Nov. 5, 1957 J. R. GOODYKOONTZ, JR 2,812,143

TOROIDAL COIL WINDING MACHINE

Filed May 23, 1956

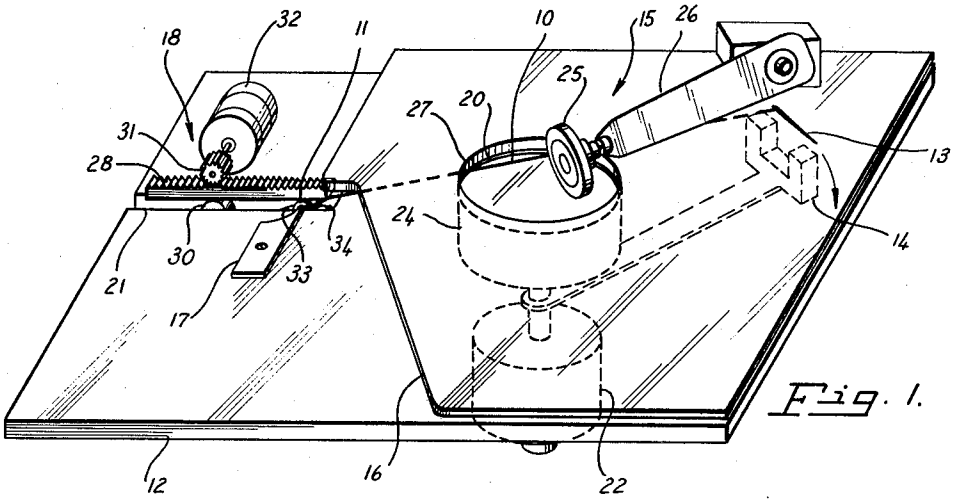



Fig. 1.

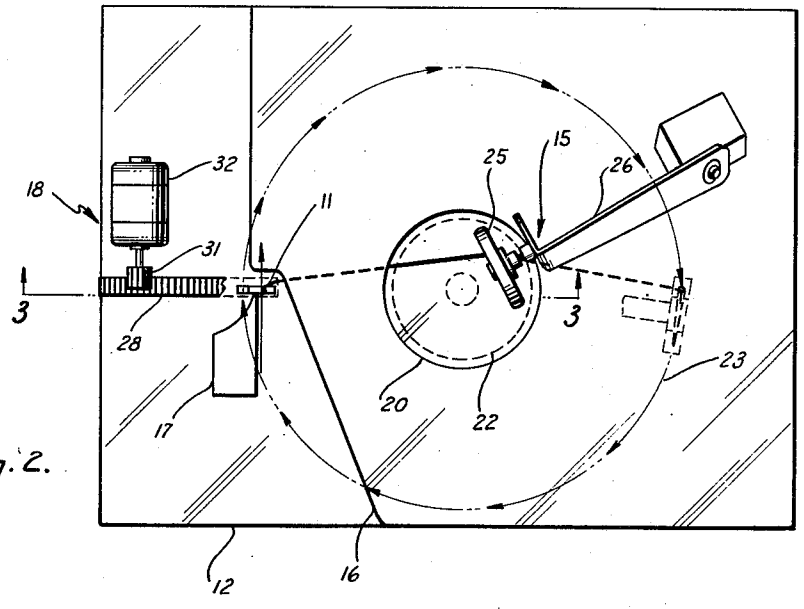
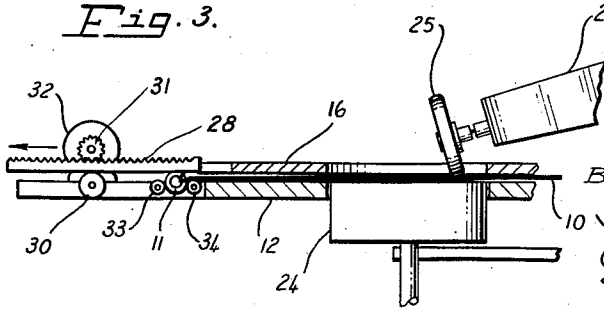



Fig. 2.

Fig. 3.




INVENTOR,
JAMES R. GOODYKOONTZ JR.
BY

ATTORNEY

United States Patent Office 2,812,143 Patented Nov. 5, 1957



2,812,143

# TOROIDAL COIL WINDING MACHINE

James R. Goodykoontz, Jr., Venice, Calif., assignor to Hughes Aircraft Company, Culver City, Calif., a corporation of Delaware

Application May 23, 1956, Serial No. 586,872

12 Claims. (Cl. 242—4)

The present invention relates in general to devices having utility in the field of coil winding and more particularly to a machine for winding relatively small toroidal coils.

Heretofore, numerous problems have existed with respect to the winding of wire about a toroidal core, inasmuch as manual winding is very time consuming and inaccurate and mechanical winding by means of wire-carrying bobbins has been impractical due primarily to the relatively small sizes of toroidal coils that have become necessary in contemporary electrical and electronic circuitry. It is not uncommon, for example, in miniaturized electrical devices, to employ toroidal coils that are in the nature of one-eighth of an inch in overall diameter, having a central opening of approximately one-sixteenth of an inch. In such instances, it has heretofore been practically impossible to pass the wire-carrying bobbin through the opening in the toroidal core for several reasons such as, for example, the necessity for supporting and moving a bobbin or shuttle arrangement while still permitting passage thereof through the central core opening. In general, prior mechanisms have been either too large, too heavy or propelled in such a manner as to prohibit their use in mechanical winding of the small toroidal cores.

It is, therefore, an object of the present invention to provide a machine for winding toroidal coils of relatively small diameter.

It is another object of the present invention to provide a machine for winding toroidal coils by means of a sewing action.

It is a further object of the present invention to provide a machine that winds wire onto a toroidal core of relatively small diameter by means of a wire-threaded needle that is periodically passed through the central opening of the core under the control of a magnetic field.

The toroidal coil winding machine of the present invention overcomes the limitations of machines found in the prior art by employing a new winding technique. More particularly, in the machine of the present invention, fine copper wire is wound onto miniature toroidal cores with a simple sewing action which is accomplished by threading a length of the wire onto a sewing needle and causing the needle to move in a circular path on a suitable horizontal working surface by means of a permanent magnet which is moved in a circular path directly beneath the working surface. The toroid is positioned so that its axis coincides with the path of the needle at a chosen point in the path with the result that with each revolution of the magnet the needle passes through the toroid, thereby wrapping a turn of wire onto the toroid. It will be obvious that for all practical purposes, the only limitation on the smallness of the central opening or, stated differently, the inner diameter of the toroid is the needle itself, the thinner the needle utilized the smaller the obtainable inner diameter.

The novel features which are believed to be characteristic of the invention, both as to its organization and



method of operation, together with further objects and advantages thereof, will be better understood from the following description considered in connection with the accompanying drawings in which an embodiment of the invention is illustrated by way of example. It is to be expressly understood, however, that the drawings are for the purpose of illustration and description only, and are not intended as a definition of the limits of the invention.

Fig. 1 is a perspective view of one embodiment of a toroidal coil winding machine in accordance with the present invention;

Fig. 2 is a top view of the machine of Fig. 1 illustrating the path taken by the wire-threaded needle, the operation of the turn-tightener and the function of the needle guide, the parts of the machine unessential for such an illustration being omitted for purposes of clarity; and

Fig. 3 is a cross-sectional view of the machine of Fig. 1 taken along the lines 3—3 of Fig. 2.

Referring now to the drawings, there is shown in Fig. 1 a machine for winding an electrical wire **10** upon a toroidal core **11** having a relatively small inner diameter. As shown in the figure, the machine basically comprises a baseboard **12**, a sewing needle **13**, a permanent magnet **14**, a turn-tightener mechanism, generally designated **15**, an anti-kinking device **16**, a needle guide **17**, and means, generally designated **18**, for holding and rotating core **11** as wire **10** is wound upon it.

Baseboard **12** is made of a non-magnetic material and has a smooth upper working surface. In addition, baseboard **12** has a relatively large circular opening **20** and a slot **21** wherein core **11** is positioned. Baseboard **12** is preferably flat and preferably maintained in a horizontal position.

Sewing needle **13** is no different than any other sewing needle except that, of necessity, it is made of a magnetic material, such as steel. Sewing needle **13** rests freely on the smooth upper working surface of basebaord **12** and is threaded with wire **10**.

Permanent magnet **14** is positioned beneath baseboard **12** and contiguous to the lower surface thereof in order that the magnetic field produced by the magnet may be applied through the baseboard to the upper working surface whereon needle **13** rests. Magnet **13** is mechanically coupled to a motor **22** which continuously moves the magnet in a circular path about the motor shaft as indicated by arrows **23** in Fig. 2.

Turn-tightener mechanism **15** is provided to pull the turns of wire wound on core **11** to the desired degree of tightness and, as shown in the figure, comprises a turntable **24** connected directly to the shaft of motor **22** that turns magnet **14**. Turntable **24** is positioned in hole **20** of baseboard **12** and is flush with the upper working surface of the baseboard. Turn-tightener mechanism **15** further includes a rubber-rimmed wheel **25** resiliently mounted at one end of an arm **26**, the other end of the arm being rigidly fixed in position. Wheel **25** engages turntable **24** and, since the turntable is rotated by motor **22**, the wheel is also caused to rotate since the latter is free to turn on its shaft. Moreover, it will be noted that wheel **25** is canted so that its outer edge is lifted above the turntable surface. Such an arrangement facilitates the passage of wire **10** under wheel **25**. The canting of the wheel may be seen from Fig. 1 and more specifically from Fig. 3.

Anti-kinking device **16** is preferably a sheet of non-magnetic material positioned above the upper surface of baseboard **12** and, as is apparent from the figures, parallel and contiguous thereto. Sheet **16** has a circular opening **27** through it of approximately the same diameter as circular opening **20** of baseboard **12**. Circular opening

27 overlies opening 20 so that wheel 25 may be permitted to come into contact with turntable 24. Thus, sheet 16 almost entirely covers the portion of the working surface of baseboard 12 upon which wire 10 may move, thereby preventing the wire from looping or kinking.

Needle guide 17 is employed to guide needle 13 in a positive manner immediately preceding its entry into core 11. More specifically, needle guide 17 is utilized to assure that needle 13 will pass through the center of core 11 if either the radial position of magnet 14 changes slightly with use or the position of the needle changes with respect to the magnet. This is done by mounting guide device 17 on baseboard 12 in the circular path of movement of the needle as is clearly shown in Fig. 2. The needle is deflected by guide 17 and is thereafter positively directed in a straight line toward the center of the core.

Means 18 for rotating core 11 basically comprises a rack 28 movably mounted between an idler gear 30 and a drive gear 31 coupled by means of a shaft to a motor 32. Means 18 also includes an additional pair of idler gears 33 and 34 between which core 11 is positoined as is clearly shown in the figures. Rack 28 rests at one end on core 11 and as the rack is slowly moved by means of drive gear 31 and motor 32, the core is slowly rotated about its axis, thereby permitting wire 10 to be distributed on the core. Obviously, the speeds of motors 22 and 32 may be synchronized so that core 11 is rotated at such a speed relative to the speed of rotation of needle 13 that the wire is uniformly wound on the core.

Considering now the operation, a length of wire 10 is threaded onto needle 13, a toroid core 11 is positioned between idler gears 33 and 34 and motors 22 and 32 are turned on. As a result, magnet 14 is driven in a circle by motor 22 and needle 13, which has been placed on the working surface of baseboard 12 so that it lies in the field of the magnet, follows the magnet and, thereby, tends to describe a circular path. The circular path followed by magnet 14 as well as the circular path sought to be followed by needle 13 is indicated by arrows 23 in Fig. 2.

With each complete revolution of magnet 14, needle 13 passes through the central opening of core 11, thereby wrapping or winding a turn of wire onto the core. More specifically, during each rotation of needle 13, the needle is deflected at one point in its path by needle guide 17 which causes the needle to travel in a straight line immediately prior to and during its entry into the core. Since the straight line path of needle 13 is determined by guide 17, it is, therefore, substantially independent of the normal circular path defined by the field of the moving magnet. Thus, once the toroid core is positioned with respect to the needle guide, no great attention need thereafter be paid to the path which the needle would take without the guide. In other words, tolerance requirements on the magnet driving and positioning mechanism and the field configuration of the magnet are thereby greatly reduced with the result that the machine is easier to build and less likely to get out of alignment during operation.

At the same time that the wire winding operation is going on, motor 32 slowly rotates core 11 about the latter's axis at a speed that is a predetermined fraction of the rotational speed of magnet 14. Stated differently, the speed of motor 32 may be synchronized in such a manner with the speed of motor 22 that the core, driven by motor 32 through rack 28 and gear 31, is rotated through a small angle during each revolution of the magnet. As a consequence, wire 10 is distributed about core 11 and uniformly wound thereon.

It will be obvious that the only force ordinarily available for pulling the turns of wire tight about core 11 is the force exerted on needle 13 by magnet 14 and that while this magnetic force is sufficient to move the needle and wire, it may not be sufficient to pull the individual turns of wire to the desired degree of tightness.

Turn-tightener mechanism 15 provides the additional force that may be required for pulling the wire tight.



Since turntable 24 is coupled to motor 22, the turntable is also rotated in the same direction as magnet 14. Furthermore, since rubber-rimmed wheel 25 engages turntable 24, the rotation of the turntable causes the wheel to rotate. Thus, when wire 10 passes between turntable 24 and wheel 25, as it does during each rotation of needle 13, the wire is moved slightly to the right with the result that a slight tug occurs which pulls the wire tight about the core.

It will also be obvious that unless suitable preventative measures are taken, wire 10 may loop or kink during the winding operation due to the fact that for half of each cycle the wire is in a slack condition and essentially uncontrolled. The kinking difficulty is overcome by anti-kinking device 16 which constrains the wire to lie essentially in a plane at all times.

It should be noted that the coil winding machine shown in Figs. 1–3 may be modified by adding a counter, clutch and brake mechanism which would automatically stop the machine when the required number of turns had been wound on the core. It should also be mentioned that means 18 could be replaced by a toroid dispensing mechanism mechanized to put a toroid core into position by the pressing of a button and to automatically rotate the core by driving it, through suitable gearing, from the magnet motor.

Having thus described the invention, what is claimed as new is:

1. A machine for winding wire onto a toroidal core, said machine comprising: a baseboard having a smooth working surface on one side thereof and a slot therethrough wherein the core is positioned, the core being oriented in such a manner that the core axis is substantially parallel to said working surface; a magnet movably positioned on the other side of said baseboard and contiguous thereto; a sewing needle, made of a magnetic material and threaded with the wire to be wound on the toroidal core, resting on the working surface in the magnetic field of said magnet, said sewing needle being movable under the influence of said magnet along a path on said surface corresponding to the path of movement of said magnet; and means for continuously moving said magnet in a predetermined closed path such that said needle is successively moved through the center of the core, whereby a turn of wire is wound upon the core with each passing of said needle through the core.

2. A machine for winding wire onto a toroidal core, said machine comprising: a baseboard made of a non-magnetic material and having a smooth working surface on one side thereof, said baseboard having an opening therethrough wherein the core is positioned; means for producing a magnetic field through said baseboard to said working surface, said means being movably positioned on the other side of said baseboard and contiguous thereto; a sewing needle resting on the working surface of said baseboard and threaded with the wire to be wound on the core, said needle being made of a magnetizable material and, under the influence of the magnetic field, being movable along said surface in a path corresponding to the path of movement of said means; and means for continuously moving said last-named means in a predetermined closed path such that said needle recurrently passes through the center of the core, one turn of wire being wound upon the core with each such passage of said needle.

3. A machine for winding wire onto a toroidal core, said machine comprising: a baseboard made of a non-magnetic material and having a smooth working surface on one side thereof, said baseboard having an opening therethrough wherein the core is positioned; a magnet movably positioned on the other side of said baseboard and contiguous thereto for applying a magnetic field through said baseboard to the working surface; a sewing needle resting on the working surface of said baseboard in the field of said magnet and threaded with the wire

to be wound on the core, said needle being made of a magnetic material and, under the influence of the magnetic field, movable along said surface in a path corresponding to the path of movement of said magnet; drive means for continuously moving said magnet in a predetermined closed path such that said needle recurrently passes through the center of the core, one turn of wire being wound upon the core with each such passage of said needle; and additional means for rotating the core in such a manner that the turns of wire are uniformly distributed about the core.

4. A machine for winding wire onto a toroidal core, said machine comprising: a baseboard made of a non-magnetic material and having a smooth working surface on one side thereof, said baseboard having an opening therethrough wherein the core is positioned; means for producing a magnetic field through said baseboard to said working surface, said means being movably positioned on the other side of said baseboard and contiguous thereto; drive means for continuously moving said magnetic field producing means in a circular path; a sewing needle resting freely on the working surface of said baseboard and threaded with the wire to be wound on the core, said needle being made of a magnetic material and, under the influence of the magnetic field, moved along said surface in a circular path corresponding to the circular path of movement of said means; and a guide device mounted on said working surface and positioned in the circular path of movement of said needle for deflecting said needle during each rotation thereof positively to guide said needle through the center of the core.

5. A machine for winding wire onto a toroidal core, said machine comprising: a flat horizontally positioned baseboard made of a non-magnetic material and having a smooth upper working surface, said baseboard having an opening therein wherein the core is positioned; means for producing a magnetic field, said means being rotatably positioned beneath said baseboard and contiguous to the lower surface thereof for applying the magnetic field through said baseboard to said upper working surface; drive means for continuously rotating said means in a circular path; a sewing needle resting freely on the upper surface of said baseboard and threaded with the wire to be wound on the core, said needle being made of a magnetic material and, under the influence of the magnetic field, moved along said smooth upper surface in a substantially circular path corresponding to the circular path of movement of said means; a guide device mounted on said baseboard and positioned in the circular path of movement of said needle for deflecting said needle during each rotation thereof positively to guide said needle toward the center of the core; and a flat sheet of non-magnetic material positioned parallel to said baseboard and contiguous to the working surface thereof for preventing the wire from kinking.

6. A machine for winding wire onto a toroidal core, said machine comprising: a flat horizontally positioned baseboard made of a non-magnetic material and having a smooth upper working surface, said baseboard having an opening therein wherein the core is positioned; a magnet rotatably positioned beneath said baseboard and contiguous to the lower surface thereof for applying a magnetic field through said baseboard to said upper working surface; drive means for continuously rotating said magnet in a circular path; a sewing needle resting on the working surface of said baseboard in the field of said magnet and threaded with the wire to be wound on the core, said needle being made of a magnetic material and, under the influence of the magnetic field, moved along said surface in a substantially circular path corresponding to the circular path of movement of said magnet; a guide device mounted on said baseboard and positioned in the circular path of movement of said needle for deflecting said needle during each rotation thereof positively to guide said needle through the center of the core, one



turn of wire being wound upon the core with each passing of said needle through the core; additional means for rotating the core in such a manner that the turns of wire are uniformly distributed about the core; and a flat sheet of non-magnetic material positioned parallel to said baseboard and contiguous to the working surface thereof for preventing the wire from kinking.

7. A machine for winding wire onto a toroidal core, said machine comprising: a baseboard having a smooth working surface on one side thereof and a slot therethrough wherein the core is positioned; means for producing a magnetic field through said baseboard to said working surface, said means being movably positioned on the other side of said baseboard and contiguous thereto; a sewing needle made of a magnetic material resting on the working surface of said baseboard in the magnetic field produced therethrough, said needle, under the influence of the magnetic field, being movable along said surface in a path corresponding to the path of movement of said means; drive means for continuously moving said magnetic field producing means in a predetermined closed path such that said needle recurrently passes through the center of the core, one turn of wire being wound upon the core with each such passage of said needle; and a turn-tightener mechanism for applying a slight tug to each turn of wire as it is wound upon the core, thereby to pull the individual turns to the desired degree of tightness.

8. A machine for winding wire onto a toroidal core, said machine comprising: a baseboard having a smooth working surface on one side thereof and a slot therethrough wherein the core is positioned; means for producing a magnetic field through said baseboard to said working surface, said means being movably positioned on the other side of said baseboard and contiguous thereto; a sewing needle made of a magnetic material resting on the working surface of said baseboard in the magnetic field therethrough, said needle, under the influence of the magnetic field, being movable along said surface in a path corresponding to the path of movement of said means; drive means for continuously moving said magnetic field producing means in a predetermined closed path such that said needle recurrently passes through the center of the core, one turn of wire being wound upon the core with each such passage of said needle; a turn-tightener mechanism for applying a slight tug to each turn of wire as it is wound upon the core, thereby to pull the individual turns to the desired degree of tightness; and means for preventing the wire from kinking during the winding operation.

9. The machine defined in claim 8 wherein said means for preventing the wire from kinking comprises a sheet of non-magnetic material positioned in spaced parallel relationship to said baseboard and contiguous to the working surface thereof.

10. A machine for winding wire onto a toroidal core, said machine comprising: a baseboard made of a non-magnetic material and having a smooth working surface on one side thereof, said baseboard having an opening therethrough wherein the core is positioned; a magnet movably positioned on the other side of said baseboard and contiguous thereto for applying a magnetic field through said baseboard to said working surface; drive means for continuously moving said magnet in a circular path; a sewing needle made of a magnetic material resting freely on said working surface in the field of said magnet, said needle being threaded with the wire to be wound on the core and, under the influence of the magnetic field, moved along said surface in a circular path corresponding to the circular path of movement of said magnet; a guide device mounted on said working surface and positioned in the circular path of movement of said needle for deflecting said needle in such a manner during each rotation thereof positively as to guide said needle through the center of the core, thereby to suc-

cessively wind turns of wire onto the core; means for preventing the wire from kinking during the winding operation; and a turn-tightener mechanism for applying a slight tug to each turn of wire after being wound upon the core, thereby to pull the individual turns to the desired degree of tightness.

11. A machine for winding wire onto a toroidal core, said machine comprising: a baseboard made of a non-magnetic material and having a smooth working surface on one side thereof, said baseboard having an opening therethrough wherein the core is positioned; a magnet movably positioned on the other side of said baseboard and contiguous thereto for applying a magnetic field through said baseboard to said working surface; drive means for continuously moving said magnet in a circular path; a sewing needle made of a magnetic material resting freely on said working surface in the field of said magnet, said needle being threaded with the wire to be wound on the core and, under the influence of the magnetic field, moved along said surface in a circular path corresponding to the circular path of movement of said magnet; a guide device mounted on said working surface and positioned in the circular path of movement of said needle for deflecting said needle in such a manner during each rotation thereof positively as to guide said needle through the center of the core, thereby to successively wind turns of wire onto the core; means for rotating the core in such a manner that the turns of wire are uniformly distributed about the core; apparatus for preventing the wire from kinking during the winding operation, and a turn-tightener mechanism for applying a relatively slight tug to each turn of wire after being wound upon the core, thereby to pull the individual turns to the desired degree of tightness.

12. A machine for winding wire onto a toroidal core, said machine comprising: a baseboard made of a non-magnetic material and having a smooth working surface on one side thereof, said baseboard having a first circular opening therethrough and a slot wherein the core is positioned; a magnet rotatably positioned on the other side



of said baseboard and contiguous thereto for applying a magnetic field through said baseboard to the working surface; drive means for continuously rotating said magnet in a circular path about the first circular opening; a sewing needle resting freely on the working surface in the field of the magnet and threaded with the wire to be wound on the core, said needle being made of a magnetic material and, under the influence of the magnetic field, moved along the working surface about the first circular opening in a substantially circular path corresponding to the circular path of movement of said magnet; a guide device mounted on said baseboard and positioned in the circular path of movement of said needle for deflecting said needle during each rotation thereof positively to guide said needle through the center of the core, one turn of wire being wound upon the core with each passing of said needle through the core; means for rotating the core in such a manner that the turns of wire are uniformly distributed about the core; a sheet of non-magnetic material positioned parallel to said baseboard and contiguous to the working surface thereof for preventing the wire from kinking, said sheet having a second circular opening therethrough overlying the first circular opening of said baseboard; and a turn-tightener mechanism for applying a slight tug to each turn of wire as it is wound upon the core, thereby to pull the individual turns to the desired degree of tightness, said turn-tightener mechanism including a turntable mechanically coupled to said drive means and positioned in the first circular opening of said baseboard in the plane thereof, and a rubber-rimmed wheel rotatably mounted on the one side of said baseboard in such a manner that the rim of said wheel is at all times in contact with said turntable.

**References Cited** in the file of this patent

UNITED STATES PATENTS

2,192,694 Quinlan ---------- Mar. 5, 1940