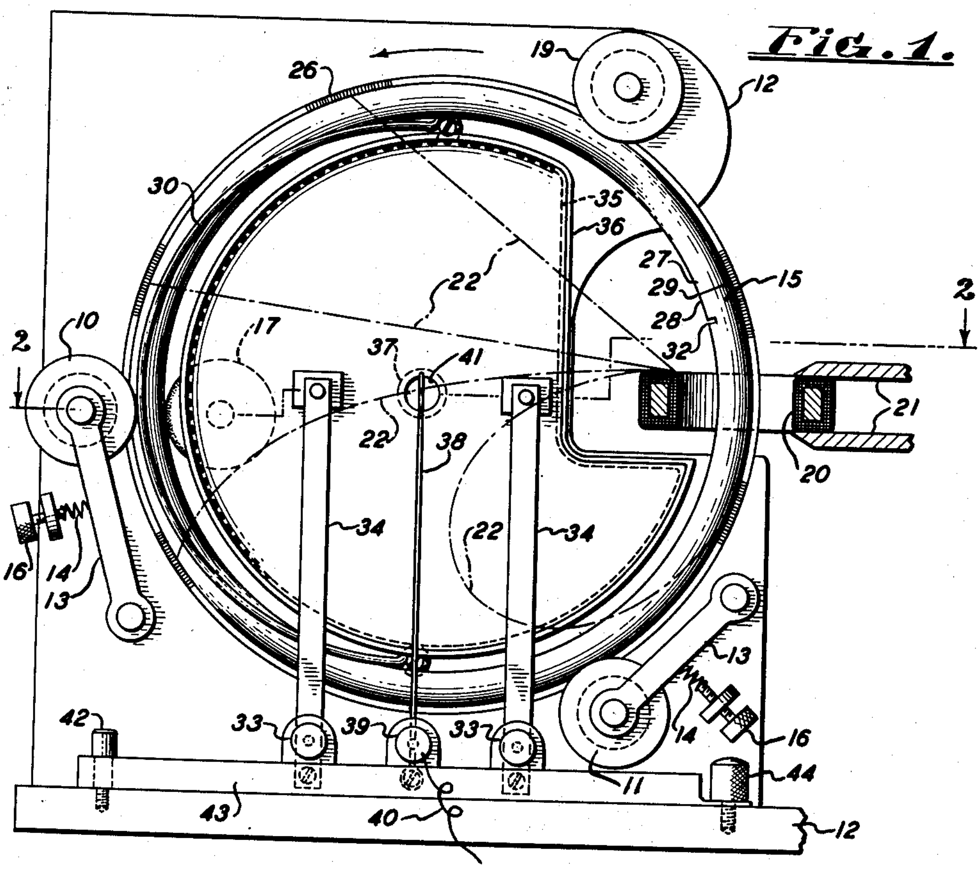
March 16, 1954 D. C. HARDER 2,672,297

MACHINE FOR WINDING TOROIDAL COILS

Filed Nov. 16, 1949 2 Sheets-Sheet 1



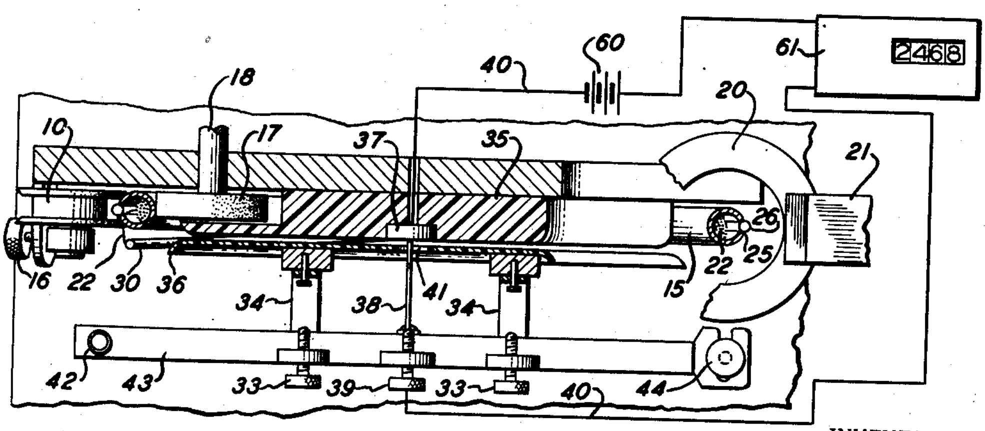


Fig. 2.

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Fig. 3.

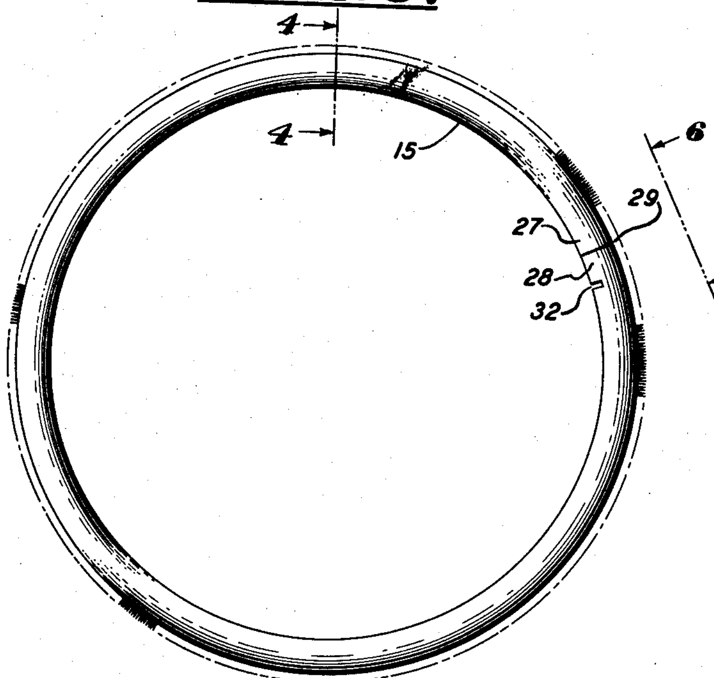


Fig. 4.

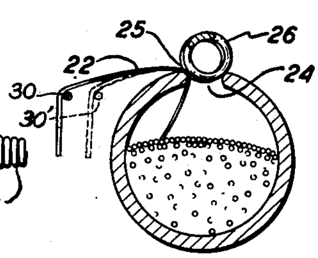


Fig. 5.

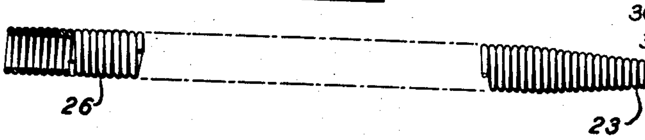


Fig. 6.

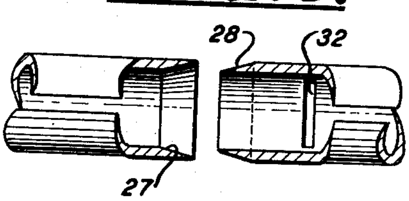


Fig. 7.

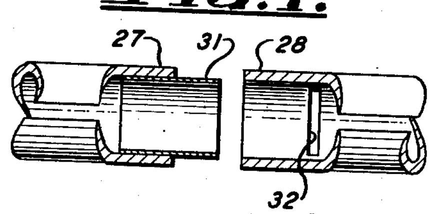
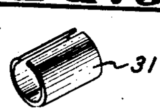


Fig. 8.



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UNITED STATES PATENT OFFICE

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MACHINE FOR WINDING TOROIDAL COILS

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4 Claims. (Cl. 242—4)

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This invention relates to coil winding machines, and more particularly to machines for winding filament, such as wire, spirally around curved objects, particularly around toroidal cores.

Ever since the invention of the Pupin loading coil, the manufacture of toroidally wound inductance coils has been of great importance in the telephone industry. Many machines and improvements thereon have been designed, to enable toroidal cores to be effectively and rapidly wound with wire.

The basic essentials of all these machines are the same. There is an annular bobbin, made separable so that it can be linked with a toroidal core. The bobbin carries the wire which is to be wound onto the core. Cooperating with the bobbin and mounted slidably thereon is some form of shuttle which serves to feed the wire from the bobbin onto the core. Since it is characteristic of this type of machine that wire is pulled from the bobbin during only a portion of a bobbin turn, the shuttle, of necessity, moves intermittently around the edge of the bobbin. In some cases the relative movement between the shuttle and the bobbin is in one direction only, being simply an intermittent, uni-directional movement. In other cases, the shuttle actually oscillates back and forth relative to the periphery of the bobbin.

The earliest machines adopted the straightforward principle of directly driving the shuttle, or feeding mechanism, and allowing it to frictionally carry the bobbin. These machines had the serious drawback of requiring the entire roll of wire, including the bobbin, to be accelerated with respect to the shuttle at each portion of the cycle when there was a demand for wire. This relatively large mass which the wire was forced to accelerate intermittently seriously limited the speed of operation of such machines, because with increased speed of operation, the tension in the wire became so great that the wire was broken as it jerked the bobbin forward.

Such machines quickly gave way to the bobbin-driven machine, wherein the bobbin was rotated at relatively constant velocity, and the shuttle was mounted to move intermittently over the periphery of the bobbin. Here the art has rested, in its basic essentials, for half a century.

In the bobbin-driven machine, it is not neces-

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sary for the wire to accelerate the bobbin and the remaining wire roll with each pull of wire from the bobbin, but it is necessary for the wire to intermittently accelerate the feed member or shuttle. This accelerative force is in addition to the friction drag between bobbin and shuttle, which must be precisely determined to be just great enough to bring the shuttle to a stop—after the wire has jerked it along the bobbin periphery—before an undue amount of wire has been drawn from the bobbin. The necessity for such acceleration is the principal factor in limiting top speed of operation, since as machine velocity increases, the accelerative forces for even the lightest of shuttles, becomes so prohibitively high that tension soon causes the wire to break.

An aggravating concomitant to the problem of shuttle acceleration is brought about by the fact that as the wire being pulled from the annular bobbin approaches a position where it is extended almost diametrically across the bobbin, the pull which the wire must exert to move the shuttle along the periphery of the bobbin is almost at right angles to the path of motion between the two parts. The vector angle is thus so unfavorable that tension in the wire increases sharply in spite of the fact that the useful force applied to move the shuttle along the bobbin may be rather small. Attempts have been made to alleviate this condition by changing the angle of attack between the wire and the shuttle as the wire approaches its diametral position, thereby producing a more favorable force vector situation. The results complicate and increase the cost of the machine.

Attempts have been made to eliminate the shuttle entirely by prewinding the wire into a curved helix and inserting it into one of the separated ends of the bobbin. This, while eliminating the acceleration problem, has the serious disadvantage of requiring a specially shaped and pre-formed supply of wire which must be stuffed into one end of the open bobbin.

It is an object of this invention to provide a winding machine having a bobbin to which wire may be applied in a simple and expeditious manner, and from which wire may be withdrawn during operation of the machine without requiring the wire to accelerate anything but its own weight.

It is another object of this invention to provide a winding machine capable of operating at markedly higher speed than prior art machines without danger of breaking the wire being wound.

It is a further object of this invention to provide a winding machine of the class described in which tension in the wire being wound does not increase to a dangerous point as the wire approaches a diametral position with respect to the winding bobbin.

It is another object of this invention to provide a winding machine of the class described in which wire is withdrawn from the bobbin under a uniform and readily pre-set tension.

It is another object of this invention to provide a simplified bobbin capable of holding a greater amount of wire for a given bobbin cross section.

It is an additional object of this invention to provide simple and effective means for counting the number of turns placed on a toroidal core by a winding machine.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following description.

In accordance with the instant invention, the coil winding machine comprises a rotatable, annular bobbin, having an annular groove or slot adapted to receive filament, such as wire, to be wound on a core. The ring bobbin is characterized by the provision of withdrawal means for permitting continuous withdrawal of filament completely around the ring, while maintaining constant tension on the filament. This withdrawal means includes an annular slit, biased closed, which runs around the ring, the filament passing through and progressing by increments around the slit.

It is preferred to form this slit in the following way. The bobbin is made of a hollow ring having an annular slot running completely around the ring, through which filament may be applied to and removed from the ring. A ring-like resilient member, such as a Garker spring, is disposed around the bobbin and rests partly within the slot; the Garker spring and an adjacent edge of the slot form the above mentioned resiliently closed slit, through which filament may be unwound from the bobbin under substantially constant tension. Both the bobbin and the Garker spring are constructed so that they may be broken and linked around a toroidal core. The term "Garker spring," as used in this application, means an endless band formed by connecting the two ends of a long helical spring.

The invention also contemplates means for conveniently counting the number of turns placed on the toroidal core. This means in the instant invention assumes the form of a pair of electrodes biased to touch each other in the plane of the filament loop formed with each turn of the bobbin. As the loop is drawn around the core, the wire passes between the electrodes, breaking their contact momentarily. An electric circuit including the electrodes is provided with means for counting the intermittent breaks in the circuit with each passage of filament between the electrodes.

Even though there is no shuttle or other mass to accelerate (the weight of the short length of filament itself being negligible), the friction of the resilient slit against the wire is greater under static condition than when the filament is actually passing through the slit. To absorb the

shock of initial withdrawal of filament from the bobbin, resulting from this fact that static friction is greater than sliding friction, there is provided a resilient guide, against which the filament comes into contact shortly before it is drawn tight for removal of an additional portion from the bobbin. The resiliency of the guide serves to initiate withdrawal of filament through the slit more gently than would be the case without it. The guide also serves the purpose of guiding the loop, as it is formed, in between a pair of tension plates which maintain a generally constant tension in the loop as it is being drawn around the outside of the toroidal core.

Particular embodiments of the instant invention described generally above will now be described in detail in connection with the accompanying drawings, wherein:

Fig. 1 is a side view of a winding machine embodying the principles of the instant invention;

Fig. 2 is a cross section plan view, taken along line 2—2 in Fig. 1;

Fig. 3 is a fragmentary detail of the annular bobbin forming one of the features of the instant invention and employable in the machine of Fig 1;

Fig. 4 is an enlarged cross section of the bobbin taken along line 4—4 in Fig. 3;

Fig. 5 shows one embodiment of a resilient annular member used in connection with the bobbin; in this case a Garker spring, uncoiled; and

Figs. 6, 7, and 8 illustrate alternative methods of forming the joints in the bobbin, by means of which it may be separated for interlinking with a toroidal core on which wire is to be wound.

Referring to Fig. 1, a bobbin in the form of a hollow ring **15** is mounted rotatably upon and laterally supported by three idler rollers **10**, **11**, and **19**. Roller **19** is journaled upon an upright frame **12**, while rollers **10** and **11** are journaled at the respective ends of two arms **13**, which are in turn pivoted to the frame **12**. Centripetal pressure is thus maintained upon the bobbin **15** through a pair of springs **14**, pressing the arms **13** inward against the bobbin **15**. Screws **16** provide a means for adjusting the pressure against the arms **13**. Bobbin **15** is frictionally driven by means of a driving wheel **17**, the periphery of which is formed of rubber, leather, or other resilient material which engages the inner periphery of the bobbin **15**. The wheel **10**, in addition to balancing the centripetal forces on the bobbin, also serves to press the bobbin **15** against the driving roller **17**. To provide lateral guidance of the bobbin **15**, as well as to minimize interference with withdrawal of wire from the bobbin **15**, the idler rollers **10**, **11**, and **19** are deeply grooved in the center, as readily seen in Fig 2, so that only the tapered flanges thereof are in contact with the bobbin **15**. These flanges are faced with resilient material such as rubber. Driving wheel **17** is supported and driven by a shaft **18**, journaled in frame **12**, which is in turn driven by any suitable source of power, not shown. The shaft **18** may be driven in either direction, the bobbin **15** being rotated clockwise while being loaded with wire in preparation for winding a core, and counter-clockwise during actual winding.

A toroidal core **20** to be wound with wire is held in a horizontal plane by means of clamp members **21**, which are so arranged that the core **20** may be oscillated about its axis during the winding operation, so as to guide wire **22** from the bobbin **15** onto the core **20** in any desired manner. The bobbin 15 is broken at 29 so that the two ends thus formed may be separated, and the ring interlinked with the core 20, as shown in Fig. 1.

The bobbin ring 15 of the instant invention is characterized by the provision of virtually inertialess withdrawal means, in contrast to the shuttles and flyers of the prior art. This is achieved in the instant invention by slotting the perimeter of the bobbin 15 as shown at 24, and then closing the slot by linking annularly around the ring a resilient annular member such as a Garker spring 26, which rests partially within the slot 24, as shown in Fig. 4, one edge of the slot 24 forming in cooperation with the Garker spring 26 the resilient lip of an annular slit 25, through which wire 22 may be continuously unwound from around the bobbin 15.

In the past, it has been necessary to provide a shuttle or flyer riding on a suitable track around the bobbin, through which the wire passes before being wound on the core 20. The mass of such a shuttle, though small, must nonetheless be repeatedly accelerated as the core 20 demands more wire from the bobbin 15 during a predetermined portion of each cycle of operation. Thus the small shuttle mass may, by virtue of large acceleration at high operating speeds, produce excessive tension in the wire 22 and break it. It will be readily evident that the instant invention obviates entirely such disadvantage. Here there is no mass whatever to accelerate or decelerate, except the relatively small mass of that short portion of the wire actually being withdrawn. At the same time the wire is prevented from drooping out of the bobbins 15 by the fact that the slot 24 is normally closed by the Garker spring 26.

While in the specific embodiment shown, the means for maintaining constant wire tension while permitting annular withdrawal of the wire have assumed the form of a slot and Garker spring, it will be readily evident that the resiliently closed annular slit 25 may be formed in many different ways. For example, the slot 24 could be on the inner periphery instead of the outer periphery of the bobbin 15, and be closed by a resilient, compressive annular member. There still results an annular, resiliently closed slit 25, through which the wire may be continuously withdrawn from around the bobbin 15.

For the winding of toroidal cores 20, not only must the bobbin 15 be separable as at 29, but the Garker spring 26 must also be separable as shown in Fig. 5. The spring, when rejoined under tension, and seated in the slot 24, should present a substantially continuous drag on the wire 22. To that end, the juncture of the two ends should be as smooth as possible. One way of achieving this is to reduce the diameter of the spiral coils at one end of the spring, as shown at 23, permitting it to be threaded into the other end of the spring 26.

Two methods of effecting the joint 29 in the bobbin 15 are shown by way of example in Figs. 6 and 7, respectively. In Fig. 6, the ends are tapered, one internally as shown at 27, the other externally as shown at 28. The bottom or inner wall of the bobbin 15 is slotted at 32 to provide a convenient means of attaching the end of the wire to the bobbin as the latter is being loaded. The slot 32 also provides a convenient means for removing excess wire inadvertently wound upon the bobbin 15. This may be done by cutting the wire exposed through the slot 32.

In Fig. 7, the joint is formed by the use of cylindrical insert 31, pressed into one end of the broken bobbin and dimensioned to fit snugly into the other end. Like the bobbin ring itself, the insert 31 must be slotted to match the ring slot 24, as shown in Fig. 8.

As each turn is placed upon the core 20, a loose loop is formed, as shown by the dot-dash lines in Fig. 1. It is desirable to maintain tension in this loop, and to this end pressure plates 35 and 36 are provided, the plates being mounted face to face in a plane substantially normal to the rotative axis of the bobbin 15. One of the plates 35 is fixedly mounted to the frame 12 as shown in Fig. 2, while the other is of lighter construction, and is movable toward and away from the stationary face 35 through the intermediary of a pair of leaf springs 34, the upper ends of which are secured to the plate 36, the lower ends being mounted to a horizontal bar 43 pivoted at 42 to the frame 12. Adjusting screws 33 on the bar 43 provide a ready means for regulating the pressure between the plates 36 and 35.

It is generally necessary to know the number of turns placed upon the toroidal coil 20. This is not equal to the number of revolutions of the bobbin 15, since with each turn, the wire 22 is withdrawn from a different point along the slit 25. It therefore becomes necessary to count the turns as they are actually formed, and to this end there is provided a means for counting each loop as it passes between the faces of the pressure plates 35 and 36. A hole 41 is provided in the pressure plate 36, and through an opposite opening in the plate 35 an electrode 37 is mounted flush with the face of the plate 35. Extending through the hole 41 in the plate 36 is a cooperating electrode in the form of a spring urged wire loop 38, which is biased to press against the electrode 37, the magnitude of the pressure being determined by an adjusting screw 39 on the bar 43. The two electrodes 37 and 38 form a portion of an electric circuit 40, including a source of current 60, which is connected to any suitable counting means 61, for counting the number of breaks in the circuit 40, resulting from each separation of the electrodes 37—38, as the loop of wire 22 passes therebetween and breaks the continuity of the circuit.

The bar 43, on which the electrode 38 and the leaf springs 34 are mounted, is pivoted to the base of the frame 12 at 42, and locked in operating position by means of a thumb screw 44, as shown in Fig. 2. This provides a ready means of access to the machine proper. In this manner the plate 36, electrode 38, and all its accoutrements may be swung out of the way for access to the bobbin 15 and other parts of the machine.

In all devices of this type, there is a point in each cycle when the loop in wire 22 is tautened into a straight line and withdrawal of wire from the bobbin recommences, and it is at this point that the wire is most likely to break. In the present device, there is no shuttle to increase, by its inertia, the tension in the wire at that point, yet the tension nevertheless increases somewhat due to the fact that static friction opposing travel of the strand longitudinally of the slot 24 is higher than sliding friction. In order to obviate the slight shock which would thus result, there is provided a guide member 30 in the form of a semicircular spring wire, secured by screws at both ends to the stationary frame of the machine and having its intermediate portion extending in laterally spaced relation to the bobbin 15. The wire 22 being withdrawn from the bobbin passes over this guide member on its way to the coil, and when tension in the wire increases, as at the tautening point just mentioned, the guide member moves yieldingly toward the bobbin to the point indicated at 30' in Fig. 4. The sudden tension or shock in the wire is thus minimized by the giving way of the wire 30, and since the static friction drops to sliding friction the moment the wire starts to feed through the slit 25, the actual tension in the wire is maintained substantially constant throughout the entire withdrawal.

At this time it is well to point out the two striking advantages of the instant method of controlling wire withdrawal from the bobbin 15, over the shuttle method of the prior art. First: In shuttle type machines, the initial acceleration (or deceleration) of the shuttle at the moment the wire 22 is drawn taut reaches very high magnitude. By eliminating the shuttle entirely, it is clear that the instant invention completely obviates this difficulty. Second: During the latter portion of the withdrawal arc, when the shuttle is disposed substantially diametrically across the bobbin from the core, the accelerative force demanded by the shuttle is relatively small. However, the unfavorable angle (nearly 90°) at which the wire is forced to produce this acceleration again creates a critical point in the operating cycle of prior art machines. Here again it will be manifest that the instant invention is entirely free of this disadvantage since the only restraint upon the wire 22 (besides its own negligible mass) is the frictional restraint produced in the slit 25 by the Garker spring 28, which is, within the operating limits of the instant machine, virtually independent of the angle of withdrawal of the wire 22.

OPERATION

Use and operation of the instant machine is as follows. Bobbin 15 is separated at joint 29 and the ends deflected laterally so that the bobbin may be interlinked with a core 20 upon which it is desired to wind the wire. After rejunction of the bobbin 15, the core 20 is clamped in the holding jaw 21 so that the core axis coincides with the tangential center line of the bobbin 15. The end of a wire from a stationary supply spool is attached to the inside of the bobbin 15 by passing the wire through the slot 24 and thence into the slot 32, after which it is bent back upon itself or attached to the inner face of the bobbin 15 by means of adhesive tape. Through the shaft 18 and the driving wheel 17, the bobbin ring 15 is then rotated in a clockwise direction (Fig. 1) until the desired amount of wire has been passed into the interior of the bobbin 15 through the annular slot 24.

A Garker spring 26 of suitable minor diameter, depending upon the size of the wire to be withdrawn through the slit 25, is then linked annularly around the outside of the bobbin 15, resting against the edges of the slot 24, the loose end of the wire 22 being left outside the bobbin 15 by passing through the slit 25 formed by the spring 26 and one edge of the slot 24.

This loose end of the wire 22 is then secured to the core 20, and the winding operation is begun by rotating the bobbin 15 in a counterclockwise direction. In practice, wire may be wound on the core 20 by rotating the bobbin 15 in either direction, the only limitation being that the bobbin must be loaded by rotation in the direction opposite to that from which it is removed when being wound on the core 20.

As the bobbin 15 rotates, the wire 22 is withdrawn therefrom, passing through the biased-closed slit 25, and forming, with each cycle, a loop tensioned by the plates 35—36. Each loop is counted by the successive and momentary breaks between the electrodes 37 and 38. The core 20 is steadily moved, automatically or otherwise, so that the loops of wire 22 may be made to cover any portion of the core desired and to any desired thickness.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed is:

1. A bobbin for a toroidal coil winding machine comprising a split ring designed to be interlinked with a toroidal core and provided with an annular external groove for containing filament wound on said ring, and means for controlling withdrawal of filament from said groove while maintaining substantially constant tension on said filament, said means including a tensioned helical spring resiliently closing said groove to form therewith a slit permitting movement of said filament through and along said slit under substantially constant tension.

2. A bobbin for a toroidal coil winding machine, comprising a split ring designed to be interlinked with a toroidal core and formed with an annular outwardly opening groove for containing filament wound on said ring, and means for controlling withdrawal from said groove of filament under tension, comprising a helical spring having adjacent coils substantially in contact with each other, said spring closing said groove and forming with one edge thereof a resiliently closed slit permitting movement of said filament through and along said slit under tension.

3. A toroidal coil winding machine for winding filament upon a toroidal core, comprising an annular bobbin formed with an annular external groove to contain filament, means to rotate said bobbin upon its own axis while it is interlinked with a core to cause intermittent withdrawal of filament from the groove and transfer thereof to the core, means for frictionally restraining movement of the length of filament between the bobbin and the core during the periods when filament is not being withdrawn from the bobbin, and a Garker spring extending around said bobbin and forming with one edge of said groove a resilient closed slit permitting movement of said filament through and along said slit under tension.

4. A machine for winding strand material upon closed cores, comprising an annular bobbin formed with an external annular groove to contain strand material, means to rotate said bobbin upon its own axis while it is interlinked with a core to cause intermittent withdrawal of strand material from the groove and transfer thereof to the core, means for applying yielding tension to the length of strand intermediate said groove and said core comprising a member positioned in laterally spaced relation to the bobbin and engaging said length in laterally and longitudinally sliding relation and deflecting it from a straight-line path but yielding in a direction

parallel to said axis in response to tension in said length to permit said length to approach such path, and a flexible longitudinally elastic coil spring extending around said bobbin and contacting an edge of said groove to frictionally oppose passage of the strand from the groove.

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