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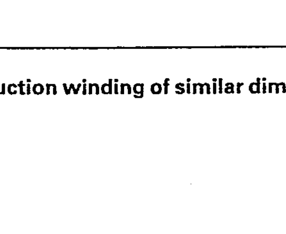
(54) Method and apparatus for copying a reference winding for making a production winding of similar dimensions.

(57) The method and apparatus may be used for copying a reference winding in order to produce a production winding similar to a reference winding. With regard to making spools of sewing thread, the production winding may have the same length of thread and winding cross-section as the reference winding. Alternatively, the main aim may be to make production windings having the same cross-section as the reference winding. According to the invention, reference data is stored in a microprocessor system whilst making the reference winding. Production data is the derived whilst making the production winding. Corresponding instantaneous values of the reference data and the production data are compared in order to derive an error signal. The error signal is supplied to an adjustable tensioner, whereby the tension of the material is adjusted, whilst making the production winding, so that a production winding is made which is similar to the reference winding. One arrangement uses a measuring wheel and a revolution counter to provide the data. Another arrangement uses a revolution counter and an arm which pivots in response to an increase in the cross-section of the winding to provide the data.

FIG. 2



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METHOD AND APPARATUS FOR COPYING A REFERENCE WINDING FOR MAKING A PRODUCTION WINDING OF SIMILAR DIMENSIONS

This invention relates to a method and apparatus which is used in a process for winding material in overlying turns, for example, in a process where elongate material, such as thread, is wound on a spool, or where sheet material is wound into a roll. The invention enables a production winding to be made which has a similar dimension, or dimensions to that of a reference winding. The term "winding", as used herein, is intended to cover an article which contains a plurality of overlying turns of material and which may, or may not include a core or spindle on which the material is wound. The windings can have different shapes, for example, cylindrical, conical, and other regular or even irregular shapes. A particularly useful application of the invention is in the field of winding sewing thread on spools so that each spool contains a predetermined length of thread having a predetermined cross-section. The term "length" is used herein, with respect to wound material, to denote the lineal length on a winding or roll.

In the process of winding sewing thread on spools, it has been common practice to lead the thread through a manually adjustable clamping device or tensioner and then onto a spool which is rotated at high speed. It is necessary to employ an operator, at the winding machine, to adjust the clamping device, in order to increase or to decrease the clamping pressure, so that the finished spool of thread has a uniform and predetermined shape. For example, thread can be wound onto a cylindrical spool by means of a reciprocating thread guide. The spool of thread then has a generally cylindrical shape. The outer diameter of the thread windings may be, for example, 18 ㎜

for a 200 metre length of thread. If the clamping pressure was too tight during the process of winding thread on the spool, a high tension would have been applied to the thread with the result that the outer diameter of the windings are less than a predetermined value (e.g. less than 18 %). Conversely, a low clamping pressure would result in an outer diameter which is greater than the predetermined value (e.g. greater than 18 %). Thus, it is necessary for the machine operator to measure the outer diameter of each spool and to adjust the tension of the clamping device in order to try to maintain the production of thread spools having outer diameters which are as close as possible to the required value. Besides this disadvantage, the cross-section of the thread may not be constant and there may be variations in its coefficient of friction, due to a patchy coating. (Thread may be coated with oil, for example, to reduce the drag caused by the clamping device. In some places, along the length of the thread, the coating may be thin, or it may even be missing.) Clearly, a variation in cross-section, or in the coefficient of friction can affect the tension applied to thread during the winding process (i.e. because the thread must pass through a relatively fixed clamping device), and this can lead to variations in the outer diameter of the thread windings on the finished spool. Thus, despite the care which may be taken by the machine operator, there will be variations in the outer diameter of the windings. If a measuring device (such as measuring wheel) is not used to measure the length of thread wound on each spool, then the thread length will also vary from spool to spool. If a measuring device is used during the winding process, the operator is faced with the additional problem of controlling the thread tension to produce a spool of thread of a given length, as well as of a given outer diameter.

Clearly, in either case, operator fatigue will make the problem worse. The present invention seeks to provide a solution to these problems of quality and quantity control and to provide a more accurate and reliable winding process.

UK 1495003 describes a method and apparatus for measuring a length of thread during winding. The technique depends on a mathematical relationship between the total length of thread on a spool, the spool diameter and the number of revolutions which the spool makes during the winding process. The apparatus includes a thread guide which contacts the windings on a spool and which is thereby moved through an angle as the diameter of the windings increase. This angular movement is used to move the slider of a potentiometer, whereby the frequency of a voltage controlled oscillator is adjusted as the diameter of the windings increase. Another transducer provides two pulses for each revolution of the spool during winding and these pulses are used to gate the output of the voltage controlled oscillator. Bursts of pulses, having a gradually increasing frequency, are available at the output of the gate. A counter is employed to count the bursts of pulses and the count is thereby related to the length of thread wound on the spool.

Although the latter arrangement may be used to provide a continuous readout, during the winding process, of the length of thread on the spool, it does not attempt to solve the problem of variations in the diameters of spools containing thread. The disclosure of UK 1495003 recognises that an increase in the tension on the thread may have undesirable effects on the thread itself, or on the shape of the package being wound, these effects being most marked when winding at very high speed and when winding conical packages. Therefore, the solution provided by UK 1495003 only offers a continuous readout of the length of thread being wound on the spool and it does not solve the problem of irregularities in the shape of the thread wound on the spool.

The present invention provides a solution to the above-mentioned problems. It also enables a reference winding (such as a standard spool of thread) to be "copied" so as to manufacture production windings (such as spools of thread which are mass-produced) which have similar dimensions to the reference winding. This is largely achieved by automatically regulating the tension of the material (e.g. thread tension), during the winding process, so as to end up with a production winding having the required dimensions. No such automatic regulation of (e.g. thread) tension is taught by UK 1495003. As the invention enables a winding to be copied, the shape of the winding is somewhat immaterial. For example, the machine which is used to wind thread on a cylindrical or conical core, can also be used to wind similar thread on a similar core. The shape of the thread wound on the core depends on how the thread is guided (e.g. by a reciprocating guide which provides a helical winding), and also on the shape of the core.

More particularly, the invention provides a method of winding material in overlying turns to make a production winding, the production winding having a similar dimension of material (i.e. length, or cross-section, or both) as that of a reference winding, the method including the steps of:

(a) storing reference data relating to instantaneous values of the number of turns and to a dimension of the material on the reference winding;

(b) providing production data, during the process of making the production winding, relating to instantaneous values of the number of turns and a similar dimension of the material on the production winding;

(c) comparing corresponding instantaneous values of the reference data and the production data during the winding process; and

(d) regulating the tension of the material during the winding process in accordance with the comparison of step (b), in order to adjust the given dimension of the material on the production winding.

In the case of winding spools of sewing thread, it is usually desirable to obtain spools which contain a predetermined length of thread and which contain windings of a given cross-section, e.g. a predetermined cylindrical diameter. However, when using the method according to the invention, the primary aim may be to make production windings having a given cross-section, without being too concerned about the length of material which is wound. Particular embodiments of the invention are described below which can be used to achieve either of these aims.

The invention further provides apparatus for use with equipment for winding material in overlying turns to make a production winding having a similar dimension (i.e. length, cross-section, or both) of material to a reference winding, the apparatus comprising:

(a) means for storing reference data relating to instantaneous values of the number of turns and to a dimension of the material on the reference winding;

(b) means for providing production data, during the process of making the production winding, relating to instantaneous values of the number of turns and a similar dimension of the material on the production winding;

(c) comparison means for comparing corresponding instantaneous values of the reference data and the production data and for providing an output signal when the production data differs from the reference data;

(d) adjustable tensioning means responsive to said output signal for regulating the tension of the material during the winding process, in order to adjust the given dimension of the production winding to that of the reference winding.

The means to provide the production data may include:

(e) means to provide first signals which represent the number of revolutions of a drive for winding the material, said first signals being proportional to the number of turns of the material which are wound during the winding process, and

(f) means to provide second signals which are proportional to the length of the material which is wound during the winding process.

In the above arrangement (which is useful for making spools of thread having the same thread length and winding cross-section), the means to produce the second signals may comprise a measuring wheel. In the case of winding thread, the thread passes around the measuring wheel, which thereby rotates during the winding process. As the circumference of the measuring wheel is known, each revolution of the wheel represents a known length of thread which passes into the production winding. Suitably, an electronic transducer provides a pulse for each revolution of the winding wheel, whereby each pulse represents the predetermined length of thread passing to the production winding.

Alternatively, the means to produce the production data may include:-

(g) means to provide first signals which represent the number of revolutions of a drive for winding the material, said first signals being proportional to the number of turns of the material which are wound during the winding process, and

(h) means to provide second signals which are proportional to the cross-section of the material which is wound during the winding process.

In the above arrangement (which is also useful for making spools of sewing thread), a thread guide may contact the production windings, during the winding process. The thread guide is displaced as the cross-section of the production windings increases. Transducer means are also provided which respond to the displacement of the thread guide to produce a signal which is proportional to the cross-section of the material being wound. In this case, the cross-section of the production winding is of primary importance. However, the length of the material which is wound is generally proportional to its cross-section and hence similar lengths may also result (i.e. within acceptable tolerances).

In the case of using means to provide length related (second) signals, (e.g. as provided by a transducer responsive to a measuring wheel), the shape of the production winding is immaterial because a direct and continuous measure of the amount of thread (passing to the production winding)is provided. However, when using cross-section related (second) signals (e.g. a thread guide which contacts the winding), it may be necessary to decide which point of contact will provide the best output, i.e. which output is proportional to the cross-section of material which is being wound. For example, in the case of a conical winding, contact may be made by means of a roller which is inclined with respect to the winding axis and which engages the conical face of the windings. Alternatively, a short roller or wheel may engage the windings at a given point along the length of the winding axis, e.g. at the centre of a conical winding.

Preferably, the method and apparatus of the invention include a microprocessor system for storing the reference data, for processing the production data, and for comparing the production data with the reference data in order to provide the output signal for regulating the tensioning means. In this case, the reference data is stored in the memory of the microprocessor system when the reference winding is made on the winding machine. For example, for each ten revolutions of the winding drive, the output of a transducer associated with either the measuring wheel, or the thread guide which contacts the winding, is stored. When the production winding is made, the output of the transducer is compared with the stored values, for each ten revolutions of the winding drive, in order to determine if there is any difference or error. If there is, an error signal is produced and this is supplied to the adjustable tensioning means in order to regulate the tension so as to compensate for the difference. For example, if an insufficient length of material is present on the production winding after a given number of revolutions of the winding drive, the control signal causes the tensioning means to reduce the tension on the material. With a reduced tension, the material is not so tightly wound and hence more material is drawn onto the production winding for each revolution of the winding drive. Conversely, the tension is increased in order to produce a tighter winding if too much material has been wound after a given number of revolutions of the winding drive. The situation is checked at intervals (e.g. on every 10th revolution of the winding drive) to see if the error has been corrected. If not, the tension is regulated until the correct amount of material has been fed to the production winding. Thus, the winding process is periodically checked throughout the complete winding cycle so as to ensure that, at the end of the cycle, the production winding has the required length and cross-section, or the required cross-section.

Clearly, the intervals at which the situation is checked can be made so short that the tension of the material is regulated in an almost continuous manner.

In the case of using a microprocessor control system, characteristic reference data may be placed in store for reference windings of different shapes. In the case of spools of sewing thread, this data may be stored with reference to a serial number which represents the length of thread on a spool of a given shape. Thus, the apparatus can be programmed so that the serial number is entered into the microprocessor system whereupon the correct reference data characteristics are available from the store so as to provide the correct form of control for making production spools of a specific type.

Examples of the invention will now be described with reference to the accompanying drawings, in which:

Fig 1 diagrammatically illustrates different characteristic curves which relate to the number of turns and to either the length, or the cross-section of a reference winding.

Fig 2 shows one example of the invention, in schematic form, which uses a measuring wheel.

Fig 3 shows another example of the invention, in schematic form, which uses a thread guide which contacts the thread wound on a spool during the winding process.

Fig 4 is a cross-sectional view of a preferred form of thread brake for use in the arrangements of Figs 2 and 3.

Embodiments of the invention will now be described with reference to winding sewing thread on a spool to make a production winding having a similar length and diameter, or a similar diameter to that of a winding of similar thread on a reference spool. However, it will be understood that the arrangements described can be modified or used as a basis for winding other material either with, or without a core (such as a spool).

Fig 1 is a graph illustrating typical characteristic curves (a) and (b) which relate a measured length (L) of thread to the number of revolutions (n) of a spool on which the thread is wound. The meaning of the graph will become apparent with regard to the following description of the arrangement shown in Fig 2.

Fig 2 schematically illustrates one form of a winding machine which embodies the invention. Thread 10 passes through an adjustable thread brake 1 to a measuring wheel 11. The thread 10 passes once around the periphery of the measuring wheel 11 and then it passes down towards and through a thread guide 12. The thread passes from the guide 12 onto a spool 13 which is rotated at high speed by a drive (not shown). The measuring wheel and the spool 13 both rotate in the direction of the arrows shown on the drawing.

A transducer 14 provides a pulsed output signal representing the number of revolutions of the measuring wheel 11. The transducer 14 may be of the type which responds, for example, to the passage of a small magnet 15 attached the periphery of the measuring wheel 11. Alternatively, it may be of a photoelectric type wherein a beam of light is periodically interrupted by the passage of a shutter as the wheel 11 rotates. A similar transducer 16 senses the passage of a permanent magnet 17 which is attached to the drive (not shown) of the spool 13. Transducer 16 also provides a pulse output signal representing the number of revolutions of the spool 13. The outputs from transducers 14, 16 are converted from analog to digital form (by an A/D converter not shown) and the corresponding digital signals are supplied to respective registers 18, 19. Registers 18, 19 are both connected to, or are part of a microprocessing system 20 which includes a microprocessing unit together with a suitable memory. An output from the microprocessor system 20 is connected to the adjustable thread brake 1 for supplying a control signal to adjust the clamping pressure of the brake, and hence to regulate the tension of the thread 10 passes to the measuring wheel 11 and hence to the spool 13.

The thread brake 1 is preferably of the type described in our Copending European Patent Application No. 0045643 This type of thread brake is generally illustrated in Fig 4. It employs a pair of circular braking discs 2, 3 which are freely and rotatably mounted on a sleeve 8 adjacent an end face of an electromagnet 4. The electromagnet 4 has a cylindrical body, the longitudinal axis of which is coaxial with the braking discs 2, 3. Both discs 2, 3 have a central aperture to receive the sleeve 8, the sleeve being made of wear-resistant material and being mounted on a pin 8a passing through the cylindrical magnet. A retaining ring 9 is fitted to the end of the sleeve 8 to retain the discs 2, 3 whilst allowing them to move axially on the sleeve 8. The central aperture 16 in disc 3 is countersunk. As the bearing face of each disc 2, 3 on sleeve 8 is small, both discs can tilt with respect to the longitudinal axis of the sleeve 8. Disc 2, which is nearest to the end face of the electromagnet 4, is generally plain, but disc 3 has a series of countersunk apertures 7 extending radially around its central aperture 16, the countersunk side of the apertures facing outwardly away from the electromagnet 4. The other side of disc 3, which faces the opposite side of disc 2, is also slightly concave. The thread passes between the opposed major faces of the braking discs 2, 3 and around a part of the circumference of sleeve 8. The thread thereby makes an angle with the sleeve 8 (preferably between 110 to 160 degrees) and this prevents the disc 3 from tilting round the thread (e.g. where the thread acts as a tilt bearing). The angle of the thread also serves to avoid direct contact between the two discs 2, 3. The thread is thereby clamped between the discs when the electromagnet 4 is energised. The outermost disc 3, with the radial apertures, is made of ferromagnetic material, but the other disc is made of non-ferromagnetic material. The radial apertures 7, in the ferromagnetic disc 3 provide an exist for material abraded from the thread, due to friction between the thread and the thread brake. The electromagnet 4 is controlled by varying a supply of direct current thereto whereby the braking pressure is adjusted and hence the tension of the thread is regulated.

The mode of operation of the arrangement shown in Fig 2 will now be described. It will be assumed that the same thread and winding machine is used for winding thread on a reference spool as well as on a production spool.

Thread is first wound onto the reference spool 13 so that the reference spool contains a predetermined length of thread and so that the thread windings have a predetermined outer diameter. This may be achieved by winding thread on reference spools with different tensions, in order to select the reference spool with the optimum thread winding diameter. Conventional means are employed, such as a reciprocating thread guide (not shown), so as to feed the thread helically onto the spool 13 in order to build up a cylindrical winding. During this process, the registers 18, 19 are indexed in accordance with the number of revolutions of the measuring wheel 11 and the spool 13 respectively. Instantaneous values of register 18 are entered, at regular intervals into the memory of the microprocessor system 20. For example, each time that the register 18 counts ten revolutions of the spool 13, the contents of register 18 are gated into the memory of the microprocessor system 20. The gating circuitry, which may be conventional, is not shown but its construction and operation will be clear to those skilled in the art. The contents of register 18, i.e. the instantaneous values of the number of revolutions of the measuring wheel 11 for every tenth revolution of the spool 13, are stored in the memory of the microprocessor 20 so that they can be retrieved in the sequence in which they were recorded.

The diameter of the measuring wheel 11 is constant, whereby a predetermined length of thread is passed to the spool 13 for each revolution of wheel 11. However, the diameter of the windings on the spool 13 will gradually increase from a small to a large diameter as the winding proceeds. If the diameter of the measuring wheel 11 was somewhere between the small and large diameters of the thread windings on spool 13, the counting rate of register 18 will initially be lower than that of register 19. The counting rates will then become similar, when the winding diameter on spool 13 is similar to the diameter of wheel 11. Then, the counting rate of register 18 will exceed that of register 19, i.e. when the winding diameter in spool 13 exceeds the diameter of wheel 11. If the instantaneous values of register 18 are plotted on a graph against every ten revolutions of the spool 13, a characteristic curve of the ratio of a measured length of thread to the number of revolutions of the spool 13 is obtained as shown in Fig 1. In practice, the diameter of the measuring wheel 11, with respect to the minimum and the maximum diameters of the thread windings on the spool 5, is such that the characteristic curve is approximately linear, at least over its initial length. If thread having a different thickness is used, or if the thread is wound onto a spool having a different diameter, the characteristic curve will be different and this is indicated by the broken line (b) in Fig 1.

After the memory of the microprocessor system 20 has been loaded with the instantaneous values derived from register 18, the reference spool is replaced by a production spool. Thread 10 is then wound onto the production spool 13 and, during the winding process, similar instantaneous values of register 18 are periodically supplied to the microprocessor system 20. For example, for every ten revolutions of the production spool 13, the contents of register 18 are entered into the system 20. The system 20 then compares the production data with the reference data (by conventional means, not shown in detail), in order to provide a control signal for adjusting the clamping pressure on the thread brake 1. For example, assuming that the production spool 13 has made fifty revolutions, the corresponding instantaneous value of regiser 18 stored in the memory whilst winding the reference spool is compared with the same instantaneous value of register 18 which is obtained during the winding of the production spool. If the readings differ, an error signal is generated and this is converted, by the system 20, into the control signal which is supplied to the thread brake 1. This control signal regulates the amount of direct current supported to the electromagnet and hence it adjusts the clamping pressure applied by the braking discs 2, 3 whereby the thread tension is regulated during the winding process. For example, if the reading on register 18 when winding thread on the production spool is less than it was when winding the thread on the reference spool, this will mean that the thread is being wound too tightly on the production spool.

Hence, the braking pressure is relieved so that the thread is more loosely wound on spool 13. Relieving the braking pressure will reduce the thread tension hence resulting in a looser winding. Therefore, more thread will be wound on spool 13, for each revolution, and hence the counting rate of regiser 18 will increase until it "catches up" with the "correct" value stored in the memory of the microprocessor system 20. The clamping pressure of the thread brake 1 is adjusted until the instantaneous values of the production data and reference data coincide whereupon the error signal is zero and the correct thread tension is applied for winding the thread on the production spool. Conversely, the braking pressure is increased to increase the tension if the thread is wound too loosely on the spool 13. The operation is such that, at the end of the winding cycle, a predetermined amount of thread is wound onto the spool 13 and that the diameter of the thread windings is the same as that on the reference spool.

The construction and mode of operation of the transducers 14, 16 the registers 18, 19 and the microprocessor system 20 are generally conventional and hence known to those skilled in the art. Therefore, no detailed description will be given in order to facilitate the description of the novel features of the arrangements which embody the invention.

The above arrangement has distinct advantages compared with, for example, the arrangement described in UK 1495003.

A change in the nominal thickness of the thread, i.e. a distinct change in thickness of the material which is wound, will provide a different characteristic curve in Fig 1. However, by using the same characteristic curve, it is possible to compensate for small changes in nominal thread thickness. Despite the usual quality control which is exercised when manufacturing thread, there are bound to be slight differences in nominal thread thickness due to the nature of the thread and the manufacturing process. Whereas such variations gave rise to problems in the prior art, the present invention can be applied to compensate for slight differences in nominal thread thickness. For example, if the thread is slightly thicker than it should be, the thread can be wound more tightly onto the spool 13 so as to end up with windings of the predetermined diameter. Conversely, if the thread is slightly thinner than usual, it is wound more loosely to provide windings having the required diameter.

The arrangement according to the invention will also compensate for variations in the coefficient of friction between the thread 16 and the thread brake 1. Thread is normally coated with oil so that it runs smoothly through thread guides without too much friction. However, despite quality control, the coating may be patchy or thin, or even missing entirely in some places. Clearly, there will be greater friction between the thread brake 1.and the thread 10 when the coating is missing. This has the result of increasing the thread tension and hence causing the thread to be wound more tightly onto the spool 13. However, the arrangement shown in Fig 2 will detect and compensate for this problem, because the control signal from the microprocessor system 20 would cause the braking pressure to be relieved, to reduce the thread tension, whereby the thread is wound more loosely on the spool 13.

A further advantage is that the winding speed does not effect the mode of operation of an arrangement which embodies the invention. An increase in winding speed merely results in increasing the rate at which the production data is supplied to the microprocessor system 20 for comparison with the reference data which is already in the memory. Thus, operation is generally independent of winding speed.

An alternative embodiment is schematically illustrated in Fig 3. Similar elements have been given similar reference numerals and will therefore not be described.

The main difference between the arrangement shown in Figs 2 and 3 is that the measuring wheel 11 is replaced by a device which responds to a variation in the diameter of the windings on the spool 13. This device comprises an arm 21 which is supported on a pivot 22 for movement relative to thread wound on the spool 13. A roller 23 is rotatably supported on the upper end of arm 21. The roller 23 contacts the thread windings 24. The full-line circle 24 represents the maximum diameter of the thread windings and the minimum diameter is represented by the broken line 24'. Similarly, the respective positions of the arm and the roller are represented by the full-lines 21, 23 and broken lines 21' and 23'. It can be seen that the arm 21 moves through an angle "a" as the diameter of the windings increase from 24' to 24. This angular movement is transferred by a link 25 having one end pivotally connected to the arm 21 and its other end connected to a slider 26 of a potentiometer 27. The resistive track of the potentiometer is connected to a voltage source which is represented by a cell 28 in the drawing. As the arm 21 moves through the angle "a", the slider 26 moves along the resistive track of the potentiometer 27. Hence, a variable voltage signal V is available across terminals 29, 30. This voltage signal V is converted from analog to digital form (by conventional means not shown) and is supplied to register 18. Thus, in this arrangement, the register 18 records instantaneous values of the voltage V (in digital form), instead of instantaneous values of the number of revolutions of a measuring wheel 11 as in the previous arrangement.

Apart from the difference described above, the mode of operation is similar to that described with reference to Fig 2. In this case, however, the instantaneous values of the reference and production data are voltage signals.

As the arrangement described with reference to Fig 3 employs a device which is responsive to the outer diameter of the thread windings, it may be used where the primary arm is to produce windings of a given outer diameter. However, as the diameter of the windings is related to the length of thread on the spool, there will only be small differences in the lengths of thread wound on production spools. The arrangement of Fig 3 also has the advantages of the arrangement of Fig 2, i.e. in compensating for variations in the nominal thickness and/or coefficient of friction of the thread, and being generally independent of the winding speed.

The invention may be applied to single spool or multispool winding machines. With regard to the arrangements described above, the microprocessor system 20 may be supplied with multiplexed inputs and conditioned to provide respective error signals to the corresponding thread brakes on a multispool winding machine. The arrangement may also be such that the microprocessor system stores reference data which can be retrieved in response to a serial number which is entered by means of a keyboard. The serial number represents a certain type of spool carrying a predetermined length of a particular type of thread.

Both arrangements (described with reference to Figs 2 and 3) may be used to wind material in overlying turns so as to produce a winding having a shape other than cylindrical. As the arrangement shown in Fig 2 supplies measured lengths of thread 10 to the spool 5, the arrangement is independent of the winding shape (given the same machine, the same type of thread and similar spools). However, the arrangement shown in Fig 3 depends on the shape of the winding in order to provide the voltage signals. Thus, with the latter arrangement it may be necessary to decide where the roller should contact the winding for the best result. With a conical winding, roller 23 may be inclined at the same angle as the conical face to the winding axis and it may extend along the length of the winding. Alternatively, the roller 23 may be a wheel which contacts the winding of a central point along its axis. The shape of windings will clearly depend on the shape of the spool and on the means by which the material is supplied to the spool (e.g. by a reciprocating arm to provide a helical thread winding). Such means are generally known in the art.

Thus, it can be seen that the arrangements which embody the invention operate in accordance with direct digital control in order to manufacture production windings which are "copies" of a reference winding.

CLAIMS:

1. A method of winding material in overlying turns to make a production winding, the production winding having a similar dimension of material (i.e. length, or cross-section, or both) as that of a reference winding, the method including the steps of:

(a) storing reference data relating to instantaneous values of the number of turns and to a dimension of the material on the reference winding;

(b) providing production data, during the process of making the production winding, relating to instantaneous values of the number of turns and a similar dimension of the material on the production winding;

(c) comparing corresponding instantaneous values of the reference data and the production data during the winding process; and

(d) regulating the tension of the material during the winding process in accordance with the comparison of step (b), in order to adjust the given dimension of the material on the production winding.

2. A method according to claim 1, in which the instantaneous values of the reference data and of the production data relate measured lengths of the material to said number of turns of the material.

3. A method according to claim 1 in which the instantaneous values of the reference data and of the production data relate the diameter of the windings to said number of turns of the material.

4. Apparatus for use with equipment for winding material in overlying turns to make a production winding having a similar dimension (i.e. length, cross-section, or both) of material to a reference winding, the apparatus comprising:

(a) means for storing reference data relating to instantaneous values of the number of turns and to a dimension of the material on the reference winding;

(b) means for providing production data, during the process of making the production winding, relating to instantaneous values of the number of turns and a similar dimension of the material on the production winding;

(c) comparison means for comparing corresponding instantaneous values of the reference data and the production data and for providing an output signal when the production data differs from the reference data;

(d) adjustable tensioning means responsive to said output signal for regulating the tension of the material during the winding process, in order to adjust the given dimension of the production winding to that of the reference winding.

5. Apparatus according to claim 4, in which the means to provide the production data includes:

(e) means to provide first signals which represent the number of revolutions of a drive for winding the material, said first signals being proportional to the number of turns of the material which are wound during the winding process, and

(f) means to provide second signals which are proportional to the length of the material which is wound during the winding process.

6. Apparatus according to claim 5, in which the means to produce the second signals comprises a measuring wheel and a transducer which provides a pulsed output proportional to the number of revolutions of the measuring wheel, whereby each pulse represents a predetermined length of thread passing to the production winding.

7. Apparatus according to claim 4, in which the means to produce the production data includes:-

(g) means to provide first signals which represent the number of revolutions of a drive for winding the material, said first signals being proportional to the number of turns of the material which are wound during the winding process, and

(h) means to provide second signals which are proportional to the cross-section of the material which is wound during the winding process.

8. Appartus according to claim 7, in which the means to provide the second signals comprises a thread guide which contacts the production windings, during the winding process, and a transducer which responds to the displacement of the thread guide to produce a signal which is proportional to the cross-section of the material being wound.

9. Appartus according to any one of claims 4-8 including a microprocessor system for storing the reference data, for processing the production data, and for comparing the production data with the reference data in order to provide the output signal for regulating the tensioning means.

10. Apparatus according to claim 9, in which the reference data and the production data is derived by providing a counting signal each time a predetermined number of turns of the material have been wound, the counting signal representing either a measured length, or a measured cross-section of the material at the respective instant.

11. Apparatus according to claim 9 or 10, in which the microprocessor system stores reference data for reference windings of different types, the data being retrievable with regard to respective codes, and the system being programmed so that when the code is entered, the correct reference data is available from storage so as to provide the correct form of control for making production spools of a specific type.

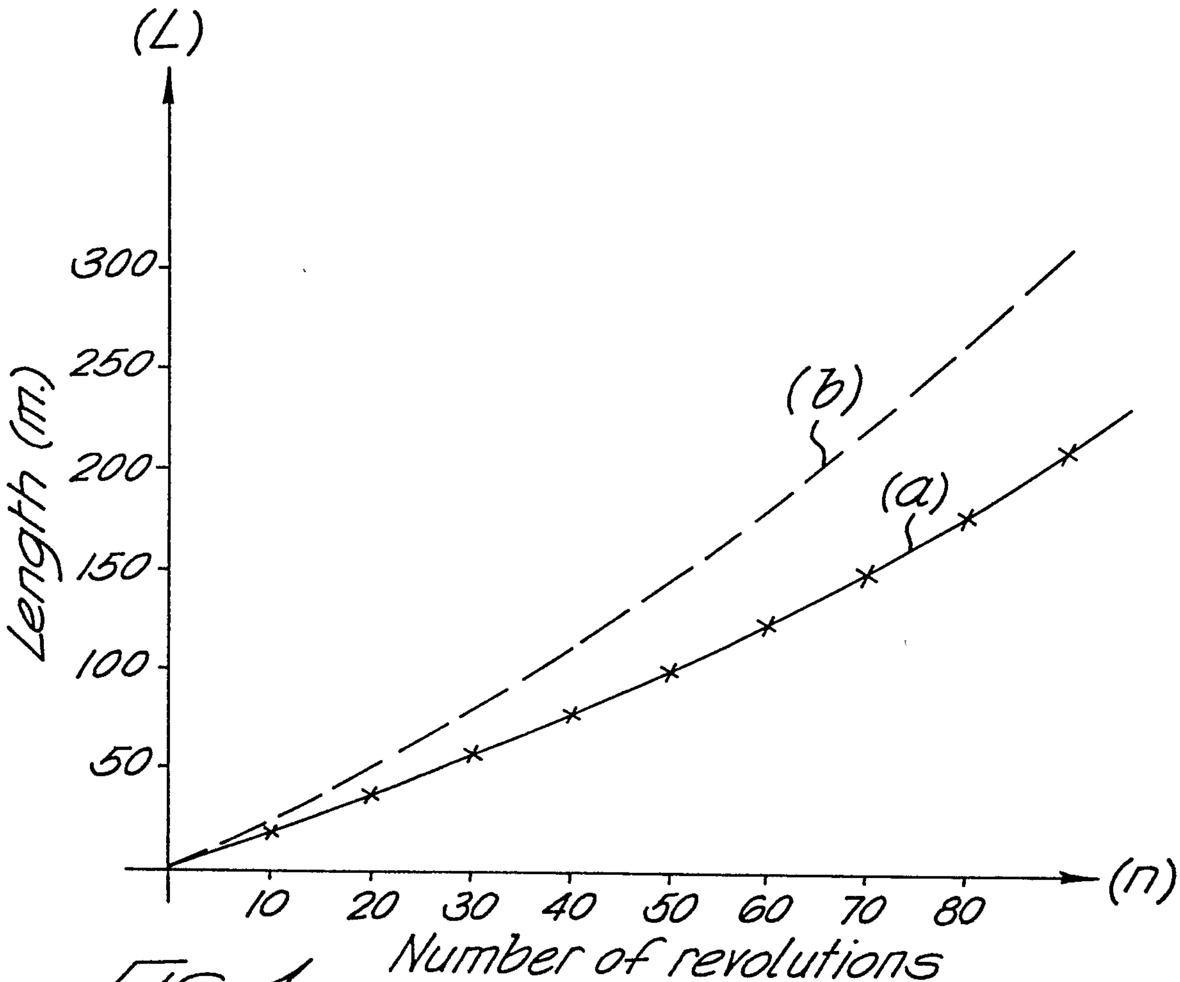
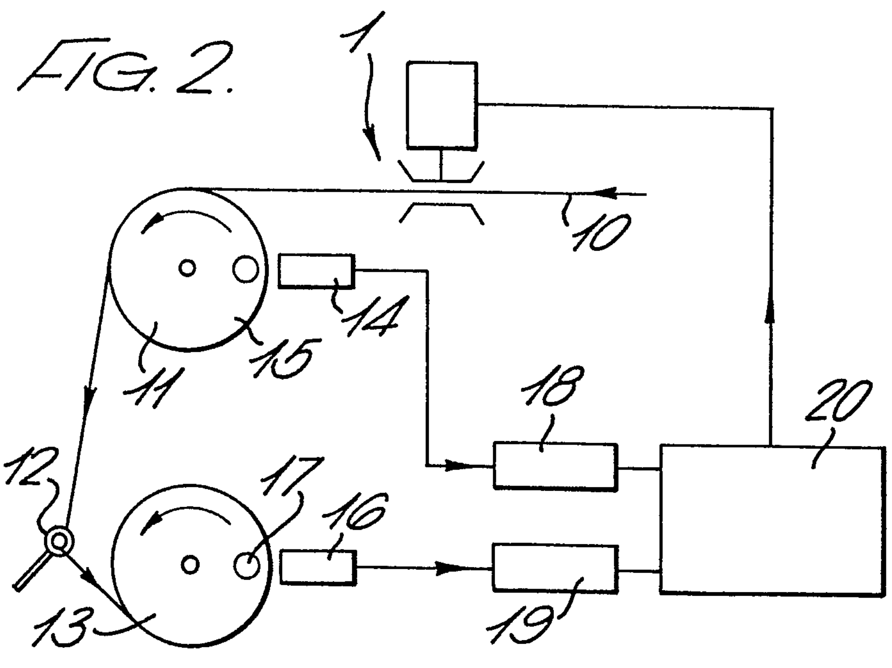

(L)
Length (m.)
300
250
200
150
100
50
(b)
(a)
10
20
30
40
50
60
70
80
(n)
Number of revolutions

FIG. 1.

FIG. 2.


1
10
11
12
13
14
15
16
17
18
19
20

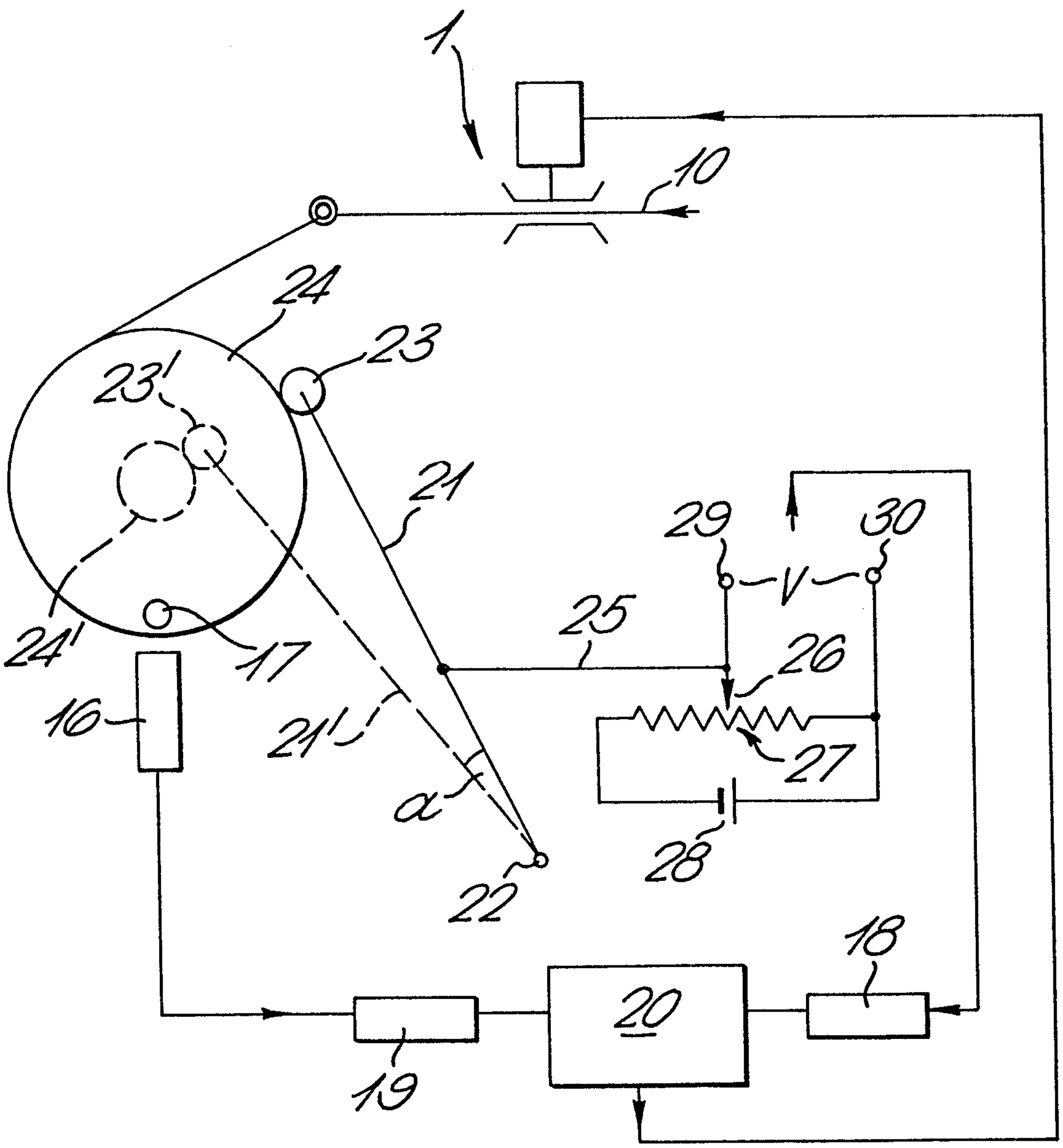
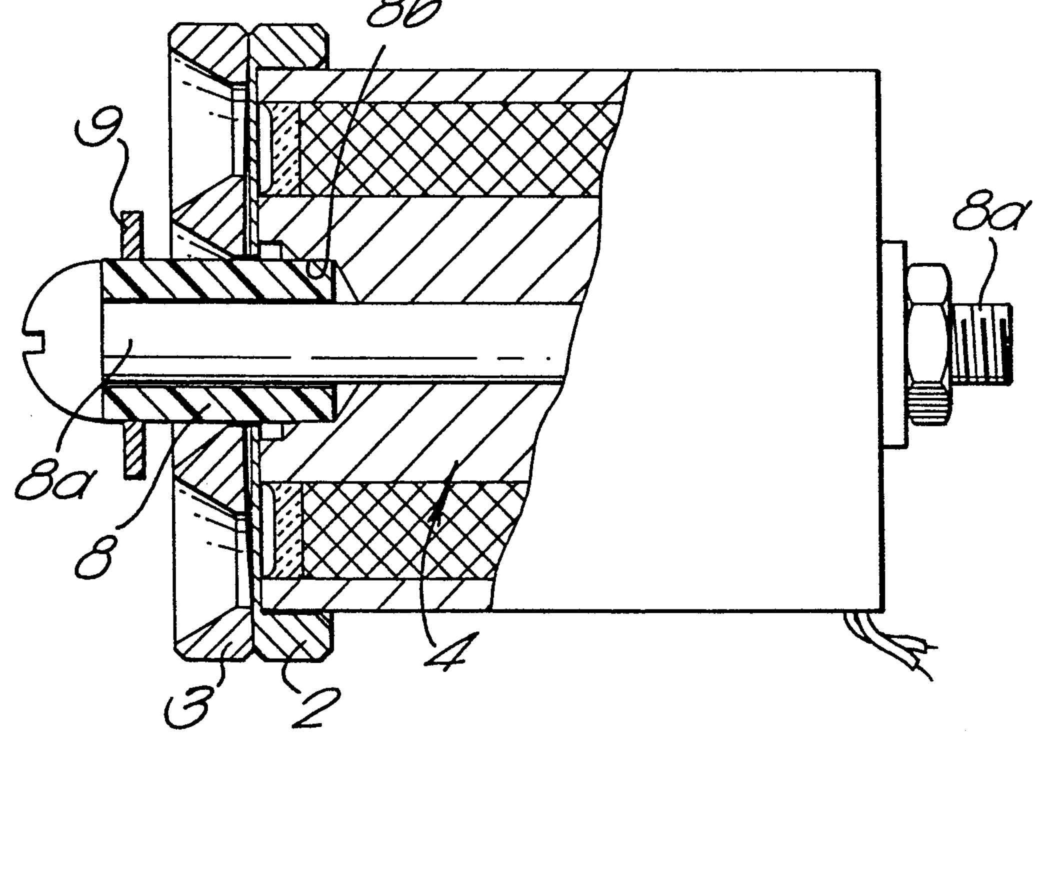


FIG. 3.

FIG. 4.



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European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 82303742.9

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
X	DE - B2 - 1 774 229 (REINERS) * Fig. 1, 3, 4 * --	1-8,10	B 65 H 61/00
A	DE - A1 - 2 433 786 (J. HENGSTLER K.G.) * Page 3 * ----	4	

TECHNICAL FIELDS SEARCHED (Int.Cl. 3)

B 65 H

CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone
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A: technological background
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L: document cited for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	08-09-1982	NETZER