

June 25, 1946.

H. W. DOUGHTY, JR

2,402,739

WINDING MACHINE

Filed Oct. 16, 1943

6 Sheets-Sheet 1

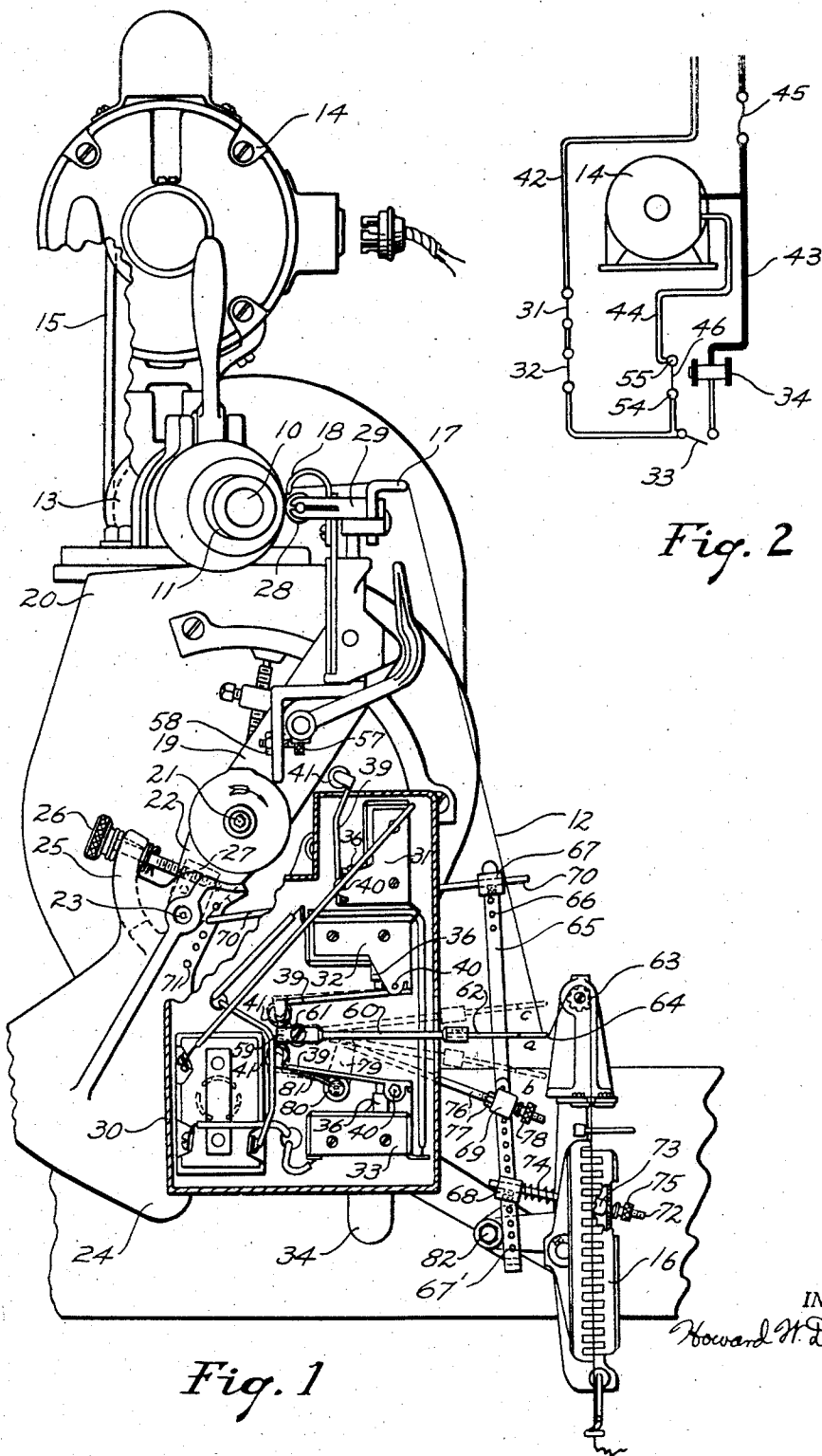


Fig. 2

Fig. 1

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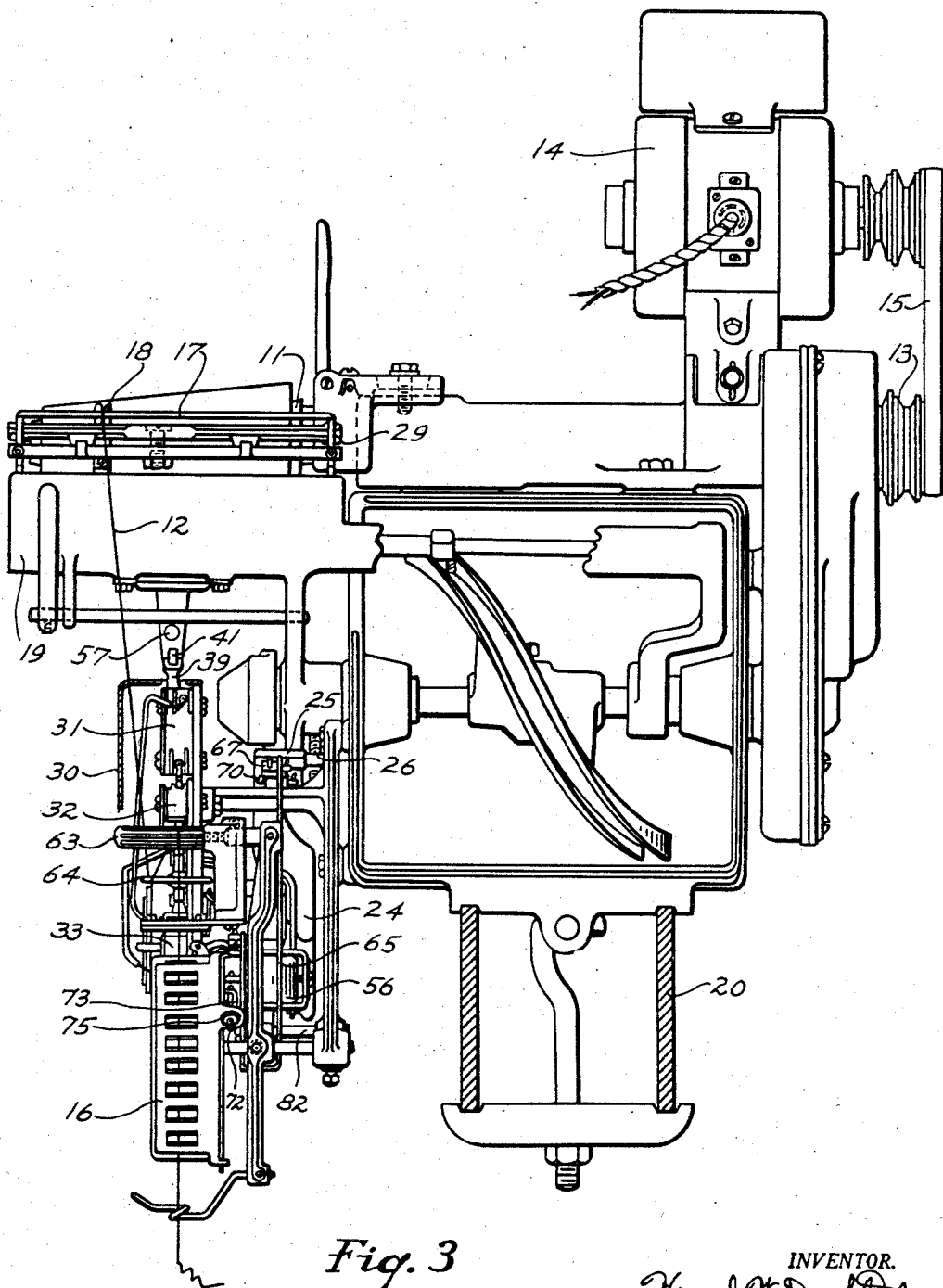
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6 Sheets-Sheet 3

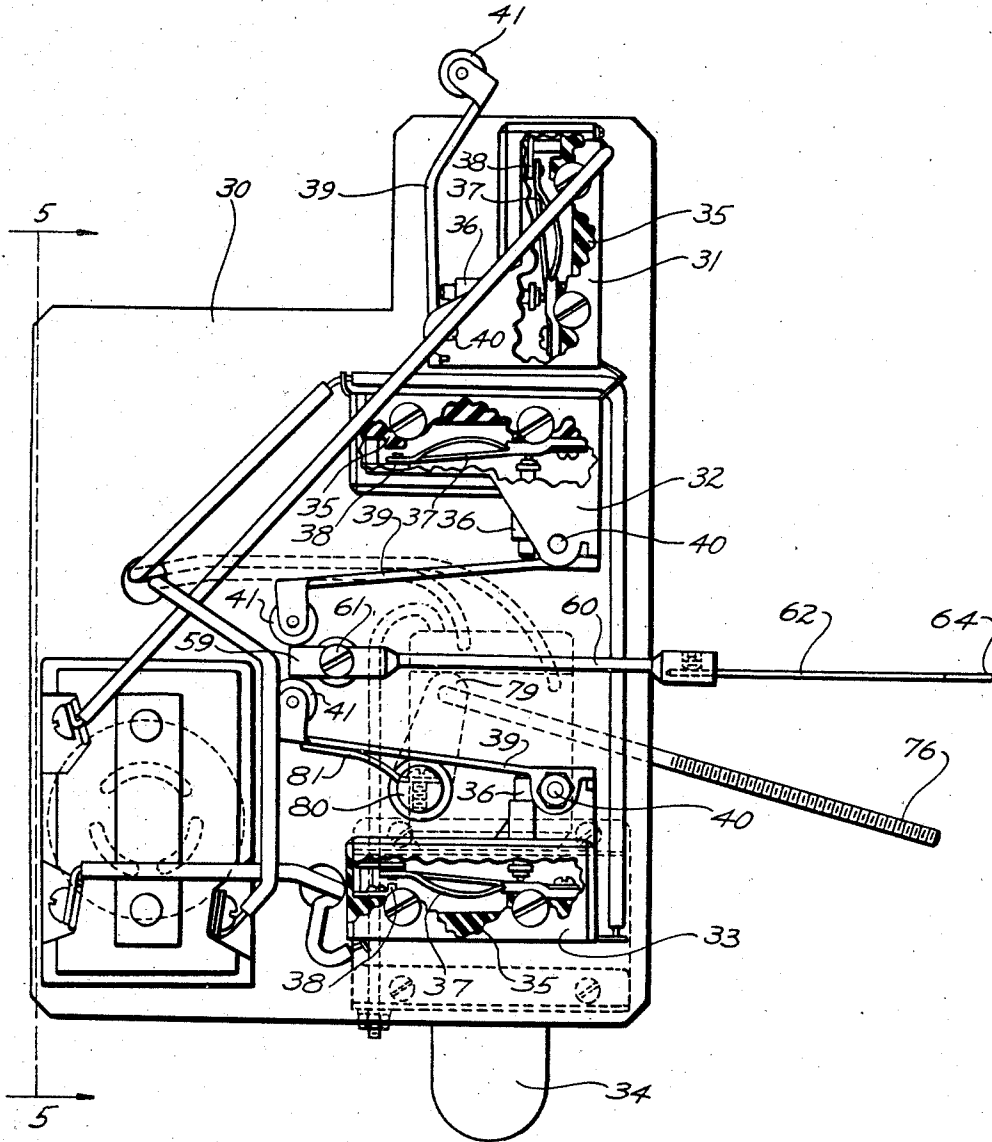


Fig. 4

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6 Sheets-Sheet 4

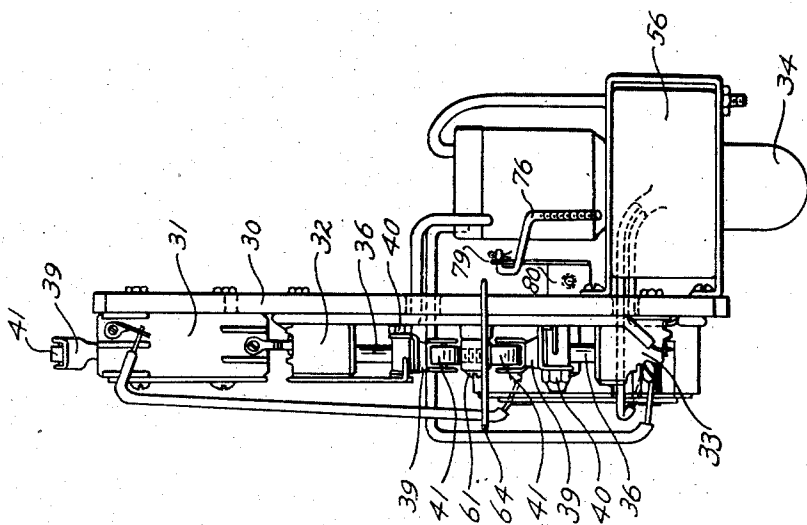


Fig. 6

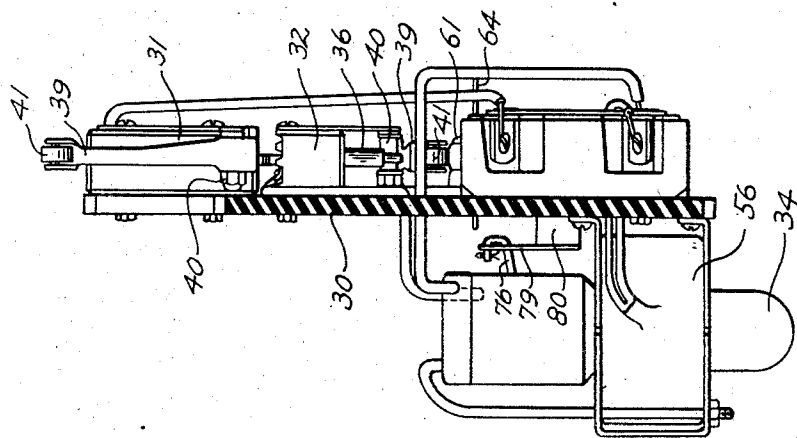


Fig. 5

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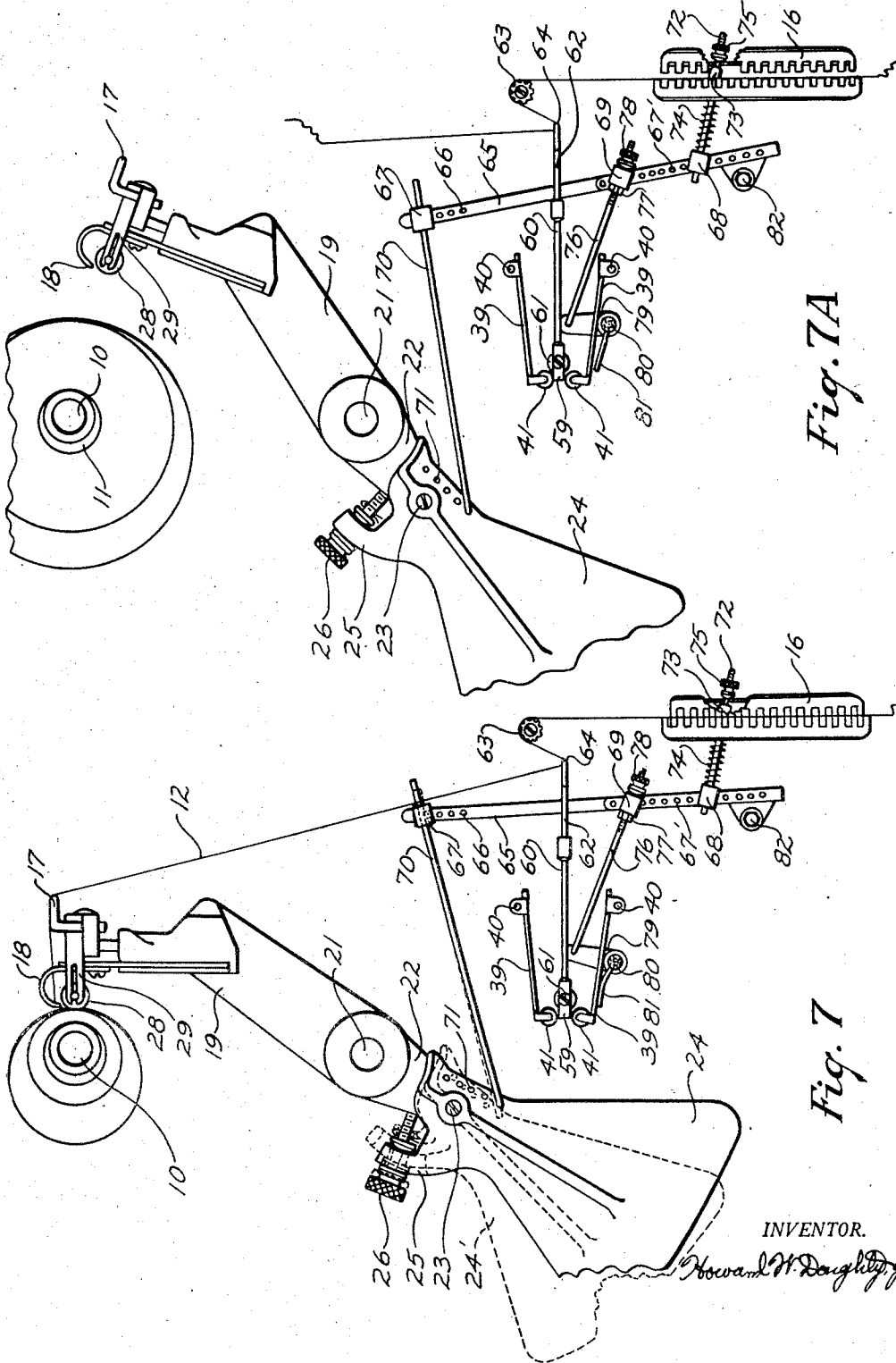
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6 Sheets-Sheet 5



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2,402,739

WINDING MACHINE

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6 Sheets-Sheet 6

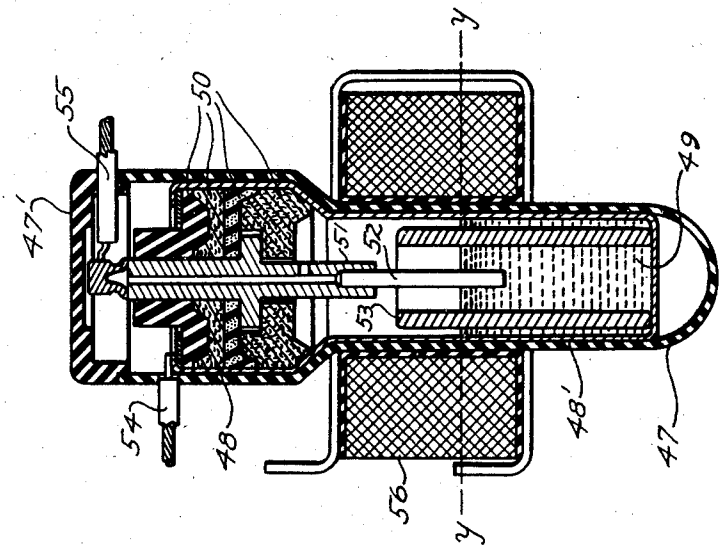


Fig. 8

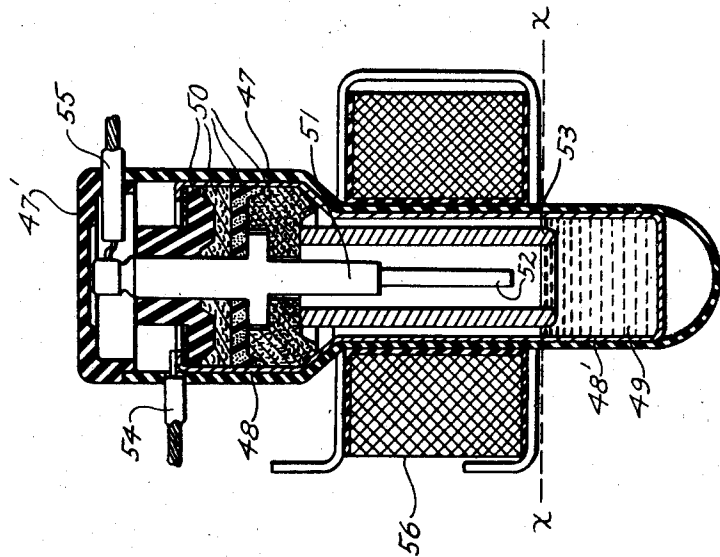


Fig. 9

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UNITED STATES PATENT OFFICE

2,402,739

WINDING MACHINE

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Application October 16, 1943, Serial No. 506,481

29 Claims. (Cl. 242-45)

1.

The present invention relates to a new and improved yarn winding machine, and particularly to improvements in high-speed yarn winding machines of the type disclosed in my prior Patent No. 2,355,634, for Winding yarn on paper cores, or the like.

Objects and advantages of the invention will be set forth in part hereinafter and in part will be obvious herefrom, or may be learned by practice with the invention, the same being realized and attained by means of the instrumentalities and combinations pointed out in the appended claims.

The invention consists in the novel parts, constructions, arrangements combinations and improvements herein shown and described.

The accompanying drawings, referred to herein and constituting a part hereof, illustrate one embodiment of the invention, and, together with the description, serve to explain the principles of the invention.

Of the drawings:

Fig. 1 is a front elevation, with certain parts omitted and other parts broken away, of a typical and illustrative winding machine embodying the present invention;

Fig. 2 is a wiring diagram, showing the electrical connections of the electrical parts of Fig. 1;

Fig. 3 is a side elevation, with parts broken away and in section, of the winding machine shown in Fig. 1;

Fig. 4 is a detailed side elevation of the control box, with its cover removed, and with the micro-switches broken away to show their internal construction;

Fig. 5 is a detailed sectional view on the line 5-5 of Fig. 4;

Fig. 6 is an end elevation of the control box of Fig. 4, also with the cover removed;

Fig. 7 is a fragmentary detailed sectional view, showing the tension adjusting means for regulating the action of the control spring and the maximum tension which may be applied to the winding strand, as well as the counterbalance and adjusting means for regulating the pressure which may be applied to the winding package;

Fig. 7-A is a fragmentary detailed sectional view, showing the tension adjusting means for regulating the action of the control spring and the minimum tension which may be applied to the winding strand, as at the finish of a full wound package;

Fig. 8 is a sectional view on an enlarged scale of the mercury relay, showing the parts thereof in normal circuit closing position; and

2

Fig. 9 is a similar view, showing the parts of the mercury relay in cut-out or open position.

The present invention has for one of its objects the provision of an improved high-speed winding machine for winding yarn into packages at a tension best suited to the yarn and in which the winding action is controlled by the tension of the yarn being wound. A further object of the invention is the provision of a winding apparatus which will wind an improved package of any size and of yarn of any kind without difficulties causing the formation of irregular packages or damage to the yarn by excessive and/or irregular tension during the winding process. The invention further provides a yarn winding machine in which the drag tension imposed on the yarn being wound can be accurately set and the operating tension on the yarn automatically controlled, and in which the speed of winding is automatically regulated by the operating tension on the yarn being wound, whatever it may be.

Still another object of the invention is the provision of an improved winding machine for yarn having means for applying any desired pressure on the package while it is being formed, for quickly stopping the machine on the breakage or exhaustion of the yarn, and for regulating the tension of the yarn and governing the winding speed in proportion to the yarn tension so as to produce perfect packages.

Still another object of the invention is to provide electrical speed controlling and mechanical tension controlling means for controlling the winding speed and tension so as to maintain a proper working ratio as between winding speeds and tensions and to prevent excessive and/or irregular tension on the yarn from any cause.

Still another object of the invention is to provide means for imposing and maintaining a desired and/or regular tension on the yarn or reducing the effective tension on the yarn from start to finish of a package, so as to enable a high speed winding action to be carried out.

Still another object of the invention is to provide novel electrical means for driving a winding spindle and for automatically controlling the speed of the spindle to sensitively and accurately vary and regulate the winding speed in accordance with the tension on the yarn.

In the winding of yarn, particularly synthetic yarns, such as rayon, nylon, and other filaments, it is of great importance that the yarn be wound under a suitable and/or regular tension, varying with the particular yarn, and that the yarn should

3

not be subjected to any excessive and/or irregular tension during the various winding and other operations to which it is subjected prior to dyeing. Not only does excessive tension increase the liability of breakage of the yarn, but lesser degrees of excessive tension may strain the yarn so as to render it unsuitable for use or permanently damage the yarn so as to change its affinity for dye, thereby producing "shiners" in the finished fabric and increasing the spoilage. Winding of the yarn at a tension suitable for the yarn, and which can be accurately controlled, is also of great importance in the preparation of the yarn for knitting, and other operations, as the quality of the resultant product is improved by the free, uniform delivery of the yarn from the wound packages.

Heretofore, it has been customary to vary the drag on the yarn with the object of decreasing the winding tension, but devices designed for this purpose have hitherto not proved to be entirely satisfactory. It has also been proposed to vary the speed of the winding spindle to compensate for its increasing diameter, so that the yarn may be wound at a substantially constant linear speed, but these devices have proved to be unsatisfactory, as they do not compensate for variations in tension caused by the thread or yarn itself, by the supply package from which the yarn is being wound, by the traverse of the yarn across the package of either a tube or a cone, or by the difference in diameter between the ends of a conical package.

In accordance with the present invention, the winding or packaging of textile yarns is controlled by the tension of the yarn being wound, and this control is exercised by varying the applied tension on the yarn as the package builds up and by varying the linear speed of the yarn under the control of and in accordance with the tension of the yarn itself. As illustrated, the invention is shown as applied to a winding machine corresponding in general to a Foster standard winder for producing "precise" wound cones or tubes. The spindle of the winding machine is adapted to receive a paper core on which the package is to be wound, and this spindle is driven by an electric motor which can operate at widely different speeds but normally is operated so as to drive the package at a high speed comparable to or exceeding that of conventional winders. The yarn to be wound is led in the usual manner from the supply package through a tensioning device which subjects the yarn to a predetermined tension. Thereafter, the yarn passes through a feeler guide or drop wire which is raised by increases in tension and is lowered as the yarn tension decreases, after which the yarn passes to the traversing thread guide which moves back and forth along the surface of the package being wound on the spindle.

The feeler guide or drop wire controls a normally open quick acting motor control snap switch which is adapted to be actuated on minute movement such as is caused by relatively small movements of the feeler guide corresponding to minor changes in the tension of the yarn. A normally closed mercury relay is interposed in the motor circuit and is adapted to be opened or closed by energizing and de-energizing, respectively, the solenoid coil thereof through the actuation of the snap switch thereby opening the power circuit to the motor whenever the yarn tension exceeds or falls below the proper operating tension so that the motor speed is regulated to maintain the

4

proper winding speed and yarn tension. A second switch is preferably provided in the motor circuit and is adapted to be opened on a decrease in yarn tension corresponding to a breakage or exhaustion of the yarn to stop the motor when the yarn is broken or its supply is interrupted for any reason. A third switch is also preferably provided in the circuit to stop the motor when a package of the desired size is formed and the action of this switch may be controlled to effect the stopping of the motor when a package of any desired size is formed. Due to the variations in tension of the yarn being supplied to the package being wound, and to the constant variations in speed of yarn travel due to the movement of the yarn guide in supplying yarn to the "precise" wound package, the motor control switch, particularly at high and highest possible winding speeds, is constantly closed and opened to control the relay for current supply actions, the time periods during which the relay opens and closes the circuit determining the speed of running of the motor driving the winding spindle, which is designed to be precisely suited to the tension of the yarn being wound.

The tension device which subjects the yarn to a predetermined frictional drag is capable of manual adjustment so as to produce the desired normal or initial tension on the yarn at the start of winding and is thereafter responsive to the action of a machine part controlled in the winding action to reduce the friction on the yarn as the winding speed increases due to the increase in diameter of the package being wound. Other means, controlled also by the said machine part, are preferably provided for varying the response of the feeler guide or drop wire to the changes in yarn tension and the sensitiveness of action of the motor control switch as the diameter of the package increases, thereby providing accurate means for controlling the tension of the wound yarn. Such means for performing these automatic controlling actions are adjustable so that their actions may be varied to secure maximum efficiency of operation and to suit the character of the yarn which is to be wound.

As illustrated, the feeler guide or drop wire, the quick acting snap switches, the relay and their control means preferably comprise a removable unit which can be quickly detached from the machine, the units being interchangeable, and may be replaced on the same or another machine, thereby facilitating and expediting replacement of the machine in service if adjustment or repair of the control unit is required, as well as permitting the control units to be accurately adjusted while they are removed from machines serving for production.

Referring now in detail to the illustrative embodiment of the invention as shown in the accompanying drawings, the invention is applied to a Foster winding machine having a spindle 10 to receive the usual paper core 11 on which the yarn 12 is to be wound. Spindle 10 is mounted for rotation and is provided with a pulley 13 by which it is driven from the electric motor 14 through belt 15. This motor may be a capacitor-run, capacitor-start motor of fractional horsepower, or a motor of any other suitable type. The yarn 12 is supplied from a conventional supply package (not shown) and passes between the slotted tension plates of the tension device or gate 16 including a laterally movable member adapted to be controlled, as hereinafter described, to impose a desired frictional pressure and operating

5

tension on the winding yarn. From the tension gate the yarn extends to and passes over a fluted bar 63, then under drop wire 62 up to a guide bar 17, to the traversing yarn guide 18 by which the yarn is traversed back and forth over the surface of the package to produce a "precise" wind conical package. The guide bar 17 and yarn guide 18 are mounted on a swinging frame 19 pivoted to the machine frame 20 at 21 and having a tail end 22 projecting beneath its pivot. For this purpose, the end 22 of the bar is pivotally connected, as at 23, to a counterweight 24 having an offset arm 25 in which is swiveled or otherwise suitably fitted an adjusting screw 26 in threaded engagement with a threaded block or socket 27 on the bar end 22. By means of this screw the counterweight may be easily, accurately and positively adjusted to balance the weight of the upper guide parts and to also apply any desired pressure from 0 to 500 grams to the winding package without the use of any additional levers, weights or other means for the purpose. The guide bar 17 and yarn guide 18 are mounted on the swinging frame 19 and by the same on the machine frame in the usual manner so that the guide 18 is and its driving parts are moved away from the spindle 10 progressively as the package builds by the winding of yarn thereon. Preferably the guide 18 is spaced from the package by means of a freely rotatable roller 28 mounted in a yoke 29 and supported on the frame 19 and bearing against the package, and the guide 18 is driven in its traversing movement by means of the usual traverse rod, cam, etc. (not shown), so that it makes one traverse to and fro along the surface of the package, each several revolutions of the package.

Between the spindle 10 and the tension device 16 is provided the electrical control apparatus in accordance with the present invention, which illustratively comprises a box or casing 30 of generally rectangular form which is or may be detachably mounted in any preferred manner on the winding machine frame. Mounted within or supported by this box are control switches 31, 32 and 33 and a control relay 34. The switches 31, 32 and 33 are preferably quick acting snap or toggle switches adapted to operate rapidly on slight movement and requiring only light pressure for their operation, those shown being of the type disclosed in the McGall Patent 1,960,020 and known in the trade as "Micro Switches." These switches require only a few thousandths of an inch movement and a few ounces of pressure to operate them, but due to the cam action and leverage of the drop wire only a few grams are required to operate the drop wire by the yarn and thus very rapid operation of the switch is provided; for instance, as rapidly as several times per second.

The switches 31, 32 and 33 are similar in construction, differing only in their relative arrangement and position of their parts with respect to each other and to the parts of the control mechanism with which they cooperate, and in the fact that switches 31 and 32 are normally closed switches, while switch 33 is a normally open switch. Each switch comprises an insulating switch housing 35 in which is slidable a switch actuating plunger 36 contacting with a snap acting spring contact 37 near its fulcrum, so that minute movement of the plunger 36 moves the contact spring 37 out of or into contact with a coacting fixed contact 38, thereby quickly breaking or making the circuit. Each switch plunger is adapted to be actuated by an operating lever

6

39 pivoted at 40 adjacent one end thereof and provided at its free end with a roller 41. The plungers 36 of switches 31 and 32 are operative when actuated to move their contact springs 37 from closed to open position, while the plunger of spring 33 is operative when actuated to move its contact spring 37 from open to closed position.

The switch 31 is employed in association with coacting controlling means to control the motor circuit to automatically stop the operation of the motor when a package of a prescribed size is formed, and the action of the said control means may be regulated to stop the winding operation when a package of any prescribed size is formed. The switch 32 is employed in connection with associated controlling means to control the motor circuit to automatically stop the operation of the motor when the yarn breaks or the yarn supply runs out. The switch 33 is adapted to be shunted across the circuit and employed in conjunction with the relay 34 and associated controlling means for motor circuit controlling actions to stop the operation of the motor when a predetermined high operating tension of the feeding yarn is exceeded and to cut the motor in and out as the yarn tension varies and by such actions govern its winding speed in accordance with or in proportion to the tension on the yarn as it builds up in the package, to secure, in connection with automatic tension controlling means, a high speed winding operation in which the operating tension of the yarn is varied in accordance with or proportional to its winding speed while its winding tension is kept uniform or reduced, and at all times is controlled during the winding operation.

The wiring diagram of the circuit in which the motor, micro-switches and mercury relay are arranged is shown in Fig. 2 and the construction of the mercury relay is shown in detail in Figs. 8 and 9. In Fig. 2 the motor 14 is shown as arranged in a 110 v.-A. C. circuit including conductors 42, 43, 44 and a fuse 45. The normally closed switches 31 and 32 are disposed in the conductor 42 in series with each other and with the normally open switch 33. Conductor 43 is connected to one terminal of the motor and conductor 42 is connected to the other terminal of the motor through the normally closed mercury relay switch 46 when the latter is closed. The relay 34 includes a controlling solenoid whose coil is arranged in a portion of the conductor 43 adapted to be connected by the switch 33 with the conductor 42 to energize said coil to open the mercury relay and the motor circuit and stop the operation of the motor.

The mercury relay, which is controlled by but makes and breaks the motor circuit electrically independent of the contacts of switch 33, comprises an insulated outer shell or casing 47 having a closure cap 47' and inclosing an inner metallic stationary input electrode shell 48, the lower portion of which forms a cup 48' containing a body of mercury 49, and the upper portion of which provides a receiving chamber for supports 50 of insulating material carrying a conductor 51 from which depends an output electrode rod 52 which projects downwardly into the mercury cup. Loosely arranged for vertical movement in the mercury cup is a hollow cylindrical displacing plunger or solenoid core 53 of suitable material. The electrodes 48 and 52 are connected by the input and output conductors 54 and 55 to portions of the circuit conductor 44 and surrounding the shell 47 is an electromagnet coil 56

which is terminally connected to portions of the circuit conductor 43. Normally the core 53 rests on the bottom of the cup 48' and its specific gravity is such as to displace and raise the level of the mercury from its normal level $x-x$, at which it lies below the electrode 52, as shown in Fig. 9, to a level $y-y$ in which it contacts said electrode and electrically connects the same with the electrode 48, as shown in Fig. 8, and electrically connects the motor in circuit with the conductors 42 and 43. The core is adapted to be raised by the influence of the magnetic flux of solenoid coil 56 when the latter is energized and thereby lower the level of the mercury and electrically disconnect the electrodes 48 and 52, thus cutting out and stopping the operation of the motor 14. Solenoid coil 56 is de-energized when switch 33 is in its normally open position and energized when switch 33 is closed and bridges the conductors 42 and 43.

The switch 33 and relay switch 46, as before stated, operate in conjunction with each other to control the speed of the motor and are in turn controlled by means governing and governed by the tension on the yarn to regulate the winding speed to correspond to or in accordance with the tension, whatever it may be at the time, on the yarn, as hereinafter more fully described.

In the structure disclosed in my aforesaid Patent No. 2,355,634, a micro-switch is employed to alternately shunt in and out of the motor circuit a 150-ohm fixed resistor to control the motor speed and necessarily the winding speed. This type of control is satisfactory under many conditions, but, as used, in the structure disclosed in said application, has been found open to certain disadvantages. Because of the open contact construction of the micro-switch, the necessarily small air gap between the contacts in the open position and the rapidity of actuation, a sufficiently great electronic bombardment and arcing occurs to cause heating and inter-transfer of contact materials resulting in an ultimate welding together of the contacts and short active life of the switch. Also, in the structure disclosed in my said prior application the yarn tension control means is designed to maintain the operating tension on the yarn fixed and constant throughout the package doff. This, while satisfactory when winding certain yarns, has been found objectionable with others, such as in causing poor package forming in winding low denier, low twist yarns, and reducing output in winding yarns capable of being wound at high speed, since the prior controlling means, by holding the tension to a pre-adjusted level, so greatly reduced the winding speed in winding certain yarns as to cause a greatly reduced production in winding. In contradistinction, the present invention provides new and improved means to decrease the tension on the yarn progressively, as the package builds up. The use of a mercury switch alone is advantageous from the standpoint of durability, because of the electrical non-destructive nature of mercury as a contact material, but too great a force is required to operate it by ordinary switching means from the tension control means and its differential balance in its use alone would be so wide as to permit undesirable surges in winding speeds. By, however, employing a mercury relay in the motor circuit to directly control the motor and a micro-switch governed by means controlled by the winding speed and the yarn tension to in turn control the relay a rapid control of the motor and desired balancing differentials in motor

cut out and cut in actions are obtained to overcome the aforesaid objections to the use of a micro-switch alone or a mercury switch alone to perform the governing functions. The use of these two control devices in combination, furthermore, permits of the employment of control means to control the yarn tension and winding speeds in a novel manner to secure the formation of perfect packages, to reduce liability of breakage of the yarn, to prevent imperfections in the yarn causing "shiners" and other defects in the finished fabric, and to increase winding production.

The electrical controlling apparatus above described coacts with novel and improved parts of the winding mechanism to control the winding operation in a simple, reliable and efficient manner to secure the desired results. As shown, the switch 31 is arranged vertically at the top of the box 30 and the roller end 41 of its operating lever 39 projects outwardly and upwardly into the path of a contact device 57 mounted on the swinging frame 19 and movable therewith. The arrangement of this contact 57 is such that at the end of the operation of winding a package it engages the roller 41 and operates the lever 39 to open the switch 31 and automatically stop the operation of the motor. The contact 57 is threaded for adjustable engagement with the swinging frame 19 so that its position with respect to the roller end of the lever 39 of switch 31 may be varied, to control the operation to stop the motor when a package of any desired size is formed, and suitable means, such as a lock-nut 58, may be provided to firmly secure the contact in any of its positions of adjustment.

The switches 32 and 33 are arranged horizontally in the box 30, one above the other, and their operating levers 39 are so mounted that their rollers 41 are closely adjacent to each other and bear against the short end 59 of a lever 60 pivotally mounted on pin 61 and carrying the feeler or drop wire 62. Normally, and with the drop wire 62 in its intermediate position *a*, switch 32 is closed and switch 33 open. Movement of the drop wire 62 downward to position *b* by gravity in the absence of tension on the yarn, due to its breakage or running out, causes the lever 60 to open switch 32 and thereby quickly stop the operation of the motor. Movement of the drop wire 62 upwardly under excessive yarn tension to position *c* causes the lever 60 to close switch 33 and thereby open the relay 34 to stop the motor or to cause switch 33 and relay 34 to alternately open and close the motor circuit to control the motor so as to govern its speed and enable its speed to be regulated to keep the yarn under proper operating tension while winding it at variable high speeds. As shown, the yarn 12 passes from the tension device over a fluted bar 63 and through a guide loop 64 at the outer end of the drop wire. This loop 64 is positioned to one side of the yarn path between the bar 63 and the guide bar 17 and the yarn is looped over the fluted bar 63 under the end then through the loop 64, which deflects the yarn from its straight path. Thus, as the yarn tension increases in the length of the yarn between the tension device 16 and bar 63 and the bar 17, the drop wire is lifted, while a decrease in yarn tension allows the drop wire to fall.

For variably adjusting the tension gate 16 to impose a desired starting and variable operating or running tension on the yarn, and for further controlling and regulating the action of the

switch 33 and relay 34 to regulate the motor speed and linear speed of travel of the yarn, to secure rapid winding without injury to the yarn at a tension best suited for the character of the yarn being wound at the winding speed at any time at which it is being wound, means are provided which may be manually set to impose a desired starting tension on the yarn and will thereafter automatically perform the aforesaid speed and tension control functions. These means comprise a vertically disposed, laterally swinging, floating motion transmitting or regulating bar or lever 65 disposed between the tension device 16 and box 30. The swingable bar 65 pivotally supported on a stud 82, is provided with a plurality of openings 66 at its upper end for the adjustable engagement therewith of a pivot block 67, and at its lower end the bar is provided with an elongated series of openings 67' for the adjustable engagement therewith of pivot blocks 68 and 69. A rod 70 is connected at one end to the block 67 and is suitably formed at its opposite end for engagement with any one of a series of openings 71 in the balancing and pressure controlling counter-weight 24. The bar 65 is thus coupled to the counter-weight of the swinging guide frame so as to move therewith and so as to be moved rearwardly with the tail portion of said frame and impart similar motion to the bar 65 as the package builds up. The extent of this movement of bar 65 under prescribed movements of the swinging frame may obviously be varied by varying the adjustable connections, one or both, between the rod 70, bar 65 and counter-weight 24. A rod 72 is engaged at one end with the block 68 and carries at its opposite end a sliding clip or clutch member 73 which engages the movable member of the tension gate 16, whereby said member is coupled to the bar 65 for movements therewith. A coiled spring 74 on the rod between block 68 and gate 16 furnishes sufficient pressure to keep the gate normally closed, while allowing it to be manually opened for "threading up" without disturbing its adjustment. A knurled elastic retaining and adjusting nut 75 bears on the clip 73 and has threaded engagement with the rod to hold the clip in adjusted position and is adapted to be threaded in or out to allow any initial or starting tension to be imposed on the yarn which may be reduced with respect to the initial tension by movements of the bar 65 away from the gate and through the movements of the weight 24 rearwardly as the package builds up. The amount of the initial tension and the extent of tension reducing movement may also be varied by adjustable engagement of the block with the openings 67'. A third rod 76 has one of its ends threaded and passing through the block 69 and provided with a check nut 77 and an adjusting and clamping nut 78 whereby it is adjustably connected with said block 69. The opposite end of this rod is connected to an arm 79 on a rock shaft 80 carrying a control spring 81 which bears against the underside of the operating lever 39 of the micro-switch 33 to oppose a predetermined resistance to the switch closing movement of said lever. The pressure exerted upon the drop wire 62 by the tension created on the yarn must exceed the pressure of control spring 81 in order for micro-switch 33 to be actuated, and this spring by its pressure establishes the high tension on the yarn which the electrical control mechanism will permit. This pressure, and consequently the high permissible tension, may be

varied by changing the position of the block 69 on the bar 65 and more particularly by adjustment of the rod by the nut 78 to vary the effective length and throw of the rod. Through the connection of the rod 76 with the bar 65 motion is applied to control spring 81 in a counter-clockwise direction for a pressure reducing action as the guide frame moves under the diameter increase of the winding package. This automatically reduces the pressure at which switch 33 may be operated and at the same time the movement of the bar 65 effects adjustment of the tension device through the connection 72 to allow progressively less tension to be imposed by the tension device on the yarn during the package doff.

In winding machines of the general type to which the present invention relates it is the usual practice to rotate the spindle at a constant rate of speed and to wind the yarn on a cylindrical or conical tube or other holder mounted on the spindle. When yarn is wound on a machine of this type the linear speed or draft of the yarn passing to the spindle is gradually increased, due to the constantly increasing diameter of the package being wound. Owing to this linear increase in speed of the yarn ballooning of the yarn as it unwinds from the supply bobbin occurs, which is progressive as the linear speed increases, the effect of which causes an increase in tension of the yarn and an increased resistance to its passage through the tension device from start to finish of the package. As a result, the yarn may be subjected to an excessively high tension, causing its breakage or its improper winding on the package, or it may be subjected to strains rendering it imperfect or unfit for use.

As before briefly stated, to overcome the deficiencies above mentioned, it has heretofore been proposed to provide various means in the form of compensating devices for gradually reducing the operating tension on the yarn as its linear speed increases, whereby to progressively decrease the tension at the package during the entire winding operation, and while the spindle is operating at a constant rotative speed, but such devices, besides being of complex character and requiring constant attention on the part of the operator, have not proved to be entirely efficient.

It has also been heretofore proposed to overcome the aforesaid objections to prior machines by providing a winding machine in which the linear speed of the yarn is maintained substantially constant during the entire winding operation, without the use of compensating devices, but by motor speed controlling means governed solely by the change in diameter of the package being wound for gradually reducing the rotative speed of the winding spindle in accordance with the progressive increase in diameter of the package being wound in such manner as to keep the linear speed of the yarn and the tension on the yarn constant throughout the winding operation. Such a control means, however, is unsatisfactory because it does not take care of the many variables entering into practical winding, due to variations in tension caused by the thread or yarn itself, by the supply package from which the yarn is being wound, by the traverse of the thread across the package of either a tube or a cone or by the difference in diameter between the ends of a conical package, and any method of winding governed solely by maintaining a constant linear speed of the yarn greatly reduces

the quantity of yarn which may be wound in a given time and the production of the machine from an economical standpoint. Basically, therefore, winders operating on the principle of maintaining a constant rotative speed of the spindle are too fast and have a detrimental action on and cannot maintain or preserve the quality of the thread, while winders operating on the principle of maintaining a constant linear speed of the thread are too slow from the standpoint of economical production.

The present invention differs from machines operating on the principle of maintaining a constant speed of the spindle or maintaining a constant linear speed of the thread, and its operating action is based on the principle of generally controlling the tension of the thread and the linear speed of the thread in proportion to the winding speed as the winding package increases in diameter and controlling the spindle or winding speed by the tension of the thread, which may be a constant tension, a decreasing tension or a fluctuating or variable tension, according to the character of the yarn, and to the winding speed required at different times during the winding operation, whereby the quality of the yarn may be maintained and wound packages of perfect form economically produced without imposing an excessive tension on the thread.

It is well known that different kinds of yarn, particularly synthetic yarns, have different frictional and other properties, requiring their winding at different proportional speeds and under different tensions, and that the tension developed by different yarns in winding operations varies according to speed increases in the winding doff. It is, therefore, necessary, because of the varying frictional coefficients of different yarns, to establish a proper surface contact between the yarn and the friction gate to provide a constant basic tension suited to the particular yarn and which alone or in connection with added resistance means determines the maximum tension which may be imposed thereon at a predetermined winding speed to prevent breakage thereof or undue strain thereon, and to provide means for variably reducing the tension to proper degrees as the winding speed varies and to control the winding speed in proportion to or accordance with the yarn tension to allow the yarn to be rapidly wound to form a perfect package and without liability of breakage or injury. As the coefficient of friction of the yarn varies, the winding speed must be varied proportionately. The friction value in some cases may be low and such that increases in speed of winding do not greatly affect the tension developed, while in other cases the frictional value may be high and such that the tension increases rapidly with the increased winding speed. In the majority of cases the frictional value is sufficiently low to allow the frictional surface contact on the winding strand to be progressively reduced as the diameter of the package increases. By this means advantage may be taken of the increasing periphery of the winding package to obtain greater winding speeds without changing or increasing the tension. In those cases, however, where the frictional value is high and of varying frictional coefficients in various yarns, the initial tension on the yarn must be varied and established for a given yarn and in the winding operations a gradual decrease of tension and fluctuations in ten-

sion (increases and decreases in certain limits) must be allowed to govern the tension according to the winding speed and linear speed of travel of the yarn and to govern the winding speed in proportion to or accordance with the tension on the yarn.

The operation of the apparatus in accordance with these principles is as follows:

The tension gate 18 is first adjusted by adjustment of its controller 72 to impose the desired initial friction and tension on the yarn. The control devices 57, 70 and 75 are also adjusted, if not properly adjusted, to control the action of switch 31 to stop the machine when a package of the desired size is formed, and to govern the movements of the bar 65 which governs the actions of the controlling devices 72 and 75. The machine is then started into action to wind the yarn on the core 11 as the spindle 10 revolves. In practice the spindle 10 is driven by the motor 14 at a uniform generally high motor speed suited for the yarn, and varied only by the control actions of the switch 33 and relay 34 as running conditions require. As the winding builds up and progressively increases in diameter, the guiding means, which maintains a desired pressure on the package, moves outward, thus transmitting movement through the control rod 72 to the bar or lever 65, which in turn adjusts the control elements 72 and 75 to gradually and progressively reduce respectively the frictional pressure of the tension gate 18 on the yarn and to similarly reduce the resistance of the control spring 81 to the operation of lever 39 of switch 33 by the drop wire or feeler 62. The reduction in friction of the tension gate 18 on the yarn as it occurs is proportional to the increases in winding speed as the package increases in diameter and its peripheral speed increases, so that, generally speaking, a proper operating tension is maintained on the yarn while it is permitted to travel at gradually increasing linear speeds and to be moved at highest permissible speed, suited to the yarn, on the core 11. When the winding reaches a stage to form a package of the proper diameter contact 57 engages the roller 41 of lever 39 of switch 31 and opens said switch to break the motor circuit and stop the motor 14. If at any time the operating tension on the yarn should drop to an abnormal degree, due to breakage or exhaustion of the yarn, the drop wire or feeler 62 will fall to position b and actuate the operating lever 39 of switch 32 which will be moved to open position to break the motor circuit and stop the motor. It will, of course, be understood that the initial friction on the yarn imposed by adjustment of the gate 18 may vary within wide limits, according to the character and frictional coefficients of different yarns, so that the initial friction imposed on some yarns may be comparatively high while the friction imposed on other yarns may be comparatively low, and in some cases very light and almost negligible. Very light initial frictional pressures may be imposed on yarns which in their running action tend to impose upon themselves the proper tension proportional to their linear speed to keep the tension more or less substantially constant.

The winding operation, however, is always under the control of the switch 33 and relay 34, which control the spindle speed from start to finish of the package to regulate and maintain a proper tension on the yarn for high winding speed, and which are controlled by the tension of the yarn itself to govern the spindle speed

13

accordingly. At any and all times in the winding operation, notwithstanding the general tension regulating action effected by movements of the bar 55, the yarn tension may fluctuate due to the many variables referred to, and particularly at high winding speed, which it is desirable to secure and maintain, and the switch 33 and relay 34 are provided to take care of these fluctuations and to maintain a proper operation tension on the yarn at high winding speed.

With any given rate of uniform speed of the spindle the winding speed increases as the diameter of the winding increases. At low winding speeds the friction of the gate and resistance of the spring 81 may be high. As the winding speed increases friction and resistance are reduced, but due to various factors the tension on the yarn may be raised to an extent to cause the drop wire or feeler 62 to move to position c. When this occurs the switch 33 will be operated against any prevailing resistance of the spring 81 to energize the coil of relay 34 to open the relay switch. The motor will then slow down or its operation will be slowly arrested until the yarn tension is reduced within safe limits sufficiently to bring drop wire 62 back to its normal position a, thereby causing switch 33 to open and the relay coil to be de-energized, with the result that switch 46 is closed and the motor speeded up or started into action. The fluctuations mentioned necessarily increase in number as the winding speed increases, during which the resistance of the spring 81 is reduced and the sensitiveness of the switch 33 to actuation by the drop wire 62 is increased, so that at high winding speeds the switch 33 and relay 34 may be more or less constantly in action to allow the high winding speed to prevail while governing the speed of the motor and spindle whenever the yarn tension rises unduly or becomes excessive to reduce the winding speed and the yarn tension to proper proportionate ratios. The switch 33 and relay 34 are adapted to operate very rapidly at the highest permissible winding speed and yarn tension under slight plus and minus tension changes above and below the highest permissible operating tension so that, even at highest speed, breakage of or injurious strains on the yarn will be prevented while the machine operates to rapidly produce perfect windings in an economical manner.

As in the employed micro-switch-mercury-relay combination, the micro-switch 33 does not directly control the flow of current to the motor, but simply energizes and de-energizes the solenoid coil 56 of the mercury electric relay which controls the current flow, a rapidly operating combination is produced and one which is of durable character. With this arrangement the micro-switch is subjected to only the current influences of the solenoid coil 56 of the mercury relay, for small periods of time only, an influence of approximately 6 milliamperes, rather than to the total influence of the full motor circuit which would be approximately $1\frac{1}{2}$ amperes. Such reduction in current influence across the micro-switch minimizes the electronic bombardment or other action liable to cause injury to or the welding together of its contacts. Also while this switch operates with great frequency, especially at high winding speeds, the number of times it operates in any given winding operation is reduced by reason of the fact that the mechanical tension control means relieves it of a part of the tension control work. The use

14

of the mercury switch to directly control the flow of current to the motor is advantageous from the standpoint of durability, due to the electric indestructibility of its working electrodes. The main objection to the use of such a relay, i. e., its slowness of action when used in connection with any other type of energizing switch, is overcome by the use of the rapidly operating micro-switch which will energize and de-energize the solenoid coil of the relay with such rapidity that the working actions of the plunger 53 will be speeded up. For rapid actions it is not essential that the plunger make full strokes as short strokes sufficient to change the level of the mercury to cause it to make and break contact with the electrode 52 are all that is necessary, and such strokes are effected by rapid and short periods of energization and de-energization of the solenoid coil 56.

The invention in its broader aspects is not limited to the specific mechanisms shown and described, but departures may be made therefrom within the scope of the appended claims without departing from the principles of the invention and without sacrificing its chief advantages.

What I claim is:

1. The method of winding a strand on a package, which includes initially subjecting the running yarn to a predetermined amount of friction, controlling the speed of rotation of the package in accordance with the tension of the yarn, and reducing the friction on the yarn as the diameter of the package increases.

2. The method of winding a strand on a package which includes initially subjecting the running yarn to a predetermined amount of friction, controlling the speed of rotation of the package in accordance with the tension of the yarn, reducing the friction on the yarn as the diameter of the package increases, and increasing the normal speed of winding of the yarn with the increase in package diameter whereby the speed of winding is substantially increased while maintaining a substantially constant tension on the yarn.

3. The method of winding yarn in a package, which consists in rotating the package to draw yarn thereon, imposing a predetermined initial surface friction on the winding yarn, reducing the surface friction on the yarn progressively as the diameter of the winding increases until the maximum allowable tension of the yarn is reached or exceeded, and raising and lowering the winding speed as the tension fluctuates in the region of and between points above and below the maximum allowable tension to maintain a substantially uniform tension on the yarn proportionate to the winding speed.

4. The method of winding yarn in a package, which consists in initially subjecting the running yarn to a predetermined amount of friction, controlling the speed of rotation of the package in accordance with the tension of the yarn, opposing a resistance to a change in the speed of rotation, and reducing the friction on the yarn and resistance to the speed of rotation as the diameter of the package increases.

5. The method of winding yarn in a package, which consists in imposing a predetermined initial friction on the winding yarn, varying the surface friction on the yarn as the diameter of the winding increases, and raising and lowering the winding speed as the tension fluctuates between an excessive and a maximum allowable tension

15

to maintain a substantially uniform tension on the yarn proportionate to the winding speed.

6. The method of winding yarn in a package, which consists in winding yarn under an applied predetermined starting tension, progressively decreasing the applied tension as the linear speed of the yarn and the diameter of the winding increases, and controlling the speed of the winding and the applied tension on the yarn at highest permissible winding speed for the applied operating tension of the yarn through fluctuations in yarn tension above and below the applied tension.

7. In a yarn winding apparatus, the combination of a motor driven spindle to support a package to be wound, a tension gate through which the yarn passes as it is wound, means for varying the friction of the tension gate on the yarn as the diameter of the package increases by winding, and means controlled by the tension of the winding yarn for controlling the speed of the motor to maintain the winding speed as high as consistent with a predetermined tension of said yarn.

8. In a yarn winding apparatus, the combination of a motor driven spindle to support a package to be wound, a tension gate through which the yarn passes as it is wound, means for varying the friction of the tension gate on the yarn as the diameter of the package increases by winding, and power supply controlling means controlled by the tension of the yarn and actuated by the yarn being wound for controlling the motor speed to maintain the winding speed as fast as permitted by the applied tension on the yarn.

9. In a yarn winding apparatus, the combination of a motor driven spindle to support a package to be wound, a tension gate through which the yarn passes as it is wound, means for adjusting the tension gate to impose a predetermined tension on the yarn, means for varying the friction of the tension gate on the yarn in accordance with the diameter of the package, and means controlled by the tension of the yarn as it is wound for varying the motor speed to maintain the winding speed as fast as permitted by the imposed tension on the yarn being wound.

10. In a yarn winding apparatus, the combination of a motor driven spindle to support a package to be wound, a tension gate through which the yarn passes as it is wound, means for varying the friction of the tension gate on the yarn, and means controlled by the tension of the yarn as it is wound for regulating the friction of the tension gate and controlling the power supplied to the motor to coordinately control the tension of the yarn and to vary the motor speed to keep the winding speed and linear speed of the yarn substantially constant.

11. In a yarn winding apparatus, the combination of a motor driven spindle to support a package to be wound, a tension gate through which the yarn passes as it is wound, means for varying the friction of the tension gate on the yarn in accordance with the diameter of the package, a switch controlling the supply of power to the motor, and means operated by the tension of the yarn between the gate and package for operating the switch to supply power to the motor on a predetermined decrease in yarn tension and to cut off the supply of power to the motor on a predetermined increase in yarn tension.

12. In a yarn winding machine, the combination of a spindle on which the package is to be wound, a motor for driving the spindle, a switch

16

operated by changes in yarn tension as the winding speed changes, said switch being capable of relatively rapid operation with respect to the change in motor speed whereby the speed of switching determines the motor and spindle speed, and a relay operated by the switch and controlling the power supplied to the motor for varying the spindle speed.

13. In a yarn winding machine, the combination of a motor driven spindle on which the package is to be wound, a control device actuated by the tension of the yarn and controlling the speed of the motor, a spring opposing a resistance to the actuation of said device, and means for varying the resistance of the spring as the package increases in diameter by winding.

14. In a yarn winding machine, the combination of a motor driven spindle on which the package is to be wound, means controlling the supply of power to the motor and actuated by the tension of the yarn, a spring opposing a resistance to the actuation of said means, and means for varying the resistance of the spring as the winding progresses.

15. In a yarn winding machine, the combination of a motor driven spindle on which the package is to be wound, a device for controlling the supply of power to the motor, a device actuated by the tension of the yarn for actuating the first named device, a spring normally opposing movement of the second named device by the first named device, and means operating as the diameter of the package increases for reducing the effective resistance of the spring.

16. In a yarn winding machine, the combination of a motor driven spindle on which the package is to be wound, means including a switch for controlling the supply of power to the motor and actuated by the tension of the yarn, a spring opposing a resistance to the actuation of the switch by the yarn, and means controlled in accordance with the diameter of the package being wound for lessening the resistance of the spring.

17. In a yarn winding apparatus, yarn winding means, a tension device for imposing an initially predetermined tension on the running yarn, means controlled by yarn tension for controlling the speed of the winding means, and means controlled by the increase in diameter of the package being wound for controlling the tension device to regulate the tension on the yarn.

18. In a yarn winding apparatus, yarn winding means, a tension device for imposing an initially predetermined tension on the running yarn, means controlled by the action of the machine for varying the yarn tension as the diameter of the winding increases, and means controlled by yarn tension for controlling the winding means and regulating the winding speed proportionate to yarn tension as the diameter of the winding increases.

19. In a yarn winding apparatus, a motor driven winding spindle, a tension device for imposing an initially predetermined tension on the yarn being wound by the spindle, a controller governed by yarn tension for regulating the spindle speed, a device for normally opposing a resistance to the action of the controller, and means governing said tension device and said resistance device for progressively reducing the tension on the yarn.

20. In a yarn winding apparatus, a motor driven winding spindle, means for imposing an initially predetermined tension on the yarn being wound on the spindle, means for progressively reducing

17

the tension on the yarn as the diameter of the winding progressively increases, and means controlled by yarn tension for regulating the speed of the spindle.

21. In a yarn winding apparatus, a motor driven winding spindle, means for imparting an initially predetermined tension on the yarn being wound on the spindle, and means controlled by the tension of the yarn as the diameter of the winding increases for controlling the speed of the spindle in accordance with the yarn tension.

22. In a yarn winding apparatus, a motor driven winding spindle, means for imposing an initially predetermined tension on the winding yarn, means operative in the winding action for reducing the tension on the yarn as the diameter of the winding increases, and means controlled by the tension of the yarn as the diameter of the winding increases for controlling the speed of the spindle in accordance with the yarn tension.

23. In a yarn winding mechanism, winding means, electrical means for driving the winding means, tension means for imposing an initially predetermined tension upon the yarn being wound, and current control means for controlling the supply of current to the driving means, said current control means comprising a normally closed mercury relay and a normally open micro-switch, said switch being closed and opened by relatively high and low tensions on the yarn to open and close the relay.

24. In a winding machine, a winding spindle, a motor for rotating the spindle to wind yarn thereon to form a package, means for imposing an initially predetermined surface friction on the yarn, means controlled by the tension on the yarn for controlling the speed of the spindle to vary its effective winding speed during a period of time when the yarn tension exceeds or falls below a predetermined maximum tension at a predetermined linear speed of the yarn, and means operative in the winding of the package for progressively reducing the surface friction on the yarn as the diameter of the package increases.

25. In a winding machine, a winding spindle, an electric motor for rotating the spindle to wind yarn thereon to form a package, means responsive to an increase in diameter of the package being wound for imposing a predetermined surface friction on the winding yarn and progressively reducing the friction as the package increases in diameter, and means responsive to variations in the tension of the yarn, with respect to a predetermined maximum tension, for cutting off or letting on the supply of current to the motor.

26. In a winding machine, a winding spindle, an electric motor for rotating the spindle to wind yarn thereon to form a package, a tension device for imposing an initially predetermined friction on the yarn being wound, a switch for cutting off or letting on the supply of current to the motor, a device for opposing a resistance to

18

the current cut off action of the switch, means responsive to an increase in diameter of the package being wound for controlling said tension and resistance devices to progressively reduce the surface friction of the tension device on the yarn and the resistance of the resistance device to the operation of the switch as the diameter of the package increases, and means responsive to the tension on the yarn for operating the switch when a predetermined tension of the yarn is exceeded.

27. In a winding machine, a winding spindle, a motor for rotating the spindle to wind yarn thereon to form a package, means for imposing a predetermined initial surface friction on the yarn and varying the friction proportional to the winding speed as the package builds up to maintain the speed of winding substantially in accordance with a substantially constant tension on the yarn, and means governed by yarn tensions above and below a predetermined high tension for rapidly cutting off and letting on the supply of current to the motor under small fluctuations of tension above and below the high tension to maintain a high speed of the spindle and proportionate yarn tension at a high linear speed of the yarn.

28. In a yarn winding apparatus, a winding spindle on which the yarn is wound to form a package, a motor for driving the spindle, a tension device for imposing a predetermined initial tension on the yarn being wound, means operative in the action of the apparatus for controlling the tension device to progressively decrease the tension on the yarn as the diameter of the package increases, motor controlling means for throwing the motor out of and into action, and means controlled by the tension on the yarn and influenced when the yarn tension exceeds a high limit to influence the motor controlling means to throw the motor out of action and when the tension falls below the high limit to influence the motor controlling means to throw the motor into action, said motor controlling means and said means controlled by the tension on the yarn being adapted for quick actions on slight fluctuations of yarn tension above and below the high limit to rapidly throw the motor out of and into action when such fluctuations occur to keep the winding speed as high as possible without substantially exceeding the high tension limit.

29. In a yarn winding mechanism, winding means, electrical means for driving the winding means, tension means for imposing a predetermined tension upon the yarn being wound, and current control means for controlling the supply of current to the driving means, said current control means comprising a normally open mercury relay and a normally closed micro-switch, said switch being opened and closed by relatively high and low tensions respectively on the yarn to close and open the relay.

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