July 28, 1925. 1,547,274

R. VARLEY

WINDING MACHINE

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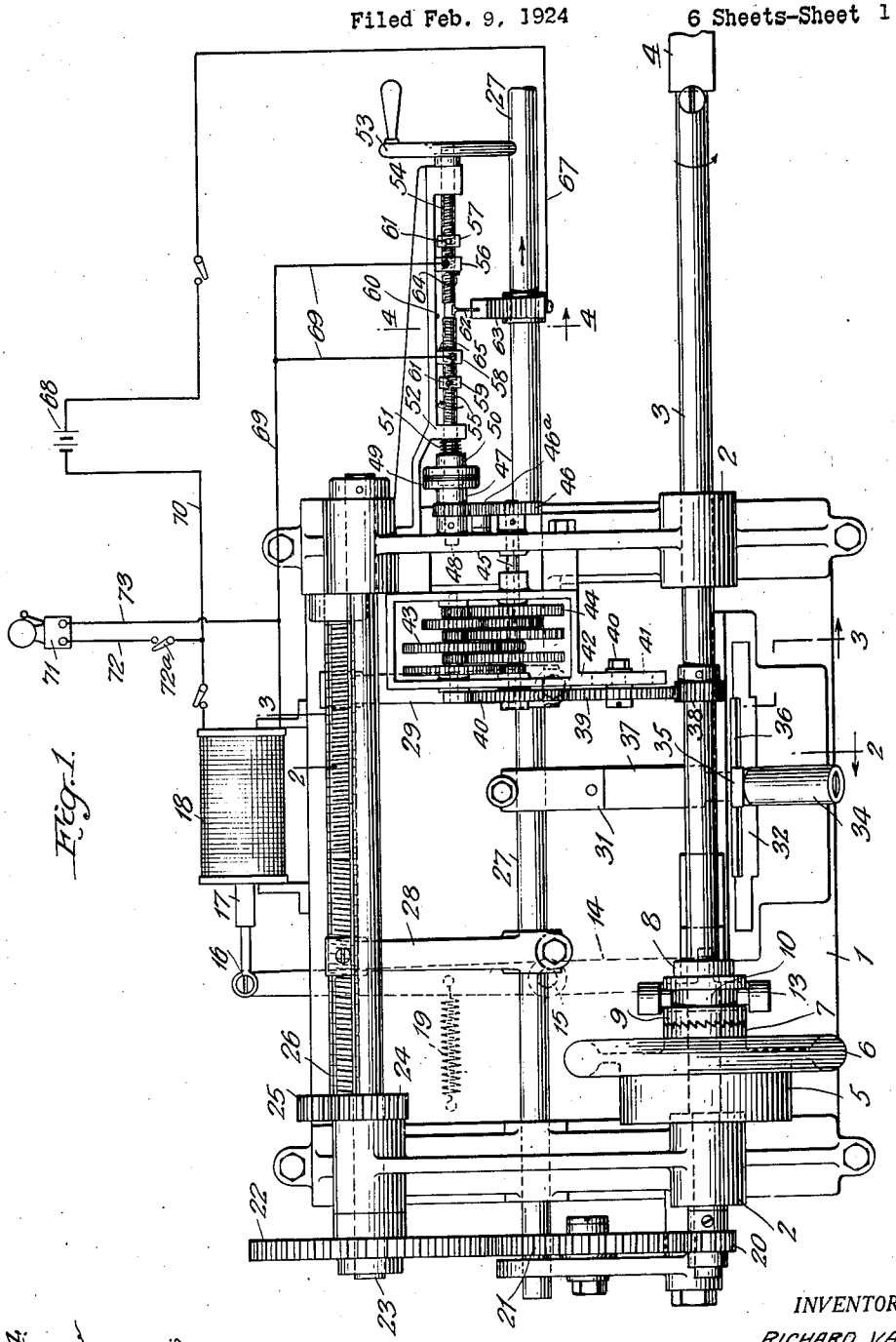


Fig. 1.

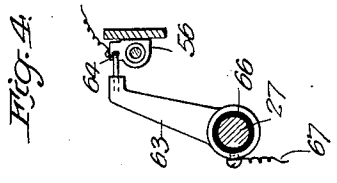


Fig. 4.

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Fig. 2.

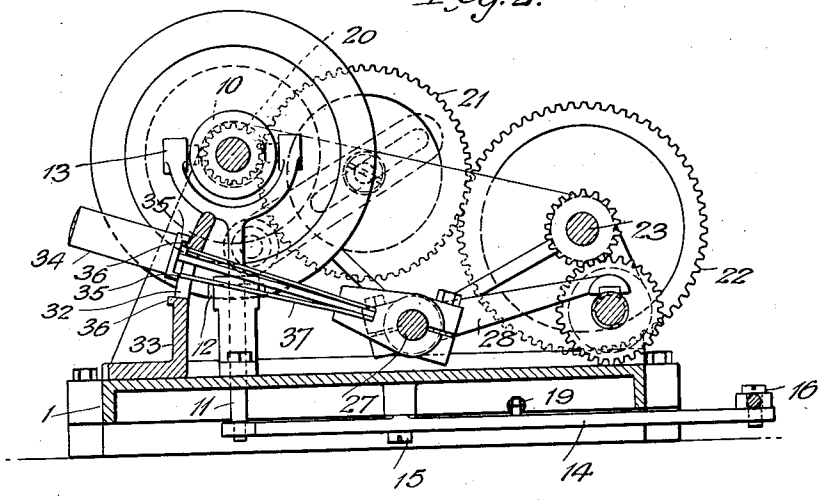


Fig. 6.

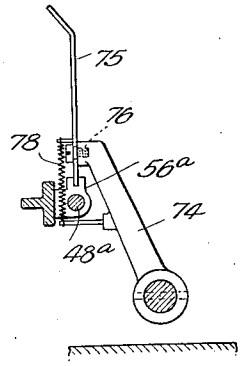


Fig. 3

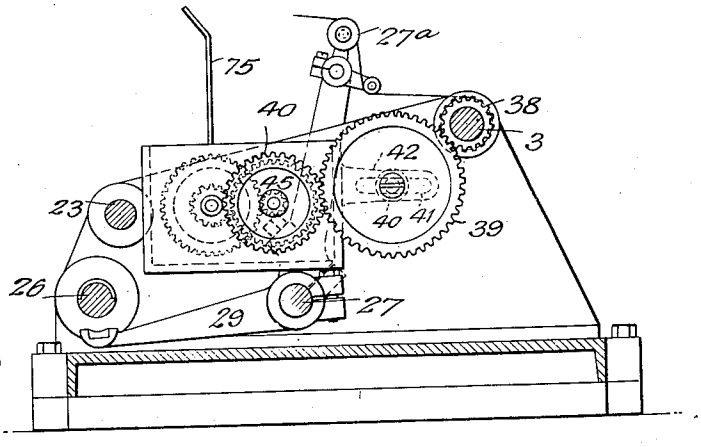
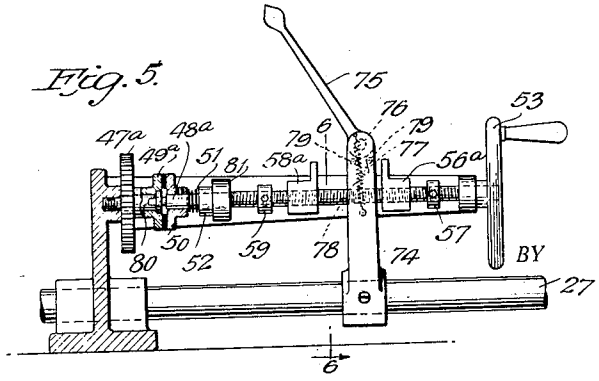


Fig. 5.



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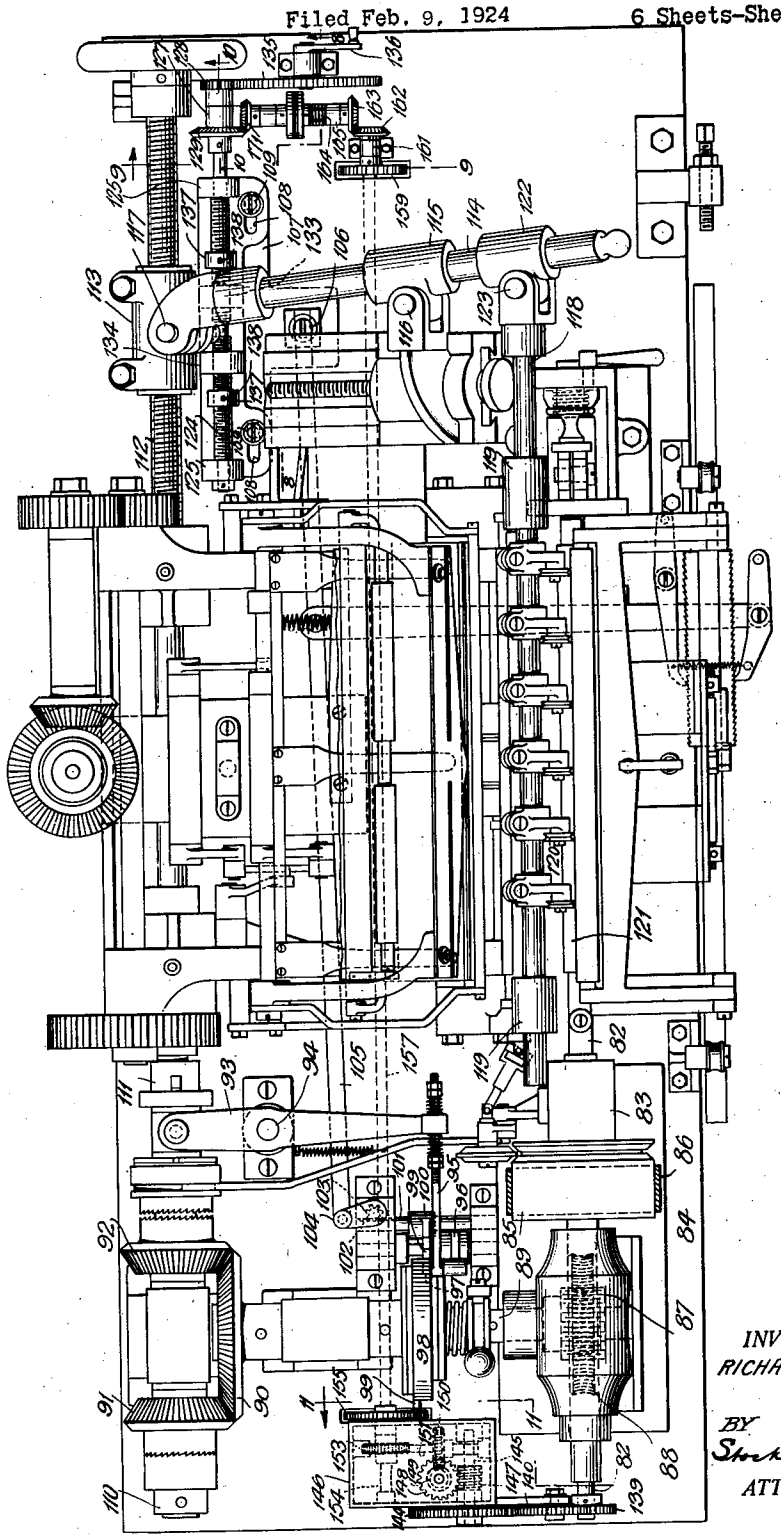


Fig. 7.

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Fig. 8.

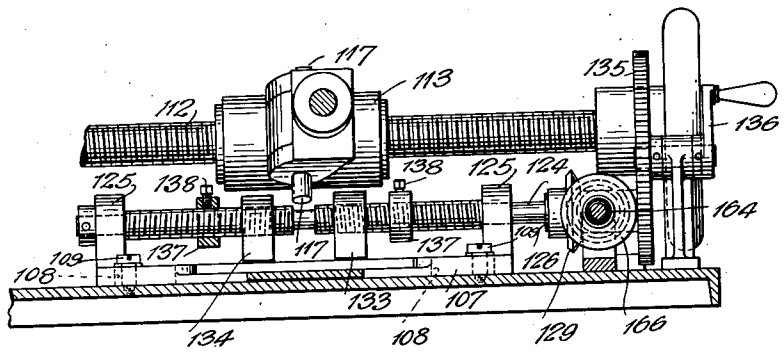


Fig. 9.

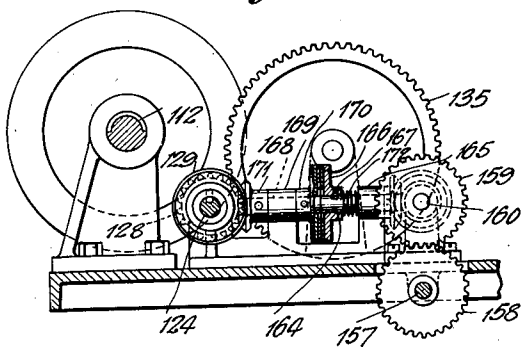


Fig. 10.

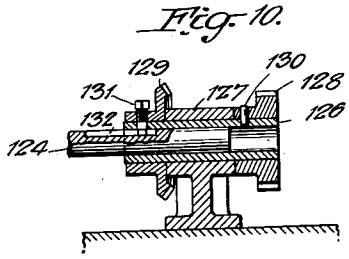
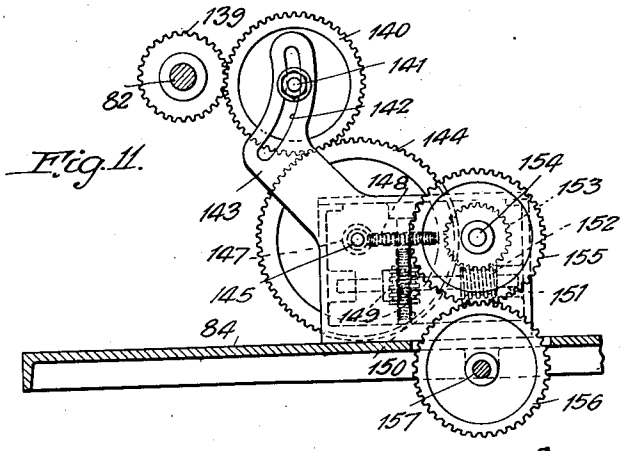


Fig. 11.



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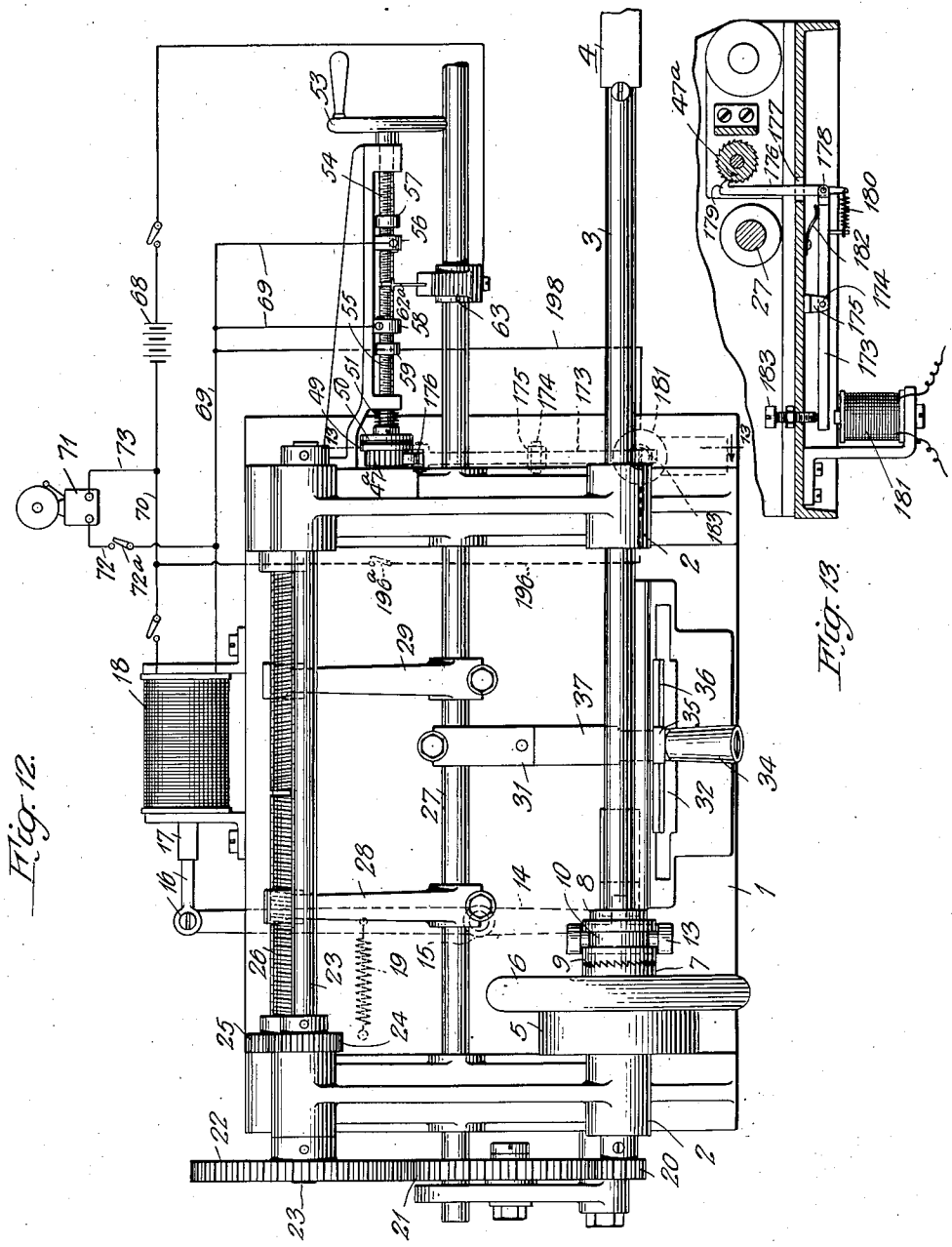


Fig. 12.

Fig. 13.

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WINDING MACHINE

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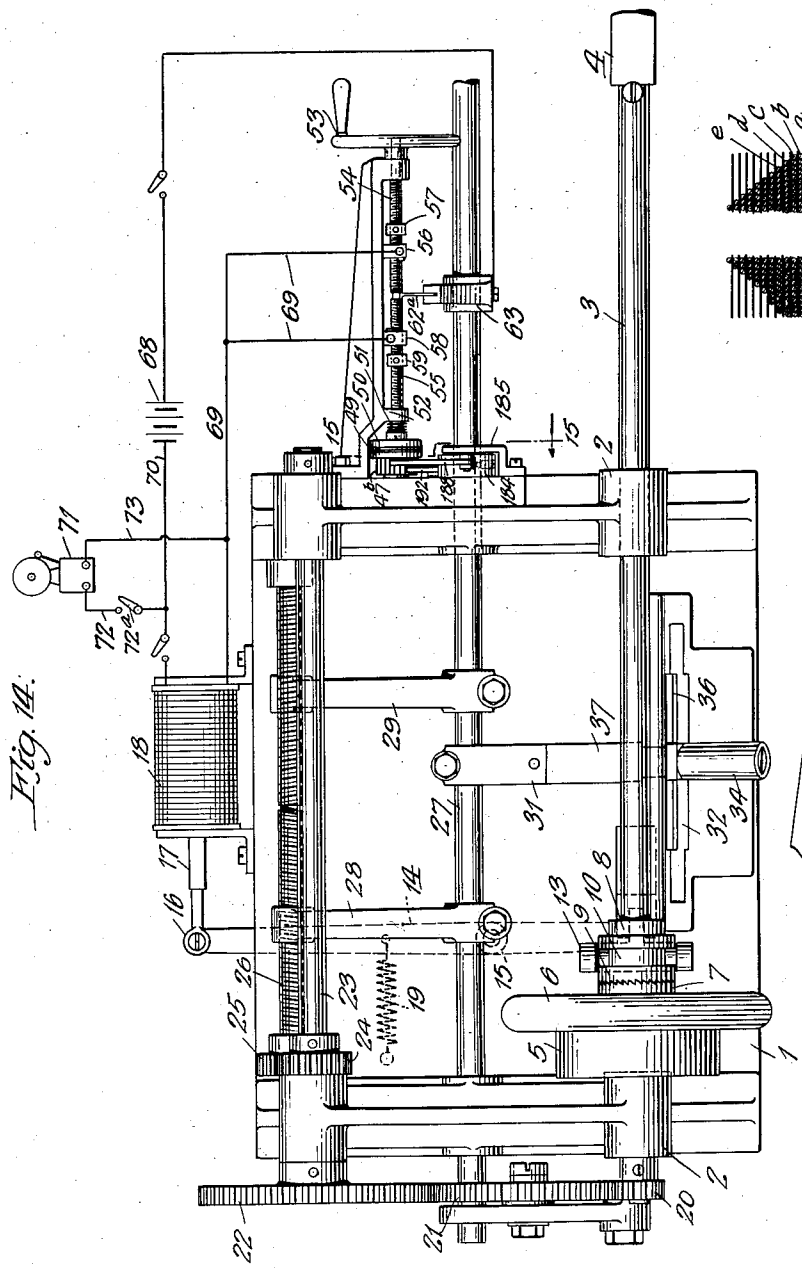


Fig. 14.

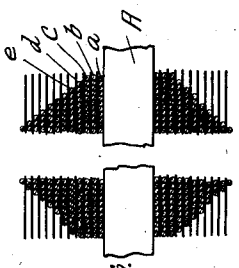


Fig. 16.

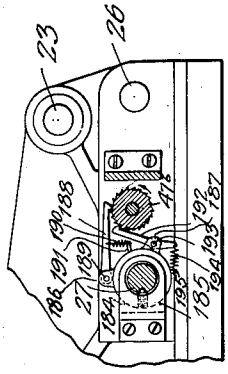


Fig. 15.

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Patented July 28, 1925. 1,547,274

UNITED STATES PATENT OFFICE.

RICHARD VARLEY, OF ENGLEWOOD, NEW JERSEY, ASSIGNOR TO VARLEY DUPLEX MAGNET COMPANY, A CORPORATION OF NEW JERSEY.

WINDING MACHINE.

Application filed February 9, 1924. Serial No. 691,613.

To all whom it may concern:

Be it known that I, RICHARD VARLEY, a citizen of the United States, residing at Englewood, in the county of Bergen and State of New Jersey, have invented certain new and useful Improvements in Winding Machines, of which the following is a full, clear, and exact description.

This invention relates to machines for winding strands of material, such as wire, thread, ribbon or filaments into coils, helices or bobbins, more particularly to machines for winding copper wire into coils or helices whose successive layers are progressively shorter and which are known as pyramid coils. The invention has to do with the mechanism of such machines for assisting or determining the operations of winding, by which the progressive shortening of the layers is effected. An object of the invention is to provide an improved machine of this type, with which the winding of such coils or helices with progressively shorter layers may be facilitated, and which will be comparatively simple, convenient, rapid and relatively inexpensive. Various other objects and advantages will be apparent from the following description of several embodiments of the invention, and the novel features will be particularly pointed out hereinafter in claims.

In the accompanying drawings:

Fig. 1 is a plan of a simple winding machine constructed in accordance with the invention;

Fig. 2 is a transverse sectional elevation of the same taken substantially along the line 2—2 of Figure 1;

Fig. 3 is another transverse sectional elevation of the same taken substantially along the line 3—3 of Figure 1;

Fig. 4 is a sectional elevation of a portion of the machine, the section being taken substantially along the line 4—4 of Figure 1;

Fig. 5 is an elevation of a portion of the machine illustrated in Figure 1, showing certain modifications therein;

Fig. 6 is a transverse sectional elevation of the same taken substantially along the line 6—6 of Figure 5;

Fig. 7 is a plan of another type of winding machine which is also constructed in accordance with the invention;

Fig. 8 is a front sectional elevation of a portion of the same taken substantially along the line 8—8 of Figure 7;

Fig. 9 is a transverse sectional elevation through a portion of the same taken substantially along the line 9—9 of Figure 7;

Fig. 10, is a front sectional elevation through a portion of the same taken substantially along the line 10—10 of Figure 7;

Fig. 11 is a transverse sectional elevation through another part of the machine, taken substantially along the line 11—11 of Figure 7;

Fig. 12 is a plan of a simple winding machine of the type shown in Figure 1, with certain modifications therein;

Fig. 13 is a transverse sectional elevation through a portion of the same taken substantially along the line 13—13 of Figure 12;

Fig. 14 is a plan of a simple winding machine similar to that shown in Figures 1 and 12 but with still further modifications therein;

Fig. 15 is a transverse sectional elevation through a portion of the same taken substantially along the line 15—15 of Figure 14; and

Fig. 16 is a section through a coil which may be wound upon any of the machines herein disclosed.

Referring particularly to Figures 1 to 4, the winding machine comprises a frame 1 having bearings 2 for rotatably supporting a winding spindle or shaft 3, which passes through and between the bearings and is adapted to detachably support a winding form or core 4. A pulley 5 which may be driven by a belt from any suitable source of power, not shown, is provided with a hand wheel 6 and with a clutch face 7. The pulley is confined upon the spindle against endwise movement thereon in any suitable manner, not shown, such as by a pin on the hub of the pulley running in an annular groove in the spindle.

A clutch element 8 is keyed to the spindle 3 for rotation therewith and sliding movement therealong, and is provided with a clutch face 9 co-operating with the clutch face 7 to effect the driving connection between the pulley and the spindle. The clutch element 8 is provided with an an-

nular groove 10, and an operating lever 11, pivoted intermediate its ends as at 12 (see Figure 2), is provided at its upper end with forked arms 13 which embrace the clutch element 8 and carry pins which run in the annular groove 10 thereof. When the lever 11 is rocked about its pivot 12, the clutch element 8 will be carried either into or out of clutching engagement with the pulley 5, thus connecting or disconnecting the spindle and driving pulley.

A lever 14 is pivoted at 15 upon the lower face of the frame 1, at one end is forked to receive and operate the lower end of the lever 11, and at its other end is connected by a pivot 16 to the solenoid core 17 of a solenoid 18. When the solenoid is energized, it will draw the core 17 therein and rock the lever 14 about its pivot, and thus rock the lever 11 in a direction to disengage the clutch element 8 from the driving pulley 5 and interrupt the driving connection from the pulley 5 to the winding spindle 3. A spring 19 is connected between the lever 14 and the frame 1 for rocking the lever 14 in a direction to couple the winding spindle to the driving pulley whenever the solenoid 18 is de-energized.

A pinion 20 on the winding spindle 3 is geared through an idler 21 to a gear 22, carried by a shaft 23, and a pinion 24 on the shaft 23 meshes with and drives a gear 25 fixed to a shaft 26 which extends substantially parallel with the winding spindle 3. The shaft 26 is provided with screw threads, a part of which at one end are right hand threads and the others at the other end are left hand threads. A traverse rod 27 is rotatably and slidably mounted in bearings carried by the frame 1 in a position substantially parallel with the winding spindle 3, and between it and the threaded shaft 26. The traverse rod 27 carries suitable pulleys 27^a (see Fig. 3) which serve to guide one or more strands of wire from supply spools or bobbins to the winding form 4 upon the winding spindle.

A pair of arms 28 and 29 are adjustably fixed upon the traverse rod 27 adjacent the threaded shaft 26, and each carries a half nut or its equivalent 30, which is adapted to engage with the screw threads on the shaft 26 when the arms are rocked into engagement with the threaded shaft. The arms 28 and 29 extend upon opposite sides of the shaft 26 with sufficient clearance to allow a slight rocking movement of the rod 27 in order to carry one of the arms into engagement with the threaded shaft while carrying the other out of engagement therewith. The arms 28 and 29 are spaced apart longitudinally along the traverse rod 27, so that one of them will engage with the right hand threads when rocked into engagement with this shaft.

An arm 31 is fixed to the traverse rod 27 and extends forwardly through a slot 32 in an upstanding frame plate 33, the slot 32 being of a length sufficient to allow lengthwise travel of the arm with the traverse rod and of a width sufficient to permit a rocking of the traverse rod to engage the arms 28 and 29 alternately with the threaded shaft 26. A handle 34 is provided upon the outer end of the arm 31 and confined thereon by a suitable spring (not shown) within the handle so that the handle may be pulled outwardly to a limited extent and when released will be pulled against the outer face of the plate 33.

The handle 34 is provided at its inner end with hooks 35 which are adapted to snap over rails 36 upon the upper and lower edges of the slot 32 for holding the arm 31 in either its upper or lower position while permitting it to move endwise along the slot with the traverse rod. Leaf springs 37 are carried by the arm 31 upon the upper and lower faces thereof and diverge from the outer end of the arm within the slot 32 for yieldingly urging the arm to a central vertical point in the slot 32 when released. This serves to prevent rattling of the arm when it is in either its upper or lower positions.

A pinion 38 is fixed upon the spindle 3 and meshes with an idler 39 mounted upon a pivot 40 which is adjustable in the slot 41 of the gear frame 42 that is mounted upon the main frame 1. The gear 39 meshes with and drives a gear 40 which is rotatably carried by the gear frame 42. The gear 40 is connected to and drives one end of a reduction gear train 43, at the other end of which is a gear 44 mounted on and driving a shaft 45. The shaft 45 carries a gear 46 that meshes with and drives an idler 46^a, in turn driving a gear 47 which is rotatably mounted upon a shaft 48 extending substantially parallel with the traverse rod 27. The gear 47 is provided with a friction clutch face or head 49, and cooperates with a friction head 50 which is keyed to the shaft 48 for rotation therewith and endwise movement therealong. The head 50 is pressed into contact with the friction head 49 by a helical spring 51 which is compressed between a bearing 52 for the shaft 48 and the friction head 50. The heads 49 and 50 provide a frictional driving connection between the gear 47 and the shaft 48. A hand wheel 53 fixed upon the shaft 48 enables its manual operation during which the frictional clutch head 50 will slide over the face of the clutch head 49.

A part of the shaft 48 is screw threaded with right hand threads 54, and another part is provided with left hand screw threads 55. Nuts 56 and 57 are threaded upon the section of the shaft 48 having the right hand screw threads 54, and nuts 58 and 59 are threaded upon the other threaded

section of the shaft 48. The two nuts 56 and 58 are held against rotation by an abutting wall 60 which extends parallel with the shaft 48 and engages with a flat peripheral surface on these nuts, so that when the shaft is rotated, the nuts will move either toward one another or separate, depending upon the direction of rotation of the shaft. The nuts 57 and 59 are not restricted in their rotation upon the shaft by reason of the wall 60, but may be secured to the shaft for rotation therewith in any adjusted position by suitable means, such as set screws 61. The two nuts 57 and 59 serve to limit the separation of the nuts 56 and 58 and may thus be adjusted along the shaft 48 to different extents so as to limit the separation of the nuts 56 and 58. In reality, but one nut 57 or 59 is necessary, since the engagement of one of the nuts 56 or 58 therewith will stop rotation of the shaft as effectively as both. A contact member 62 is carried by an arm 63, mounted upon the traverse rod 27 so as to move with the traverse rod 27 alternately toward the screws 56 and 58. When the arm 28 is in engagement with the threaded shaft 26 and the machine is operating, the traverse rod 27 will be carried toward the left in Figure 1 and carry the contact member 62 toward the nut 58. When the traverse rod is rocked in the opposite direction to carry the arm 29 into contact with the shaft 26, the traverse rod will be operated by the screw shaft 26 to the right in Figure 1, and carry the contact member 62 toward the nut 56.

The faces of the nuts 56 and 58 toward which the contact member 62 moves, are provided with contact abutments 64 and 65, respectively, which are arranged in different angular positions about the axis of the shaft 48 for a purpose to appear presently. The arm 63 is insulated by a bushing 66 (see Fig. 4) from the traverse rod 27 and a conductor 67 connects the arm 63 with one terminal of a battery or other source of electrical energy 68. The nuts 56 and 58 are connected by wires 69 to one terminal of the solenoid 18, the other terminal of the solenoid being connected by a wire 70 to the other terminal of the battery or source of energy. An audible signal 71 is connected by wires 72 and 73 to the conductors 79 and 69, respectively, so that whenever the solenoid is energized the audible signal will be active. A switch 72ª may be provided in one of the circuit wires, such as 72, so that the audible signal may be incapacitated if desired independently of the solenoid circuit.

When the traverse rod 27 is moving toward the left in Figure 1, by the engagement of the arm 28 with the shaft 26, the contact member 62 will move within the path of the abutment 65 on the nut 58, so that when the contact member strikes the abutment, an electrical circuit will be closed between the conductors 67 and 69 which completes the circuit through the battery, the solenoid, and the audible signal. The solenoid when energized operates the clutch between the driving pulley 5 and the winding spindle, and stops the rotation of the winding spindle. At the same time the audible signal by its operation will indicate to the attendant that the machine has been stopped at the end of a layer of wire. Since the shaft 26, which causes movement of the traverse rod, is geared to the winding spindle the cessation of rotation of the spindle will cause a cessation of rotation of the shaft 26, and therefore stop the movement of the traverse rod. With the parts in the position shown in Figure 1, the arm 28 will be in contact with the threaded shaft 26 and the traverse rod 27 will move toward the left until the contact finger 62 engages the abutment 65 of the nut 58 and completes the circuit through the solenoid to disconnect the spindle 3 from the pulley 5. The handle 34 is then pulled outwardly by the attendant to release it from the upper rail, whereupon the arm 31, controlled by the handle 34 is rocked downwardly, and the handle 34 hooked over the lower rail 36. During this downward movement of the handle, the traverse rod will be rocked in a direction to carry the arm 28 out of contact with the threaded shaft 26, and the arm 29 into contact with the threaded shaft 26. During this rocking movement of the traverse rod, the contact 62 will be rocked in a similar manner so as to move sidewise out of contact with the abutment 65 and open the circuit to the solenoid. The spring 19 will thereupon operate the lever 14 to connect the spindle 3 with the driving pulley 5.

The winding spindle will now be driven further, and the traverse rod will be operated in the reverse direction to form another layer upon the winding form 4, superposed upon the preceding layer, and this action will continue until the contact finger 62 engages with the abutment 64 of the nut 56, whereupon the circuit will again be completed through the solenoid and a disconnection of the winding spindle 3 from its driving pulley 5 effected. The handle 34 may then be operated to its upper position rocking the traverse rod 27 to carry the arm 28 into contact with the shaft 26, and the arm 29 out of contact therewith. During this last movement the contact member 62 will rock with the traverse rod laterally of the abutment and out of contact therewith, so as to open the circuit to the solenoid and permit of the restarting of the winding spindle. It will thus be observed that the abutments 64 and 65 are not in alignment,

but are in different angular positions about the axis of the shaft 48, and the contact member 62 is rocked with the traverse rod into different paths of travel.

Inasmuch as the screw shaft 48 is driven through a reduction train 43 from the winding spindle, it will be rotated at a very slow rate. This will cause a slow approach of the nuts 56 and 58, and the travel of the traverse rod in forming the successive superposed layers will be progressively reduced. The result will be that successive layers will be shorter than the preceding ones, and the ends of the coils thus formed will taper backwardly. Such a coil is illustrated in Fig. 16. Upon the completion of the coil and the substitution of a new winding form, the attendant may reset the nuts 56 and 58 by merely operating the hand wheel 53 in a direction reverse to that in which it is rotated by the reduction gear train, and this is possible at a rapid rate owing to the slippage between the friction clutch members 49 and 50. This reverse rotation is continued until the nuts 56 and 58 engage with the nuts 57 and 59, which are secured upon the shaft and serve as limit stops. These stops may, of course, be adjusted to determine the initial limits of the layers of wire to be laid upon the winding form.

By changing the gears 39 and 40 the driving ratio between the winding spindle and the reduction train 43 may be readily varied to some extent, and the adjustable pivot 40 enables the change in the ratio of the gears 39 and 40 to be made. It is frequently desirable to make several initial layers of the coil of equal length, and then to start the shortening of the layers progressively. To effect this, it is merely necessary for the attendant to hold the hand wheel 53 from rotation during the formation of the first few layers which it is desired to form without changes in their length and then when the hand wheel is released the windings will be tapered in the desired manner. When the hand wheel 53 is held, slippage will occur between the members 49 and 50, so that the screw shaft 48 will not be rotated during the formation of the first few layers which will be of the same length, and then when the hand wheel is released the screw shaft will be rotated at the reduced rate for shifting the layer control nuts 56 and 58 toward one another at the desired rate.

By varying the gear ratio between the gears 39 and 40 one can vary to some extent the ratio between the rate of rotation of the screw shaft 48 and the winding spindle, which will vary the rate of tapering of the ends of the coil, that is vary the rate at which the successive layers will be shortened. It will be noted that the audible signal 71 will operate each time the winding operation is stopped at the end of each layer, and will continue to operate until the attendant has reset the machine for the formation of a new layer by the operation of the handle 34. If desired, the switch 72^a may be operated to silence the audible signal.

In Figures 5 and 6, a slight modification of the machine just described is illustrated. Instead of the electrical operation of the clutch between the winding spindle and its operating spindle, the arm 63 and the contact member 62 are replaced by an arm 74 fixed on the traverse rod. An indicating hand 75 is pivoted to the outer end of the arm 74 and has a tail piece or arm 77 which depends between the nuts 56^a and 58^a, corresponding to the nuts 56 and 58 of the machine shown in Figure 1. A spring 78 is connected between the hand 75 and the arm 74 so that when the hand 75 is in a vertical position the spring will intersect the axis of the pivot 76. When shifted to either side, the spring will tend to continue its rotation of the hand in that direction, this rotation being limited in both directions by pins 79 provided upon the arm 74 within the path of the depending arm 77 of the indicating hand.

As the traverse rod moves in either direction, the arm 77 depending from the indicating hand will engage with one of the nuts 56^a or 58^a, and continued movement in the same direction will cause a movement of the indicating hand past its vertical position, whereupon the spring 78 will snap the hand in the same direction to its limit of movement. This movement of the hand serves as a visual indication to the attendant that the end of the layer has been reached, and that the machine should be stopped and the travel of the traverse rod reversed by a manipulation of the handle 34.

When the indicating hand is snapped ahead in the direction in which it is moving at any time, the depending arm 77 will move away from the nut actuating it, and thus provide a slight clearance before the hand will be again engaged by the nut. There is therefore a slight interval after the operation of the indicating hand in which the operator or the attendant must stop the machine or effect a reversal of the travel of the traverse rod, to avoid danger of injury to the indicating hand. During the formation of the successive layers of the coil, the nuts 56^a and 58^a will be moved toward one another so as to shorten the travel of the traverse rod before the hand wheel indicates that a layer has been completed. The nuts may be reset in the same manner as in the machine shown in Figure 1.

In Figures 5 and 6, the gear 47^a and its clutch head 49^a are illustrated as rotatably mounted upon a stub shaft or pivot screw 80, which is aligned with the end of the screw

shaft 48ª corresponding to the screw shaft 48 of the machine of Figure 1. A collar 81 fixed upon the shaft 48ª upon one side of a bearing 52 thereof will limit endwise movement of the shaft in one direction, and the placing of the hand wheel upon the other end of the shaft abutting another bearing of the shaft will limit endwise movement of the shaft in the opposite direction.

In Figures 7 to 11 the invention is embodied in a somewhat different type of winding machine which is automatic in action. The particular machine illustrated is of the same general character as those set forth in U. S. Patents #654,538 issued July 31, 1900, #1,368,536 issued Feb. 15, 1921 and #1,427,509 issued August 29, 1922, also disclosed in the copending application of Bernard F. Johnson Serial No. 640,696 filed May 22nd 1923. In this type of machine the spindle shaft 82 is rotatably supported in a bearing 83 carried by the main frame 84, and carries a pulley 85 which is driven by a belt 86 from any suitable source of power (not shown). A worm 87 on the shaft 82 meshes with and drives a worm wheel 88 carried by a shaft 89, and the shaft 89 carries a bevel gear 90 which meshes with and drives a pair of oppositely disposed bevel gears 91 and 92 forming part of a reverse clutch mechanism that is controlled by a clutch lever 93.

The clutch lever 93 is pivoted at 94, intermediate of its ends, and has a resilient connection to a link 95 connected to a lever 96 and having a cam pin 97 running in a cam groove (not shown) formed in a cam plate 98. The cam plate is mounted on and frictionally driven by the shaft 89. The cam groove of the plate 98 is adapted to reciprocate the link 95 in one direction during half a revolution of the cam plate, and in the opposite direction during the other half. The cam plate is provided with peripherally disposed escapement teeth 99, which cooperate with an escapement pawl 100 carried by a slidable shaft 101. The shaft 101 when moved endwise will move the pawl 100 out of the path of one of the escapement teeth 99 and into the path of the other, and since the teeth 99 are disposed substantially diametrically of the plate 98, the cam plate 98 will be released for approximately half a revolution for each endwise movement of the pawl 100 with the shaft 101.

The shaft 101 is provided with rack teeth 102 which mesh with a small pinion 103 connected to and rotating with a crank arm 104. The arm 104 is pivotally connected to a link 105 which extends along the machine to approximately the opposite end where it is connected by a pivot 106 to a plate 107 sliding upon the frame 84 of the machine. The plate 107 is provided with parallel slits 108, through which pins 109 pass into the frame 84 and guide the plate 107 for a limited endwise movement. Therefore, at each endwise movement of the plate 107, the direction of rotation of the shaft 110, to which the gears 91 and 92 may be alternately clutched by an operation of the lever 93, will be reversed. The shaft 110 is connected through a coupling 111 to a threaded shaft 112, upon which a follower 113 is mounted by a screw threaded connection, so that the follower will move in one direction or the other along the shaft 112, depending upon the direction of rotation of the shaft.

A lever 114 is slidable in a sleeve 115 which is pivotally mounted at 116 upon the frame of the machine. One end of the lever 114 is connected by a pivot 117 to the follower 113, so that as the follower moves along the shaft 112 the lever 114 will be rocked about the pivot 116, the sleeve 115 permitting of a slight endwise movement of the lever 114 required, owing to the fact that the follower 113 does not move in an arc having its center of curvature at the pivot 116. A traverse rod 118 is mounted for sliding movement in bearings 119 on the frame, and disposed parallel with and in close proximity to the winding spindle 82.

This traverse rod 118 carries suitable wire guides 120 for directing the wires or filaments to a winding form 121 mounted on and driven from the winding spindle 82. When the traverse rod moves endwise in its bearings, the guiding devices 120 will move endwise along the winding form and cause the wire guided thereto to be laid upon the form in helical layers. A sleeve 122 is pivoted at 123 to one end of the traverse rod 118, and the lever 114 passes through the sleeve 122 so that when the lever 114 is rocked it will cause a reciprocation of the traverse rod.

A threaded shaft 124 is rotatably mounted in bearings 125 provided upon the plate 107. One end of the shaft 124 extends into a sleeve 126 (Fig. 10) which is rotatably mounted in a bearing 127 on the machine frame. Gears 128 and 129 are fixed, by a pin 130 and a screw 131 respectively, to the sleeve at opposite sides of the bearing 127, so that two gears will rotate in unison with the sleeve 126 and will be held against endwise movement in the bearing 127 by the engagement of the gears with the opposite ends of the bearing. The screw 131 is extended through the sleeve into a keyway 132 provided in the shaft 124, so that the shaft will be keyed to the sleeve and the two gears carried thereby. The shaft 124 is thus capable of endwise movement with the plate 107 without interrupting its driving connection with the gears 128 and 129.

The portion of the shaft 124 between the bearings 125 on the plate 107 is screw threaded, one half at one end being left-

hand threads, and the other half at the other end being right-hand threads. Nuts 133 and 134 are provided upon the oppositely threaded ends, and each has a flat face abutting against the plate 107 (see Fig. 8) so as to be held against rotation with the shaft. As a result, when the shaft 124 is rotated, the nuts will either approach or separate with respect to one another, depending upon the direction of rotation of the shaft. The pivot pin 117 connecting the lever 114 to the follower 113 depends between the nuts 133 and 134, with the result that as the follower 113 moves along the shaft 112, the pin 117 will approach and then engage one of the nuts 133 or 134, and through it shift the plate 107 endwise and effect a reversal of rotation of the shaft 112 by the operation of the link 105 and its control of the reverse lever 93.

When the follower moves in the opposite direction, it will eventually engage with the other nut on the shaft 124 and operate the plate 107 in the opposite direction to cause another operation of the reverse lever 93 and a consequent reversal in the direction of rotation of the shaft 112. The reversals in the movement of the follower 113 will cause corresponding reversals in the direction of travel of the traverse rod 118, and consequently reversals in the direction of feeding of the wire to the winding forms, thus starting new layers. If the shaft 124 is rotated, the nuts 133 and 134 may be given any desired relative spacing which will determine the lengths of the layers of wire to be wound upon the winding form. The gear 128 meshes with a larger gear 135 which may be operated manually by a crank 136. One or more nuts 137 upon the shaft 124 may be secured in different adjusted positions upon the shaft in any suitable manner, such as by screws 138, and rotate with the shaft. These nuts 137 serve as limit stops for the nuts 133 and 134, when the latter are separated by a rotation of the shaft 124 in one direction.

It is desirable that the spacing of the nuts 133 and 134 be varied as the winding of the coils proceeds, in order that the layers may be progressively shortened, and the mechanism for doing this automatically will now be described. A gear 139 (Figs. 7 and 11) is fixed upon the spindle shaft 82 and meshes with an idler gear 140 which is rotatable upon a pivot 141. The pivot 141 may be clamped in different adjusted positions in an arcuate slot 142 provided in a supporting bracket 143. The idler 140 meshes with a gear 144 carried by a shaft 145 extending into a reduction gear box 146. The shaft 145 within the box carries a worm screw 147, which meshes with and drives a worm wheel 148, and a worm screw 149 rotating with the worm wheel 148 meshes with and drives a worm wheel 150 carried by a shaft 151. The shaft 151 carries a worm 152 (see Figure 11) which meshes with and drives a worm wheel 153 carried on the shaft 154. The shaft 154 extends outwardly from the gear box 146 and mounts a gear wheel 155 which meshes with and drives a gear wheel 156 carried by a shaft 157.

The shaft 157 is rotatably supported beneath the frame 84, extends to the opposite end thereof, and at that opposite end carries a gear 158 (see Fig. 9). The gear 158 meshes with a gear 159 carried by a shaft 160 which is rotatably mounted in a bearing 161 upon the machine frame 84. The shaft 160 also carries a bevel gear 162 which meshes with a bevel gear 163 carried by a shaft 164 that is rotatably mounted in a bearing 165. A friction head 166 is connected by a key 167 (Figure 9) to the shaft 164 so as to rotate therewith and be slidable to a limited extent endwise thereon.

Another shaft 168 is rotatably mounted in a bearing 169 in alignment with the shaft 164, and carries a friction head 170 which abuts against the friction head 166. A bevel gear 171 is provided upon the shaft 168 at the side of the bearing 169 opposite the friction head 170, so that the shaft 168 will be held against endwise movement in its bearing. A helical spring 172 is compressed between the friction head 166 and the bearing 165, so as to yieldingly urge the friction head 166 into engagement with the friction head 170 and thus effect a frictional driving connection between the shafts 164 and 168. The gear 171 meshes with the gear 129 which is keyed to the shaft 124.

It will be observed that the winding spindle shaft 82 is connected by reduction gearing to the shaft 157. The latter is coupled by a frictional coupling device to the worm screw or shaft 124, so that the latter will rotate concomitantly with the winding spindle and at a very reduced rate relative thereto. Therefore, as the winding spindle rotates the shaft 124 will slowly rotate and cause the nuts 133 and 134 to approach one another, thus gradually shortening the travel of the follower 113 between the operations of the plate 107 and consequently the intervals between the reversals in the travel of the traverse rod.

The layers will be progressively shortened in this manner, and by varying the gear ratio in the reduction train between the winding spindle and the shaft 124 the extent of tapering of the ends of the coils, that is, the rate at which the layers will be shortened, may be varied to some extent. This variation in gear ratio may be accomplished in any suitable manner such as by the substitution of new gears 139 and 140 of a different relative ratio. The winding machine as illustrated, also has mechanism for measur-

ing, cutting, and inserting strips of paper between the successive layers, of the coil during their formation, but since this mechanism is not directly connected with the particular invention to be claimed in this application, a description of it will be omitted for the sake of clearness and brevity.

In the operation of this machine, the attendant will first adjust the nuts 137 along the shaft 124 and secure them thereon in positions to define the starting positions of the other nuts 133 and 134. The crank 136 is next operated to rotate the sleeve 126 and the shaft 124 in a direction to separate the nuts 133 and 134 to the extent permitted by the nuts 137. During this operation of the shaft 124, slippage will occur between the friction sleeves 166 and 170, and therefore the gear reduction train from the winding spindle will not be operated during this resetting movement. The machine is then started in the usual way. During the rotation of the winding spindle the shaft 89 will be rotated concomitantly, and through the bevel gears 90, 91 and 92 will rotate the threaded shaft 112 in a direction dependent upon the position of the lever 93. During this movement, the cam plate 98 will be held against rotation with the shaft 89 by the engagement of one of its escapement teeth 99 with the bolt 100.

As the follower 113 moves along the shaft 112, the traverse rod will be shifted endwise to guide the wire to the winding frame in a helical manner and form one layer, and when the pin 117 of the follower 113 engages one of the nuts 133 and 134, it will slide the plate 107 endwise and through it cause a rotation of the crank 104. The crank 104 through the pinion 103 moves the shaft 101 and the pawl 100 endwise to allow a half revolution of the cam plate. The cam plate during its half revolution will operate the reverse lever 93 and effect a reversal in the direction of rotation of the shaft 112. The traverse rod will then be operated in the reverse direction for forming a second layer, until the pin 117 engages with the other nut 133 or 134 and operates the plate 107 in the reverse direction to effect another reversal in the direction of rotation of the shaft 112.

During the rotation of the winding spindle, the reduction train between it and the shaft 124 will cause a very slow rotation of the shaft 124 and consequently a slow approach of the nuts 133 and 134. This gradual approach lessons the travel of the pin 117 before a reversal of movement of the traverse rod occurs, and consequently the layers of wire being wound upon the spindle will be gradually shortened. After the desired number of layers have been wound, and a new coil is to be started, the nuts 133 and 134 may be reset to their initial positions against the limit nuts 137 in a rapid manner by the operation of the crank 136 in a direction reverse to its operation by the connection from the winding spindle.

In the event that one desires to form several initial layers of equal length, before the tapering of the coils begins, it is merely necessary for the attendant to hold the crank 136 from rotation while the layers of equal length are being formed, and owing to the frictional connection between the reduction gear train and the shaft 124, the latter will not rotate with the spindle. Thereupon when the crank 136 is released the tapering of the layers will proceed. This result may also be accomplished by inserting a clutch in the shaft 157, or at any other suitable part of the connection between the winding spindle and the threaded shaft 124, so that the driving action can be interrupted during the formation of the layers of equal length.

In Figures 12 and 13 another modification of the machine shown in Figure 1 is illustrated. In this form of the invention, the gear 47 of the machine of Figure 1 is replaced by a ratchet wheel 47^a, and the reduction gear train between the winding spindle and the gear 47 is eliminated. An armature lever 173 intermediate of its ends is supported by a pivot 174 rotating in depending ears 175 on the under face of the frame 1. A pawl 176 extends through a slot 177 in the plate 1, and is pivoted at 178 to one arm of the armature lever 173. The pawl 176 is provided with a nose 179 which is adapted to engage and operate the ratchet wheel 47^a, and is held yieldingly in engagement with the teeth of the ratchet wheel 47^a by a spring 180 which is connected between the pawl and the lever 173, as shown clearly in Figure 13.

An electromagnet 181 is supported in any suitable manner from the frame 1 in a position to operate the armature lever 173 in one direction, and a spring 182 connected between the armature lever and the frame serves to operate the armature lever in a direction opposed to the operation of the lever by the attraction of the electromagnet. This electromagnet 181 is connected by conductors 181^a and 181^b in parallel with the clutch operating solenoid 18 and the audible signal 71, so as to be operable simultaneously with the opening of the clutch. A switch 181^c may be included in the conductor 181^a so as to enable one to incapacitate the electromagnet at will. The contact member 62^a is similar to the contact member 62 of the machine of Figure 1, but is preferably flexible laterally for a purpose to be explained presently.

In this machine, when the contact member 62^a engages with one of the abutment nuts 56 or 58 and an electric circuit is closed to the solenoid 18 to stop further operation

of the winding spindle, the electromagnet 181 will be operated to rock the armature lever 173 in a direction to lift the pawl 176 and engage it behind a new tooth of the ratchet wheel 47ª. When the attendant operates the handle 34 to reverse the direction of travel of the traverse rods, the traverse rod will be rocked so as to carry the contact member 62ª out of engagement with the abutment 64 or 65 on the nuts 56 or 58, and thus open the electric circuit through the solenoid 18 and permit of a recoupling of the winding spindle with its driving pulley 5.

When the circuit is opened the electromagnet 181 will be de-energized and the spring 182 will rock the armature lever in a direction to advance the pawl 176 and thereby turn the ratchet wheel through a given angular distance. The angular distance through which it may be operated each time may be limited by an adjustable abutment screw 183 carried by the frame in a position to limit the rotation of the armature lever by the spring 182. The increment of angular movement thus given the ratchet wheel 47ª will be transferred to the screw shaft 48 and cause an approach of the nuts 56 and 58.

The nuts 56 and 58 may be reset at the beginning of each coil by a mere operation of the hand wheel 53 as in the machine described in connection with Figure 1. By holding the handwheel 53, any desired number of layers of equal length may be formed, or the switch 181ᶜ may be opened so as to prevent actuation of the screw shaft 48 until the desired number of layers of equal length have been formed. Since the contact 67ª will be rocked out of engagement with the abutment 64 or 65 before the electromagnet 181 will be de-energized and the ratchet wheel operated forwardly, there will be some clearance for the slight movement of the nut 56 or 58 without re-engagement of the same with the contact 62ª, but the contact 62ª is made flexible so as to avoid any likelihood of breakage in case the nuts should be adjusted by accident toward one another while in contact with the contact member.

In Figures 14 and 15, the machine illustrated is similar to that described in connection with Figures 1 to 6, 12 and 13, except that the electromagnetic actuation of the screw shaft 48 is replaced by a mechanical actuation. The construction is the same as in Figures 12 and 13, except that the ratchet wheel 47ᵇ which is similar to the ratchet wheel 47ª is made wide enough to accommodate two pawls arranged side by side. A collar 184 is keyed to the traverse rod 67 so as to be rotatable therewith, and also permit sliding movement of the traverse rod freely therethrough. The collar may be confined against endwise movement in any suitable manner, such as by a bracket arm 185.

The collar is provided with a pair of angularly spaced arms 186 and 187 which are also placed in different planes transversely of the traverse rod. A pawl 188 is pivoted at 189 to the arm 186 and is adapted to engage and operate the ratchet wheel 147ᵇ, being held in contact with the same by a spring 190 which is connected between the pawl and an arm 191 on the collar. A second pawl 192 is pivoted at 193 to the arm 187 of the collar and is held in contact with the teeth of the ratchet wheel by a spring 194 which is connected between the pawl and an arm 195 on the collar.

From this construction, it will be obvious that both pawls will be held yieldingly in engagement with the ratchet wheel, and as arranged, one pawl will be operative to rotate the ratchet wheel when the traverse rod is rocked in one direction and the other will be operative when the traverse rod is rotated in the reverse direction. Thus when the traverse rod is rocked in order to change the direction of its endwise movement, the ratchet wheel 47ᵇ will be given a slight angular increment of rotation so as to advance the nuts 56 and 58 toward one another. In case it is desired to decrease the rate of rotation of the screw shaft 48 one of the pawls 188 or 192 may be taken off or rendered inoperative, and in that case the screw shaft will be given an increment of rotation only at every alternate rocking movement of the traverse rod.

The type of coil which may be wound on the machines which have hereinbefore been described is illustrated in Figure 16, and comprises a plurality of superposed layers *a*, *b*, *c*, *d*, *e*, etc. wound upon a winding form A. In this particular coil, the first three layers *a*, *b* and *c* are of equal length, and the other successive layers are progressively shorter. In all of the machines illustrated, the shortening of the layers may be delayed until after any desired number of layers have been first wound by the attendant holding the hand wheel 53 or the crank 136, the frictional driving connection to the controlling screw shaft permitting this holding to occur without injury to the machine.

It will be obvious that various changes in the details and arrangements of parts in the various embodiments, herein described and illustrated for the purpose of explaining the nature of the invention, may be made by those skilled in the art within the principle and scope of the invention as expressed in the appended claims.

I claim:

1. In a winding machine, a winding spindle, a traverse member for guiding a wire to said spindle to be wound thereon in layers,

means for shifting the member in directions lengthwise of the spindle to lay the wire in helical layers, means for indicating when the end of a layer has been reached, said indicating means being adjustable to indicate the end of a layer at the ends of progressively shorter movements of the member, whereby the layers formed may be made progressively shorter.

2. In a winding machine, a winding spindle, a traverse member for guiding a wire to the spindle to be wound thereon in layers, means for moving the said member in directions lengthwise of the spindle so as to lay the wire in helical layers, means for indicating when the ends of the layers have been reached during their formation, and means connected to be driven with the spindle and adapted to vary progressively the points in the travel of said member when the ends of the layers will be indicated so that the layers may be made progressively shorter.

3. In a winding machine, a winding spindle, a traverse member for guiding a wire to the spindle to be wound thereon in layers, means for moving the said member in directions lengthwise of the spindle so as to lay the wire in helical layers, a rotatable element connected to be driven with the spindle and at a reduced rate, said element having right and left hand screw threads thereon, a pair of non-rotary follower members shiftable along the element in opposite directions by engagement with the screw threads thereon, whereby the follower members may be made to slowly change their relative spacing as the spindle rotates, and indicating means operable with the traverse member and cooperating with the follower members to indicate when the traverse member has reached desired limits of movement in both directions, the changes in the spacing of the follower members causing corresponding changes in indications.

4. In a winding machine, a winding spindle, a traverse member for guiding a wire to the spindle to be wound thereon in layers, means for moving the said member in directions lengthwise of the spindle so as to lay the wire in helical layers, a rotatable element connected to be driven with the spindle and at a reduced rate, said element having right and left hand screw threads thereon, a pair of non-rotary follower members shiftable along the element in opposite directions by engagement with the screw threads thereon, whereby the follower members may be made to slowly change their relative spacing as the spindle rotates, means movable concomitantly with the traverse member and cooperating with the follower members to cause reversals in the direction of travel of the traverse member and thus determine the lengths of the layers, the changes in the spacing of the follower members causing corresponding changes in the reversals of the traverse member and thereby corresponding changes in the lengths of the layers.

5. In a winding machine, a winding spindle, a traverse member for guiding a wire to the spindle to be wound thereon in layers, means for moving the said member in directions lengthwise of the spindle so as to lay the wire in helical layers, a rotatable element connected to be driven with the spindle and at a reduced rate, said element having right and left hand screw threads thereon, a pair of non-rotary follower members shiftable along the element in opposite directions by engagement with the screw threads thereon, whereby the follower members may be made to slowly change their relative spacing as the spindle rotates, indicating means operable with the traverse member and cooperating with the follower members to indicate when the traverse member has reached desired limits of movements in both directions, the changes in the spacing of the follower members causing corresponding changes in indications and means by which the follower members may be reset to a desired initial relative spacing before the beginning of each coil.

6. In a winding machine, a winding spindle, a traverse member for guiding a wire to the spindle to be wound thereon in layers, means for moving the said member in directions lengthwise of the spindle so as to lay the wire in helical layers, a rotatable element connected to be driven with the spindle and at a reduced rate, said element having right and left hand screw threads thereon, a pair of non-rotary follower members shiftable along the element in opposite directions by engagement with the screw threads thereon, whereby the follower members may be made to slowly change their relative spacing as the spindle rotates, and indicating means operable with the traverse member and cooperating with the follower members to indicate when the traverse member has reached desired limits of movement in both directions, the changes in the spacing of the follower members causing corresponding changes in indications, the connection between the rotatable element and the spindle permitting variations in the driving ratio between them.

In witness whereof, I hereunto subscribe my signature.

RICHARD VARLEY.