No. 720,092. PATENTED FEB. 10, 1903.

E. L. AIKEN.

APPARATUS FOR MAKING COILS FOR ELECTRICAL APPARATUS.

APPLICATION FILED DEC. 5, 1898.

NO MODEL. 2 SHEETS—SHEET 1.

FIG. 1.

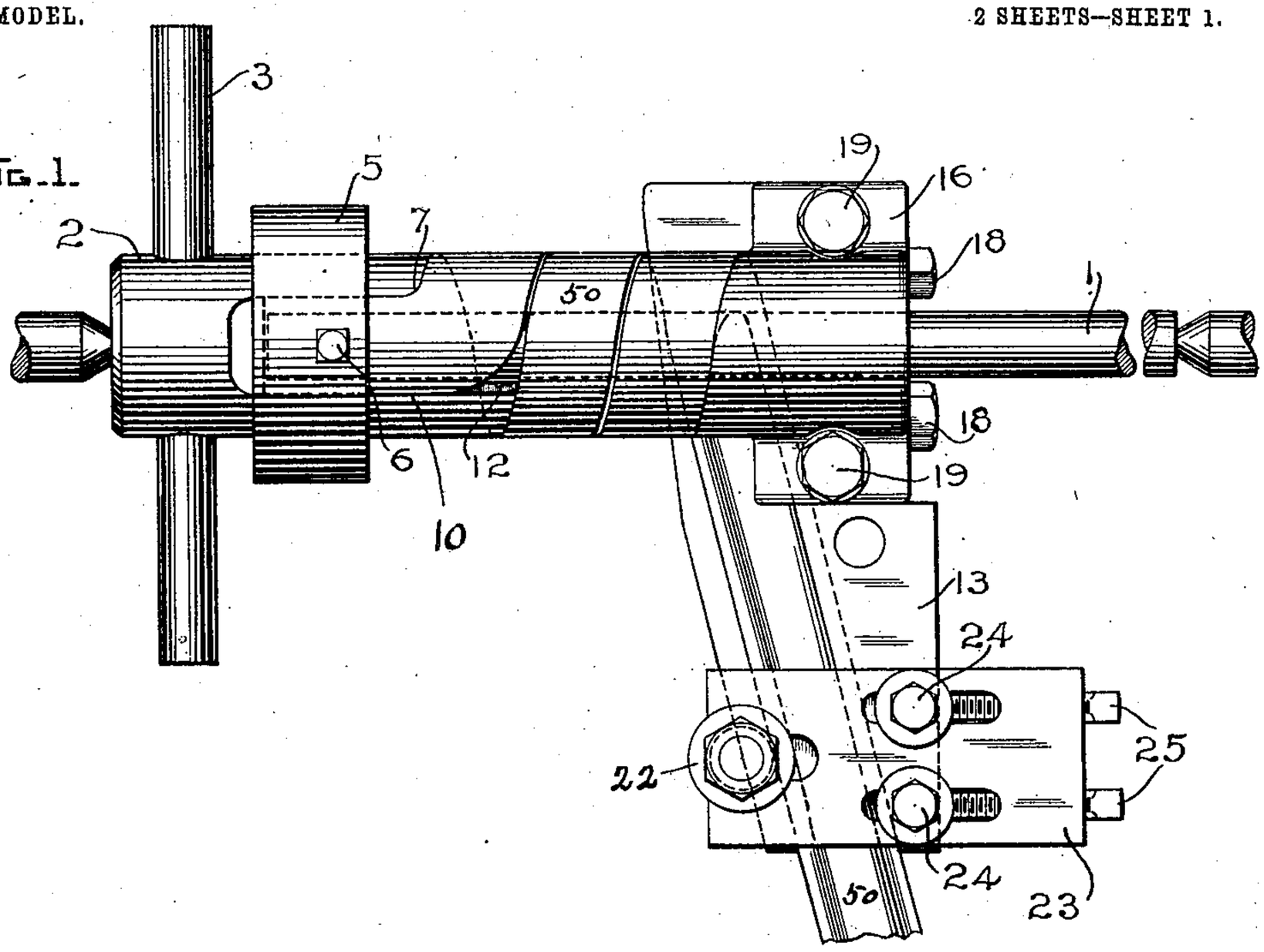


FIG. 2.

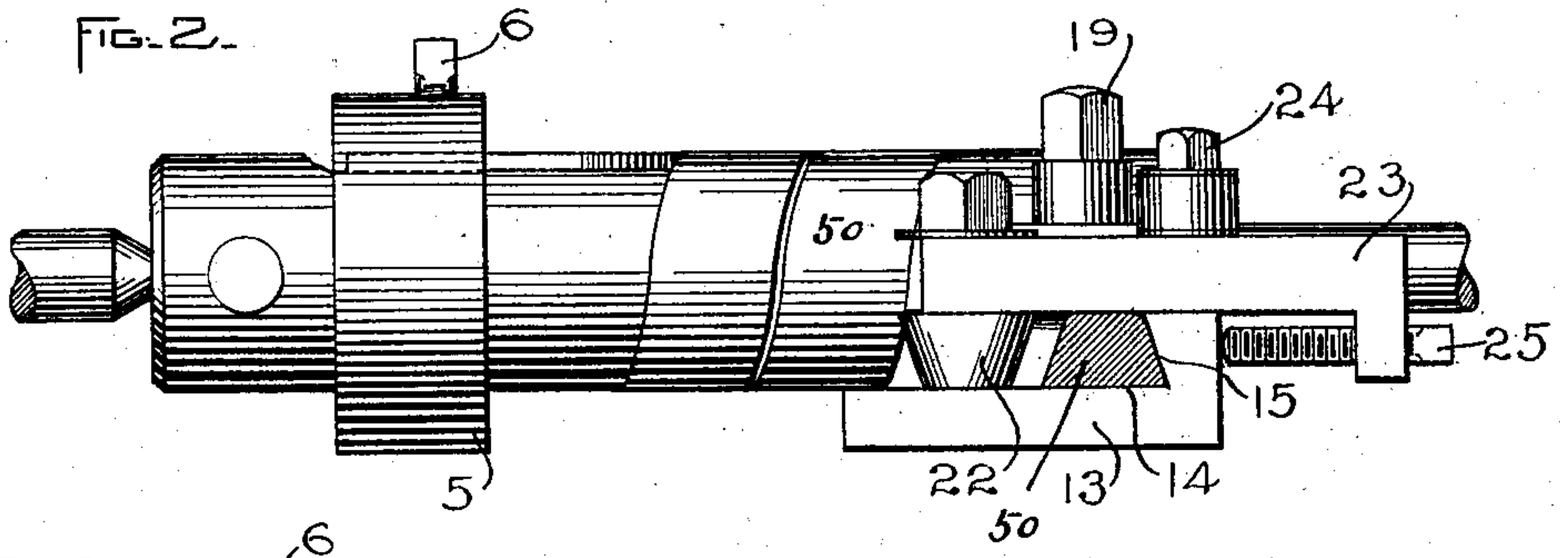


FIG. 3.

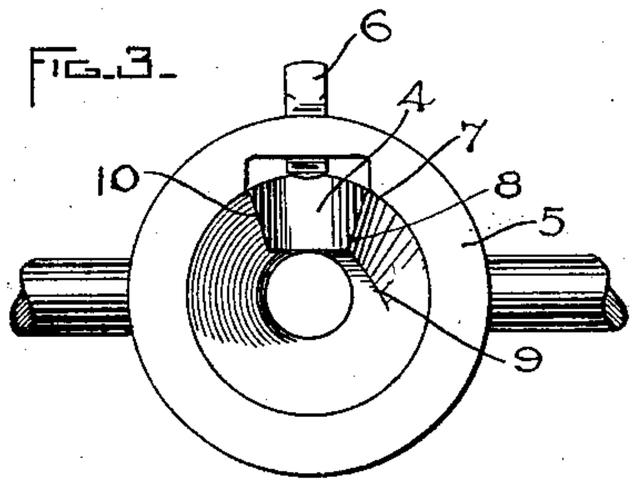
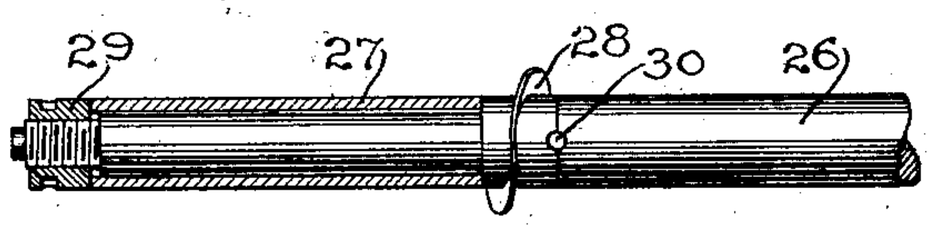


FIG. 5.



WITNESSES.
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NO MODEL. 2 SHEETS—SHEET 2.

FIG. 4.

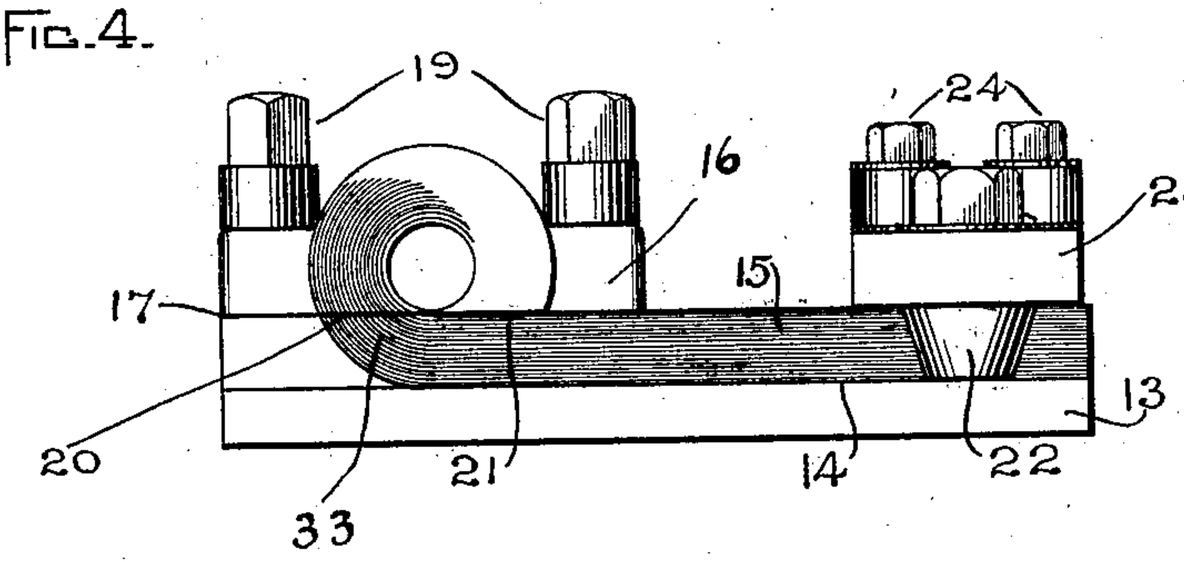


FIG. 6.

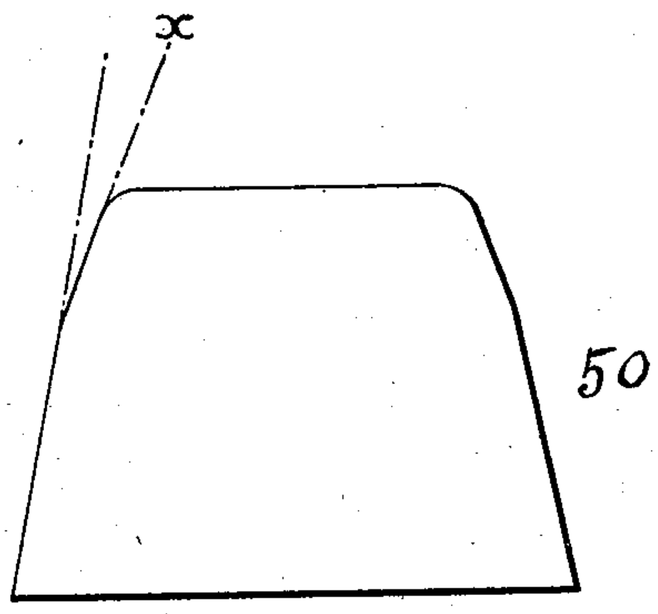


FIG. 7.

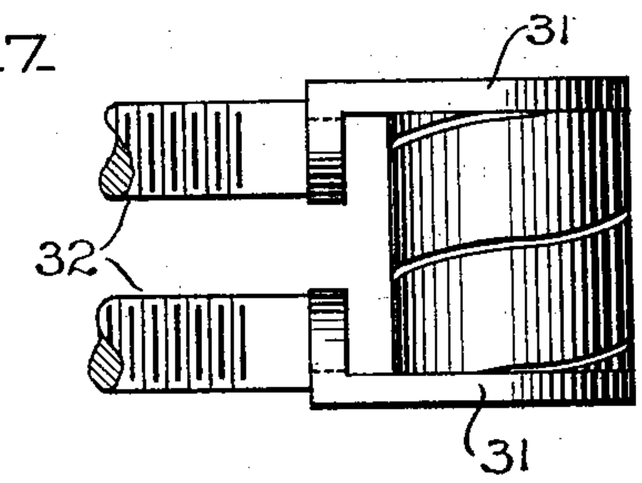
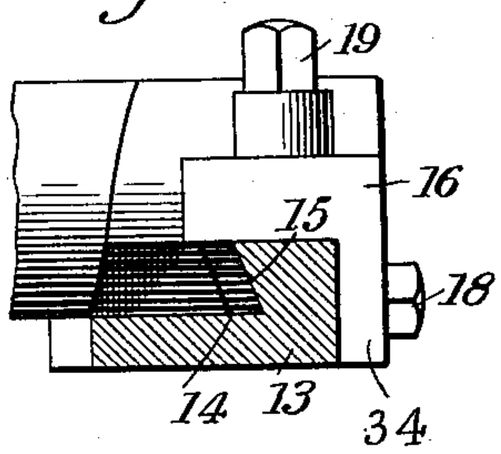


Fig. 8.



WITNESSES.
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UNITED STATES PATENT OFFICE.

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APPARATUS FOR MAKING COILS FOR ELECTRICAL APPARATUS.

SPECIFICATION forming part of Letters Patent No. 720,092, dated February 10, 1903.

Application filed December 5, 1898. Serial No. 698,244. (No model.)

To all whom it may concern:

Be it known that I, EDWARD L. AIKEN, a citizen of the United States, residing at Schenectady, in the county of Schenectady, State of New York, have invented certain new and useful Improvements in Apparatus for Making Coils for Electrical Apparatus, of which the following is a specification.

In certain forms of electromagnetically-actuated apparatus in which currents of large volume are utilized it is common to form the actuating-coils of but a small number of turns, but with the individual turns of large cross-sectional area in order to carry the currents employed without being unduly heated thereby. Heretofore these coils have been fashioned out of solid metal by operating upon a blank in the shape of a hollow cylinder. This blank was cut into the required form by the use of a traversing cutter in a screw-cutting lathe, or, if preferred, by the employment of a saw or milling-cutter in a milling-machine. The finished article resulting from this operation was open to several objections. Not only was the article thus formed expensive, but it possessed in addition the drawback due to the fact that the turns of the helix or coil were separated from each other by a considerable space, as was inevitable from the mode of manufacture employed. In order properly to carry out its function, the turns of the helix or coil need to be separated from each other only by a distance just sufficient to maintain them out of contact with each other. Where this distance is greater, as was the case in the coil resulting from the mode of manufacture above described, the length of the coil required to obtain a given magnetizing effect was increased, thus requiring the size of the parts operating in immediate conjunction therewith to be increased correspondingly, and so producing a bulky and cumbersome article. A further disadvantage of the old method was the resultant waste metal, which could only be scrapped.

It is the object of the present invention to obviate the disadvantages above set forth by producing a coil in which the turns are of comparatively large cross-sectional area and are separated from each other by a space of a width just sufficient to allow the turns of the coil by their inherent rigidity to be maintained out of contact with each other. Instead of cutting the coil out of solid metal I produce a coil free from the disadvantages of the method of manufacture described by winding a rod, strip, or bar of suitable cross-sectional area about a mandrel while at a temperature below that of the softening-point of the metal. In carrying out this operation I make use of a guide having suitably-shaped working surfaces and movable longitudinally along the mandrel as the rod, bar, or strip is wound thereon, motion being communicated to the guide by reason of the pressure against its working surfaces of the coil as it is being wound. The pitch of the coil is thus determined by the particular character and curvature of the guiding-surfaces and is not due to any external means for feeding the carriage carrying the guide.

Broadly considered, my invention embraces the idea of winding a bar, rod, or strip of metal—such, for instance, as copper or an alloy of copper—on a mandrel of suitable diameter while at a temperature below the softening-point of the metal and preferably cold. In the particular method to be described the metal is forced into the required shape by passing it along the surface of a suitable guide or die.

In my pending application, Serial No. 698,243, filed herewith I have disclosed and claimed an invention which as to some of its features embodies certain broad ideas set forth in the present application.

Other aspects of my invention, including those more limited than that above set forth, will be more apparent from an inspection of the following description, taken in connection with the accompanying drawings, while the scope of the invention, both in its broad and its limited aspects, will be clearly and particularly pointed out in the appended claims.

In the drawings, Figure 1 is a plan view, and Fig. 2 is a side elevation, of an apparatus employed in carrying out my invention. Fig. 3 is an end view of a twisting-head form-

ing part of the apparatus; and Fig. 4 is a side elevation of the guide, also forming part of the apparatus. Fig. 5 represents an adjunctive device used for separating the turns of a coil when the coil is closely wound. Fig. 6 is a full-sized cross-sectional outline of the rod employed in forming coils having turns of large cross-sectional area. Fig. 7 is a view of a coil as completely finished and ready to be assembled in some electrical apparatus; and Fig. 8 is a front elevation of the cap-piece, showing its connection with the base.

The winding apparatus shown in the drawings comprises three esssential features—first, the mandrel on which the coil is wound; second, the twisting-head or other device for winding the rod on the mandrel, and, third, the guide through which the rod passes as it is being wound and by which the pitch of the coil is determined. Such in its general nature is the apparatus used for winding the coils. As to its details reference must be had to the various figures of the drawings.

The mandrel about which the coil is wound is a plain cylindrical metallic rod of any desired diameter and is designated in the drawings as 1. In general the diameter of this rod is comparatively small, and it has been found by experience that if the force necessary to wind the coil on the mandrel were transmitted directly through the mandrel itself the mandrel would be twisted and broken off. For this reason one end of the mandrel is mounted so as to be freely rotatable within a cylindrical opening in the twisting-head 2, the diameter and the depth of the opening being indicated in Fig. 1 by the dotted lines, which represent the mandrel projecting into the body of the twisting-head. The mandrel 1 and the twisting-head 2 are mounted so as to rotate, and this rotation is secured by applying force to either or both ends of the bar 3, which projects through and is secured to the twisting-head. This twisting movement may be obtained in any desired manner other than in the way described. Although, if desired, a special machine may be constructed for this purpose, I find it convenient instead of so doing to mount the mandrel 1 and the twisting-head 2 between the head and tail centers of a sufficiently powerful engine-lathe. A center is drilled in the twisting-head in a line with the axis of the mandrel, and another center is drilled in the free end of the mandrel. The twisting-head is mounted on the head-center of the engine-lathe, and the bar or dog 3 engages a suitable projection or projections secured to the face-plate of the lathe.

The twisting-head, already referred to and shown in detail in Fig. 3, has that end which surrounds the end of the mandrel cut away, so as to form a helicoidal surface of less than one complete turn, the pitch of the helicoid being the same as that desired in the finished coil. In order to secure to the twisting-head the end of the rod which is to be wound upon the mandrel, a recess is formed in the twisting-head parallel to the axis of the hole or opening drilled therein and of a depth such that the bottom is practically tangent to such opening or hole. The depth of this recess is shown at 4, Fig. 3. The width and cross-sectional shape correspond to the shape of the rod before being wound, and the recess itself extends along the twisting-head parallel with the axis a sufficient distance so that the twisting-head may obtain a firm grip on the end of the rod which is inserted in this recess. In order to hold the end of the rod in place after it has been inserted in this recess, a sleeve 5 is slipped over the twisting-head, and a set-screw 6 carried thereby serves to clamp the end of the rod in place. At the point where one side of the recess in the twisting-head cuts the helicoidal surface of the same the metal is cut away, so as to form a rounded corner 7. The edge of this recess (shown at 8 in Fig. 3) is gradually merged into the helicoidal surface already referred to and is best shown at 9. The object of this formation is to prevent the presentation of sharp corners to the rod after it has been inserted under and clamped down by the set-screw 6 and with its free end bent around into the position for winding on the mandrel. From the point 7 the generatrix of the helicoidal surface of the twisting-head revolves about the axis of the mandrel and moves along the axis uniformly from left to right, as will be readily understood. Where this helicoidal surface intersects the wall 10 of the recess 4, an angular projection is formed, as shown perhaps best at 12 in Fig. 1.

In winding a rod, bar, or strip on the mandrel the pitch at which the same is wound is determined, not by feeding the rod to the mandrel through the instrumentality of a positively-traversed guide, but by feeding it through a guide having surfaces such that the pressure of the rod against the guiding-surfaces as it is being wound forces the guide to traverse the mandrel longitudinally, the guiding-surfaces being such that the rod is wound on the mandrel at a pitch predetermined by the formation and relation of the guiding-surfaces referred to. In order to permit of this mode of operation, the guide is mounted in such a manner as to be free to move parallel with the axis of the mandrel, but restrained from rotation about it. Where the operation of winding is carried on in an engine-lathe, the guide may be mounted on the slide-rest of the lathe, the longitudinal and cross feeds of the slide-rest being disconnected, so as to allow the same free motion along the ways of the lathe, resisted only by the friction incident to such motion. In matter of detail the guide may either be cut out of solid metal or built up from separate pieces for convenience in mechanical construction and operation. Owing to the diffi-

culty, however, of forming the required guiding-surfaces out of a solid block of metal, I find it more convenient to fashion the same out of separate pieces, the pieces being bolted together in proper relation when finished. In the drawings I have shown the guide as made in two parts, which I find it convenient to designate as a "base" and a "cap-piece." The base is indicated at 13 and has formed thereon straight guiding-surfaces, along which the rod or the like is passed as it is fed to the mandrel. These straight guiding-surfaces consist of two intersecting planes, one of which is parallel to the axis of the mandrel and is approximately tangent to the coil after it is wound on the mandrel, sufficient space, however, being left between this surface and the surface of the coil to allow for clearance. The other surface of the straight guide is formed by a plane which intersects the plane guiding-surface already mentioned and is inclined thereto at an angle less than a right angle. This angle is such as to coincide with the angle made by the base and one side of the rod or bar as it passes to the mandrel. The line formed by the intersection of these two guiding-surfaces is inclined to the axis of the mandrel at an angle corresponding to the pitch of the coil to be wound, as will readily be understood. The two guiding-surfaces spoken of are perhaps best indicated at 14 and 15 in Figs. 2 and 4, and the rod to be bent is shown in cross-section adjoining these surfaces in Fig. 2. The top surface of the base of the guide is planed away parallel to the surface 14, so as to be on a level with the top of the rod when placed in position against the guiding-surfaces, the construction being best shown in Fig. 2. The cap-piece 16, which forms the other part of the guide, consists of a block of metal having a hole drilled therethrough of such diameter as to make a working fit with the mandrel. For a portion of its length parallel to the axis of this hole the cap-piece is planed away tangent to the hole, thus leaving the cap-piece with a downwardly-projecting lip, which makes a right angle with the flat cut-away portion. The plane along which the cap-piece is cut away is clearly shown at 17 in Fig. 4. The cap-piece is fitted over one edge of the base 13 and is secured thereto by bolts 18, which pass through the downwardly-projecting lip 34 of the cap-piece into one side of the base, and by bolts 19, which pass down through the cap-piece into the base-piece. That side of the cap-piece which is nearest to the plane guiding-surfaces 14 and 15, already described, is cut into a guiding-surface in the form of a helicoid the generatrix of which makes a right angle with the axis of the hole in the cap-piece and the pitch of which corresponds to the pitch of the coil to be wound. Owing to the fact that the guiding-surface 15 (shown in Figs. 2 and 4) is inclined to the axis of the opening in the cap-piece at an angle different from the inclination to such axis of the generatrix of the helicoidal surface formed on such cap-piece, it is evident that the two surfaces can never be so related as to pass smoothly from one into the other. The angle which would otherwise be formed when this condition is obtained as nearly as possible is therefore cut and smoothed away, so as to merge one surface into the other. The point at which this merger takes place is indicated approximately at 33, Fig. 4. The helicoidal surface proper of the cap-piece commences along the line indicated at 20 and terminates along the line 21, which indicates the outer edge of the projecting angle of the cap-piece, under which passes the rod to be wound, as will be seen from Figs. 1 and 4.

It is of course to be understood that the guide as a whole is bolted or otherwise secured to the slide-rest of the lathe, so that the hole in the cap-piece has its axis in common with the axis of the mandrel and so that the mandrel as a whole is free to rotate and slide in the opening in the cap-piece.

The rod or bar which is to be wound is maintained in contact with the straight guiding-surfaces by means of a roller 22, carried by an adjustable plate 23, held down by bolts 24 to the top surface of the base 13. The guide or antifrictional roller 22 is in the form of a truncated cone of such nature as to bear against one of the sides of the trapezoidal-shaped rod or bar to be next described, the opposite side of which is by the pressure of this roller maintained in contact with the guiding-surface 15, all of which is best shown in Fig. 2. The securing-plate 23 serves to hold down the rod or bar against the flat guiding-surface 14. The position of the guiding-roller 22 may be adjusted by means of the adjusting-screws 25 passing through the downward projection of the plate 23 and bearing against the side of the base 13.

In winding a rod of any appreciable thickness about a mandrel the outer circumference of the finished coil is greater than the inner circumference, and it consequently follows that the metal on the outer circumference of the coil is stretched, while that on the inner is condensed or compressed. As a result of this action the cross-section of a turn of the finished coil is different from the cross-section of the rod or bar before being wound, the width of the outer dimension of a turn of the coil being less than the corresponding dimension of the bar from which the turn is formed. In order, therefore, to obtain a coil in which the turns have a cross-section substantially rectangular, it is necessary to employ in making the coil a rod or bar the cross-section of which is trapezoidal, the rod or bar being fed to the mandrel with its shorter parallel side in contact therewith. If the trapezoidal section of the rod or bar properly corresponds to the diameter of the man-

drel and the pitch of the finished coil, the trapezoidal section will be changed to a rectangular section during the process of winding. A bar 50 of the trapezoidal section referred to is shown in Figs. 1 and 2 in the operation of being wound on a mandrel. Where rods or bars of large cross-sectional area are wound, it has been found in practice that the edge of the coil in contact with the mandrel bulges out, so as to cause the turns in a closely-wound coil to make contact with each other along their inner edges. In order to allow for and prevent the metal from flowing in this manner, I chamfer or cut away the corners formed by the intersection of the non-parallel sides with the shorter of the two parallel sides of the rod or bar which is to be wound. Fig. 6 indicates in outline the general form of the cross-section of a bar fashioned in this manner. The corners of the trapezoid are cut away, as indicated, along the line *x*. I consider this formation of the blank from which the coil is formed as novel and important, especially in cases where a closely-wound coil of large cross-sectional area is to be produced.

Little remains to be said as to the operation of the mechanism described. The end of the bar to be wound is bent nearly to a right angle and is inserted in the twisting-head 2, in which it is secured by the set-screw 6, carried by the sleeve 5. The guide 13 is brought up and the straight guiding-surfaces thereof placed in contact with the rod or bar as it projects from the twisting-head. The anti-friction-roller 22 and its carrying-plate 23 are then secured in position, and the operation of winding upon the mandrel 1 is then ready to commence. As the twisting-head is turned the rod or bar 50 is gradually drawn into the guide and is forced to traverse the straight and the helicoidal surfaces thereof and in so doing is bent into a helicoid, the pitch of which corresponds to the pitch of the helicoidal surface of the guide. By properly proportioning the width of the bar or rod to be wound to the pitch of the helicoidal surface of the guide a coil may be obtained with any desired distance between the turns. For the purpose for which I intend to employ the coils made by this apparatus this proportion is made such as to leave just sufficient distance between the turns of the coil to maintain them out of contact, although it is obvious that any other desired proportions may be employed without departing from my invention. In some cases where the turns of the coil are not of unduly large cross-section the turns are wound closely together and are afterward separated by screwing through the coil and between its turns a small section of fin-like screw-thread. Such a screw-thread, together with its carrying-mandrel, is shown in Fig. 5, in which 26 indicates the mandrel proper, 27 the sleeve forced by means of the nut 29 against the short sleeve carrying the screw-thread 28. The pin 30, engaging with the mandrel and with the sleeve bearing the integrally-formed screw-thread 28, prevents the screw-thread from turning about the mandrel 26.

In Fig. 7 is shown a view of the coil in its finished condition and ready to be assembled in an electrical apparatus. This coil consists of a small number of turns cut from the long length of coil ordinarily wound in one operation of the mechanism above described. To the ends of this short length of coil angle-pieces 31 are secured by sweating or brazing or in any other manner to give good electrical connection. Bolts 32 are secured to the projecting ends of the angle-pieces and serve both as mechanical supports for the coil and as conductors for conveying the current supplied thereto.

Although the coil of the nature described and the method and apparatus for manufacturing the same, as above set forth, are peculiarly applicable in connection with the manufacture of electrical apparatus, it will of course be evident that my invention as regards these features is not to be limited in its scope to any particular utilization of the product which is the result of my invention.

What I claim as new, and desire to secure by Letters Patent of the United States, is—

1. In a mechanism for winding rods or strips, the combination of a mandrel, and a guide embracing said mandrel movable axially thereof and having a helicoidal working surface, the elements of which are at right angles to the axis of the helicoid.

2. The combination of a mandrel, a guide movable longitudinally thereon, and a twisting-head having its axis in common with that of the mandrel and movable about said axis independently of said mandrel.

3. In a mechanism for winding metallic strips or rods, a guide having a helicoidal working surface of an extent not greater than one turn, and a plane working surface merged into said helicoidal surface.

4. In a mechanism for winding rods or strips, the combination of a mandrel, and a guide embracing said mandrel and movable along the axis thereof, the said guide having a helicoidal working surface.

5. In a mechanism for winding rods or strips, the combination of a mandrel, and a guide having a plane working surface merging into a helicoidal working surface, the plane surface making an angle with the axis of the helicoid different from that made therewith by the generatrix of the helicoid.

6. In a mechanism for winding metallic rods or strips, a guide having a helicoidal working surface of an extent not greater than one turn, and a plane working surface merged into said helicoidal surface and making with the axis of the helicoid an angle different from that made by the generatrix of the helicoid.

7. In a mechanism for winding metallic

rods or strips, a guide having a helicoidal working surface the generatrix of which makes a right angle with the axis of the helicoid and a plane guiding-surface merged into said helicoidal surface and making with said axis an angle different from a right angle.

8. In a mechanism for winding rods or strips, the combination of a mandrel, and a guide having a helicoidal working surface merging into a plane working surface.

9. In a mechanism for winding rods or strips, the combination of a mandrel, and a guide embracing said mandrel and movable axially thereof, the said guide having a helicoidal working surface the elements of which are at right angles to the axis of the mandrel.

10. In a mechanism for winding metallic rods or strips, a guide having a helicoidal working surface, the generatrix of which makes a right angle with its axis and the extent of which is not greater than that due to one revolution of the generatrix, and a plane surface making an angle with the axis different from a right angle and merged into said helicoidal surface.

11. In a winding mechanism, the combination with a mandrel on which the material is wound, of a twisting-head to which the end of the material is secured, and a helicoidal guide through which the material is fed to the mandrel.

12. In a winding mechanism, the combination with a mandrel on which the material is wound, of a guide along which the material passes to the mandrel, said guide being adapted to be forced along the axis of the mandrel by the pressure of the material fed to the mandrel.

13. In a winding mechanism, the combination with a mandrel mounted so that it may be rotated, of a twisting-head concentric with said mandrel, and adapted to be positively rotated independently of said mandrel.

14. In a winding mechanism, the combination with a concentric mandrel and twisting-head, the adjacent ends of which parts abut for independent rotation, and the separate ends of which are supported at their centers, of means for positively rotating said head.

15. A twisting-head for a winding mechanism, which is formed with a helicoidal guiding-surface, and a trapezoidal groove for the reception of the end of the material to be wound.

16. A twisting-head for a winding mechanism, which is formed with a helicoidal guiding-surface and is adapted to receive and support a mandrel upon which the material is to be wound, and to be itself connected to said material.

17. A twisting-head for a winding mechanism, which is formed with a helicoidal guiding-surface, a trapezoidal groove, and a hole for the reception of the mandrel upon which the material is to be wound.

18. The combination with a twisting-head formed with a groove having the configuration of the material to be wound and adapted to receive the end of the same, of a sleeve encircling said twisting-head, and a set-screw extending through said sleeve and adapted to bear on the material in said groove.

19. A twisting-head for a winding mechanism, which is formed with a helicoidal guiding-surface, and a groove adapted to receive the end of the material to be wound, said groove being merged gradually into said helicoidal surface.

20. In a winding mechanism, the combination with a mandrel, of a guide formed with a helicoidal surface along which the material to be wound passes to the mandrel, said guide being shaped to determine the pitch of the winding and to be moved parallel to the axis of the mandrel by the pressure of the material as it passes to the mandrel.

21. In a winding mechanism, the combination with a mandrel, of a guide through which the material to be wound passes to the mandrel, said guide having surfaces such that the pressure of the material passing to the mandrel causes the guide to be moved parallel to the axis of the mandrel.

22. A guide for a winding mechanism, formed with surfaces corresponding to the configuration of the material to be wound, one of said surfaces being inclined, to determine the pitch of the winding.

23. In a winding mechanism, the combination with a mandrel, of a guide formed with a surface parallel to the axis of the mandrel, and with another surface intersecting the first surface at an inclination less than a right angle.

24. In a winding mechanism, the combination with a mandrel, of a guide formed with a surface parallel to the axis of the mandrel, and with another surface inclined to the first surface at an angle less than a right angle, the line of intersection of said surfaces being inclined at an angle to the axis of the mandrel in correspondence to the pitch of the winding.

25. A guide for a winding mechanism which comprises a base-piece formed with plane guiding-surfaces, and a cap-piece formed with a helicoidal guiding-surface and a downwardly-projecting lip by which the cap-piece is secured to the base-piece.

26. In a winding mechanism, the combination with a mandrel, of a guiding base-piece having plane surfaces, and a guiding cap-piece having a helicoidal surface through which the mandrel extends.

27. A guide for a winding mechanism, which comprises plane and helicoidal surfaces, and a roller which with said plane surfaces corresponds to the configuration of the material to be wound.

28. A guide for a winding mechanism, which comprises plane and helicoidal surfaces, and a roller which with said plane surfaces forms a trapezoidal opening for the passage therethrough of the material to be wound.

29. A winding mechanism, which comprises a rotatable mandrel, a concentric and independently-rotatable twisting-head provided with means for holding the end of the material to be wound and with a helicoidal guiding-surface, and a guide having a helicoidal surface and adapted to be moved parallel to the axis of the mandrel by the material which passes along the guide to the mandrel.

30. An apparatus for separating the turns of a helical metallic strip, which consists of a mandrel provided with a fin-screw.

In witness whereof I have hereunto set my hand this 3d day of December, 1898.

EDWARD L. AIKEN.

Witnesses:

B. B. HULL,

A. D. HUNT.