller, a proportional counterbalancing of the forces acting upon the dancer roller is no longer necessary. The pulling force acting upon the dancer roller, which force is adjustable to any desired value, may either act at one or both ends, or in the middle, or at any other location of the torsionally rigid shaft.

Other objects, advantages and features of my invention will be apparent from the following description.

The drawings illustrate, schematically, various preferred embodiments of the invention.

FIG. 1 shows schemtaically a winder drive provided with a regulating device having a hydraulic impulse transmitter;

FIG. 2 illustrates a V-belt type of stepless or continuously variable speed ratio transmission mechanism for transmitting the torque of the electric motor to the winder beam and to various other parts of the machine;

FIG. 3 is a schematic diagram of the variable delivery oil pump employed to turn the oil motor which is used to operate the transmission regulator shaft;

FIG. 4 is a schematic and detailed view of a roller bearing mounting for the compensator or tensioning roller;

FIG. 5 is a side view of a slightly modified form of the tensioning disc used to operatively connect the hydraulic constant tensioning device to the tensioning, or compensating, roller, and also to the oil pump which operates the transmission regulator shaft;

FIG. 6 is a vertical and schematic diagram of a tensioning roller, the axis of which is constrained to a path of compensating movement which is a horizontally disposed arc, the axis of the roller being pendulously supported;

FIG. 7 illustrates schematically a winder drive similar to FIG. 1, but in which the hydraulic impulse transmitter comprises a slide valve device which is separately shown in FIG. 8 in detail;

FIG. 9 shows schematically another winder drive equipped with an electric impulse transmitter, the circuit diagram of which is separately shown in FIG. 10.

In all illustrations similar components are denoted by the same reference numerals.

As shown in FIG. 1, the array of threads **1**, comprising a large number of individual threads all located in a plane perpendicular to the plane of illustration, passes over a guide roller **2** and around a feed roller **3**, which is driven at constant speed. The threads are then looped about a horizontally arranged compensator, provided with two stationary journaled rollers *4a* and a horizontally displaceable roller **4**, and are finally wound up upon winding beam **5**.

The displaceable roller **4**, located in the bight of a loop formed by the travelling thread, is journaled in a pair of slide blocks *4b*, each of which is located at an axial end of the roller **4** and is movable along one of the slideways formed by two pairs of rails *4c* and *4d*. Each slide block *4b* is connected by a chain or rope *4e* with a rotatable tensioning disk **9** on whose periphery the rope or pull members *4e* are wound up. Depending upon the rotational setting of the disk **9**, the pull members *4e* act upon the compensator roller **4** in the sense required to hold the loop of thread taut under a force which produces a desired tension in the thread material dependent upon the quality of the thread. As the material is being wound onto the beam **5**, the winding gradually increases its diameter so that, for maintaining constant linear traveling speed of the material 1, it is necessary to gradually reduce the speed of beam rotation.

The tensioning force, which is preferably constant, is produced by means of a hydraulic piston 6 displaceable in a cylinder *6a*, the latter being connected with an oil pump 7 through an adjustable pressure control valve 8 in a conduit *8a*. The piston 6 when moved upwardly in dependence upon the oil pressure supplied from pump 7, imposes upon the tensioning disk 9 a pulling force in the counter-clockwise direction. This is accomplished by means of tie means *6b* looped around disk *9b* (FIG. 1) or *9c* (FIG. 5). The disk 9, which is mounted on a torsionally stiff shaft *9a*, pulls the compensator roller 4 toward the left. Alternatively, two disks 9 may be provided, one for each rope *4e*. The shaft *9a* of the tensioning disk 9 is made torsionally rigid so that a single tensioning piston 6 is sufficient to guide or restrict the shaft of dancer roller 4 to parallel motion, the shaft axis remaining perpendicular to the plane of illustration. Mounted on shaft *9a* is a sheave or sprocket *9d* which is connected by an endless belt or chain 10 with the regulator shaft 110 of an oil pump 11 of controllable volumetric delivery, so that any change in rotational position of the tensioning disk 9, acting through the transmission 10 upon the pump 11, is accompanied by a variation in the delivery, particularly the stroke volume, of the oil pump 11.

The oil pump 11 is similar to the fuel injection pumps of internal combustion engines. The oil pump 11, illustrated in FIG. 3, has a reciprocating member *11b* driven by an eccentric 13 on a transmission shaft *12a*.

The member *11b* carries a cylindrical push rod or plunger *11c* which reciprocates in a chamber or recess *11d* formed in the housing *11e* of the oil pump 11. The housing is stationary. The plunger is turned or reciprocated about its longitudinal axis by a spur gear *110a* which is free to rotate about housing *11e* and which is in engagement with a worm gear *110b* fixed on regulator shaft 110 of the oil pump. The amount of oil delivered at each stroke of the plunger is determined by the angular position of slanting face 111 with respect to the oil intake port 18'. In the illustrated position the pump delivers practically nothing because the oil drawn in from conduit 18 cannot be pressed into the line 14 because of the impossibility of closing the port 18'. The quantity of oil delivered by the pump depends upon the angle of rotation of the piston. It reaches its maximum when the piston is turned 180° relative to the illustrated position, so that the slanting surface 111, instead of running from top left to bottom below, extends from top right to bottom left. In the latter case, the line 18 is closed after a very short stroke of travel of the piston, so that a maximum of the inducted liquid is pressed into the line 14. The broken line *111a* represents the lower position of the upper piston surface. Nut *11f*, spring *11g*, and ball *11h* provide a one-way, spring-pressed, adjustable oil outlet. A compression spring *11k* is seated in a recess 11L in the plunger. It bears against the upper wall of the chamber *11d* about the oil outlet pipe *11m* thereof. The dotted line at *111a* indicates the position of the face 111 at the approximate end of the stroke of the plunger. Gear *110a* carries rods *11q* which turn plate *11n* fixed on member *11b*. Any other conventional means may be used to obtain simultaneous rotary oscillation and translatory reciprocation of the plunger, and substitutes for the mechanism described can be found in handbooks on diesel engine design or maintenance. The oil delivered under pressure by pump 11 is supplied through line 14 to a hydraulic or oil motor 15. Motor 15 has its power output shaft connected by a chain transmission 16 with the regulator shaft 17 of a steplessly variable-ratio transmission capable of continuous stepless variation, such as that shown in FIG. 2, and more fully described below.

The output shaft 12 of this transmission carries, in addition to the above-mentioned eccentric 13, a sheave or sprocket *12a* which drives a corresponding sheave or sprocket *5a* on the beam shaft *5b* through an endless belt or chain *5c*.

It will be recognized that a change in setting of the tensioning disk 9 controlled by the hydraulic piston 6 not only regulates the thread tension by acting upon the compensator roller 4 but also acts upon pump 15 to vary the transmission ratio of the variable-ratio transmission that drives the winder beam 5, thus varying the speed of rotation of beam 5.

The oil return line 18 of pump 15 and the oil return line *18a* of pump 11 are connected with the gear housing 30. The input shaft *31b* (FIGS. 1 and 2) of the variable-ratio transmission, which shaft is in housing 30 and which drives the output shaft 12 (FIG. 1), is driven at constant speed by a belt or chain transmission *31a* (FIG. 1) from a drive shaft 32 which also serves to drive the feed roller 3 at constant speed through a belt or chain transmission *3a*. Shaft 32 is driven by a constant-ratio transmission in gear housing 134 powered by an electric drive motor 33 operating at constant speed. Motor 33 is operative during normal winding operation whereas, preferably, for creeping operation a second motor (not shown) may be provided for driving the shaft 32 at the much smaller speed desired for threading, fault-locating, and other setting-up operations. Upon the occurrence of a fault in the threads, or of an error by the attendant, the compensator roller 4 may become excessively displaced. For that reason the machine is provided with two normally closed limit switches 34 (FIG. 1) which are connected by leads *a* to a control unit 35 which is connected to the current supply line 35' and which controls the supply of current through leads *b* to the constant speed drive motor 33. When one of the limit switches 34 is opened the solenoid 350 is not energized. This permits armature 351 and the contactor 352 to drop down and cause the motor 33 to be disconnected. This stops the machine so that the occurrence of a fault need not have detrimental effect upon the material, the operation being continued after elimination of the fault.

FIG. 4 schematically illustrates a means for reducing the friction between the tensioning roller and the guides. The tensioning roller 400 corresponds in function to roller 4 of FIG. 1. It is mounted upon a carriage 24 having a projection 24' which serves to actuate a switch 200 which may be either or both an electric limit switch of the character described above, and below, and/or a push rod for the piston of the oil circuit controlling slide valve described below. The carriage is supported upon roller bearings *4f*.

One form of steplessly variable speed ratio transmission utilizable between shafts *31b* and 12 is shown in FIG. 2. This is the well known V-belt transmission. The belt *31c* adjusts itself radially with respect to shafts *31b* and 12 in dependence upon the spreading apart or bringing together of the opposite faces of the two pulleys 170, 171. This depends upon the setting of regulator shaft 17, which corresponds to the shaft of element 17' of FIG. 1. Shaft 17 spreads apart the two arms 131 having respective pivots 132.

In FIG. 6 is illustrated another type of mounting for the tensioning pulley. The axis 4' of the tensioning pulley 4'' is carried in a slot in pendulously suspended lever 81, to permit the roller to travel along a circular arc. The threads run over idler roller 2' and driven feed roller 3', the axes of which are fixed, and thence over the tensioning roller 4'' to roller *4k* and the winder beam. Roller 3' serves as a guiding means for pulley or roller 4''; however, a separate circular guide member may be provided. At 45' and 46' are limit switches. Tension is applied from the piston 6 to disk 9 and from the latter to 81 by the rope *81a*.

The apparatus thus far described operates as follows:

During winding operation the diameter of the winding increases. If the speed of beam rotation were constant the thread tension would not increase but the loop of thread material formed in the compensator would be shortened. However, any change in the length of the loop has the effect of regulating the beam rotational speed. This regulation is effected by the compensator roller 4 which acts upon the tensioning disk 9, in opposition to the adjusted and constant pulling force of piston 6. When the winding diameter increases so that the velocity of the thread running onto the beam tends to increase, the compensator roller 4 is moved toward the right by the shortening loop of material, and the tensioning disk 9 is turned clockwise. This has the effect of imparting, through the transmission chain 10, a rotational adjustment to the regulator of the oil pump 11 with the effect of varying the volumetric delivery of pump 11. In other words the turning of disk 9 varies the setting of the variable delivery pump 11 and thus, through the oil motor 15, controls the regulator shaft 17 of the driving transmission. This changes the transmission ratio, so that the linear speed of the thread material running onto the winding beam 5 remains constant. The regulating system according to the invention operates completely astatically, in contrast to the prior known weight or spring-controlled regulators.

The new compensator described has a number of advantages. In the first place, the horizontal-type compensator can more readily and more conveniently be accommodated within the machine since in this field in most cases there is more space available in the horizontal direction than in the vertical direction. The horizontal position also permits a very much larger length of a single loop of material than is available with a vertically displaceable dancer roller for which, if the length of travel exceeds a certain limit, it is necessary to provide a multiple loop guided several times in the upward and downward direction like a multiple pulley.

Since the guidance of the dancer roller in a compensator according to the invention, along the horizontal rails, can be effected by means of anti-friction bearings, such as roller bearings, ball bearings or other rolling-motion bearings, practically friction-free operation is obtainable. When a vertically displaceable dancer roller is used the effect of kinetic energy of the roller mass varies during lifting and lowering of the roller. This variation in kinetic energy is eliminated in a compensator disposed according to the present invention. The compensator may be made with the smallest possible mass. This permits a finely sensitive regulation, which is very important for freshly sized arrays of thread, for example. A horizontal compensator, designed according to the invention, has the further advantage that both the thread tension on the one side, as well as the counteracting tensioning force on the other side, are directed in the displacement direction of the roller, that is horizontally. The hydraulically operated tensioning piston shown in FIG. 1 is particularly advantageous because it can be accurately and very sensitively adjusted to any desired thread tension. however, compressed air or mechanical means may also be used to produce the tensioning force acting upon the dancer roller. For this purpose, tensioning force can be applied to the horizontally moving dancer roller by loading it with weights movable in a multiple loop. Due to the high transmission ratio and the resulting small displacement and the very small displacing velocity, the variations in kinetic energy, occurring during the lifting and lowering movements of the weights, have no appreciable influence upon the accuracy of regulation, as contrasted with the use of a similar weighting arrangement when applied to a multiple-loop vertical moving dancer roller.

The regulating pulses issuing from the compensator 4 may be transmitted by means differing from those described in the illustrated embodiment but obvious to persons skilled in the art. For instance the transmission from the compensator to the driving transmission may be effected by compressed air or mechanically. Hydraulic control devices other than those illustrated in the drawing may also be used.

While in the foregoing reference is made to a horizontal path of dancer-roll motion, it will be understood that the dancer roller may also be guided along a circular arc or any other curvature as long as the path is approximately horizontal or provides a substantial horizontal component of motion.

The embodiments of FIGS. 7 and 9 are to a large extent similar to that of FIG. 1 with the exception of the features described presently.

According to FIGS. 7 and 8 the oil delivered from the variable-delivery pump 11 passes through oil line 14*a* to slide valve 20 through which it passes through line 21 to oil motor 15 when the compensator roller 4 has the illustrated position. The oil motor 15, as described above, operates pulley or gear 17′ to control the setting of the regulator shaft 17 of the variable-ratio beam driving transmission 30. The oil from oil motor or pump 15 passes through line 22 and through slide valve 20 to conduit 23, which returns it to the oil reservoir within the gear housing 30. The bearing unit of the longitudinally displaceable regulator roller 4 carries a cam 24 which, when the loop of thread material lengthens sufficiently, enters into engagement with a vertically displaceable, spring-biased control pin 200 of the slide valve, and then forces the valve slider 201*b* (FIG. 8) downwardly. When this happens the oil flows to and from the motor 15 in the opposite direction. That is, the oil flows from line 14*a* first through line 22 to the oil motor 15 and from oil motor 15 through line 21 to the return line 23 so that now the oil motor 15 operates upon the regulator shaft element in the opposite direction of rotation, thus somewhat increasing the rotating speed of the winding beam 5. It is to be understood that this reverse rotation of the regulator shaft can also be applied in the system of FIG. 1. In other words, the two limit switches of FIG. 1, and the connections in and to the switch box 35 of FIG. 1, can be added to the system of FIG. 7. In fact, any compatible device of any of the figures can be applied to the other figures.

FIG. 8 illustrates schematically a well-known type of slider control valve to be employed at 20 in FIG. 7. Pin 200 is attached to a slider rod 201*b* which is reciprocated in a cylindrical chamber 202. Rod 20*b* has positioned thereabout an upwardly biasing compression spring 203 and four pistons 204 serving as valves to control the passage of oil to or from the conduits 14*a*, 21, 22, 23, and 23′. The control slider is normally not in the illustrated mid-position but is displaced by the spring 203 into the upper limiting position or, by the pressure of the cam 24, into the lower limiting position. Passage 14*b* is wider than the pistons.

In the embodiment illustrated in FIG. 9, the control of the variable-ratio transmission driving the winder-beam is effected by means of an electric impulse transmitter. The tensioning control piston 6 and the tension disk 9′ which maintain the predetermined thread tension by cooperation with the compensator roller 4, correspond to the same numbered devices described above with reference to FIG. 1. However, the tensioning disk 9′ is provided with a spur gear 39 which, when the compensator roller 4 is being displaced, moves a rack 40 upwardly or downwardly depending upon the direction of displacement of the roller 4. The rack 40 carries a brush contact 41 which is connected through one of the leads *b* to a supply line 60 through customary switches and protective devices mounted within a housing 48. A number of brush contacts 41 can be employed, to obtain multiple control.

The winder-beam drive shaft 12′ carries a sprocket

12b for a chain transmission 12c which is connected with the shaft of a contact drum 42 through a set of bevel gears 12d. The contact drum 42 thus rotates at a constant rate of rotation or in synchronism with or at a speed proportional to that of the winder-beam 5. Synchronism is preferred. Drum 42 carries two contact segments 43 and 44 which are connected by stationarily mounted contact brushes 43a and 44a with respective pulse contact transmitters 45 and 46. The contact transmitters comprise each a pair of contact springs which do not engage each other when in normal position. The contact springs are mounted on a slider 47a, in insulated relation to one another. The slider 47a is frictionally displaceable on a guide rod 47 the friction being such that any displacement of carrier 47a is opposed by a braking resistance stronger than the resiliency of the contact springs. The dragging switch 45, 46 is effective to a different degree dependent upon the direction of motion of the regulating member The dragging switch inherently operates so that, after the displacement of compensator 4 from original datum position, the issuance of impulses is immediately interrupted when the compensator returns only a slight distance toward said position.

The basic circuit diagram of the pulse transmitter contacts or dragging switches 45, 46, the drum contactor 42, and of the motor 49 employed for operation of the transmission regulator 17, is separately illustrated in FIG. 10. The pulse transmitter contacts 45 are serially connected with the drum contactor 42 through leads *b* with a control unit 48 whose power input terminals 60 are connected to a current supply line and which energizes the regulator motor 49 under control by two reversing contactors 61, 62 and a pole selector switch 63. The motor 49 is energized from line terminals 60 whenever one of the contactors 61, 62 is actuated and then runs in one or the other direction depending upon which of the two contactors is picked up at a time. The motor 49 is shown to be a two-speed induction motor which has two groups of stator terminals to run with respectively different numbers of poles so as to operate at one or another speed respectively depending upon whether the group of terminals connected to leads *a* or the group of terminals connected to leads *c* is energized at a time. As a rule one of the two speeds is twice as large as the other and is due to operation with one-half the number of field poles as are effective when the motor runs at the lower speed. In the illustrated position of switch 63 the leads *a* are energized, but the motor speed can be changed simply by changing the setting of switch 63 so that leads *c* are energized. It will be obvious that motors with more than two selective speeds can be used analogously if desired.

When during the winding operation the diameter of the winding is increasing the compensator roller is pulled toward the right. An actuator structure 4*f* mounted on the bearing structure of roller 4 then engages the pulse transmitter and temporarily closes the pulse contact 45. During the displacement of compensator roller 4 the tensioning disk 9 is also actuated and lifts the rack 40. When the brush contact 41 is lifted into engagement with the segment 43 of the drum contactor 42, a current flows through pulse contact 45 and segment 43 through leads *b* and energizes the contactor 61 with the result of supplying current from line terminal 60 to motor 49. The motor starts running and turns the shaft 50 with the result of imparting rotational displacement to the regulator shaft 17 thus varying the transmission ratio of the drive that operates the winder beam. It will be noted that the phase reversing contactors 61, 62 serve for reversing the running direction of the electric motor 49, whereas the pole selector switch 63 permits the selection of a different speed of rotation of motor 49 in cases where it is desired to change the setting of the regulator shaft 17 at different speeds.

After the above-mentioned operation has taken place, the compensator roller 4 is returned toward the left by the action of the tensioning disk 9. The contact springs 45 become separated from each other whereas now the contact springs 46 are placed into mutual engagement. Upon rotation of the tensioning disk 9 in counterclockwise direction, the rack 40 again moves downward until the brush contact 41 is again located, and at standstill, between the contact segments 43 and 44 of the drum contactor 52. Due to the separation of the contact springs 45 from each other, control pulses are no longer produced even though the brush contact 41 may still rest upon the contact segment 43. If over-regulation has occurred, that is if the speed of beam rotation has become too low, then the compensator roller 4 moves farther toward the left, and the rack 40 moves farther downwardly so that by engagement of the brush contact 41 with the contact segment 44 a circuit is closed through the now mutually engaging contact springs 46. This energizes the contactor 62 and causes the motor 49 to run in the opposite direction, thus again increasing, by actuation of the regulator shaft 17, the speed of rotation of the winder beam.

The particular design and details of the electric devices and circuit connections are not essential to the invention proper and can be given various forms. For instance the pulse transmitting device may be equipped with contact segments of different length or width. They are preferably shaped in accordance with the datum speed curve of the winder beam, to control the number, magnitude, and/or duration of the control pulses. Furthermore, the strength of the impulses at different regulator positions can be made respectively different by a corresponding graduation of the current intensity or voltage, and the like. It will be understood that FIG. 10 shows the circuit diagram of the pulse transmitter only by representing basic components; if desired, intermediate relays between leads *b* and contactors 61, 62 as well as overload-protective devices and conventional circuit breakers may be added.

The invention is not limited to the particular embodiments illustrated on the drawing. In particular the hydraulic devices for regulating the transmission ratio of the driving transmission may be given any different known design, or may be substituted or supplemented by an air pressure device. Mechanical impulse transmitters are likewise applicable although not as advantageous as the hydraulic and electric pulse transmitters illustrated and described herein. The compensator 4 may be provided with various switching contacts for controlling the oil quantity passing through the oil pump 11, and FIGS. 7 and 9 may also be equipped with one or two limit switches which completely discontinue the operation of the machine when the compensator roller 4 reaches the end of the guiding rails and the constant tensioning hydraulic device can take any conventional form of constant hydraulic pressure or suction means. For instance, a tank having a constantly maintained head of water can be used.

The invention furthermore is not limited to winding machines for textile threads but is also applicable, with advantage, to winding machines for fabrics, foils, webs of paper, peeled sheets of wood for the manufacture of plywood and veneer, and the like.

I claim:

1. An apparatus for winding a length of material comprising a rotatable winding beam, means defining a travel path for supplying the textile material to the winding beam, said means including a compensator device for controlling the tension of the material, the compensator device including a tensioning roller about which the material is looped, means to constrain movement of the axis of the roller to a transverse horizontal plane, means to apply a substantially constant and horizontal material tensioning force to the tensioning roller to move its axis in said plane, power means to turn the winding beam, a

variable transmission means through which the power means turns said beam, a liquid pump of variable volumetric delivery, the pump being continuously driven, while the winding machine is in winding operation, at a speed proportional to the rotating speed of the winding beam, a liquid delivery regulator means for said pump, means for setting the quantity of liquid delivered by the regulator means, the operation of which means for setting is governed by the horizontal displacement of the axis of the tensioning roller, an hydraulic motor connected to control the transmission ratio of the said transmission means, the said pump delivering the liquid to the hydraulic motor to operate the same.

2. An apparatus for winding a length of material comprising a rotatable winding beam, means defining a travel path for supplying the material to the winding beam, said means including a compensator device for controlling the tension of the material, the compensator device including a tensioning roller about which the material is looped, means to constrain movement of the axis of the roller to a transverse horizontal plane, means to apply a substantially constant and horizontal material tensioning force to the tensioning roller to move its axis in said plane, power means to turn the winding beam, a steplessly variable transmission means, capable of continuous speed ratio variation, through which the power means turns said beam, a liquid pump of variable volumetric delivery, the pump being continuously driven, while the winding machine is in winding operation, at a speed proportional to the rotating speed of the winding beam, a liquid delivery regulator means for said pump, means for setting the quantity of liquid delivered by the regulator means, the operation of which means for setting is governed by the horizontal displacement of the axis of the tensioning roller, an hydraulic motor connected to control the transmission ratio of the said transmission means, the said pump delivering the liquid to the hydraulic motor to operate the same, said transmission means comprising a regulator element movable in opposite directions to set the speed of the winding beam, control means operable when the loop lengthens sufficiently to reverse the direction of the regulator element.

3. An apparatus for winding a strand of material comprising a rotatable winding beam, means defining a strand path for supplying the material to the winding beam, said means including a compensator device for controlling the tension of the material, the compensator device including a tensioning roller about which the material is looped, means to apply a substantially constant and horizontal strand tensioning force to the tensioning roller, power means to turn the winding beam, a variable speed ratio transmission means through which the power means turns said beam, a liquid pump of variable volumetric delivery, the pump being continuously driven, while the winding machine is in winding operation, at a speed proportional to the rotating speed of the winding beam, a liquid delivery regulator means for said pump, means for setting the quantity of liquid delivered by the pump, the operation of which means for setting is governed by the horizontal displacement of the axis of the tensioning roller, an hydraulic motor connected to control the transmission ratio of the said transmission means, the said pump delivering the liquid to the hydraulic motor to operate the same.

4. An apparatus for winding a material, comprising a rotatable winder device on which the material is to be wound, means for supplying the material to the winder device, said means including a tensioning roller having a horizontal axis and about which the material is looped, means to constrain translatory movement of the axis of the roller to a transverse horizontal direction, and means not directionally biased by gravity to apply substantially constant horizontal force to the tensioning roller to bias its axis in said horizontal direction inwardly of the loop to tension the material, power means and steplessly variable speed transmission means connected thereto to turn the winder device, means governed by the said movement of the roller axis to determine the setting of the variable speed transmission means, whereby the rotating speed of the winder device is controlled in dependence upon the change in diameter of the winding on the winder device, said means applying horizontal force comprising a fluid chamber, a piston therein, means to apply a constant fluid pressure on a force of the piston, a rotatable tensioning member, a flexible tie means connected to the piston and wrapped on the rotatable member to turn the latter, and means operatively connecting the rotatable member to the tensioning roller so that turning movement of the rotatable member in one direction moves the tensioning roller to lengthen the loop to take up slack in the material.

5. An apparatus for winding a material comprising a rotatable winder device on which the material is to be wound, means for supplying the material to the winder device, said means including a compensator device for controlling the tension of the material, the compensator device including a tensioning roller about which the material is looped, means to constrain movement of the axis of the roller to a transverse horizontal direction, and means not directionally biased by gravity to apply a substantially constant horizontal force to the tensioning roller to bias its axis in said horizontal direction inwardly of the loop to tension the material, the latter means comprising a fluid chamber, a movable element in said chamber, means to apply fluid pressure in said chamber and thereby apply force on said movable element, and means operably connecting the movable element to the tensioning roller, said connecting means comprising tieing means unbiased in operation by gravity, power means and continuously variable speed transmission means connected thereto to turn the winder device, and means governed by the said horizontal movement to determine the setting of the variable speed transmission means, whereby the rotating speed of the winder device is controlled in dependence upon the change in diameter of the winding on the winder device.

6. An apparatus for winding a length of material comprising a rotatable winding beam, means defining a travel path for supplying the material to the winding beam, said means including a compensator device for controlling the tension of the material, the compensator device including a tensioning roller about which the material is looped, means to constrain translatory displacement of the axis of the roller to parallel movement in a transverse horizontal plane, means to apply a substantially constant and horizontal strand tensioning force to the tensioning roller to translate its axis in said plane, power means to turn the winding beam, a steplessly variable transmission means through which the power means turns said beam, the variable transmission means including a speed regulator, means responsive to the horizontal displacement of the tensioning roller axis to set the speed regulator, the latter means comprising a motor operatively connected to set the speed regulator, and control means for said motor operatively connected between the motor and the compensator device and responsive to horizontal displacements of the compensator device to translate such displacements into motor speed adjusting pulses.

7. The apparatus defined in claim 6, said variable transmission means comprising a variable V-belt speed ratio transmission, said transmission having a movable regulator shaft, said control means for the motor including means for reversing the direction of movement of said shaft when the tensioning roller moves beyond a predetermined position.

8. An apparatus for winding a length of material comprising a rotatable winding beam, means defining a travel path for supplying the material to the winding beam, said means including a compensator device for controlling the tension of the material, the compensator device in-

cluding a tensioning roller about which the material is looped, means to constrain translatory displacement of the axis of the roller to parallel movement in a transverse horizontal plane, means to apply a substantially constant and horizontal strand tensioning force to the tensioning roller to translate its axis in said plane, said means comprising a fluid chamber, a piston therein, means to apply fluid pressure on a face of the piston, means to adjust said pressure, and means operatively connecting the piston with the axis of the tensioning roller, power means to turn the winding beam, a steplessly variable transmission means through which the power means turns said beam, the variable transmission means including a speed regulator, means responsive to the horizontal displacement of the tensioning roller axis to set the speed regulator, the latter means comprising a motor operatively connected to set the speed regulator, and control means for said motor operatively connected between the motor and the compensator device and responsive to horizontal displacements of the compensator device to translate such displacements into motor speed adjusting pulses.

9. An apparatus for winding a length of material comprising a rotatable winding beam, means defining a travel path for supplying the material to the winding beam, said means including a compensator device for controlling the tension of the material, the compensator device including a tensioning roller about which the material is looped, means to constrain translatory displacement of the axis of the roller to parallel movement in a transverse horizontal plane, means to apply a substantially constant and horizontal strand tensioning force to the tensioning roller to translate its axis in said plane, said means comprising a fluid chamber, a piston therein, means to apply fluid pressure on a face of the piston, means to adjust said pressure, and means operatively connecting the piston with the axis of the tensioning roller, power means to turn the winding beam, a steplessly variable transmission means through which the power means turns said beam, the variable transmission means including a speed regulator, means responsive to the horizontal displacement of the tensioning roller axis to set the speed regulator, the latter means comprising a motor operatively connected to set the speed regulator, and control means for said motor operatively connected between the motor and the compensator device and responsive to horizontal displacements of the compensator device to translate such displacements into motor speed adjusting pulses, said speed regulator comprising a V-belt continuously variable speed ratio device.

10. An apparatus for winding a material comprising a rotatable winder device on which the material is to be wound, means including a motor and a steplessly variable speed ratio transmission device for the latter, to turn the winder device, means for supplying the material to the winder device, said means including a compensator device for controlling the tension of the material, the compensator device including a tensioning roller about which the material is looped, means to constrain movement of the axis of the roller to a transverse horizontal path, and means to apply a substantially constant horizontal tensioning force to the tensioning roller to move its axis in said path, the latter means comprising a fluid chamber, a movable element in said chamber, means to control the fluid pressure in said chamber, and thereby the force on said movable element, means operably connecting the movable element to the tensioning roller, the latter means including a rotatable member operably connected to be turned by the movable element in said chamber to apply said tensioning force to the tensioning roller, and means responsive to the turning of the rotatable member to set the steplessly variable speed-ratio transmission device to vary the speed of the winder device, the continuously variable speed ratio transmission device including a ratio regulator, said means responsive to the turning including a liquid-driven motor connected to operate the regulator, means to supply driving liquid to said motor, the rotatable member being operably connected so that the said turning thereof regulates the supply of driving liquid to said motor.

11. The apparatus defined in claim 10, and means including a liquid valve to reverse the direction of flow of liquid to the liquid-driven motor to reverse the direction of rotation of the said motor, said means having actuating means operated upon that movement of the tensioning roller which increases the horizontal component of length of the loop beyond a set magnitude.

12. An apparatus for winding a material comprising a rotatable winder device on which the material is to be wound, means for supplying the material to the winder device, said means including a compensator device for controlling the tension of the material, the compensator device including a tensioning roller about which the material is looped, means to constrain movement of the axis of the roller to a transverse horizontal direction, and means to apply a substantially constant horizontal tensioning force to the tensioning roller to move its axis in said direction, the latter means comprising a piston and chamber, means to control fluid pressure on the piston, and thereby the displacement force on the piston, power driven means for rotating the winder device, stepless transmission means, capable of continuous variation of the transmission ratio thereof, the transmission means being connected between the power driven means and the winder device, means controlled by the position of the tensioning roller to transmit actuating impulses at intervals to the transmission means, the latter means including a device which controls the frequency, direction sense, and duration of said pulses.

13. An apparatus for winding a material comprising a rotatable winder device on which the material is to be wound, means for supplying the material to the winder device, said means including a compensator device for controlling the tension of the material, the compensator device including a tensioning roller about which the material is looped, means to constrain movement of the axis of the roller to a transverse horizontal direction, and means to apply a substantially constant horizontal tensioning force to the tensioning roller to move its axis in said direction, power driven means for rotating the winder device, stepless transmission means, capable of continuous variation of the transmission ratio thereof, the transmission means being connected between the power driven means and the winder device, means controlled by the position of the tensioning roller to transmit actuating impulses at intervals to the transmission means, the latter means including a device which controls the frequency, direction sense, and duration of said pulses.

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