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Fahrbach

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[54] **TOROIDAL COIL-WINDING MACHINE**

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[21] Appl. No.: **174,104**

[52] **U.S. Cl.** ..... **242/4 B,** 242/4 C

[51] **Int. Cl.** **H01f 41/08**

[58] **Field of Search** ..... 242/4 R, 4 C, 4 BE, 4 B, 242/DIG. 1; 269/63

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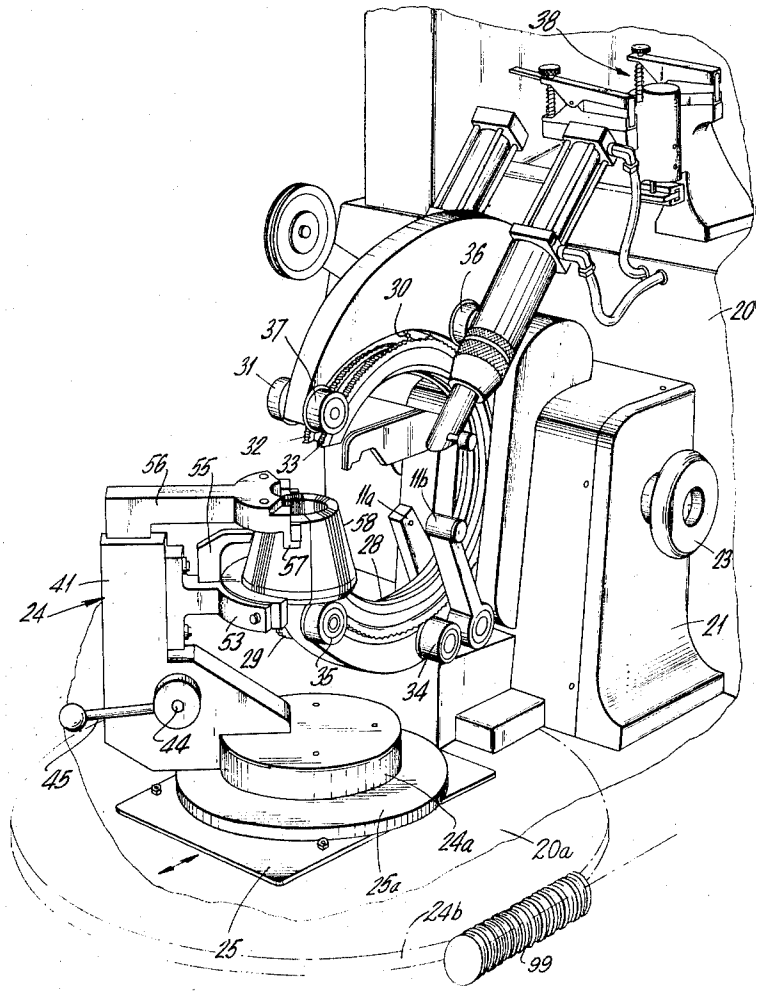
Primary Examiner—Billy S. Taylor

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[57] **ABSTRACT**

A machine for the winding of toroidal coils enables each turn of the windings to be accurately laid on the core. The machine is controlled by a numerical control system which reads punched tape. The core is held by an adjustable clamp and the clamp is mounted on an indexing wheel which is progressed under control of the tape reader by means of a step motor and an adjustable worm gear.

9 Claims, 8 Drawing Figures



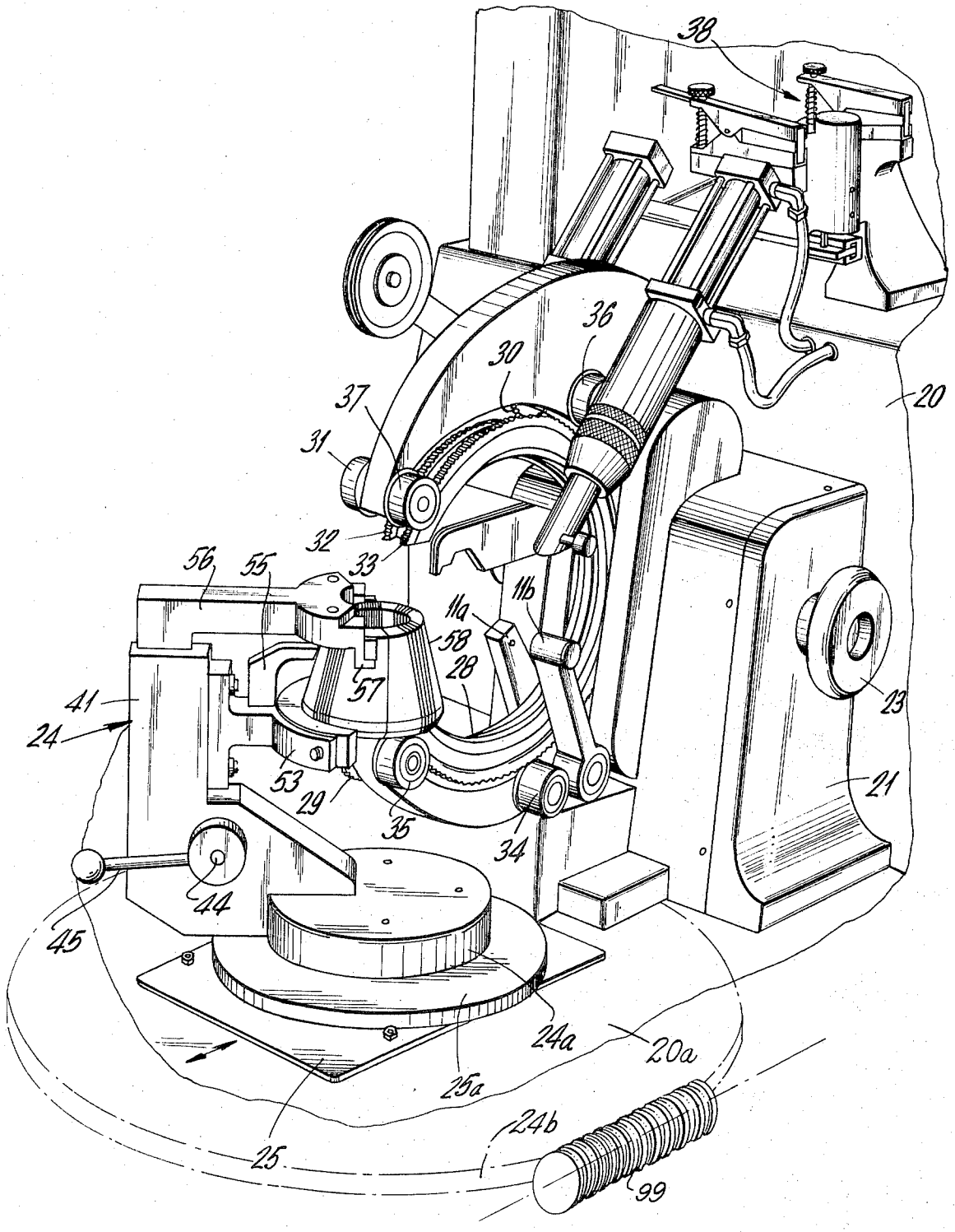


FIG. 1

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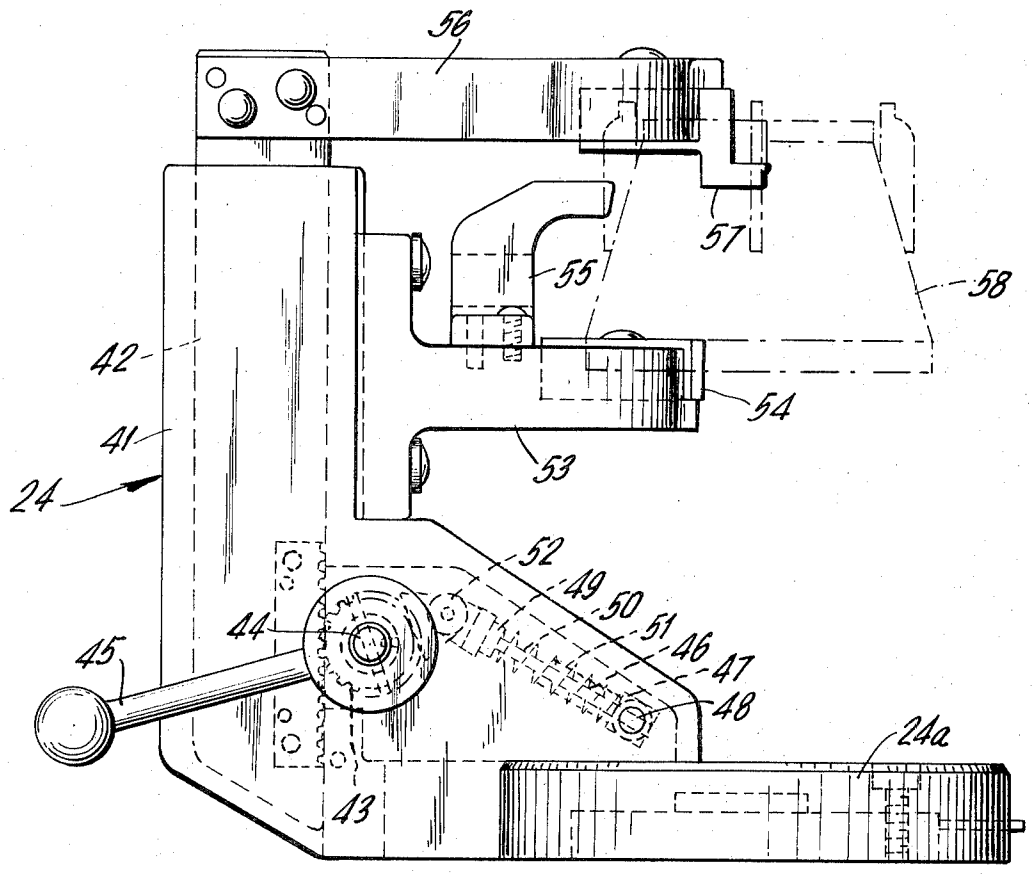


FIG.2

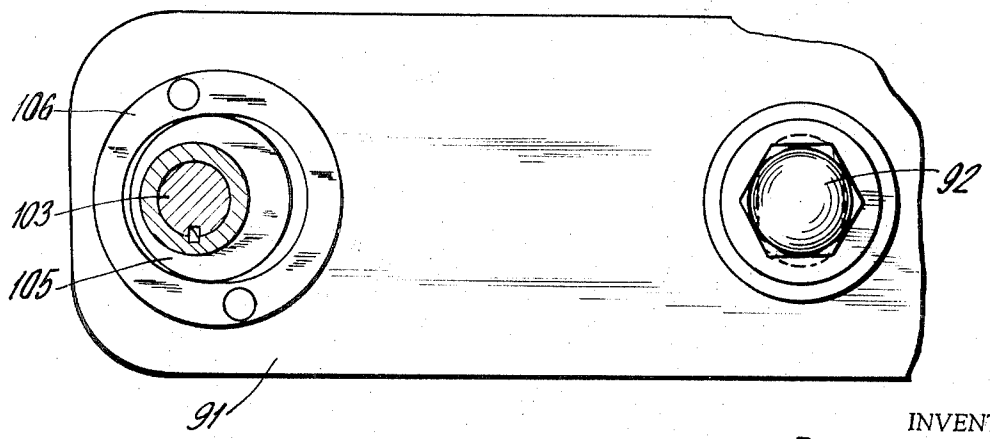


FIG.4

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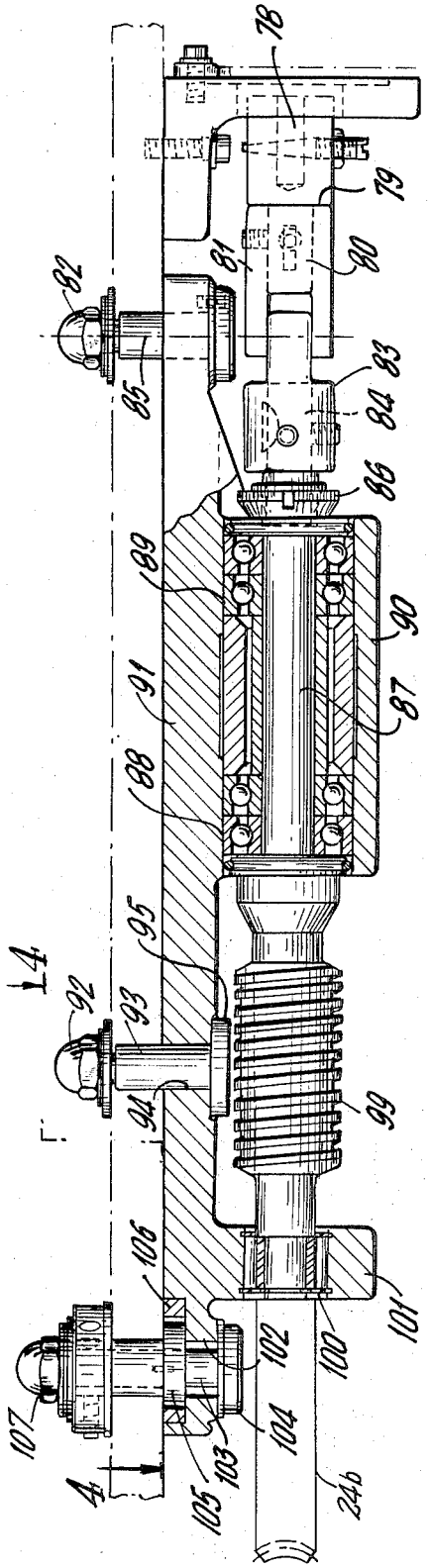


FIG. 3

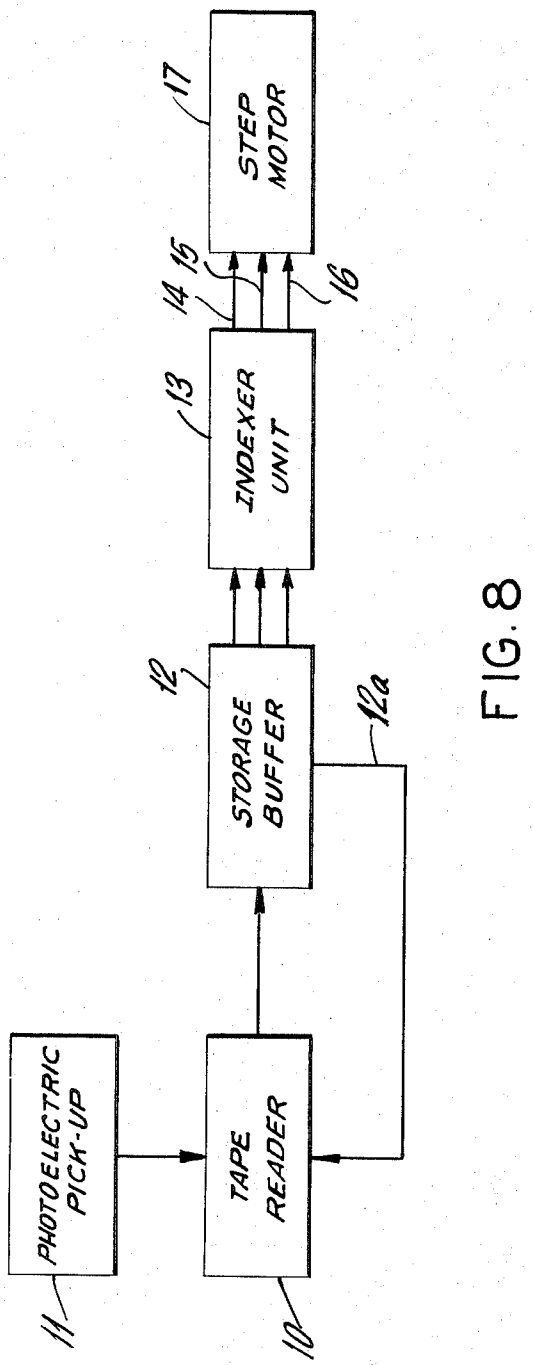


FIG. 8

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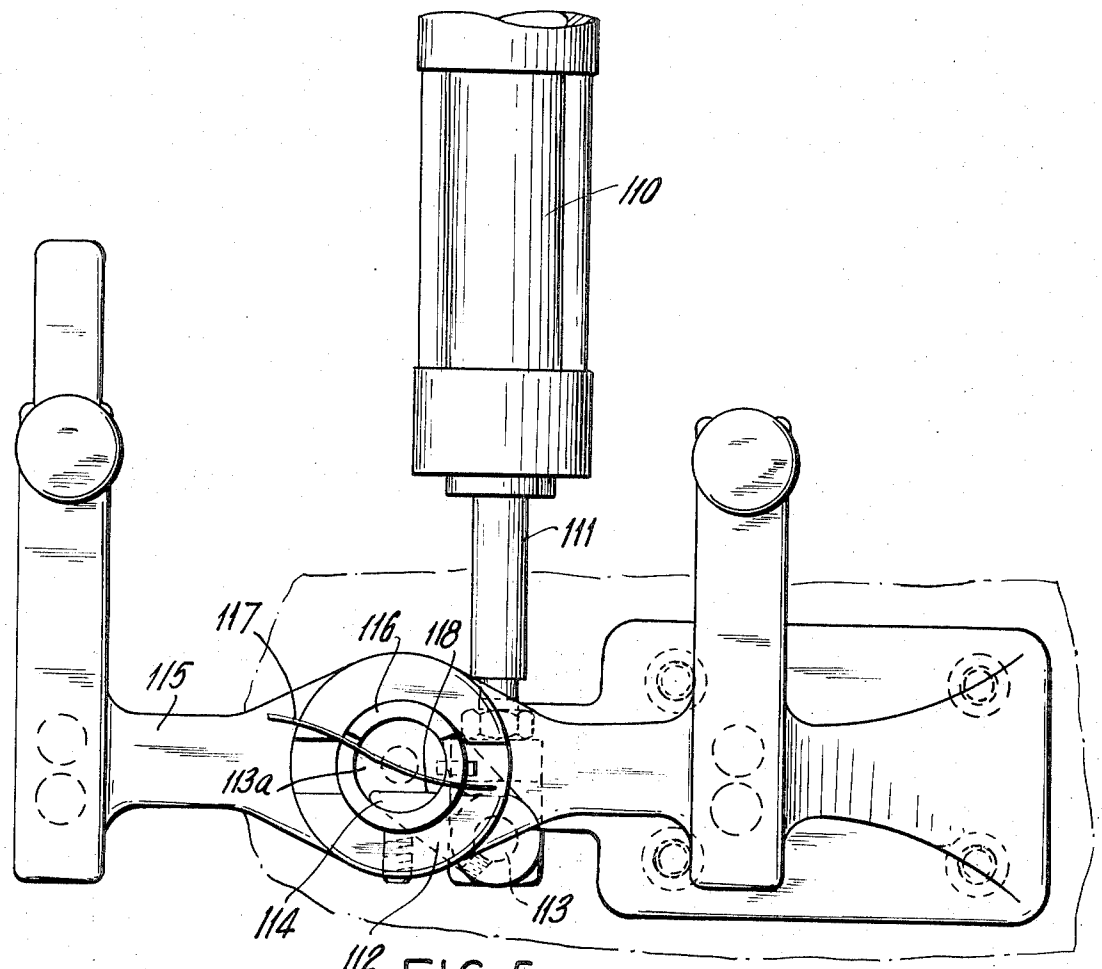


FIG. 5

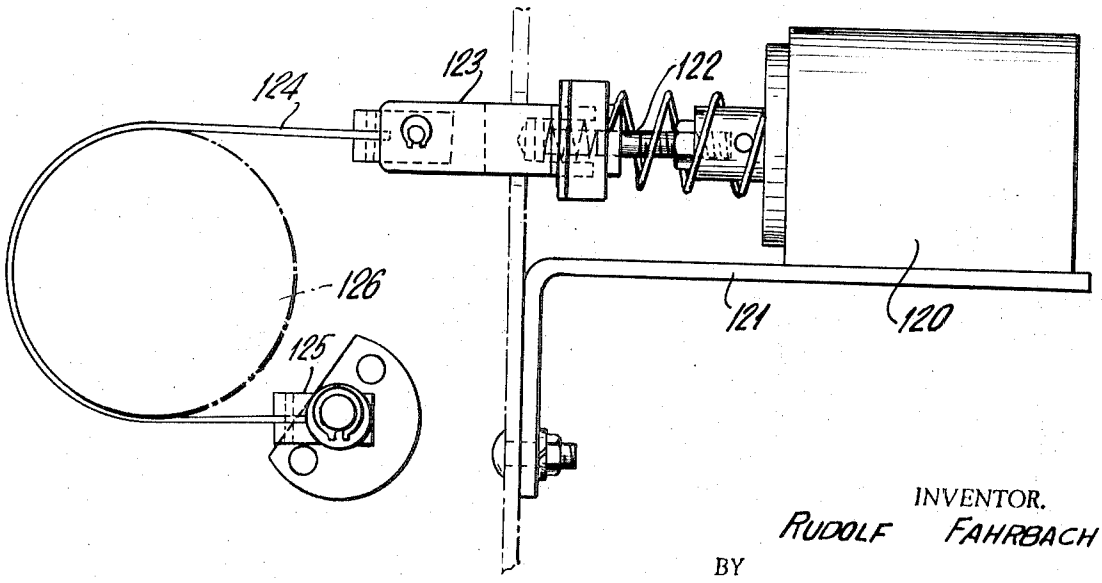


FIG. 6

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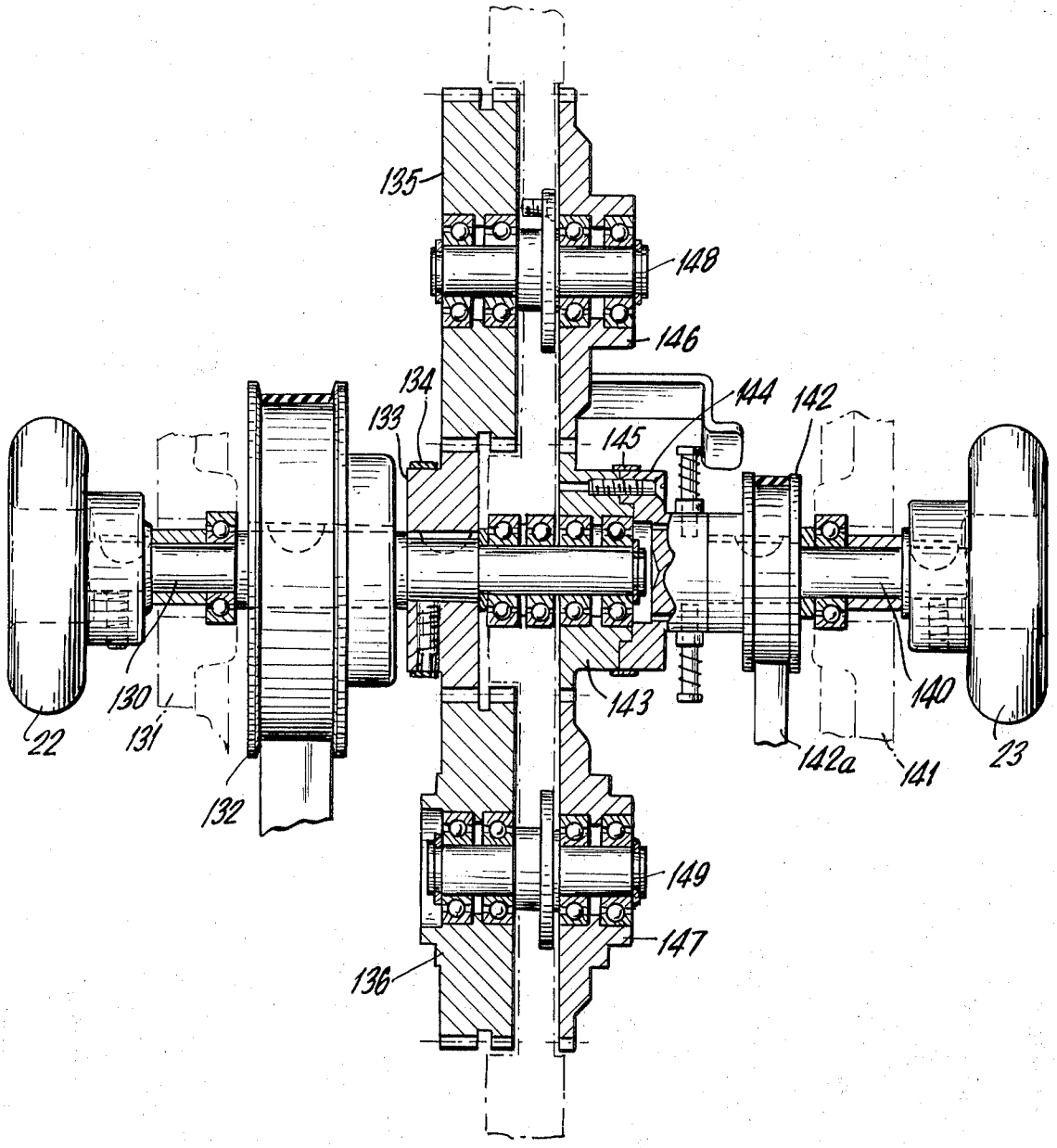


FIG. 7

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TOROIDAL COIL-WINDING MACHINE

BACKGROUND OF THE INVENTION

The present invention relates to coil winding machines and more particularly to machines to accurately wind a toroidal coil.

Toroidal coils, in which the turns are accurately positioned on the core, are useful in various electronic instruments. For example, it is necessary to precisely locate the turns on a core, possibly within certain recesses, in the deflection coil of a color television set.

It has been proposed that a suitable coil winding machine may be produced by using an indexing wheel whose teeth correspond to the turns to be wound. Such machines, however, sometimes could not be operated at high speed, without the eventual wear or destruction of teeth of the index wheel. An improved coil winding machine of this type, using an index wheel, is shown in the inventor's United States Letters Patent No. 3,559,899. However, even that improved machine is not entirely flexible because it is necessary to change the index wheel every time a different coil is to be wound.

SUMMARY OF THE INVENTION

A toroidal coil (yoke) winding machine is provided which is controlled by an electronically controlled stepping motor system which reads a numerical (digital) punched tape. A simply operated spring-loaded yoke clamp permits the operator to readily change yokes. The wire is cut automatically under control of the footage counter, by an air-cylinder device. The footage counter is reset automatically when the wire is cut. Separate solenoid operated brakes accurately position respectively the magazine and the shuttle gear ring of the winding head.

An accurate drive system is provided by a worm gear mounted and fixed on a shaft. The axis of he shaft may be shifted by means of an eccentric arrangement and removably fixed in place. The handle for the shuttle gear ring and the handle for the magazine are aligned along a common axis, although each operates independently. An open shuttle magazine is used, saving operator time, which magazine is automatically and accurately positioned.

These measures decrease to a minimum the steps required for the operator to wind a yoke, and consequently may speed production. At the same time they permit different sizes and shapes of cores each to be accurately wound with very little costly change-over time when changing the size or shape of the core or the spacing of its windings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a perspective over-all view of the coil winding machine of the present invention;

FIG. 2 is a side plan view of the clamping mechanism;

FIG. 3 is a side plan view of the worm gear and support for the index table drive system;

FIG. 4 is a top plan view of the mechanism of FIG. 3;

FIG. 5 is a top plan view of the automatic wire cutter;

FIG. 6 is a side plan view of the braking mechanism;

FIG. 7 is a front plan view of the drive system for the magazine and gear ring; and

FIG. 8 is a block schematic drawing of the control circuit of the coil winding machine.

The overall control system of the present invention is shown in FIG. 8. As shown, a tape reader 10 reads a punches plastic or paper tape, the holes in the tape representing, in digital form, instructions for the machine. Preferably a standard 8-hole code format is used, a suitable photoelectric tape reader being available from Superior Electric Company. The tape reader 10 receives an input control signal from the photoelectric pick-up 11 which indicates to the tape reader the passage of the wire. The tape reader 10 is connected to a storage buffer 12, consisting of gates and shift registers, which holds the read code for processing. A control signal, on line 12*a* provides advance and stop signals to the tape reader 10. The storage buffer 12 provides the control signals, in the form of a parallel word code, to the indexer unit 13, which is a solid state electronic unit which converts the parallel code to serial pulses on three output lines 14, 15, 16, in sequence. The three lines 14–16 are connected to stepping motor 17 upon whose output shaft is mounted a worm gear, described below, to index the rotatable table upon whch the core clamp is mounted. A suitable stepping motor provides 200 steps per revolution and 5 or more revolutions per minute of the head (not the motor), and is also available from Superior Electric Co., Connecticut.

The general construction of the machine is shown in FIG. 1. As shown, it consists of a base 20 having a table portion 20*a* upon which is mounted a drive mechanism 21 having two protruding hand operable handles 22 and 23. A fixture 24 is fixed to the rotatable index wheel 24 which is rotatably mounted on dial base 25*a*. The dial base 25*a* is fixed on plate 25 which is movable, about one inch, toward or away from the front of the machine, in the direction of the arrows. The fixture 24, described below, removably holds the core during the winding operation. A series of four guide rollers 28, 29, 30, 31 mesh with, and are adapted to rotate, a large shuttle gear ring 32. The gear ring 32 has an open segment, i.e., it is not a complete ring. A magazine 33, also having an open segment, is similarly supported by four rollers 34, 35, 36, 37 which rotate it in one direction to load the magazine and the opposite direction to wind the coil. An automatic wire cutting mechanism 38 is positioned upon a platform of the base and the tape reader 10 is positioned at the top of the base. The photoelectric pick-up 11 consists of a light emitter 11*a* which projects a light beam across a gap to a photoelectric sensor 11*b*. Every time the wire being wound is pulled through the gap, the sensor 11*b* sends a pulse to the tape reader 10.

The fixture (clamping) mechanism 24 is shown in FIG. 3. A base is adapted to be fixed to the rotatable index table 24*a* which is fixed to rotatable geared wheel 24*b*, the wheel 24*b* being below table portion 20*a*. The wheel 24*b* meshes with worm 99. An elongated vertically extending member 41, integral with or firmly affixed to the base, has an internal bore which is rectangular in cross-section. An elongated slide 42, having a long shank, rectangular in cross-section, slides within the bore. The slide 42, which may have other cross-sectional shapes, is elongated to provide an exact holding position to the core and avoid any wobbling. An edge of the slide 42 has gear teeth, forming a rack, which mesh with the teeth of the pinion gear 43. The

pinion gear 43 is fixed to a shaft 44. A lever 45 is fixed to the pinion gear 43. A toggle-like effect is provided by means of a compressible coil spring 46. The spring is compressed between a bottom block 47 which pivots on shaft 48 and a top ring 49. The ring 49 is fixed on shaft 50 and shaft 50 slides within the tube 51 fixed to the block 47. The ring 49 applies pressure on the cam 52 which is fixed to the pinion 43.

A bottom bracket 53, which supports the coil, extends horizontally and is fixed to the vertical member 41. A jaw insert 54 is removably attached to the bracket 53, the effective vertical height of the block support may be changed by changing the jaw insert 54 to one having a different height. A locator 55 is removably fixed to the bracket and is used to locate the core by means of a rib or slot at the top of the core.

A horizontal bracket 56 is fixed to the top of the slide 42. A locator member 57 is fixed to bracket 56.

In operation, an appropriate locator 55, jaw insert 54 and locator member 57 are attached to the clamp, depending upon the coil to be wound. Assuming that the slide is up, i.e., the clamp is open, the operator will place the coil on the jaw insert and locator and lower the lever 45. The spring 46 will push ring 49 to act upon cam 52 to bring down the slide with its attached arm 57. The arm 57 will descend on the coil 58 with the correct pressure. The spring 46 serves a double function. As mentioned above, it brings down the slide 42 upon closure and it also keeps the clamp normally open.

FIGS. 3 and 4 illustrate the drive system for the worm gear which meshes with a gear integral with the revolvable index table upon which the core clamp is fixed. The stepping motor 17 has an output shaft 78 which is fixed to a joint member 79 having protruding portion 80. The protruding portion 80 is fixed within a bushing 81. A shaft extension 84 is fixed within the joint member 83. The joint members 79 and 83 and bushing 81 constitute a universal joint which transmits rotating force from the stepping motor to the shaft 87. The universal joint permits movement of the shaft 87 in relationship to the shaft 78 about the pivot axis 85.

The shaft 87 is connected, by means of joint 86, to ball bearings. Shaft 87 rotates within two pairs of ball bearings, respectively 88 and 89. The outer races of the ball bearings 88 and 89 are held within a tubular portion 90 integral with the bracket support 91. The bracket support 91 is rotatably secured to the table portion of the base by means of the bolt assembly 82. The bracket support 91 is rotatable about the axis 85, the axis of the bolt assembly 82, as well as that of the universal joint. The bracket support 91 may be clamped securely to the table portion by means of the bolt assembly 92. A shank 93 of the bolt assembly fits within an elongated slot 94 within the bracket support 91 so that rotation of the bolt in one direction will clamp the support against the table and rotation in the opposite direction will loosen the bracket support 91 for pivoting motion about axis 85. The shaft 87 is integral with the worm 99 and an end of the shaft 87 fits within the needle bearing 100, which bearing 100 is held within a flange 101 integral with the support bracket 91. The outer end of the support 91 has an enlarged hole 102 through which loosely protrudes the shaft 103 of an eccentric mechanism. The shaft 103 has a lower holding member 104 below the support bracket 91, an eccentric portion 105 which fits within a cavity 106 of the support bracket 91, and an upper head 107. The rotation of the head 107 will cause the eccentric 105 to act against the shoulders of the cavity 106, causing a shifting movement of the support bracket 91 about its axis 85. The operator will determine the desired position of the worm, push the worm support bracket 91 into the desired position by loosening the bolt assembly 92 and turning the head 107 to rotate the eccentric 105. When the desired position has been obtained, he will cease rotation of the eccentric 105 and clamp the support bracket 91 against the table portion by tightening the bolt assembly 92.

FIG. 5 shows the automatic wire cutter. As shown, an air cylinder 110 has an output piston shaft 111 which is pivotally connected to a link 112 by means of a rod 113. The opposite end of the link is fixed to a rotatable shaft 113a having an upraised protruding portion 114. A fixed bracket 115 attached to the base has thereon an upraised protruding portion 116 which is fixed. The air cylinder 110 is operated from a source of air pressure (not shown) and is controlled by means of an electrically operated valve which receives its control signals from the wire footage counter. Upon receiving a control signal to cut the wire 117 the shaft 111 will be retracted, thereby rotating the link 112 in a counterclockwise direction. Such counterclockwise motion of the link 112 causes the protrusion 114 to move counterclockwise and cut the wire 117 which is between the nose 118 of the protrusion 114 and the fixed protrusion 116. The wire footage counter is automatically reset at zero by the same signal that causes the wire to be cut.

A preferred brake mechanism to exactly stop the rotation of the magazine in its desired position is shown in FIG. 6. The same type of brake mechanism, but a second unit, is used to brake the gear ring. A solenoid 120, or alternatively, an air operatied cylinder, is mounted on a bracket 121 fixed to the base. The solenoid 120 receives its control signals from a photoelectric pick-up which, in turn, is informed of the position of the gear and magazine by means of a synchronized gear train. Two small gear trains (not shown) each mesh with the respective gears driving the magazine and gear ring. A gear in each gear ring rotates at the same speed relative position as the respective magazine and gear ring. Each of the two synchronized gears has a hole which may be aligned with a light beam produced by a light emitter and detected by a photoelectric sensor. When the hole is aligned with the beam, the sensor produces a control pulse to the solenoid, or air cylinder, braking the magazine or gear ring and correctly positioning them. The output shaft 122 of the solenoid is connected, by means of connection member 123, to a flexible strap 124. The opposite end of strap 124 is held fixed in a clamp 125, the clamp 125 being pivotly fixed to a support member affixed to the base. A shoulder of the drive gear 126 for the gear or magazine fits within the curve of the flexible strap 124. Preferably the strap 124, on its face towards the drive gear of the magazine, has a highly frictional material, for example, the strap may be of steel. Upon receipt of a braking control signal, the solenoid 120 will pull in the output shaft 122, causing the strap 124 to brake the motion of the drive gear for the magazine.

The driving gear system for the magazine and the shuttle gear ring is shown in FIG. 7. It has two handles 23 and 22 which are aligned along a common axis but are completely independent of each other. Rotation of handle 22 by the operator will not move handle 23 and

its associated gearing, nor will rotation by the operator of the handle **23** turn the handle **22** and its associated gearing. The handle **22** turns the shuttle gear ring **32** and the handle **23** turns the magazine **33.**

The handle **22** is fixed to a shaft **130** which is rotatable within the support portion **131** which is part of the casing of the winding head drive mechanism **21.** A pulley **132** is fixed to the shaft **130.** A timing belt operatively connects the pulley **132** to an electric motor. The shaft **130** is also connected to the ring drive gear **133.** A rim **134** of the ring drive gear is used for braking, by means of the solenoid operated strap, as described above. The ring drive gear meshes with two shuttle gear ring idlers, **135** and **136,** shown in FIG. **7.** The shuttle gear ring idlers **135, 136** and ring drive gear **133** mesh with and rotate the shuttle gear ring.

The handle **23** is fixed to a shaft **140** which rotates within the support portion **141** of the drive mechanism **21.** A pulley **142** is fixed to the shaft **140** and a belt **142***a* operatively connects the pulley **142** with an air motor. The air motor winds the wire in the magazine (in one direction of rotation of the magazine) and provides some braking resistance during the wire winding operation (in the opposite direction of rotation of the magazine). The magazine drive gear **143** is fixed to the shaft **140** and has a rim **144** upon which is positioned a brake band **145.** The brake band **145** is preferably of the same type of mechanism as described above, using a steel strap which may be pulled taut by a solenoid. The magazine drive gear **143** is connected to two magazine idler gears, **146** and **147,** shown in FIG. **7.** The magazine idler gears **146** and **147** are carried by bearings which rotate on, respectively, shafts **148** and **149.** The shafts **148** and **149** also carry the bearings for the shuttle gear idlers. However, there are no operative connections between the shuttle gear idlers and the magazine idler gears, as each rotates independently on the same shaft.

I claim:

1. A toroidal coil winding machine including a base, motor means positioned on the base, a magazine adapted to be loaded with wire and rotated by said motor means, a clamp adapted to hold a core for winding, an index table upon which said clamp is mounted and which is rotatably mounted relative to said base; a worm wheel fixed to said index table; a stepping motor operatively connected to a worm mounted on a shaft rotatably held in a bracket pivotally mounted on said base and rotatably mounting said worm gear shaft, said worm meshing with said worm wheel; and a universal joint operatively connecting said worm shaft and the shaft of said stepping motor.

2. A toroidal coil winding machine as in claim **1** wherein said bracket is removably fixed to said base by a fixing means, said bracket is mounted to move about an axis, and said bracket may be shifted about its axis by an eccentric mechanism.

3. A toroidal coil winding machine including a base, motor means positioned on the base, a magazine adapted to be loaded with wire and rotated by said motor means, a rotatable clamp adapted to hold a core for winding, in combination:

an index table upon which said clamp is mounted and which is rotatably mounted relative to said base, a gear connected with said index table;

a stepping motor operatively connected to a gear system and said gear system being operatively connected to said index table;

said gear system including a worm gear mounted on a shaft, pivotable bracket means to rotatably support said worm gear shaft, and a universal joint operatively connecting said worm gear shaft and the shaft of said stepping motor, said worm gear meshing with said gear connected with said index table;

a numerical control and tape reader system connected to said stepping motor to provide control signals to said motor; and

a pick-up system connected to said control system and positioned on said base to monitor the wire being wound and to provide control signals to said control system.

4. A toroidal coil winding machine as in claim **3** wherein said control system includes a tape reader, a storage buffer, and an indexer unit which produces pulses to said stepping motor on a plurality of lines.

5. A toroidal coil winding machine as in claim **3** and also including an automatic wire cutter mounted on said base, said wire cutter comprising motor means, a rotatable cutter connected to said motor means and a fixed cutter member secured to said base.

6. A toroidal coil machine as in claim **3** and further including pivot means to mount said bracket to said base so that said bracket is pivotable about an axis, and an eccentric mechanism operable between said bracket and said base to selectively pivot said bracket.

7. A toroidal coil machine as in claim **1** and further including pivot means to mount said bracket to said base so that said bracket is pivotable about an axis, and an eccentric mechanism operable between said bracket and said base to selectively pivot said bracket.

8. A toroidal coil winding machine as in claim **3** wherein the pivot center of said pivotable bracket and the pivotable center of said universal joint are vertically aligned.

9. A toroidal coil winding machine as in claim **1** wherein

a plurality of idler rollers support and rotate said magazine and the machine further includes a magazine drive gear meshing with said idler rollers, a handle fixed to the shaft of said magazine driver gear, connection motor means to selectively rotate said magazine drive gear;

a rotatable gear ring, a plurality of idler gear ring rollers meshing with and adapted to rotate said gear ring, a gear ring drive gear meshing with and driving said idler gear ring rollers, and a second handle fixed to the shaft of said gear ring drive gear,

wherein the shafts of said magazine drive gear and said gear ring drive gear lie along a common axis and those shafts are not operatively connected.

* * * * *