

April 18, 1939.

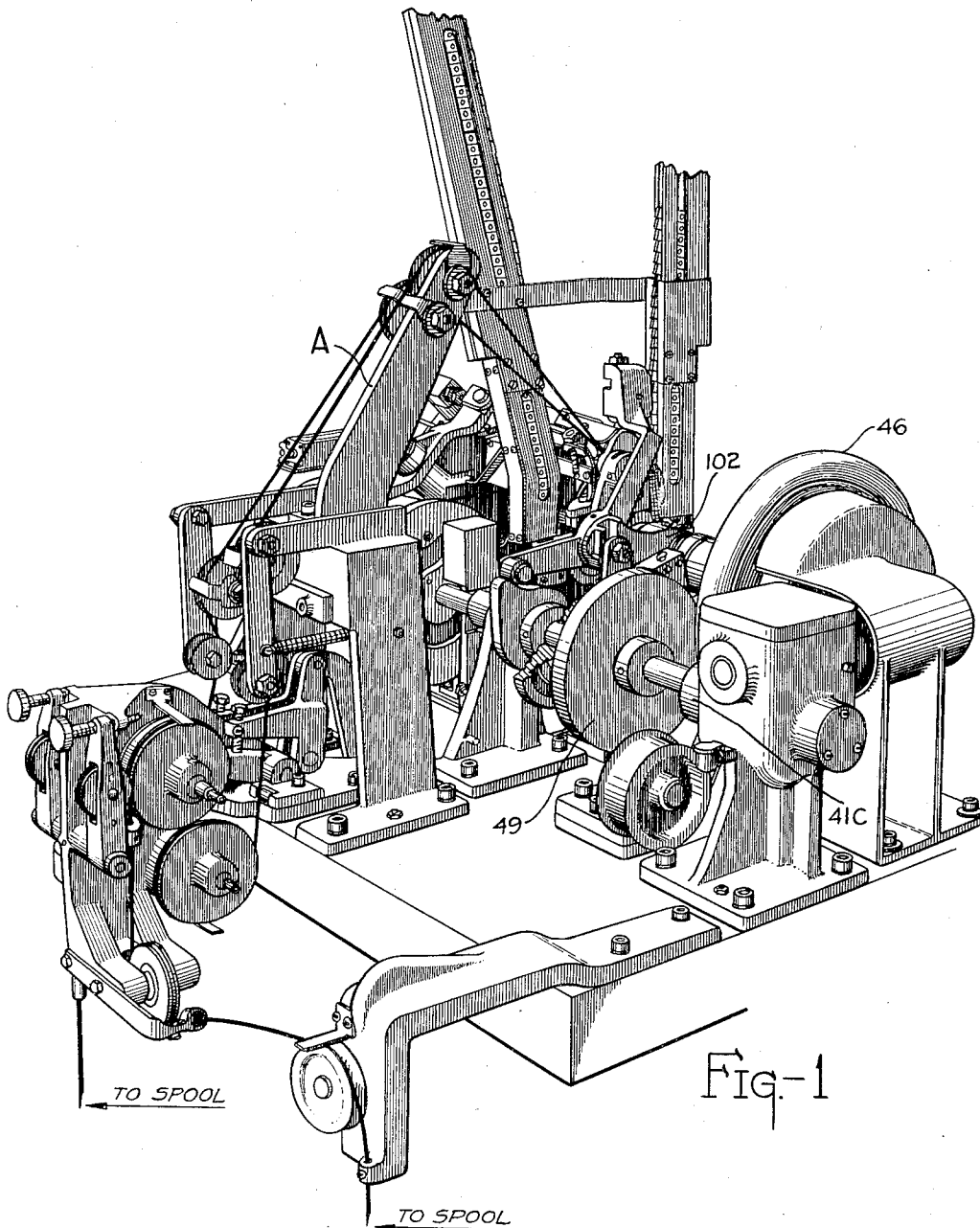
K. H. WEBER

2,154,792

COIL WINDING MACHINE

Filed Oct. 24, 1936

9 Sheets-Sheet 1



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COIL WINDING MACHINE

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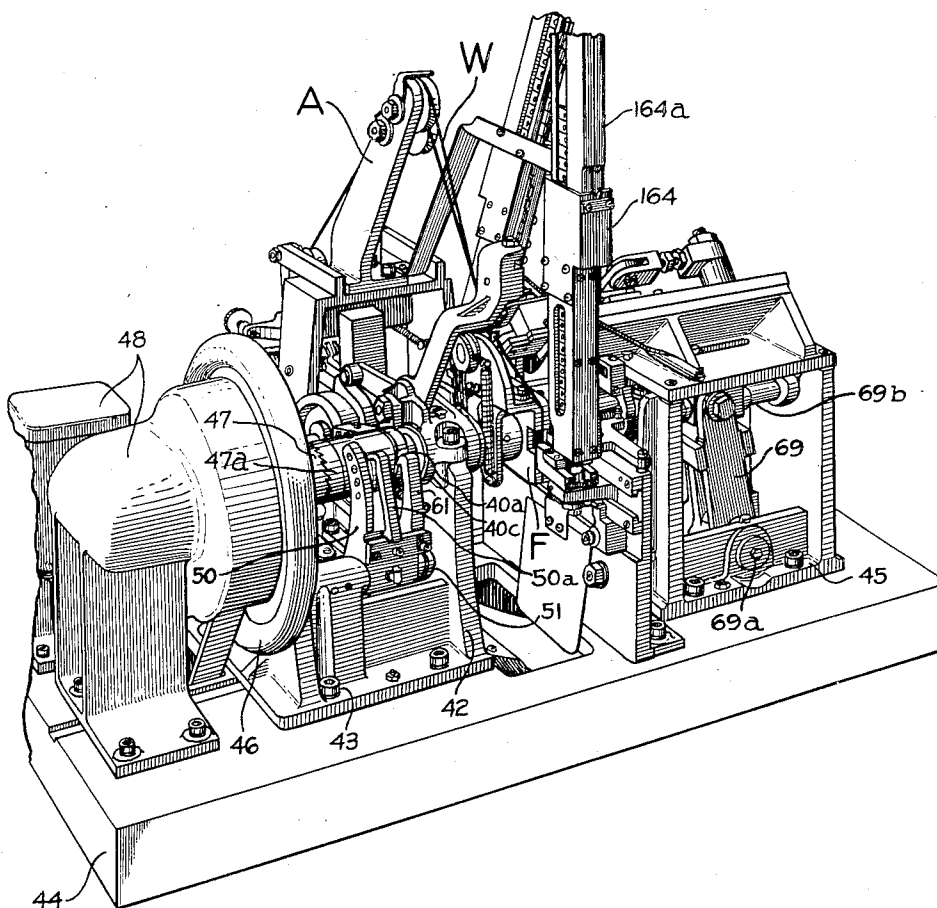


FIG.-2

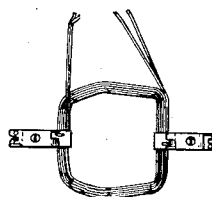


FIG.-3

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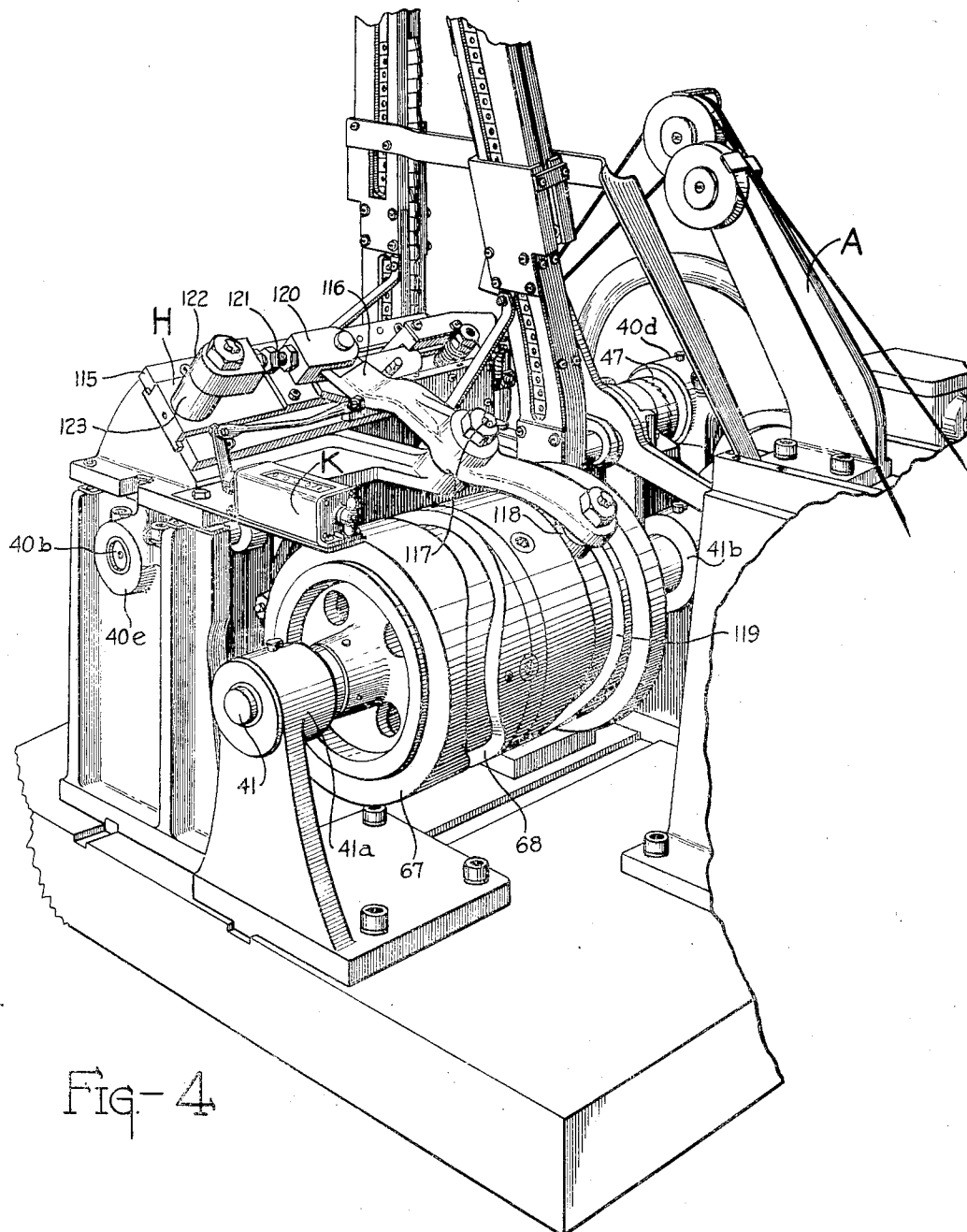
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COIL WINDING MACHINE

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9 Sheets-Sheet 3



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COIL WINDING MACHINE

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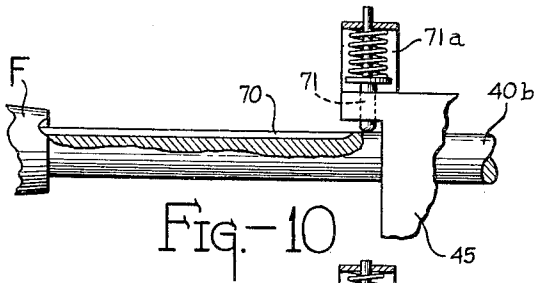


Fig.-10

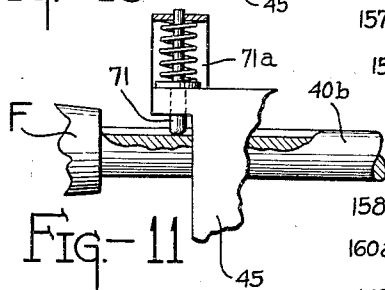


Fig.-11

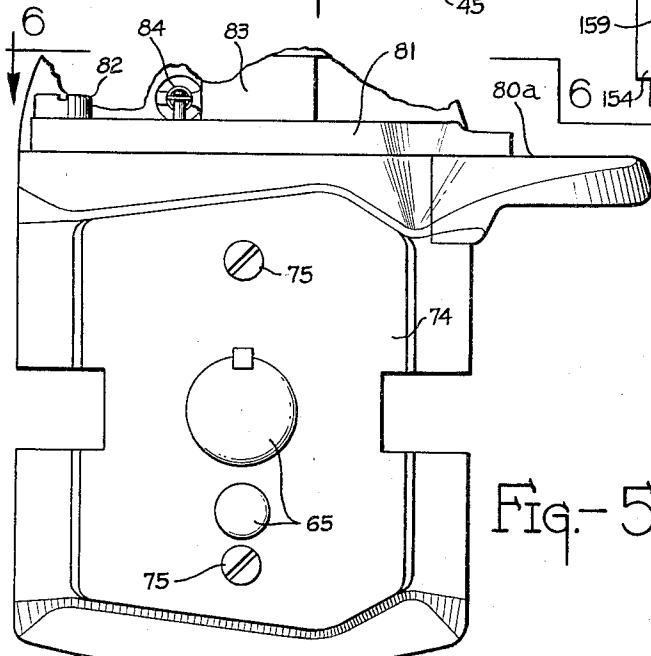


Fig.-5

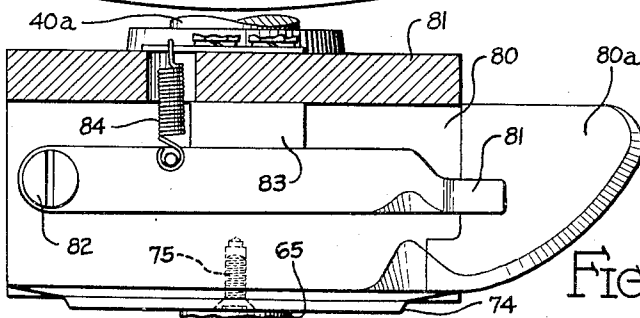


Fig.-6

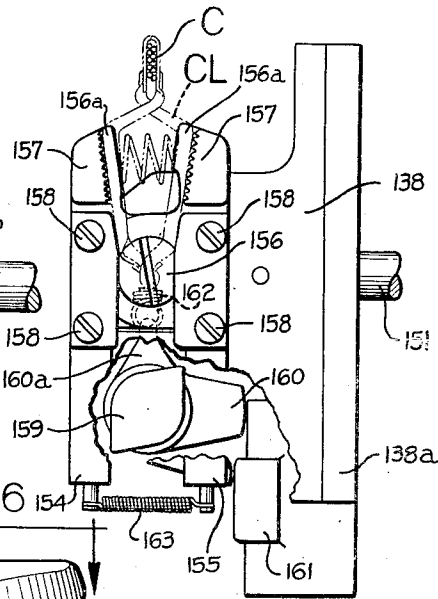


Fig.-31

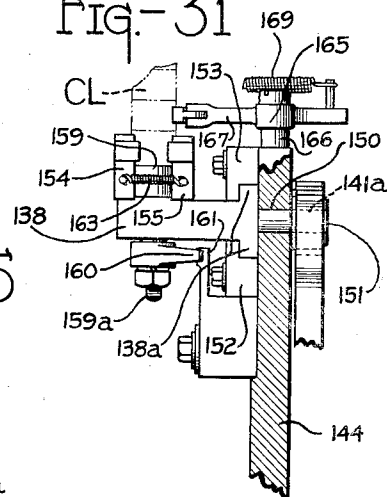


Fig.-33

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COIL WINDING MACHINE

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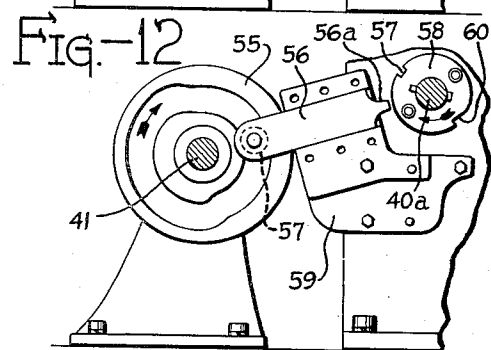
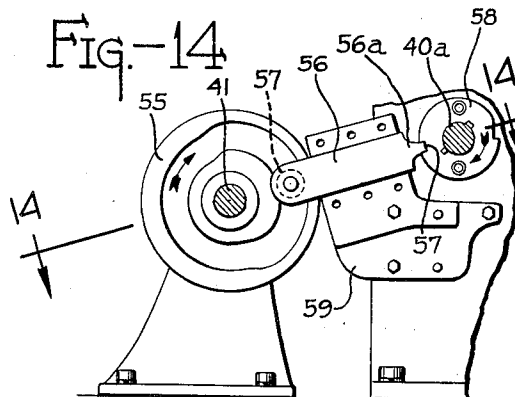
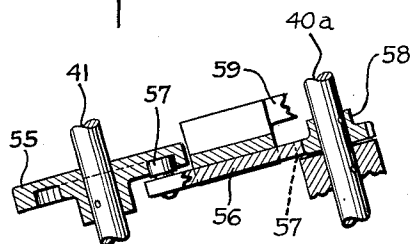
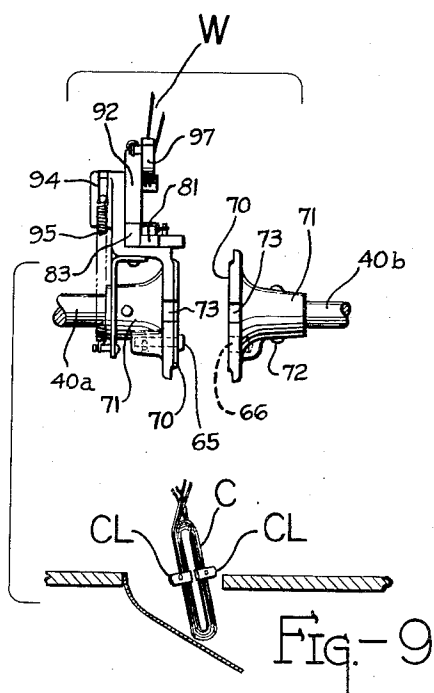
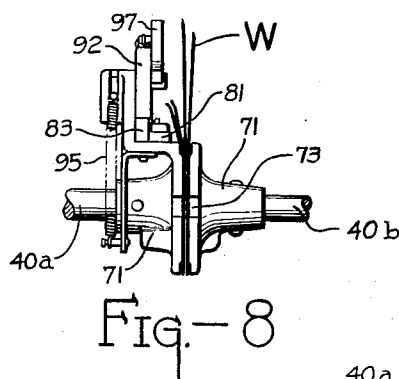
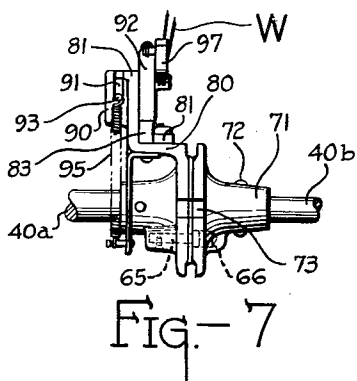


Fig.-13

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COIL WINDING MACHINE

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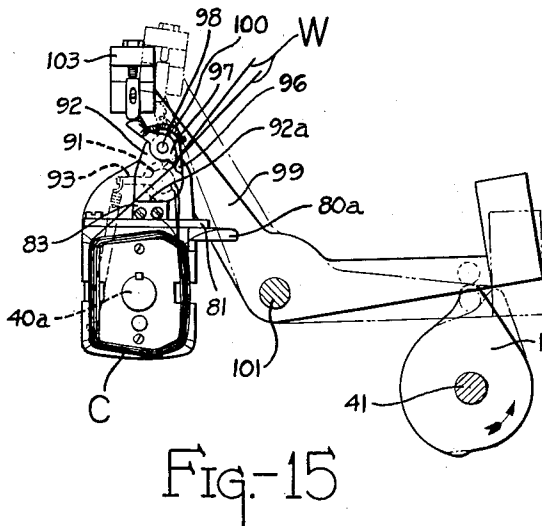


Fig.-15

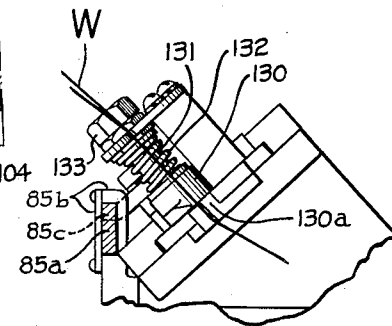


Fig.-22

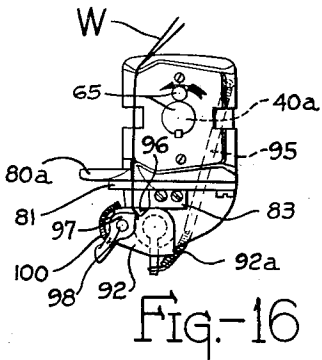


Fig.-16

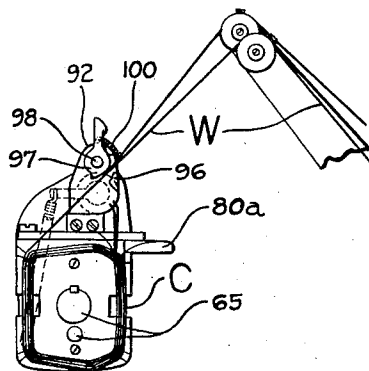


Fig.-18

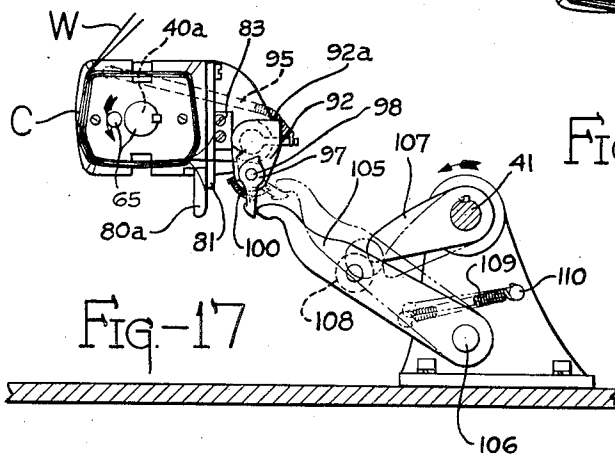


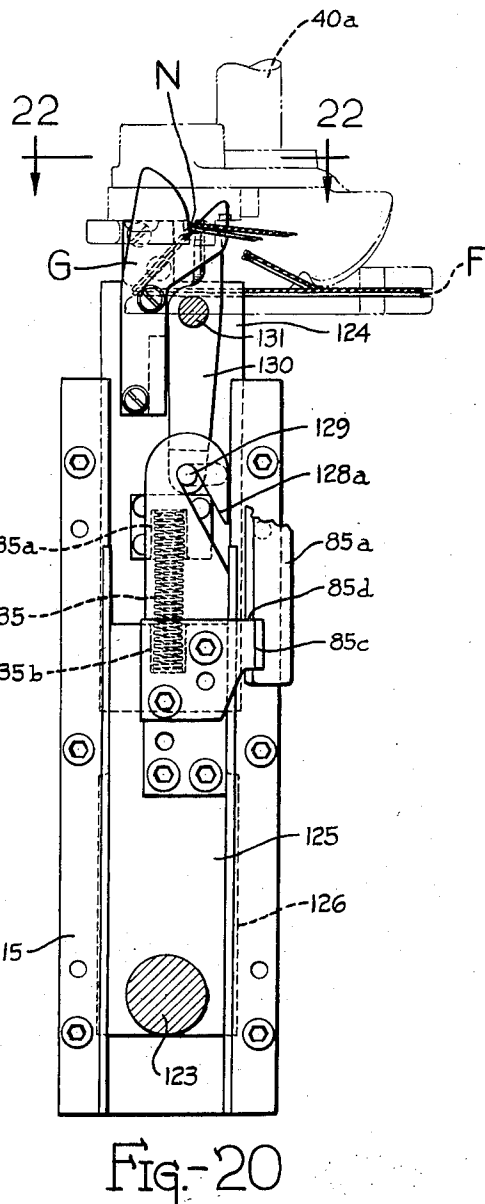
Fig.-17

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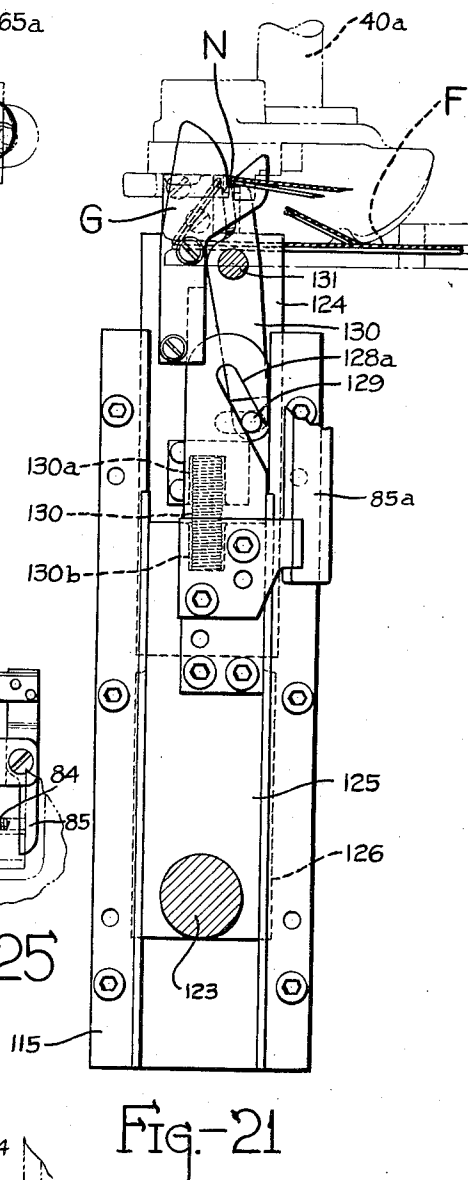
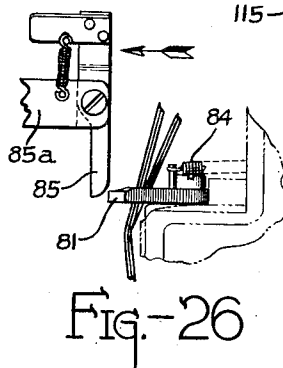
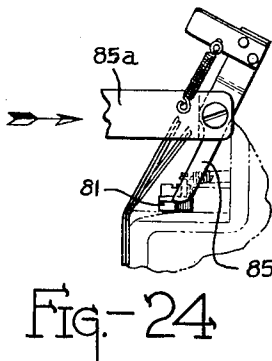
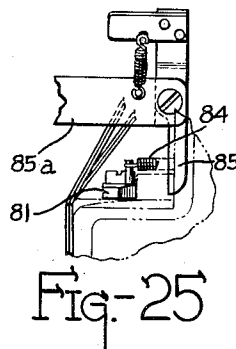
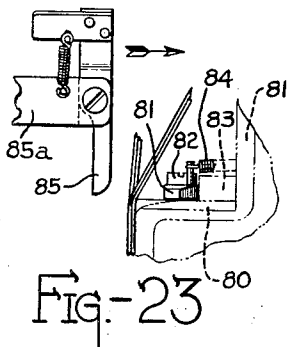
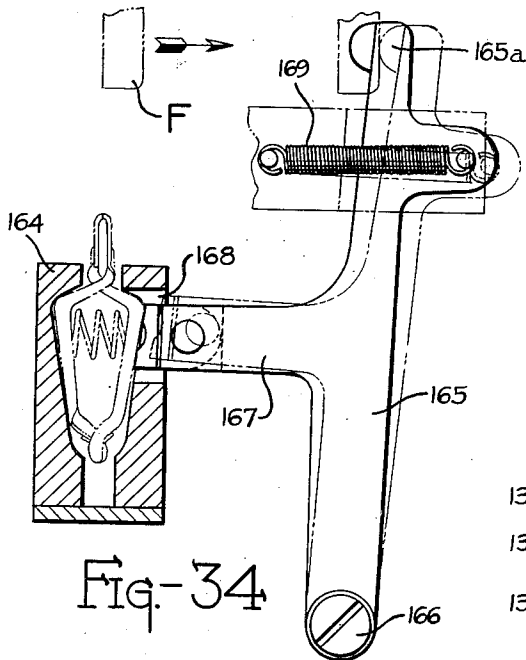
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COIL WINDING MACHINE

Filed Oct. 24, 1936

9 Sheets-Sheet 8



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COIL WINDING MACHINE

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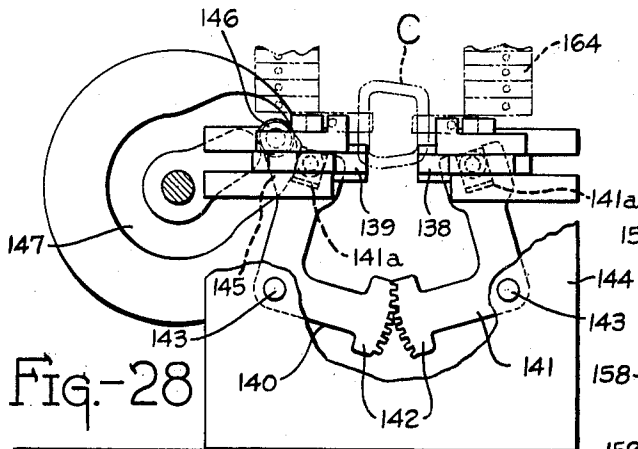


Fig.-28

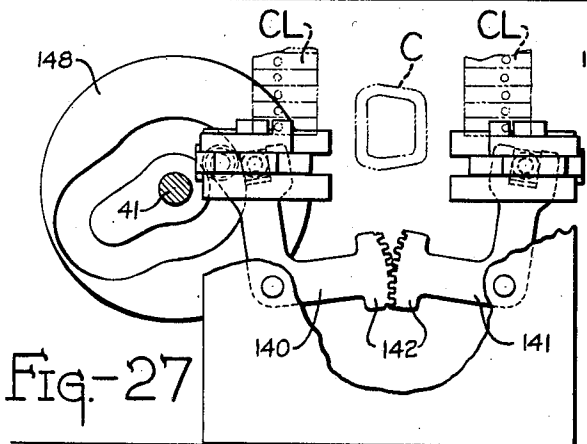


Fig.-27

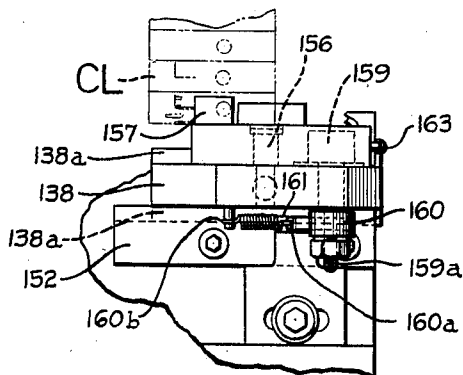


Fig.-32

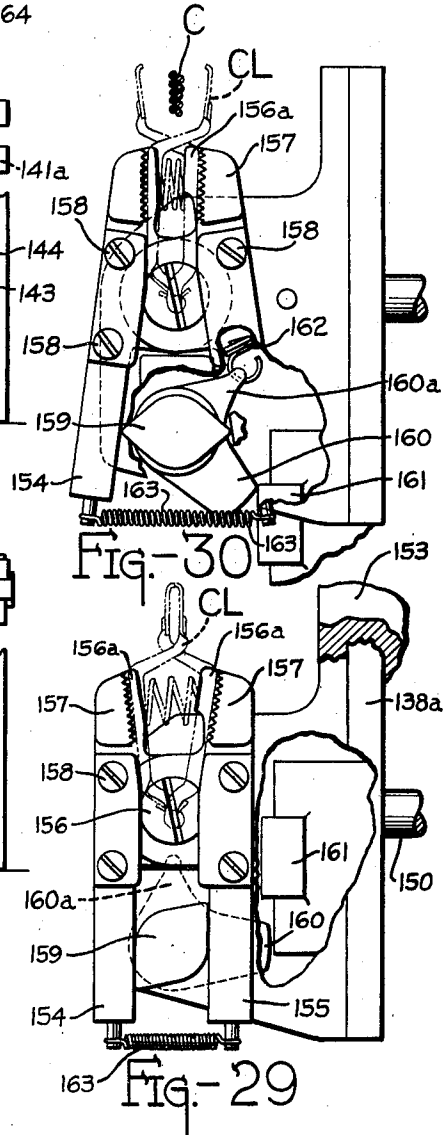


Fig.-30

Fig.-29

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2,154,792

COIL WINDING MACHINE

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Application October 24, 1936, Serial No. 107,340

38 Claims. (Cl. 140—92.2)

This invention relates to coil-winding machines, more particularly to machines which automatically wind coils on forms for use in fabricating armatures for automobile generators or the like.

To obtain an armature suitable for rotation at high speeds, the weight disposed around the axle must be carefully balanced, so that the center of gravity of the mass may be as near as possible to the axis of rotation of the armature. Heretofore, armatures with coils wound directly on the core either by machine or manually, have been used but, due to the overlapping of the coils as wound in the slots by the winding machine (or manually), a larger mass was positioned on one side of the axle than on the other, giving an unbalanced condition, which was remedied by reducing the weight on the opposite side by boring holes in the laminations of the core. The old method was empirical and resulted in somewhat unbalanced armatures which were unsuitable for rotation at higher speeds.

Furthermore, the electrical characteristics of the directly-wound armature were unsatisfactory, because the output of the machine was unsteady. The different amounts of wire used in the several coils of the armature affected the output and made it vary within wide limits. Those coils that were wound first had a minimum of wire, while those wound last had a maximum of wire, caused by the increased amount of wire used in forming the inactive end portions of the windings, the last windings having greater lap than the earlier ones. The voltage generated in each coil during rotation was substantially the same because each coil had an active portion of equal size cutting flux lines but the output for the individual coils, as collected by the commutator, fluctuated considerably due to the variations in the resistances and the resulting unequal power losses of the several coils. This variation in output is undesirable. The efficiency of the machine is appreciably decreased by this fluctuation.

On the other hand, the form-wound armature has a balanced characteristic, both mechanically and electrically, because every coil has substantially the same amount of wire in its makeup. The disposition of the weight of the coils will, therefore, be uniform so that a mechanically balanced armature will be the result. An armature of this kind will rotate with a minimum of vibration at high speeds because the center of gravity of the mass is substantially located on

the axis of rotation. Furthermore, the output of the machine will be more uniform because the electrical resistance of each coil is substantially the same. The IR drop and the I^2R losses will be the same in each of the several coils.

It is, therefore, clearly advantageous to use a form-wound coil in fabricating the armature to obtain the results outlined above. By careful design of the form, it has been found that further advantages are to be obtained by the use of this armature winding system. The winding form has been contoured to shape the individual coils so that a minimum amount of wire is used in their makeup and at the same time the coils are adapted to fit together in assembly so that a minimum of space is necessary in a direction longitudinal of the shaft to form the inactive coil ends. This allows the use of a shorter armature shaft.

To fabricate these armature coils most efficiently mechanically and with the smallest cost, an automatic winding machine has been evolved, which will wind wire from a spool (a multiplicity of wires may also be used to form the coils) into coils to obtain the advantages outlined above. Uniformity and speed are essential in this automatic machine, which will issue the coils held in form by clips ready for taping.

It is, therefore, a principal object of this invention to provide an automatic coil-winding machine adapted for continuous operation which will wind wire from a spool into a form, cut the completed coil loose, and issue it from the machine held together by clips.

It is a further object of this invention to provide an automatic coil-winding machine adapted for continuous operation which is capable of being operated by unskilled labor whose services will be simple, consisting of feeding material into the machine.

It is a further object of this invention to provide an automatic coil-winding machine which will utilize wire most efficiently by using all the wire taken from the spool in fabricating the coils.

It is a further object of this invention to provide an automatic coil-winding machine which will wind coils of flat contour having substantially quadrilateral cross-sections on their sides and substantially circular cross-sections at their ends so that a minimum amount of wire will be utilized in the formation of the coils and providing, at the same time, a coil which will subsequently be shaped to be fitted into the armature slots to nestle together on the armature

ends to give the most efficient utilization of space and material.

Other objects and advantages of this invention relating to the arrangement, operation and function of the related elements of the structure, to various details of construction, to combinations of parts and to economies of manufacture, will be apparent to those skilled in the art upon consideration of the following description and appended claims, reference being had to the accompanying drawings forming a part of this specification wherein like reference characters designate corresponding parts in the several views.

Figure 1 is a perspective view of the automatic coil-winding machine, looking at the rear, showing the cam shaft in its relation to the main shaft.

Figure 2 is a perspective view of the machine taken from the front side.

Figure 3 is a plan view of the completed coil as it issues from the automatic coil winding machine.

Figure 4 is a rear perspective view, showing the details of the cutter mechanism.

Figure 5 is an elevational view of the stationary element of the winding form.

Figure 6 is a plan view, partly in section, taken along the line 6—6 of Figure 5.

Figures 7 and 8 are side elevational views of the winding form, showing the two halves of the form in operable position.

Figure 9 is a side elevational view of the winding form, showing the form split and the coil removed therefrom.

Figure 10 is an elevational view of the shaft of the movable half of the winding form showing the guide means to maintain the shaft in a predetermined position.

Figure 11 is a view similar to Figure 10, showing the guide in use during the lateral movement of the movable half of the winding form.

Figure 12 is an end elevational view, looking in the direction of the driving shaft, showing a locking means to hold the driving shaft in a predetermined position.

Figure 13 is a view similar to Figure 12, showing the locking means in disengaged position.

Figure 14 is a view taken along the line 14—14 of Figure 12.

Figure 15 is an end elevational view of the winding form, showing the fixed half thereof and its relation to the clamp-closing levers.

Figure 16 is a view similar to Figure 15 with the clamping levers removed, showing the action of the wire tension upon the movable clamping means.

Figure 17 is a view similar to Figure 15 with the clamping lever removed, showing the manner in which the clamp is released to free the leading ends of the coil.

Figure 18 is a view similar to Figure 15 with the clamping lever removed, showing the position of the clamping means just prior to the action of the clamping lever as illustrated in Figure 15.

Figure 19 is a plan view of the reciprocating guide and cutter means, shown generally in the perspective view in Figure 4, the cutter means being in a retracted position.

Figure 20 is a view similar to Figure 19, showing the guide and cutter means in operable position.

Figure 21 is a view similar to Figure 19, showing the guide and cutter means in extended position

with the cutter means being fully actuated to sever the trailing ends of the coil.

Figure 22 is a view taken along the line 22—22 of Figure 20.

Figures 23, 24, 25 and 26 are side elevational views of a brushing device, cooperating with the reciprocating guide and cutter means illustrated in Figures 19 to 22, showing the action of the brushing device for removing the coil positively from the winding form while being reciprocated by the guide and cutter means.

Figures 27 and 28 are end elevational views of the mechanism for attaching clip devices into holding position with the coil in the winding form.

Figures 29, 30, and 31 are plan views, showing the details of the mechanism for flexing the clip and snapping it into position on the coil.

Figure 32 is a side elevational view of the mechanism illustrated in Figures 29, 30, and 31.

Figure 33 is an end elevational view similar to Figure 32.

Figure 34 is a plan view of a clip-holding device to maintain the position of the clips in the magazine during the actuating period of the clip-attaching mechanism.

A brief description of the coil winding machine will be given to outline the general scheme of operation. As pointed out above, a coil must be provided with flat sides having the smallest transverse dimensions possible to fit into the armature slots and with end sections of such contour as to use the least amount of wire possible and to occupy the smallest possible space longitudinally when the completed coil is fitted into the armature. A winding form is provided to shape the coils to this contour, the winding form being split at a mid-point for displacement of one of the parts of the form, facilitating the removal of the coil upon its completion. The winding form is preferably in the nature of transverse face plates positioned upon aligned stub shafts and cooperating together to form a peripheral groove in which the wire is to be wound.

One of the stub shafts is mounted for rotation in a fixed position and the other stub shaft may be adapted for longitudinal movement to allow the splitting of the winding form. The stub shaft, which is adapted for longitudinal movement, is provided with proper actuating mechanisms to move the two face plates into cooperation in timed relation in a cycle of operation. Pins and other holding members are fitted to the face plates and to the stub shafts to hold them in predetermined positions both while stationary and rotating. Preferably power for rotation is supplied to the fixed stub shaft, the cooperating stub shaft rotating simultaneously therewith through the medium of pins.

The wire to be used in winding coils is preferably fed to the winding forms in double strands and is taken from feed spools in any well known manner. These wires are led through straightening and tensioning devices as is well known in the art. They are then led to the rotating wire form and wound into the peripheral groove, as described before, in which the wires are formed into a completed coil of the desired contour. To control this operation, one portion of the winding form, preferably that one which is longitudinally stationary (adapted for rotation only) is provided with a laterally extending portion rotating simultaneously therewith. On this laterally extending portion, a clamp means is posi-

tioned to hold the leading ends of the wire coil as it is being taken from the wire feed spools.

When the wire form is being rotated, the clamp means is adapted to be displaced by the tension of the wire at the beginning of the winding cycle. The clamp means remains in this displaced position until the winding form has rotated a predetermined number of turns, at which time, the clamp means is adapted to be released. It then returns to the initial position through the action of a resilient means. This action releases the leading ends of the coil and allows the clamp means to be free to receive the trailing ends of the coil after the requisite number of turns have been placed in the peripheral groove of the winding form. After the proper number of turns have been placed in the wire form, the rotation stops and the coil is held in fixed position to allow an extraneous guide and cutter means to cooperate with the clamp means. By lateral movement of the extraneous means, the wire from the spools is displaced into alignment with the clamp means, the clamp means being actuated at this time, to obtain a new grip upon the leading end of the next consecutive coil to be wound and upon the trailing end of the coil whose winding has been just completed, the two ends being still connected. After the wire is tightly held in the clamp means, the cutter severs the wire between the clamp means and the coil, forming, by this operation, the trailing ends of the coil, the clamp means still retaining its grip on the leading ends of the next consecutive coil.

Simultaneously with the clamping and cutting operations, means extraneous of the wire form attach a pair of holding clips upon the flat sides of the completely wound coil, still positioned in the wire form to hold the turns of the completed coil in proper relation after removal from the wire form. The wire form is then split and the finished coil, held together by the clips, is removed from the machine. After this the wire form is again closed, and a new cycle of operation is ready to begin.

Drive mechanism

The coil winding machine is driven by two shafts in parallel juxtaposition, one being a broken main shaft 40 for intermittently rotating a split winding form, and a counter-shaft 41 provided with several rotating cams to actuate the various supplementary operations of the machine in timed relation with the rotation of the winding form. The main shaft 40 is broken adjacent its mid-point, the two portions of the shaft being mounted in alignment. One portion 40A is mounted for rotation only while the complementary portion 40B is mounted both for rotation and for longitudinal movement. The relatively fixed portion of the main shaft 40A is journaled in bearings 40C and 40D which are positioned upon a bracket 42 which is firmly mounted by means of screws 43 upon base member 44. The complementary portion of the main shaft 40B is journaled in the bearings 40E positioned in the uprights of a bracket 45, also mounted by means of screws upon the base member 44. At the point where the main shaft 40 is broken, a winding form F is provided as will be described in detail hereinafter.

The counter-shaft 41 may be journaled in three bearings 41A, 41B, and 41C to hold it in parallel alignment with the main shaft 40. These bearings are positioned upon suitable mounting

brackets which are mounted upon the base 44 by any convenient means as, for example, screws.

Adjacent the exterior upright of the mounting bracket 42, a pulley-flywheel 46, preferably of integral construction, is mounted to rotate upon the shaft 40A, a sleeve extending therefrom through the bearing 40D to rotate the driving portion 47 of a saw-tooth clutch. Power is applied to the flywheel by any convenient means as, for example, by a belt cooperating with the pulley 46, the belt being moved by any primary source of power, an electric motor or the like. The pulley-flywheel 46 drives a gear train (not shown in detail) enclosed within a housing 48. The gear train transmits power from the pulley-flywheel to the counter-shaft 41 so that the counter-shaft may be driven at a definite speed ratio with regard to the main shaft. Any gear ratio may be used, the main shaft preferably rotates twelve revolutions per one revolution of the counter-shaft.

The driving portion 47 of the saw-tooth clutch is adapted for constant rotation inasmuch as it is fixed to the pulley-flywheel 46. The driven portion 47A of the saw-tooth clutch is adapted to be moved along the main shaft 40A into cooperative relation with the driving portion to transmit power to the main shaft from the pulley-flywheel. This movement is obtained by the action of a cam wheel 49, mounted upon the counter-shaft 41. The cam wheel 49 has a rider (not shown) for actuating a lever 50 mounted upon a stub shaft 51 firmly affixed to the mounting bracket 42. The lever 50 cooperates with a projection (not shown) upon the driven portion 47A of the saw-tooth clutch through a cam surface which moves the driven portion of the clutch out of cooperation with the driving portion. A second lever 50A also cooperates with the projection to hold the driven portion 47A of the saw-tooth clutch in a fixed position.

Resilient means urge the driven portion into cooperation with the driving portion, except when interfered and prevented by the interaction of the projection on the driven portion and the cam surface on the levers 50. This clutch construction is well known in the art and need not be described in further detail.

Simultaneously with the action of the clutch disengaging mechanism, a main shaft locking device, illustrated in Figures 12, 13 and 14, is actuated to hold the main shaft in a fixed position for selected periods of time. A cam 55, mounted on the counter-shaft 41, moves the bar 56 in a longitudinal direction by means of the rider 57, the bar having a projection 56A to cooperate with the notch 57 in a sleeve 58 fixedly mounted upon the main shaft 40A. The bar 56 is positioned in a guide 59 which is firmly attached to any convenient means to the frame of the machine. The interaction between the projection 56A and notch 57 locks the main shaft firmly in position against rotation. Diametrically opposed from the notch 57 is a second notch 60 which cooperates with the lever 61 to prevent overrunning of the sleeve 58 and thereby helping to align the slot 57 in the projection 56A for the locking operation.

As pointed out before, the main shaft 40 is broken adjacent its midpoint, the ends of the main shaft portions 40A and 40B cooperating at that point by having two transverse face plates defining a winding form F mounted upon the cooperating ends as will be described hereinafter. The main shaft complementary por-

tion 40B is driven by having power applied thereto from the portion 40A. This power transference is accomplished by means of pins 65, one of which is centrally located on the face plate and the

- 5 second is eccentric, both being preferably mounted upon the portion 40A of the main shaft. The pins 65 cooperate with aligning apertures 66 (Figure 9) in the face plate mounted upon the complementary portion 40B of the main shaft.
- 10 In order that the face plates defining the winding form F and mounted upon the portions of the main shaft, may be separated, the complementary portion 40B of the main shaft is adapted to be moved in a longitudinal direction.
- 15 A drum 67, mounted upon the counter-shaft 41 is adapted by means of a cam track 68 to move the complementary portion of the main shaft 40B in longitudinal direction at selected times by the action of a rider, (not shown) which cooperates with the cam track 68 to move a system of
- 20 levers 69 fulcrumed at 63A. The complementary portion 40B of the main shaft cooperates with the upper ends of the levers 69 by means of the pivoted block 69B which transmits the longitudinal movement thereto.

- 25 To prevent rotation of the complementary portion 40B of the main shaft during the longitudinal movement thereof, a guide means is provided, comprising a longitudinal slot 70 on the shaft into which a spring-pressed rider 71 is thrust to prevent rotation. The spring-pressed rider 71 is attached to the frame member 45 by means of a bracket 71A. When the face plates of the winding form F are in cooperative position, the guide is substantially in the position
- 30 shown in Figure 10, the rider 71 pressing upon the cylindrical surface to allow rotation of the complementary portion 40B of the main shaft. However, as the face plates are separated by movement of the complementary portion 40B of
- 35 the main shaft to the right, as shown in Figure 10, the rider 71 will cooperate with the slot 70 to prevent rotation of the shaft while it is being moved. Upon return of the shaft into its initial position, the condition illustrated in Figure 10
- 40 obtains.

Winding form

- 45 As pointed out before, the winding form F is defined between two transverse face-plates attached to the respective ends of the main shaft portions 40A and 40B, called a headpiece and a tailpiece respectively. The two transverse face-plates are capable of being separated to split
- 50 winding form by the longitudinal movement of the shaft portion 40B, moving the tailpiece away from the headpiece. The headpiece and the tailpiece each comprise a plate portion 70 and a boss portion 71 respectively, the latter portions being apertured and keyed to the ends of the
- 55 main shaft portions 40A and 40B. The shaft portion 40A may extend beyond the plate portion of the headpiece to form the pin 65 as described hereinbefore. Pins 72 may be provided to hold the parts rigidly in position.

- 60 The headpiece and the tailpiece are provided with aligning slots 73 at their sides to expose a portion of the completed coil to allow holder clips to be automatically attached to the coil to prepare it for removal from the winding form
- 65 without loss of form. Figure 3 shows the holder clips positioned upon the coil. This mechanism for automatically attaching clips to the coil will be described in detail hereinafter.

- 70 Between the headpiece and the tailpiece, a

shim plate 74 is positioned to separate the plane surfaces of the transverse face-plates. The shim-plate 74 is apertured to allow the pins 65 to project therethrough and also to provide opening for the holding screws 75 which are threaded into the headpiece. The thickness and peripheral contour of the shim-plate 74 are varied to suit the dimensions of the coil that is to be wound in the form and may vary widely. Adjacent the edges of the shim-plate, the corners of the headpiece and the tailpiece are chamfered and rounded so as to guide the wire to be wound into the trough of the form, the rounded edges protecting the insulation of the wire from chafing.

15 The contour of the trough of the winding form may be designed to suit specific conditions as, for example, the coil to be wound for use in form-wound armatures as described in my co-pending application Serial No. 107,341. In this case, the perimetrical contour of the coil is made of suitable dimensions to embrace the armature core and fit into the slots thereof. The transverse contour of the form is shaped so that the sides of the coil which fit into the armature slots are made into quadrilateral form, the smaller dimension thereof being a minimum to permit the use of a narrow slot in the armature core and the transverse contour forming the end portions of the coil are shaped so as to place the wires forming the coil as near the center as possible so as to employ the smallest possible amount of wire in the winding of the coil.

20 On the upper side of the headpiece is positioned a backwardly extending flange 80 having an upstanding portion 81 parallel to the face-plate of the headpiece. A clamping means for holding the wire during the winding operation is positioned on the upstanding portion 81 as will be described in detail hereinafter.

25 Referring to Figures 5 and 6, the backwardly extending flange 80 is provided with a lateral projection 80A which acts as a guide to direct the wire into the winding form. The projection is contoured to force the wires toward the shim-plate 74, the edges being rounded and chamfered to prevent injury to the insulation of the wire. The ledge formed by the backwardly extending flange 80 is fitted with a bar 81 pivoted about a headed stud 82. The bar is held against a stop block 83 which is held in position by screws or the like by means of a resilient spring 84 anchored in any convenient manner to the upstanding portion 81. The bar 81 is actuated by means of a moving finger 85 attached to the cutter head as shown in Figures 23, 24, 25 and 26. The finger 85, moving to the right in Figure 23, is displaced by the cam surface on the lower end of the finger coming into contact with the bar 81 to override the bar as shown in Figure 24 and attain the position shown substantially in Figure 25, at which time the cutter head and the finger 85 have advanced to their maximum position. Then, upon the return stroke, as shown in Figure 26, the finger contacts the back side of the bar 81 and displaces it about the stud 82 so that the bar will force the completed winding coil from the form which is split at this moment as will be described hereinafter.

Wire clamping mechanism

70 Positioned upon upright portion 81 of the headpiece is a movable clamp means which obtains a grip on the leading end of the coil when in an initial position and holds the leading end at a

displaced point during the operational cycle for a definite period of time and then, by the action of an extraneous means, releases the leading end of the coil and returns to the initial position through the pull of a resilient means to grip the trailing end of the coil preparatory to the cutting operations to be described hereinafter. After the cutting operation has been completed, the clamp means again has a grip upon the leading end of the next consecutive coil which is about to be wound in the new cycle of operation.

The upright portion 81 of the headpiece is provided with a boss 90 which is apertured to journal a stud 91 which may be integral with a clamp block 92. The stud 91 is transversely bored and fitted with a projecting pin 93 extending through a segmental slot 94 in the boss 90. The slot 94, by its cooperation with the pin 93, provides a means to hold the block 92 in position and to limit the rotative displacement of the clamp block by the cooperation between the pin 93 and the ends of the slot 94. A resilient means 95 acts between the end of the pin 93 and a fixed point on the headpiece to urge the clamp block 92 in a counter-clockwise direction (Figure 15) so as to buttress the flat base 92A of the clamp block against the stop block 83 already described. The clamp block 92 may rotate about the pivotal stud 91 through a limited angular displacement being normally held in an initial position by the resilient means 95.

The clamp block 92 is positioned so that its free face is slightly displaced from the plane of the winding form allowing the wire to be wound into the form to be guided therein without interference. This is clearly shown in Figure 8. When the trailing end of the wire is to be positioned between the jaws of the clamp, it is displaced by a guide G, shown generally in Figures 19 and 20, being positioned on a reciprocating cutter means to be described hereinafter, the guide pushing the wire laterally so as to thrust it between the clamping jaws.

The clamping jaws comprise a fixed element 96 preferably integral with the clamp block 92 and a movable element 97, the movable element being in the nature of a lever pivoted at an intermediate point on a pin 98 anchored in the clamp block 92. The lower branch of the lever-like movable element cooperates with the fixed portion to form the clamp jaws and the upper branch having appropriate cam surfaces cooperating with an extraneous bell-crank 99 to apply force to the movable element to actuate the clamp. A resilient means 100 urges the movable element of the clamp to open position and acts between the upper branch of the lever-like movable element and a fixed point on the clamp block 92.

The bell-crank 99 is pivoted at a central point on a stud 101 which is held in fixed position on a projection 102 (Figure 1) of the bearing bracket 42. The upper end of the bell-crank is provided with an adjustable block 103, adapted to cooperate with the movable element of the clamp so that when the lower end of the bell-crank, which cooperates with a rotating cam 104 positioned on the counter-shaft 41 is thrust upwardly by the cam, the clamp jaws will be closed, this operation taking place when the headpiece is in locked position, preferably in the upright position shown in Figure 15.

As described before, the clamp block 92 is displaced by the pull of the leading end of the wire of the coil during the first 180 degrees of rotation

as is clearly shown in Figure 16. The clamp block 92 is rotated through a predetermined angular displacement, preferably about 90 degrees by the pull of the leading wire of the coil. It remains in this position for a definite predetermined period of time during the operational cycle until released by a cam-actuated finger 105 (Figure 17). The angular displacement of the clamp block has the advantage of displacing the leading end of the coil to prevent interference with the subsequent operations on the trailing end of the coil in relation with the clamp block in normal upright position, and at the same time leaves the leading end of the coil substantially straight and free of bends which would interfere with the operations in positioning the wires in the commutator segments.

The finger 105 is positioned in the rotational plane of the movable element of the clamp and is normally displaced outside the path of the lever but at selected times is moved into rotational path of the lever by a cam means to release the leading end of the wire from the clamp and allow the resilient means 95 to move the clamp block 92 back to the initial position. The finger 105 is pivoted on a stud 106 positioned on the central bearing bracket which journals the counter-shaft 41. A cam 107 is keyed to the counter-shaft and adapted to rotate therewith to displace the finger 105 by cooperating with the cam rider 108, positioned on the finger. A resilient means 109 acts between the finger 105 and a fixed point 110 to pull the cam 107 and the cam rider 108 into cooperative relation. In this manner, the finger 105 is moved into the rotational path of the movable element of the clamp at predetermined times to give a blow to release the clamp hold on the leading end of the wire and allow the clamp block 92 to move from its displaced position to the initial position.

Cutter mechanism

To position the trailing end of the completed coil as wound in the form F between the clamp jaws on the headpiece and to separate the coil from the wire issuing from the spool, a reciprocating head H is provided which has a guide G and a cutting shears attached thereto to fulfill these functions, the general view of which is shown in Figure 4. The head H is reciprocated in its guide 115 through action of a lever 116 which is pivoted at a central point on the stud 117 anchoring the fixed point preferably a part of the guide.

The lower end of the lever 116 is provided with a cam rider 118 which cooperates with a properly contoured cam surface 119 in the periphery of the cam drum 67. As already described, the cam drum 67 is fixed on the countershaft 41 and rotates therewith so that the cam rider 118 is displaced in timed relation with the operation of the other parts of the machine as will be described in detail hereinafter.

The upper end of the lever 116 is provided with a stirrup 120 which is pinned to the lever for limited rotation thereabout. The stirrup 120 is fitted with a stud 121 which is adjustably attached to apertured block 122, the stirrup, the stud, and the block being in the nature of an adjustable pitman to transmit reciprocatory motion from the lever 116 to a boss 123 positioned on the reciprocating head H. If convenient, a counter means K may be attached to the guide 115 having an arm cooperating with the lever 116 to register the num-

ber of actuations of the machine for the formation of coils.

The reciprocating head H is divided into two portions. A cutter head 124 and a pusher element 125 (Figure 19). Boss 123 is positioned on the end of the pusher element 125 and, through the action of the lever 116, moves the pusher element in the guide 115 which has grooves 126 cooperating with tongues 127 on the sides of the pusher element. The cutter element similarly cooperates with the guide 115. In this manner, both portions of the cutter head are capable of reciprocating motion in the plane of the guide 115, each being separate but cooperating together by a mechanism to be described hereinafter.

Projecting forwardly from the pusher element, a bar 128 is provided to overlay the cutter head 124. The bar 128 cooperates with a stud 129 on the movable element 130 of the cutting shears, the element being pivoted on the stud 131. A resilient means 132 (Figure 22) holds the movable element 130 in position, the tension of the resilient means being controlled by lock nuts 133. A fixed element 130A of the cutting shears is fixedly positioned on the forward end of the cutting head 124. The opening between the cutting edges on the shears element is opened in the same direction as the bight to guide G so that the wires, as moved by the guide G, after falling into the notch N, will likewise be aligned with the bight of the shears so as to be positioned therebetween for the cutting action.

As pointed out before, the bar 128 overlays the cutter head 124 and cooperates with the stud 129 on the movable element 130 of the cutter shears. In order that the movable element of the shears may be displaced so as to create a shearing stress in the bight of the shears, the bar 128 is provided with an oblique slot 128A in which the stud 129 moves to actuate the movable element of the cutter shears. This action severs the wire at the trailing end of the coil. The bottom of the oblique slot 128A prevents separation of the cutter head 124 and the pusher head 125 and to keep the stud 129 normally at the bottom of the slot 128A, a resilient means 135 is provided which acts between the pusher element and the cutter head being in normal position as shown in Figures 19 and 20. Proper sockets 135A and 135B are provided upon the two portions of the cutter head to hold the resilient means 135 in position. The resilient means 135 is sufficiently stiff to remain in unflexed condition during the initial movement of the cutter head; that is, during the period in which the guide G positions the wires of the trailing end of the coil in the notched end so as to position them between the jaws of the clamping means and in the bight between the cutters of the shears. However, when the forward end of the cutter head 124 abuts against the headpiece, as shown in Figures 20 and 21, the continued displacement of the pusher head causes the stud 129, positioned upon the movement element of the shears 130, to be displaced to the right (Figure 21) by the action of the sides of the oblique slot upon the stud 129. This displacement closes the bight of the shears and effectuates the cutting action of the trailing end of the coil to release the coil completely from the wire issuing from the spools. This allows the coil to be removed from the machine.

The guide G is positioned relatively above the jaws of the clamp, while the cutting shears is located relatively below the jaws of the clamp so that the wire from the spool may cut below the

jaws of the clamp to sever the coil therefrom and at the same time allow the end of the wire from the coil to remain fastened between the clamping jaws to become the leading end of the next consecutive coil.

As described before, the guide G and the finger 35, as shown in Figures 23, 24, 25, and 26, are actuated by the action of the reciprocating head H to perform the functions heretofore described. The guide G is in the nature of a plate having cam surfaces on the forward end thereof so as to gather the wires issuing from the form together into the notch N whereafter by further movement the guide positions these wires between the jaws of the cutting machines and in the bight of the cutting shears. The finger 35 is actuated by a bar 35A which is reciprocated within the guide 35B fixedly positioned to the frame. The bar 35A cooperates with the pusher head 125 by means of the laterally extending lug 35C which cooperates with the notch 35D in the bar 35A so that the thrust of the pusher head 125 reciprocates the finger 35 as described hereinbefore.

Clip-attaching mechanism

After the coil is completely wound and ready for removal from the winding form of the machine, some temporary holding means is preferably provided to retain the loose wires of the coil in form until some more permanent holding means may be applied to the coil, tape binders for example. For this purpose, holding clips of the type generally illustrated in Figure 34 are provided which are attached to the coil sides (as shown in Figure 3) by an automatic mechanism to be described in detail hereinafter. This mechanism is best illustrated in the drawings in Figures 27 to 34 inclusive.

As pointed out before, aligning slots are provided in the sides of the headpiece and tailpiece to expose the sides of the wound coil to which the clips are to be attached before the coil is removed from the winding form of the machine. The clips are preferably attached to the coil sides at the time before the cutting of the trailing end of the coil from the wire of the spool is consummated so that the wires of the coil may be held compactly together and in convenient form for the taping operation.

Referring particularly to Figures 27 and 28, reciprocating heads 132 and 139 are provided which approach the coil C (shown in phantom) from its sides to attach the holding clips to the exposed portion of the coils in the slots described hereinbefore. The reciprocating heads are moved by two bell-cranks 140 and 141 which cooperate through their horizontal arms by the intermeshing of gear sectors 142 positioned on the ends of the arms. The gear sectors 142 enforce uniform movement of bell-cranks and provide the same simultaneous lateral movement of the reciprocating heads by the action of the upright arms of the bell-cranks. The bell-cranks are pivotally mounted on studs 143 positioned on an upright plate 144 which is fixedly attached to the frame of the machine. The upright arm of the bell-crank 140 is provided with an ear 145 to which a cam rotor 146 is attached to cooperate with cam path 147 in a disc 148 fixed to the counter-shaft 41 for rotation therewith. The rotation of the disc 148 causes the cam rotor 146 to follow the cam path so that the bell-crank 140 is moved about its pivot, this motion being transferred to the other bell-crank 141 by the cooperating gear sectors 142. The two reciprocating

heads 138 and 139 are thereby advanced inwardly toward the coil sides where the clip is attached to the exposed portion of the coil in the slots of the headpiece and tailpiece by an automatic mechanism shown generally in Figures 29 to 33 inclusive. For convenience in description, the details of actuating mechanism of one reciprocating head will be described.

Referring particularly to Figure 33, the upright plate 144 is provided with slots 150 through which a stud 151 extends to connect the head 138 to the upright arm of the bell-crank 141. The stud 151 may be made integral with the head 138 and designed to cooperate with the upright arm of the bell-crank 141 by sliding bearing 141A which compensates for the arcuate path of the end upright arm. Guides 152 and 153 are suitably positioned by bolts or the like on the upright plate 144 to cooperate with lateral projections 138A on the reciprocating head 138 in the plane of the exposed coil side so that the clip to be attached thereto by the reciprocating head will register with the slots in sides of the headpiece and tailpiece described hereinbefore. The reciprocating head 138 carries clip actuating bars 154 and 155 on its upper side which are pivoted about a bolt 156 fixed to the reciprocating head. (See Figure 29.)

The forward bight between the two bars 154 and 155 is provided with inwardly extending flanges 156 to prevent the clip CL from falling from position between the bars. The inner sides of the bars are provided with notched jaws 157 to allow the clip sides to be gripped for application of squeezing pressure to collapse the same and open its jaws to embrace the coil. The jaws 157 may be of integral construction if desired or may be separately attached as shown in the drawings by means of the screws 158.

To apply squeezing pressure to the clip CL by means of the jaws 157, a double cam 159 is provided to act in the rearward bight of the two bars 154 and 155. The cam is fitted with a stud 159A, journaled in an aperture in the reciprocating head 138, which on the lower side thereof, is fitted with an actuating arm 160 keyed or otherwise suitably attached thereto. The actuating arm 160 cooperates with a projection 161 adjustably positioned on the upright plate 144 so that when the actuating arm contacts the projection, the cam 139 will be turned to separate the bars 154 and 155 which, acting about the pivot bolt 156, will squeeze clip CL between the jaws 157, thereby preparing it for attachment to the coil sides as shown in Figure 30.

The projection 161 is of predetermined length in the plane of reciprocation of the head 138 so that the clip will be released after the required distance has been traveled by having the actuating lever 160 overrun the projection 161 as shown in Figure 31. Two resilient means 162 and 163 are provided to return the bars 154 and 155 to an initial position, the resilient means 162 acting between the ends of the bars 154 and 155, and the other resilient means 163, acting between an arm 160A integral with the actuating arm 160 and a fixed point 160B on the reciprocating head. On the return stroke of the reciprocating head 138, the actuating arm 160 again drags across the surface of the projection 161 to return to the initial position substantially shown in Figure 29 to begin a new cycle of operation.

The initial position of the reciprocating head 138 is located below a magazine 164 containing holding clips which are fed to the reciprocating

head consecutively. The magazine preferably has a removable portion 164A which may be removed for filling without interrupting the continuous operation of the machine. To allow the clips to fall consecutively into the reciprocating head, a feeder is provided which comprises a lever 165 (Figures 33 and 34) pivotally mounted on the upright plate 144 by means of the stud 166. The lever 165 has a laterally projecting arm 167 which cooperates with an aperture 168 in the base of the magazine 164 and is adapted to contact the last clip in the magazine to hold the same in position during a predetermined period of the cycle of operation. A resilient means 169 is provided to hold the arm 167 in contact with the clip to prevent it and all the other clips above it from falling out of the magazine when the head 138 is in its innermost position. When the tailpiece, shown in phantom in Figure 34, is moved to open the wiring form F, it contacts the projecting end 165A of the lever 165 and displaces it so as to release the clip CL. This allows the clip to fall into operable position in the reciprocating head 138 between the squeezing jaws. When the form F is again closed by the return of the tailpiece, the resilient means again pulls the lever back to the holding position, to prevent the clips in the magazine from being displaced until the next cycle of operation.

Each reciprocating head 138 and 139 is provided with similar mechanisms to attach the holding clips to the coil sides.

Operation

The wire used in forming the coils is supplied to the machine in spools which are mounted adjacent thereto in any convenient manner, the wire being led from the spools to wire straightening devices shown in general in Figure 1. Positioned between the wire straightening devices and the winding form, an upwardly projecting arm A is provided to direct the wire from the wire straightening devices into the winding form, preferably at a steep angle, by leading the wire over the top of two pulleys to the clamping devices on headpieces of the winding form.

The number of wires used in the winding operation for forming the coils is optional, a multiplicity of wires is preferably used, depending upon the design of the armature in which the completed coils are to be incorporated. In the drawings, a coil having two wires has been illustrated in connection with the automatic machine.

The main shaft 40a of the machine with the incorporated winding form F is driven directly from the primary power source by the driving belt, intermittent rotation of the winding form being obtained by the use of the saw-tooth clutch. The counter-shaft 41 is driven by a gear train from the constantly rotating driver portion of the saw-tooth clutch and rotates preferably one revolution for twelve revolutions of the driver portion. Positioned on the counter-shaft 41 are the cam means which actuate the various supplemental devices cooperating with the winding form F to obtain full automatic operation of the machine, which may thereby operate steadily without special attention of an operator other than to replenish the source of materials without which the machine is inoperative; viz, the holding clips and the wire. The time relations between the main shaft and the counter-shaft during the cycle of operation are based upon the speed ratio as determined by the interconnecting gear train while the sequential operation of the

supplemental devices, cooperating with the winding form, is obtained by angular displacement between the various cams on counter-shaft 41.

Assuming for convenience in description that the cycle of operation of the automatic coil winding machine begins with the condition of the winding form F, substantially as shown in Figure 9, a description of the sequential operation of a complete cycle in winding a coil will be described in detail hereinafter. As illustrated in Figure 9, the automatic coil-winding machine has just released the coil C from the winding form by the longitudinal movement of the tailpiece on the shaft portion 40B, the coil C being held in form by the attached clips CL. The leading ends of the wires W are tightly held in the clamping mechanism on the headpiece as is best illustrated in Figure 16 (the headpiece in this figure being rotated from its upright form and the clamp block 92 is displaced by the pull of the wires W). The cam path 68 on the periphery of the cam drum 67 has moved the tailpiece from its cooperative relation with the headpiece which will allow removal of the completed coil. The headpiece, during this portion of the operative cycle, is held in locked position by the locking mechanism shown generally in Figures 12, 13, and 14. The saw-tooth clutch is disengaged just prior to the operation of the locking mechanism, so that the headpiece may be rigidly held in upright position. The counter-shaft, rotating continuously one twelfth the speed of the driver portion of the saw-tooth clutch, causes the cam path 68 to move the tailpiece again into cooperative relation with the headpiece to the position shown substantially in Figure 7. In doing so, the guide means shown in Figures 10 and 11 is released from the locking position as shown in Figure 11 which obtains when the tailpiece is in retracted position shown in Figure 9 to the free position shown in Figure 10, in which the plunger 71 rides on the cylindrical surface of the shaft portion 40B and presents no interference with the rotation thereof. The tailpiece, under these circumstances, is in close cooperation with the headpiece to close the winding form F substantially as shown in Figure 7.

With the headpiece and tailpiece cooperating as shown in Figure 7, the winding form is in closed condition and ready for the beginning of the new coil-winding cycle. The locking mechanism shown in Figures 12, 13, and 14, is released at this time by the cam rider 57 contacting the low portion of the cam 55 to retract the bar 56 and disengage the projection 56A from the slot 57. Simultaneously, the driven portion of the saw-tooth clutch is released and its resilient means shifts it into engaging relation with the driver portion so that the winding form F will begin to rotate.

The headpiece and tailpiece rotate together, the driving force being transmitted from the headpiece to the tailpiece by the pin 65 which engages the aperture 66 in the tailpiece. They are held in cooperative relation by the action of the cam rider (not shown) in the cam path 68.

The initial pull of the headpiece on the leading ends of the wires W displaces the clamp block 92 approximately 90 degrees about its pivot against the pull of the spring 95 to the position shown substantially in Figure 16. The wires issuing from the pulleys on the guide A to the clamp block 92 on the headpiece are slightly displaced from the plane of the winding block, and during the first 90 degrees of rotation, the

wires are guided into the winding form F by contacting the chamfered edges of the lateral projection 80A on the headpiece. Thereafter the wires will smoothly wind into the form for a predetermined number of turns from the pulleys without interference.

After the predetermined number of turns have been wound into the form (not necessarily the number of turns necessary to complete the coil) the leading end of the wire is released from the clamp block 92 on the headpiece by the action of the finger 105 (as shown in Figure 17) contacting the movable portion 97 of the clamp. The counter-shaft 41 rotates to bring the cam 107 into relation with the cam rider 108, positioned on the finger 105, the finger 105 being moved thereby into the path of rotation of the movable portion 97 of the clamp, so that the resulting impact between the two parts will displace the movable portion in a clockwise direction about its pivot. This action releases the grip of the clamping jaws on the leading end of the wire and completely frees the leading end of the wire from the headpiece. The coil may not unwind even though its end is free because the subsequently-wound turns overlap the first turn and prevent it from being displaced. The form F continues its rotation in the interim until the required number of turns have been wound into the form to complete the coil. The clamp block 92, no longer influenced by the pull of the leading wires of the coil, is snapped back to its original position (Figure 18) by the action of the resilient means 95 and by the centrifugal force of rotation of the headpiece. In this position, the clamp block 92 with its jaws opened under influence of the resilient means 100, cooperates with the clamping and cutting mechanisms whose actions are to be described hereinafter.

After the full number of turns have been wound into the winding form, the lever 50 and the locking mechanism shown in Figures 12, 13 and 14 again operate to disengage the saw-tooth clutch and lock the headpiece in upright position as shown in Figure 15. This places the headpiece and clamp block 92 in proper position to cooperate with the clamping and cutter mechanisms. The position of the wires W is defined between the left upper corner of the winding form (Figure 18) and the pulleys on the guide A so that they are substantially aligned with the bight of the cutting shears on the moving head H and the space between the clamping jaws 96 and 97.

Cam rider 18, cooperating with the cam path 119 on the cam drum 67 at this time, advances the cutter head H toward the headpiece by the lever mechanism already described, the cutter head H moving in substantially parallel juxtaposition with the main shaft 40. This advances three elements into cooperative relation with the headpiece; namely, the guide G, the cutter shears (both shown generally in Figures 19, 20, and 21), and the finger 85 (shown generally in Figures 23 to 26).

The guide G projects slightly farther in the direction of the headpiece than the cutting shears, and is fitted with cam surfaces on its forward edge to collect the wires W into the notch N, which aligns the wires W with the gap between the jaws of the clamp. The guide G is spaced relatively above the clamp jaws and the cutter shears is spaced relatively below the clamp jaws and both being positioned along the line of the wire issuing from the winding form to the

pulleys on the upwardly projecting arm A. The action of the guide G, therefore, positions the wires in the bight of the cutting shears for the cutting operation of the trailing end of the completed coil below the clamp and in the space between the clamp jaws to allow a grip to be obtained by the clamp on the leading end of the next consecutive coil to be wound. The guide G has a further function to displace the wires from the plane of the winding form to the plane of the clamp block 92 as is clearly shown in Figure 20 which shows the head H in its maximum position of displacement. The movement of the guide and cutter head, as limited by contact with the headpiece, is shown in the Figures 19 and 20.

Simultaneously with the action of the guide G, the bell-crank 99 is actuated by the cam 104 positioned for rotation with the counter-shaft 41. When the wires W are positioned between the clamp jaws by the guide G, the movable element 97 of the clamp is displaced downwardly by the block on the bell-crank 99 to close the jaws thereof and grip the wires. The movement of these parts is clearly shown in Figure 15, the adjustable block on the upper end of the bell-crank contacting the element 97 to accomplish the clamping action. This gives the headpiece a grip on both the trailing end of the coil already wound and the leading end of the next consecutive coil.

While the clamp jaws are being closed by the action of the bell-crank 99, the cutter shears are being actuated by the cooperation of the pin 129 on the movable portion of the shears and the oblique slot 128A on the pusher portion of the head H. The cutter portion as described before abuts at its forward end against the headpiece as shown in Figure 20 at the beginning of the cutting action. The pusher element, however, is designed to advance farther and must do so against the action of the resilient means 135, which acts between the cutter portions and the pusher element and holds the pin 129 in the bottom of the oblique slot 128A so that the cutter shear jaws are open during the initial stages. When the pusher element advances against the resilient means 135, the cutter portion being held stationary by its abutment against the headpiece, the pin 129 is displaced from the bottom of the oblique slot 128 and advanced toward the right (Figure 21) by riding up the slot. This action displaces the shear element and closes the bight and inasmuch as the wires have been positioned therein by the guide G, they will be cut so that the trailing end of the coil is severed. This frees the completed coil for removal from the machine.

During the interval of time in which the guide G and the cutter shears have been actuated, the finger 85, shown in Figure 23, has been advancing in the direction of the headpiece by the action of the pusher element through the stages shown generally in Figures 23 to 25. The finger, by this process, has been positioned on the rear side of the bar 81, the finger being flexible on the forward stroke to allow it to be displaced as shown, but is rigid on the stroke away from the headpiece so that the bar 81 must be displaced about its pivot. The displacement of the bar 81 assures the removal of the coil from the form by thrusting the leading and trailing ends of the coil outwardly from the form. This action is generally shown in Figure 26.

At the time the head H is moving into cooperation with the headpiece to perform the functions

required of it, a clip-attaching mechanism, shown generally in Figures 27 to 33, is set in motion to position a holding clip on each side of the coil as exposed in the slots of the winding form F. The holding clips are released and positioned on the coil sides an instant before the trailing end of the coil is severed by the cutting shears below the clamping means, so that the wires of the coil will be held in compact relation which will allow the cutter to operate without destroying the form of the coil. When the coil is removed from the machine, the clips hold the coil together until more permanent holding means may be applied.

The cam path 147 in the disc 148 moves the reciprocating heads 138 and 139 in a plane transverse to the main shaft 40 through the agency of the bell-cranks 140 and 141 so that the clips may be attached to the exposed coil sides. As the heads move inwardly, the fixed projection 161, which is of predetermined length, contacts the actuating lever 160 of the double cam 159 to apply squeezing pressure to the clip CL to open its jaws to allow entry of the coil sides therebetween. When the extended clip is adjacent the coil side (as shown in Figure 30), the actuating lever 160 is disengaged from the contact with the projection 161 and allows the squeezing pressure on the clip to subside, closing the clip in engaged position on the coil side. The reciprocating head then retreats to its initial position to be replenished with new clips from the magazine as will be described hereinafter.

The winding form, after the cutting action of the trailing end of the wire, is opened by the action of the rider (not shown) in the cam path 68 on the cam drum 67 so that the completed coil may be removed from the machine. The tailpiece is moved longitudinally to open the winding form to the position shown substantially in Figure 9, the head H retreating simultaneously so that the finger 85 moves the bar 81 outwardly, as described before, to thrust the coil out of the form to fall into a hamper below. When the tailpiece is displaced to its maximum distance from the headpiece, it contacts the end of the lever 165 to displace it a short distance to the right (Figure 34) so that a clip in the magazine is released to fall into position in the reciprocating head. The lever 165 is released by the return of the tailpiece and allows the projection 167 to hold the clips in position in the magazine to prevent them from falling out. From this point, a new cycle of operation is started.

It is to be understood that the above detailed description of the present invention is intended to disclose an embodiment thereof to those skilled in the art, but that the invention is not to be construed as limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of being practiced and carried out in various ways without departing from the spirit of the invention. The language used in the specification relating to the operation and function of the elements of the invention is employed for purposes of description and not of limitation, and it is not intended to limit the scope of the following claims beyond the requirements of the prior art.

I claim:

1. In a device of the class described, a revolving head piece, a tail piece cooperating with the head piece, means to allow relative axial movement between the head piece and the tail piece, a wire form means positioned between the

head piece and the tail piece and adapted to be split by the relative axial movement of the head piece and the tail piece, wire holding means cooperating with the form means and adapted to hold the leading end of the wire for predetermined intervals, cutter means cooperating with the form means to sever the trailing end of the wire, and means to position holding clips at predetermined times on the sides of the wire coil formed in the wire form.

2. In a device of the class described, a revolving head piece, a tail piece cooperating with the head piece and adapted to rotate therewith, means to allow relative axial movement between the head piece and the tail piece, a peripheral channel formed between the head piece and the tail piece to form the wire coil and adapted to be split by the relative movement of the head piece and the tail piece, clamp means cooperating with the peripheral channel to hold the leading end of the wire, cutter means cooperating with the channel to sever the trailing end of the wire, shifting means cooperating with the clamp means, and the cutter means to release the leading end of the wire and to grip the leading wire of the next consecutive coil.

3. In a device of the class described, a revolving headpiece, a tailpiece cooperating with the headpiece and adapted to be rotated thereby, a peripheral groove formed between the headpiece and the tailpiece and adapted to form the wire coil upon rotation of the headpiece and the tailpiece, means to allow relative movement of the headpiece and tailpiece to remove the completed coil, oscillating clamp means cooperating with the peripheral groove and adapted to hold the leading end of the wire coil during winding by being displaced from normal position, releasing means to open the clamp means at predetermined times to free the leading end of the wire coil and return the clamp means to normal position, means to secure the trailing end of the coil in the clamp means, and means to sever the trailing end of the coil between the clamp means and the peripheral groove.

4. In a device of the class described, a rotatable form for the formation of the wire coil, means to hold and to release the leading end of the wire coil for predetermined times in a plane displaced from the winding plane, means to secure the trailing end of the wire coil and the leading end of the next consecutive coil in the means to hold and release by displacement from the winding plane, means to cut the trailing end of the coil to free the coil, and means to remove the coil from the rotatable form.

5. In a device of the class described, a wire guide, a rotatable form, means cooperating with the form to hold the leading end of the wire in a plane displaced from the winding plane, means to cause the wire to pass into the form during rotation thereof, releasing means to break the hold of the means cooperating with the form at predetermined times to release the leading end of the wire, guide means to displace the trailing end from the winding plane to position the trailing end of the coil in the means cooperating with the form to obtain a new hold on the wire forming the leading end of the next consecutive coil, means to sever the trailing end of the coil between the means cooperating with the form and the coil, means to position clips on the coil sides, and means to remove the completed coil from the form.

6. In a device of the class described, a rotatable form for the wire coil adapted to be rotated for a predetermined portion of the operational cycle

and to remain stationary for the balance thereof, shiftable holding means cooperating with the rotatable form to hold the leading end of the wire coil adapted to be shifted from normal position during rotation of the form, means to release the holding means during the rotation of the form to return the holding means to normal position, means cooperating with the holding means to position the trailing end of the wire coil in the holding means to effectuate the holding operation, cutter means to sever the wire of the coil between the holding means and the coil, means to position clips on the sides of the coil and means to remove the coil from the rotatable form.

7. In a device of the class described, a split rotating form, guide means to lead the wire into the form, driver means to rotate the form at predetermined times, locking means to hold the form stationary at predetermined times and places, wire holding means cooperating with the form to grip the leading end of the coil adapted to be shifted during the winding cycle from an initial position, releasing means cooperating with the holding means to free the leading end of the coil and allow the holding means to shift to the initial position at predetermined times, means to position the wire of the completely wound coil in the holding means and to actuate the holding means to grip the wire, cutter means to sever the wire between the holding means and the form, and means to open the form and remove the coil from the form.

8. The device defined in claim 7, further characterized by a means to position holding clips on the sides of the coil prior to the severing of the wire by the cutter means.

9. In a device of the class described, the combination of a split rotatable wire-winding form, means positioned on the form to hold the wire end in a plane displaced from the winding plane, non-rotating cutter means cooperating with the form at predetermined times to sever the wire adjacent the means to hold the wire and in a plane displaced from the winding plane, and means to remove the completed coil from the form.

10. The device defined in claim 9, further characterized by a magazine for holding clips and means to position the holding clips on the sides of the coil from the magazine.

11. In a device of the class described, the combination of a rotatable winding form, means to hold the leading end of the wire in a plane displaced from the winding plane and for predetermined times, means to sever the trailing end of the wire, non-rotating means to position holding clips on the sides of the coil, and means to remove the coil from the form.

12. In a device of the class described, the combination of a rotatable winding form, means mounted on the form to hold the leading end of the wire in a plane displaced from the winding plane, reciprocating means cooperating with the form to release the leading end of the wire, means to position the trailing end of the wire by displacement from the winding plane into the means mounted on the form for holding the leading end of the wire, and to cut the trailing end of the coil to free the coil, means to position holding clips on the coil sides, and means to remove the completed coil from the form.

13. In a device of the class described, the combination of a rotatable form, pivoted holding means on the rotatable form adapted to assume two positions, an initial position and a winding position, reciprocating means cooperating with the form to guide the trailing end of the coil

from the winding plane into cooperation with the holding means in a plane displaced from the winding plane, and to cut the completed coil free from the supply wire, means to position holding clips on the coil sides and means to remove the coil from the form.

14. In a device of the class described, the combination of a rotatable form, means mounted on the form for holding the leading end of the coil and adapted to assume a displaced position from an initial position, means to position the supply wire into the holding means in its initial position and anchoring the same therein, means to cut the supply wire below the holding means to free the trailing end of the coil, and means to release the leading end of the coil from the holding means when the holding means is in displaced position.

15. In a device of the class described, the combination of a rotatable form, guide means for the supply wire to establish an angle of tangency between the form and the supply wire during stationary periods of the form, holding means mounted on the form to anchor the leading end of the wire, the holding means being moved from an initial position to a displaced position by the pull of the supply wire, means to release the holding means to free the leading end of the wire and allow the holding means to return to the initial position, reciprocating means cooperating with the form along its rotative axis to position the supply wire in cooperation with the holding means to anchor the supply wire, and to cut the trailing end of the coil free from the supply wire, reciprocating means cooperating with the form along its transverse axis to position holding clips on the coil sides, and means to remove the completed coil from the machine.

16. In a device of the class described, a winding form providing a wire-holding portion for the wire end displaced from the plane of the winding form capable of being disposed into two positions, an initial one at which the wire is gripped and severed; and a displaced position employed during a portion of the winding operation.

17. In a device of the class described, a rotatable winding form alternately rotating and stationary, holding means on the form to grip the wire during the rotating period of the form and adapted to be released before the end of the rotating period to free the leading end of the coil, guide and cutter means cooperating with the form during the stationary period of the form to position the supply wire in the holding means and to sever the trailing end of the coil, attaching means to position holding clips on the coil sides simultaneous with the action of the guide and cutter means, and means to remove the completed coil from the form.

18. In a device of the class described, the combination of a rotatable wire-winding form, holding means on the form adapted to be displaced from an initial position to grip the leading end of the coil, releasing means cooperating with the holding means to break the grip thereof on the leading end of the coil and allow the holding means to return to the initial position, cutter means to sever the trailing end of the coil between the holding means and the form, actuating means for the holding means to give the holding means a grip on the leading end of the coil, and means to remove the coil from the form.

19. In a device of the class described, a winding form provided with non-rotating means to attach holding clips to the sides of a completed

coil, comprising reciprocating heads moving in a transverse plane of the winding form to cooperate with the exposed sides of the coil as held in the winding form, said heads being provided with means for applying and releasing a squeezing pressure to the clips to prepare them to grip the coil sides.

20. In a device of the class described, a rotatable wire winding form, holding means on the form adapted to grip the leading end of the coil, releasing means to break the grip of the holding means on the leading end of the wire, reciprocating means to position the wire in the holding means and to sever the trailing end of the coil therefrom, and actuating means cooperating with the holding means to clamp and grip the new leading end of the coil to be wound, attaching means to position holding clips on the coil sides, means to remove the coil from the form, and power means adapted to actuate the various means in predetermined time sequence to obtain full automatic action of the device.

21. In a device of the class described, a revolving head piece, a tail piece cooperating with the head piece, means to allow relative axial movement between the head piece and the tail piece, a wire form means positioned between the head piece and the tail piece and adapted to be split by the relative axial movement of the head piece and the tail piece, wire holding means cooperating with the form means and adapted to hold the leading end of the wire for predetermined intervals, cutter means cooperating with the form means to sever the trailing end of the wire, means to position holding clips at predetermined times on the sides of the wire coil formed in the wire form, means to remove the coil from the form and power means to apply an actuating force to the various means at predetermined times to obtain full automatic action of the device.

22. In a device of the class described, a head piece, a tail piece cooperating with the head piece and adapted to rotate therewith, means to allow relative axial movement between the head piece and the tail piece, a peripheral channel formed between the head piece and the tail piece to form the wire coil and adapted to be split by the relative movement of the head piece and the tail piece, clamp means cooperating with the peripheral channel to hold the leading end of the wire, guide and cutter means cooperating with the channel and the clamp means to position the wire in the clamp means and to sever the trailing end of the coil between the clamp means and the coil, means cooperating with the clamp means to grip the leading end of the wire for the formation of the next consecutive coil, means to remove the coil from the form, and actuating means cooperating with the various means to apply power thereto at predetermined times in a predetermined sequence to obtain full automatic operation of the device.

23. In a device of the class described, a revolving head piece, a tail piece cooperating with the head piece and adapted to be rotated thereby, a peripheral groove formed between the head piece and the tail piece and adapted to form a wire coil upon rotation of the head piece and the tail piece, means to allow relative movement of the head piece and the tail piece to move the completed coil, oscillating clamp means cooperating with the peripheral groove and adapted to hold the leading end of the coil during winding by being displaced from normal position, releasing means to open the clamp means at predetermined

times to free the leading end of the wire coil and allow the clamp means to return to normal position, means to guide the trailing end of the coil in the clamp means, means to actuate the clamp means to obtain a grip upon the leading end of the coil, means to sever the trailing end of the coil between the clamp means and the peripheral groove means to remove the coil from the peripheral groove, and actuating means to supply power to the various means at predetermined times and in predetermined sequences to obtain full automatic operation of the device.

24. In a device of the class described, a rotatable form for the formation of the wire coil, means to hold and means to release the leading end of the wire coil at predetermined times in the winding period, guide means to position the trailing end of the wire coil and the leading end of the next consecutive coil in the means to hold, means to actuate the means to hold the leading end of the wire to obtain a grip thereon, means to cut the trailing end of the coil to free the coil, means to position holding clips upon the coil sides, means to remove the coil from the rotatable form, and means to supply power to the various means at predetermined times and in predetermined sequence to obtain full automatic operation of the device.

25. In an automatic coil winding device, a winding cycle adapted for continuous operation for the production of a series of similar coils comprising a rotating period for the winding form during which the leading end of the partially completed coil is released and a stationary period for the winding form during which the trailing end of the coil is gripped in a plane displaced from the winding plane for cutting and to obtain a hold on the leading end of the next consecutive coil, of positioning holding clips on the coil sides, of severing the trailing end of the coil below the grip forming the hold on the leading end of the next consecutive coil to free the completed coil, of opening the winding form to remove the completed coil from the device, and closing the winding form to begin a new cycle.

26. In a device of the class described, a separable winding form, means in the winding form to allow the positioning of suitable holding means thereon to hold the coil temporarily in shape after removal from the form, reciprocating means adapted to cooperate with the means in the winding form, to manipulate the suitable holding means to position the holding means on the coil sides at predetermined times in the winding cycle of the coil, and magazine means to supply holding means to the reciprocating means.

27. In a device of the class described, a separable winding form, slots in the winding form to expose the sides of a completed coil to allow positioning of holding clips on the coil sides to hold the coil in shape temporarily after removal from the winding form, reciprocating means adapted to cooperate with the slots in the winding form and adapted to apply pressure to the holding clips to open the jaws thereof and to release the same in such timed relation that the holding clips will be positioned on the coil sides at predetermined times in the winding cycle of the coil, and magazine means cooperating with the reciprocating means to supply holding clips thereto.

28. In a device of the class described, the combination of a rotatable winding form, means positioned on the form to hold the wire end, means to release the leading end of the coil and to ob-

tain a grip on the trailing end including the leading end of the next consecutive coil, cutter means cooperating with the form to sever the trailing end of the coil below the means to hold the wire, non-rotating means to position holding clips on the sides of the completed coil, and means to remove the completed coil from the form.

29. In a device of the class described, the combination of a means to wind similar coils consecutively from continuous wire strands, means to sever the coils from the strands, holding means for the coil sides, non-rotating means to position the holding means on the coil sides, and means to remove the completed coil from the device.

30. In a device of the class described, the combination of a form means to wind similar coils consecutively from continuous wire strands, means to sever the coils from the strands, holding means for the coil sides, magazine means for the reserve holding means, non-rotatable means to position the holding means on the coil sides from the magazine means, and means to remove the completed coil with its holding means from the device.

31. In a device of the class described, the combination of means to wind similar coils consecutively from continuous wire strands, means to sever the completed coils from the strands, holding means adapted to be attached to the coil sides prior to the severance of the coil, non-rotating reciprocating means to position the holding means on the coil sides, and means to remove the completed coil including the holding means from the device.

32. In a device of the class described, the combination of means to wind similar coils consecutively from continuous wire strands, means to sever the completed coils from the strands, holding means adapted to be attached to the sides of the complete coil to hold the coil intact after removal from the winding means, magazine means to contain unattached holding means, non-rotatable means acting between the magazine means and the completed coil to position the holding means on the coil sides, and means to remove the completed coil with the attached holding means from the device.

33. In a device of the class described, the combination of means to wind similar coils consecutively from continuous wire strands, means to sever the completed coil from the strands in a plane displaced from the winding plane, holding means adapted to be attached to the sides of the completed coil, non-rotating means to position the holding means on the coil sides to hold the coil intact upon removal from the device, and means to remove the completed coil with the holding means attached to the coil sides from the device.

34. In a device of the class described, the combination of means to wind similar coils consecutively from continuous wire strands, means to sever the completed coil from the strands, non-rotating holding means adapted to be attached to the sides of the completed coil, means to position the holding means on the coil sides to hold the coil intact upon removal from the device, and means to remove the completed coil with its holding means from the device.

35. In a device of the class described, the combination of means to wind similar coils consecutively from continuous wire strands, means to sever the completed coil from the strands, non-rotating holding means adapted to be attached to the sides of the completed coil, magazine means

to contain a series of holding means, means co-
operating between the magazine means and the
coil sides to position holding means from the
magazine on the sides of the completed coil, and
5 means to remove the completed coil with its
holding means from the device.

36. In a device of the class described, the com-
bination of means to wind similar coils consecu-
tively from continuous wire strands, means to
10 sever the completed coil from the strands in a
plane displaced from the winding plane, non-
rotating holding means adapted to be attached
to the sides of the completed coil, means to po-
sition the holding means on the coil sides to hold
15 the coil intact upon removal of the coil from the
device, and means to remove the completed coil
with its holding means from the device.

37. In a device of the class described, a sepa-
rable winding shaft rotating intermittently, a
20 control shaft rotating constantly, a winding form
positioned on the separable portions of the wind-
ing shaft, means actuated by the control shaft to
grip the leading end of the coil in a plane dis-
placed from the winding plane of the form during
25 the stationary period of the winding shaft, re-

leasing means actuated by the control shaft to
break the grip of the holding means during the
rotating period of the winding shaft, means actu-
ated by the control shaft to fasten clips on the
5 coil sides during the stationary period of the
winding shaft, means to sever the trailing end of
the coil after the holding means has obtained a
new grip on the leading end of the next consecu-
tive coil and means to remove the completed coil
from the winding form.

38. In a device of the class described, a sep-
arable winding form, stub shafts extending co-
axially from the separable portions of the wind-
ing form, means to drive the winding form in-
termittently, a control shaft, means to drive the
15 control shaft at a substantially constant speed,
means cooperating between the control shaft and
the winding form to grip the leading end of a coil
and to sever the trailing end of the previous coil;
to position holding clips on the coil sides and to
20 remove the coil from the winding form during the
stationary period of the winding form and means
to release the leading end of the coil during the
stationary period of the winding form.

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