C. R. UNDERHILL.

WINDING MACHINE.

APPLICATION FILED OCT. 20, 1913.

1,140,924.

Patented May 25, 1915.

2 SHEETS—SHEET 1.

Fig. 1

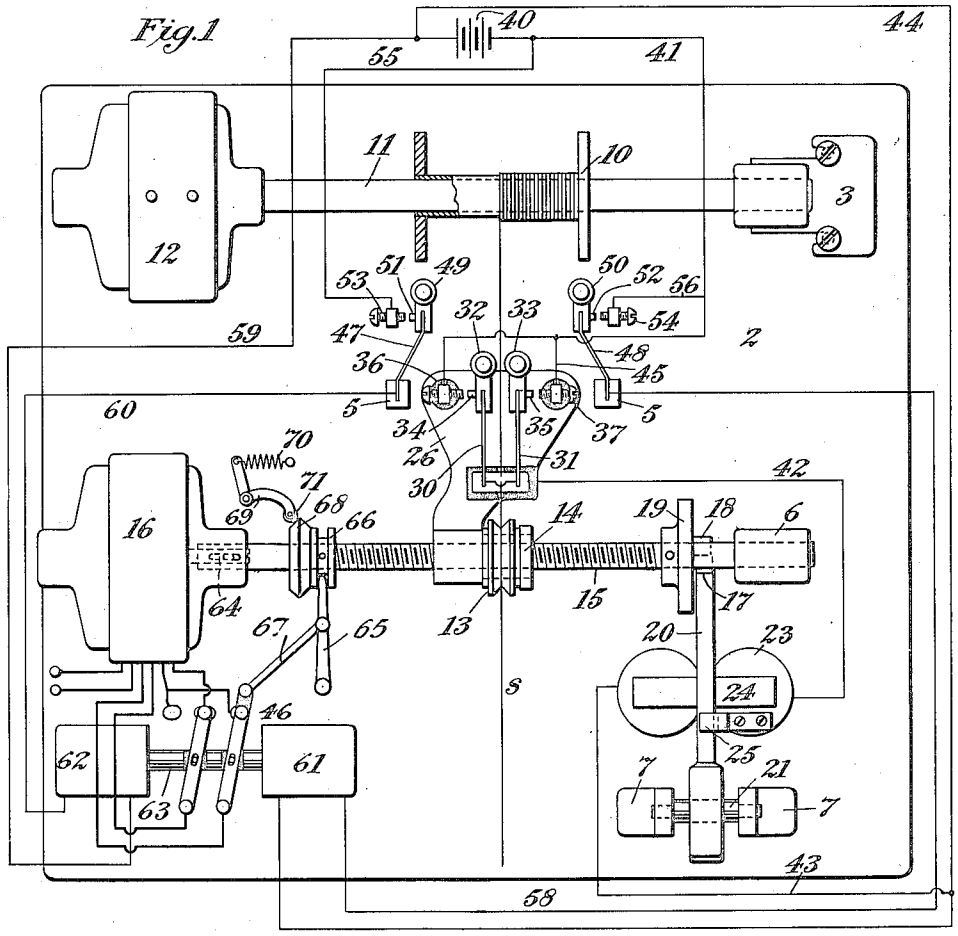
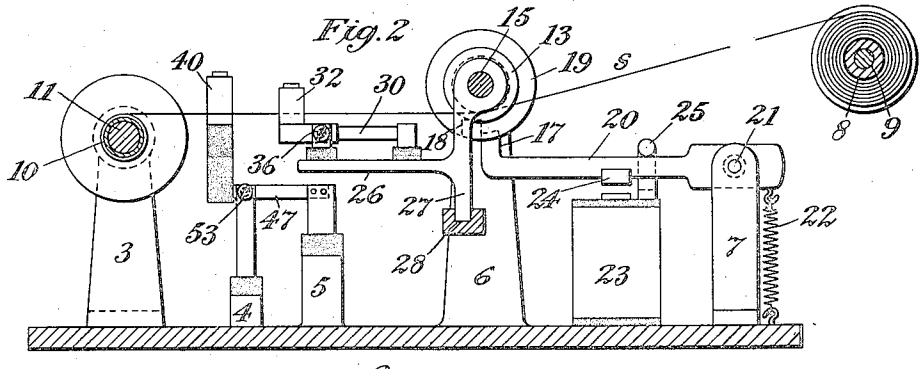



Fig. 2

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2 SHEETS—SHEET 2.

Fig. 3

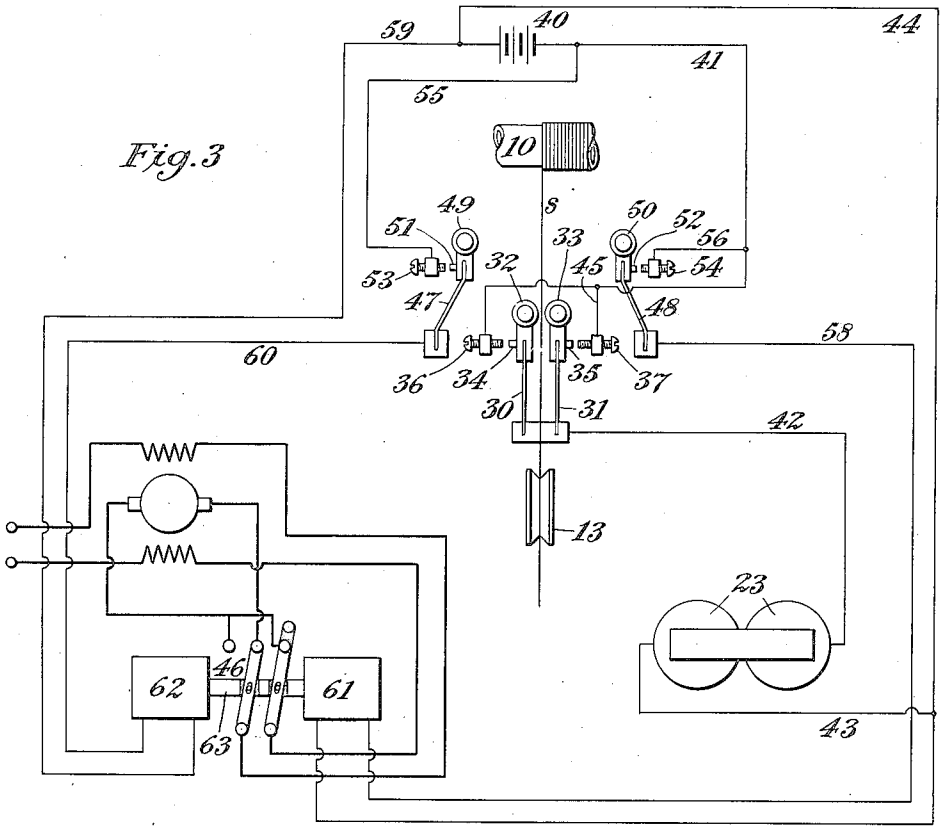



Fig. 4

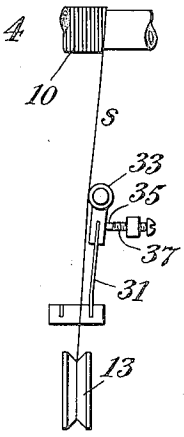
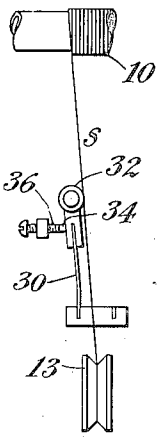



Fig. 5

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## WINDING-MACHINE.

1,140,924. Specification of Letters Patent. Patented May 25, 1915.

Application filed October 20, 1913. Serial No. 796,181.

*To all whom it may concern:*

Be it known that I, CHARLES R. UNDERHILL, a citizen of the United States, and a resident of New Haven, in the county of New Haven and State of Connecticut, have invented certain new and useful Improvements in Winding-Machines, of which the following is a specification.

This invention relates to a winding machine, and especially to a machine for laying the turns of a wire or other strand in close contact with one another, it being particularly adapted to the winding of insulated wires to form electromagnets.

In winding magnets the maximum amount of wire has heretofore been coiled into a given space by the old hand method in which each turn of wire acts as a guide for locating the next succeeding turn of the strand, and in which the tension on each turn is sufficient to assure the winding of a tight coil. For the formation of machine-made coils it has been the practice to employ one of two types of winding mechanism. In the first of these, which is especially adapted for the winding of bare wires, positive means, to wit, the usual screw-traverse feed mechanism, is employed to lay the successive turns in such a manner that they are separated by definite intervals from one another. In this type of feed mechanism it is not possible to produce the maximum number of turns of wire in each layer or helix, owing to the fact that the feed movement must be such as to allow for the winding of wire of the maximum diameter instead of wire of the average diameter. In addition to this an extra allowance must be made for the end thrust of the winding mandrel. In the second type of machine referred to, provision is made for winding the turns in contact with one another, but the control of the position of the strand during the winding of each turn is not sufficiently positive to produce the best results, particularly when winding at high speeds.

The principal object in the present case is to provide for the winding of machine-made coils at high speed and in such a manner as to obtain the maximum number of turns or coils in each layer, substantially as in hand winding, in which for some size of insulated wire the gain with an average coat of insulation over machine winding with machines of the type first referred to is about ten per cent., while with other sizes of wires the gain in turns is twenty per cent. or more.

In the present machine the principal features of difference over the machines heretofore used for winding insulated wires are greater sensitiveness and positiveness in the control of the operation of laying the strand on the winding mandrel. The construction is such that at all points in the winding of a layer the position of the strand being wound is determined by a source of power outside the moving strand and adapted to exercise such control over the strand as to keep the turn being wound always in close contact with the last preceding turn of a series. The means for controlling the laying of the turns may be any power-operated means exerting a positive controlling action on the strand being wound, but preferably will be means for positively controlling the position of the strand in such a manner as to give the strand a lag during a considerable portion of the winding of each layer or helix. To do this I prefer to employ automatic traversing means, the guide-point of which locates the strand at a suitable point in its length and has a lag during the winding operation controlled positively by means other than the moving strand. The operation of this traversing means may be variable and is preferably intermittent. Normally it serves to maintain the winding strand in such a position that it lags not less than the predetermined amount. The amount of lag is variable and when it becomes too great it is preferably reduced, as by the controlling action of the strand itself, but this control by the strand of the extent of the lag does not interfere with the operation of the traversing means, which in the preferred construction determines that throughout or substantially throughout the winding of each turn the strand shall lag and lag sufficiently to assure the winding of each turn in close contact with the next preceding one. The reduction of the lag of the winding strand may be brought about by electrical means, under the control of the strand, which electrical means may be actuated whenever the lag exceeds a predetermined maximum in either direction of movement of the automatic traverse device. All of the parts should be light and quick acting so that there will be a substantially in-

stantaneous response whenever it is desired to bring about an automatic change in the angle of lag of the strand passing to the mandrel. I prefer at this time to employ automatic traversing means in which the traverse device normally has no movement and is caused to impart a traverse movement to the strand through the controlling action of the strand itself when the angle of lag of the strand becomes too great. An intermittently rotatable feed-screw, normally under restraint and released each time the controlling means described becomes effective, may be employed for the purpose of imparting the necessary variable or intermittent movements to the strand.

An important feature of my improved winding mechanism is the provision of winding and controlling mechanism for positively laying the turns in close contact with one another and for regulating the lag of the strand in whichever direction the helix may be wound. In order to accomplish this suitable controlling means will be employed operative in both directions of traverse, and suitable means will also be employed for reversing the direction of winding at the end of each helix.

Other features of the invention not hereinbefore referred to will be hereinafter described and claimed and are illustrated in the accompanying drawings, in which—

Figure 1 is a sectional plan and diagram of a simple type of winding machine embodying means for automatically laying successive turns in close contact with one another on a winding mandrel in each direction that the helices are wound, and of suitable reversing means for said winding machine; Fig. 2 is a sectional elevation of the same; Fig. 3 is a diagrammatic view of the main elements showing the operating and controlling circuits more in detail, and Figs. 4 and 5 are enlarged details illustrating the action of a pair of controlling devices governed by the lag of the strand for starting the operation of the automatic traversing means.

Similar characters designate like parts in all the figures of the drawings.

Any suitable means may be employed for mounting and operating the several parts of my present improved winding machine. The necessary mechanism of such a machine is simple and comprises principally suitable means for supporting and turning a winding mandrel, automatic traversing means for controlling the position of the strand being wound, and suitable means for positively controlling the automatic traversing action. All of these parts may be mounted upon a suitable base, such as 2, or upon suitable standards rising therefrom, such as are shown at 3, 4, 5, 6 and 7.

The upright 3 serves as a means for supporting at one end the winding mandrel to which the strand passes from a suitable supply spool, such as 8, which may be mounted in any suitable manner on a shaft or arbor, 9, for turning movement. The rotation of this supply spool and its shaft may be controlled in any suitable manner to obtain the proper tension on the traveling strand. The mandrel, which may be of the type shown at 10, is carried in this case by a long winding arbor, or shaft, 11, constituting in the construction shown, part of the driving means for the mandrel, it being illustrated as the armature shaft of an electric motor, 12, employed for turning said mandrel. The operation of this motor and the turning of the shaft, 11, and hence of the mandrel itself, may also be suitably controlled to obtain the proper tension upon the winding strand.

The strand in passing from the spool or supply means 8 to the winding mandrel 10 passes in this case, as is usual, around a guide-sheave operative for laying a strand on the mandrel in turns in close succession. This guide-sheave may be of the type indicated at 13, it being suitably mounted in this instance on a feed-nut, 14, mounted to travel back and forth along a feed-screw, 15, which may be rotated by any suitable driving means, such as an electric motor, 16. This feed-screw 15, as here shown, constitutes an extension of the armature shaft of the motor 16 and has its free end mounted in the upright 6 for support. Separate driving means or motors are preferably employed for turning the feed-screw and the arbor of the winding mandrel respectively, in order that the work to be done in turning the winding mandrel may be reduced to the minimum and high speeds at the winding point readily obtained.

The feed-nut and feed-screw 14 and 15 are illustrated in the present case as a simple and well-known means for obtaining the desired traverse movements of the strand passing to the mandrel. Other means may of course be employed to accomplish the same result. Here these two parts constitute the main elements of the positive operating means hereinbefore referred to for assuring the passage of the strand to the winding point of the mandrel with a lag corresponding substantially to the lag of the strand in hand-winding. Normally, however, these elements have no movement, they being held under restraint by suitable means and released whenever the lag of the strand becomes too great. In the construction illustrated an escapement mechanism having a shiftable pawl, such as 17, normally in position for engaging a stop, 18, carried by the feed-screw 15, is employed for the purpose of releasing said feed-screw and permitting it to turn. The escapement members 17 and

18 coöperate in such a manner as to permit, in this case, only a single rotation of the feed-screw when released, the movable pawl 17 when withdrawn from the path of the stop 18 on the collar, 19, of the feed-screw, being almost immediately returned into the path of said stop to engage it at the end of one rotation of said screw. The escapement pawl 17, in the construction illustrated, is carried at the end of an armature-lever, 20, pivoted at 21 on the support 7 and normally held in the path of the stop 18, as by means of a spring, 22. It is preferably retracted out of the path of the stop 18 by the action of electrical controlling means including an electromagnet, 23, the armature of which is shown at 24. A suitable back-stop, 25, limits the upward movement of the armature-lever 20. The magnet 23 is intended to be energized whenever the strand *s* lags too far behind the normal. It will be seen that as the winding arbor 11 turns, and with it the mandrel 10, a series of turns will be wound on the mandrel, which will cause the winding point of the strand to shift gradually from end to end of the mandrel. If the guide-sheave 13 is set at the beginning of the winding operation, as should be the case, in such a position that its guide-point has a slight lag with respect to the winding point at the mandrel and said guide-sheave remains stationary, it will be obvious that the angle of lag of the strand and of said guide-point will increase progressively. The specific construction illustrated herein is one in which the controlling means operates intermittently to reduce this angle of lag by permitting an intermittent feed movement of the feed-screw 15 and the guide-sheave 13 carried thereby, this intermittent feed movement serving to permit the guide-point intermittently to follow up the movement of the strand at the winding point. To bring about the release of the escapement mechanism just described I have shown electrical controlling means embodying a light circuit-controlling arm in the path of the moving strand and in position to coact therewith and be shifted thereby when the angle of lag of the strand is excessive. Preferably two of these circuit-controlling arms are employed, one coöperating with the strand in one direction of wind of a helix and the other coöperating with the strand when a helix is being wound in the opposite direction. These circuit-controlling arms are preferably movable in unison with the guide-sheave 13 and the feed-nut 14, they being illustrated herein as mounted on a bracket, 26, mounted to travel back and forth on the feed-screw with an intermittent movement, and suitably guided, as by means of a depending arm, 27, working in a guide, 28. On the bracket or slide 26 are mounted, in this construction, two insulated circuit-controlling arms or switches, 30 and 31, the former of which is coöperative with the strand *s* when the winding is proceeding in the direction shown in Fig. 1, and the other of which is coöperative with said strand when the winding is in the opposite direction. Here each of these arms 30 and 31 carries preferably an antifriction roller, 32 or 33, to be engaged by the strand *s*, each of these being of sufficient length to coöperate properly with the strand both at the beginning of the winding of the magnet and when the winding is about finished. Each arm 30 and 31 also carries a contact, such as 34 and 35, adapted to engage an insulated and preferably adjustable contact 36 and 37, on the bracket or slide 26. The manner in which these controlling arms coöperate with the strand *s* will be clear by reference particularly to Figs. 4 and 5, from which it will be seen that the antifriction roller 32 is engaged by the strand *s* and moved to the left when the angle of lag of the strand becomes excessive during the winding in the direction of Fig. 1; while the contact-arm 31 is moved in the opposite direction by a corresponding action of the strand on the antifriction roller 33 when the winding is proceeding in the reverse direction. These circuit-controlling arms are connected, in this instance, in parallel branches of a controlling circuit through the electromagnet 23 from a suitable source of energy, and whenever the strand forces either of these circuit-controlling arms sidewise far enough to bring either the contact 34 into engagement with the contact 36 or contact 35 into engagement with contact 37, a circuit will be closed from a source of energy, such as 40, through the electromagnet 23.

In the case of the controlling arm 30 the circuit is from the battery 40 through conductor 41, contacts 36 and 34, switch-arm 30, conductor 42, magnet 23, conductor 43 and conductor 44, back to the battery. In the case of the switch-arm 31, the course is substantially the same except that from conductor 41 the current passes by way of conductor 45, contacts 37 and 35 and switch-arm 31 to the conductor 42. Whenever contact is made at the points 36 or 37 and the magnet 23 is energized the escapement will release the feed-screw and permit it to be turned instantly a single rotation by the motor 16, which will result in a single forward movement of the feed-nut 14 and the guide-sheave 13 along the feed-screw. As often as the winding of the turns on the mandrel causes an excessive lag in the portion of the strand between the winding point and the guide-point of the sheave 13 this feed movement will take place, and each time that it does take place the strand will be automatically shifted away from the antifriction roller 32 or 33 with which it is

in engagement and will also be withdrawn from its coöperating contact, thus breaking the circuit through the magnet 23.

Whenever the winding strand arrives substantially at the end of the mandrel its movement is intended to be reversed also in this case through the action of suitable electrical governing means. The reversing means shown comprises a reversing switch, 46, for the electric motor 16, the action of which reversing switch may be controlled by an electric circuit including circuit-controlling arms similar to those shown at 30 and 31. The means illustrated comprises two switch-arms 47 and 48, mounted on the uprights 5 and having near their free ends antifriction rollers, 49 and 50, and contacts, 51 and 52, corresponding to those of the switch-arms 30 and 31. A pair of contacts 53 and 54, preferably adjustable, also coöperate with the contacts 51 and 52 on said switch-arms 47 and 48, said contacts 53 and 54 being mounted on the supports 4. Conductors, 55 and 56, connect the contacts 53 and 54 respectively with the conductor 41 leading to one side of the battery 40, while conductors, 44 and 58, and 59 and 60, are shown as connecting the battery through a pair of solenoids, 61 and 62, with the respective switch-arms 48 and 47. A common core, 63, properly insulated is herein illustrated as connected to the reversing switch 46 and controlled by both of the solenoids 61 and 62. The parts described are so combined and coöperate with the strand in such a manner that when the strand arrives at the left-hand end of the helix being wound in Fig. 1 it will, at the proper point, engage the antifriction roller 49 and shift the same to the left to bring the contact 51 of the switch-arm 47 into engagement with the contact 53; whereupon a circuit will be closed from the battery through conductors 41, 55, contacts 53, 51, switch-arm 47 and conductor 60, to the solenoid 62, the opposite side of which is connected through conductor 59 to said battery. When thus energized solenoid 62 shifts the reversing switch 46 in the usual manner to reverse the direction of flow of the current through the motor 16, and thereby reverse the direction of rotation of the armature shaft and feed-screw 15 in a manner well understood. If the traveling strand is at the opposite end of the mandrel it will of course shift the switch-arm 48 instead of 47 and will close contact at the points 52 and 56, whereupon current will flow from the battery, through conductors 41 and 56, contacts 54 and 52, switch-arm 48 and conductor 58, through the solenoid 61, the return circuit being by way of conductors 44 and 59. This will of course result in the energization of the solenoid 61 and the shifting of the reversing switch 46 in the opposite direction to cause a flow of current through the motor 16 in the reverse direction to bring about a reversal of the direction of rotation of the armature-shaft and the feed-screw 15.

At the beginning of the operation of winding a layer or helix in either direction on the mandrel it will be necessary to give the strand to be wound a suitable lag. This is preferably accomplished automatically with each layer after the first, that is to say, by the action of the machine itself, and means are illustrated in the present case for this purpose. The means employed may be of any proper construction and is connected in the present instance with the reversing switch 46 so as to be governed thereby. By referring to Fig. 1 it will be seen that the feed-screw 15 is connected with the armature shaft by a pin-and-slot connection, 64, which permits a slight longitudinal movement of the feed-screw and the parts carried thereby. The shifting of the feed-screw and these parts is here shown as brought about by a shifting-lever, 65, working in the groove of a collar, 66, secured to the feed-screw and connected at its opposite end by a link, 67, to the electrical reversing switch 46. It will be obvious that on the movement of the reversing switch in one direction or the other the connections just described will serve to shift the feed-screw endwise in a corresponding manner the desired distance. The feed-screw should of course be held in the position to which it is so shifted until the end of a new layer is reached and the parts are to be shifted again. For the purpose of holding said feed-screw and the parts carried thereby in either position to which it may be shifted I have shown secured to the feed-screw a double cam wheel, 68, the circumference of which is substantially V-shaped and which coöperates with a spring-pressed rock-arm, 69, the pressure of a spring, 70, serving through an antifriction roller, 71, to hold said cam-wheel and the feed-screw in either extreme position to which they may be shifted. The construction of the spring-pressed arm 69 is such that movement of the feed-screw to its extreme position in either direction will cause the wheel 71 to ride over the high point or neutral point of the periphery of the cam-wheel 68 to the opposite cam face upon which it will exert pressure in the proper direction for maintaining said feed-screw in either position to which it is shifted. These devices constitute an automatic means for setting the feed-screw with its guide-sheave 13 in position to give the guide-point of said sheave a lag with respect to the winding point of the mandrel in each direction of winding.

By means of the feed mechanism disclosed herein substantially the same number of turns in each layer may be obtained that

are obtained in hand winding, as the turns are wound successively in close contact with one another and not at predetermined exact distances apart corresponding to the maximum diameter of the strand being wound. Moreover, there is an exceedingly sensitive control of the laying of each turn in close contact with the next preceding one through the positive control of the angle of lag of the strand and also a correspondingly positive control of the reversal of the direction of winding and of the setting of the parts automatically in a position suitable for giving the strand a lag at the beginning of the winding of each helix. In addition to this the parts, being light and forming elements of electrical controlling means, are capable of coöperating properly with the strand when the winding mandrel is rotated at very high speeds.

What I claim is:

1. In a winding machine, the combination with a winding mandrel, of automatic means controlled by the winding and including a source of power other than the strand being wound for positively locating the winding point of the strand and laying each turn on the mandrel in close contact with the last preceding turn from end to end of a helix.

2. In a winding machine, the combination with a winding mandrel, of automatic means controlled by the lag of the strand being wound and including a source of power other than said strand for laying a turn on the mandrel in close contact with the last preceding turn.

3. In a winding machine, the combination with a winding mandrel, of means having a positive power action for laying successive turns thereon, said means being intermittently movable during the winding of any turn.

4. In a winding machine, the combination with a winding mandrel, of intermittently-movable means controlled by a turn that has been wound for laying a succeeding turn.

5. In a winding machine, the combination with a winding mandrel, of intermittently-movable means controlled by the last turn wound for laying the next succeeding turn.

6. In a winding machine, the combination with a winding mandrel, of automatically-operated traversing means having a positive power action controlled by a turn that has been wound for laying a succeeding turn.

7. In a winding machine, the combination with a winding mandrel, of automatically-operated traversing means having a positive power action controlled by a turn that has been wound for laying a succeeding turn in close contact with the last turn wound.

8. In a winding machine, the combination with a winding mandrel, of an automatic traverse device movable in parallelism with the axis of said mandrel and the guide-point of which is located by positive power action and at times at various points in its traverse movement has a lag with respect to the winding point of the turn being wound.

9. In a winding machine, the combination with a winding mandrel, of an automatic traverse device movable in parallelism with the axis of said mandrel and the advancing guide-point of which is located by positive power action and has a lag during the major portion of the winding of a helix with respect to the advancing winding point of each turn being wound.

10. In a winding machine, the combination with a winding mandrel, of automatic intermittently-movable traversing means the guide-point of which at times has a lag with respect to the winding point of the turn being wound.

11. In a winding machine, the combination with a winding mandrel, of automatic traversing means including a source of power other than the strand being wound the guide-point of which is positively located by power from said source and at times at various points in its traverse movement has a lag with respect to the winding point of the turn being wound.

12. In a winding machine, the combination with a winding mandrel, of automatic traversing means including a source of power other than the strand being wound the advancing guide-point of which is positively located by power from said source and has during the major portion of the winding of a helix a lag with respect to the advancing winding point of the turn being wound.

13. In a winding machine, the combination with a winding mandrel, of automatic traversing means for laying successive turns on the mandrel, said means having a positively intermittent progressive traverse movement corresponding to each turn of the winding.

14. In a winding machine, the combination with a winding mandrel, of automatic traversing means for laying successive turns on the mandrel, said means having an intermittent progressive traverse movement corresponding to each turn of the winding.

15. In a winding machine, the combination with a winding mandrel, of automatic traversing means for laying successive turns on the mandrel, said means having a positive variable traverse movement controlled by a turn that has been wound.

16. In a winding machine, the combination with a winding mandrel, of automatic traversing means for laying successive turns on the mandrel, said means having a posi-

tive variable traverse movement in which the guide-point of the traverse device has a normal lag with respect to the winding point of the turn being wound.

17. In a winding machine, the combination with a winding mandrel, of automatic traversing means for laying successive turns on the mandrel, said means having a positive variable traverse movement controlled by a turn that has been wound and in which the guide-point of the traverse device has a normal lag with respect to the winding point of the turn being wound.

18. In a winding machine, the combination with a winding mandrel, of automatic traversing means for laying successive turns on the mandrel, said means having means with a positive power action controlled by the winding for positively locating and imparting traverse movement to the guide-point of the strand.

19. In a winding machine, the combination with a winding mandrel, of automatic traversing means for laying successive turns on the mandrel, said means having normally no movement and also having means for imparting traverse movement during the winding of any turn.

20. In a winding machine, the combination with a winding mandrel, of automatic traversing means for laying successive turns on the mandrel, said means having normally no movement and also having means controlled by the strand for imparting traverse movement.

21. In a winding machine, the combination with a winding mandrel, of an automatic traverse device for laying successive turns on the mandrel the guide-point of which device normally has a lag with respect to the winding point of the turn being wound, and means for intermittently reducing said lag.

22. In a winding machine, the combination with a winding mandrel, of an automatic traverse device for laying successive turns on the mandrel the guide-point of which device normally has a lag with respect to the winding point of the turn being wound, and means controlled by a turn on said mandrel for intermittently reducing said lag.

23. In a winding machine, the combination with a winding mandrel, of an automatic traverse device for laying successive turns on the mandrel the guide-point of which device normally has a lag with respect to the winding point of the turn being wound, and means controlled by the last turn wound for intermittently reducing said lag.

24. In a winding machine, the combination with a winding mandrel, of an automatic traverse device for laying successive turns on the mandrel the guide-point of which device normally has a lag with respect to the winding point of the turn being wound, and means having a positive power action for imparting a variable feed movement to said traverse device.

25. In a winding machine, the combination with a winding mandrel, of an automatic traverse device for laying successive turns on the mandrel the guide-point of which device normally has a lag with respect to the winding point of the turn being wound, and means controlled by a turn wound on said mandrel for intermittently imparting feed movement to said traverse device.

26. In a winding machine, the combination with a winding mandrel, of automatic traversing means for laying successive turns on the mandrel, and electrical controlling means governed by each turn wound, for governing the progressive movement of said traversing means.

27. In a winding machine, the combination with a winding mandrel, of automatic traversing means for laying successive turns on the mandrel, said means having an intermittent progressive traverse movement, and electrical controlling means governing said movement.

28. In a winding machine, the combination with a winding mandrel, of automatic traversing means for laying successive turns on the mandrel, and electrical controlling means governing the progressive movement of said traversing means and controlled by each turn that has been wound.

29. In a winding machine, the combination with a winding mandrel, of automatic traversing means for laying successive turns on the mandrel, said means having an intermittent progressive traverse movement, and electrical controlling means governing said movement and controlled by a turn that has been wound.

30. In a winding machine, the combination with a winding mandrel, of a power-operated traverse device for laying a turn on the mandrel, and means controlled by each turn of the strand being wound for governing the movement of said power-operated device.

31. In a winding machine, the combination with a winding mandrel, of a power-operated traverse device for laying a turn on the mandrel, and means controlled by the strand being wound for starting said power-operated device.

32. In a winding machine, the combination with a winding mandrel, of a power-operated traverse device for laying a turn on the mandrel, and means controlled by each turn of the continuous strand being wound for stopping said power-operated device.

33. In a winding machine, the combination with a winding mandrel, of a power-operated traverse device for laying a turn on the mandrel, and means controlled by the strand being wound for starting and stopping said power-operated device.

34. In a winding machine, the combination with a winding mandrel, of a power-operated traverse device for laying a turn on the mandrel, and means controlled by each turn of the strand being wound for bringing about a variable movement of said power-operated device.

35. In a winding machine, the combination with a winding mandrel, of a power-operated traverse device for laying a turn on the mandrel, and means controlled by the strand being wound for intermittently starting and stopping said power-operated device.

36. In a winding machine, the combination with a winding mandrel, of a power-operated traverse device for laying a turn on the mandrel, and a controlling device mounted on said power-operated device and operable by each turn of the strand being wound for governing the movement of said power-operated device.

37. In a winding machine, the combination with a winding mandrel, of a power-operated traverse device for laying a turn on the mandrel, and an electrically-controlled device mounted on said power-operated device and operable by each turn of the strand being wound for governing the movement of said power-operated device.

38. In a winding machine, the combination with a winding mandrel, of a power-operated traverse device for laying a turn on the mandrel, and electrically-controlled means including a yielding contact mounted on said power-operated device and operable by each turn of the strand being wound for governing the movement of said power-operated device.

39. In a winding machine, the combination with a winding mandrel, of a reciprocatory power-operated device for laying on the mandrel turns of helices running alternately in opposite directions, and a pair of controlling devices operable alternately by each turn of the strand being wound for governing the movement of said power-operated device.

40. In a winding machine, the combination with a winding mandrel, of a traverse device for winding successive helices in opposite directions, and automatic means effective on a change in the direction of winding for shifting the traverse device to a position in which its guide-point has a lag with respect to the winding point of the new turn to be wound.

41. In a winding machine, the combination with a winding mandrel, of a traverse device for winding successive helices in opposite directions, and duplex automatic means effective alternately at opposite ends of the mandrel for shifting the traverse device to the right and to the left respectively to either of two positions in each of which the guide-point of said traverse device has a lag with respect to the winding point of the new turn to be wound.

42. In a winding machine, the combination with a winding mandrel, of a feed-screw, a traveler thereon, and automatic means effective on a change in the direction of winding for shifting the traveler to a position in which its guide-point has a lag with respect to the winding point of the new turn to be wound.

43. In a winding machine, the combination with a winding mandrel, of a feed-screw, a traveler mounted to move back and forth thereon, and automatic means effective at each end of the movement of said traveler for shifting said traveler to a position in which its guide-point has a lag with respect to the winding point of the new turn to be wound.

44. In a winding machine, the combination with a winding mandrel, of a feed-screw, a traveler thereon, automatic means effective on a change in the direction of winding for shifting the feed-screw and its traveler to a position in which the guide-point of the traveler has a lag with respect to the winding point of the new turn to be wound, and means for holding the feed-screw in said shifted position.

45. In a winding machine, the combination with a winding mandrel, of a feed-screw, a traveler mounted to move back and forth thereon, automatic means effective at each end of the movement of said traveler for shifting said feed-screw and its traveler to a position in which the guide-point of the traveler has a lag with respect to the winding point of the new turn to be wound, and means for holding the feed-screw in each of said shifted positions.

46. In a winding machine, the combination with a winding mandrel, of a traverse device mounted to move back and forth for winding successive helices in opposite directions, electrical reversing means for said traverse device, and automatic means controlled by said reversing means for shifting the traverse device to a position in which its guide-point has a lag with respect to the winding point of the new turn to be wound.

47. In a winding machine, the combination with a winding mandrel, of a traverse device mounted to move back and forth for winding successive helices in opposite directions, electrical reversing means for said traverse device, and automatic means con-

trolled by said reversing means for shifting the traverse device at each end of its movement to a position in which its guide-point has a lag with respect to the winding point of the new turn to be wound.

48. In a winding machine, the combination with a winding mandrel, of a traverse device, and electrical controlling means governed by the sidewise movement of the strand for reversing the direction of movement of said traverse device.

49. In a winding machine, the combination with a winding mandrel, of a traverse device, and electrical controlling means governed by the sidewise movement of the strand for reversing the direction of movement of said traverse device at each end of the range of movement of said traverse device.

Signed at New Haven in the county of New Haven and State of Connecticut this 17th day of October, A. D. 1913.

CHARLES R. UNDERHILL.

Witnesses:

C. R. CONDON,

A. V. MANNING.