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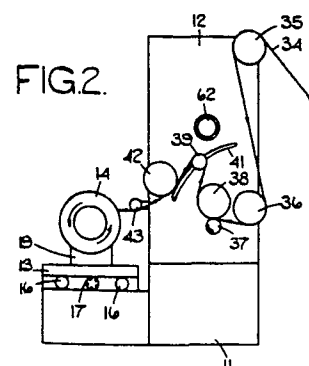
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54 **Spooling machine and method of spooling.**

57 A spooling machine for spooling elongate material such as metal wire and tape, wherein the material is fed to the spool 14 by a pinch wheel capstan drive 37, 38 and the spool 14 is rotated by a torque motor so that the power setting of the motor determines the tension in the spooled material and the pass speed of the capstan drive 37, 38 determines the speed of rotation of the spool 14. The invention further resides in a method of spooling wherein the lay of turns adjacent the axial ends of the spool 14 is wider than throughout the remainder of the axial length of the spool.



This invention relates to a spooling machine for winding elongate material, particularly but not exclusively metal tape or wire onto a take-up spool.

In the interests of clarity throughout the majority of this specification we shall refer to the spooling of metal tape, but it is to be understood that the invention is not restricted to the spooling of metal tape, and that references to tape are intended to encompass other spoolable materials, for example wire and other elongate material not necessarily of a metallic nature.

It will be understood that as tape is wound onto a spool the diameter onto which tape is wound increases as the layers of turns of tape build up on the spool. If the rotational speed of the take-up spool is maintained constant then the pass speed of the tape entering the spooling machine must increase. Conversely if the tape pass speed is maintained constant then the rotational speed of the take-up spool must decrease. This latter situation is true of many conventional machines since the pass speed of the tape is maintained constant by prior processing apparatuses through which the tape passes at constant speed, for example, the spooling machine may be preceded by a tape mill. In many conventional spooling machines the rotational speed of the take-up spool is controlled by a closed loop feed-back system which senses the tension in the tape and controls the take-up spool speed accordingly. However, by its very nature a closed loop feed-back system is inaccurate since there must be an "error" in the relationship between the tape tension and take-up spool speed which is sensed before a correction can be applied. Usually therefore such a system tends to "hunt" about a mean correct value and the tape is thus spooled with fluctuating tension. It is an object of the present invention to provide a spooling machine wherein the aforementioned problem

encountered when spooling tapes applied at constant pass speed is mitigated.

A spooling machine in accordance with a first aspect of the present invention comprises, a take-up spool carrier, a pinch wheel capstan drive for supplying material to be spooled to a spool carried in use by said carrier, and an electric torque motor for driving said carrier, whereby, in use, the take-up spool rotational speed is determined by the pass speed of the material supplied to the spool by said pinch wheel capstan drive, and the tension of the material being spooled is determined by the power input to the torque motor.

Desirably means is provided whereby the power input to the torque motor can be adjusted by an operator.

Conveniently the machine includes means whereby the speed of the capstan drive can be varied, to vary the pass speed of the material being spooled.

Preferably there is provided means whereby upon initiation of the spooling operation there is a short delay after energisation of the torque motor at its chosen value for the spooling operation, before operation of the capstan drive at its chosen speed for the spooling operation the capstan drive speed being increased automatically and progressively from zero to the chosen speed during said delay, whereby initially spooling occurs at a high, but decreasing tension until such time that the speed of the capstan drive increases to said chosen value.

It will be recognised that when winding onto a take-up spool it is necessary to traverse the spool in a reciprocatory manner laterally relative to the approach path of the material to the spool, so that the material is wound on the spool in a series of axially adjacent

turns, to fill the axial length of the spool, and then in a series of overlying axially adjacent turns to fill the axial length of the spool in the opposite direction. In this way the material is wound in a radial series of layers, each layer being formed from a plurality of axially adjacent turns of the same diameter.

In order that turns which should be axially adjacent are not wound on top of one another at the axial ends of the spool it is necessary that the change in direction of traverse occurs substantially instantaneously, and at very least within the period taken for a complete revolution of the take-up spool. Traverse movement of the spool is normally generated by the action of a nut fixed in relation to the take-up spool in engagement with an axially fixed but rotatable lead-screw. The lead-screw is driven by an electric motor. It has previously been proposed to effect traverse reversal by reversing the polarity of the lead-screw drive motor. However, such an arrangement is extremely disadvantageous in that it is slow in its operation, since the motor has considerable inertia which must be overcome in order to reverse its rotation, and additionally in that such polarity reversal is damaging to the motor, inducing high motor loading, excessive brush wear, and extremely high current flow in the armature of the motor.

A further prior proposal for reversing the direction of traverse is the use of a double helix screw thread on the lead-screw. The double helix arrangement is also disadvantageous in that it is slow to operate, requiring a dwell point where the drive is transferred from one helix to the reverse helix and is also mechanically complex.

It is an object of a second aspect of the present invention to provide a spooling machine wherein traverse reversal is effected without the problems of the aforementioned prior proposals.

In a spooling machine in accordance with the second aspect of the invention the reversal of the traverse movement between the spool and the material to be spooled is effected by a traverse mechanism including first and second clutches, the first clutch being engaged and the second clutch disengaged for traverse in one direction, and the second clutch being engaged and the first clutch being disengaged for traverse in the opposite direction.

Preferably said take-up spool carrier is carried on a take-up spool carriage and the machine further includes a captive nut carried by said carriage, a rotatable lead-screw co-operating with the nut and held against axial movement whereby as the lead-screw rotates the nut is caused to move axially along the length of the lead-screw, and a lead-screw drive mechanism, the lead-screw drive mechanism comprising means driving the input of said first clutch in one direction, means driving the input of said second clutch in the opposite direction, and a combined output member for the first and second clutches, the lead-screw being driven from the combined output member of the first and second clutches, and being driven in one rotational direction, to move the carriage in one linear direction, by engagement of the first clutch with the second clutch disengaged, so that the combined clutch output member is driven by the first clutch input member, and the lead-screw being driven in the opposite rotational direction to move the carriage in the opposite linear direction by engagement of the second clutch while the first clutch is disengaged, so that the second clutch input member drives the combined clutch output member.

Preferably said first and second clutches are electromagnetic clutches.

Conveniently said means driving the input of said first clutch includes a first electric motor and said means driving the input of said second clutch includes a

second electric motor.

Desirably said first and second electric motors are constant speed motors, and share a common speed control mechanism whereby carriage traverse speed can be altered, the common control mechanism altering the speed of both the first and the second electric motors simultaneously and by the same amount.

Alternatively said means driving the input of said first clutch includes an electric motor and said means driving the input of said second clutch includes said electric motor and a drive reversing mechanism whereby said electric motor drives both the first clutch input and the second clutch input at the same rotational speed but in opposite rotational directions.

The term "lay" is used herein to refer to the positioning of axially adjacent turns of a layer of materials wound onto the take-up spool. Thus wide lay is where there is a gap between axially adjacent turns of a width substantially equal to the material width. Narrow lay is where there is zero, or substantially zero gap between axially adjacent turns. An overlap lay is where axially adjacent turns of tape actually overlap one another, and in most applications an overlap lay is extremely undesirable, and is to be avoided since it results in damage to the marginal edges of the tape. The lay of the winding is of course determined by the relationship between the rotational speed of the take-up spool and the traverse speed of the take-up spool.

Spools of wound material are often subject to rough handling during transit, and a problem which is often encountered is a spool being dropped onto one axial end. If the spool has been wound with a wide lay then particularly in the case of wound tape the gap between the marginal edges of the adjacent turns of the tape acts in effect as

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a shock absorbing space and minimizes the risk of damage to the marginal edges of the turns. However, in taking up the gap between the axially adjacent turns the tension in the turns is lost, and the winding on the spool becomes very loose, and adjacent turns, and even adjacent layers of turns can become entangled rendering the spool substantially impossible to unwind at a later date. On the other hand, if the spool is wound with a narrow lay then axial movement of the turns when the spool is subject to an axial shock is minimized, and the attendant problems of entanglement of the turns is also minimized. However, such axial movement as does occur results in the turns impacting against one another, with a substantially increased risk of damage, in the case of tape, to the marginal edges of the turns.

It is an object of a further aspect of the present invention to provide a method of, and apparatus for, spooling material wherein the aforementioned problems are minimized.

In accordance with a further aspect of the present invention there is provided a method of spooling material wherein adjacent the axial ends of the spool the lay of axially adjacent turns of each layer of the winding is wider than throughout the remainder of the axial length of the spool.

It will be recognised that in accordance with this aspect of the present invention the narrower lay throughout the majority of the axial length of the spool maximizes the length of material which can be contained by the spool, and avoids axial collapse of the turns as can be encountered with a wider lay. However, the wider lay at the two axial ends of each layer of turns provides a shock absorbing effect to minimize damage, in the case of tape, marginal edge damage, to the intermediate narrow lay turns, the axial extent of the turns wound at the wider lay being insufficient to result in significant tangling as a result of

axial collapse.

A spooling machine in accordance with this further aspect of the present invention comprises means operable during relative traverse movement of the spool and material being wound as the material is wound adjacent the axial ends of the spool, to produce a variation in the relationship of the speed of traverse to the speed of rotation of the spool, such that the spacing between adjacent turns of the material being wound is greater adjacent the axial ends of the spool than over the remainder of the spool.

Preferably the spooling machine comprises a reciprocable carriage for carrying a take-up spool in use, means for reciprocating the carriage, and means sensing the position of the carriage in relation to the input path of material to the take-up spool in use, said sensing means in use controlling the speed of traverse of the reciprocable carriage in a manner to increase the speed of traverse at those points in the movement of the carriage where material is being wound adjacent the two axial ends of the take-up spool.

This further aspect of the present invention also resides in a spool of ^{material} wherein the lay of the turns of each layer is wider adjacent the axial ends of the spool.

One example of the present invention is illustrated in the accompanying drawings, wherein:-

Figure 1 is a diagrammatic front elevational view of a spooling machine;

Figure 2 is a diagrammatic view in the direction of arrow A in Figure 1;

Figure 3 is a diagrammatic representation of part of the spool traverse drive mechanism of the machine shown in Figures 1 and 2; and

Figures 4 and 5 are views similar to Figure 3 of two alternative spool traverse drive mechanisms.

Referring to the drawings, the machine includes a free-standing base 11 to the rear of which is a control console 12 and in front of which is a take-up spool carriage 13. The carriage 13 is reciprocable to the left and right (in Figure 1) relative to the base 11 and the console 12 through a stroke which can be adjusted to be equal to the length of the core of a take-up spool 14. The carriage 13 is formed with a pair of downwardly extending bearing lugs 15 at front and rear, each pair of lugs slidably engaging a support rod 16 carried by the base 11. The rods 16 and lugs 15 form the sliding support for the reciprocatory movement of the carriage 13. Parallel to the rods 16 and lying therebetween is a rotatable lead-screw 17 which is held against axial movement relative to the base 11, and which is engaged between its ends by a nut 18 secured to the carriage. The nut 18 is non-rotatable, and thus as the lead-screw 17 rotates the nut 18 is caused to traverse the length of the lead-screw carrying the carriage 13 with it along the rods 16.

A bearing block 19 extends upwardly from the carriage 13 in front of the console 12 and supports an electric torque motor 21 the output shaft 22 of which extends through the block 19 parallel to the plane of sliding movement of the carriage. At the side of the block 19 remote from the motor 21 the shaft 22 is connected to a spool carrier 23 which detachably supports the spool 14 with the axis of the spool 14 coincident with the axis of the shaft 22. Thus when the motor 21 is energised the spool 14 is rotated about an axis parallel to the plane of traversing movement of the carriage 13. The direction of rotation of the spool 14 is indicated in Figure 2, and is counter-clockwise in that Figure.

The front face of the console 12 presented to the carriage 13 carries nine control knobs 24, 25, 26, 27, 28, 29, 31, 32 and 33 each of which bears a reference mark which during operation of the knob traverses a scale or series of markings on the console. Exposed on the right-hand face of the control console (as viewed in Figure 1) are a plurality of pulleys which define the path which tape takes from the exterior of the machine to the take-up spool 14. Tape, for example nichrome tape having a width of 0.040 inches and having a thickness of 0.002 inches reaches the spooling machine from a source, which may be a bulk reel of tape, or may be a previous tape processing apparatus, for example an annealing oven and is indicated at 34 in Figure 2. Referring to Figure 2, the tape 34 passes over a first freely rotating pulley 35 at the upper right of the side face of the console 12 and then passes downwardly beneath a second freely rotating pulley 36 at the lower right of the side face. After the pulley 36 the tape 34 passes through a pinch wheel capstan drive comprising a driven capstan roller 37 and an idler pulley or pinch wheel 38^{which} is spring pressed against the capstan roller 37 to press the tape 34 firmly into contact with the roller 37. After the pinch wheel 38 the tape 34 is looped over a "dancer" pulley 39 which is spring urged along an arcuate path 41 towards the rear of the console 12. Thereafter the tape 34 passes beneath a freely rotating large diameter guide pulley 42 and beneath a smaller diameter freely rotating pulley 43 to the take-up spool 14. The tape 34 is driven through the spooling machine by the action of the capstan drive defined by the capstan roller 37 and the pulley or pinch wheel 38. The drive roller 37 is driven by an electric motor housed within the console 12 the speed of the electric motor being controlled by a number of factors, one of which is the setting of the control knob 26. The setting of the control 27 controls the setting of a variable transformer whereby power is supplied to the torque motor 21 and thus the power output of the motor 21 is determined.

by the setting of the control knob 27. When tape is being wound onto the spool 14 the tape is not drawn through the machine by the torque motor 21, but is driven through the machine at a constant speed by the capstan drive 37, 38. The power output of the torque motor 21 determines the tension in the tape between the take-up spool 14 and the capstan drive 37, 38. As will be recognised therefore the speed of rotation of the take-up spool 14 will be determined by the pass speed of tape through the machine, and this in turn is determined by the speed of the capstan drive. The torque motor attempts to rotate the spool 14 faster than is permitted by the pass speed of the tape, and thus tension in the tape is maintained. The amount of torque generated by the motor 21 is dependent upon the power supplied to the motor 21 and this in turn therefore determines the tension in the tape. As the diameter onto which tape is being wound increases, (by virtue of layers of tape already wound on the spool 14) the speed of rotation of the spool 14 will decrease since the pass speed of tape is constant. If the power input to the motor 21 is maintained constant, then the torque will increase as the speed of rotation of the spool 14 decreases, and in theory the tension in the tape will increase. However, as the winding diameter increases the turning moment of the spool decreases (because the increase in winding diameter increases the radius of action insofar as tape being drawn onto the spool is concerned) and the decrease in turning moment has a compensating effect compensating for the increase in torque as the speed of the spool decreases, so that the overall effect, between the beginning and the end of a spooling operation, on the tension in the tape is substantially zero. The position of the pulley 43 in relation to the axis of the spool 14 is adjustable to accommodate different dimensions of spool to keep the pulley 43 as close as possible to the spool. However, during a spooling operation the position of the pulley 43, once set, is maintained throughout

the spooling operation.

In order to ensure that the turns of tape wound on the spool 14 are axially adjacent one another, rather than completely overlying one another, the carriage 13 is traversed in a reciprocatory manner as tape is wound onto the spool 14. Thus the spool 14 is moved axially in relation to the path of the tape.

As mentioned briefly above a lead-screw and nut arrangement is provided for traversing the carriage 13, but of course the direction of traverse must be reversed each time the incoming tape reaches an end flange of the spool 14. The change in direction of traverse is achieved electronically, and the drive mechanism for the lead-screw 17 is illustrated diagrammatically in Figure 3. The lead-screw 17 is supported in bearings in the base 11, and adjacent one end is formed with a pulley 44 around which extends a toothed drive belt 45. The belt engaging surface of the pulley 44 is correspondingly toothed so that a non-slip drive connection is established. The belt 45 extends around a similar toothed pulley 46 secured to the output members 47, and 48 of first and second electromagnetically operated clutches 49, 51. The clutches 49, 51 are positioned with their axis co-extensive, and the input members 52, 53 of the clutches are supported by fixed bearing brackets 54, 55 secured to the base 11. Each clutch input member 52, 53 carries a toothed pulley 56, 57 the toothed pulley 56 being engaged by a toothed belt (not shown) which also extends around a correspondingly toothed pulley on the output shaft of a respective electric motor. The toothed pulley 57 of the second electromagnetic clutch 51 is similarly driven from a further respective electric motor, the two electric motors being identical, and always being operated at the same speed. The two electric motors are controlled by a single control mechanism the setting of which is adjustable by the control knob 25. The two electric motors

rotate their respective pulleys 56 and 57 in opposite directions, and it will be recognised that when the electromagnetic clutch 49 is energised then the combined clutch output member 46, 47, 48 will be driven in one direction, provided that the clutch 51 is de-energised, whereas when the clutch 49 is de-energised and the clutch 51 is energised then the combined output member 46, 47, 48 will be driven in the opposite direction. Thus the direction of rotation of the lead-screw 17 is determined by which of the two clutches 49, 51 is energised.

For the purposes of example let us assume that the energisation of the clutch 49 and de-energisation of the clutch 51 causes traversing movement of the carriage 13 to the right in Figure 1, then energisation of the clutch 51 and de-energisation of clutch 49 will cause traversing movement to the left in Figure 1. A linkage (not shown) movable by the carriage 13 controls operation of a pair of micro-switches which in turn control energisation of the clutches 49, 51. As the carriage 13, moving to the right in Figure 1, reaches a position wherein the tape being wound onto the spool 14 reaches the left-hand end flange of the spool 14 then the appropriate micro-switch is operated by the linkage to de-energise the clutch 49 and to energise the clutch 51 so that the lead-screw 17 is immediately rotated in the opposite direction returning the carriage 13 to the left. Similarly as the carriage reaches a position where the tape being wound onto the spool reaches the right-hand end flange of the spool 14 then the other micro-switch is operated, by way of said linkage, to de-energise the clutch 51 and re-energise the clutch 49. Once again to reverse the direction of traverse.

It can occur that for some reason an operator will wish to reverse the direction of traverse of the carriage before the tape entering the spool 14 reaches an end flange

thereof. For example, a fault may have occurred at some point which results in a low region in the tape being wound onto the spool, and it may be advantageous in such circumstances for the operator to cause the machine to traverse across the low region to fill the low region before the machine is then allowed to continue to perform a complete traverse. In order to facilitate such manual control by the operator the control knob 29 is provided, rotation of the control knob 29 causing the direction of traverse of the carriage 13 to reverse irrespective of the point along the axial length of the spool at which tape is being wound onto the spool. The knob 29 either operating to aforementioned microswitches or alternatively operating switches in parallel with said microswitches.

Clearly although a batch of spools 14 may be manufactured theoretically to the same dimensions individual variations will occur, and thus the facility for adjustment is built into the linkage which causes automatic reverse of the traverse of the carriage 13. The control knob 31 may be used to accurately set the point of traverse reversal at the left-hand end of the traverse of the carriage 13, and similarly the control knob 32 may be used to accurately set the point of reversal at the right-hand end of the traverse. The control knobs 31 and 32 are mechanically linked to the arrangement of linkage and microswitches, and effect minute adjustments in the position of the linkage in relation to the microswitches thereby to effect precise control over the points in the traverse of the carriage 13 at which the linkage operates the microswitches.

An alternative traverse mechanism drive arrangement is illustrated in Figure 4. The arrangement includes an electric motor 71 the output shaft 72 of which carries a pulley wheel 73 and a gear wheel 74. The gear wheel 74 is part of a reversing gear box 75 and meshes, within the gear box 75, with a second gear wheel 76. A shaft 77 coupled

to the gear wheel 76 carries a pulley 78 the diameter of which is identical to the diameter of the pulley wheel 73.

Parallel to the shaft 72 is a shaft 79 one end of which is in driving engagement with the pulley wheel 81 and the other end of which is in driving engagement with the input member 83 of a first electromagnetic clutch 82. A drive belt 84 extends around the pulley wheels 73 and 81 so that the shaft 79 is driven by the pulley wheels 73, 81 and the belt 84 in the same rotational direction as the shaft 72. The diameter of the pulley wheel 81 is greater than the diameter of the pulley wheel 73 by an extent calculated to achieve a five to one gearing reduction between the shaft 72 and the shaft 79.

The gear wheels 74 and 76 are such that the shaft 77 rotates at the same rotational speed as the shaft 72, but in the opposite rotational direction. Parallel to the shaft 77, and having its axis co-extensive with the axis of the shaft 79 is a shaft 85 which, at one end, is in driving engagement with a pulley wheel 86 and at its opposite end is in driving engagement with the input member 88 of a second electromagnetic clutch 87. The relative diameters of the pulley wheels 78 and 86 are such that again a five to one reduction in gear ratio occurs between the shaft 77 and the shaft 85. Thus it will be recognised that while the motor 71 is operative the shaft 79 is driven at a predetermined rotational speed in one rotational direction, while simultaneously the shaft 85 is driven in the opposite rotational direction, but at the same rotational speed.

The output members of the clutches 82 and 87 are interconnected to constitute a single output member 89. The speed of rotation of the output member 89 will thus be equal to the rotational speeds of the shaft 79 and the shaft 85, but the direction of rotation of the output member 89 will

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be determined by which of the first and second clutches 82, 87 is energised at any given time. Assuming that the clutch 82 is energised and the clutch 87 is de-energised then the member 89 will rotate with the shaft 79 and conversely when the clutch 82 is de-energised and the clutch 87 is energised then the output member ⁸⁹will rotate with the shaft 85.

A drive belt 91 couples the output member 89 and a lead-screw 17 of the traversing mechanism so that the lead-screw 17 is driven in a direction determined by the direction of rotation of the output member 89.

Preferably the drive belt 91, and the drive belt coupling the pulleys 73 and 81, and 78 and 86 are toothed drive belts so that inaccuracies in the operation of the traverse mechanism, arising from slippage between the belts and the pulleys, is obviated.

In the arrangement illustrated in Figure 5, which of course is alternative to the arrangements shown in Figures 3 and 4, parts common to the arrangements shown in Figure 4 carry the same reference numerals. Thus the motor 71 again drives a pulley wheel 73 through the intermediary of an output shaft 72. A shaft 79 is positioned parallel to the shaft 72 and is driven from the shaft 72 by way of the pulley wheel 73, a drive belt 84, and a pulley wheel 81 carried by the shaft 79. A five to one reduction in rotational speed is achieved between the shaft 72 and the shaft 79 by appropriate choice of the diameters of the pulley wheels 73 and 81. There is of course no change in the rotational direction.

At its end remote from the pulley wheel 81 the shaft 79 is coupled to the input member 83 of the first electromagnetic clutch 82, the clutch 82 sharing a common output member 89 with the second electromagnetic clutch 87. The input member 88 of the clutch 87 is driven by a shaft 85 having its axis co-extensive with the axis of the shaft 79. The lead screw 17 of the traverse mechanism is again driven from the output member 89 by way of a toothed drive belt 91.

Intermediate the pulley wheel 81 and the clutch input member 83 the shaft 89 carries a second pulley wheel 92 which drives a pulley wheel 93 through a drive belt 94. The pulley wheel 93 is secured to a shaft 95 parallel to the shafts 79 and 85, and the pulley wheels 92 and 93 are of the same diameter so that there is no change in rotational speed, or rotational direction, between the shaft 79 and the shaft 95. At its end remote from the pulley wheel 93 the shaft 95 carries a gear wheel 96 which meshes with a similar gear wheel 97 carried by the shaft 85. Clearly therefore the shaft 85 is caused to rotate in the opposite direction to the shaft 95, and the gear wheels 96 and 97 are so arranged that there is no change in rotational speed.

It will be apparent therefore that when the motor 71 is operative the shaft 79 and the shaft 85 are rotated simultaneously at the same rotational speed, but in opposite rotational directions. The operation of the mechanism illustrated in Figure 5, in relation to the change in direction of the lead screw driven by the belt 91, is identical to that described in relation to Figure 4. Moreover the control 25 used to effect control of both motors in the Figure 3 arrangement is used to control the motor 71 in the Figures 4 and 5 arrangements.

The control knob 24 (Figure 1) is merely an on-off switch for the machine. When the knob 24 is in its off position then none of the control circuits or motors of the

machine can be energised. When the knob 24 is in an on position indicator light 24a is illuminated, and the control circuits of the machine are energised. However, none of the motors are at this stage energised. The indicator lamp 24b is illuminated whenever the machine is connected to a power supply. The control knob 28 is the start switch of the machine, and provided that control knob 24 is in its on position then rotation of the knob 28 to the start position will supply power to the torque motor 21, the one or two electric motors of the traverse mechanism, and the drive motor of the capstan drive 37, 38. In each case of course the power actually supplied to those motors is determined by the setting of their various control knobs. Moving switch 28 to its start position results in immediate energisation of the torque motor 21 and the motor(s) of the traverse mechanism at the power settings governed by their respective control knobs. However, immediately the knob 28 is moved to the start position the power supply to the capstan drive motor is supplied by way of a variable resistor the setting of which is automatically altered by a hydraulically damped spring arrangement from a high resistance value to zero resistance. This variable resistor is in series with the main resistance control the setting of which is governed by the control knob 26. The effect of the variable resistor is to ensure that while the motor 21 and the traverse motors are operated at their predetermined power setting the capstan motor is operated at a considerably reduced power setting which over the short delay period rises back to the predetermined power setting. Thus the capstan drive motor starts slowly, and over the period of the delay, which may only be two or three seconds, runs up to its predetermined operating speed. The reason for this is that if the capstan motor is allowed to operate immediately at its predetermined speed, then the torque motor 21 may not have had time to apply sufficient torque to the spool 14 to maintain tension in the tape, and a loop of tape would be

formed between the capstan drive roller 37 and the spool 14. The delay provided by the start control knob 28 and its associated mechanism ensures that the spool 14 will take up the whole of the throughput of tape from the capstan drive from the instant that the machine is rendered operative. A further reason for such a "start-up" procedure is that where the machine receives tape from an annealer then a sudden increase in speed at the capstan drive can stretch the hot tape in the annealer since the necessary rapid increase in tape speed will be resisted by the inertia of tape supply feeding the annealer. Since the traverse

electric motor(s) are also immediately operated at their predetermined power setting the lay of the turns wound initially will be wider than required for the remainder of the winding operation, and the width of the lay will decrease as the speed of the capstan drive increases towards its predetermined value.

It will be recognised that when the speed of operation of the capstan drive is varied by means of the control knob 26 then unless the speed of the traverse motor(s) is varied in proportion the lay of the turns on the spool will be varied. For this reason the control knob 26 is ganged to the control knob 25 so that when an adjustment is made in the capstan drive speed by means of the knob 26 then a corresponding adjustment is made in the speed of operation of the traverse drive motor(s) to maintain the width of the lay constant. However, the ganging of the control knobs 26, 25 is a one-way ganging since the control knob 25 can be operated to adjust the speed of operation of the traverse drive motor(s) without affecting the speed of operation of the capstan drive motor.

The manner in which the two controls are ganged is as follows. The controls 25 and 26 are rotatable potentiometers, each including a spindle to which the respective control knob 25, 26 is secured, and a casing which is normally held stationary relative to the spindle. Rotation of the spindle relative to the casing varies the setting of the potentiometer. The casing of the potentiometer of the control knob 26 is fixed relative to the console 12, and the spindle linking the control knob 26 to the potentiometer mechanism carries a pulley wheel. The casing of the potentiometer associated with the control knob 25 is not fixed relative to the console 12, and can rotate. This casing carries a further pulley wheel, and the pulley wheel of the spindle of the control knob 26 is linked to the pulley wheel of the casing of the potentiometer of the control knob 25 by means of a loop of non-

extensible cord the two runs of which between the two pulleys are crossed so that a clockwise rotation of the control knob 26 results in a counter-clockwise rotation of the casing of the potentiometer normally controlled by the control knob 25. The relative diameters of the two pulley wheels determines the angular extent through which the casing of the potentiometer normally controlled by the knob 25 is moved for a given angular movement of the knob 26.

It will be recognised therefore that when the knob 26 is rotated there is simultaneously an adjustment in the speed of the capstan drive motor, and a corresponding adjustment in the speed of the traverse drive motor(s) so that the lay of the winding on the spool remains constant irrespective of the change in pass speed of the tape through the machine. A small frictional drag is imposed upon the spindle of the control knob 26 to ensure that when the control knob 25 is rotated the casing of the potentiometer operated by the control knob 25 remains stationary and movement of the control knob 25 is thus not transmitted to the potentiometer of the control knob 26. The traverse drive motor(s) speed can thus be varied without varying the capstan drive motor speed, but the capstan drive motor speed cannot be varied without a corresponding variation in the traverse drive motor(s) speed.

The lay of tape on the spool 14 is an important criteria since a wide lay, that is to say where the gap between adjacent turns of a layer is substantially equal to the width of the tape provides good shock absorbing qualities in a wound spool, but has associated disadvantages. The shock absorbing qualities are important during handling of a wound spool, since they minimize the danger of the marginal edges of the turns of tape being damaged by impact with one another if the spool is subject to an axial shock. However, the use of a wide lay is disadvant-

ageous in that firstly it reduces the capacity of the spool, and secondly in that in the operation of the shock absorbing qualities the turns of tape can slide relative to the spool to absorb the gaps therebetween, and in so doing the tension in the turns is lost, and turns of the same layer can overlap with one another. In serious cases turns of adjacent layers may also overlap rendering the spool extremely difficult to unwind.

An alternative winding is a narrow lay in which there is substantially no gap between axially adjacent turns of each layer. The narrow lay maximizes the capacity of the spool, and overcomes to a large extent the problem of turns overlapping with one another and becoming entangled if the spool is subject to an axial shock. However, it has the disadvantage that if the spool is subject to an axial shock then the shock is absorbed by the marginal edges of the turns impacting against one another and thus there is a significant risk of damage to the marginal edges.

In the machine disclosed herein these problems are to a large extent mitigated by varying the lay of the winding adjacent the axial ends of the spool. As will be described in more detail later the machine automatically winds the tape onto the spool 14 with a narrow lay throughout the majority of the axial length of the spool, but with a wider lay at the axial end regions of the spool. When a spool wound in this manner is subject to axial shock the wide lay axial end regions act as shock-absorbers and collapse to absorb the axial shock. This protects the narrower lay turns which form the majority of the winding so that marginal edge damage as a result of the axial shock is minimized. However, the axial extent of the wider lay turns at opposite axial ends of the spool is relatively small, so that little or no entanglement occurs as a result of absorption of the axial shock. Furthermore of course the capacity of the spool is only slightly less

than that of a spool wound completely with turns of narrow lay.

The lay of the turns is, as will be recognised from the foregoing description, determined by the relationship of the capstan drive speed to the traverse motor drive speed. Thus the lay can be varied manually by altering the setting of the control 25 which operates a potentiometer controlling the power supply to the traverse drive motor(s). However, it would be extremely undesirable to vary the lay at the axial ends of each layer of the winding manually since a skilled and wholly attentive operator would be required. In order that the machine can produce the varied lay automatically control of the traverse drive motors is effected in the following manner. The potentiometer of the control knob 25 provides the primary adjustment of the speed of the traverse drive motor(s). A further control knob 33^{is} linked similarly to a potentiometer, the potentiometer of the control knob 33 being electrically in parallel with the potentiometer with the control knob 25. Although not important in consideration of the feature of varying the lay at the axial ends of the spool there is a further potentiometer 58 which has a controlling effect on the speed of the drive motor(s). However, ignoring for the moment the potentiometer 58 it will be recognised that during normal operation of the spooling machine the power supplied to the traverse drive motor(s) is determined by the settings of the control knobs 25, 33. It will be recalled that reversal of the traverse motion at opposite axial ends of the spool is effected by a pair of micro-switches operated by a linkage, the linkage in turn being directly operated by the movement of the carriage 13. This linkage therefore in effect determines where the machine considers that the end flanges of the spools are in relation to the incoming tape path of the machine, and alters the traverse direction accordingly. This linkage is also used to vary the speed of traverse adjacent the

axial ends of the traverse movement. Although the linkage operates the traverse reversal micro-switches as the tape reaches an end flange of the spool, the linkage also serves to operate, prior to the tape reaching the end flanges, a pair of reed switches which short out of the control circuit the potentiometer controlled by the knob 25. The reed switches are set to be operated by the linkage when the tape is within perhaps $\frac{1}{4}$ of inch from an end flange of the spool 14. Thus as the tape approaches either end flange of the spool 14 when it is within $\frac{1}{4}$ of inch of the end flange an appropriate reed switch is operated to short circuit the potentiometer of the control knob 25 leaving the speed of operation of the traverse motors governed by the potentiometer of the knob 33. The knob 33 is so adjusted as to give an increased traverse rate by comparison with the traverse rate in existence with both potentiometers in circuit. Thus during the final $\frac{1}{4}$ of an inch of traverse the traverse speed increases, the traverse motion is then reversed and the speed increase is maintained for the first $\frac{1}{4}$ inch of the travel of the tape away from the end flange whereupon the reed switch is de-energised and the potentiometer of the control knob 25 is brought back into circuit and the speed of the traverse motor drops to the predetermined speed. The winding then continues at the predetermined traverse speed until the opposite end flange is approached whereupon a second reed switch again short circuits the potentiometer of the knob 25 for the final $\frac{1}{4}$ inch of travel, the traverse is reversed, and the speed increase is maintained for the first $\frac{1}{4}$ of an inch of the return travel whereafter the potentiometer of the control knob 25 is put back into circuit. Thus the machine continues in this manner until the whole of the spool has been filled. The effect of increasing the traverse speed as the tape is in the vicinity of the end flanges of the spool is to widen the lay of the winding by an amount determined by the speed increase. The speed increase is of course determined by the setting of the

potentiometer of the knob 33. The speed increase of the traverse drive motor(s) is not, of course, accompanied by an increase in the speed of the capstan drive motor.

Earlier in this description it was disclosed that since the tape pass remains constant, then as the diameter of tape wound on the spool 14 increases then the speed of rotation of the spool 14 decreases. At this earlier point in the description the effect upon tension in the winding was considered. What was not considered at that point was the effect on the lay of the turns of the winding, and it will be recognised that as the speed of rotation of the spool 14 decreases while the pass speed of the tape is kept constant then unless there is an adjustment in the traverse speed corresponding to the reduction in the speed of rotation then the width of the lay will progressively increase as the speed of rotation of the spool decreases. In order therefore to provide compensation for the decreasing speed of rotation of the spool 14 as the tape diameter wound on the spool increases the potentiometer 58 is provided. A synthetic resin finger 59 is lightly biased into contact with the tape wound on the spool 14. The finger 59 is carried by an arm 61 coupled to the control spindle of the potentiometer 58. The casing of the potentiometer 58 is secured to the bearing block 19, and thus as the tape diameter on the spool 14 increases the finger 59 and thus the arm 61 are moved. The arm 61 is moved angularly with respect to the potentiometer 58 and adjusts the setting of the potentiometer 58. As previously mentioned the potentiometer 58 effects a controlling function on the power supplied to the traverse drive motor(s), and is electrically in series with the parallel combination of the potentiometers controlled by the knobs 25 and 33. Thus the setting of the potentiometer 58 has, in relation to the traverse drive motors, a modifying effect on the power setting determined by the potentiometers of the knobs 25, 33. As the diameter of tape

wound on the spool increases the setting of the potentiometer 58 is altered to reduce the power supplied to the traverse drive motor(s) so that the speed of traverse is reduced to maintain the lay of turns on the spool constant notwithstanding that the speed of rotation of the spool 14 is dropping.

It will be recognised therefore that for a predetermined tape, and a predetermined spool dimension all of the controls 25, 26, 27, 29, 31, 32, and 33 can be preset, the tape can be threaded through the machine and attached to an empty spool, the power switch 24 can be put into the on condition, and the spooling operation can then be initiated by operation of the control 28. Thereafter, provided that the tape is constant in its dimensions and properties throughout its length the spooling operation will continue without alternation to the setting of any of the controls until the spool is full. The spool-full condition is sensed also by the finger 59 which, in addition to operating the potentiometer 58 operates a micro-switch which breaks the power supply to all of the motors of the apparatus. Thus the machine will not continue to wind after a spool has reached a condition which is predetermined as the full condition of that spool. Moreover, the point of operation of the micro-switch is adjustable to facilitate the use of different diameters of spool, and the knob (not shown) for adjustment of the operating point of the micro-switch can be calibrated, for a given tape dimension, in terms of the weight of tape on a spool. In fact there is no weight measurement as such, but it is known that for a particular lay, and tension of winding, then on a spool of known diameter the full condition of the spool relates to a predetermined weight of tape on the spool. Since spools of tape are normally sold by weight, and not by length of tape then calibrating the setting knob for the micro-switch in terms of weight rather than in terms of length of spool or

diameter of spool is advantageous.

It will have been noted that a control knob 62 is provided on the side of the console 12. The control knob 62 controls the tension in the spring urging the dancer wheel 39 along its track 41. In the absence of tape the dancer wheel 39 will move to the clockwise end of its track 41 (as viewed in Figure 2) and when in this position, the dancer wheel assembly within the console operates a micro-switch in series with the micro-switch operated by the finger 59. Thus should the supply of tape 34 run out, or alternatively should the tape break, then the dancer wheel 39 will be moved, by its tension spring, to a position wherein it operates the micro-switch thus de-energizing all of the motors of the machine.

Desirably the portion of the base 11 upon which the carriage 13 is movable is hollow, and contains the guide rods 16, the lead-screw 17, and the lugs 15 and 18. The hollow region is in the form of an oil bath so that the bearings of the carriage 13 on the guide rods 16, and the captive nut 18 engaged with the lead-screw 17 are either partially, or totally oil immersed.

It will be understood that between the pulley 46 and the carriage there can be a significant mechanical advantage by virtue of the sizes of the pulleys 46 and 44 and the reduction effect of the lead-screw and nut. Thus should there, after wear, be a slight slippage in either of the clutches 49, 51 as they are energised, the effect in terms of loss of carriage movement will be insignificant.

Throughout the foregoing description it is assumed that both carriage traverse drive motors operate at the same speed to give the same tape lay for each layer of turns wound on the spool. If desired a deliberate imbalance in the speeds can be provided in order to give different lays for adjacent layers of turns. For example, if the

motor driving pulley 56 runs faster than motor driving pulley 57 then each layer of turns would during traverse to the right will have wider lay than those wound during traverse to the left and a spool will be filled with turns of tape the layers of which are alternately wider and narrower layer. Such a method of winding is believed to be both novel and useful particularly where damaged tape is to be wound onto spools having capacity of a large number of layers of turns. In such circumstances where, for example, the tape is buckled, creased or of uneven thickness then winding with the same lay in adjacent layers can result in a build-up of errors resulting in an unevenly wound spool (that is to say the layers may not be cylindrical but may include troughs and peaks along the axial length of the spool). Varying the lay of adjacent layers has been found to minimise the tendency for the errors to become cumulative. In the past the usual way of overcoming the problems is to interleave layers of turns with sheets of paper, and clearly this is expensive and time consuming. It will be recognised that this effect can not so readily be obtained with the arrangements shown in Figures 4 and 5 where only one motor is used. If desired however, the effect can be achieved by controlling the speed of the motor 71 in relation to the clutch energised at any given time. For example, the motor can have a resistor automatically connected in series with it whenever the clutch 82 is energised. In this manner the motor speed will be reduced when it is driving the lead-screw 17 through the clutch 82 but will return to its preset value when driving the lead-screw through the clutch 87.

Lastly, it should be recognised that the terms "wide lay" and "narrow lay" as used herein are somewhat subjective, and the definitions of these terms given herein are by way of example only.

CLAIMS:

1. A spooling machine of the kind wherein a take-up spool mounted on a spool carrier is rotated to wind thereon material to be spooled characterised in that there is provided a pinch wheel capstan drive 37, 38 for supplying material to be spooled to a spool carried in use by said carrier 23, and an electric torque motor 21 for driving said carrier 23, whereby, in use, the take-up spool rotational speed is determined by the pass speed of the material supplied to the spool by said pinch wheel capstan drive 37, 38 and the tension of the material being spooled is determined by the power input to the torque motor 21.
2. A machine as claimed in claim 1, characterised by the provision of means whereby the power input to the torque motor 21 can be adjusted by an operator.
3. A machine as claimed in claim 1 or claim 2 characterised by means whereby the speed of the capstan drive 37, 38 can be varied, to vary the pass speed of the material being spooled.
4. A machine as claimed in any one of claims 1 to 3 characterised by means whereby upon initiation of the spooling operation there is a short delay after energisation of the torque motor 21 at its chosen value for the spooling operation, before operation of the capstan drive 37, 38 at its chosen speed for the spooling operation, the capstan drive speed being increased automatically and progressively from zero to the chosen speed during said delay, whereby initially spooling occurs at a high, but decreasing tension until such time that the speed of the capstan drive increases to said chosen value.

5. A machine as claimed in any one of the preceding claims characterised in that in order to effect reversing traverse movement between, in use, the spool and the material to be wound onto the spool, there is provided a traverse mechanism including first and second clutches 49 (82) and 51 (87), the first clutch 49 (82) being engaged and the second clutch 51 (87) disengaged for traverse in one direction, and the second clutch 51 (87) being engaged and the first clutch 49 (82) being disengaged for traverse in the opposite direction.

6. A machine as claimed in claim 5 characterised in that said take-up spool carrier 23 is carried on a take-up spool carriage 13 and the machine further includes a captive nut 18 carried by said carriage 13, a rotatable lead-screw 17 co-operating with the nut 18 and held against axial movement whereby as the lead-screw 17 rotates the nut 18 is caused to move axially along the length of the lead-screw 17, and a lead-screw drive mechanism, the lead-screw drive mechanism comprising means 56 (79) driving the input of said first clutch 49 (82) in one direction, means 57 (85) driving the input of said second clutch 51 (87) in the opposite direction, and a combined output member 46 (89) for the first and second clutches, the lead-screw 17 being driven from the combined output member 46 (89) of the first and second clutches, and being driven in one rotational direction, to move the carriage 13 in one linear direction, by engagement of the first clutch with the second clutch disengaged, so that the combined clutch output member 46 (89) is driven by the first clutch input member, and the lead-screw 17 being driven in the opposite rotational direction to move the carriage 13 in the opposite linear direction by engagement of the second clutch while the first clutch is disengaged, so that the second clutch input member drives the combined clutch output member 46 (89).

7. A machine as claimed in claim 5 or claim 6 characterised in that said first and second clutches are electromagnetic clutches.

8. A machine as claimed in any one of claims 5 to 7 characterised in that said means 56 driving the input of said first clutch includes a first electric motor and said means 57 driving the input of said second clutch includes a second electric motor.

9. A machine as claimed in claim 8 characterised in that said first and second electric motors are constant speed motors, and share a common speed control mechanism whereby carriage traverse speed can be altered, the common control mechanism altering the speed of both the first and second electric motors simultaneously and by the same amount.

10. A machine as claimed in any one of claims 5 to 7 characterised in that said means driving the input of said first clutch includes an electric motor 71 and said means driving the input of said second clutch includes said electric motor 71 and a drive reversing mechanism 75 (95, 96, 97) whereby said electric motor 71 drives both the first clutch input 83 and the second clutch input 88 at the same rotational speed but in opposite rotational directions.

11. A machine as claimed in any one of the preceding claims characterised in that it includes means operable during relative traverse movement of the spool 14 and material being wound as the material is wound adjacent the axial ends of the spool 14, to produce a variation in the relationship of the speed of traverse to the speed of rotation of the spool 14, such that the spacing between adjacent turns of the material being wound is greater adjacent the axial ends of the spool than over the remainder of the spool.

12. A machine as claimed in claim 11 characterised in that there is provided a reciprocable carriage 13 for carrying the take-up spool 14 in use, means 17, 18 for reciprocating the carriage 13, and means sensing the position of the carriage 13 in relation to the input path of material to the take-up spool in use, said sensing means in use controlling the speed of traverse of the reciprocable carriage 13 in a manner to increase the speed of traverse at those points in the movement of the carriage 13 where material is being wound adjacent the two axial ends of the take-up spool.

13. A method of spooling material characterised in that adjacent the axial ends of the spool the lay of axially adjacent turns of each layer of the winding is wider than throughout the remainder of the axial length of the spool.

14. A spooling machine characterised in that there is provided means operable during relative traverse movement of the spool 14 and material being wound as the material is wound adjacent the axial ends of the spool 14, to produce a variation in the relationship of the speed of traverse to the speed of rotation of the spool 14, such that the spacing between adjacent turns of the material being wound is greater adjacent the axial ends of the spool than over the remainder of the spool.

15. A machine as claimed in claim 14 characterised by a reciprocable carriage 13 for carrying the take-up spool 14 in use, means 17, 18 for reciprocating the carriage 13, and means sensing the position of the carriage 13 in relation to the input path of material to the take-up spool in use, said sensing means in use controlling the speed of traverse of the reciprocable carriage 13 in a manner to increase the speed of traverse at those points in the movement of the carriage 13 where material is being wound adjacent the two axial ends of the take-up spool.

16. A spool of material characterised in that the material is so wound that the lay of the turns of each layer is wider adjacent the axial ends of the spool.

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FIG.1.

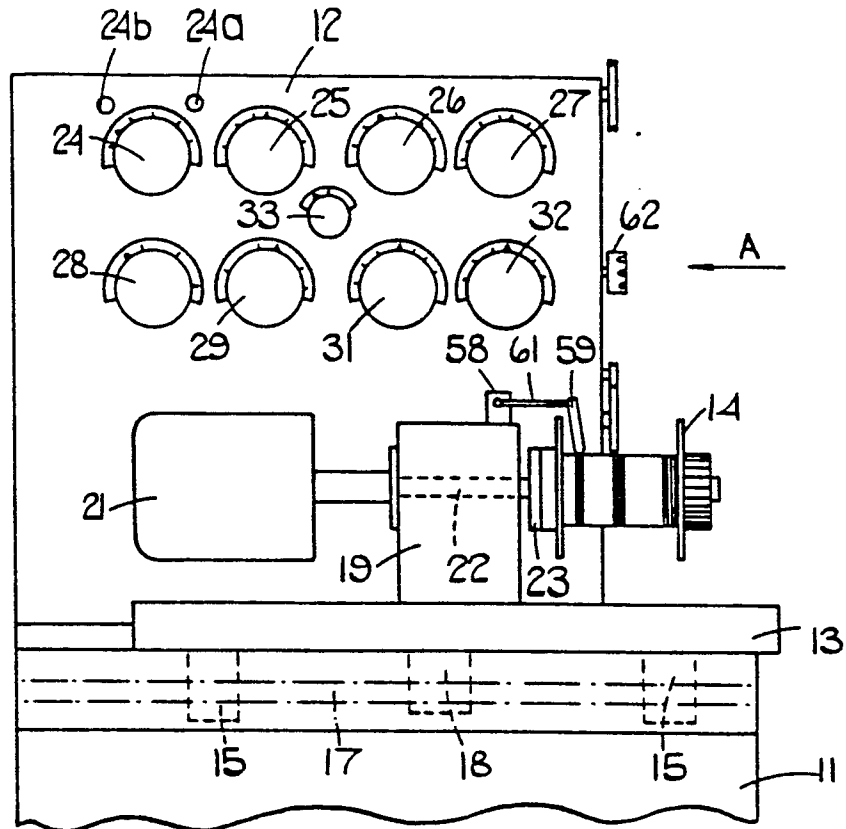
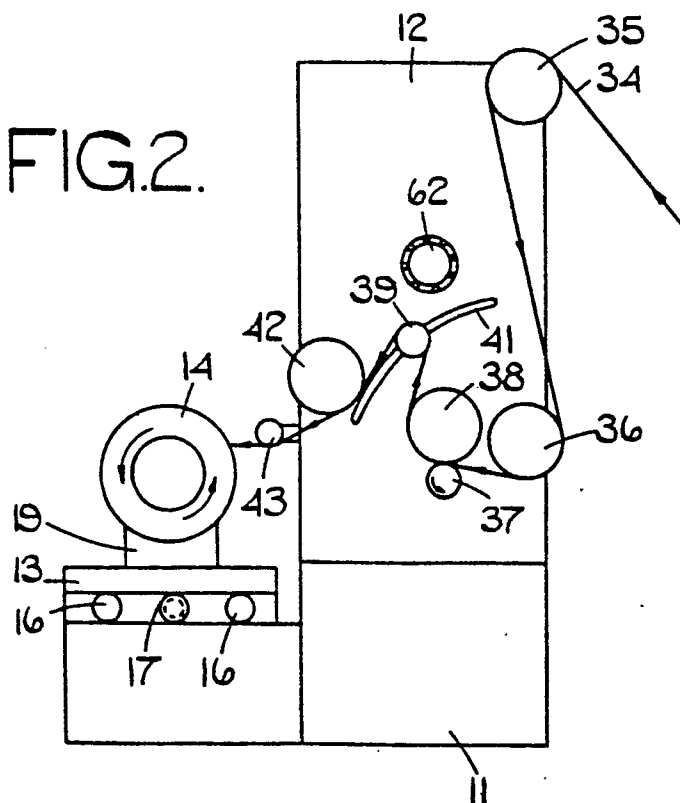
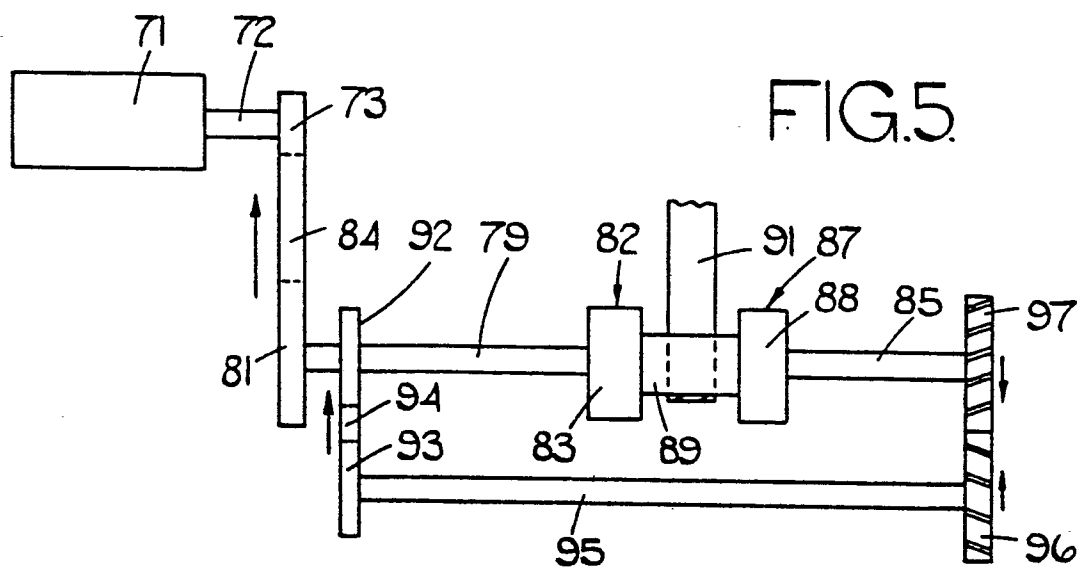
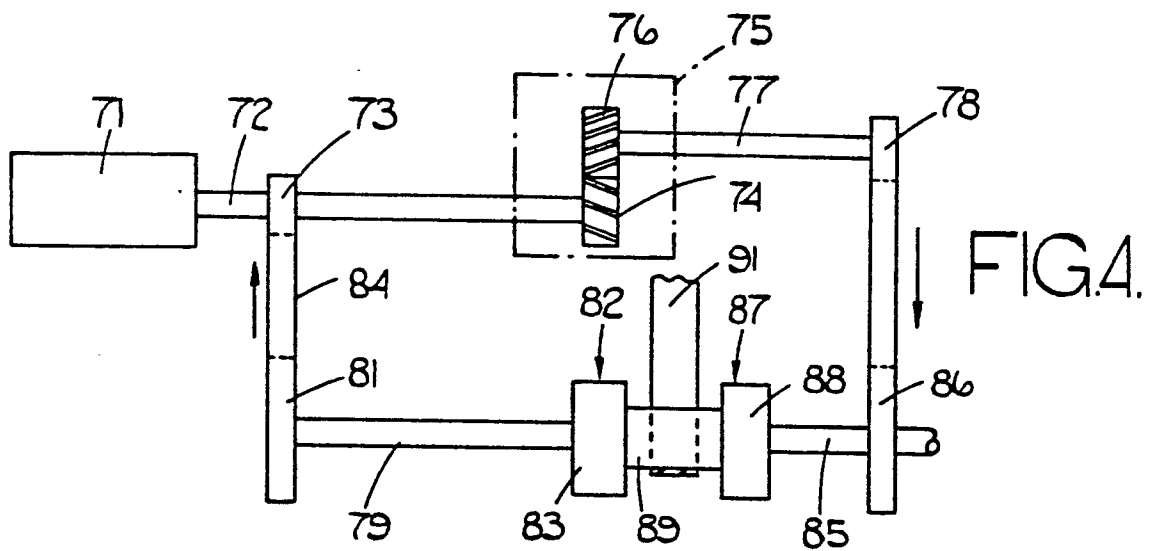
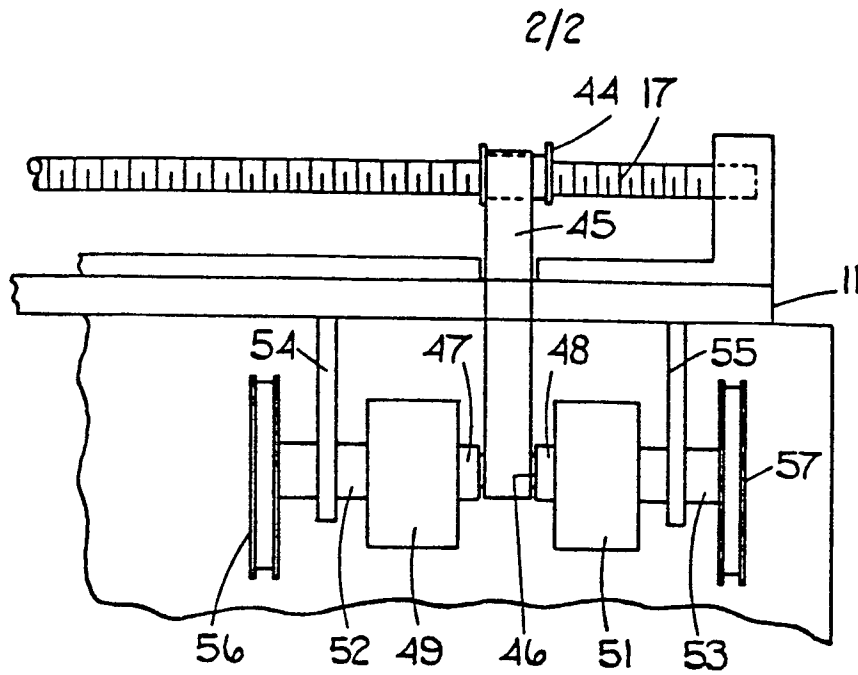


FIG.2.







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EUROPEAN SEARCH REPORT

0023391

Application number

EP 80302205.2

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	
	<u>AT - B - 268 948</u> (MASCHINENFABRIK SCHWEITER) + Totality + --	1,2	B 65 H 54/00 B 65 H 59/00
	<u>AT - B - 301 402</u> (MASCHINENFABRIK SCHWEITER) + Claim; Page 2, lines 34-45 + --	1,2	
	<u>US - A - 3 680 801</u> (REGAL MANUFACTURING) + Totality + --	2	TECHNICAL FIELDS SEARCHED (Int.Cl. 3)
	<u>DE - C - 807 296</u> (SIEMENS SCHUKERTWERKE) + Totality + --	1,2	B 21 C 47/00 B 65 H 54/00 B 65 H 57/00 B 65 H 59/00 B 65 H 67/00
	<u>US - A - 3 854 668</u> (E.I. DU PONT) + Fig. 1,3,4 + --	2	
	<u>US - A - 4 049 211</u> (RIETER MACHINE WORKS) + Column 6, lines 57-68; column 7, lines 1-5; fig. 2 + --	2	
	<u>DE - A - 1 474 231</u> (LÜTKE) + Page 9, lines 11-18; fig.3 + --	5,6,8,9	CATEGORY OF CITED DOCUMENTS X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons
	<u>CH - A - 272 935</u> (ALBISWERK) + Page 2; fig. 1,2 + --	5-7,10	
X	The present search report has been drawn up for all claims		&: member of the same patent family, corresponding document
Place of search		Date of completion of the search	Examiner
VIENNA		26-09-1980	TROJAN

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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	
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