Oct. 2, 1934. W. F. SAUL 1,975,620

COIL WINDING MACHINE

Filed Feb. 13, 1932 3 Sheets-Sheet 1

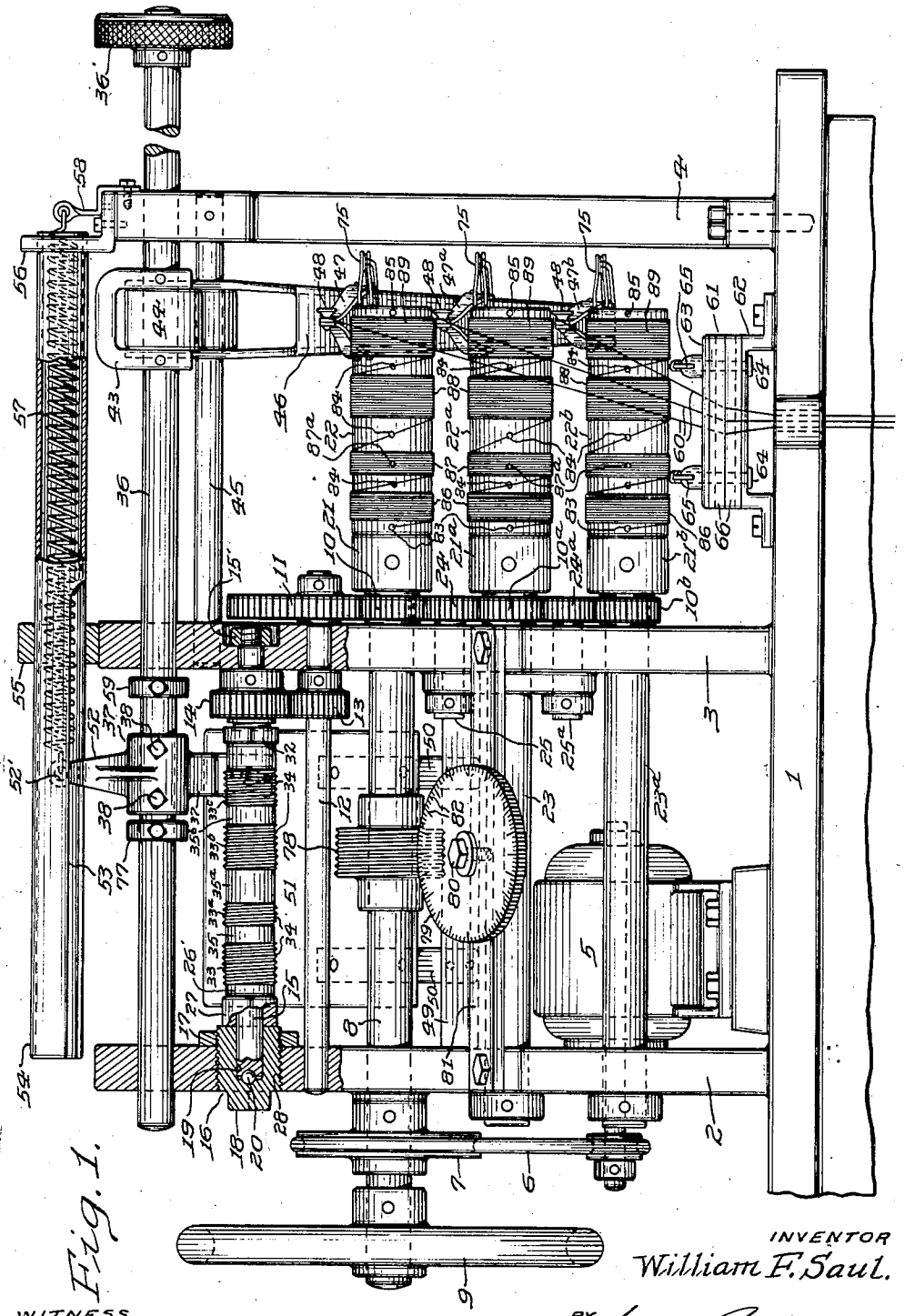


Fig. 1.

WITNESS
F. J. Hartman.

INVENTOR
William F. Saul.

BY Watson E. Coleman
ATTORNEY

Oct. 2, 1934. W. F. SAUL 1,975,620

COIL WINDING MACHINE

Filed Feb. 13, 1932 3 Sheets-Sheet 2

Fig. 2.

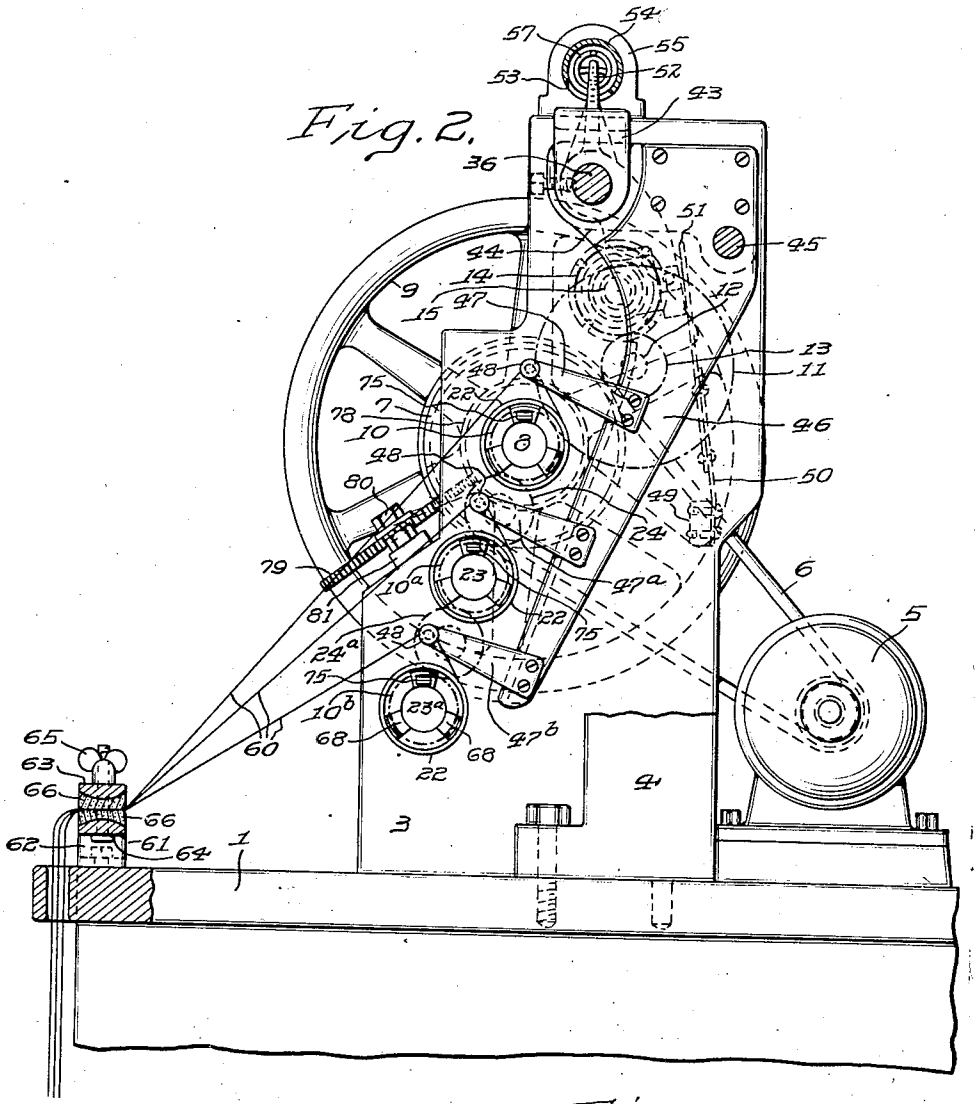


Fig. 10.

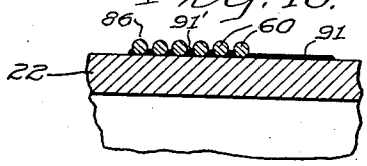
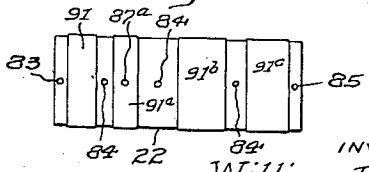


Fig. 9.



INVENTOR
William F. Saul.

WITNESS
H. J. Hartman.

BY Herbert P. Moulton
ATTORNEY

Oct. 2, 1934. W. F. SAUL 1,975,620

COIL WINDING MACHINE

Filed Feb. 13, 1932 3 Sheets-Sheet 3

Fig. 3.

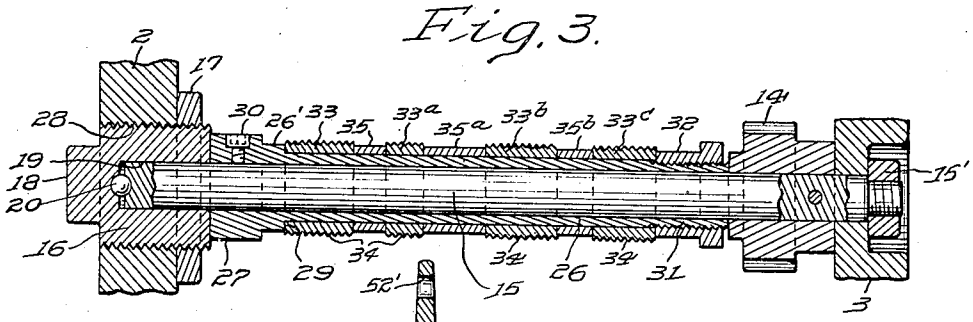


Fig. 4.

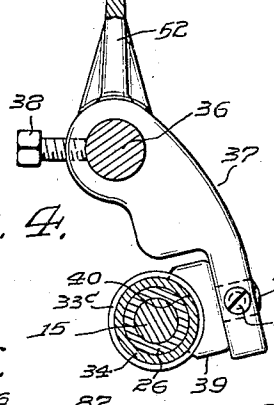


Fig. 5.

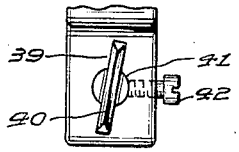


Fig. 6.

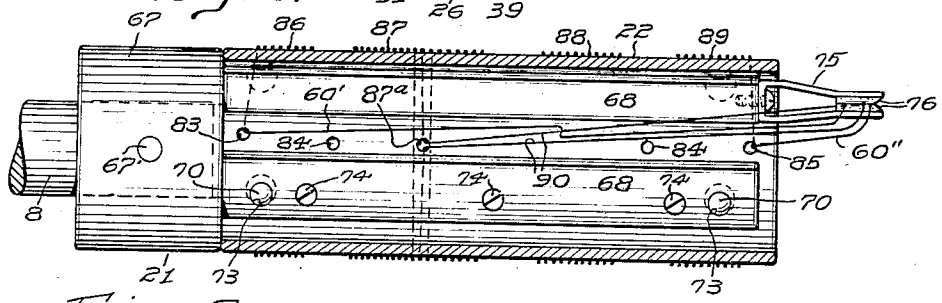


Fig. 7.

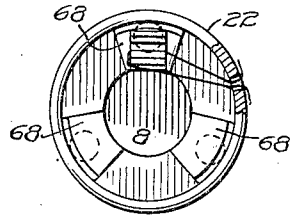
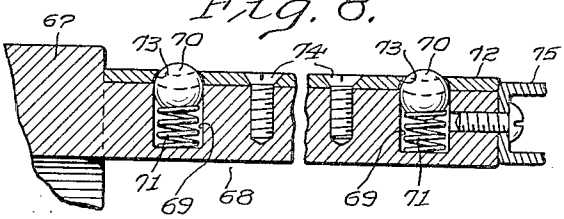


Fig. 8.



INVENTOR

William F. Saul.

BY Alexander B. Woodcock

ATTORNEY

WITNESS

F. J. Hartman.

Patented Oct. 2, 1934 1,975,620

UNITED STATES PATENT OFFICE

1,975,620

COIL WINDING MACHINE

William F. Saul, Westmont, N. J.

Application February 13, 1932, Serial No. 592,727

7 Claims. (Cl. 242—9)

My invention relates to coil winding machines and particularly to those machines which are adapted to wind coils for electrical purposes, as for use in radio apparatus, and more particularly to a machine which may be readily adjusted and adapted to wind coils which will conform exactly to predetermined specifications, as to capacity, induction, resistance and similar factors essential to the proper construction of certain electrical apparatus in which these factors or properties must be correct to give proper results.

Heretofore it has been common to wind upon a single tube or hollow core of insulating material a plurality of wire coils operative for various uses and adapted to be connected into electrical circuits but where the resistance or capacity or inductance of such a coil must be exact, it has been necessary to overwind the coil, (that is wind a few more convolutions than it is known to require) and after the coil has been so overwound, to separate or spread or remove from one end of the coil so much of the winding as may be necessary to bring that factor back to the predetermined quantity or amount. Such adjustments of an overwound coil were frequently effected by sliding on the core or tube a fraction of one or more than one of the convolutions so that the portion of the wire so separated does not operatively form a part of that coil. The amount to be so separated from the coil is thus determined empirically for each coil, for the final result is a matter of repeated manual test, experiment and measurement.

When two coils or windings are on the same core, the wire is often separated from its close relationship with the other convolutions of one coil and is slipped over the gap between the two coils and is added to the second coil, whereupon a like adjustment of the other end of the second coil is made by test and experiment to properly adjust that second coil with respect to the desired factors and characteristics. Thus the old method is slow, particularly in the quantity production of coils, wherein these factors are essential, requires expert labor, and, no two finished coils are so exactly alike that they could without further tests and adjustment be substituted for a similar coil in another assembly.

It is the object of the present invention to provide an apparatus in which such individual manual expert testing and adjustment of a coil, after it has been wound, is absolutely unnecessary once the winding machine has been properly set up and adjusted, and to provide means whereby having once made a coil having the desired factors and characteristics, any number of like coils can thereafter be made thereon or thereby with the assurance that all the coils will be exactly alike as to those factors and can be substituted in an apparatus, one for another, without further test or adjustment.

A further object of this invention is to provide a mechanism wherein a plurality of coils having inductances and capacities different from each other can be formed on a single tube or core of insulating material, and thereafter, and/or simultaneously therewith any number of coils exactly like it with respect to those factors may be formed without care or attention on the part of the operator other than seeing to it that the machine is kept in operation and supplied with a supply of wire. No other care or attention is required of the operator, and, after the coil has once been so formed on the apparatus further tests as to its capacity of inductance will be unnecessary in the further operation of the machine in the duplication of said coils, for the length of wire wound into a coil cannot thereafter vary from the predetermined length and number of convolutions for which the machine was originally adjusted.

A further object of this invention is to provide a winding machine in which any one unit or a plurality of like or different units selected from a set of master units, screw templates and guides, and hereinafter referred to as "formers" or "unit formers" may be readily assembled in substantially any predetermined order and sequence and at the same or different distances from each other, and the assembly being placed in the winding machine, each will control exactly the number of convolutions with which the respective coils will contain, whereby coils having known predetermined capacities or inductances or resistances will be formed on cores of a given diameter with a wire of given diameter, and each coil may be provided with sectional windings or separate small coils on the tube, arranged in the same order or sequence as that of the assembled unit formers.

A further object of this invention is to provide a winding machine in which single unit formers or sets of unit formers may be readily inserted and fixed therein and may be readily taken out and replaced with other unit formers or sets of unit formers for the production of different coils, without taking down the machine or disturbing the other adjustments thereof.

A further object of this invention is to provide a winding machine in which unit formers or

different lengths may be readily assembled, attached and detached to a coil winding machine to control the feed of wire to the tubes without changing the adjustments of other parts of the winding mechanism.

A further object of my invention is to provide a winding machine wherein the exact number of convolutions to be wound upon a core or tube of insulating material is absolutely controlled by the length of the unit former and conversely, wherein by slightly decreasing the length of the former, as for example, by carefully grinding away one end thereof, the number of fractions of convolutions of the coil, the winding of which is controlled by such former, may be slowly and carefully reduced to produce a coil which has a predetermined capacity or inductance and the unit former thus resulting from this adjustment of the same will therefore be a "standard unit former" which, when again used in connection with that machine, and in winding a coil with a wire of the same diameter will therefore always produce on the core or tube of the same diameter, a coil having an exact predetermined capacity or inductance or resistance.

A further object of this invention is to make unnecessary the grooving of the cores for the reception of the convolutions wound thereon, by providing the core with a quick drying coating material having a base of high dielectric value, and to wind the wire into said coating material before the latter solidifies, thereby forming in the completed coil a spiral ridge of rigid dielectric material filling the space between adjacent convolutions and operative to prevent any movement of the convolutions longitudinally of the core in the subsequent handling of the coil and to cement the convolutions to the core.

A further object of my invention is to dispense, in a coil winding machine, with the lead screw ordinarily used for controlling the spacing of the convolutions of the wire on the tube or core upon which the wire is being spirally wound, and to substitute for such lead screw, a master or controller shaft, the end of which is readily accessible and over which may be slipped and to which may be secured to rotate therewith, a sleeve on which may be assembled and rigidly mounted, in any reasonable order, sequence and spacing, one or more unit coil formers, selected from a set of coil formers, and which may differ from each other in length and/or in the pitch of the screwthread with which the outer surface of each unit is provided. Each unit former is of a length known to be that necessary to feed the coil forming fingers or guides through the exact distance necessary to wind a coil having an exact capacity, resistance or inductance, with a given wire on a core of given diameter, with the result that the winding on the tube or core, when a certain unit former is used will have an exact and invariable number of convolutions and fractions of convolutions, and each coil so formed will, therefore, have an electrical capacity, inductance and resistance which is invariable.

The unit formers having been standardized and properly marked, it is the object of the present invention to provide a winding machine for which any one or a plurality of such unit formers may be selected, arranged and assembled, and in which the assembly may be readily rigidly secured to said controller shaft, and used to produce uniform coils of known electrical characteristics without making it necessary to empirically test and adjust the coil after winding.

Further objects of this invention will appear in the specification and claims below.

Referring now to the drawings in which the same reference characters are used throughout the various views to designate the same parts.

Fig. 1 is a front elevational view of my improved coil winding machine showing the same as having completed the winding of four coils on three tubes or cores simultaneously, each tube or core having thereon coils exactly like the corresponding coils of the other tubes, but wherein the coils on the same tube are or may be different from each other with respect to the number of convolutions thereof. In this view, however, portions of certain parts are broken away to clearly illustrate the construction.

Fig. 2 is an end elevational view of the right-hand end of the apparatus shown in Fig. 1 except that a portion of the framework at the right-hand end of Fig. 1 is broken away for the sake of clearness in illustration.

Fig. 3 is a longitudinal sectional view showing a plurality of unit or master formers operatively assembled upon a sleeve and rigidly attached to the master shaft in the winding machine for winding on each tube or core four coils differing from each other as to the number of convolutions in each coil.

Fig. 4 is a side elevational view of the follower for cooperating with the rear side of the master coil formers to control the laying of the wire on the cores or tubes in evenly spaced convolutions.

Fig. 5 is a front view of the lower end of the follower showing the adjustable thread following blade.

Fig. 6 is a fragmentary view showing the chuck on which the tube or core is held during the winding operation, the tube being in longitudinal cross-section and also showing the manner in which the wire between two windings may be looped into the tube and held for the purpose of making terminals for the adjacent ends of two adjacent coils on the tube and the clamp for holding the looped wire during the winding operation.

Fig. 7 is an end view of the construction shown in Fig. 6;

Fig. 8 is a detail view on an enlarged scale of one of the arms of the tube holding chuck and showing the mechanism for tightly holding the tube on the chuck arms.

Fig. 9 is a side elevational view of a core having applied to the surface thereof bands of quick drying lacquer for anchoring the coils to be wound thereon to the core; and

Fig. 10 is a fragmentary section of a core on an exaggerated scale showing the way the wire cuts through the semiplastic lacquer in the winding operation and how the lacquer, when set, will separate adjacent convolutions by a wall or shoulder and prevents any displacement of the convolutions longitudinally of the core.

My improved coil winding machine comprises preferably a rigid base 1 from which vertically rise two parallel bearing plates or supports 2, 3 and a bracket or support 4.

Mounted in any suitable position and as shown in the drawings preferably on the base 1 is an electric motor 5 connected in any suitable manner as by a belt 6 with the driving pulley 7 rigidly mounted on the main driving shaft 8 of the machine. Also rigidly mounted on the main driving shaft 8 is the hand wheel 9 by means of which the mechanism may be manually turned and operated for the purposes of adjustment and also

operative as a balance or flywheel. This main driving shaft 8 is journaled in any suitable manner in the bearing supports 2 and 3 and is provided with a pinion 10 adapted to intermesh with a driven gear 11 on the countershaft 12. This countershaft 12 is also provided with a pinion 13 meshing with and driving a gear 14 rigidly mounted on the master shaft 15, one end of which is suitably journaled in a bearing support 3 and the other end of which is journaled in a thrust bearing member 16 threaded through the bearing support 2, and rigidly held in position by a lock nut 17. The bearing member 16 is preferably provided with a polygonal bolt head 18 and with a coaxial cylindrical recess 19 and a ball thrust bearing 20 between it and the adjacent end of the master shaft 15.

The master shaft may be retained in its bearing in the support 3 by a nut 15', as indicated in Figs. 1 and 3. The right-hand end of the main driving shaft 8 (as shown in Fig. 1) is also provided with a chuck 21 over which may be slid a tube 22 preferably of insulating material and upon which the coils are to be wound.

Also rotatably mounted in the bearing supports 2 and 3 is a shaft 23 parallel with the main driving shaft 8 and provided with a chuck 21^a like the chuck 21 for supporting the tube 22^a and with a pinion 10^a, of the same diameter as the pinion 10 on the shaft 8, and meshing with an idler 24 which also meshes with the pinion 10, the idler 24 being mounted on a stud shaft 25 journaled in the bearing support 3.

Similarly mounted in the bearing supports 2 and 3 is a shaft 23^a parallel to the main driving shaft 8 and provided with a chuck 21^b and a pinion 10^b meshing with an idler 24^a which also meshes with the gear 10^a on the shaft 23, the idler 24 being mounted on a stud shaft 25^a like the stud shaft 25 above referred to. Over the chuck 21^b may be slipped a tube 22^b like the tubes 22 and 22^a. From the above it must be plain that the shaft 23 is driven through a pinion 10^a and idler 24 from the main driving shaft 8 and in the same direction as the said shaft 8 and that similarly the shaft 23^a is driven through the pinion 10^b and idler 24^a from the gear 10^a on shaft 23 and in the same direction as the shafts 8 and 23.

Preferably the ratio between the pinion 10 and the gear 11 is

$$\frac{1}{2.5}$$

and the ratio between the pinion 13 and the gear 14, is ½, so that the main driving shaft 8 revolves five times for one revolution of the master shaft 15. Of course any other suitable predetermined ratio may be adopted, but since that is the ratio which has actually been used and is shown in the accompanying drawings reference is made to herein in order to make it plain that preferably the speed of the rotation of the master or controller shaft 15 is slow as compared to that of the shafts which rotate the tubes and that the pitch of the convolutions of the coils being wound is much higher per inch than that of the screwthreads of the master formers.

Referring now to Fig. 3 wherein the master unit formers are shown in an assembled relation on the master shaft 15, I provide a cylindrical sleeve 26 having a bore therethrough adapted to smoothly fit the master shaft 15, and provided with a squared bolt head 27 of a diameter smaller than that of the thrust bearing member 16, so that it can be freely slid through the threaded opening 28 in the bearing plate 2 in which the thrust bearing member 16 is threaded and also provided with a shoulder 29. I preferably provide the head 27 with a set screw 30 for the purpose of rigidly attaching said sleeve 26 to the shaft 15. The opposite end of the sleeve 16 is also preferably provided with a threaded portion 31 over which is threaded a nut member 32.

When the sleeve 26 is out of the machine and the nut member 32 is removed therefrom, this sleeve is adapted to receive and carry one or more master unit formers 33. In Fig. 3 I have shown four of such units and to distinguish between them I have given them the same numeral, but with different exponents, namely, 33, 33^a, 33^b and 33^c although it is to be understood that these represent but four of a set comprising a large number of the same or different lengths and of the same or different pitches, for each unit former comprises a sleeve having screwthreads 34 on the outside and extending the full length thereof.

Separating these master unit coil formers are sleeves or spacers 35, 35^a, 35^b, and 35^c also smoothly fitting the exterior surface of the sleeve 26 and having cylindrical outer surfaces the diameter of which is the same as that of the master unit coil formers at the bottoms of the threads 34 thereon, the purpose of which will be referred to again below.

The length of each of the master unit coil formers is assumed to have been tested and measured most accurately and it is known by the user of the machine that, for instance, the unit former 33 will form on a tube 22 carried by the chuck 21 a coil of wire of known capacity or inductance or resistance as the case may be. If, therefore, he wishes to have the first coil to be formed on the tube, of that capacity or other factor, he will place it in the sleeve 26 as the first unit former from the head 27 on the sleeve 26 abutting it against the shoulder 29. The length of the cylindrical spacers 35 placed between adjacent unit formers, may be different and will determine the distance that the coils, to be formed on the tubes 22, will be separated from each other and from the ends of the tube 22.

Having selected, for instance, from the complete set of unit master formers the set of four required for a particular piece of work, (for instance the unit formers 33, 33^a, 33^b and 33^c) the operator will slip over the threaded end 31 the sleeve 26, the former 33, then a spacer 35, then the coil former 33^a, then a spacer 35^a, then the former 33^b, then the spacer 35^b, then the former 33^c, it being assumed that he wishes to form the four coils on the tubes, as shown in the drawings forming a part of this application.

He then threads the nut member 32 over the threaded nut 31 of the sleeve and tightly compresses the coil formers 33 and the sleeves 34 tightly between the nut member 32 and the shoulder 29 of the sleeve. The sleeve is now assembled and is ready for insertion into the machine. This he does by sliding it through the opening or threaded hole 28 over the shaft 15 until it abuts squarely against the shoulder formed by the hub of the gear 14. He then tightens the set screw 30 to make the sleeve 26 fast to the master shaft 15 and then proceeds to thread the thrust bearing member 16 into the threaded hole 28 until the ball bearing 20 bears with sufficient pressure against the end of the

shaft 15. He then tightens the lock nut 17 to hold the thrust bearing 16 rigid and immovable with respect to the bearing plate or support 2 and the master shaft 15 is then provided with the necessary master unit coil formers for the winding of the coils on the tubes 22.

Also mounted to slide longitudinally in the bearing supports 2 and 3 and in the bearing bracket 4 is a rod 36 to which is rigidly secured a follower 37 by set screws 38. The follower 37 extends from the rod 36 toward but to one side of the master shaft 15 and is provided with a blade 39 having a relatively sharp front edge 40 adapted to lie between any two consecutive convolutions of the threads 34 on the outer surface of the master formers 33. This blade 39 is preferably provided with a cylindrical stem 41 in the rear thereof adapted to rotate into a cylindrical recess in the follower block 37 and to be fixed therein by a set screw 42. In this way with the set screw 42 loose, the blade may be adjusted as to lie squarely between any two convolutions of the thread 34 and may then be retained in that position by tightening the set screw 42. The front edge of this blade may be arcuate so as to contact with a substantial portion of the circumference of the groove in which it rests to avoid undue wear of the threads or blade.

Also rigidly secured to the rod 36 is a yoke 43 engaging both ends or sides of a block or carriage 44 in which the rod 36 is rotatable. Through this carriage 44 also extends a stationary rod 45 parallel to the rod 36 and extending between the bearing support 3 and the bracket 4. On this rod 45 the carriage 44 slides freely longitudinally thereof and with the rod 36 which is longitudinally slidable in the supports 2, 3 and 4. The rods 36 and 45, therefore, prevent any rotative movement of the block or carriage 44 about the axis of either of the said rods. The construction permits of the rotation of the rod 36 freely within the block or carriage 44, and permits the longitudinal movement to the rod 36 to be communicated to the block 44.

Extending downwardly from the opposite sides of the block 44 and generally parallel to the line connecting the axes of the shafts 15, 23 and 23^a is an arm 46, all of suitable rigid construction and provided with wire guiding fingers 47, 47^a, 47^b, extending forwardly to positions respectively over the chucks 21, 21^a and 21^b and the tubes 22, 22^a and 22^b carried thereby. The end of each finger 47 is provided with a smoothly grooved button 48 over which the wire to be wound can smoothly slide.

Also extending between the bearing plates or supports 2 and 3 is a rigid bar 49 which forms a support for two upwardly extending springs 50—50, said springs being rigidly attached at their lower ends to said bar 49 and carrying at their upper ends a plate 51, which is normally pressed by the tension of said springs 50—50 hard against the back of the follower 37, to normally hold the knife edge 40 of the blade hard against a master unit coil former 33 when it is in engagement with the threads 34 of any of them, and firmly against the cylindrical surface of the spacers 35 when it is not in engagement with the threads of a master former 33.

The rod 36 is provided with a knob or handwheel 36′ on the right-hand end thereof, as shown in Fig. 1 by which the rod 36 may be manually rotated to throw the knife edge out of its engagement with the master former 33 when desired, pressing the plate 51 rearwardly against the tension of the springs 50.

Extending upwardly from the follower 37 is an arm 52 somewhat flattened at its upper end so as to freely enter into and slide within a slot 53 in a tube 54 arranged parallel to the rod 36 and rigidly retained on the supports 3 and 4 in brackets 55, 56 respectively. The slot 53 in said tube 54 extends from the free end of said tube at the left (Fig. 1) to a point near the bracket 55. Within this tube 54 is a tension spring 57, one end of which is hooked into an eye 52′ at the free end of the arm 52 which is within the tube 54 and the other end of which is connected with a rigid post 58.

The spring 57 tends at all times to draw the follower 37 to the right (Fig. 1), that is to say, in the direction in which the follower 37, and the parts moving therewith, are drawn by the engagement of the edge 40 of the blade 39 with a rotating master unit former 33, and the spring 57 is operative, as soon as the said knife edge completes its travel of a coil former 33 or 33^a or 33^b or 33^c to quickly draw the knife edge 40 over the cylindrical surface of the spacers 34 into the first convolution of the next master unit former, and when it has traversed the last master unit (33^c) to draw the stop washer or collar 59 up against the bearing support 3.

Adjacent the front edge of the base 1 I may provide any suitable device for imparting the required tension to the wires 60 during the winding operation. In Figs. 1 and 2, I have shown such an appropriate tension device 61, comprising a base 62 and a plate 63 thereover and through which two bolts 64—64 pass vertically, the upper ends of the bolts being provided with thumb nuts 65. The adjacent surface of said plate and base are preferably respectively provided with a strip of felt 66 between which the wires 60 are drawn as it winds upon the tubes 22.

The shafts 15, 23 and 23^a are respectively provided with like chucks 21, 21^a and 21^b and the construction of a chuck is clearly shown in Fig. 6. The head 67 of a chuck 21 is rigidly secured to the shaft 15 (and to the shafts 23 and 23^a as the case may be) by a pin 67′ and from the head extend forwardly, parallel to the axis of the chuck, three fingers 68, the length of each of which is substantially the same as that of the tube 22 to be carried thereby. Each finger is preferably provided with radially disposed holes 69—69 within each of which is a ball 70 and a light coil spring 71 beneath it, the tension of the spring being such as to tend to push the ball out of the recess 69.

Covering the outer surface of each finger is a plate 72 with openings 73 therein through which the balls 70 project slightly, the plate being rigidly secured to the outer side of the fingers 68 by screws 74. When a tube 22 upon which a coil is to be wound is slipped over the fingers 68 of the chuck, the outer surface of which it slidingly fits against, it depresses the balls 70 slightly and the pressure with which these balls exert against the interior surface of the tube supplements the friction with which the interior diameter of the tube fits the outer surface of the plates 72 and the tube is firmly held on the chuck and prevented from rotating with respect to the chuck.

One of the arms or fingers 68 may be provided with a forwardly projecting spring clip 75 which extends out beyond the end of the tube 22 and the ends of the arms of the spring

clip are provided with friction pads 76 of leather or felt, this clip being for the convenience of the operator when it becomes necessary to provide terminal wires for the separate coils being wound on the tube as will be referred to again below.

The rod 36 is also provided with another washer or collar 77 similar to the collar 59 on the opposite side of the follower 37 to limit the movement of the rod 36 to the left (Fig. 1).

It is often desirable for the operator to know just how many convolutions have been wound during the winding of a coil or section on a tube 22 and particularly when the coil is nearly completed, and, for that reason I may and preferably provide the shaft 15 with a worm 78 which is in engagement with and drives a worm wheel 79 mounted to rotate on the front of the machine between the supports 2 and 3 on a stud 80 secured to a bar 81 extending between the supports 2 and 3 and rigidly secured thereto. The pitch of the worm 78 and the diameter of the worm wheel 79 and the graduations 82 on the face of the worm wheel are such that every time the shaft 15 makes a complete revolution, the worm wheel 79 is advanced from one to the next graduation on the worm wheel, and, therefore, by taking a reading as the fingers 47 near the end of their travel and slowing the machine by gently braking the balance wheel 9 the exact number of convolutions which have been wound can be readily ascertained.

Reference should here be made to the fact that it is usual to provide the tubes 22 with suitable openings adjacent where the first winding begins and where the last winding ends, and frequently at a point or points between the windings to be formed thereon. I have shown in Figs. 1 and 6, three of such openings 83, 84, 85. As the operator slips the tube over the fingers or arms 68 of the chuck 21, he so places the tube that the said openings lie in the space between the arm or fingers 68. In order to begin the winding the operator inserts the ends 60' of wires 60 through the openings 82 nearest the head of the chuck 21 and draws it out through the open end of the tube and clamps the end between the fingers of the clip 75. This provides a length of wire sufficient to form a coil terminal to which to solder the end of a wire of an electric circuit in installing the tube for use.

In the drawings each tube 22 is shown as provided with four coils or windings 86, 87, 88 and 89, the winding operation being nearly completed with respect to the last coil 89. The windings of the coils 86, 87, 88 and 89 are respectively controlled by the master coil units 33, 33^a, 33^b, and 33^c.

It is not infrequent that different coils on a single tube form, when installed in an apparatus, parts of different electrical circuits, whereupon it is desirable to provide each of such coils with a center tap terminal wire. To form such terminals, for instance for the coil 87, the operator, after the winding of coil 87 has been completed up to the opening 87^a, will stop the machine, and holding a finger pressed tightly against the last wound convolution of the coil 87, he will then draw from between the tension device 61 as much wire as will suffice to reach to the end of the tube and back again, will form that wire with a loop 90, will insert the loop down into the hole 87^a, draw the loop to the open end of the tube and clamp it in the clip 75, will then draw taut the stretch running back to the tension device 75, and start the machine to wind the balance of coil 87 (see Fig. 6).

Since in describing the apparatus, considerable reference has been made to the manner in which the same has been operated, a brief description of the complete operation will now suffice.

Knowing what are the number of coils to be wound on the tubes and the factoral characteristic (capacity, and/or resistance, and/or inductance) that each is to have, from a complete set of master formers of possibly different lengths and possibly of different pitches, the operator selects, it is assumed, the four master formers 33, 33^a, 33^b, 33^c which are known to produce, on the tubes, coils of the desired and specified factoral characteristics with a given wire and a tube of the diameter of the tubes 22. He then, after removing the thrust bearing member 16, and withdrawing the cylindrical sleeve 26 from the master shaft 15 and places those four master units 33, 33^a, 33^b in the predetermined and desired order on the sleeve 15, spacing them properly from each other by introducing the sleeves 34, 34^a, 34^b and 34^c, and he then clamps the same rigid with respect to the sleeve, by the nut 32. He then slips the sleeve with the master formers and spacers so mounted thereon back through the threaded hole 28 over the master shaft 15 until the end of the sleeve abuts squarely against the hub of the gear 14. He then replaces the thrust bearing member 16 within the hole 28 bringing the ball bearing 20 against the end of the master shaft 15 and then he locks this member 16 by means of the lock nut 17. He also firmly secures the sleeve 26 to the shaft 15 by the set screw 30.

He also slips over the chuck fingers 68 of the respective chucks 21, 21^a, 21^b, as many cores as he wishes to wind at a single operation, bringing the ends of the tubes squarely against the shoulders of the chuck heads 21, 21^a and 21^b respectively. In doing this the tubes depress the balls 70 which firmly hold the tubes on the chucks.

But before placing the cores on the chuck fingers 68, annular bands or stripes 91, 92, 93 and 94 of a coating material, the base of which has a high dielectric value, preferably of a quick drying lacquer, are applied to the cores at the places where the coils are to be wound thereon. The lacquer may be brushed on by hand, but preferably the stripes are applied by rotating the core in a coating machine having cement applying rollers so spaced as to properly apply the stripes to the cores. If a coil is to be wound continuously for the whole length of the core, then the coating is preferably applied to the entire surface of the core.

The knife edge 40 is also adjusted to the screw-threads 34 of the master former 33 and the set screw 38 tightened. Unless the pitches of the threads on the different masters subsequently vary, a single adjustment of the blade 39 will suffice.

The rod 36 is then rotated by the knob 36' in an anticlockwise direction (Fig. 1) thereby throwing the knife edge 40 clear of the threads 34, thereby pressing rearwardly the plate 51 against the tension of the spring arms 50. The rod 36 is then pushed to the left (Fig. 1) until the collar 77 engages the upright 2. The rod 36 is then rotated in the reverse direction and the knife edge 40 bears against the cylindrical surface 26' of the sleeve 26 where it is held by the spring pressed plate 51, and the spring 57, upon the release of the knob 36' by the operator, draws the rod 36 and the follower 37, back to a position wherein the

knife edge 40 comes to rest against the left-hand side of the first convolution of the screwthread 34 in the first master former.

The operator may then take the wire 60 (one for each tube to be wound) and thread each over a button or guide 48 respectively on the ends of the wire guiding fingers 47, 47a, 47b, may insert the free end 60' of the wire down through the holes 82 of the three tubes respectively, and draw the wire longitudinally through each coil, clamping and holding each end 60' between the fingers 68 of the clips 75 respectively.

Power is applied to the motor 5 to drive the shaft 8 in a clockwise direction. The gearing is such that the drive shaft 8, the master shaft 15 and the chuck shafts 23 and 23a geared thereto, all rotate in the same direction, to wit, clockwise. As the master unit former 33 rotates, the knife edge 40 of the blade 39 slowly travels to the right (Fig. 1) due to the engagement of the edge 40 between a pair of adjacent convolutions of the screw 34 on the rear surface of the unit former 33. Since the master shaft 15 makes but one revolution for every five revolutions of the main driving shaft, it will be apparent that five convolutions of fine wire will be wound on the coil 85 for every single revolution of the master shaft 15 and the distance between adjacent convolutions of the same coil 85 will be only one-fifth of the pitch of the thread 34 on the master unit 33.

The wire 60 of each of these coils so formed may be very fine wire; in diameter less than that of a horsehair. As the operation of the machine continues, the coil 86 will continue to be wound until the knife edge or blade 39 reaches the last convolution of the master unit 33.

As soon as the knife edge 40 clears (feeds out of) the last convolution of the unit 33, the tension spring 57 comes into action and rapidly pulls or draws the rod 36 and the parts carried thereby to the right. The knife edge 40 smoothly slides over the smooth surfaces of the spacer 35 without hindrance or likelihood of being held on a shoulder, for the diameter of all the spacers is the same as that of the bottom of the grooves forming the screwthread 34. The edge 40 of the blade 30 is thus brought into contact with the first convolution of the second master former 33a, and the winding of coil 87 begins.

As has been above set forth, the yoke 43 is rigid with the rod 36 and bears smoothly without backlash on opposite sides of the block or carriage 44 so that the block moves longitudinally with the rod 36 and slides longitudinally on the rod 45, thereby moving with it the fingers 47, 47a, 47b slowly over the tubes 22, 22a and 22b. As soon as the knife edge 40 clears the last convolution in the master unit former 33a it similarly is slidingly pulled over the cylindrical surface of the spacer 35a into engagement with the first convolution of the third unit former 33b.

In like manner, after traveling across the master former 33b the knife edge 40 is drawn over the spacer 35b by the spring 57 into engagement with coil former 33c and upon the completion of its travel in engagement therewith the spring 57 again quickly pulls the rod 36 to the right and the collar 59 into engagement with the support 3.

The operator then stops the machine, places his finger on the last convolution to hold it in place, cuts the wire 60, inserts the free end 60'' through the holes 84 in the tubes and clamps that cut end 60'' between the spring fingers of the clip 75 (see Fig. 6). In this way, three spools are simultaneously wound and are provided with four coils 86, 87, 88 and 89 thereon, all exactly alike with respect to winding of the different tubes but wherein the coils on the same tube may be different from each other.

Unless taps are to be made intermediate the ends of a coil, the winding is a continuous operation from one end to the other of the tubes 22 without stopping. If terminals are required for the different windings on a tube, then the speed of the rotation of the tubes 22 in winding is so proportioned to the speed with which the follower 37 moves over the spacers 35 that a length of wire is wound on the spacers 35 sufficient to reach to the end of the tube and back again before the winding of the next coil on the tube begins. For convenience of illustration I have shown in Fig. 1 the wire as extending across the spaces between adjacent windings in about half a revolution, but if the coils 86, 87, 88 and 89 are to be provided with terminal connections between them, then the winding between the respective coils will comprise a few convolutions and at the completion of the winding a cut will be made in these intermediate convolutions, the wire between the coils straightened and inserted into the holes 84 at the ends of the respective coils and inserted in the clips 75.

The number of convolutions in any individual coil on a tube is dependent upon and is controlled by the length of the master unit former by means of which the winding fingers are fed longitudinally of the coils. Of course, the determination of what shall be the correct length of any unit former to produce a coil on a tube of given diameter with the wire of a given diameter, is a matter of empirical determination. When a coil is wound with a master former its capacity is measured and if the capacity or resistance or inductance is too great, then the end of the unit coil former is ground slowly down, the operation is repeated and that coil is tested until a master is produced having a length which will always produce, on a core of a given diameter and with a wire of given diameter, a coil of wire which has a capacity or an inductance or a resistance which has been predetermined and is invariable.

Since the distance between the coils being wound is determined by the spacers 35, this shortening of the length of a master coil former will not affect the spacing of the windings on the tubes 22. This is very important and heretofore impossible of attainment, particularly in the winding of balanced induction coils where such a shortening of a master section would require a further adjustment of the coacting coil because of the change in the spacing of the windings. In my improved machine, however, the proper balance of coacting coils may be attained and the length of the winding of either coil may be adjusted by grinding a few ten thousandths of an inch of a master coil former to shorten the winding by even a fraction of a convolution, without changing the spacing.

In no other winding machine of which I am aware is any like operation possible. In many winding machines a lead screw is provided for traversing the winding fingers slowly over a coil, but there is no way of determining or accurately fixing how long the shaft shall be revolved to produce a coil of a predetermined characteristic except by overwinding and empirically testing and trying each winding and modifying its inductance or other characteristic of the coil after winding it by sliding and spacing from the coil one or more convolutions at one end of the over-

wound coil. Nor am I aware of any other wire coil winding machine wherein different coils having different characteristics may be wound on a single core or tube at a single operation, each coil having a known capacity, inductance or resistance determined exactly, by a master coil former which can be assembled and placed in the machine, in a position to provide for correctly winding the wire in the proper and predetermined position longitudinally of the tube or core.

It is now to be observed that during the winding of any one coil into a band or stripe of quick setting lacquer, which almost immediately after application becomes semi-plastic, and rapidly sets and hardens, the wire 60 being under sufficient tension imposed by the tension device 6, will cut through the cement down to the surface of the core. The semiplastic lacquer 91 will also be forced upwardly by displacement to form ridges 91' between adjacent convolutions. When this cement 71 hardens it will absolutely prevent any lateral movement of one convolution with respect to the other convolutions during the subsequent handling of the coil. In delicate coils where such movement must be prevented, it has heretofore been common to provide the tubes or cores with grooves of the necessary pitch corresponding to the feed of the wire forming fingers. In the practice of my invention, the formation of threads or grooves in the cores is absolutely dispensed with, for the wire, in winding, makes or forms in the semiplastic cement or lacquer, a groove of the correct pitch for the winding. When the lacquer has hardened, which is completed almost immediately the tube has been wound, it forms a rigid spiral ridge or wall of solid dielectric material filling the spaces between adjacent convolutions, and operative to prevent the displacement of the convolutions in the subsequent handling of the coil.

And this winding of the convolutions of the coil in quick drying cement or lacquer is also of great utility when terminals are to be provided between adjacent coils, for upon the completion of the winding operation and the removal of the core from the chuck, these convolutions between the coils may be cut and the cement will retain the convolutions which form the true coils 86, 87, 88 and 89 fast to the core. The true length of the winding of the individual coils will not be disturbed when the wire is thus severed. In no other coil winding machine of which I am aware, is such an operation possible.

A set of unit formers of lengths necessary to produce coils on a tube of standard capacity, inductance or resistance, can be comparatively easily made and marked or otherwise identified, and when so made, such unit coil formers as may be necessary to form any number of coils of predetermined and different resistance, capacities and inductance may be readily selected from the set, easily secured to the master sleeve and easily adjusted. A machine, so constructed may be operated week in and week out, to produce large numbers of coils, all exactly alike, none of which will thereafter require individual manual adjustment, alteration or other manipulation in order to insure that they have the predetermined characteristic. Moreover, the convolutions will not be subject to easy displacement, due to subsequent handling in making assemblies, due to the rigid wall of hardened lacquer or other suitable cement between them. The coils so formed are as nearly absolutely correct as it is possible to make them, and the completed coils will be duplicates of each other, ready upon the completion of its winding, for installation in a radio receiver, or other apparatus, for which it was wound, or for replacement in an apparatus for a unit coil which may not properly function.

Having thus described my invention, what I claim and desire to protect by Letters Patent of the United States is:

1. In a coil winding apparatus, the combination of a frame, a winding shaft rotatable in said frame, means mounted on said shaft for supporting a core to be wound in said machine, a master shaft, a removable sleeve on the end of said master shaft, a series of master coil units mounted on said sleeve and secured thereto in spaced relationship with respect to each other, each unit being provided with a screwthread extending the entire length of the outer surface thereof, a follower mounted on said frame to slide parallel to said master shaft and normally held in engagement with the outer surface of one of said master coil units, a wire guiding finger mounted in said frame to slide with said follower and extending to a point close to said core, a spring under tension connected to said follower and tending to draw said follower in a direction in which said follower is moved when it is in engagement with said master coil units and operative to draw said carrier and said wire guiding finger longitudinally from one master coil unit to the next the instant said follower arrives at the end of the thread of a master unit.

2. In a coil winding machine, the combination with a frame, a winding shaft mounted for rotation in said frame, means mounted on said shaft for supporting a core upon which the wire is to be wound, a master shaft, gearing between said master shaft and said first mentioned shaft, whereby a fixed ratio of rotation is maintained between said winding shaft and said master shaft, a master coil unit insertable over and removable from the end of said master shaft, and having a screwthread extending throughout the entire length of the outside thereof, means to rigidly secure said unit to said master shaft to rotate therewith, a follower normally in engagement with the thread on the outer surface of said unit, whereby said follower is moved in a direction parallel to the axis of said master shaft upon the rotation of said unit coil former, and wire guiding fingers operatively connected to said follower and actuated thereby to travel longitudinally therewith, parallel to said core to deliver wire to the surface of said core as said core is rotated.

3. In a coil winding machine, the combination of a winding shaft, means mounted on said shaft to support a core for rotation therewith, means to rotate said winding shaft, a wire guiding finger movable parallel to the axis of said winding shaft and adjacent thereto, a master shaft, means to rotate said master shaft at an angular speed having a fixed ratio of rotation with respect to that of said winding shaft, a sleeve insertable over and removable from the end of said master shaft, a plurality of master coil winding units, rigidly secured to said sleeve in spaced relationship longitudinally of said sleeve, each unit having a screwthread cut in the outer surface thereof and extending the full length of the master unit, spacers between said master units on said sleeve, the outer diameters

of said spacers being practically the same as the diameter of said master units at the bottom of the screwthreads, and a follower normally held against said master coil units and spacers mounted on said sleeve, and movable in a direction parallel to the axis of said master shaft by reason of the engagement of said follower with the threads on the outsides of the master coil units, and a spring mounted operative to normally draw said follower in the direction in which it is fed by said screwthread in said formers and to draw said follower over the spacers between said units the instant said follower reaches the end of a thread in a master coil unit.

4. In a coil winding machine, the combination of a master shaft, a sleeve insertable over the end of said master shaft, means to rigidly secure said sleeve to said master shaft, a plurality of master coil units insertable over the end of said sleeve and removable therefrom, spacers freely slidable longitudinally of said sleeve to position said units longitudinally of said sleeve at distances from each other equal to the length of the spacers respectively therebetween and means to removably secure said units and said spacers rigidly with respect to said sleeve and each other.

5. In a coil winding machine, the combination with a master unit having a screwthread in its surface extending the full length of said unit, a master shaft, means to rigidly secure said master unit to said master shaft for rotation therewith, a winding shaft, gearing between said winding shaft and said master shaft to maintain a fixed ratio between the speed of said master shaft and the speed of said winding shaft, means carried by said winding shaft to hold a core to be wound for rotation therewith, a follower normally held in engagement with the thread on the surface of said master units, and a wire guiding finger operatively connected to said follower to move therewith parallel to said winding shaft to deliver wire to the core on said winding shaft, the length of said master units being such as to impart to said wire guiding finger a travel sufficient to form on a core of known diameter carried by said winding shaft, a coil of wire having a fixed, known and predetermined resistance, capacity and inductance.

6. In a coil winding machine, means to simultaneously wind a plurality of coils having substantially indentical and predetermined resistances, inductances and capacities, comprising the combination of a plurality of winding shafts, means to rotate the same simultaneously at the same speed of rotation, a master shaft geared to said winding shafts to rotate at a fixed ratio of speed with respect to said winding shafts, a plurality of master coil units insertable over and removable from the end of said master shaft each having a screwthread formed in its outer surface extending the full length thereof, means to rigidly secure said master coil units to said master shaft to rotate therewith, means to space said units on said shaft and placed between adjacent master units, the diameter of said means being the diameter of the thread in said master units at the bottoms thereof, a follower, means to yieldingly hold said follower against said master units and spacers, the capacities, inductances and resistances of the coils wound on the cores carried by said winding shafts being controlled and regulated to an exact quantity by the length of the said master units, and means to draw said follower over said spacing means between any two of said master units the instant the follower reaches the end of the thread in a master unit.

7. In a coil winding apparatus, the combination of a frame, a winding shaft rotatable in said frame, means mounted on said shaft for supporting a core to be wound in said machine, a master shaft, a removable sleeve on the end of said master shaft, a series of master coil units carried by said sleeve and secured thereto in spaced relationship with respect to each other, each unit being provided with a screw-thread extending the entire length thereof, a follower mounted on said frame and slidable parallel to said master shaft and normally held successively in engagement with the threaded surfaces of said master coil units, a wire guide mounted on said frame to slide with said follower and positioned relatively close to said core, means connected to said follower and tending to draw said follower in the direction in which said follower is moved when it is in engagement with said master coil units and operative to draw said carrier and said wire guide longitudinally from one master coil unit to the next the instant said follower arrives at the end of the thread of a master coil unit.

WILLIAM F. SAUL.