Oct. 17, 1967 A. E. FRANK 3,347,474

STATOR WINDING MACHINE

Filed Aug. 20, 1964 16 Sheets-Sheet 1

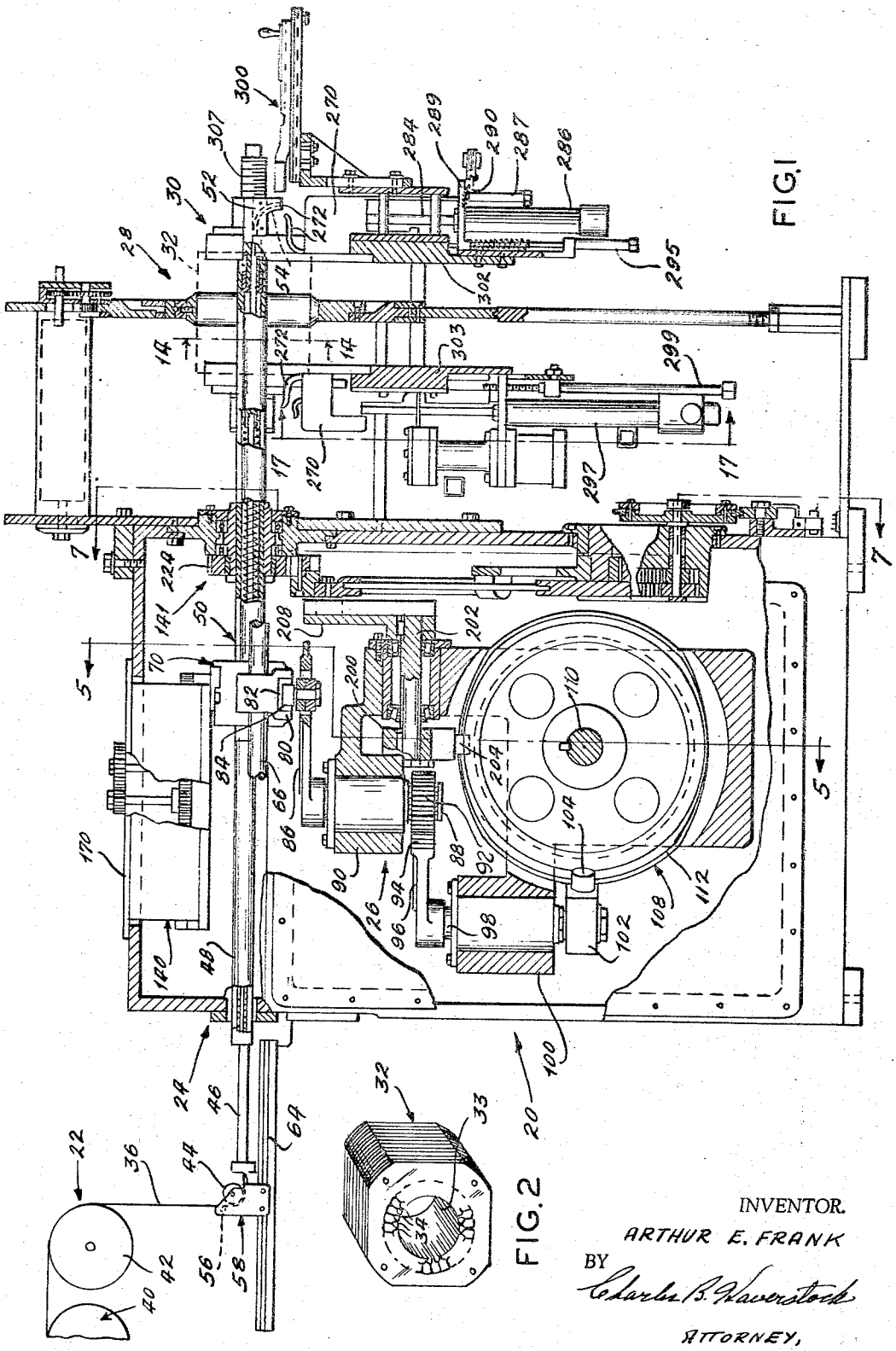


FIG. 1

FIG. 2

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Oct. 17, 1967 A. E. FRANK 3,347,474

STATOR WINDING MACHINE

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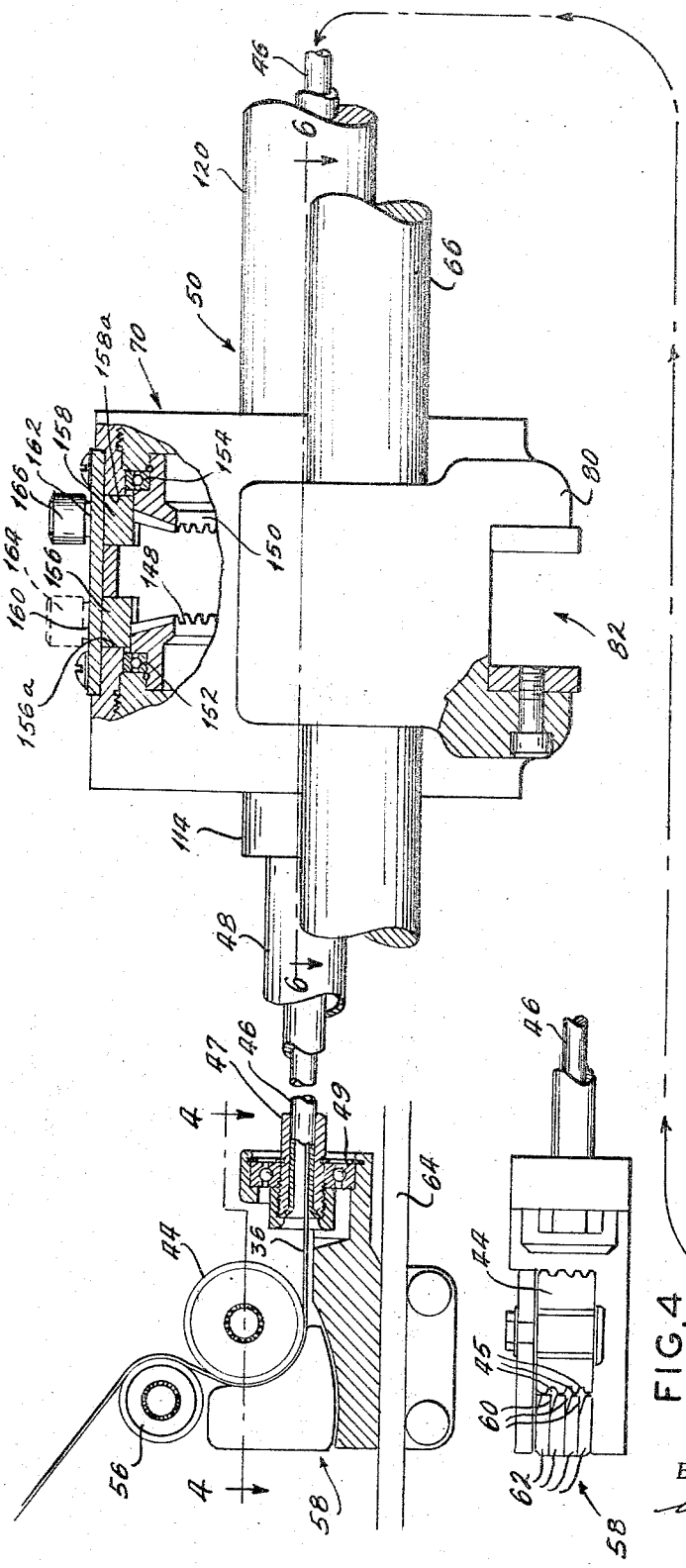


FIG. 4

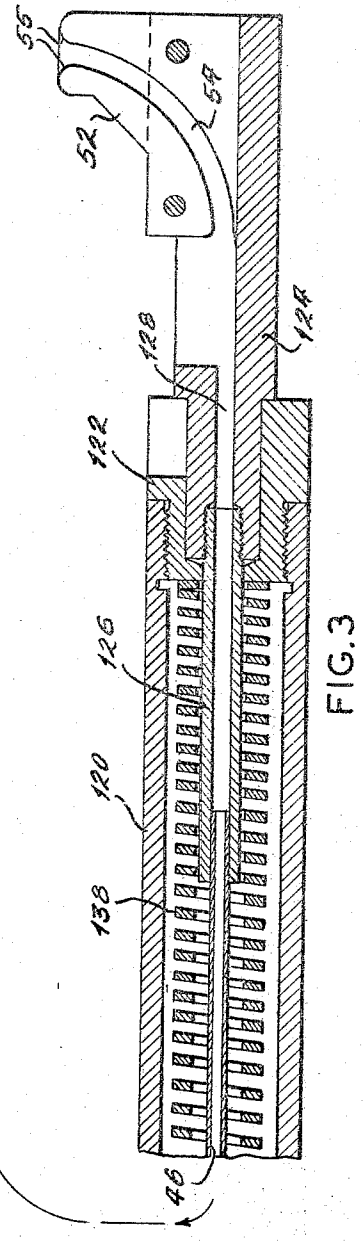


FIG. 3

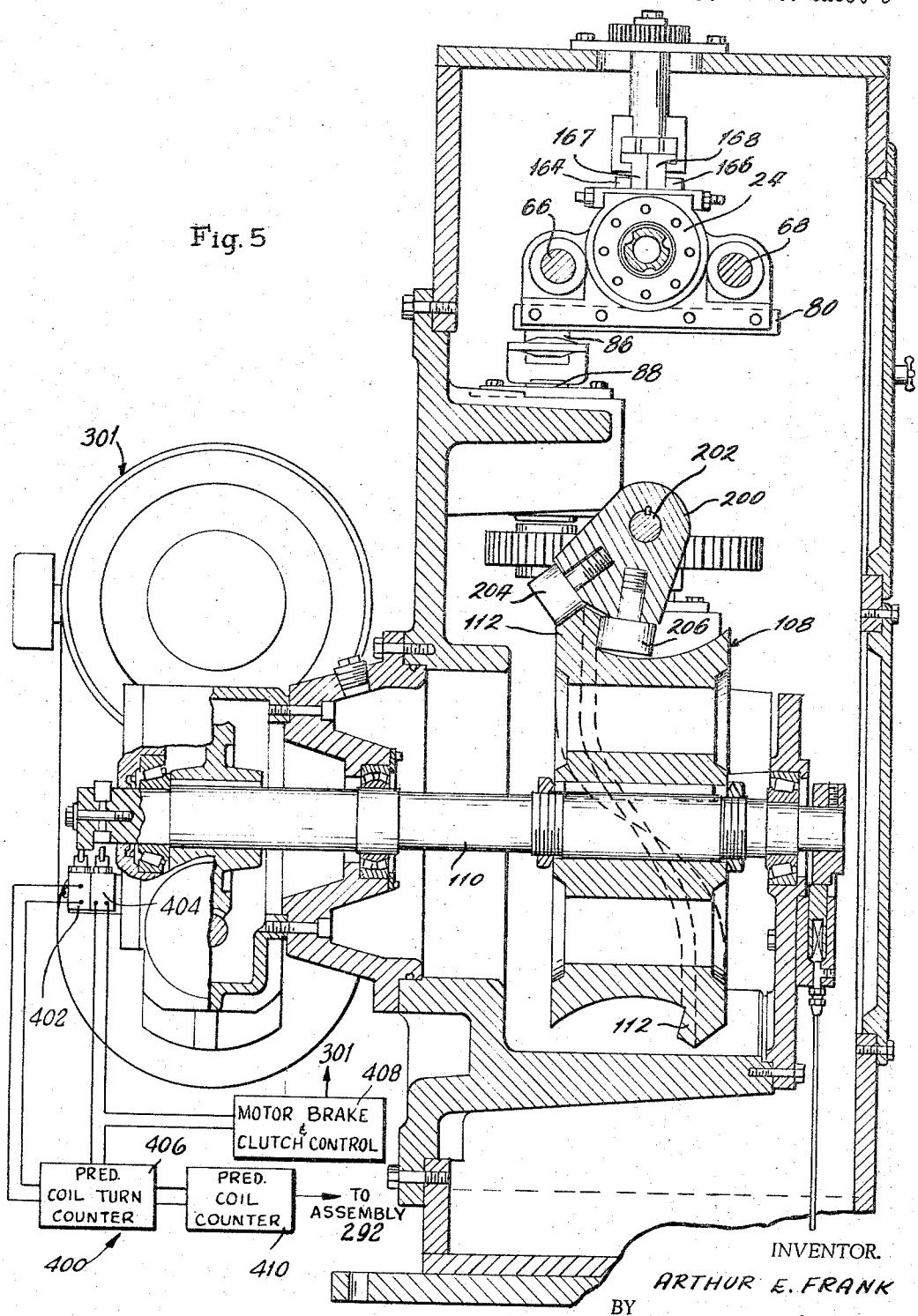
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STATOR WINDING MACHINE

Filed Aug. 20, 1964 16 Sheets-Sheet 3

Fig. 5



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STATOR WINDING MACHINE

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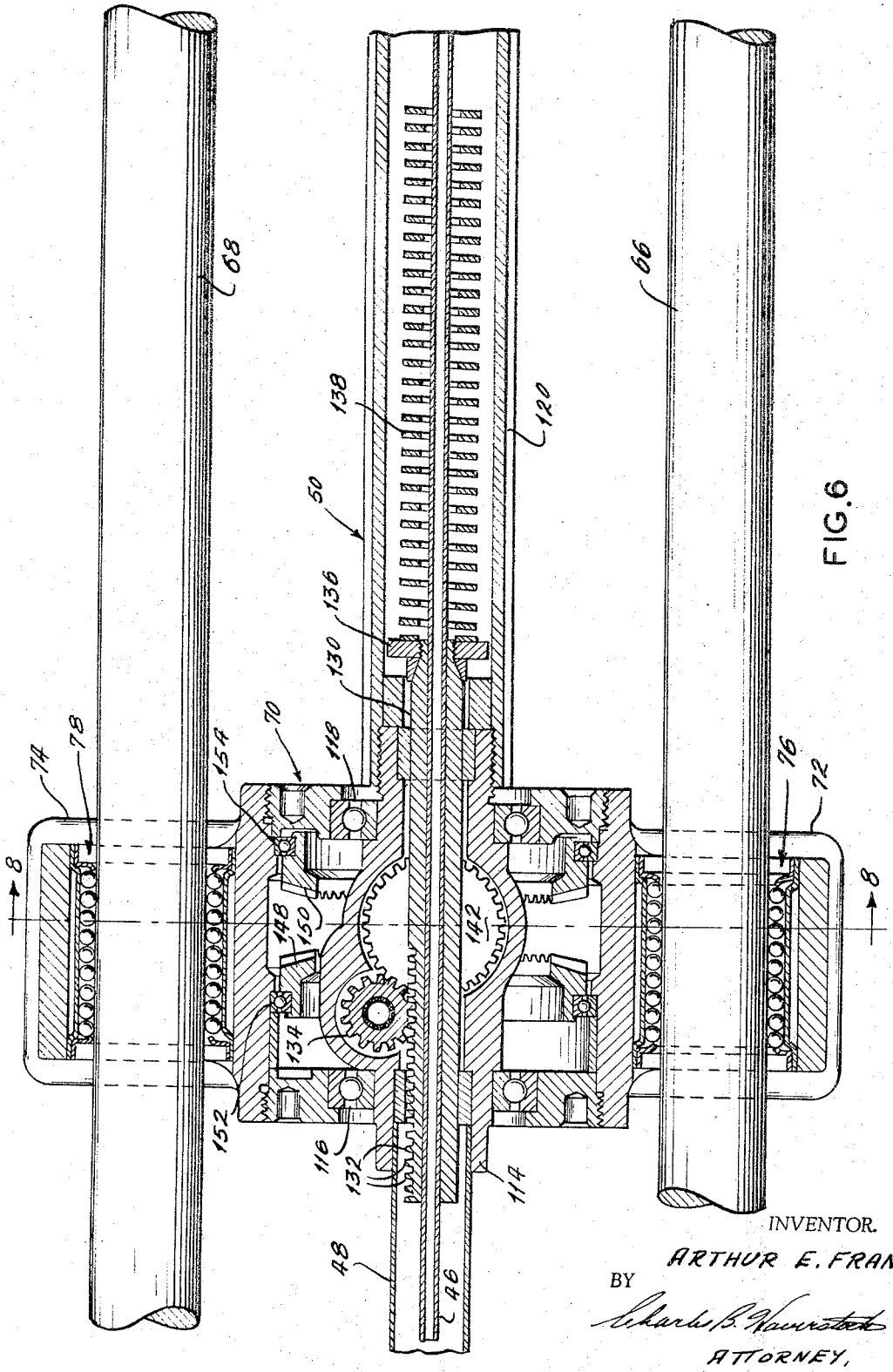


FIG. 6

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Oct. 17, 1967 A. E. FRANK 3,347,474

STATOR WINDING MACHINE

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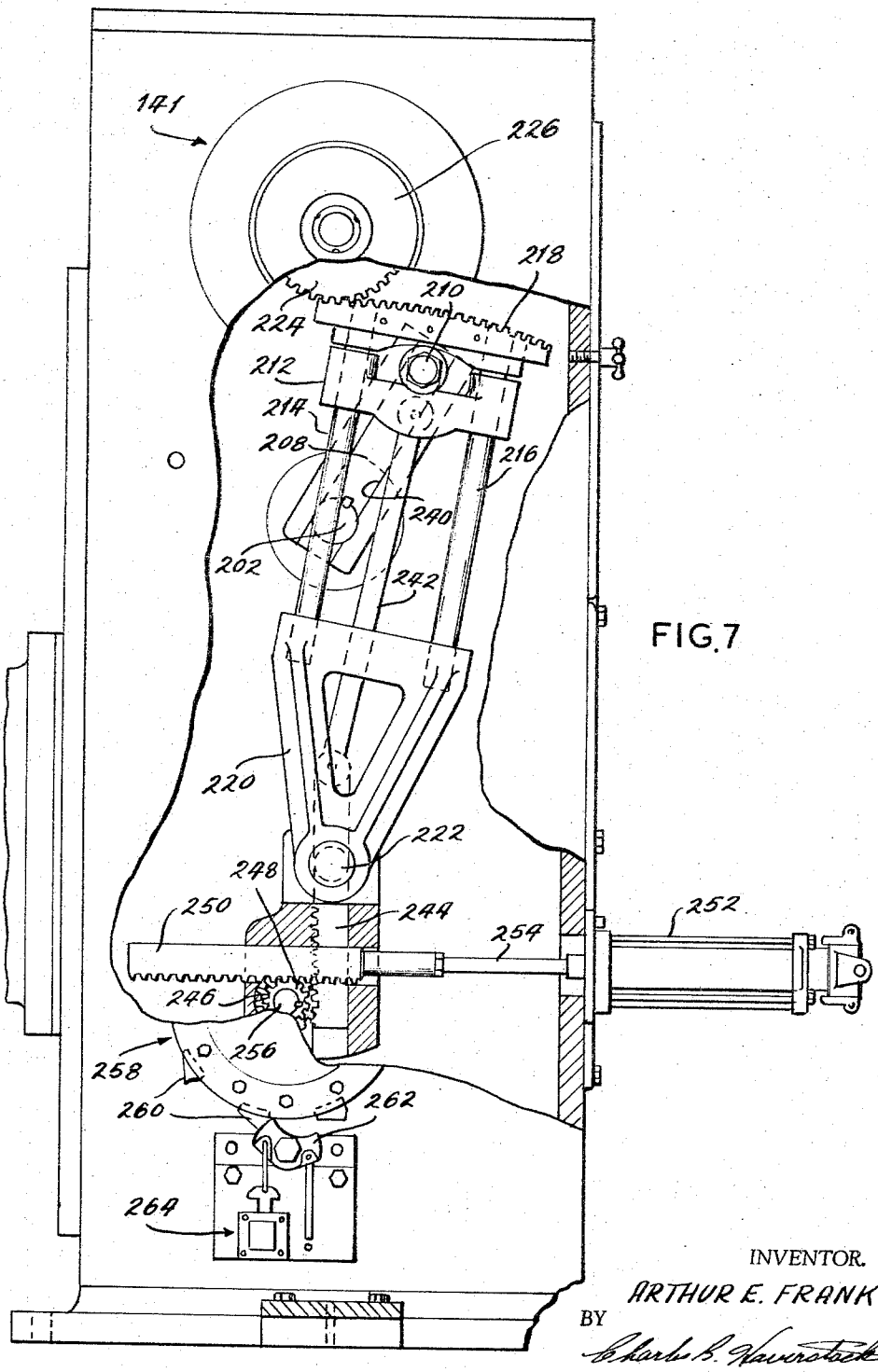


FIG. 7

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STATOR WINDING MACHINE

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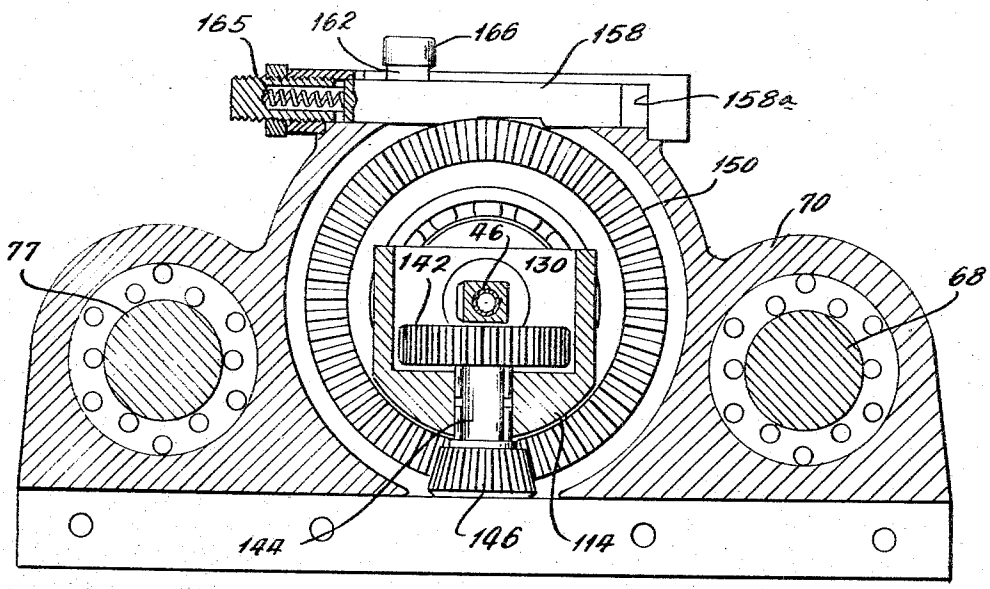


FIG. 8

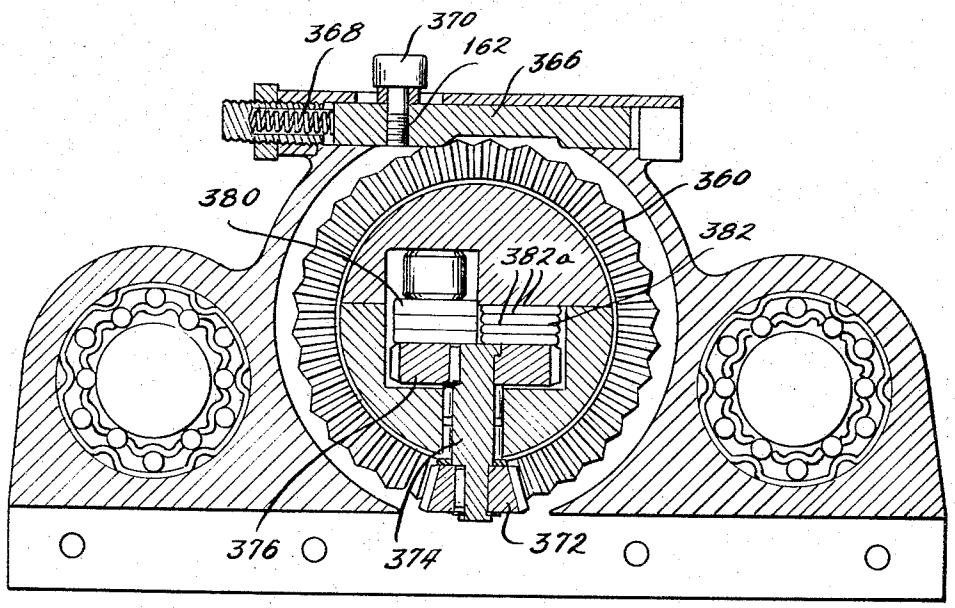


FIG. 25

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STATOR WINDING MACHINE

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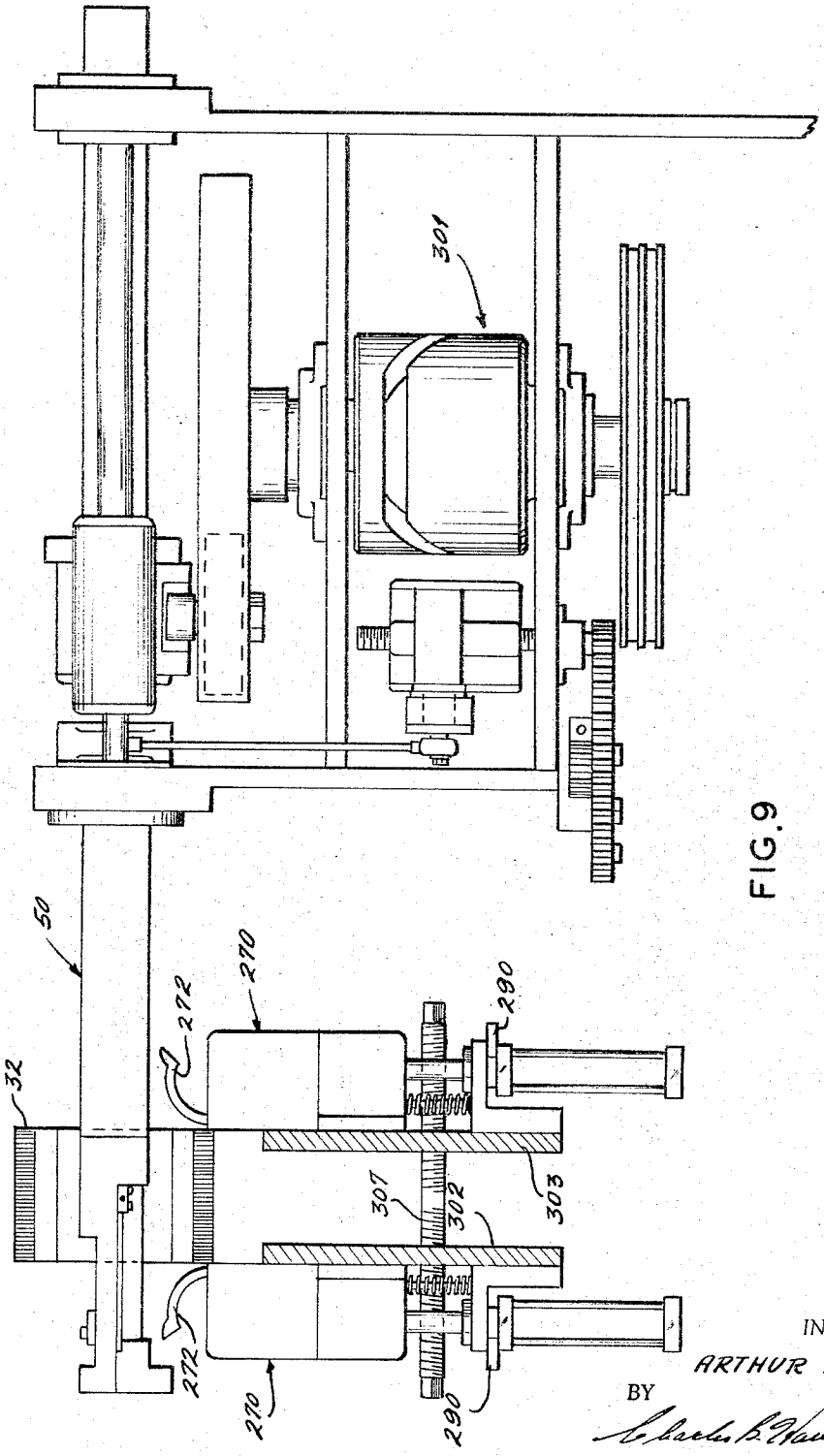


FIG. 9

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STATOR WINDING MACHINE

Filed Aug. 20, 1964 16 Sheets-Sheet 8

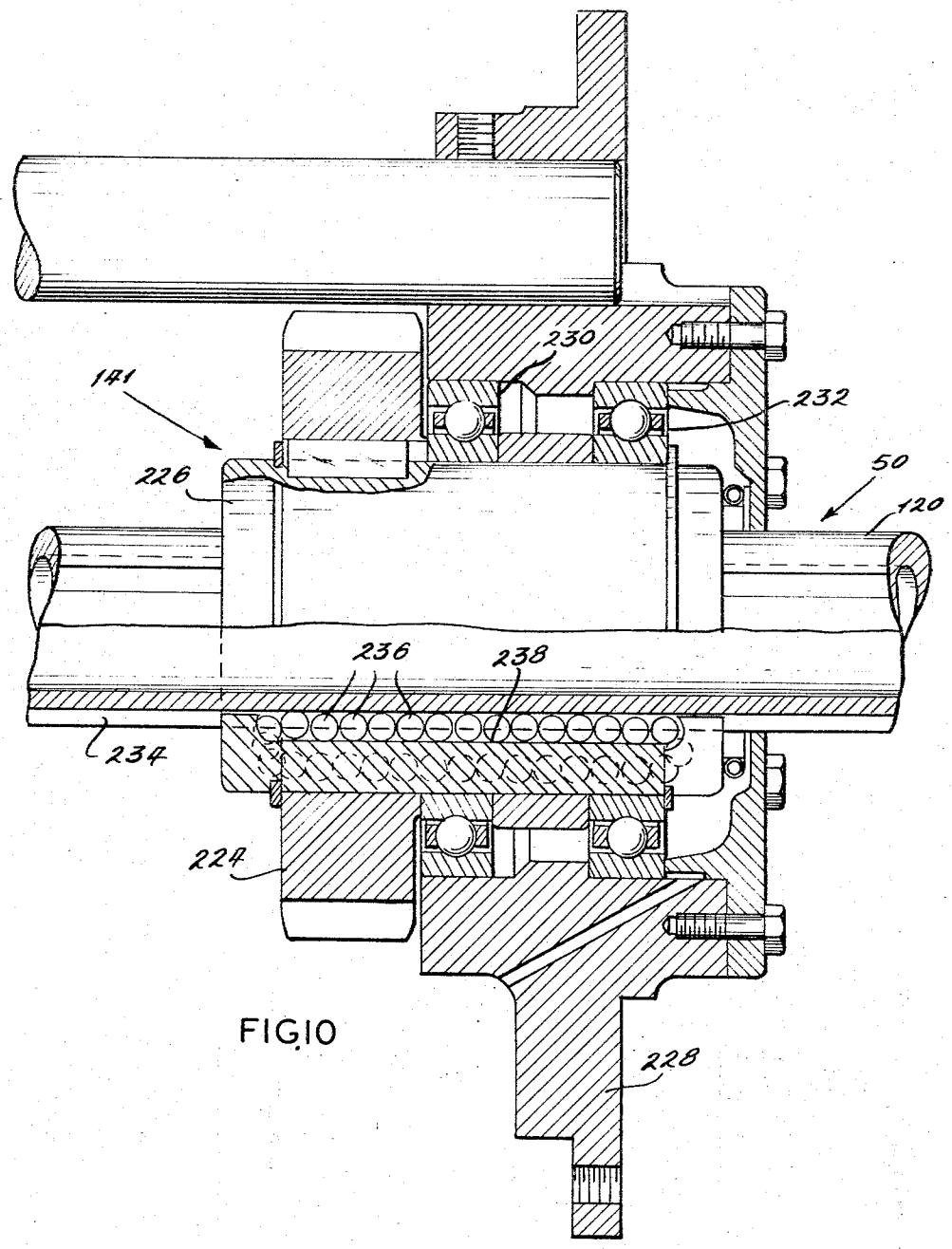


FIG.10

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STATOR WINDING MACHINE

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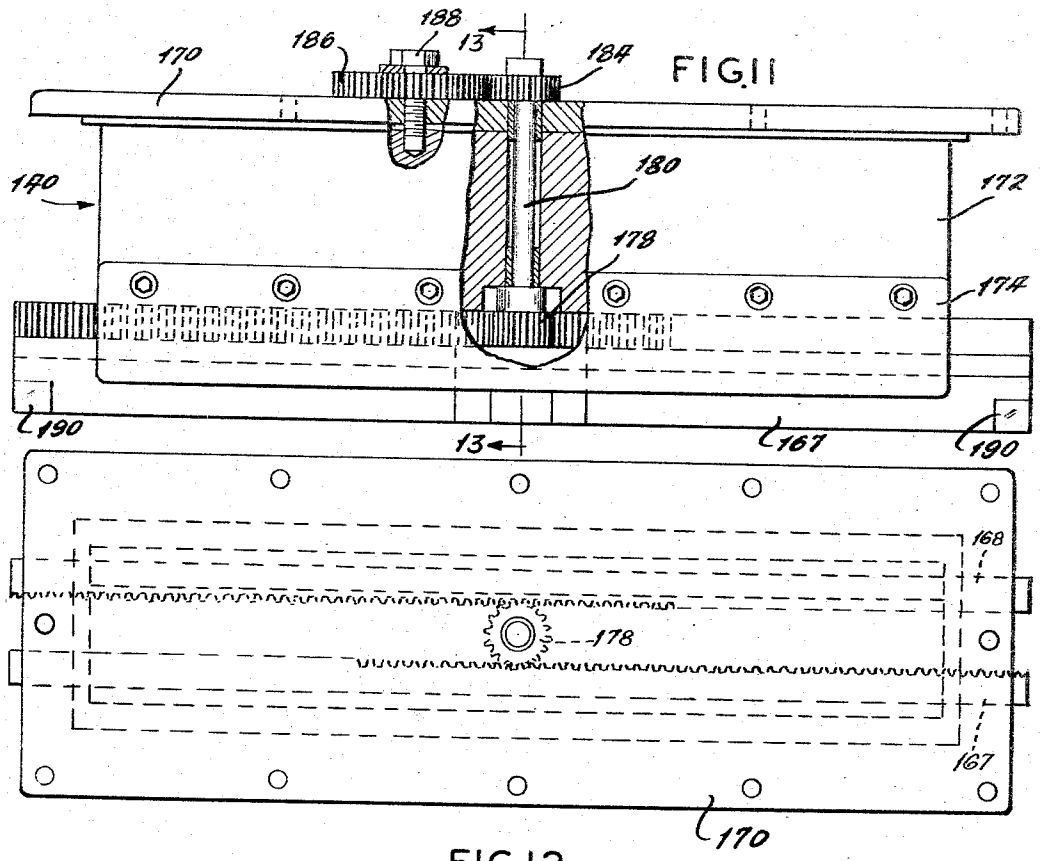


FIG.11

FIG.12

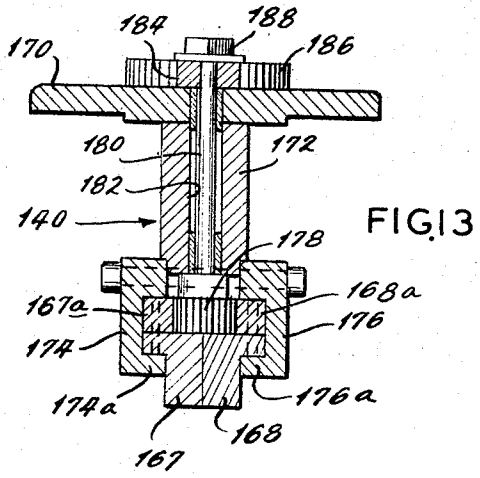


FIG.13

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Oct. 17, 1967 A. E. FRANK 3,347,474

STATOR WINDING MACHINE

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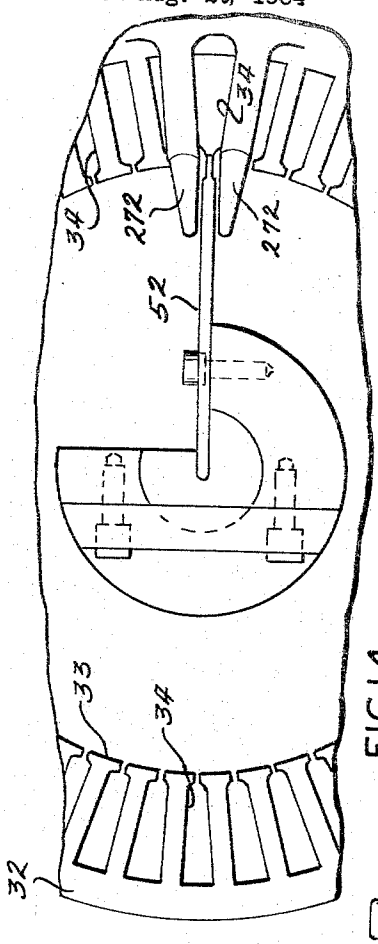


FIG. 14

FIG. 21

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Oct. 17, 1967 A. E. FRANK 3,347,474

STATOR WINDING MACHINE

Filed Aug. 20, 1964 16 Sheets-Sheet 11

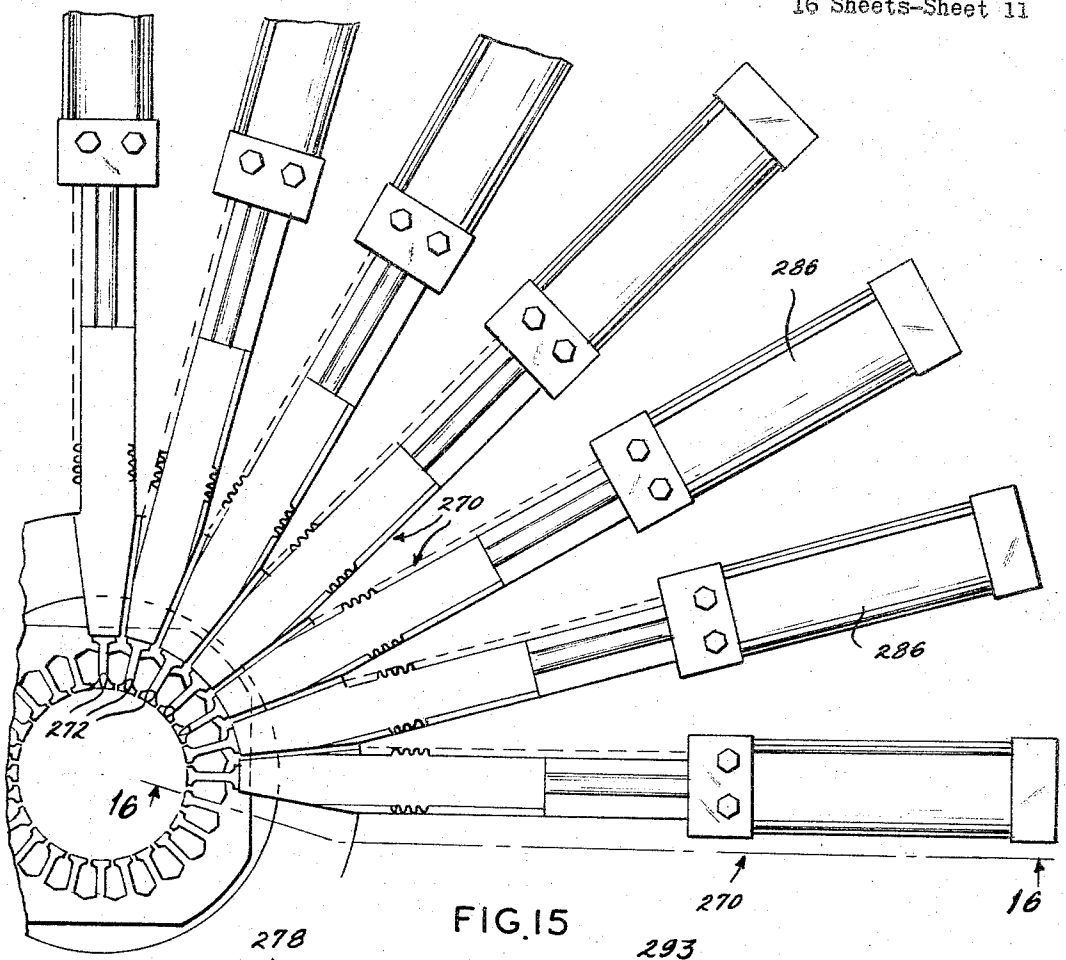


FIG. 15

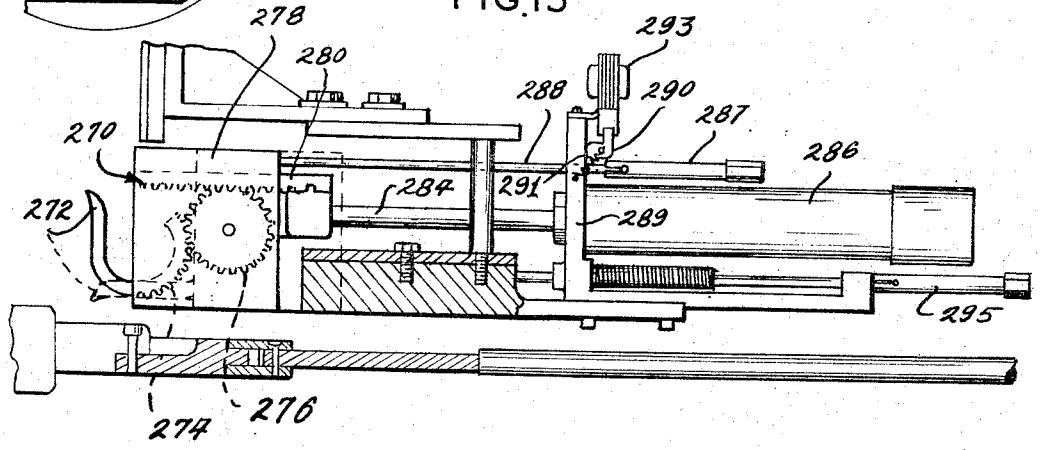


FIG. 16

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STATOR WINDING MACHINE

Filed Aug. 20, 1964 16 Sheets-Sheet 12

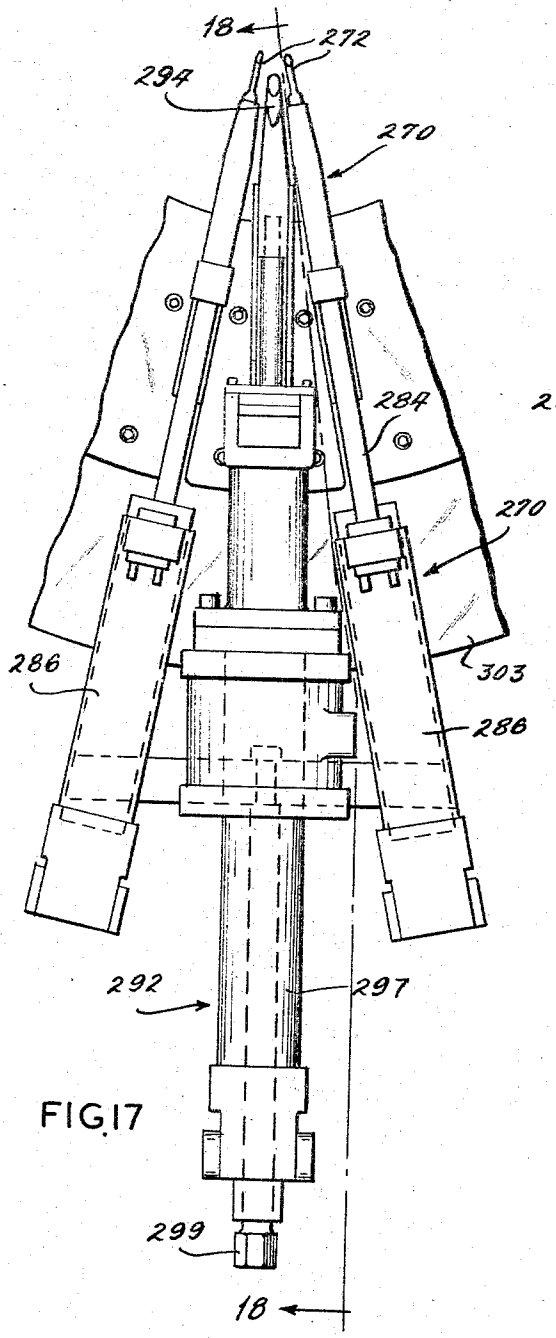


FIG.17

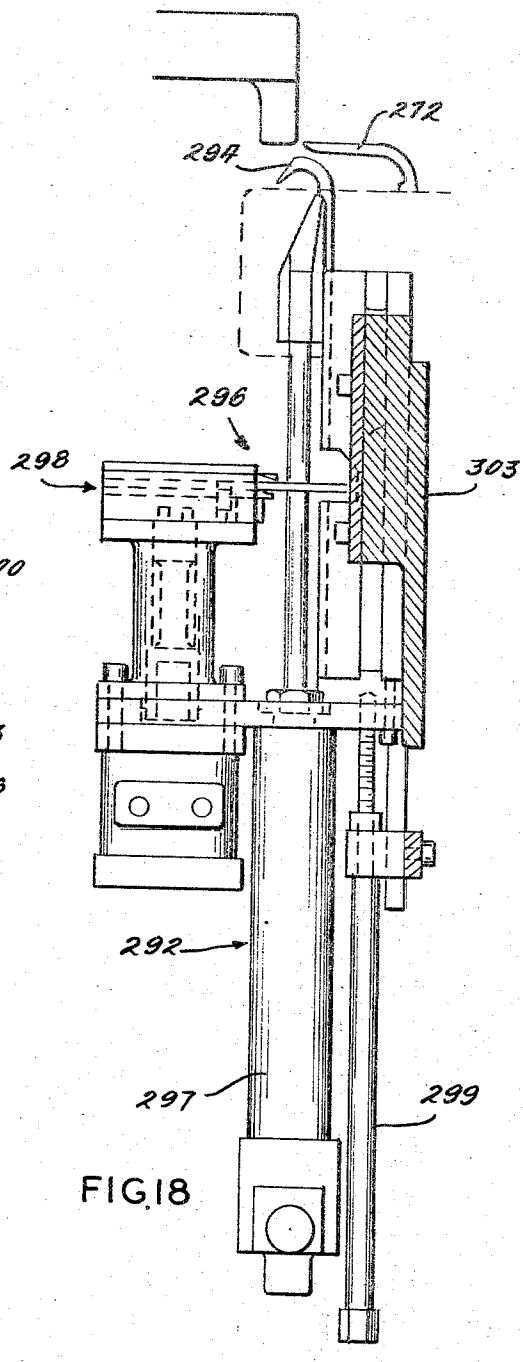


FIG.18

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Oct. 17, 1967 A. E. FRANK 3,347,474

STATOR WINDING MACHINE

Filed Aug. 20, 1964 16 Sheets-Sheet 13

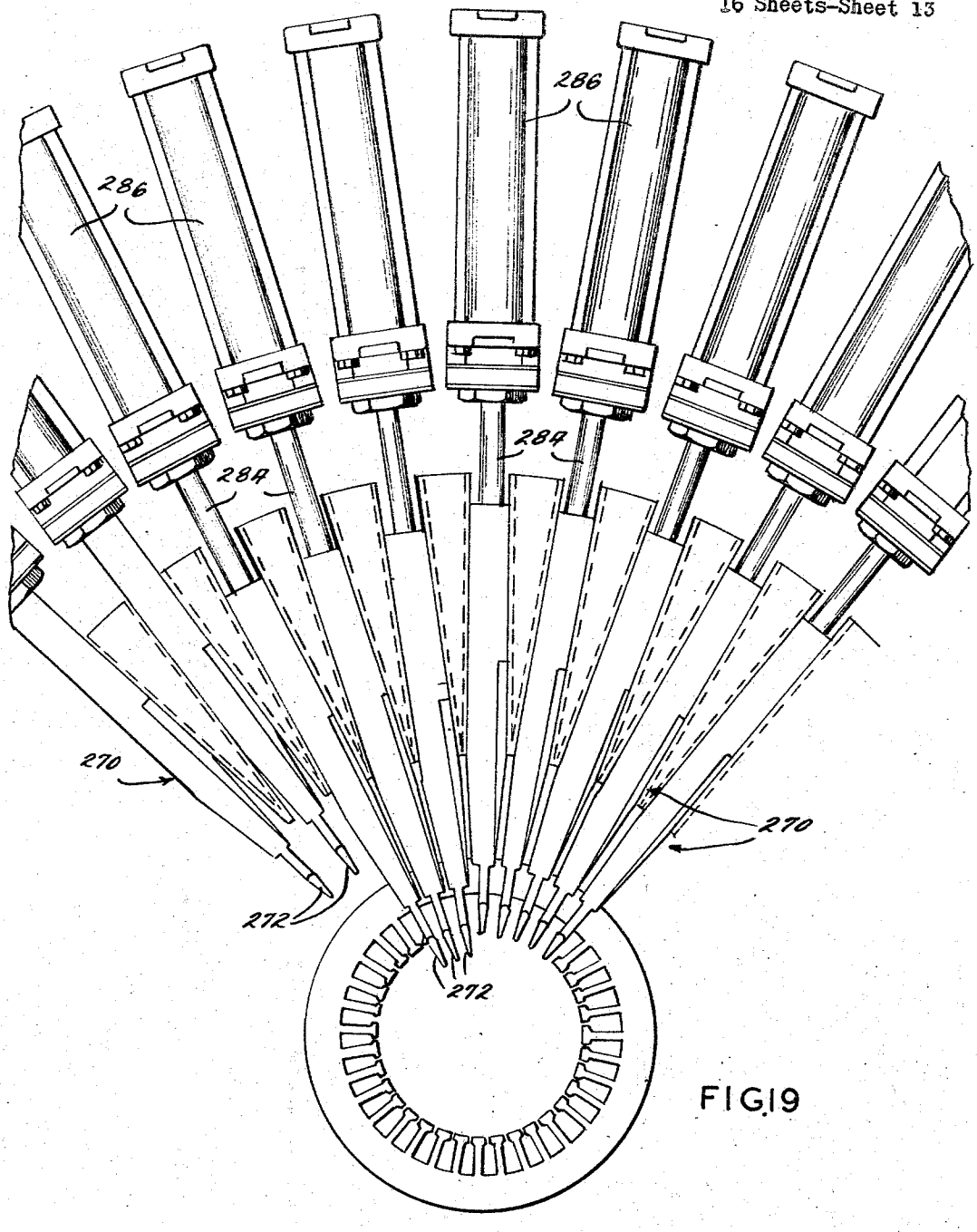


FIG.19

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STATOR WINDING MACHINE

Filed Aug. 20, 1964 16 Sheets-Sheet 14

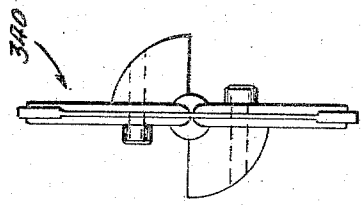


FIG. 23

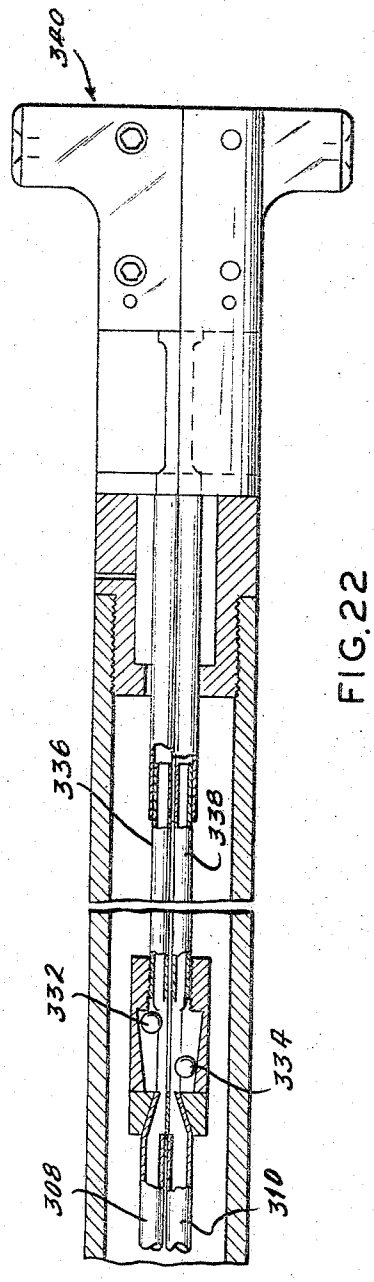


FIG. 22

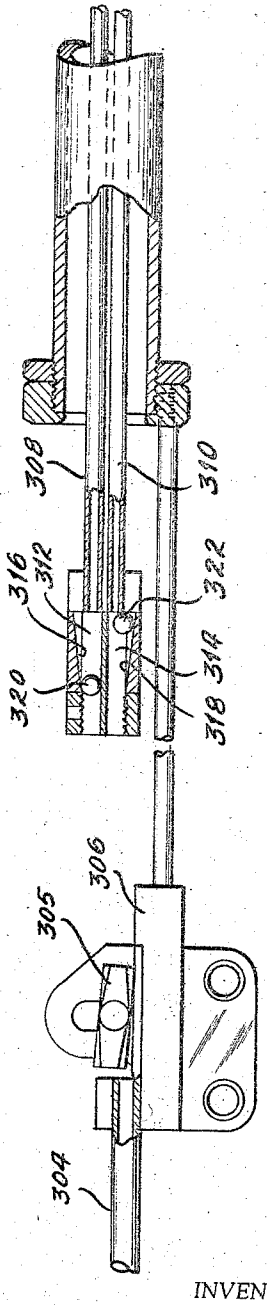


FIG. 20

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STATOR WINDING MACHINE

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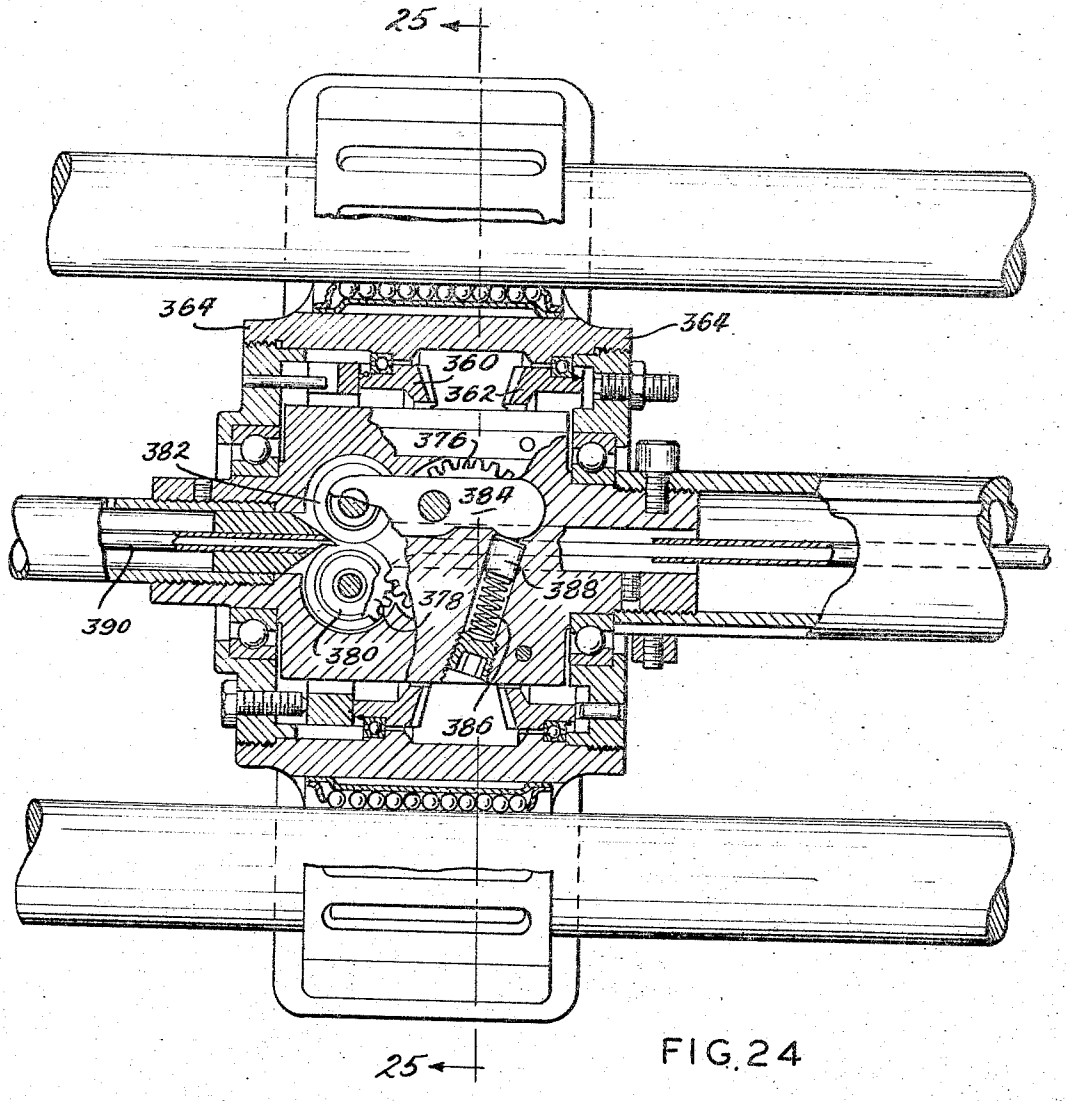


FIG. 24

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STATOR WINDING MACHINE

Filed Aug. 20, 1964 16 Sheets-Sheet 16

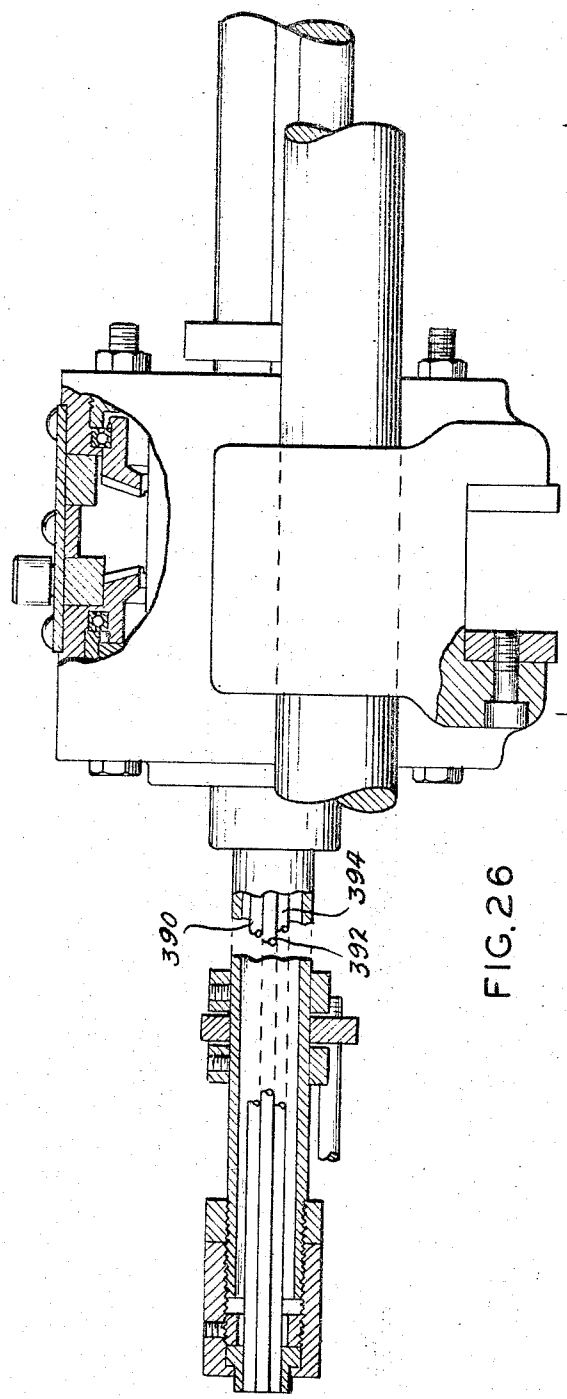


FIG. 26

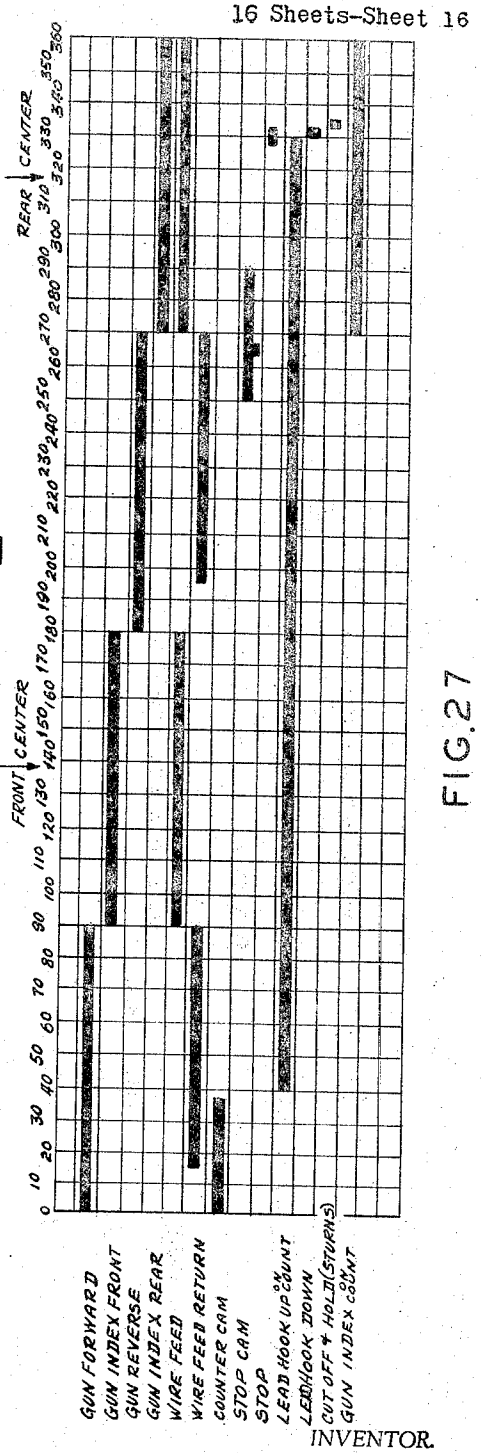


FIG. 27

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United States Patent Office 3,347,474 Patented Oct. 17, 1967

3,347,474

STATOR WINDING MACHINE

Arthur E. Frank, Imperial, Mo., assignor to Wagner Electric Corporation, St. Louis, Mo., a corporation of Delaware

Filed Aug. 20, 1964, Ser. No. 390,938
21 Claims. (Cl. 242—1.1)

The present invention relates generally to winding machines and like devices and more particularly to a machine for winding stators for dynamo-electric machines and other similar devices.

Briefly, the present device comprises a machine having means thereon for mounting a slotted stator core or similar device on which one or more wire windings are to be wound. The machine also includes wire guide means positioned adjacent opposite ends of the mounted stator core for guiding wire into preselected core slots during the winding thereof, and means for feeding wire to said guide means and to and through the preselected core slots in a predetermined arrangement until all of the slots to be wound have the proper number of winding turns positioned therein. The wire feed means for the subject device include means for feeding wire to the aforementioned guide means in such a manner as to prevent undue stressing, bending, kinking or otherwise damaging the wire, and the subject machine also includes means for predeterminately adjusting the guide means and the feed means to vary the winding arrangement or pattern so that the machine can wind many different kinds and sizes of windings and core structures.

It is a major object of the present invention therefore to provide improved means for winding stator cores and like devices.

Another important object is to reduce the cost of manufacturing dynamo-electric machines and similar devices.

Another object is to reduce or eliminate manual labor in the winding of core structures.

Another object is to provide fully automatic means for laying windings in stator core slots and the like.

Another object is to provide a stator winding machine that is versatile and flexible to be able to wind many different winding patterns and many different core constructions and sizes.

Another object is to reduce or eliminate wire damage in wire wound devices.

Another object is to provide automatic means for winding slotted stator cores and like devices regardless of the physical characteristics of the cores, the number of winding slots therein, the winding pattern, and the spacing of the slots.

Another object is to improve the uniformity, quality, and reliability of wire wound devices such as dynamo-electric machines and the like.

Another object is to minimize human errors and other waste in the winding of stators and like devices.

Another object is to reduce the time required to wind stators and similar devices.

Yet another object is to provide a winding machine which can be operated by personnel having relatively little skill and training.

These and other objects and advantages of the present invention will become apparent after considering the following detailed specification covering preferred embodiments of the subject machine in conjunction with the accompanying drawings wherein:

FIG. 1 is a side elevational view, partly in section, showing a stator winding machine constructed according to the present invention;

FIG. 2 is a perspective view of a typical slotted stator core to be wound by the subject machine;

FIG. 3 is an enlarged fragmentary side elevational view of the wire feed mechanism of the subject machine;

FIG. 4 is a fragmentary cross-sectional view taken on line 4—4 of FIG. 3;

FIG. 5 is a cross-sectional view taken on line 5—5 of FIG. 1;

FIG. 6 is an enlarged fragmentary cross-sectional view taken on line 6—6 of FIG. 3;

FIG. 7 is a cross-sectional view taken on line 7—7 of FIG. 1;

FIG. 8 is an enlarged cross-sectional view taken on line 8—8 of FIG. 6;

FIG. 9 is a fragmentary plan view showing a somewhat modified form of the subject machine including the drive means therefor;

FIG. 10 is an enlarged fragmentary cross-sectional view of the indexing means employed on the subject machine;

FIG. 11 is an enlarged side elevational view partly in section of the adjustable index control means employed on the subject machine;

FIG. 12 is a top plan view of the index control means of FIG. 11;

FIG. 13 is a cross-sectional view taken on line 13—13 of FIG. 11;

FIG. 14 is an enlarged fragmentary cross-sectional view taken on line 14—14 of FIG. 1;

FIG. 15 is an end view showing a portion of one bank of wire guide elements employed on the subject device;

FIG. 16 is a side elevational view, partly in section, of a single wire guide assembly as seen along line 16—16 of FIG. 15;

FIG. 17 is an enlarged fragmentary view, partly in section, taken on line 17—17 of FIG. 1;

FIG. 18 is an enlarged cross-section view taken along line 18—18 of FIG. 17;

FIG. 19 is an enlarged fragmentary view showing a portion of one bank of wire guides in the different operating positions thereof;

FIG. 20 is a fragmentary side elevational view partly in section showing a modified form of wire feed mechanism;

FIG. 21 is a view similar to FIG. 6 for the modified feed mechanism of FIG. 20;

FIG. 22 is a fragmentary side elevational view showing a modified form of the output end portion for the wire feed mechanism of FIG. 20;

FIG. 23 is a right end view of the modified wire assembly of FIG. 22;

FIG. 24 is another cross-sectional view similar to FIG. 6 showing still another modified form of wire feed mechanism for the subject machine;

FIG. 25 is a cross-sectional view taken on line 25—25 of FIG. 24;

FIG. 26 is a side elevational view, partly in section, of the modified wire feed mechanism shown in FIGS. 24 and 25; and

FIG. 27 is a chart showing the relative time and sequence relationships for the more important operating components of the subject machine.

Referring to the drawings more particularly by reference numbers, the number **20** refers generally to a machine for winding stator cores and similar devices. The machine **20** includes an input source of wire indicated generally by **22**, a wire feed mechanism indicated generally by number **24**, drive means **26** for the wire feed mechanism **24**, stator mounting means **28**, and guide means **30** positioned adjacent to the stator mounting means **28**. The guide means **30** support and properly locate the coil turns fed by the wire feed mechanism **24** between succeeding slots of a stator core. A typical slotted stator core **32** is shown in FIG. 2. The guide means **30**

also establish the most desirable length and shape for the coil end turns and they minimize looseness and waste of wire.

The machine **20** receives wire from the bulk wire source **22** and feeds it to and through the feed mechanism **24**. The feed mechanism **24** in turn feeds the wire through the slots of the core **32** and also around and onto the guide means **30**. The core **32** is usually a laminated structure having a large central opening **33** with a plurality of spaced winding slots **34** positioned around the opening **33** as shown in FIG. 2. The number, size, shape, and spacing of the slots are all variables depending upon the type and capacity of machine for which the stator is being made and the particular arrangement and pattern desired for the windings to be positioned in its slots.

The subject machine also includes means for placing insulation or insulating segments in the slots, means for indexing the machine to produce a particular winding arrangement, means for drawing out the end loops of the windings and for cutting and holding the end loops drawn out, and other structural and operational features which will be described hereinafter. The main portions of the subject machine including the wire feed mechanism, the guide means, and the indexing means will be described separately hereinafter. It is to be understood, however, that each portion of the machine is constructed, coordinated and adjusted to operate in conjunction with all other portions thereof during a winding operation.

Wire feed mechanism

The wire feed mechanism **24**, and the drive means therefor, are shown in detail in FIGS. 1, 3, 4, 5, 6, 7 and 8. The feed mechanism **24** is constructed and operated to feed winding wire **36** from a bulk feed wire spool **40** around a freely rotatable first feed roll **42** and then down and around a second rotatable feed roller **44**. The wire **36** is then fed through a feed tube **46** which extends through a larger diameter tube **47**. The tube **47** extends through a still larger diameter tubular member **48** which is part of a reciprocating wire feed assembly or gun **50**. The tube **47** is also supported for rotational movement by a bearing assembly **49** which is mounted in a non-rotatable inlet guide assembly **58** which will be described later.

During a winding operation the gun assembly **50** moves axially back and forth a predetermined distance under control of a reciprocating drive and on alternate strokes feeds wire through different spaced slots **34** of the core **32**. The axial feed strokes of the gun assembly **50** alternate with machine indexing operations as will be shown. The distance the gun assembly **50** travels during its axial movements is adjustable depending upon the dimensions and physical characteristics of the core being wound, and the indexing operations of the gun assembly are also adjustable depending on the spacing of the succeeding core slots **34** into which wire is placed. The location of the wire guide means are also adjustable. The gun assembly **50** is therefore controlled for axial as well as for rotational movement during a winding operation.

The wire fed into the assembly **50** passes through the assembly and out at the opposite or output end thereof. The output end of the assembly **50** includes a wire guide member **52** that has a curved groove or channel **54** formed therein (FIGS. 1 and 3). The wire which moves through the tubes **46** and **48** of the assembly **50** moves out therefrom along the curved groove **54** during a feeding operation. The curved groove **54** is rounded at **55** to be able to discharge the wire **36** at any angle without binding or rubbing unduly. The guide member **52** is attached to the end of the reciprocating feed assembly **50** and rotates with the assembly as will be shown. The amount of rotation of the assembly **50** and the attached guide **52** is carefully controlled and depends upon the angular spacing between succeeding core slots in which the wire is to be placed. The angular rotation of the assembly **50** is also adjustable to enable the machine to wind different winding arrangements and different core constructions as aforesaid.

It is important that all parts of the wire feed mechanism **24**, including the assembly **50**, the input rollers **42** and **44**, the guide **52**, and the associated parts handle the wire in a gentle firm and precise manner so as not to unduly stress, rub, scrape, bend, twist, kink or otherwise damage the wire during winding. At the same time, the wire must be positively, accurately, and precisely controlled at all times and under all conditions of feeding, and the wire must never be subjected to excessive drag, although some drag or wire tension is desired in order to more accurately form the end loops of the winding turns. All of these requirements are met by the feed and guide means of the subject device.

The incoming wire **36** after being fed around the roller **42** passes between the roller **44** and a smaller diameter roll **56** which is positioned adjacent thereto. Thereafter, the wire passes between the roller **44** and a curved segmented guide assembly **58** shown in detail in FIGS. 3 and 4. The guide assembly **58** is constructed to operate in conjunction with the guide roller **44** to permit the wire to easily advance forwardly during a feeding operation but prevents the wire **36** from moving backwards in the feed **24** during the return strokes of the feed assembly **24**. The guide assembly **58** has a plurality of curved or tapered grooves **60** any one or more of which can be used to guide wire around corresponding aligned grooves **45** of the roller **44** and into the feed mechanism. The grooves **60** are curved to the shape of the roller **44**, and are formed by beveled edges of segment members **62** which form the assembly **58**. During forward feeding movements of the wire, the wire moves around the roller **44** in the grooves **45** and is spaced from the surfaces of the grooves **60**. At other times, during the operation of the machine as when the assembly **50** is moving on its rearward strokes, there is a tendency for the wire to also move rearwardly. During these times, however, the wire will move away from the surface of the roller **44** and against the tapered surfaces of the associated grooves **60**. In so doing, the wire will engage the tapered groove surfaces and will be prevented thereby from moving rearwardly. The assembly **58** including the rollers **44** and **56** is mounted for reciprocating movement along a track **64** but does not rotate.

The gun assembly **50** includes a housing **70** which is mounted for reciprocating movement on a pair of spaced guide rails **66** and **68** (FIGS. 1, 3, 5 and 6). The housing **70** has a pair of sidewardly projecting portions **72** and **74** which house bearing assemblies **76** and **78** respectively. The bearing assemblies **76** and **78** are constructed to permit the housing **70** and the feed assembly **50** to move easily along the rails **66** and **68**. The housing **70** also has a downwardly extending portion **80** (FIG. 3) with an elongated transverse track **82** formed in the bottom thereof, and the track **82** cooperatively receives a roller **84** (FIG. 1) which moves therealong to impart reciprocating motion to the assembly **50**. The track **82**, the roller **84** and the drive means therefor operate as a Scotch Yoke to impart motion to the assembly **50**, although other motion producing devices could also be used.

The roller **84** is mounted on an arm **86** which is rotatably supported by a vertical shaft **88**. The shaft **88** is journaled in a fixed support **90** and the opposite end of the shift **88** carries a gear **92** which meshes with a sector gear **94** on another pivotal arm **96**. The arm **96** is attached to another vertical shaft **98** that is journaled in another fixed support **100**. The lower end of the shaft **98** carries a follower assembly **102** which includes a pair of spaced rollers **104** and **106**. The rollers **104** and **106** engage and roll on opposed cam surfaces formed on a rotating structure **108** which is mounted for rotation with a shaft **110**. The structure **108** is rotated at a predetermined speed by a drive motor and suitable gear reducer means. The opposed cam surfaces are formed on an annular peripheral cam portion **112** (FIGS. 1 and 5) which moves between

the rollers **104** and **106**, and the portion **112** is shaped to impart predetermined angular motion to the arm **86** and hence also to the roller **84** in the track **82** to cause the assembly **50** to move back and forth along the rails **66** and **68** at predetermined times in the cycle as can be seen by referring to the sequence chart of FIG. 27.

Referring to FIGS. 3 and 6, the housing **70** is shown having a rotatable structure **114** extending therethrough. The structure **114** is journaled to the housing **70** by bearing assemblies **116** and **118** and is attached at one end to the tubular member **48** and at the opposite end to another tubular member **120**. The other end of the tubular member **120** is connected to a fitting member **122** which in turn is connected to an adaptor **124**. The wire guide member **52** is fixedly mounted on the adaptor **124**. The adaptor **124** is also threadedly connected to a smaller diameter tubular member **126** which receives an end portion of the tubular member **46**. The member **46** therefore extends from adjacent to the input end of the wire feed mechanism **50** to adjacent the output end thereof, and has an internal diameter large enough to freely receive the wire or wires **36** but small enough to prevent the wire from bending or kinking therein. The tubular member **46** communicates with the tubular member **126** as aforesaid and also with a passage **128** in the adaptor member **124** and thereafter with the curved outlet groove **54** in the guide **52**. As already noted, the outlet end of the curved groove **54** is rounded at **55** to minimize friction with the wire in all positions thereof and to enable the wire to feed from the end of the groove at different angles without damage or excessive rubbing.

The portion of the tubular member **46** that passes through the housing **70** carries a rack gear member **130** which has teeth **132** along one side that cooperate with teeth on a pinion gear **134** (FIG. 6). The rack gear **130** also has a flange member **136** attached to one end thereof which engages one end of a compression spring **138** that is positioned around the member **46** and inside of the tube **120**. The opposite end of the compression spring **138** (FIG. 3) extends around the tubular member **126** and engages the end of the fitting **122**. The spring **138** is compressed during indexing operations of the machine and is released thereafter during the next axial movement of the gun assembly **50** as will be shown.

Indexing means

Part of the mechanism that controls the rotation of the gun assembly **50** is included in the housing **70**, part is in an adjustable cam assembly **140** that is attached to the upper wall of the machine **20** as shown in FIGS. 1, 11, 12 and 13, part is in an indexing mechanism **141** shown in FIGS. 1 and 10, and part is also in the drive means for the indexing mechanism **141** shown in FIGS. 1, 7 and 10.

In FIGS. 6 and 8, a gear **142** is shown positioned in the housing **70** inside of the rotatable structure **114** and adjacent to the elongated rack gear **130**. The gear **142** is mounted on one end of a shaft **144** and the opposite end of the shaft is connected to bevel gear **146**. The bevel gear **146** is positioned between and cooperatively engages two larger diameter spaced and opposed beveled gears **148** and **150** which are mounted for rotation in the housing **70**. The bevel gears **148** and **150** are annular in shape and extend around the rotatable structure **114**. The annular bevel gear **148** is journaled for rotation in the housing **70** by means of a bearing assembly **152**, and the annular bevel gear **150** is similarly journaled for rotation in the housing **70** by another bearing assembly **154**. Each of the bevel gears **148** and **150** is also provided with associated brake means which operate to prevent rotation thereof at certain times. The brake means for the gears **148** and **150** include brake members **156** and **158** respectively (FIGS. 3 and 8). The brake members **156** and **158** are oppositely disposed in transverse slides **156***a* and **158***a* respectively on the housing **70**. Each brake member **156** and **158** also has an upwardly extending shaft **160** and **162** attached thereto, and the shafts **160** and **162** have rollers **164** and **166** respectively mounted thereon. The brake members **156** and **158** are also biased by springs such as the spring **165** shown in FIG. 8 into positions engaging their associated bevel gears **148** and **150** to prevent rotation thereof.

The rollers **164** and **166** act as cam followers and engage and move along surfaces of adjustable cam members **167** and **168** respectively on the assembly **140** (FIGS. 11, 12 and 13) during axial movement of the gun assembly **50** as will be shown. The cam members **167** and **168** are positioned in the overhead assembly **140** as shown in FIGS. 5, 11 and 13, and are shaped as shown in FIGS. 11, 12 and 13. The follower rollers **164** and **166** and their associated brake members **156** and **158** are cammed outwardly (FIGS. 5 and 13) in opposition to springs **165** during most of the longitudinal movement of the gun assembly **50**. In the cammed out position, the bevel gears **148** and **150** are free to rotate in the housing **70**. At the forward and rearward end positions respectively of the assembly **50**, however, a different one of the bevel gears **148** and **150** will be locked by its associated brake member **156** or **158** and prevented thereby from rotating in the housing **70**. At these times, the indexing drive mechanism **141**, which will be described later, operate to rotate the assembly **50** in opposite directions at each end position of the assembly **50**. This is done to move the wire guide **52** from a position aligned with the end of one core slot **34**, which has just been wound, to a position aligned with a different core slot to thereafter be wound. For example, at one end of travel of the assembly **50**, the bevel gear **148** will be prevented for rotating and this will cause the small bevel pinion gear **146** to roll therearound during rotation of the assembly **50** by the indexing means. This in turn will move the rack gear **130** forwardly in the gun assembly **50** to compress the spring **138**. At the opposite end of travel of the assembly **50**, the bevel gear **150** instead of the gear **148** will be prevented from rotating and in this condition the index means will rotate the assembly **50** in the opposite direction so that the bevel gear **146** will roll around the gear **150** instead of around the gear **148**. Rotation of the assembly **50** in this condition will produce the same effect as before in that it will also compress the spring **138** by advancing the rack gear to the right as seen in FIG. 6. Between the end positions of the assembly **50**, however, both of the bevel gears **148** and **150** are unrestrained or unlocked and free to rotate to allow the rack gear **130** and the associated mechanism in the housing **70** to be restored by the spring **138**.

The annular rotation of the guide **52** produced by the indexing means during each indexing operation is also adjustable as will be shown to cause the guide means **52** to move between different slots depending on the core construction and the winding pattern desired. During angular movement of the wire guide **52**, wire will be laid around guide means positioned adjacent to opposite ends of the core and provided to form the end loops of the windings to the desired shape and position. The guide means on which the end loops of the windings are positioned also prevent the wire from being in contact with sharp edges on the core structure which might otherwise damage the wire. It is important to understand that for most winding operations the guide **52** will rotate in one direction at one end of each stroke of the gun assembly **50**, and will rotate in the opposite direction at the other end of each stroke in order to wind complete winding turns. This is accomplished by rotating cam **112** which alternately produces reciprocating and rotational movements of the gun assembly **50** as herein described, and also by the action of locking and releasing the bevel gears **148** and **150** so that the spring **138** can be restored.

The means for controlling the rotatability of the bevel gears **148** and **150** are shown in detail in FIGS. 1, 5, 11, 12 and 13 and are included in the overhead assembly **140**. The structure **140** has an upper wall member **170** which

is attached by bolts or other means to the top wall of the machine. The assembly **140** also has a downwardly extending elongated portion **172** which is positioned above the gear housing **70** and extends in the direction in which the gun assembly **50** including the housing **70** moves. Two channel shaped members **174** and **176** are attached to the member **172** adjacent its lower edge and together define an elongated channel which slidably receives the two relatively movable cam members **167** and **168** (FIGS. 5 and 13). The cam members **167** and **168** are slidable in the channel on spaced flanges **174***a* and **176***a*, and each cam member **167** and **168** has an elongated gear portion **167***a* and **168***a* which cooperates with a pinion gear **178** positioned therebetween. The pinion gear **178** is mounted on the lower end of a shaft **180** which extends through a bore **182** and suitable bearing means in the portions **172** and **170**, and the upper end of the shaft **180** has another gear **184** attached thereto which meshes with a larger diameter adjustment gear **186**. The adjustment gear **186** is mounted on a threaded member **188** and has an upper surface which is calibrated with a suitable scale to cooperate with a mark formed on the upper surface of the member **170**. When the member **188** is loosened the gear **186** can be rotated for adjustment purposes, and this in turn rotates the gears **184** and **178**. Rotations of the gear **178** causes the cam members **167** and **168** to slide longitudinally in opposite directions along the channel in which they are positioned. This changes the positions of the cam members and also the position at which the rollers **164** and **166** move out of engagement therewith at the end positions of the gun travel to lock their associated bevel gears **148** or **150**.

It should also be noted that the ends of the cam members **167** and **168** are beveled at **190** (FIG. 11) to enable the rollers **164** and **166** to easily become re-engaged therewith when the gun assembly begins a stroke. The position of one end only of each of the cam members **167** and **168** is critical to the operation since each of the members controls the locking and releasing of a different one of the bevel gears **148** and **150**. In substantially all other positions of the assembly **50** the gears **148** and **150** are free to rotate. The spacing between the critical ends of the members **167** and **168** is adjustable over a wide range as can be seen, and this is desirable because it greatly increases the flexibility and versatility of the machine.

The actual stroke length of the gun assembly **50** can also be controlled by the shape of the cam **112**, and by adjustment of the yoke assembly including the position of the roller **84** on the arm **86**.

The gun assembly **50** including the non-rotatable inlet wire guide assembly **58** extends from the guide assembly **58** at one end to and including the rotatable wire guide **52** at the other end and this entire structure reciprocates and rotates as a unit during a winding operation. The guide assembly **58** does not rotate, however, because it must maintain an operative relationship with the incoming wire. For this reason, the assembly **58** is mounted for reciprocating movement on the rail **64**. During longitudinal movement of the gun assembly **50**, however, when both of the bevel gears **148** and **150** are free to rotate no rotation of the gun assembly **50** can take place because at these times, the guide **52** is moving longitudinally along and through a slot **34** in the stator core **32** laying wire therein. Furthermore, the energy stored in the spring **138** during the last indexing operation will be dissipated as soon as the assembly **50** moves far enough to release the locked bevel gear **148** or **150**. Thereafter, until the gun assembly **50** again reaches the end of the stroke, the index means will not be able to again rotate the assembly **50**.

The indexing means are shown in FIGS. 1, 5, 7 and 10 and includes a second follower assembly **200** which is mounted for rotatable movement on a shaft **202**. The assembly **200** has two follower rollers **204** and **206** mounted thereon which, like the rollers **104** and **106**, are engaged with opposite surfaces on the rotatable cam member **112**. During rotation of the structure **108** (FIG. 5), the cam **112** alternately angularly moves the follower assemblies **200** and **102** in opposite directions and through a predetermined angle to produce axial and rotational movements of the assembly **50**. Movements of the assembly **200** moves an arm **208** (FIGS. 1 and 7) which is located on the opposite end of the shaft **202** from the assembly **200**. The arm **208** carries a shaft **210** which is pivotally connected to a slide member **212** movably positioned on a pair of spaced parallel rods **214** and **216**. The rods **214** and **216** are attached at their upper ends to a segment gear **218** and at their lower ends to a rocker member **220** mounted on a shaft **222**.

The segment gear **218** meshes with another gear **224** which is mounted on a rotatable member **226** that is part of the indexing mechanism **141**. The member **226** is in turn mounted on the barrel **120** of the gun assembly **50**. The rotatable structure **226** is journaled to the machine frame structure **228** by bearing assemblies **230** and **232** (FIG. 10) and is also slidable but not rotatable on the barrel member **120** by means of a sliding connection therebetween. The sliding connection between the members **226** and **120** is formed by one or more elongated grooves **234** in the barrel **120**, rows of bearing rollers **236** which cooperate with said grooves **234** and other grooves **238** in the member **226** which also cooperate with the bearing rollers **236**. This means that barrel **120** can slide back and forth through the member **226** during reciprocating longitudinal movements of the gun assembly **50**, and it also means that the rollers **236** and the cooperating grooves **234** and **238** provide a drive connection between the member **226** and the barrel **120** for rotating the gun assembly **50** during the indexing operations. Any number of rows of bearing rollers **236** and cooperating grooves **234** and **238** can be provided.

During certain portions of the angular rotation of the structure **108**, the cam **112** will impart movements to the segment gear **218** which in turn will rotate the gear **224**, the assembly **226**, and hence also the gun assembly **50**. This will also rotate the structure **114** (FIG. 6) in the housing **70** and the wire guide member **52** (FIG. 3) both of which are parts of the gun assembly. As already discussed, rotation of the structure **114** occurs alternately with the reciprocating movements of the gun. At one end of travel, however, the segment gear **218** will move in one direction and at the opposite end will move in the opposite direction. However, in both positions a different bevel gear **148** and **150** will be prevented from rotating to enable the spring **138** to store energy for returning the rack gear during the next feed cycle. Thereafter, during the reciprocating movements of the gun assembly **50** the segment gear **218** will have no effect on the operation, see FIG. 27.

Again referring to FIG. 7, it can be seen that the connection between the arm **208** and the seqment gear **218** is adjustable to change the amount of angular movement imparted to the assembly **50** by the index mechanism during each indexing cycle. This in turn controls the amount of angular movement of the guide **52** and hence also the angular spacing between adjacent coil sides to be wound. The adjustment is obtained by changing the position of the slide **212** on the spaced rods **214** and **216**. The slide **212** is connected to the arm **208** by the pivot shaft **210** as aforesaid, and the shaft **210** is mounted for slidable movement along a track **240** in the arm **208**.

To adjust the position of the slide **212** on the rods **214** and **216**, and hence also the location of the shaft **210** on the arm **208** which also includes a sliding connection, the slide **212** is pivotally connected to the upper end of a link **242**. The lower end of the link **242** is pivotally connected to a vertically movable rack gear **244** which meshes with a round gear **246**. The gear **246** is connected to another gear **248** which meshes with another rack gear **250**. The rack gear **250** is connected to a fluid or pneumatic motor **252** by means of a movable piston and rod assembly **254**. The gears **246** and **248** are mounted for rotational

movement on a shaft **256** which is part of a larger diameeter rotatable structure **258** which includes means for obtaining a plurality of fixed adjustment positions for the slide **212**. The fixed adjustment positions are obtained by means of spaced stops **260** mounted on the structure **258** that cooperate with a pivotal solenoid controlled member **262** under control of solenoid operator **264**. When the solenoid operator **264** is energized the member **262** pivots to release the stop **260** engaged therewith and to allow the gears **246** and **248** to rotate a predetermined amount to reposition the slide **212** on the rods **214** and **216**. This in turn changes the travel of the segment gear **218** and hence also the angular movement of the guide member **52**. The position of the slide **212** therefore control the angular travel of the segment gear **218** for each movement of the arm **208**, and this in turn controls the angular movement of the gun assembly **50**. Suitable electrical controls are also provided for energizing the solenoid **264**, and suitable controls are also needed for the fluid or pneumatic motor **252**.

Referring again to FIG. 1, it can be seen that during the forward movements of the assembly **50** (from left to right) the guide **52** will move through a desired core slot. At this time, the whole assembly **50** will also be pulling the wire tight on the core and thereafter pulling additional wire from the bulk feed spool **40** through the feed mechanism and laying it in the slot. On the return stroke of the assembly **50**, however, the feed mechanism will also be laying wire in a slot but at this time the wire will not be pulled from the spool **40** but instead will remain stationary while the gun assembly moves relative thereto. In fact, the wire, as already noted, will be prevented by construction of the inlet guide assembly **58** or by other means to be described later from moving backwards toward the input end of the feed. During angular movements of the guide **52** under control of the indexing means, some wire may also be pulled through the gun assembly **50** under tension as aforesaid.

Wire guide means

The wire guide means employed on the subject device are shown in FIGS. 1, 15, 16, 17 and 19. It is understood, however, that only part of the total guide means are shown in any one figure and that a similar guide assembly **270** is usually provided for between each two adjacent core slots **34**. Two banks of guide assemblies are also needed, one bank being located adjacent to each end of a core being wound. Each guide assembly **270** includes a guide finger **272** which has a gear portion **274** that cooperates with a pinion gear **276** rotatably mounted in a supporting structure **278** (FIG. 16). The pinion gear **276** also meshes with teeth on a movable slide gear **280** positioned in the structure **278**, and the slide gear **280** is connected to a piston and rod assembly **284** that is operated by a fluid motor **286**. When the piston and rod assembly **284** is in its extended position as shown in solid outline in FIG. 16, the gear **276** will be in its most counter-clockwise position and the guide finger **272** will be in its operative position as shown. When the piston and rod **284** are moved to their retracted position, on the other hand, the pinion gear **276** will be in its clockwise position and the finger **272** will be rotated to the position shown in dotted outline. When the assembly **284** moves the fingers **272** to its retracted position it also moves the finger assembly **270** to a retracted or radially outward position to clear the core **32**.

When the necessary fingers **272** are in their operating positions, they form a path or channel around and adjacent to the end of a core being wound between succeeding core slots **34** in which the wire is being positioned by the guide **52**. Only certain of the fingers **272** are in operative positions during winding of each coil and they are retracted to their inoperative positions for indexing when the winding is completed. The finger assemblies **270** are also retracted to their inoperative positions to clear the windings when a core is completed. After each winding is completed the same or different finger assemblies can be used for winding the next succeeding winding and this process is repeated for each new winding until the core are completely wound at which time all the finger assemblies are retracted as aforesaid so that the wound core can be removed from the machine. During winding each succeeding winding turn is laid on the previously wound turns until the proper number of turns have been wound. This is indicated and controlled by counter means (not shown) which register a count each time a certain machine operation takes place. When a predetermined count is reached the counter actuates means which initiate the succeeding machine operations including drawing out and severing end connections for the windings, as will be explained. The electrical and pneumatic circuits under control of the counter and other means can take many different forms and is not deemed necessary to consider any particular control means in detail in this specification.

Each finger assembly **270**, as already mentioned, is movable between various operation positions under control of the motor **286** and its piston **284**. In order to move the assembly from its inoperative to retracted position to one of its several operating positions, the piston and rod assembly must move from its retracted to its extended condition. In so doing, the piston performs two functions, first, it moves the whole finger assembly **270** radially inwardly relative to the core structure being wound until it is stopped by engagement between an adjustable stop member **287** which is mounted on a rod **288** that is attached to the assembly **270** and a fixed stop member **289**. During the movement of the assembly **270** just described, the associated guide finger **272** will be in its retracted inoperative position as shown in dotted outline in FIG. 16. After the assembly **270** has been stopped, however, further movement of the piston **284** will move the slide gear member **280** in the structure **278** (which was stopped by engagement of the members **287** and **289**), and this further movement will rotate the finger **272** and move it from its inoperative to its operative position as already described. The adjustable stop member **287** is threadedly mounted on a rod **288** and is adjustable thereon to change the position at which the assembly **270** stops during its inward movement under control of the motor **286**. Also by changing the position of the stop **287** on the rod **288** the operating position of the assembly can be adjusted for any particular core to be wound regardless of the core diameter and the dimensions of the core slots. The adjustable stop member **287** may also engage and be stopped by a movable stop member **290** which is controlled by a solenoid **293** and can be interposed between the stop member **287** and the fixed stop **289** to change the operating level or position of the guide finger **272** relative to a slot being wound. This also enables the machine to lay windings at different depths in the slots. As shown in FIG. 16, the interposed stop member **290** is normally biased by a spring **291** to a position interposed between the cooperating stops **287** and **289** and is moved out of this inbetween position by energizing the solenoid **293**. The adjustment member **287** controls the long stroke movement of the assembly **270**, and a second similar adjustment member **295** which may also include solenoid control means may be provided to control the short stroke adjustment of the assembly **270**. Both adjustment members can easily and quickly be adjusted for any particular winding operation.

Many stators have turns of more than one winding or winding portion positioned in the same slots. In such constructions it is usually desirable to have the guide fingers **272** positioned radially further out when winding the outermost turns in a slot than when winding the intermediate or innermost winding turns. In order for the fingers **272** to be at the different winding positions for winding each winding portion in a slot, different preselected radial stop levels may be provided. Adjustment

of the stop levels can be made by the adjustment members **287** and **295** and control of the level selection can be made by the solenoids **293** which control the abutment members **290**, which may be interposed between the fixed abutments and the adjustable members **287** and **295**. Any desired number of different finger operating levels can be provided in this way and the level selection can be controlled automatically. In the outermost level illustrated by the two leftmost assemblies **270** in FIG. 19 the fingers are in their inoperative positions. The next three assemblies **270** to the right have their fingers positioned at the innermost level for winding the final turns in the associated slots, and the rightmost assemblies **270** are shown positioned for winding the first or outermost winding turns in the associated slots. Additional levels, as noted above, can also be provided depending upon the particular physical characteristics of the stator, the depts of the slots, and the number of different windings or winding portions to be positioned in the slots. It is also within the scope of the invention to have two sides of the same windings wound at different slot depths in which case the fingers **272** may be arranged at different or staggered levels between succeeding slots in which the same winding or winding portion is positioned. It is usually also desirable, as noted above, to maintain tension on the wire at all times during winding in order to keep the windings free from looseness, to minimize the amount of wire used, and to make the end loops more nearly and accurately conform to the shape defined by the fingers **272**. This also makes for a neater and more orderly construction.

Various devices can be used to control the level of operation of the fingers **272** including providing means to control the radial positions of the finger assemblies **270**. The control means can also be manual or they can be under control of solenoid or other operating means as disclosed. Where a number of stators requiring the same finger levels for the windings are to be mass produced, the positions of the assemblies are usually manually set for reasons of economy. However, if the finger levels must frequently be changed other means for setting them may be preferred.

FIGS. 1, 17 and 18 show an auxiliary finger assembly **292** which includes a finger **294** used for pulling out lead wires at the end of each winding. The lead wires are then later used for connecting the winding in a desired manner. The assembly **292** also may include means **296** for cutting off the lead wires after they are pulled out and other means **298** for holding the severed wire ends for a predetermined period such as during formation of the next winding. The auxiliary assembly **292** is positioned between two adjacent guide assemblies **270** and is actuated by solenoid operated hydraulic or pneumatic means **297** (FIGS. 17 and 18) under control of impulses which are produced in a counting circuit (not shown) which counts the number of turns being wound in each winding. When the correct number of winding turns have been counted the finger **294** on the assembly **292** will move to a position between the two adjacent guide fingers **272**. Thereafter, when the next winding turn is laid over the finger **294** the finger will be moved radially outwardly pulling the said last winding turn with it. The wire turn thus pulled out will then be cut off by cutter assembly **296** with which the finger **294** cooperates and the end thereof will be clamped by clamp means **298** associated therewith. The clamp means **298** can be operated simultaneously with the finger **294** and the cutter **296** using the same operator means for all, if desired. An adjustment member **299** similar to the adjustment members **287** and **295** (FIG. 16) is provided to control the inward movement and operating position of the auxiliary assembly **292** and its associated finger **294** (FIG. 18). The cut ends are thereby maintained in accessible positions for later connections.

The subject machine also includes means **300** (FIG. 1) for inserting insulating strips into the core slots to be wound. The means **300** may include means for inserting insulation strips at the bottom of the slots and it may also include means for inserting insulation strips between portions of different windings positioned in the same slots. Several means for inserting insulation strips are available for this purpose and can be used on the subject machine.

FIG. 9 of the drawings is a plan view showing the relative position of various parts of the machine including the drive motor **301** and the drive connections therefor. FIG. 9 also shows spaced annular mounting members **302** and **303** on which the guide assemblies **270** are mounted. The members **302** and **303** are positioned adjacent to the opposite ends of the core **32** and are mounted respectively on oppositely threaded portions of threaded members **307** which when turned by a wrench or other means will change the axial spacing between the members **302** and **303** and between the guide means thereon to enable the machine to be adjusted to wind different length core structures.

FIG. 14 shows the guide member **52** moving through one of the slots **34** of the core **32** between two adjacent guide fingers **272**.

Several modified forms of feed mechanism for the subject machines are also shown in the drawings and will be described hereinafter in connection with FIGS. 20, 21, 22, 23, 24, 25 and 26. Referring to FIG. 20 there is shown a modified form of the input end of the feed mechanism which is constructed for feeding two or more wires simultaneously into the same or into different core slots. In this construction, the incoming wires are fed through an input conduit **304** and under a pivotal rocking member **305** which acts as a one way feeding device to prevent the wires from back feeding during operation of the machine. The wires pass under the rocking member **305** which cooperates with grooves in a slide member **306** that reciprocates with the feed mechanism. The individual wires are then fed through the same or through separate feed tubes **308** and **310** each of which is also provided with a oneway feed mechanism adjacent the input end including a chamber **312** and **314** respectively. The chambers **312** and **314** have tapered walls **316** and **318** respectively and each chamber also contains a ball **320** and **322** respectively past which the wire is allowed to move in one direction only. Each of the tubes **308** and **310** has its own rack gear **324** and **326** mounted thereon, and the two rack gears are arranged back to back and are slidable relative to each other (FIG. 21). The tubes **308** and **310** also extend to adjacent the outlet end of the feed mechanism and are provided with other means to limit movement of the wire in one direction therethrough. The oneway means at the outlet end of the tubes **308** and **310** are similar in construction to the means described above at the input end and include chambers **328** and **330** with tapered surfaces and ball members **332** and **334** that cooperate therewith. After the wire has passed through the oneway feed mechanisms described, it passes through other tubes **336** and **338** (FIG. 22) or through a single tube **339** (FIG. 21) to an outlet wire guide device such as a guide member **52** (FIG. 3) or to a double headed guide **340** (FIGS. 22 and 23). The double headed guide **340** can be used to lay wire in two opposite slots in a stator core simultaneously.

In the modified constructions of FIG. 20–23 no spring means are required to restore the rack. Instead, during indexing operations the two rack gears **324** and **326** move in opposite directions providing a balanced operation. The indexing mechanism employed with the modified constructions can be similar to that described above even though the gear arrangement is somewhat different. For example, in the modified construction of FIG. 21 a single annular non-rotatable beveled gear **340** is provided in housing **342**. Therefore, during an indexing operation gear **344** will rotate in one direction during indexing at one end of the strokes to rotate gears **346** and **348**.

Since the gears **346** and **348** engage opposite sides of the associated rack gears **324** and **326** the gears **324** and **326** will move in opposite directions. At the other end of each stroke, when the indexing mechanism is moving in the opposite direction, the reverse condition will take place and the two rack gears **324** and **326** will move in the opposite directions and so on. Furthermore, in this construction no locking means are provided because only one nonrotatable bevel gear **340** is provided. Except for these differences in the feed mechanism, however, and also the fact that the wire guide may have two instead of one outlet (FIGS. 22 and 23) the modified construction operates similarly to the construction previously described.

Another modified form of feed mechanism is shown in FIGS. 24, 25, and 26. This modified feed mechanism, like the preferred form described above, has two annular rotatable bevel gears **360** and **362** positioned in a movable housing **364**. The bevel gears **360** and **362** are also similar to the bevel gears described in connection with the preferred construction of FIG. 3 and each of them is provided with means to alternately prevent rotation thereof at opposite ends of the feeding strokes. The means to prevent rotation of the bevel gears include slide members **366** which are similar to the slide member **158** (FIG. 8). The slide members **366** are also spring loaded into locking positions by means of springs **368** (FIG. 25). Two similar oppositely operating locking members are provided and are controlled by similar follower members **370** and adjustable cam means in the manner described above. In this particular construction the slide members **366** and the gear members **360** and **362** are constructed to provide more positive means to prevent movement of the gears in their locked or nonrotating conditions. In the modified construction of FIGS. 24 and 25, the gears **360** and **362** are likewise engaged by a pinion gear **372** which is mounted on a shaft **374**. The opposite end of the shaft **374** has another gear **376** which meshes with yet another gear **378** (FIG. 24). The gear **378** drives a roller member **380** which is engaged with a spring loaded grooved roller member **382** carried on one end of a rocker member **384**. The opposite end of the rocker member **384** is spring loaded by means of spring member **386** and plunger member **388** (FIG. 24). During an indexing operation similar to that described in connection with the preferred construction, a different one of the beveled gears **360** and **362** is locked and prevented from rotating at each opposite end of the feeding strokes. Thereafter, during the indexing operations in which the gun mechanism is rotated, the gear **372** rolls around the locked bevel gear **360** or **362** to positively rotate the gear **378** and the associated roller **380**. While the roller **380** is turning the spring biased roller **382** will also be rotated and will apply pressure on the wire which is being fed between the two rollers **380** and **382**. The speed of rotation of these rollers and the pressure applied on the wire therebetween keeps the wire under controlled tension and serves substantially the same purposes as the spring **138** described above. The roller **382** as shown in FIG. 25 has a plurality of spaced grooves **382***a* formed therearound. A different wire can be fed between each of the spaced grooves **382***a* and corresponding grooves in the roller **380** depending upon how many wires are to be wound simultaneously. Except for the features described above, a machine equipped with the modified feed construction of FIGS. 24 and 25 operates substantially the same as the preferred construction.

FIG. 26 shows the input end of the feed mechanism of the modified construction of FIGS. 24 and 25. It should be noted that in the modified feed, three feed tubes **390**, **392**, and **394** are provided and each is capable of feeding wire to a different groove on the roller **382** (FIG. 25). Many other modifications and changes in the subject device are also possible but it is not practical to describe them all in this specification.

The chart in FIG. 27 shows the time sequence of operation of the more important components of the subject machine. For example, it can be seen starting at the 0° position to the left of the chart, which is an arbitrary beginning point, that the first operation includes moving the gun assembly **50** forwardly under control of the cam **112** and the associated mechanism. Thereafter, at the end of the forward motion which represents a quarter turn of the member **108**, the gun assembly will stop and remain stopped while an indexing operation takes place also under control of the cam **112**. During the indexing operation the gun assembly rotates through a predetermined angular displacement as described above. After the indexing operation is completed the gun assembly will move in the reverse or rearward direction during which time the guide **52** will move through another slot in the core structure **32**. When the gun reaches the end of its reverse travel it will again stop and remain stopped for about a quarter turn of the cam member **112** while the index mechanism again takes over to rotate the gun assembly in the opposite direction until the guide **52** is aligned with the slot previously wound during forward movement thereof. During both of the indexing operations, wire will be fed through the feed mechanism from the input spool **40** and be placed on the associated guide fingers **272** which are positioned between the slots being wound. During the forward and rearward movements of the gun assembly, the wire feed mechanism will also restore itself under control of the spring **138** if such is used. In the other cases, this may not be necessary. At certain times during each operating cycle, as for example during the forward gun movements, counter means **400** such as are shown in FIG. 5 will be actuated to count each occurrence of particular operations which is also a count of the number of winding turns completed. The counting means **400** are controlled by cam operated switches **402** and **404** (FIG. 5) which are connected to the input of a predetermined coil turn counter **406**. The switch **404** and the counter **406** are connected to control motor brake clutch control means **408** which in turn control the energizing of the drive motor **301**. The counter **406** also has another output that controls predetermined coil counter means **410** which is provided to count the number of coils that are wound. The output of the counter means **400** also controls the auxiliary finger assembly **292**. The counter means **400** therefore controls the stopping of a winding operation after a predetermined number of winding turns have been wound and the counter also controls a circuit which will cause the hook **294** to move into operating position to pull out the next winding turn to form the lead wires. This operation is identified on the sequence chart by the words Lead-Hook Up On Count and refers to the control for the assembly **292** of FIGS. 17 and 18. Thereafter, the hook **294** is pulled downwardly under control of the Lead-Hook Down Control. Likewise the cutoff and hold signals shown on the sequence chart control the cutting off or severing of the lead ends and the holding thereof so that the machine can move on to wind another set of windings without losing the lead ends of the previously wound windings. Thereafter, the gun index on count is again energized to repeat the sequence of operations already described.

Many different forms of controls and control circuits can be provided to control the operation of the subject winding machine. All of the controls are quickly and accurately adjustable to enable the machine to wind many different kinds and sizes of cores. In an actual operating machine a set-up sheet or card is provided for each different core to be wound and each set-up card will include information as to how the different machine adjustments should be set. For example, a typical set-up card will include information as to the adjustments for the members **287**, **295** and **299**, whether their associated

solenoids should be operated or not, it should include information as to the counter adjustments that control the number of turns to be wound in each winding and in each slot, and it should include information as to the number of coils to be wound, the span between succeeding slots into which the same windings are to be positioned and information for controlling the time during which the end leads are held to prevent the wire from slipping and so on. The set-up card should also include information for setting the spacing between the spaced banks of guide finger assemblies depending on the length of the stator to be wound, it should include information for adjusting the travel of the gun assembly **50** and the cam assemble **140** and information as to the number of winding wires to be fed through the gun assembly and the kind of wire to be used. The set-up should also indicate the kind and size of insulators to be used in the slots.

Thus there has been shown and described a novel winding machine which fulfills all of the objects and advantages sought therefor and which includes means for mounting a core structure to be wound, means for feeding wire in a predetermined manner through the slots of the core structure, means for guiding and forming winding end portions that extend between succeeding slots being wound, means for counting the number of winding turns being wound on each winding, means for pullling out an end loop at the conclusion of each winding operation and means for cutting off the pulled out end leads and means for holding them so that succeeding winding cna be wound without losing the end leads. The subject machine also includes means for adjusting the feed and indexing means to accommodate different core constructions and different winding patterns, means determining the operating positions of the guide means to wind at different slot depths, means for preventing reverse movement of wire in the feed mechanism, and means for predeterminately loading or tensioning the wire during feeding and indexing operations in order to reduce waste and and at the same time obtain accurately formed windings.

Many changes, alterations, modifications, and other uses and adaptations of the subject machine will become apparent to those skilled in the art after considering this specification and the accompanying drawings which show several different embodiments thereof. All such changes, alterations, modifications and other uses and adaptations which do not depart from the spirit and scope of the invention are deemed to be covered by the invention which is limited only by the claims which follow.

What is claimed is:

1. Means for winding stators and the like including a core structure having an opening with spaced winding slots communicating therewith comprising means for supporting the core structure during winding thereof, a source of winding wire, means for directing the winding wire from said source into the slots of the core structure in a predetermined arrangement, said wire directing means including a reciprocating assembly having an inlet end receiving wire from the source and an outlet end including a wire guide member movable back and forth through predetermined core slots in a predetermined arrangement, means for rotating the outlet end of the reciprocating assembly in opposite directions at opposite ends of travel of the reciprocating assembly whereby the outlet end of said assembly alternately moves longitudinally through a different core slot during succeeding reciprocation movements thereof, said means for rotating the outlet end of the reciprocating assembly including means for simultaneously predeterminately moving wire through said assembly and out the outlet end thereof, and guide means positioned adjacent said core structure on opposite ends thereof in position to receive and accurately form and position wire that is fed from the feed assembly during rotations thereof and which extends between succeeding slots being wound.

2. Means for feeding wire into spaced slots formed in a core structure, said slots communicating with an opening through the core structure comprising means for mounting said core structure, a source of winding wire, means for repeatedly directing the wire from said source to and through one of the said spaced core slots in one direction and thereafter directing the wire back through another slot in said core structure in the opposite direction and so on until a complete coil is wound in said slots, indexing means operatively connected to said wire directing means for moving said feed means at the conclusion of laying wire in a slot to a position aligned with another slot to be wound on the succeeding movement thereof, said indexing means including means for feeding a predetermined amount of wire from the source through wire directing means during each operation of the indexing means, and means forming a path for the wire fed during indexing of the feed means, said path extending between the ends of succeeding slots being wound.

3. The means defined in claim **2** including means for predeterminedly tensioning said wire during feeding thereof and means to permit unidirectional movement of the wire through the wire directing means.

4. A machine for winding core structures having central openings with spaced communicating winding slots positioned therearound comprising means mounting the core structure, a source of winding wire, means for directing wire from said source into the slots of the core structure, said means having a guide member thereon which moves through preselected core slots to lay wire therein, means for moving the guide member back and forth between selected end positions, other means for rotating the guide member through a predetermined angular displacement at each opposite end position of the reciprocating wire feed assembly, said guide rotating means including means under control thereof for predeterminately advancing wire through the wire directing means in the direction of the core structure being wound independently of the tension forces on the wire, means responsive to occurrences of a predetermined machine movement for counting operating cycles of the machine during the winding of a core structure, and means under control of said counting means for ending a winding operation.

5. The machine defined in claim **4** wherein said means under control of the counting means include means for pulling out winding end leads, and means for severing and holding said end leads.

6. A stator winding machine for winding stator cores and like structures having central openings with a plurality of spaced core slots positioned therearound and communicating with the central opening comprising a source of winding wire, means for directing wire from said source into predetermined ones of the winding slots, said directing means including a reciprocating structure having an input end for receiving wire from the wire source and an output end including a guide member movable through preselected ones of said winding slots to lay wire therein, indexing means including drive means therefor for repositioning said wire guide member at each end position of reciprocating movement thereof whereby said guide member is positioned to move through a different core slot during each direction of reciprocating movement of said reciprocating structure, other means under control of the indexing means for feeding wire from the source toward the stator core during operations of the indexing means to form winding end loops, and means for predeterminately forming the winding end loops including at least one guide finger positioned to receive wire directly from the guide member during each indexing operation.

7. A machine for winding stator cores and like structures having openings with a plurality of spaced core slots positioned therearound and communicating with the opening comprising a source of winding wire, means for directing wire from said source into predetermined core slots, said wire directing means including a reciprocating struc-

ture having an input end receiving wire from the wire source and an output end including a wire guide member movable through preselected ones of said winding slots, means for moving said guide member through a first core slot to lay wire therein during one direction of reciprocating movement of the reciprocating structure, means for thereafter rotating said guide member through a predetermined angle for alignment with a second core slot, means for thereafter moving the guide member back through said second slot on the return reciprocation thereof whereafter said means for rotating said guide member rotates said member in the opposite direction to a position aligned with said first core slot, and thereafter repeating said alternate operations to complete a winding defined by spaced winding sides laid in said first and second slots and connected end portions, and means under control of said guide member rotating means for feeding wire from the source through the wire directing means toward the stator core independently of the tension on the wire, said last named means including yieldable drive means.

8. The machine defined in claim 7 wherein means are provided for predeterminately tensioning the wire during feeding operations thereof.

9. The machine for winding stator cores defined in claim 7 wherein said means under control of said guide member rotating means includes a feed element on the feed means movable from an initial position during angular movements thereof, and means automatically releasing said feed element to return to said initial position during the succeeding reciprocating movements of the guide member.

10. Means for winding stators and like devices including core structures having openings with a plurality of communicating winding slots positioned therearound in the structure comprising means for supporting the core structure during winding thereof, a source of winding wire, means for directing the winding wire from said source into the slots of the core structure in a predetermined arrangement, said wire directing means including main means for alternately directing wire from said source first in one direction into one core slot and thereafter directing the wire a predetermined angular distance around one end of the core structure to adjacent another core slot and then directing the wire back in the opposite direction through said other core slot, again directing the wire a predetermined angular distance around the other core end to adjacent said one core slot, and repeating the aforesaid operations in sequence until a predetermined number of winding turns are wound in the said core slots, auxiliary wire directing means under control of the main wire directing means for advancing the wire through the main wire directing means from the source toward the core structure during wire directing operations when the wire is being directed angularly between succeeding core slots, means positioned adjacent the core ends for receiving and accurately forming and predeterminately positioning the wire portions adjacent the core ends that extend between the said core slots being wound, said last named means including a plurality of guide fingers positioned adjacent to the core ends, said fingers being positioned to define arcuate paths adjacent the core ends between the ends of the slots being wound, and means for moving said fingers from positions defining said arcuate paths to positions spaced radially outwardly from associated ends of the core structure.

11. The means for winding stators and like devices defined in claim 10 including means to control the radial positions of said guide fingers adjacent the ends of said core structure to define predetermined arcuate paths between core slots being wound.

12. The means for winding stators and like devices defined in claim 11 wherein said means for controlling the radial positions of said guide fingers include adjustable stop means, said guide fingers including means selectively movable against said stop means.

13. The means for winding stators and like devices defined in claim 12 wherein means are provided for moving the guide fingers between operative and non-operative positions on the associated finger assemblies, and other means for moving the finger assemblies radially relative to a core structure to be wound.

14. A winding mechanism for winding wire on core structures having spaced slots communicating with a central opening therethrough, said winding mechanism including an elongated barrel structure having an input end adapted to receive wire from a wire source and an output end adapted to guide wire into core slots to be wound, means for axially moving said barrel first in one direction to guide wire through one core slot and subsequently in the opposite direction to guide wire through a different slot on the return stroke and indexing means for rotating said barrel and said output guide end at each end position thereof to reposition the output guide end in alignment with the different slot to be wound on the succeeding axial movement of the barrel, auxiliary feed means movable in one direction under control of the indexing means, said auxiliary feed means including means for feeding wire through the barrel and out the output guide end during rotations thereof and means for repeating said axial and rotational movements of the barrel in opposite directions whereby wire is wound in repeated loops in spaced core slots.

15. The winding mechanism defined in claim 14 wherein means are provided for adjusting the distance the barrel travels during axial movements thereof.

16. The winding mechanism defined in claim 14 including means for adjusting the amount of angular movement of the barrel and the guide means thereon during each indexing operation thereof.

17. The winding mechanism defined in claim 14 including means to allow wire to move through the winding mechanism in one direction only.

18. The winding mechanism defined in claim 14 including drive means to control the sequence of the axial and rotational movements of the barrel.

19. A winding mechanism for winding wire on core structures having spaced slots communicating with a central opening therethrough, said winding means including an elongated barrel structure having an input end adapted to receive wire from a wire source and an output end including a guide member for guiding wire into preselected core slots to be wound, means for axially moving the barrel first in one direction to guide wire through one core slot and subsequently in the opposite direction to guide wire through another slot spaced from said one core slot, means to cause the barrel to hesitate for a predetermined time interval at each end of its stroke, indexing means for rotating said barrel and said guide means during said barrel hesitations to reposition the guide means in alignment with the different slots to be wound, means for repeating said axial and rotational movements of the barrel alternately and in opposite directions whereby wire is wound in repeated loops in said spaced core slots, and auxiliary means for feeding wire through the barrel and to and through said guide means during and under control of the indexing means, said wire feed means including means to allow movement of the wire through the barrel in one direction only.

20. The winding mechanism defined in claim 19 wherein said means to allow movement of wire through the barrel in one direction only includes a chamber in the barrel through which the wire moves, said chamber having a tapered surface thereon, and a roller member positioned in said chamber for cooperating with said tapered chamber surface and said wire to prevent movement of the wire in one direction therethrough.

21. The winding mechanism defined in claim 19 wherein said means to allow movement of the wire through

the barrel in one direction only includes a wire guide roller and a guide member positioned adjacent to said roller member, said guide member having a curved tapered sided groove which engages said wire only during movement of the wire in one direction through the barrel.

References Cited

UNITED STATES PATENTS

2,445,937	7/1948	Carpenter	242—1.1
2,770,424	11/1956	Grove	242—1.1
2,847,170	8/1958	Lill et al.	242—1.1
2,904,269	9/1959	Eminger	242—1.1
2,949,789	8/1960	Eminger	242—1.1 X
3,052,418	9/1962	Gorski et al.	242—1.1
3,226,046	12/1965	Droll et al.	242—1.1

FOREIGN PATENTS

565,557	3/1958	Belgium.
842,287	7/1960	Great Britain.

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