

March 28, 1967

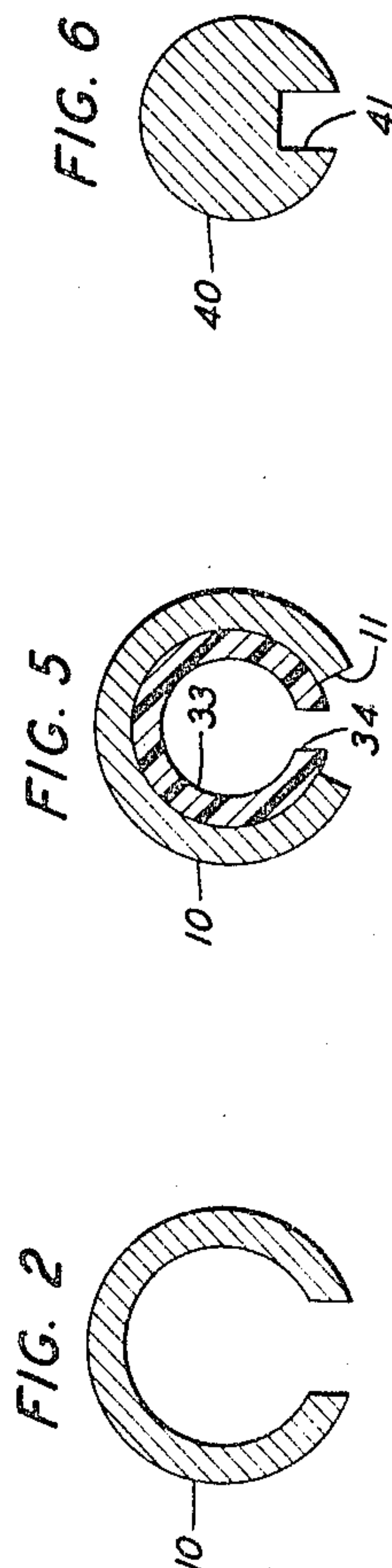
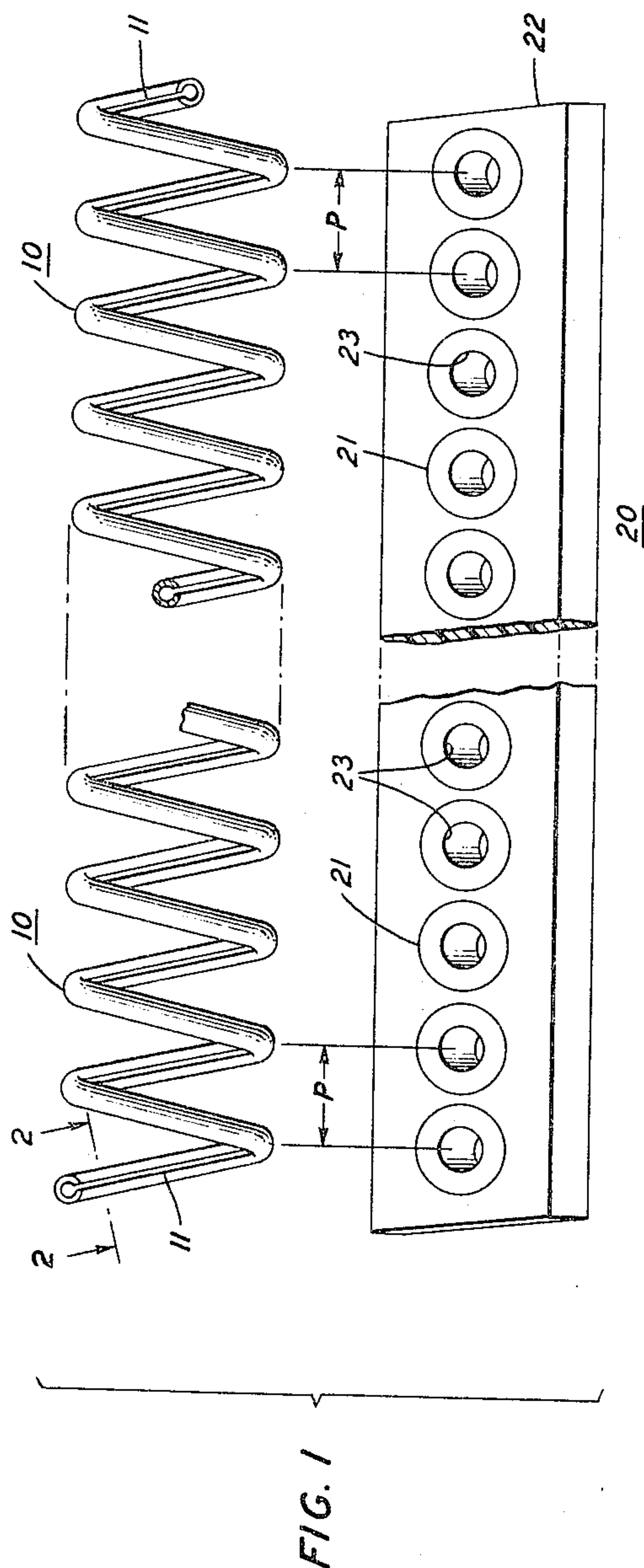
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3,310,865

MAGNETIC CORE THREADING APPARATUS AND METHOD

Filed April 22, 1964

3 Sheets-Sheet 1



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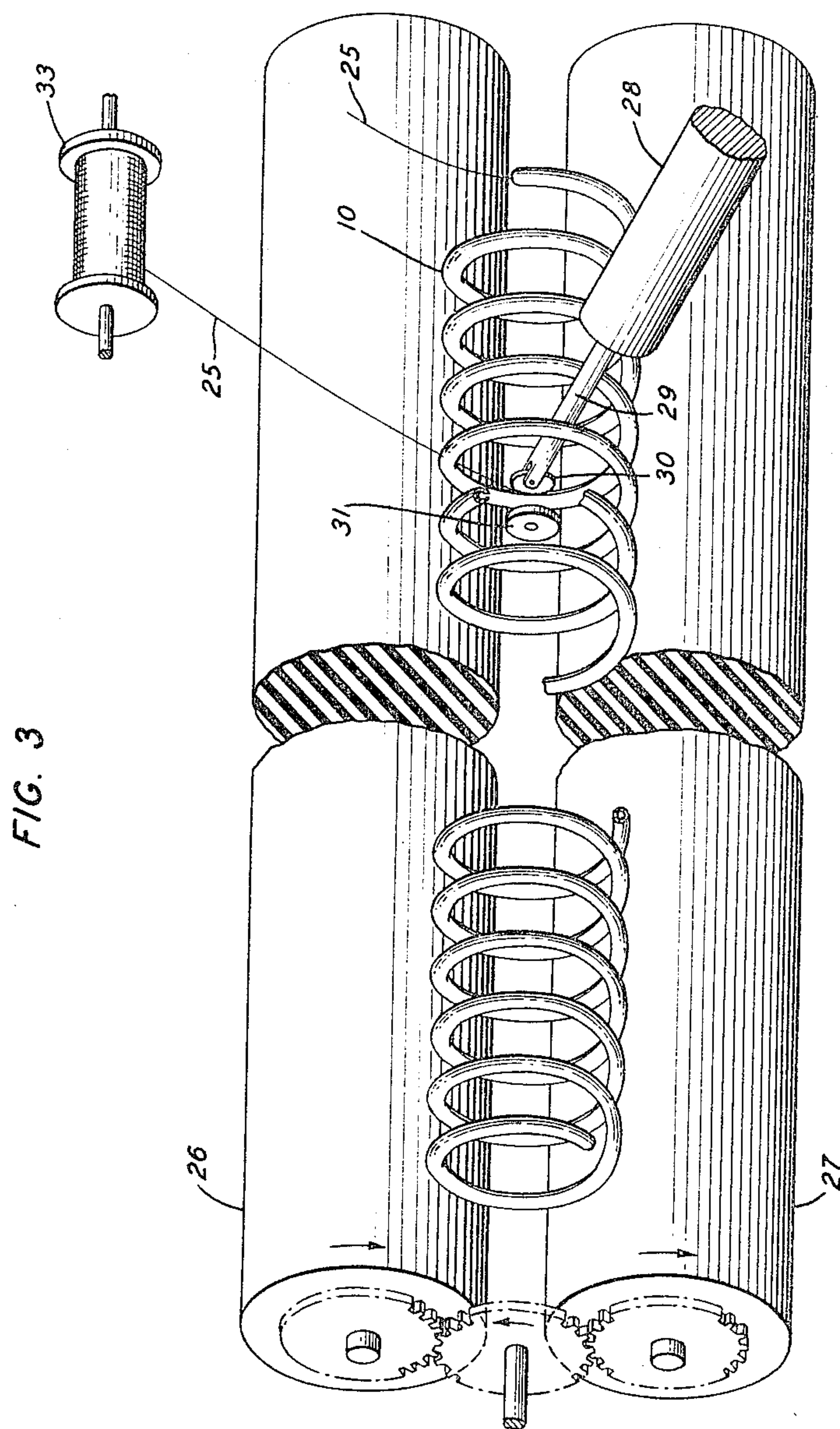
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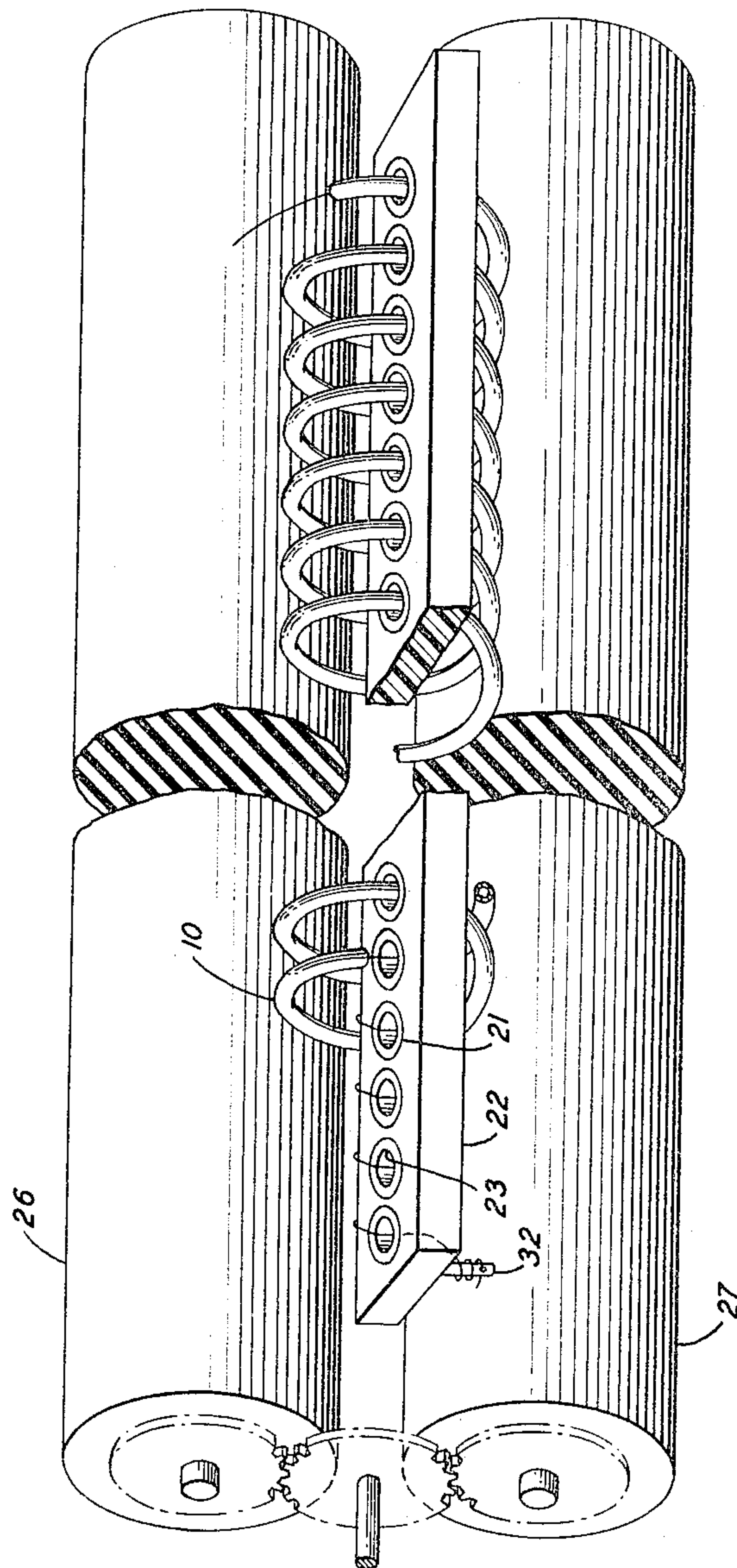
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MAGNETIC CORE THREADING APPARATUS AND METHOD

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FIG. 4



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MAGNETIC CORE THREADING APPARATUS AND METHOD

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14 Claims. (Cl. 29—155.5)

This invention relates to electrical circuits having included therein apertured magnetic elements, and more particularly to apparatus and methods for wiring such circuits.

The problem of winding apertured magnetic memory cores has long been a challenging one in the magnetic memory and switching art and the art is replete with attempts to accomplish this winding mechanically and even automatically on a mass basis. When the winding of the cores must be done individually and manually in large core circuits, the expense of laboriously threading each core with even a single turn winding adds significantly to the overall cost of the circuit. The problem is mitigated somewhat in circuits such as coordinate switches and memory matrices where the cores are functionally arranged in rows and columns. In this case either the rows or columns in which the apertures of the cores are aligned, may be quickly and simultaneously threaded by straight conductors. If the cores are arranged at the crosspoints of a coordinate array at 45° to the coordinates, as is also known in the art, both the rows and columns may be so simultaneously threaded by row and column conductors, respectively.

As a preliminary step in a number of prior art core circuit fabrication techniques, the cores are first mounted in a group sequence in some form of mounting rack or stick. A number of such mounted sequences of cores is advantageously adapted for coordinate arrangement. In the patent of L. Katzin, No. 3,106,703, issued Oct. 8, 1963, for example, a core mounting means is taught in which toroidal cores are inserted in slots provided therefor on opposite sides of a flat nonmagnetic strip. The toroidal cores are arranged in the slots with their circular axes parallel so that after a number of the strips are arranged with the corresponding apertures of the cores in alignment, conductors may be simultaneously passed through the apertures of the cores of the columns thus formed. In the patent of Katzin, the windings in the directions of the rows of cores are contemplated as being prewound. A conductor is helically threaded through the apertures of the cores and around one side of the mounting strip by either manual or machine means. A similar helical winding arrangement also characterizes a group-mounted subassembly of apertured magnetic cores in the copending application of J. C. McAlexander, Jr., Ser. No. 359,950, filed April 15, 1964. In the latter application, the core mounting means comprises a non-magnetic stick which has provided therein along its longitudinal axis a succession of circular apertures adapted to receive the toroidal magnetic cores. After the cores have been inserted in the apertures, the apertures are threaded with a conductor which passes through each core in the same direction and, between adjacent cores, around one edge of the mounting stick. Helically prewound and mounted core groups have thus become highly useful subassemblies from which larger and more complex circuit arrays may be fabricated.

It is an object of the present invention to facilitate the winding of an assembly of apertured magnetic cores.

Another object of this invention is to provide new and novel apparatus for helically threading a plurality of premounted apertured magnetic cores.

It is also an object of this invention to provide ap-

paratus adapted for the rapid threading of a series of magnetic core apertures with a continuous conductor.

A further object of this invention is a method for threading a conductor through a series of magnetic core apertures, which method is adapted for machine operation.

The foregoing and other objects of this invention are realized in one illustrative embodiment thereof comprising a hollow tube formed into a helix. The tube is slotted for its entire length at the surface facing the axis of the helix. The pitch of the helical needle thus resulting is substantially equal to the equal spacings of the apertures of the cores which are to be threaded. The width of the slot is such that the conductor to be threaded through the core apertures may just be passed through. This conductor is loaded into the hollow needle by progressively feeding it through the slot along the length of the needle. The threading needle thus loaded is most advantageously employed when the cores to be threaded are mounted in a row in a mounting stick such as is described, for example, in the aforementioned copending application of J. C. McAlexander, Jr. The threading is initiated by feeding one end of the conductor loaded helical needle into the first of the row of core apertures. The needle is then rotated around its helical axis and, as a result, passes successively through the series of equally spaced apertures of the magnetic cores. After the needle and its conductor have passed through the aperture of the last of the series of cores, the rotation of the needle is arrested and one end of the conductor is secured. The needle is then again rotated, the direction of rotation depending upon which end of the conductor was made fast. The needle thus proceeds out of the succession of core apertures or, if rotated in the reverse direction, is backed out of the succession of apertures. In either case, because one end of the conductor is secured, it is drawn into tension and then pulled through the slot leaving it helically wound through the cores as the needle is removed.

Although any suitable means may be employed to rotate the threading needle, one advantageous manner of accomplishing the rotation is by urging the needle between and into contact with two co-rotating rollers. Corresponding points on each revolution of the needle helix will be in driven contact with the rollers along its entire length. Contact with the rollers may be maintained either manually or by machine means. It will be apparent that when the conductor is fully withdrawn it will be substantially the same length as the needle helix which threaded it. A greater degree of coupling with the cores may be achieved by maintaining the width of the slot in the needle slightly less than the diameter of the conductor. Withdrawal of the needle will thus result in greater tension of the conductor with a consequent tighter winding with the cores. The degree of tension is also readily controlled by adjusting the width of the slot of the needle.

It is thus one feature of this invention that a hollow helical needle having a conductor carried therein is employed to thread a series of apertured magnetic cores. The needle is rotated through the apertures of the cores, taking with it the conductor. When the conductor is secured at one end, the needle is rotated out of the series of apertures and the conductor is withdrawn through a longitudinal slot provided in the needle leaving the conductor in its place.

According to another feature of this invention, the rotation of the helical needle is accomplished by urging it between, and into contact with, two co-rotating rollers. The tension of the threaded conductor may also be controlled by adjusting the width of the needle slot in order to provide resistance to the withdrawal of the conductor.

The foregoing and other objects and features of this invention will be better understood from a consideration of the detailed description of illustrative embodiments and methods thereof which follows when taken in conjunction with the accompanying drawing in which:

FIG. 1 shows one illustrative helical core threading needle according to this invention and a series of toroidal cores mounted to facilitate the threading operation;

FIG. 2 is a cross-sectional view of the needle of FIG. 1 taken along the line 2—2;

FIG. 3 depicts one exemplary means for loading the threading needle of FIG. 1;

FIG. 4 depicts specific apparatus for operating the threading needle of FIG. 1;

FIG. 5 is a cross-sectional view taken anywhere along the length of the needle of FIG. 1 showing a liner inserted therein in one alternate construction; and

FIG. 6 shows another illustrative cross section which may be employed for the helical needle of FIG. 1.

One illustrative core threading arrangement according to the principles of this invention is depicted in FIG. 1. This figure also shows the relative proportions of the threading needle 10 and a core subassembly 20 which may be wired thereby. The needle 10 comprises a hollow tube which has been formed into a helix in any convenient manner and which has a slot 11 cut therein facing the axis of the helix. A cross section taken at any point along the axis of the tube, such as the line 2—2, would accordingly appear as shown in FIG. 2. The tube of which the needle 10 is formed is advantageously of a material of sufficient rigidity to maintain its helical shape during the threading operation to be described. The pitch p of the needle helix is determined by the equal spacings of the center lines of the cores 21 which are shown in FIG. 1 as being maintained in a mounting stick 22. The stick 22 is preferably fabricated of an electrically insulating, nonmagnetic material and has a plurality of equally spaced apertures therein adapted to receive the toroidal cores 21. The apertures are provided in the stick 22 along a common centerline so that when the cores 21 have been inserted, the apertures 23 of the cores will be arranged substantially in a straight line. The inside diameter of the helix of the needle 10 is determined by the dimensions of the cores 21 and the mounting stick 22. Thus this diameter is sufficiently large to pass freely through the core apertures and around at least one edge of the core mounting stick 22. The needle 10 thus described is adapted to have an electrical conductor loaded therein in a manner to be considered hereinafter. As will also appear, this conductor will be substantially the same length as the axis of the tube of which the needle 10 is formed, at the time of its loading. The length of the helical needle 10 itself is determined by the degree of coupling desired between the conductor and the cores and for the purpose of the present description will be understood to be the same length as the core mounting stick 22.

One illustrative method of loading the needle 10 with a conductor 25 is depicted in FIG. 3. The helix of the needle 10 is urged, either manually or by suitable machine means, against the surfaces of two co-rotating rollers 26 and 27. The rollers 26 and 27 are caused to rotate by mechanical means, such as the representative gear train shown in the drawing, readily envisioned by one skilled in the art and the speed of rotation is governed to suit the demands of the loading operation. The latter operation may advantageously be accomplished by means of a tool 28 also depicted in FIG. 3, which tool comprises a bifurcated shank 29 having a U grooved pulley 30 rotatably mounted within the bifurcation. The pulley groove is adapted to receive the cylindrical surface of the conductor 25. The conductor 25 is started in the slot 11 of the needle 10 after which the pulley 30 is pressed manually or by machine means against the conductor 25 thereby forcing the conductor 25 inside of the tube of the needle 10. As the rollers 26 and 27 rotate, thereby caus-

ing the helical needle 10 also to rotate, the pressure of the pulley 30 continuously forces the conductor 25 into the needle 10 as it is fed from its reel 33 or other convenient source. The apparatus of which the rollers 26 and 27 are part may also be provided with a pair of guides 31 spaced to admit the outside diameter of the tube of the needle 10 to provide a backstop for the pressure of the tool 28. The guides 31, only one of which is visible in the drawing, will cause the needle 10 to be fed along the rollers 26 and 27 as it is rotated as is clear from FIG. 3. The conductor 25 is permitted to extend beyond the needle 10 in order to secure the conductor during the threading operation. Before the core subassemblies, such as the cores 20 mounted in the stick 22 as shown in FIG. 1, are threaded, a number of needles 10 may be loaded with conductors in preparation for a continuous threading operation.

A threading operation is initiated by feeding a starting end of the loaded needle 10 into the aperture of the first of the cores 21 of a stick 22. The threading needle 10 is then urged against the co-rotating surfaces of the rollers 26 and 27. As a result, the helical needle 10 is rotated and its starting end is successively fed through the series of aligned core 21 apertures thereby bringing the conductor 25 with it as the stick 22 is maintained fixed. When the trailing end of the needle 10 has proceeded out of the first of the core apertures as shown in FIG. 4, the rotation of the rollers 26 and 27 is interrupted, or equally conveniently, the needle 10 is withdrawn from contact with the rotating surfaces of the rollers, and the conductor 25 is secured to a terminal 32 provided at the end of the core stick 22. With the conductor 25 thus made fast, the rotation of the needle 10 is continued in the same direction. At this time, however, as tension is applied to the conductor 25 from the terminal 32, it is forced out of the slot 11 of the needle 10 and remains threaded through the core apertures after the needle has been successively withdrawn. The conductor 25 leaves the slot 11 rather than the end of the needle 10 due to the friction between the conductor and the inside of the needle tube. The dimensions of the latter elements may be adjusted to insure this choice of exit paths for the conductor 25. When the needle 10 leaves the aperture of the last core 21 of the stick 22, each of the cores will be threaded with a single turn winding and each core will be threaded in the same direction. The rotation of the rollers 26 and 27 was assumed for purposes of illustration to continue in the direction originally begun after its interruption to make fast the conductor 25. This obviously precludes the necessity of providing reversing mechanism for the roller drive apparatus. However, it will be apparent that the needle 10 may also be backed off the core stick 22 after the last core aperture has been threaded. In this case the starting end of the conductor is made fast and the rollers 26 and 27 are reversed in direction to accomplish the needle withdrawing operation.

As mentioned previously, the conductor 25 is the same length as the axis of the tube of which the helical needle 10 is formed. Since the circular path of the axis is longer than the length of a tightly coupled conductor through the core apertures, the conductor 25 may be slackly threaded after the needle 10 is removed. The conductor 25, however, may be drawn up by pulling on the unsecured end to any degree of coupling. On the other hand, the conductor 25 may be wound tightly through the cores 21 and around an edge of the stick 22 by providing resistance to its withdrawal through the slot 11 during the threading operation. This resistance may advantageously be provided by inserting a flexible liner 33 inside the tube of the needle 10 as shown in cross section in FIG. 5. The liner 33 which may be of a plastic material, is also provided with a slot 34 running the entire length of the liner. The slot 34 is cut slightly smaller than the diameter of the conductor 25 to resist the pas-

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sage of the latter conductor as the needle 10 is rotated. The conductor 25 will in this manner be wound closely around the stick 22 and through the core apertures. Advantageously the degree of tension of the conductor 25 may be controlled by adjusting the width of the slot cut in the liner 33.

Although a hollow tube was envisioned as forming the body of the helical needle 10 in the foregoing, an equally suitable cross section is shown in FIG. 6. A straight length of drill rod 40 has a lengthwise slot 41 milled therein, the slot being dimensioned to snugly receive the conductor 25. The rod 40 is then formed into a helix with the slot facing the helical axis.

Other arrangements may also be devised by one skilled in the art to carry out the principles of this invention and what have been described are considered to be only illustrative embodiments thereof.

What is claimed is:

1. Apparatus for threading a conductor through the apertures of a sequence of apertured magnetic cores comprising a helical tube having a pitch substantially equal to the spacings between said cores, a conductor within said tube, means for rotating said tube successively through the apertures of said cores, means for fixing said conductor at one end of said sequence of cores after said tube has at least entered each of said apertures, and means for further rotating said tube in a direction away from said one end, said tube also having a slot therein facing its helical axis for permitting the removal of said conductor as said tube is rotated in said last-mentioned direction.

2. Apparatus for threading a conductor through the apertures of an equally spaced sequence of apertured magnetic cores comprising a helical needle having a pitch substantially equal to the spacings between said cores, said needle having a recess along its length facing its helical axis, a conductor disposed in said recess, means for rotating said needle around its helical axis successively through the apertures of said cores, terminal means at one end of said sequence of cores for securing one end of said conductor after said conductor has at least entered each of said apertures, and means for further rotating said needle in a direction away from said terminal thereby withdrawing said conductor from said recess.

3. Apparatus as claimed in claim 2 in which said helical needle is substantially the same length as said sequence of cores.

4. Apparatus as claimed in claim 2 also comprising means for controlling the tension of said conductor comprising a flexible liner means inserted in said recess adapted to receive said conductor, said liner means having a slot therein of a dimension less than that of the smallest cross section of said conductor.

5. Apparatus as claimed in claim 2 in which the opening of said recess is of a dimension less than that of the smallest cross section of said conductor.

6. Apparatus for threading a conductor through the apertures of an aligned sequence of apertured magnetic cores, said cores being maintained with the circular axes parallel and equally spaced in a mounting means, comprising a hollow helical needle having a pitch substantially equal to the spacings between adjacent cores, said needle having a slot along its length facing its helical axis, a conductor inside said hollow needle, means for rotating said needle around its helical axis successively through the apertures of said cores and around one edge of said mounting means, terminal means at one end of said mounting means for securing one end of said conductor after the trailing end of said needle has passed through the aperture of the first of said sequence of cores, and means for further rotating said needle in a direction away from said terminal thereby withdrawing said conductor through said slot.

7. Apparatus for threading a conductor through the

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apertures of an equally spaced sequence of apertured magnetic cores comprising a hollow helical needle having a pitch substantially equal to the spacings between adjacent cores, said needle having a slot along its length facing its helical axis, a conductor inside said needle, and means for rotating said needle around its helical axis successively through the apertures of said cores.

8. Apparatus as claimed in claim 7 also comprising means for securing one end of said conductor after the trailing end of said needle has passed through the aperture of the first core of said sequence.

9. Apparatus as claimed in claim 7 in which said means for rotating said needle comprises a pair of co-rotating rollers having driving contact with said helical needle along its length.

10. The method of wiring a sequence of equally spaced apertured magnetic cores comprising rotating a helical hollow needle having a conductor therein successively through the apertures of said cores, securing one end of said conductor after said needle has passed through the aperture of the first core of said sequence, and continuing the rotation of said needle in a direction away from said one end to withdraw said conductor through a slot provided in said needle.

11. The method of wiring a sequence of equally spaced apertured magnetic cores comprising rotating a helical hollow needle having a conductor therein successively through the apertures of said cores, and withdrawing said conductor through a slot in said needle when said needle has passed through the aperture of the first core of said sequence comprising securing said conductor at said first core and continuing the rotation of said needle in a direction away from said first core.

12. Magnetic core wiring apparatus comprising mounting means for maintaining a plurality of apertured magnetic cores in an equally spaced relationship, a helical needle having a pitch substantially equal to the spacings between adjacent cores and a helical inside diameter at least sufficient to admit the core rim and the side portion of said mounting means, said needle having a recess along its length facing its helical axis, a conductor disposed in said recess, terminal means at one end of said mounting means for securing said conductor, and means for rotating said needle around its helical axis successively through the apertures of said cores.

13. Magnetic core wiring apparatus as claimed in claim 12 also comprising means for controlling the tension of said conductor comprising a liner means inserted in said recess adapted to receive said conductor, said liner means having a slot therein of a dimension less than that of the smallest cross section of said conductor, said liner means being of a material to permit the forcing of said conductor therethrough.

14. Apparatus for threading a conductor through the apertures of a sequence of apertured magnetic cores comprising a helical tube having a pitch substantially equal to the spacings between said cores, said tube having a slot therein facing its helical axis, a conductor within said tube, means for securing said conductor at one end of said sequence of cores, and means for rotating said needle around its helical axis successively through the apertures of said cores.

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