Feb. 3, 1959

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2,871,569

METHOD AND APPARATUS FOR WINDING CONES
WITH EQUAL THREAD LENGTHS

Filed Dec. 14, 1955

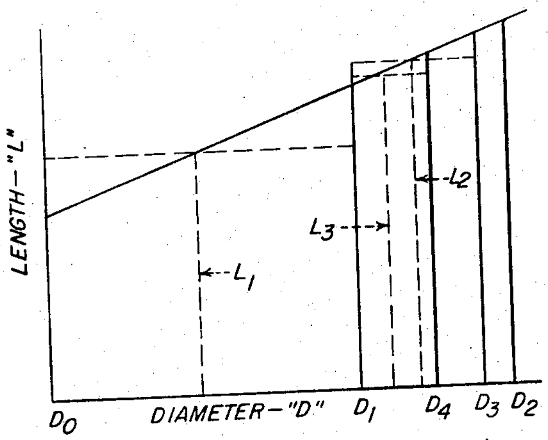

FIG. 1

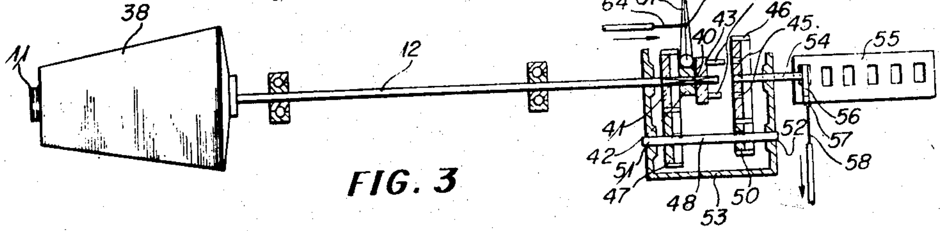

FIG. 3

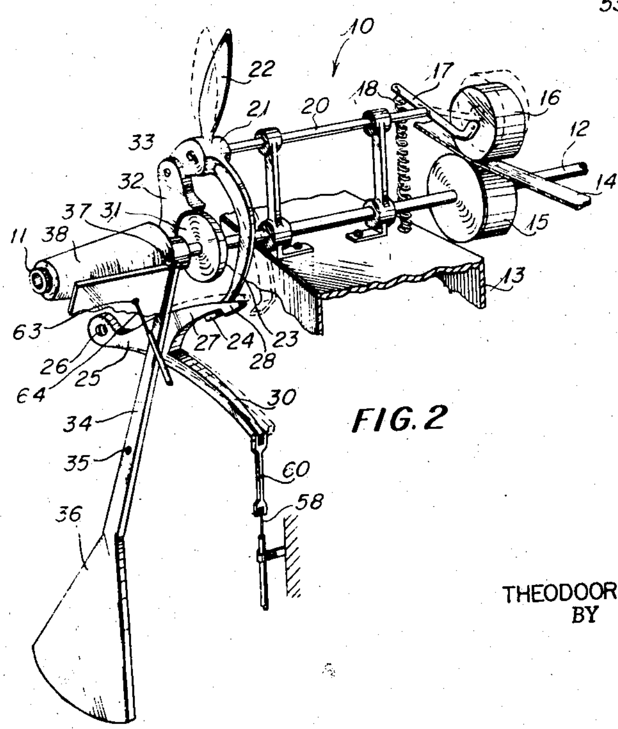

FIG. 2

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2,871,569

Patented Feb. 3, 1959

2,871,569

METHOD AND APPARATUS FOR WINDING CONES WITH EQUAL THREAD LENGTHS

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Application December 14, 1955, Serial No. 553,129

Claims priority, application Netherlands December 17, 1954

8 Claims. (Cl. 33—136)

This invention relates to winding machines, and more particularly to a novel method and apparatus for use in conjunction therewith.

In certain winding operations it is necessary that the length of thread which is wound upon each of a series of individual cones remain relatively constant. Heretofore, difficulty has been encountered in attempting to apply substantially the same length of thread to each of such cones.

While certain present-day devices such as cross-winding machines have used systems which interrupt the winding operation at the instant when the thread package attains a predetermined diameter, variations in the thread length of at least 10% have nevertheless occurred. In operations like warping, such a deviation in thread length is execessive, and causes a large amount of waste.

The undesirable variation in the thread length is attributable to various factors. One of these factors is the variable pressure with which the reciprocating thread feed mechanism rests on the thread package during winding. Another factor which causes uneven thread lengths is the moisture content of the thread. This, of course, is because threads containing a relatively higher moisture content are more easily flattened. Additionally, the variation in the denier, or fineness of the thread which is used in the winding operation can cause differences in the length of thread applied to the various cones.

All of these factors contribute to the formation of thread packages which have identical diameters and different thread lengths.

Accordingly, therefore, the present invention contemplates a method and apparatus for obtaining thread packages with substantially the same length of thread wound upon each cone. In accomplishing this, the use of the ultimate diameter of the package as the sole controlling variable is discarded, and there is substituted the total number of revolutions of the cone winding spindle. As will be explained more fully below, the total number of such revolutions will include one or more correction factors which alter the speed at which a revolution counter registers the spindle revolutions.

In practicing the invention, the threads are continuously wound during a first interval until the thread package attains a first predetermined diameter D_1. The first predetermined diameter D_1 is empirically determined and comprises the outside diameter of a thread package which contains the desired lineal yardage of thread applied at the maximum compactness observed in practice. The average outside diameter of a plurality of thread packages which have all been wound at approximately the same maximum compactness may be used in fixing the value of D_1. For purposes of this specification this diameter characterizes what is known as the most compact cone. The abbreviation MCC as used in this specification will refer to the latter mentioned most compact cone.

If the number of revolutions counted at the instant a

particular thread package arrives at the first predetermined diameter D_1 is less than the value usually attained by the most compact cone (MMC) for the same desired length, of thread, the winding operation is continued. Beyond this point, however, the actual number of spindle revolutions is not counted. Rather, by means of changing the gear ratio between spindle and counter a higher value is registered. This higher value constitutes the actual revolutions multiplied by a constant factor. This constant factor is equal to the ratio (L_3/L_1) and is usually greater than 1. The numerator L_3 is the average length of a thread coil in the range between the diameter of the most compact cone (MMC) at the desired thread length and the diameter of an equally long thread coil on a package of the most usually found compactness.

The denominator L_1 is the length of a thread coil at half the radial thickness of the thread package attained in winding the package to the first predetermined diameter D_1. The use of the ratio is best seen from the following equation:

(I) Number of revolutions required for present cone to reach D_1 $+\frac{L_3}{L_1}$ Additional number of revolutions = Number of revolutions required to wind desired length on MCO

or

$$\text{(II)} \quad n_3 + (L_3/L_1)n_4 = n_1$$

In winding cones according to this equation, the right-hand term represents the number of revolutions of the cone winding spindle which are required to wind the requisite length of thread on a most compact cone (MCC). This value is readily obtainable by simple measurement. A revolutions counter is set at this value and stops the winding machine when this number of revolutions is reached.

The first bracketed term on the left side of the equation represents the number of revolutions required for the diameter of the cone which is being wound to attain the value D_1, as earlier defined. When this value is sensed, the gear ratio between the cone winding spindle and the revolution counter is changed to provide the value of the coefficient (L_3/L_1) which precedes the second bracketed term on the left-hand side.

Hence, with the revolution counter set to halt the winding operation as soon as the value n_1 is reached, and proper mechanism for interposing the gear ratio (L_3/L_1) between the spindle and the revolution counter when the diameter D_1 is reached, the winding of each thread package continues only until the desired length of thread has been applied. In summary, the method and apparatus of the present invention includes the following sequence of operations: The number of revolutions of the cone winding spindle are accurately counted, and the winding operation is interrupted at a predetermined package diameter. After this interruption, the remaining revolutions are counted in an accelerated manner by altering the gear ratio. Then, the operation is cut-off at the final registered number of revolutions, to provide cones of equal thread length and varying diameters.

Accordingly, therefore, a primary object of the present invention is to provide a novel apparatus and method for winding substantially constant yardage on each of a plurality of thread packages.

Another object of the invention is to teach an ingenious mechanism for terminating the winding operation on each of a series of individual thread packages when a predetermined length of thread has been applied thereto.

Another object of the present invention is to disclose a method and means for accurately controlling the length of thread applied to thread packages by a cross-winding machine.

Still another object of the present invention is to teach a stepwise method of continuing the winding of a thread package in order to accurately apply a predetermined length of thread thereto.

A further object of the invention is to disclose a substantially stepless method of changing the speed ratio between the spindle of a cone winding machine and a revolution counter, in order to wind an accurately predetermined length of thread on a thread package.

Other and further objects of the present invention will become evident through reference to the following description and drawings in which like numerals indicate like parts and in which:

Figure 1 illustrates diagrammatically the relationship between the diameter of any given thread package and the length of the corresponding particular thread coil.

Figure 2 is a perspective view, in elevation and partly in section, showing a portion of a cross-winding machine operated according to the method of the present invention.

Figure 3 is a fragmentary plan view, partly in section, illustrating a portion of the cross-winding machine shown in Figure 2, and in particular the system used for changing the speed ratio between the spindle of the winding machine and the revolution counter.

Turning now to Figure 1, there is shown diagrammatically the relationship between the length and diameter of a thread package. This diagram will be utilized to expedite the understanding of the mathematical relationships which render practical the method and apparatus of the present invention.

In the diagram, there are shown several values of diameter along the horizontal axis. The point D_0 corresponds to the average length of a thread coil laid directly upon the periphery of a cone. D_1 corresponds to the diameter at which the most compact cone (MCC) attains the desired value of thread yardage. This diameter is reached after n_1 actual revolutions of the spindle, and is the value at which the revolution counter must be set, in accordance with the Equation I as explained earlier in this specification. The length of the last thread coil on such a package is indicated by that value of "L" on the ordinate which corresponds to the outside diameter D_1 for the most compact coil (MCC).

The value D_2 shown on the horizontal axis is the diameter of a thread package which is wound to the same total length "L" with the minimum compactness observed in actual practice. This value of diameter D_2 may comprise the mean or average diameter of several thread packages wound with approximately the least dense packing, or minimum compactness encountered. A thread package of such diameter requires n_2 actual revolutions of thread upon the cone.

Assume that it is desired to wind a thread package with average compactness and with the same thread length "L" as is contained on packages of diameter D_1 or D_2, which comprise the tightest and loosest packages respectively. The spindle will then make a number of revolutions intermediate between the value n_1 which characterizes D_1 and the value n_2 which characterizes D_2.

Moreover, to achieve the same desired thread length "L" on a thread package with a degree of compactness which is intermediate between that of the most compact and least compact package, the required number of revolutions will generally be less than n_1 because the average thread coil length with intermediate compactness will exceed that of the most compact package. It will be evident that for less compact windings the ultimate diameter of the package required to achieve a given yardage increases as the degree of compactness decreases. This causes the length of the thread coils up to the outermost convolution to exceed that found on more compact packages which are characterized by smaller diameters.

In practicing the invention, as will be explained in greater detail below, a given thread package is wound until it attains a diameter D_1, corresponding to diameter of the most compact winding occurring at the desired length "L." In general, some value of revolutions (say n_3) is required to wind the given thread package to this diameter.

The length of the thread windings on this package vary from layer to layer. However the average length L_1 may be considered to be constant. This is true if the winding of the thread package originates at the average diameter of the axially tapered cone used to support the threads. In other words, the winding must start at the mean diameter of the cone in order for the value L_1 to remain constant. This diameter is designated as D_0, and is the ordinate which occurs exactly at the origin of the graph shown in Figure 1. Stated mathematically, the length L_1 is constant where the thread package is wound from a value D_0 at the mean diameter of the cone to an ultimate value of outside diameter D_1.

It is significant that the constant factor L_1 is not dependent upon the degree of compactness of the package. If the compacting of the thread upon the cone up to the diameter D_1 is regular and homogeneous, the length L_1 shown in Figure 1 is the lineal yardage of a thread coil which is used in winding one-half the radial thickness of the annular thread package out to this diameter. Where the degree of homogeneity varies linearly or systematically, other values of L_1 may be employed.

In general, unless the density of the thread package being wound is identical with that of the most compact cone (MCC), the number of revolutions (n_3) used in winding the package to diameter D_1 will be less than the value n_1. The value n_1, it will be recalled, represents the preset value at which the revolution counter stops the winding operation, and has been defined earlier in this specification as the number of revolutions needed to apply the desired length "L" to one of the most compact cones (MCC).

If the thread package being formed is not wound at the utmost compactness, the diameter D_1 is reached with a number of revolutions (n_3) less than the preset value n_1. Therefore, several more revolutions (say n_4) are required to bring the package to some greater diameter D_4. The value of the additional revolutions n_4 is necessarily higher than n_3, because the winding in the interval up to D_1 is less compact, and the package has received a resultingly shorter thread length.

Turning again to Figure 1, it will be observed that if the winding operation continues after a package of intermediate compactness has attained the diameter D_1 (at n_3 actual revolutions), a length of thread having a constant average length L_1 is no longer applied. Assume that the total number of desired revolutions (n_1) is achieved only after applying n_4 additional revolutions of thread to reach a greater diameter D_4. Then, with the predetermined length "L" attained, there will exist an ordinate L_2 in Figure 1 which corresponds to the average length of the thread coils applied to the cone after it has reached the diameter D_1.

In winding such a thread package the attainment of the diameter D_1 has required a length of thread equal to $(n_3 \times L_1)$; with continued winding the ultimate reaching of the desired length "L" has required an additional length equal to $(n_4 \times L_2)$. It therefore follows that:

$$(n_3 \times L_1) + (n_4 \times L_2) = L \tag{III}$$

for, rearranging terms

$$n_3 + (L_2/L_1)n_4 = (L/L_1) \tag{IV}$$

In the last written equation, the right-hand term (L/L_1) is a constant. The numerator "L" represents the constant value of yardage desired on every cone. The denominator "L_1" comprises the average thread length of thread coils attained in winding the package up to a diameter D_1.

Moreover, the quotient (L/L_1) is identically equal to the value of revolutions n_1 required to attain diameter D_1 on a most compact cone (MCC).

It is desirable to eliminate the variable L_2 in the Equation IV. Generally, L_2 may not be completely constant because of the fact that D_3 varies. The substitution of a variable L_3 in place of L_2 has been found to yield an acceptable degree of accuracy.

This quantity L_3 is defined as the average length of thread coils of the proper length which occur between diameter D_1 on the most compact coil, and the diameter D_4 of coils of the same length which occur on thread packages with the most frequently encountered degree of compactness.

The diameter D_4, like the diameters D_1 and D_2 may be determined empirically by securing a mean value from a plurality of thread packages characterized by substantially the most frequently occurring degree of compactness. By substituting L_3 for L_2, and n_1 for the ratio (L/L_1) Equation IV now reads:

$$n_3+(L_3/L_1)n_4=n_1 \qquad \text{(V)}$$

In Equation V the values L_3 and L_1 are readily obtainable by simple measurement at the value of yardage "L" decided upon for a particular run. The significance of Equation V is brought out by substituting the verbal equivalents therein as follows:

Number of revolutions required for present cone to reach D_1 $+\frac{L_3}{L_2}$ Additional number of revolutions = Number of revolutions required to wind desired length on MCC

This, of course, is Equation I, as originally set forth in the introductory portion of the specification.

It will be appreciated that the present invention teaches a system for conducting the winding operation in accordance with the above-mentioned equation. The computation of Equation V is carried out automatically. While the specific system illustrated in the drawings is a mechanical system, the invention is by no means limited thereto. It will be understood that the inventive method disclosed herein is equally amenable to practice with hydraulic or electronic systems, and is entitled to a broad range of equivalents.

In the mechanical embodiment described in this specification, the spindle of the winding machine is coupled to a revolution counter via a controllable gear ratio system. Control means are provided for shifting the gear ratio between the spindle and counter in response to the arrival of the thread package at the predetermined diameter. Additionally, means are provided for halting the winding operation when a preset number of revolutions is ultimately registered on the counter. For this purpose, the counter is provided with a cam which controls a disconnecting mechanism between the machine spindle and its drive motor, as will be explained more fully below.

Continuing now with this aspect of the detailed description of the invention, and more particularly with the view thereof shown in Figure 2, the numeral 1 indicates generally a cross-winding machine which is used for applying a plurality of layers of thread to an axially tapered cone.

In the winding machine generally indicated by reference numeral **10**, a cone **11** is securely mounted upon the winding spindle **12** for rotation therewith. The winding spindle **12** is rotatably supported by the frame **13** of machine **10** and may be driven by belt **14** which engages drive roller **15**. During a winding operation the belt **14** is maintained in frictional contact with drive roller **15** by pressure roller **16**, which pressure roller is freely rotatably mounted on one end of double-armed lever **17**. A tension spring **18**, one end of which is secured to the frame **13** and the other end of which is attached to double-armed lever **17**, resiliently urges pressure roller **16** into the inoperative position, as shown by broken lines in the drawing.

The double-armed lever **17** is rigidly attached to one end of an elongated shaft **20**. This shaft extends parallel to winding spindle **12** and is also freely rotatably supported from frame **13**. A switching lever **21** is rigidly secured to that end of shaft **20** remote from the double-armed lever **17**. The switching lever **21** is generally in the shape of a bell-crank, having a handle portion **22** used for manually setting or re-setting pressure roller **16** in operative position and a curved arm **23**, on the outer end of which is formed a projection **24**.

A latch mechanism **25**, pivotally mounted at **26** to winding machine **10**, comprises an upper arm **27**, on the end of which is formed hook **28**, and a lower arm **30**. The hook **28** cooperates with projection **24** on the curved arm of switching lever **21** and locks said lever, shaft **20** and double-armed lever **17** against rotation due to the action of tension spring **18**, as can be seen upon inspection of Figure 2. Upon movement of latch mechanism **25** to the broken line position shown, by mechanism to be described more thoroughly hereinbelow, it can be seen that hook **28** will release the projection **24** and that, as a result thereof, pressure roller **16** will be shifted into inoperative position, which discontinues the drive between belt **14** and drive roller **15**.

Although the above-described release of switching lever **21** results in an immediate interruption of the drive for winding spindle **12**, the same would continue to rotate by virtue of momentum, and, therefore, cone **11** would continue to receive thread, unless preventative measures were taken. Accordingly, a brake disc **31** is fixed to winding spindle **12**, which disc cooperates with brake shoe **32**. One end of this brake shoe is pivoted to the frame **13**, by means not shown, and the other end is pivoted at **33** to the hub of switching lever **21**. This results in a toggle arrangement, operative upon release of projection **24** to force brake shoe **32** into engagement with disc **31**, which stops rotation of winding spindle **12** immediately upon interruption of the drive couple.

A traversing frame **34** is pivotally mounted at **35** to the winding machine and provided with a weight **36** at the lower end thereof. On the upper end of the traversing frame a thread guide **37** is mounted for reciprocatory movement, this being accomplished by known traversing mechanism not here shown. The thread guide **37** is urged lightly against the cone **11** and the thread package **38** collected thereon during winding by virtue of the weight **36**. Inasmuch as that portion of the winding machine described hereinabove is conventional, further details as to structure and operation will be omitted.

With attention momentarily directed to Figure 3 of the drawings, it will be noted that the portion of winding spindle **12** which is remote from the cone **11** is provided with a square cross-section **40**. A drive gear **31**, shown in section, is non-rotatably but slidably positioned upon section **40** and therefore is axially movable with respect thereto. Immediately adjacent to drive gear **41** there is provided an annular bushing **42** and a pinwheel **43**. The gear **41**, bushing **42** and pinwheel **43** are secured together and movable as a unit along the axis of the winding spindle.

Extending axially from the pinwheel **43** are a pair of pins **44**. Upon axial movement of gear **41** the pins **44** are caused to engage or disengage a corresponding pair of apertures **45** in driven gear **46**. In the position shown, drive gear **41** engages a first intermediate gear **47** which is fixed to idler shaft **48**. Also fixed to idler shaft **48**, but displaced axially from gear **47**, is a second intermediate gear **50**. Both of these intermediate gears **47**, **50** are keyed or otherwise secured to the shaft **48**, and the shaft is journaled for rotation between suitable bushings **51**, **52**, provided in the housing **53**.

In one position of adjustment, drive gear **41** engages first intermediate gear **47** and, through idler shaft **48** and second intermediate gear **50**, positively rotates driven gear **46** at a first rate of speed, gear **50** being at all times in mesh with driven gear **46**. In the alternative position of adjustment of drive gear 41, the same does not mesh with gear 47 but, rather, gear 46 is rotated, through pinwheel 43, at the identical speed as that of winding spindle 12.

The driven gear 46 is fixed to and supported by one end of stub shaft 54, which shaft also is journaled for rotation in housing 53. The other end of stub shaft 54 projects outwardly of the housing and is connected to revolution counter 55 through cam disc 56. Actuation of the revolution counter is accomplished, therefore, through the disc 56, which disc is adjustably connected to rotate with the slowest rotated numeral disc of the counter 55. It is to be understood that counter 55 need not indicate single revolutions exclusively, but may be of the type which indexes a new digit only after being revolved a fixed number of times.

With attention now directed both to Figure 2 and to Figure 3, it will be seen that cam disc 56 engages and cooperates with a follower 57 fixed, in the embodiment shown, to one end of a first Bowden cable 58. The opposite end of cable 58 is pivotally connected, through coupler 60, to the lower arm 30 of latch mechanism 25, as shown in Figure 2. Movement of the latch mechanism 25 into the broken line position, which releases the switching lever 21 as explained hereinabove, therefore is accomplished by cam disc 56 through cable 58. Hence, upon arrival of cam disc 56 into a predetermined circumferential position, the drive for winding spindle 12 is immediately discontinued and the brake shoe 32 immediately engages brake disc 31 to prevent further rotation thereof.

Transmission of the impulse which releases switching lever 21 in order to interrupt winding occurs simultaneously with the arrival of counter 55 at a preset value. Before starting a run, the revolution counter is set at this value, which comprises the number of revolutions n_1 required to wind the required length of thread on the most compact cone (MCC). When the required number of revolutions has been reached, the cam disc 56 engages follower 57 and releases the lever 21 by transmitting a thrust impulse in the direction of the arrow through Bowden cable 58 and coupler 60, as explained earlier.

Returning now to Figure 3, the transmission assembly comprising drive gear 41, annular bushing 42 and pinwheel 43 is positioned by means of a selector lever 61. This lever is pivotally mounted at one end upon pin 62 with the opposite end thereof nesting between gear 41 and pinwheel 43, and if desirable, resting upon the periphery of the annular bushing 42. The position of lever 61 in the annular space between these elements makes possible the axial shifting of the entire assembly in unison with movement of the lever. More particularly, the oscillation of lever 61 about pin 62 in the counter-clockwise direction, as shown by the arrow in Figure 3, slides pinwheel 43 to the right and causes the pins 44 to enter apertures 45 of driven gear 46. Simultaneous with this interengagement of parts, drive gear 41 is shifted out of engagement with first intermediate gear 47, which disconnects this gear train. In this condition, torque from spindle 12 is applied directly to the counter 55 through the pinwheel, driven gear, stub shaft and cam disc, as mentioned above.

With the selector lever 61 in the position indicated above, the gear ratio between the winding spindle and the revolution counter is increased over its previous value by a quantity (L_3/L_1). This causes the revolution counter 55 to indicate a value of spindle revolutions which corresponds to the actual number of such revolutions multiplied by a factor (L_3/L_1). The utility of accomplishing this change in gear ratios, in terms of assuring substantially identical yardage on each cone, has been explained earlier in this specification.

The sequence of operations required to slide drive gear 41 out of engagement with gear 47 and to rotate driven gear 46 through pinwheel 43 will next be explained. During a winding operation, the diameter of the thread package 38 is continuously monitored by the traversing frame 34, since the weight 36 urges thread guide 37 into contact with the thread. As the diameter of the package increases, the frame 34 is gradually moved about pivot 35 away from the spindle 12 and cone 11. When the package attains the predetermined diameter, the outer face of frame 34 engages and depresses the feeler 63. The feeler 63, in the embodiment shown, is attached to or formed integrally with one end of a second Bowden cable 64, as shown in Figure 2. Upon inspection of Figure 3 it will be noted that the other end of cable 64 is connected by pin 65 to selector lever 61. Depression of feeler 63 therefore imparts axial movement to the cable 64, resulting in the movement of the selector lever an amount necessary to disengage gears 41, 47 and engage pins 44 in the apertures 45 of driven gear 46, thus providing the desired change in gear ratio between counter 55 and winding spindle 12 and the corresponding acceleration in counting.

From the above description it will be seen that, through the operation of traversing frame 34, feeler 63, second Bowden cable 64, pin 65 and selector lever 61, the counter begins counting the revolutions of winding spindle 12 at an increased rate as soon as the package of thread 38 reaches the required diameter D_1.

In starting a winding operation according to this invention, an empty cone 11 is placed upon the spindle 12 and the revolution counter 55 is adjusted to register a value which constitutes the total number of desired revolutions. Torque is applied to spindle 12 by belt 14 upon manual movement of switching lever 21 to the operative position shown in full lines. At this time drive gear 41 is in mesh with first intermediate gear 47 and the gear train 41, 47, 50, 46 drives stub shaft 54 and revolution counter 55 at a lower speed than that of winding spindle 12.

As the thread is applied first to the surface of the cone 11 and next to the surface of package 38 by the reciprocating thread guide 37, the diameter of the package increases and deflects traversing frame 34 in the clockwise direction, as viewed in Figure 2. At the instant of arrival at the preset diameter, the frame 34 engages the feeler 63 and transmits a thrust through cable 64 and pin 65, to the selector lever 61. As previously pointed out, the diameter at which frame 34 engages feeler 63 is that diameter at which the required length of thread is achieved on the most compact cone (MCC), as observed in actual practice. Upon sensing this diameter, the aforesaid sequence of events occurs and the selector lever shifts the drive gear 41 along the axis of spindle 12, whereupon drive 41, 47 is disengaged a nd drive 44, 45 is initiated, thus increasing the gear ratio between counter 55 and spindle 12.

The winding operation now continues with the revolution counter 55 counting the spindle revolutions at a higher rate than before. As soon as the required number of revolutions has occurred, the cam disc 56 actuates follower 57 and transmits a thrust impulse through first Bowden cable 58, which shifts the latch mechanism 25 into the broken line position of Figure 2. Upon release of the projection 24 from hook 28, switching lever 21 is moved, by spring 18, to the broken line position, whereupon the drive 14, 15, 16 is interrupted and the brake means 31, 32 is applied, which, as explained, stops rotation of the spindle 12. The number of revolutions required to discontinue the application of thread to cone 11 is, of course, the preset value which was set upon the counter 55 prior to the beginning of winding.

By using the apparatus and method disclosed herein, the variations in thread length between a plurality of thread packages approximates 1%.

While the subdivision of the winding operation into two steps has been disclosed, it is to be understood that the invention is not thus limited. The winding operation which follows the arrival of the thread package at diameter D_1 need not be completed in a single additional step, but can be further subdivided into a series of steps each of which requires new gear ratio between the spindle and the revolution counter. Mathematically, this would appear as:

$$\text{(VI)} \quad n_3+(L_3/L_1)n_4+k(n_5)+k'(n_6)+\ldots=n_1$$

In this equation, n_1, n_3, n_4, and (L_3/L_1) have the same meaning as before. However, n_5 and n_6 are the additional number of revolutions required to spin the counter to the present value n_1. The constants k and k' are the new quotients, or gear ratios required to be successively interposed between the spindle and the counter. It will be appreciated that the new gear ratios may occur stepwise in discrete steps, or stepless, as with a mechanical variator or other type of infinitely variable speed changer.

In each of these additional steps a new average thread coil is taken as the basis for the changed gear ratio between the spindle and the revolution counter. In this operation, the subsequent speed ratios are maintained as closely as possible to the actual average length of the thread coils. By thus employing a series of changed gear ratios to accelerate the counting of the revolutions up to the ultimate value, the deviations in yardage may be reduced below the value of 1% previously mentioned in the specification.

In practicing the multi-step aspect of the invention, a stepwise change gear between spindle and counter may be used. The actuation of the subsequent gear changes may be accomplished in response to the several successively larger diameters attained by the thread package during winding. Or, a control mechanism which is actuated by the spindle itself may be used to initiate the successive changes in the gear ratios.

Alternatively, the system may employ a combined change drive gear which shifts through the series of steps after the first one by successive smooth steps which merge imperceptibly into each other. A mechanical variator may be used for this purpose.

In using the combined change drive gear, the diameter of the thread package may be used to initiate the change in speed ratio required upon arrival at diameter D_1, and the spindle shaft itself may be used to control the subsequent smooth steps. If desired, the thread package diameter may be periodically sensed by suitable means which initiate the successive imperceptible steps.

It will also be appreciated that throughout the specification the term "winding machines" has been used broadly to include devices such as warping machines and the like. Also, the term "thread" as used herein is not limited to the flexible elongated fibers characteristic of the textile industry but encompasses metallic threads such as wires or strands and the like.

In conclusion, it will be evident from the foregoing detailed description and drawings that I have clearly disclosed my invention in compliance with the statute. However, it is further evident that various modifications, substitutions and alterations can be made without departing in any manner from the spirit and scope of the appended claims.

What I claim is:

1. In a cross-winding machine provided with an interruptable drive means, spindle means to support a cone during the winding of a circular thread package, means mounted to deflect as the size of said package increases, means connected to count revolutions and interrupt said drive means of said winding machine at a preset value of total revolutions, and means connected between said spindle means and said counting means to accelerate the rate of counting revolutions as soon as said deflecting means detects a preset diameter.

2. In a machine adapted for winding circular thread packages and provided with an interruptable torque supply, means rotatably mounted upon said machine and supporting at least one cone during the application of said thread package thereto, means mounted to deflect as the size of said package increases, means to count revolutions at either of two rates, means connected to said counting means to interrupt said torque supply at a preset number of revolutions, and means responsive to said deflecting means to effect a change in the rate of counting after the attainment of a preset package size.

3. In a cross-widing machine provided with drive means for supplying an interruptable supply of torque, a spindle mounted to support a cone during the formation of a thread package thereupon, a revolution counter, means operable to interrupt said supply of torque in response to the arrival of said counter at a predetermined ultimate value, a variable ratio gear train mechanically interposed between said spindle and said counter for controlling the rate at which said counter registers revolutions, means to sense the increasing diameter of said thread package during the winding operation, and means responsive to said diameter sensing means for changing the gear ratio between said spindle and said counter when said thread package attains a predetermined diameter.

4. In a machine which is provided with interruptable drive means and equipped to wind a thread package upon a cone, means connected to support said cone and rotate therewith, means connected to continuously deflect as a dimension of said thread package increases, means connected to meter the number of revolutions of said support means, means mounted upon said metering means to interrupt said drive means in response to the occurrence of a preset number of revolutions, and means interposed between said support means and said metering means to change the rate of counting revolutions, said interposed means operative only in response to detection of a preset dimension of said thread package by said deflecting means.

5. In a winding apparatus provided with drive means and adapted for applying a predetermined length of thread to a cone, a spindle mounted to revolve with said cone during the winding of a thread package thereupon, a first gear slidably mounted on the end of said spindle remote from said cone, a pinwheel slidably mounted upon said spindle for axial displacement with said first gear, a plurality of pins secured to and angularly spaced about the axis of said pinwheel, a revolution counter, a second gear mounted to drive said revolution counter and provided with a plurality of angularly spaced holes, each of which is adapted to receive a respective one of said pins, a shaft rotatably mounted parallel to said spindle, a third gear secured to said shaft and mounted to fully engage said first gear only when said angularly spaced pins remain free of said angularly spaced holes, a fourth gear secured to said shaft and mounted to engage said second gear, means connected to slide said angularly spaced pins into registry with said angularly spaced holes in said second gear as soon as said thread package attains a predetermined diameter, and means connected to interrupt the application of torque to said machine and halt the winding operation as soon as said counter registers a preset number of revolutions thereupon.

6. The method of winding a predetermined length of thread on a cone which comprises winding a thread package on the cone up to the point at which a preset diameter is reached while counting the revolutions of the cone, and continuing the winding operation beyond the preset diameter in at least one more step while counting revolutions at an accelerated rate during each step beyond the point where the preset diameter has been reached.

7. The method of winding a predetermined length of thread on a cone which comprises applying successive layers of thread upon said cone up to a predetermined diameter while simultaneously counting the number of times that the cone supporting spindle revolves, accelerating the rate of counting the spindle revolutions during the interval following the attainment of the predetermined diameter while simultaneously applying addi-

tional layers of thread, and terminating the application of thread to said cone as soon as said spindle has described a predetermined number of revolutions.

8. The method of winding a predetermined length of thread into package form which comprises applying a plurality of layers of thread to a rotating cone, counting the number of revolutions of said cone at a first rate until the diameter of the package reaches a predetermined size, thereafter counting the number of revolutions of said cone at a second rate proportionate to said first rate and terminating the winding operation after a predetermined total count.

References Cited in the file of this patent

UNITED STATES PATENTS

743,961	Walker	Nov. 10, 1903
1,033,855	Wilson	July 30, 1912
2,131,086	Armett et al.	Sept. 27, 1938