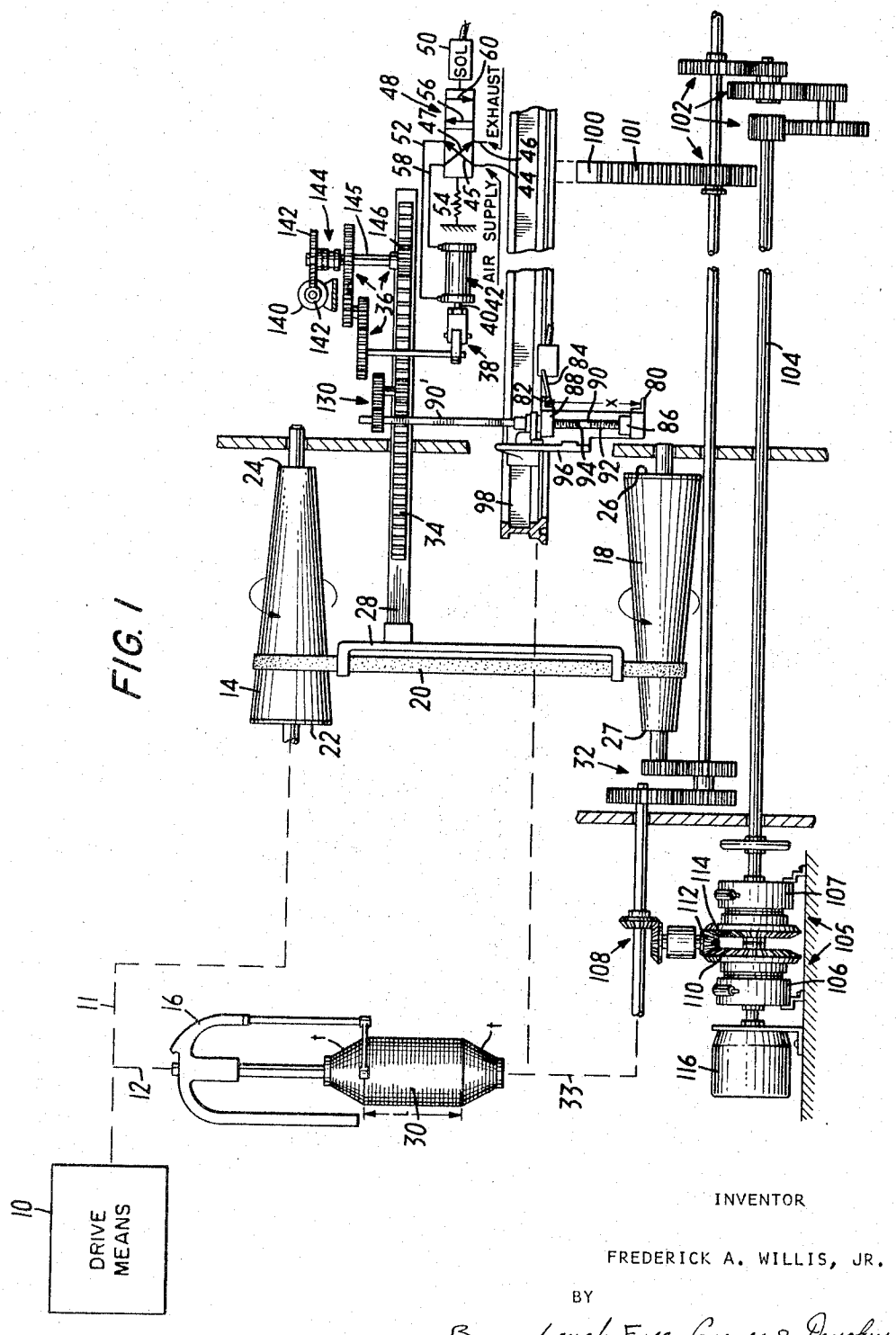
May 2, 1967 F. A. WILLIS, JR 3,317,800

ELECTRIC CONTROL CIRCUIT

Filed Nov. 9, 1964 2 Sheets-Sheet 1

FIG. 1

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ELECTRIC CONTROL CIRCUIT

Filed Nov. 9, 1964 2 Sheets-Sheet 2

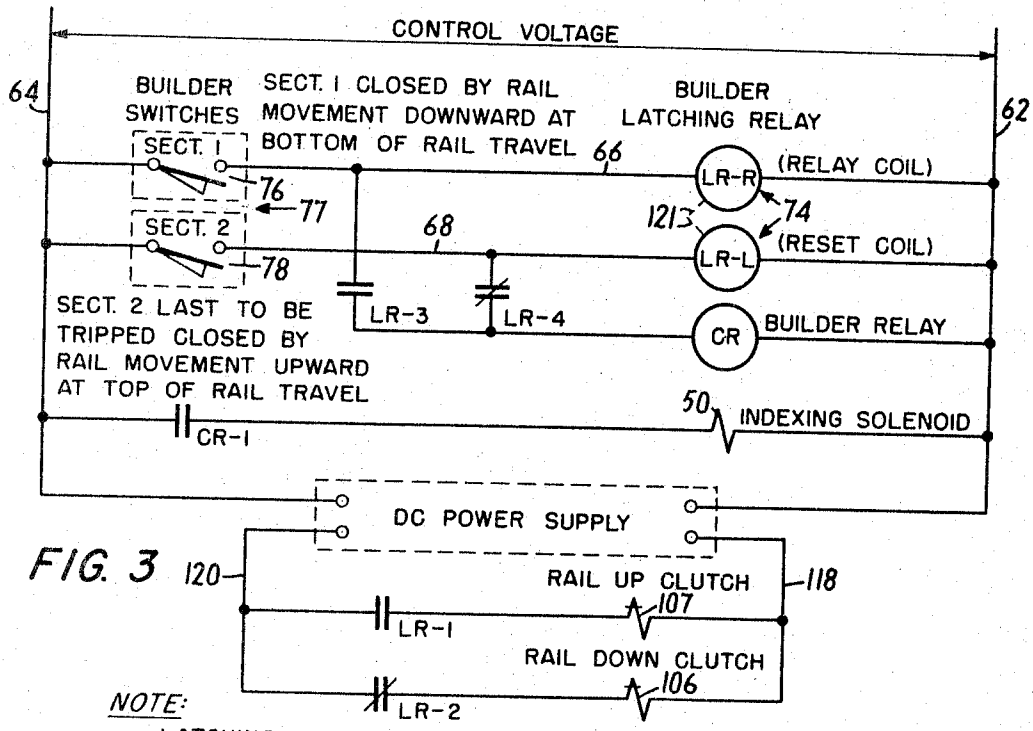


FIG. 3

NOTE:

LATCHING RELAY AS SHOWN INDICATES -

(A) RESET COIL (LR-L) LAST TO BE ENERGIZED

(B) RAIL TRAVELING DOWNWARD

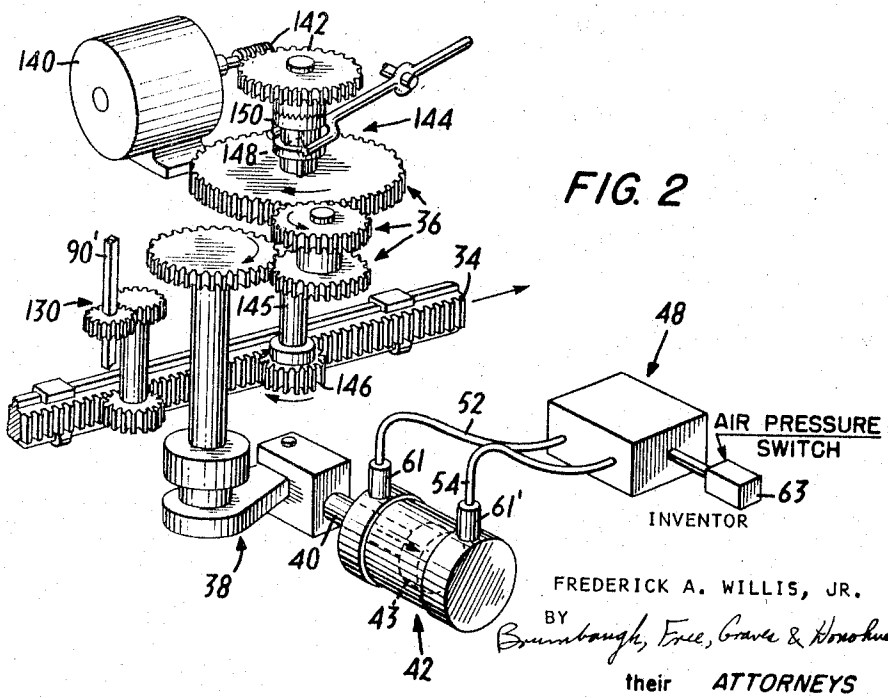


FIG. 2

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# ELECTRIC CONTROL CIRCUIT

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7 Claims. (Cl. 317—137)

This invention relates to frames for paying off a filamentary material from a feed mechanism and winding the material onto a bobbin to form a package of the material on the bobbin.

The disclosure herein, though not the claimed invention, is substantially the same as disclosures in a copending commonly-assigned application by Ronald C. Mason and William E. Strzelewicz, Jr., for "Winding Apparatus," application Ser. No. 409,669, filed concurrently herewith and a copending commonly-assigned application by Ronald C. Mason, William B. Strzelewicz, Jr., and Frederick A. Willis, Jr., for "Winding Apparatus With Electric Control Circuit," application Ser. No. 409,916 also filed concurrently herewith.

Conventional frames for paying off a filamentary material from a feed mechanism such as a roving frame and winding the material onto a bobbin to form a package of the material on the bobbin are disclosed in, for example, a patent to Hendrickson No. 2,003,362, assigned to the assignee of the present application. Such machines marked a considerable advance in the art at the time of their introduction, but further improvement of them is desirable.

For example, the conventional design gives rise to a harsh, noisy action of the contact shaft, which must be suddenly geared into a high-speed rotating shaft (the top cone shaft) and suddenly stopped after only half a revolution with much noise and shock to the skip gear, contact dogs, builder nuts, and contact shaft.

Further, conventional apparatus is subject to rail "run overs" because of the period of "no drive" when the twin bevel gears are being shifted.

Also, the front roll speed of the conventional frame must be limited to about 300 rotations per minute, because the skip gear does not mesh properly with the top cone bevel gear at speeds greater than that.

Finally, conventional machines may not be stopped safely from an operational point of view at all positions of rail travel.

An object of the present invention is to provide an electric control circuit facilitating the use of an improved frame which remedies the shortcomings of the conventional apparatus pointed out above.

In particular, an object of the present invention is to provide an electric control circuit adapted to facilitate the performance of first, second, and third functions which may be, for example, effecting a relative traverse of a feed mechanism and a bobbin in a first direction, effecting a relative traverse of the feed mechanism and bobbin in a second direction opposite the first direction, and effecting stepped movements of the cone-pulley-belt guide at the end of each traverse.

A further object of the invention is to provide an electric control circuit facilitating the use of a roving frame in which the cushioning effect of a compressible fluid is employed to minimize the noise and shock associated with movement of the cone-pulley-belt guide.

These and other objects of the invention are accomplished by providing, in apparatus for performing first, second, and third functions, the improvement comprising first and second relay coils, first, second, third, and fourth pairs of contacts governed by the first and second coils, and a control relay coil. The first pair of contacts is



adapted alternately to occupy first and second states and caused to occupy the first state on energization of the first coil and the second state on energization of the second coil. The second pair of contacts is adapted alternately to occupy third and fourth states and caused to occupy the third state on energization of the first coil and the fourth state on energization of the second coil. The third pair of contacts is adapted alternately to occupy fifth and sixth states and caused to occupy the fifth state on energization of the first coil and the sixth state on energization of the second coil. The fourth pair of contacts is adapted alternately to occupy seventh and eighth states and caused to occupy the seventh state on energization of the first coil and the eighth state on energization of the second coil. All of the pairs of contacts are prevented from changing states when both the first and second coils are de-energized. The first pair of contacts in its first state facilitates performance of the first function, the second pair of contacts in its fourth state facilitates performance of the second function, the third pair of contacts in its fifth state facilitates energization of the control relay coil, and the fourth pair of contacts in its eighth state facilitates energization of the control relay coil. A fifth pair of contacts is also provided and is adapted alternately to occupy ninth and tenth states and caused to occupy the ninth state on energization of the control relay coil and the tenth state on de-energization of the control relay coil. One of the ninth and tenth states facilitates performance of the third function.

An understanding of further particulars of the invention may be gained from a consideration of the following detailed description of a representative embodiment thereof taken in conjunction with the accompanying figures in the drawings, of which:

FIG. 1 is a fragmentary, partly-schematic partly-sectional view of one form of apparatus the operation of which is facilitated by the present invention;

FIG. 2 is an enlarged perspective view of a portion of the apparatus of FIG. 1; and

FIG. 3 is a schematic diagram of an electric circuit constructed in accordance with the invention.

FIG. 1 shows drive means **10** connected by suitable linkages **11**, **12** to a top cone pulley **14** and a flier **16**, respectively, to rotate the top cone pulley **14** at constant speed and the flier at constant speed.

The top cone pulley **14** is connected to a bottom cone pulley **18** by a cone pulley belt **20** extending therebetween and tightly drawn thereabout so that the rotation of the top cone pulley **14** in the direction indicated by the arrow associated with the top cone pulley **14** is effective to rotate the bottom cone pulley **18** in the direction indicated by the arrow associated with the bottom cone pulley **18**.

The top cone pulley **14** is tapered, either linearly as shown or non-linearly, so that its diameter perpendicular to its axis of rotation adjacent to its base **22** (the cone-frustum base to the left as seen in the figure) is larger than the corresponding diameter adjacent to its base **24**. Similarly, the bottom cone pulley **18** is tapered, either linearly as shown or non-linearly, and has a large base **26** and a small base **27**. The bottom cone pulley is arranged, however, with its large base **26** to the right of its small base **27** as seen in the figure rather than to the left.

A cone-pulley-belt guide or shipper **28** envelops a portion of the belt **20** to guide the belt **20** and move it longitudinally of the axes of the upper and lower cone pulleys **14**, **18**. Those skilled in the art will readily understand that the cone pulleys **14**, **18** and the belt **20** constitute a variable-mechanical-advantage means and that, for example, when the belt **20** is moved to the left as indicated in FIG. 1, the rotational speed of the lower cone pulley **18** increases and that, when the belt **20** is moved to the

right as seen in FIG. 1, the rotational speed of the lower cone pulley **18** decreases.

In the winding of roving, for example, it is normally desired to shift the belt towards the right as seen in FIG. 1 following each traverse with respect to each other of the flier **16** and a bobbin **30** on which the roving is to be wound. The flier **16** is made to rotate, as noted above, by the drive means **10** at a constant speed. The bobbin **30**, being connected to the lower cone pulley **18** by suitable linkages **32, 33**, rotates in the same direction in which the flier **16** rotates but more rapidly than the flier **16**. The feed mechanism and bobbin thus rotate with respect to each other at a rotational velocity *w*. As the thickness of the package of roving increases, the tangential speed of the package would become excessively great, except for the fact that the rotational speed of the bobbin **30** decreases with each successive traverse as the belt **20** moves to the right as seen in FIG. 1. Also, in order to provide the tapered bobbin shape indicated at *t*, the length of each successive traverse is preferably decreased.

The belt shipper **28** has formed thereon a rack **34** adapted to be driven by gearing **36** which is in turn actuated by a ratchet **38** under the control of a piston rod **40** of a piston-cylinder assembly **42**.

Thus, movement of the piston **43** (FIG. 2) of the piston-cylinder assembly **42** to, for example, the right as seen in FIG. 1 and in the direction of the lower arrow in FIG. 2, actuates the gearing mechanism **36** through the ratchet assembly **38** to move the rack **34** and hence the shipper **28** to the right as seen in FIG. 1 and therefore shift the belt **20** to the right and change the mechanical advantage of the variable-mechanical-advantage means constituted by the cone pulleys **14, 18** and the belt **20**. The directions of rotation of the gears constituting the gearing mechanism **36** are shown by appropriate arrows in FIG. 2. Movement of the piston **43** in the opposite direction—i.e., to the left as seen in FIG. 1—has no effect on the location of the belt **20** longitudinally of the axes of the cone pulley **14, 18**, inasmuch as the ratchet **38** is free wheeling in response to such movement of the piston **43**.

The piston **43** of the piston-cylinder assembly **42** is actuated by an air supply line **44** and an air exhaust line **46** communicating with a shiftable valve **48** under the control of a solenoid **50** and spring **54**. The valve **48** moves to the position shown in response to energization of the solenoid **50**. In the position of the valve shown, the air supply line **44** communicates through a passage **45** in the valve **48** with a line **52** for moving the piston **43** of the piston-cylinder assembly **42** to the right as seen in FIG. 1 and performing an indexing function—i.e., shifting the cone guide **28**. A line **58** communicating with a passage **47** in the valve **48** permits the exhaust of air from the right-hand end of the cylinder to the exhaust line **46**. With the valve **48** shifted to the left under the influence of the spring **54**, the solenoid **50** being de-energized, the air supply line **44** is connected through a passage **56** in the valve **48** with the line **58** to the right-hand end of the piston-cylinder assembly **42** to drive the piston of the piston-cylinder assembly to the left as seen in FIG. 1. In this position, the left-hand end of the piston-cylinder assembly **42** is connected to a passage **60** in the valve **48** to permit exhaust of air in the left-hand end of the piston-cylinder assembly **42** through the exhaust line **46**.

Flow-control valves **61, 61'** (FIG. 2) control the speed of the piston **43** and prevent shock loads.

An air pressure switch **63** stops the frame from operating if the air pressure in the mill falls below a safe builder operating pressure—usually about 40 pounds per square inch.

The solenoid **50** is shown also in FIG. 3. As that figure shows, the indexing solenoid **50** is energized when contacts CR–1 are closed, inasmuch as the contacts CR–1 and solenoid **50** are in series between lines **62, 64**, across which a D.C. control voltage is applied.



The contacts CR–1 are in turn closed when a builder relay CR is energized. Provision may be made to energize the builder relay at either end of the relative traverse of the feed mechanism or flier **16** and bobbin **30** with respect to each other, but provision is preferably made for energizing the builder relay CR at each end of the relative traverse of the feed mechanism **16** and the bobbin **30** with respect to each other. To this end, the builder relay CR is connected by a pair of normally-open contacts LR–3 to a line **66** and by a pair of normally-closed contacts LR–4 to a line **68**.

The lines **66** and **68** extend between the control-voltage leads **62** and **64** and therefore provide means for energizing the relay coil LR–R and reset coil LR–L, respectively, of a building latching relay **74**. The relay coil LR–R of the latching relay **74** is energized upon closing of a first section **76** of a builder switch **77**, and the reset coil LR–L is energized upon closing of a second section **78** of the builder switch **77**.

The first and second sections **76** and **78** of the builder switch **77** are in turn closed at opposite ends of the relative traverse of the flier **16** and bobbin **30** with respect to each other by contact of first and second contact dogs **80** and **82** with a third contact dog **84** (FIG. 1). The contact dogs **80** and **82** are mounted on builder nuts **86** and **88**, respectively, which are in turn threadedly engaged with a rotatable screw **90** having a lower portion **92** threaded oppositely to an upper portion **94** and a topmost portion **90'** square in cross section so as to be rotatable by a gear train **130**. The nuts **86, 88**, screw **90**, and contact dogs **80, 82** are mounted on support means **96** rigidly retained on a bobbin rail **98** on which is also mounted the bobbin **30**. The bobbin rail **98** is made to reciprocate upwardly and downwardly, so that a relative traverse of length *l* and at velocity *v* of the feed mechanism or flier **16** and bobbin **30** with respect to each other is established. The means for establishing the relative traverse includes a rail lifter **100** having thereon a rack **101** engaged with a train of gears **102** connected to a shaft **104**. The shaft **104** in turn is driven through a reversible clutch mechanism **105** having clutches **106, 107** which are driven respectively by a pair of bevel gears **110, 114**. The gears **110** and **114** rotate in opposite directions with respect to each other, inasmuch as they are coaxial and are driven by a bevel gear **112** in constant engagement with the gears **110, 114** and having its axis normal to the axes of the gears **110, 114**.

As noted above, the gear train **32** is driven by the lower cone pulley **18** at a speed depending on the location of the belt **20**. Inasmuch as the lower cone pulley **18** always turns in the same direction, the gear train **32** and the bevel gears **108, 112** also always turn in the same direction.

Depending on which of the clutches **106, 107** is coupled to the shaft **104** (the other clutch being disengaged from the shaft **104** and free wheeling), the shaft **104** turns in one direction or the other and, through the gear train **102** and the rack **101** and lifter element **100**, reciprocates the bobbin rail **98** and the bobbin **30** upwardly and downwardly. For example, as shown in FIG. 1, energization of the clutch **106** causes the bobbin rail **98** to move downwardly and energization of the clutch **107** causes the rail **98** to move upwardly.

A brake **116** is provided for immobilizing the shaft **104** and hence the bobbin **98** in the event of failure of both clutches, such as might occur during power failure. During normal operation, the brake **116** is electrically held open; under power-off conditions, the brake is spring set.

The clutches **106** and **107** are preferably electrically operated by the circuit shown in FIG. 3. The clutch **107** is energized to cause the bobbin rail **98** to move upwardly when normally-open contacts LR–1 are closed between D.C. leads **118** and **120**. Similarly, the rail-down clutch **106** is energized to move the rail **98** downwardly when

the normally-closed contacts LR–2 are closed between the same two leads **118** and **120**. The current-delay characteristics inherent in the electric reversing clutches insure adequate holding power during rail reversal. Thus. rail "run overs" are eliminated.

All of the contacts LR–1, LR–2, LR–3, and LR–4 are under the control of the builder latching relay **74**. The coils LR–R and LR–L of the latching relay **74** are adapted to be alternately energized, and the latching relay **74** is constructed in such a manner that, regardless of whether the relay coil LR–R or the reset coil LR–L is energized, all four of the contacts LR–1, LR–2, LR–3, and LR–4 are reversed and remain in their new states until energization of the other of the coils LR–R and LR–L. To this end, the contacts LR–1, LR–2, LR–3, and LR–4 are directly attracted by the electromagnet of the relay coil LR–R. Energization of the coil LR–R therefore magnetically moves the contacts LR–1, LR–2, LR–3, and LR–4 to their magnetically-caused states, in which states they are mechanically held by mechanical holding means represented at **121**, regardless of whether the relay coil LR–R remains energized. The electromagnet of the reset coil LR–L does not act directly on the contacts LR–1, LR–2, LR–3, and LR–4 but acts, instead, on the mechanical holding means **121** to release the mechanical holding means **121** and permit the contacts LR–1, LR–2, LR–3, and LR–4 to return to their normal or mechanically-caused states shown in FIG. 3. The holding means **121** provides a memory to prevent the rail **98** from going in the wrong direction on start-up after the frame has been stopped for any reason.

Inasmuch as there are five pairs of contacts LR–1, LR–2, LR–3, LR–4, and CR–1, each adapted to occupy alternately either of two states, there are ten different contact states which need to be separately identified. Also, there are four different times which need to be considered in a traverse cycle: time $t_1$, during which the coil LR–R is energized and the coil LR–L is de-energized; time $t_2$, during which both coils LR–R and LR–L are de-energized; time $t_3$, during which the coil LR–L is energized and the coil LR–R is deenergized; and time $t_4$, during which both coils LR–R and LR–L are de-energized. Times $t_1$ and $t_3$ are of substantially equal duration and times $t_2$ and $t_4$ are of duration substantially equal to each other and substantially exceeding the duration of times $t_1$ and $t_3$. Finally, it is to be noted that the contacts LR–1 in their closed state facilitate the performance of a first function such as energizing the rail-up clutch **107** to cause the rail **98** to move upwardly; the contacts LR–2 in their closed state facilitate the performance of a second function such as energizing the rail-down clutch **106** to cause the rail **98** to move downwardly; and the contacts CR–1 in their closed state facilitate the performance of a third function such as energization of the solenoid **50** to index the guide or shipper **28**.

The operation of the apparatus of the invention will now be readily understood by those skilled in the art. FIG. 3 illustrates the case where the reset coil LR–L was the last to be energized, so that all contacts LR–1, LR–2, LR–3, and LR–4 are shown in their normal or mechanically-caused states. Thus, the contacts LR–2 are closed, energizing the rail-down clutch **106** and causing the bobbin **30** to move downwardly with respect to the flier **16**. At the bottom of the traverse, the contact dogs **82** and **84** (FIG. 1) engage each other, closing the switch **76** shown in FIG. 3. This closing of the switch **76** energizes the relay coil LR–R and reverses all of the contacts LR–1, LR–2, LR–3, and LR–4. The contacts LR–1 are therefore closed, energizing the rail-up clutch, and contacts LR–2 are open, de-energizing the rail-down clutch, so that the rail begins to move up. The delay characteristic referred to above eliminates "run over" of the rail **98** during the reversal of traverse motion. At the same time, the contacts LR–3 close, completing a circuit through the switch **76**, the contacts LR–3, and the builder relay CR.



This causes the contacts CR–1 under the control of the builder relay to close, indexing the indexing solenoid **50**. The indexing of the solenoid **50** shifts the piston of the piston-cylinder assembly **42** in the manner noted above to move the cone guide belt shipper **28** to the right through the gear train **36**, as shown in FIG. 1.

A gear train **130** is actuated by movement of the rack **34** to turn the rod **90** and bring the nuts **86** and **88** closer together to shorten the succeeding traverse. The length $l$ of a given traverse is of course a function of the distance $x$ between the contact dogs **80** and **82**.

When the rail-up clutch **106** has caused the rail **98** to move upwardly sufficiently to disengage the contact dogs **82** and **84** from each other, the switch **76** is opened, so that the relay coil LR–R is de-energized. Because the relay coil **74** is a latching relay the contacts LR–1, LR–2, LR–3, and LR–4 remain in their magnetically-caused states even though the relay coil LR–R is de-energized. The opening of the switch **76** breaks the circuit through the now-closed contacts LR–3 and the builder relay CR, however, so that the relay CR is de-energized, the contacts CR–1 open, and the indexing solenoid **50** returns to its normal position under the urging of the spring **54** (it is to be noted that FIG. 1 shows the valve **48** in its indexing rather than in its normal position). When the valve **48** returns to its normal position, the ratchet **38** free-wheels and does not move the guide or shipper **28** to the left; the shipper accordingly remains in its new position.

At the upper end of the traverse, the contact dogs **80** and **84** make contact with each other, closing the switch **78** and energizing the reset coil LR–L of the building latching relay **74**. This causes reversal of all contacts LR–1, LR–2, LR–3, and LR–4 to their normal positions as shown in FIG. 3 and energizes the rail-down clutch **106** to cause the rail **98** to move downwardly, while again avoiding rail "run over." Also, the closing of the switch **78** actuates the builder relay CR through the contacts LR–4, closes the contacts CR–1, and indexes the indexing solenoid **50** as noted above. When the rail has moved downwardly sufficiently to separate the contact dogs **80** and **84**, the switch **78** is opened, thereby de-energizing the reset coil LR–L. Inasmuch, however, as the relay is a latching relay and all contacts are in their normal or mechanically-caused states, the contacts LR–1, LR–2, LR–3, and LR–4 remain in their new states, even though the reset coil LR–L is de-energized. The opening of the switch **78** also breaks the circuit through the contacts LR–4 and the builder relay CR, so that the relay CR is de-energized, the contacts CR–1 open, and the indexing solenoid **50** returns to its normal position under the urging of the spring **54**. The ratchet **38** again free-wheels, so that the shipper **28** remains in its new position.

A wind-back motor **140** is connected through gearing **142**, a clutch **144**, and a shaft **145** and pinion **146** forming a portion of the gear train **36** to the rack **34** to return the guide **28** and builder nuts **86**, **88** to their starting positions at the end of the package-buiding operation. The clutch **144** is keyed to a shaft **145** by a keyway **148** but movable axially along the shaft by clutch-control means **150**. The clutch **144** is disengaged during the building operation and engaged at the end thereof to eliminate the need for manual rewinding.

The present invention relates only to the subject matter of FIG. 3. It does not relate to the subject matter of FIGS. 1 and 2, which is a separate invention of Ronald C. Mason and William B. Strzelewicz, Jr., and which is disclosed in the present application merely to set forth an exemplary use of which the present invention is capable. Obviously, the subject matter of the present invention coud be used in many other environments. Nor does the present invention relate to the subject matter of FIGS. 1 and 2 in combination with the details of the subject matter of FIG. 3, which is a separate invention by Ronald C. Mason, William B. Strzelewicz, Jr., and Frederick A. Willis, Jr.

Thus, there is provided in accordance with the invention novel and highly-effective means for paying off a filamentary material from a feed mechanism and winding the material onto a bobbin to form a package of the material on the bobbin. The use of a pneumatic piston-cylinder assembly eliminates the harsh, noisy action of the contact shaft and the shock to the skip gear, contact dogs, builder nuts, and contact shaft. The reversing clutches eliminate rail "run overs" during reversal of rail movement by always maintaining positive holding of the rail. The front roll speed may be varied independently of frame speed and may be substantially in excess of 300 rotations per minute, thereby facilitating greater manufacturing efficiency. Further, the machine may be stopped safely in any position of rail travel. Many alternative embodiments within the scope of the invention will readily occur to those skilled in the art. Accordingly, the invention is to be construed as including all of the modifications thereof which fall within the scope of the appended claims.

I claim:

1. In apparatus for performing first, second, and third functions, the improvement comprising first and second relay coils, first, second, third, and fourth pairs of contacts governed by the first and second coils, a control relay coil, the first pair of contacts being adapted alternately to occupy first and second states and being caused to occupy the first state on energization of the first coil and the second state on energization of the second coil, the second pair of contacts being adapted alternately to occupy third and fourth states and being caused to occupy the third state on energization of the first coil and the fourth state on energization of the second coil, the third pair of contacts being adapted alternately to occupy fifth and sixth states and being caused to occupy the fifth state on energization of the first coil and the sixth state on energization of the second coil, and the fourth pair of contacts being adapted alternately to occupy seventh and eighth states and being caused to occupy the seventh state on energization of the first coil and the eighth state on energization of the second coil, and the first, second, third, and fourth pairs of contacts being prevented from changing states when both the first coil and the second coil are de-energized, the first pair of contacts in its first state facilitating performance of the first function, the second pair of contacts in its fourth state facilitating performance of of the second function, the third pair of contacts in its fifth state facilitating energization of the control relay coil, and the fourth pair of contacts in its eighth state facilitating energization of the control relay coil, and a fifth pair of contacts adapted alternately to occupy ninth and tenth states and being caused to occupy the ninth state on energization of the control relay coil and the tenth state on de-energization of the control relay coil, one of the ninth and tenth states facilitating performance of the third function, and means to effect energization and de-energization of said first and second relay coils, said first and second relay coils being connected in circuit with said means, and said control relay coil being connected in circuit with said third and fourth pairs of contacts and said means.

2. Apparatus as recited in claim 1 in which said means alternately energized the first and second coils.

3. In apparatus for performing first, second, and third functions, the improvement comprising first and second relay coils, first, second, third, and fourth pairs of contacts governed by the first and second coils, a control relay coil, the first pair of contacts being adapted to occupy alternately closed and open states and being caused to occupy the closed state on energization of the first coil and the open state on energization of the second coil, the second pair of contacts being adapted to occupy alternately open and closed states and being caused to occupy the open state on energization of the first coil and the closed state on energization of the second coil, the third pair of contacts being adapted to occupy alternately closed and open states and being caused to occupy the closed state on energization of the first coil and the open state on energization of the second coil, and the fourth pair of contacts being adapted to occupy alternately open and closed states and being caused to occupy the open state on energization of the first coil and the closed state on energization of the second coil, the first, second, third, and fourth pairs of contacts being prevented from changing states when both the first coil and the second coil are deenergized, the first pair of contacts in its closed state facilitating performance of the first function, the second pair of contacts in its closed state facilitating performance of the second function, the third pair of contacts in its closed state facilitating energization of the control relay coil, and the fourth pair of contacts in its closed state facilitating energization of the control relay coil, and a fifth pair of contacts adapted alternately to occupy open and closed states and caused to occupy the open state on de-energization of the control relay coil and the closed state on energization of the control relay coil, the closed state of the fifth pair of contacts facilitating performance of the third function, and means to effect energization and de-energization of said first and second relay coils, said first and second relay coils being connected in circuit with said means, and said control relay coil being connected in circuit with said third and fourth pairs of contacts and said means.

4. Apparatus as recited in claim 3 in which said means energizes and de-energizes the first and second relay coils in a cycle comprising four consecutive time intervals $t_1$, $t_2$, $t_3$, and $t_4$, the first coil being energized and the second coil de-energized during time $t_1$, both the first and second coils being de-energized during time $t_2$, the second coil being energized and the first coil de-energized during time $t_3$, and both the first and second coils being de-energized during time $t_4$.

5. Apparatus as recited in claim 4 in which times $t_1$ and $t_3$ are of substantially equal duration and times $t_2$ and $t_4$ are of duration substantially equal to each other and substantially exceeding the duration of times $t_1$ and $t_3$.

6. In apparatus for performing first, second, and third functions, the improvement comprising first and second relay coils, first, second, third, and fourth pairs of contacts governed by the first and second coils, a control relay coil, the first pair of contacts being adapted alternately to occupy first and second states and being magnetically caused to occupy the first state on energization of the first coil and mechanically caused to occupy the second state on energization of the second coil, the second pair of contacts being adapted alternately to occupy third and fourth states and being magnetically caused to occupy the third state on energization of the first coil and mechanically caused to occupy the fourth state on energization of the second coil, the third pair of contacts being adapted alternately to occupy fifth and sixth states and being magnetically caused to occupy the fifth state on energization of the first coil and mechanically caused to occupy the sixth state on energization of the second coil, and the fourth pair of contacts being adapted alternately to occupy seventh and eigth states and being magnetically caused to occupy the seventh state on energization of the first coil and mechanically caused to occupy the eighth state on energization of the second coil, and the first, second, third, and fourth pairs of contacts being mechanically prevented from changing states when both the first coil and the second coil are de-energized, the first pair of contacts in its first state facilitating performance of the first function, the second pair of contacts in its fourth state facilitating performance of the second function, the third pair of contacts in its fifth state facilitating energization of the control relay coil, and the fourth pair of contacts in its eighth state facilitating energization of the control relay coil, and a fifth pair of contacts adapted alternately to occupy ninth and tenth states and being caused to

occupy the ninth state on energization of the control relay coil and the tenth state on de-energization of the control relay coil, one of the ninth and tenth states facilitating performance of the third function, and means to effect energization and de-energization of said first and second relay coils, said first and second relay coils being connected in circuit with said means, and said control relay coil being connected in circuit with said third and fourth pairs of contacts and said means.

7. In apparatus for performing first, second, and third functions, the improvement comprising first and second relay coils, first, second, third, and fourth pairs of contacts governed by the first and second coils, a control relay coil, the first pair of contacts being adapted to occupy alternately closed and open states and being magnetically caused to occupy the closed state on energization of the first coil and mechanically caused to occupy the open state on energization of the second coil, the second pair of contacts being adapted to occupy alternately open and closed states and being magnetically caused to occupy the open state on energization of the first coil and mechanically caused to occupy the closed state on energization of the second coil, the third pair of contacts being adapted to occupy alternately closed and open states and being magnetically caused to occupy the closed state on energization of the first coil and mechanically caused to occupy the open state on energization of the second coil, and the fourth pair of contacts being adapted to occupy alternately open and closed states and being magnetically caused to occupy the open state on energization of the first coil and mechanically caused to occupy the closed state on energization of the second coil, the first, second, third, and fourth pairs of contacts being mechanically prevented from changing states when both the first coil and the second coil are de-energized, the first pair of contacts in its



closed state facilitating performance of the first function, the second pair of contacts in its closed state facilitating performance of the second function, the third pair of contacts in its closed state facilitating energization of the control relay coil, the fourth pair of contacts in its closed state facilitating energization of the control relay coil, a fifth pair of contacts adapted alternately to occupy open and closed states and caused to occupy the open state on de-energization of the control relay coil and the closed state on energization of the control relay coil, the closed state of the fifth pair of contacts facilitating performance of the third function, and means to effect energization and de-energization of said first and second relay coils, said first and second relay coils being connected in circuit with said means, and said control relay coil being connected in circuit with said third and fourth pairs of contacts and said means, said means energizing and de-energizing the first and second coils in a cycle comprising four consecutive time intervals $t_1$, $t_2$, $t_3$, and $t_4$, the first coil being energized and the second coil de-energized during time $t_1$, both the first and second coils being de-energized during time $t_2$, the second coil being energized and the first coil de-energized during time $t_3$, and both the first and second coils being de-energized during time $t_4$, times $t_1$ and $t_3$ being of substantially equal duration, and times $t_2$ and $t_4$ being of duration substantially equal to each other and substantially exceeding the duration of times $t_1$ and $t_3$.

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