

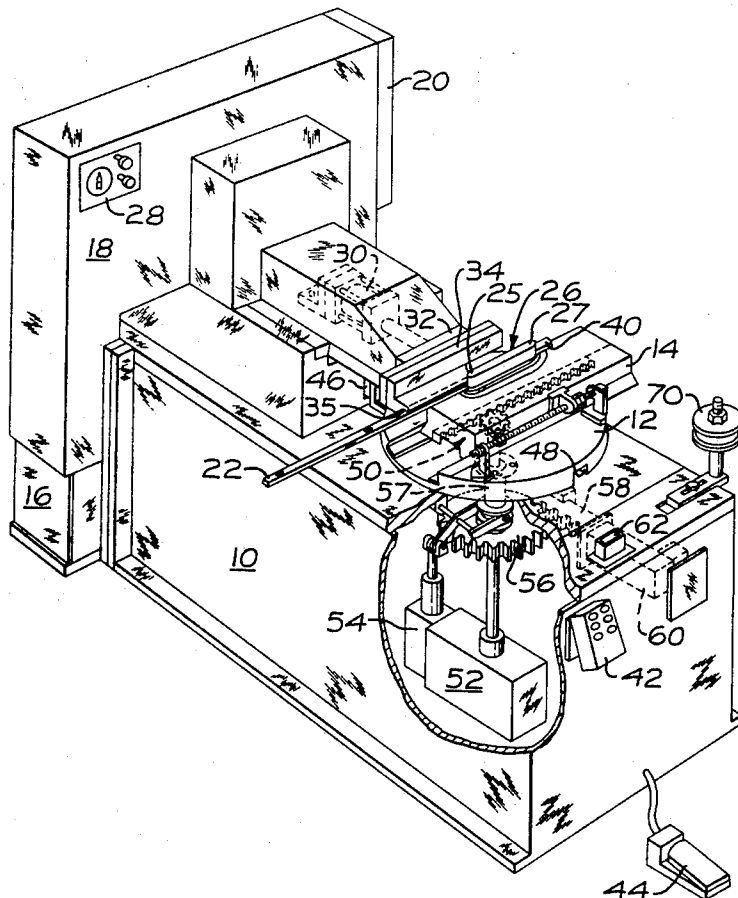
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[54] **COIL WINDING MACHINE**
12 Claims, 6 Drawing Figs.

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 [51] Int. Cl. **B21f 3/04,**
 B02c 19/00
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 143, 144; 242/82

ABSTRACT: A coil winding machine for forming edge-wound or flat-on-flat coils, featuring an indexable and rotatable die, against which the material from which the coil is to be formed is held under pressure by a wiper bar. Edge-wound coils are acted upon by a wiper bar having a surface formed thereon which serves to motivate the coil turns upwardly as they are formed so as to make room for the incoming material. The flat-on-flat coils are acted upon by a powered roller wiper bar which is actuated so as to press the material against the die, and particularly about the ends thereof as the die is rotated.



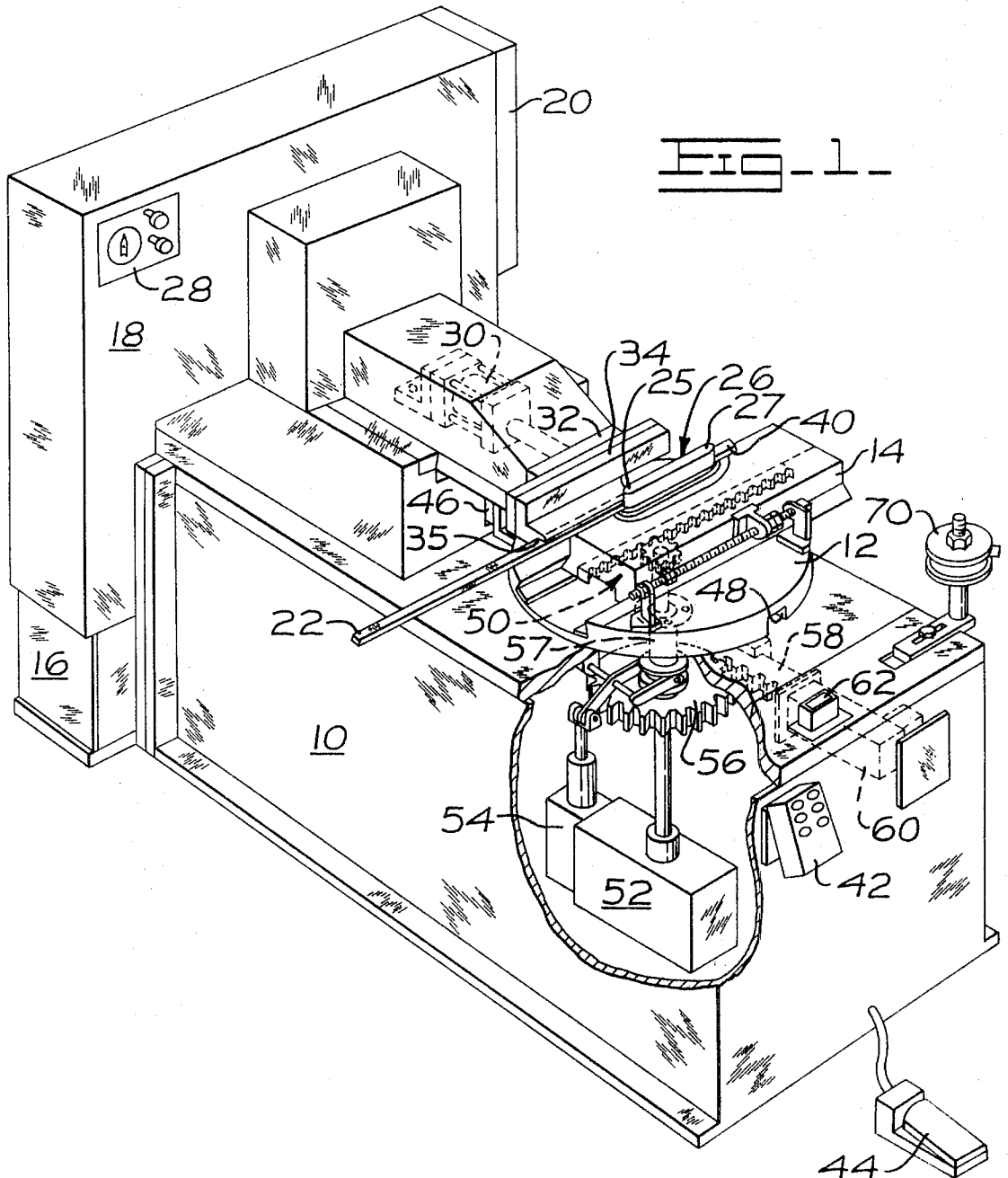
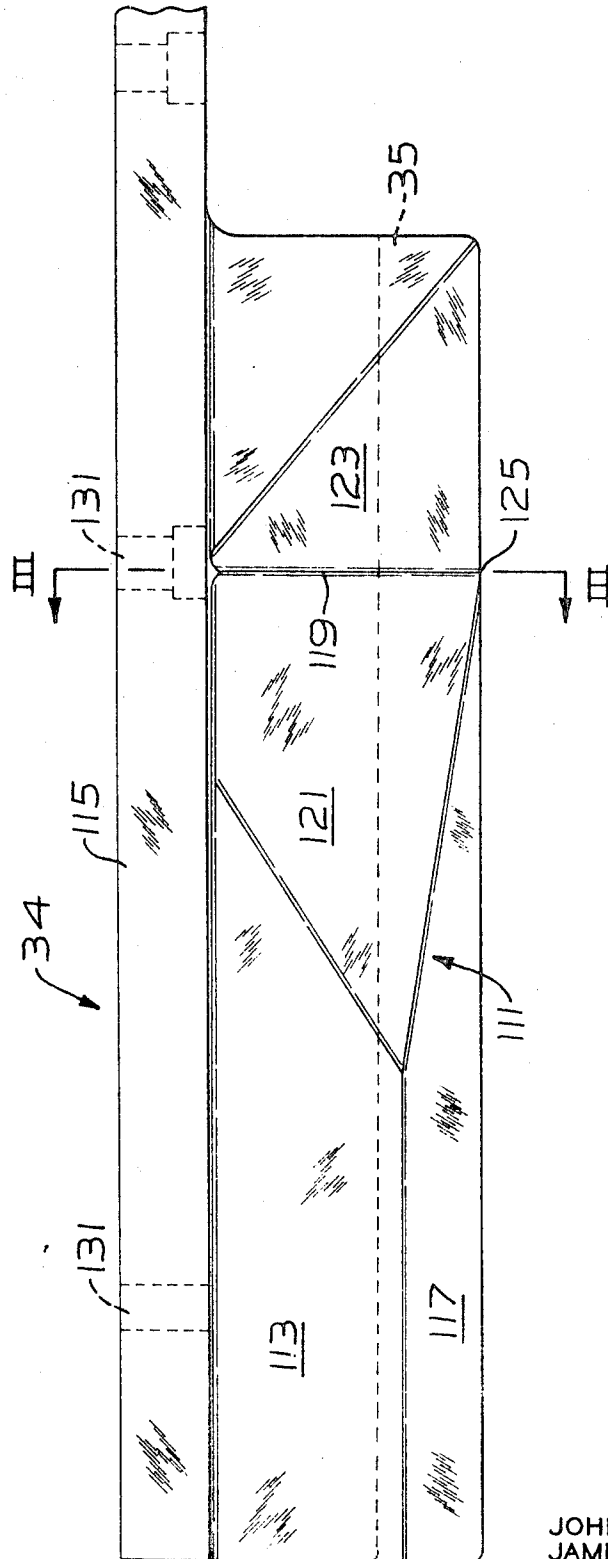


FIG. 1

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FIG. 2-



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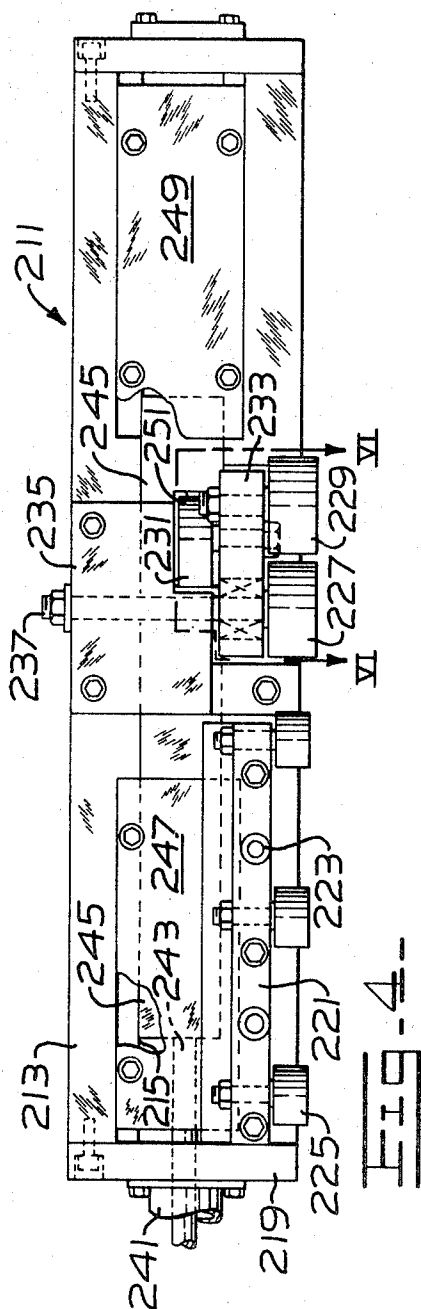
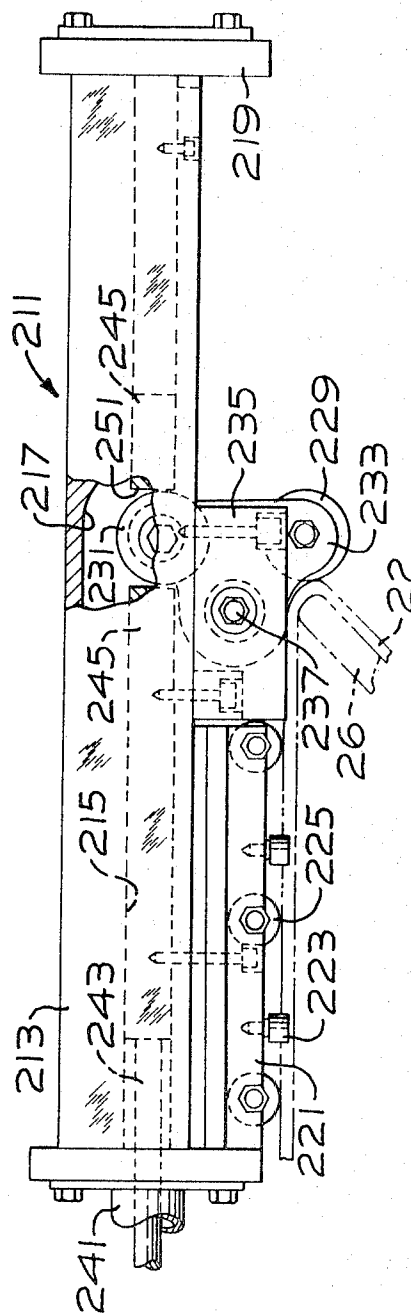


FIG. 5-



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COIL WINDING MACHINE

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates to a coil winding machine for forming coils from material such as flat copper. More particularly, the machine is designed to wind such coils in either edge-wound (smaller dimension against the die) or flat-on-flat (larger dimension against the die) configurations. The coils are wound in automated operations during which hydraulically positioned wiper bars force the copper material against the coil die at all times so as to properly size the coil dimensions and eliminate all voids between successive coil turns.

One constantly sought after goal in the manufacture and use of electrical equipment is that of optimum physical size-to-horsepower ratio. To achieve this goal, special techniques have been devised to provide proper insulation and electrical characteristics in components such as main field and commutating field coils, while allowing such components to be of the smallest possible physical size.

One of the problems encountered in attempting to achieve this goal is that of maintaining a tensioning pressure on square or rectangular copper conductor material when forming elongated coils. In order to form such coils with precise internal dimensions, while preventing looseness between adjacent turns in the end area where the copper must be formed in a small radius, a constant pressure must be maintained on the conductor material when both the coil end areas and the coil sides are being formed.

Some of the machines developed to produce these results have relied upon external counterweighted or friction tensioning devices which have proven to result in relatively expensive processes. For example, winding machines which employ external tensioning of the copper require that the operator stop the machine and pound each coil turn with a mallet to prevent looseness in the area of the coil ends. On the other hand, the coil winding machines wherein the copper is wound upon a rotating die with no tensioning means other than friction loading of the copper strap leading to the die require that the coil assembly be cold worked in a press for proper sizing and elimination of interturn voids.

It is therefore an object of this invention to provide a coil winding machine which is capable of winding coils in edge-wound or flat-on-flat configurations which obviates the disadvantages of known machines.

It is a further object hereof to provide such a machine in which coils may be produced having precise internal dimensions with no interturn voids.

It is also an object hereof to provide a coil winding machine which combines a horizontal indexing table and a cross-slide to effect rotary and transverse motion of a coil die.

It is a further object hereof to provide such a machine wherein a hydraulically actuated backup ram slide with a wiper bar forms the copper to the die compactly and tightly in all radius areas as well as in the straight areas.

It is a still further object of this invention to provide such a machine wherein the properly applied pressure of the wiper bar allows the coil to be formed without voids, while not requiring external counterweighted or friction tensioning devices.

It is also an object hereof to provide such a machine wherein edge-wound coils can be made using a slotted wiper bar attached to the face of a backup ram slide and disposed so as to always maintain pressure on the lower turn of the coil as it is being turned.

It is also an object hereof to provide such a machine wherein edge-wound or flat-on-flat coils may be formed merely by changing the wiper bars and properly positioning the material.

It is a further object hereof to provide the wiper bars which may be utilized in forming edge-wound and flat-on-flat coils.

It is a still further object hereof to provide such a machine which can form coils in a clockwise or counterclockwise configuration.

Other objects and advantages of the present invention will become apparent from the following description and claims as illustrated in the accompanying drawings which, by way of illustration, show a preferred embodiment of the present invention and principles thereof and what is now considered to be the best modes contemplated for applying these principles. It is recognized that other embodiments of the invention utilizing the same or equivalent principles may be used, and structural changes may be made as desired by those skilled in the art, without departing from the present invention and purview of the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an isometric illustration of a machine which may be utilized to form the coils according to the present invention;

FIG. 2 is a plan view of the wiper bar which is mounted on the machine illustrated in FIG. 1;

FIG. 3 is a vertical section of the wiper bar of FIG. 2, taken along a line III-III therein;

FIGS. 4 and 5 show a front elevation and top plan view, respectively, of a wiper bar which may be placed on the machine of FIG. 1 to form a flat-on-flat coil; and

FIG. 6 is an illustration of the operable portion of the wiper bar shown in FIGS. 4 and 5, as seen along a line VI-VI in FIG. 4.

DETAILED DESCRIPTION

The Machine

Referring to FIG. 1, there is shown a machine which may be utilized to form coils according to the present invention, and which, as illustrated, is set up to form an edge-wound coil from a rectangular copper workpiece.

Basically, the machine consists of a boxlike frame or table 10 in which the necessary electrical, hydraulic, and mechanical components to operate an index table 12 and a cross-slide 14 are housed. A hydraulic tank 16, hydraulic power unit 18, and electrical controls 20, all of which permit control of the hydraulic fluid to be provided to the various components inside the frame 10, may be provided adjacent the machine.

In general, the control means may be of a conventional electrohydraulic type wherein limit switches, solenoid valves, and hydraulic cylinders are arranged to produce the desired sequence of operation of the machine elements.

Although the below described series of events would occur for either type of coil configuration formation, the description will be set forth relative to an edge-wound configuration so as to be in agreement with the configuration illustrated in FIG. 1. Further, the description will be set forth for a clockwise winding of the coil, although it should be realized that simple reversal and adjustment of parts in an obvious manner will allow the coil to be wound in a counterclockwise direction.

With reference again to FIG. 1, a flat copper workpiece 22, which may be drawn from a reel or any other suitable fixture, is led through a cleaning and straightening device (not shown) and placed flat on the horizontal surface of the cross-slide 14 between a coil die 26, having ends 25 and 27 and mounted rigidly on the cross-slide and a wiper bar 34.

Before starting the winding operation, the index table and cross-slide must be properly positioned. This means that the table 12 must be so positioned that a shot pin (not shown) actuated by a cylinder 46 engages a slot 48 in the table to hold it against rotation. Further, the cross-slide 14 must be positioned at its extreme left position (as opposed to the illustrated extreme right position).

A pushbutton in a control panel 42 may then be activated to operate a solenoid valve which directs oil to a cylinder 30, exerting force on a backup ram slide 32 so as to move the wiper bar into position to receive the edge of the copper material within a slot 35 in the bar. This maintains the workpiece flat against the slide 14 while holding it tightly against coil die 26. If desired, a set of ram pressure controls 28 may be provided

so that the pressure exerted on the workpiece may be varied according to the requirements for forming different dimensioned copper coils. The lead end 40 of the workpiece may be held by suitable retaining means (not shown) such as a pin and wedge block.

When this has been accomplished, a foot switch 44 may be actuated, causing the cross-slide 14, die 26, and workpiece 22 to move toward the right-hand side of the machine to the position shown in FIG. 1. This is accomplished by means of a rack and gear unit generally shown at 50 which is driven by a torque actuator 52.

When the cross-slide reaches the extreme right position, a limit switch (not shown) is actuated to operate controls which cause cylinder 46 to withdraw the shot pin from channel 48. Complete retraction of the shot pin serves to actuate another switch, causing a clutch actuating cylinder 54 to operate. The clutch actuated by cylinder 54 causes a gear 56 to be locked to its shaft 57 which, in turn, is fixed to the underside of the index table 12. When the clutch is engaged by cylinder 54, another switch is actuated causing a cylinder 60 to move a rack 58 toward the front of the machine to rotate the gear 56. Since the gear 56 is locked up to the table 12 via shaft 57, the table will rotate 180°.

The controls then cause the clutch actuating cylinder 54 to disengage the clutch, cylinder 46 to reengage the shot pin in channel 48, and cylinder 60 to move rack 58 to the original position—since gear 56 will now rotate freely on the shaft 57. When the shot pin is in, the controls again cause the actuator 52 to function, driving the cross-slide 14 to the right. The turning and indexing cycle is then repeated as often as necessary.

If desired, a counter 62 may be provided to record one count for each 360° movement of the index table.

During the winding operation, the wiper bar 34 maintains pressure on the lower turn of the coil, in a manner to be described, and provides wiping action to form the copper tightly to the die as the table indexes and the copper is bent around the die end. The shape of the finished edge-wound coil is that of a spring with elongated turns, when using the die illustrated in FIG. 1. This edge-wound coil may be insulated after winding has been completed.

When winding flat-on-flat coils, i.e., the larger, flat part, of the workpiece abuts the die. The same machine sequence is carried out, but the copper must be fed to the machine in a position in which it is rotated 90° about its longitudinal axis from the position shown in FIG. 1. Thus, the narrow dimension of the workpiece is flat against the slide 14 and the widest dimension is flat against the side of the die 26.

When winding flat-on-flat coils, the interturn insulation may be wrapped along with the copper material as the coil is being formed. The insulation may be drawn from a spool of insulating material 70 which can be mounted on either side of the table 10.

EDGE-WOUND COIL WIPER BAR

Now with reference to FIGS. 2 and 3, illustrations are shown of two views of a wiper bar which may be utilized to form edge-wound coils.

The bar 34 has a top surface 111 which is ground so as to have a surface 113 at an angle of 5° from true right angle disposition to the upright or mounting portion 115 of the bar. A further slope 117 of 7°, ground along the length of the bar, provides a 12° slope from horizontal for the surface 117 when added to the 5° reference slope of surface 113.

The top surface of the bar is then further ground at a 2° slope upward from a line 119, in both directions, resulting in equally sloped surfaces 121 and 123 and an approximately one-sixteenth inch thickness of the top surface at point 125. The radius of point 125 and the surface 127 of slot 35 may be honed to a fine finish and chrome plated so as to minimize the abrasive action on the copper being formed. A rectangular plate 129 may be used to close the bottom of the conductor retaining slot 35.

In forming an edge-wound coil, when the die 26 reaches the extreme rightward position, as illustrated in FIG. 1, the left-hand edge of the die should be located opposite point 125 on the wiper bar. The table is then rotated and indexed until the positions of ends 25 and 27 of the die have been reversed. In other words, end 27 is now positioned opposite point 125. The end 40 of the workpiece then rides up on the 2° slope on the top surfaces 121 and 123 and the next turn of the workpiece is held within slot 35. Die 26 may be slightly tapered so as to permit the formed loops to move upwardly, and the turn to which pressure is applied by the wiper bar is always at the bottom of the coil. Thus, as each succeeding index of the die occurs, the next-to-the-last formed turn will ride up onto the top of the wiper bar.

Although the bar may be ground in a different fashion, it has been found that, with surfaces 121 and 123 at a 2° slope, the thicknesses of the edge of the wiper bar above slot 35—approximately three-eighths inch at the left side of the bar, one-sixteenth inch at point 125, and approximately one-fourth inch at the right side of the bar—produce satisfactory formation of the coils.

Mounting holes 131 may be provided in upright portion 115 to hold the wiper bar to the backup ram 32.

FLAT-TO-FLAT COILS WIPER BAR

As previously described, when it is desired to form a flat-to-flat coil, the workpiece 22 must be rotated 90° about its axis. Further, the wiper bar 34 must be replaced with a bar 211 such as is illustrated in FIGS. 4—6.

The housing or body 213 of the bar 211 is formed with a channel 215 extending its full length. The lower part of the housing is also provided with a machined cutout 217, for reasons which will be explained below. A pair of end closures 219 form flanged surfaces which aid in properly positioning the wiper bar against the ram slide face plate.

A mounting block 221 is bolted to the left side of the housing 213 and carries a plurality of stationary rollers 223 which ride on the upper surface of the copper material. It also carries a plurality of rollers 225 which bear against the flat, upright section of the workpiece.

A movable roller assembly, consisting of rollers 227, 229, and 231, attached to a lever unit 233, is fixed to a mounting block 235 by a bolt 237, about which the lever unit 233 is pivoted, permitting rollers 229 and 231 to be movable about the bolt.

As shown in the drawings, rollers 227 and 229 are mounted beneath the lever 233 and roller 231 is mounted on top of the lever. With the roller assembly mounted to the wiper bar, roller 227 remains in line with the rollers 225 regardless of the position of lever 233. On the other hand, roller 231 is free to move within the cutout 217 and roller 229 is free to move about the end of the coil die 26.

A hydraulic cylinder 241, mounted on one of the end closure 219, has a piston rod 243 extending therefrom which is attached to the end of the rectangular bar 245. The bar is slidably retained within the channel 215 by inset cover plates 247, 249, and the mounting block 235. A slot 251 is machined in the lower edge of the bar and roller 231 fits within the slot.

When the assembly 211 is used in the coil winder, pressure is exerted on it by the backup ram slide to hold the copper material against the coil die. At the same time, cylinder 241 is pressurized to apply a force on roller 231 through bar 245. When the flat side of the coil die is centered along the wiper bar, lever 233 will be turned in a counterclockwise direction, moving roller 231 to the left within cutout 217, until the surfaces of rollers 225, 227, and 229 are aligned and bearing against the copper material to hold it tightly to the coil die.

When the cross-slide has moved as far to the right as possible and the table is indexed, the conductor material and coil die will move to a position as shown in phantom FIG. 5 as the table is indexing, since the pressure in cylinder 241 forces roller 231 to the right within cutout 217 when roller 229 is no

longer against the flat portion of the die. Thus, rollers 227, and 229 maintain a force on the conductor material, causing it to be cold worked around the end of the coil die, eliminating any possibility of looseness in the coil. When the table has been indexed 180°, roller 229 will have reached its limit in the clockwise pivot about bolt 237 and, when the cross-slide moves to the right again, lever 233 will be forced to move back in a counterclockwise direction against the pressure in cylinder 241.

As successive flat-on-flat turns are added to the coil, pressure is maintained upon the assembly 211 by the backup ram slide 32 (FIG. 1) due to the force applied by cylinder 30.

If desired, the hydraulic circuits for cylinder 30 and cylinder 241 may include relief valves set to maintain the desired force on the backup ram slide and the bar 245, causing the workpiece to be wiped around the coil die and provide a coil of tightly wound construction with no interturn voids.

As previously described, insulating material may be drawn from the spool 70, shown in FIG. 1, and positioned between the turns of the coil as it is wound upon the die.

Thus, the Applicants have disclosed a coil winding machine which produces coils of much higher quality than those manufactured on presently known machines. Further, wiper bars have been disclosed for use with the machine of this invention which allow the production of high quality coils of both edge-wound and flat-to-flat configurations. Although only a single embodiment for each of these features have been illustrated and described herein, it will be obvious to those skilled in the art that many modifications and alterations may be made to these embodiments within the scope of the following claims. For example, a positive linkage could be employed to replace roller 231, bar 245, etc., while attaining the same result in winding flat-to-flat coils.

I claim:

1. A coil winding machine comprising a coil die, a flat surface upon which the coil die is mounted, a wiper bar positioned adjacent the coil die, means on the wiper bar for holding the workpiece against the coil die and against the flat surface, power means for exerting a force on the wiper bar to hold a coil workpiece between the coil die and the wiper bar, and means to both rotate and translate the coil die whereby the coil die moves both rotatively and transversely past the wiper bar.

2. The coil winding machine of claim 1 wherein the means on the wiper bar for holding the workpiece against the coil die and against the flat surface comprises a slot extending along the workholding edge of the wiper bar to hold the workpiece against both the coil die and the flat surface.

3. The machine of claim 2 including an upper surface on the wiper bar, and means on the upper surface forcing previously formed turns of the coil away from the flat surface upon which the coil die is mounted.

4. The machine of claim 3 wherein the forcing means includes machined portions of the upper surface.

5. The machine of claim 4 wherein the machined portions are so positioned as to cooperate with the ends of the coil die as the coil die is being rotated.

6. A coil winding machine comprising a coil die, a flat surface upon which the coil die is mounted, a wiper bar positioned adjacent the coil die, means exerting a force on the wiper bar to hold a coil workpiece between the coil die and the wiper bar, a first plurality of rollers on the wiper bar holding the workpiece against the coil die, a second plurality of rollers on the wiper bar holding the workpiece against the flat surface, and means to rotate and translate the coil die relative to the wiper bar.

7. A coil winding machine comprising a coil die, a flat surface upon which the coil die is mounted, a wiper bar positioned adjacent the coil die, means on the wiper bar for holding the workpiece against the coil die and against the flat surface, means exerting a force on the wiper bar to hold a coil workpiece between the coil die and the wiper bar, a lever mounted on the wiper bar, a plurality of work forming means mounted on the lever, means in the wiper bar pivoting the lever about one of the plurality of work forming means, and means to rotate and translate the coil die relative to the wiper bar.

8. A coil winding machine comprising a coil die, a flat surface upon which the coil die is mounted, a wiper bar positioned adjacent the coil die, means on the wiper bar for holding the workpiece against the coil die and against the flat surface, means exerting a force on the wiper bar to hold a coil workpiece between the coil die and the wiper bar, a lever mounted on the wiper bar, a plurality of work forming means mounted on the lever, and means to maintain the plurality of work forming means in alignment with the means on the wiper bar which hold the workpiece against the coil die when a flat surface of the coil die is opposite the lever, but which moves at least one of the plurality of work forming means out of such alignment when a curved surface of the coil die is opposite the lever.

9. A wiper bar comprising an elongated member having a slot extending along the length thereof and an upper surface thereon above the slot, the upper surface having at least one machined portion thereon at an angle relative to the main dimensional planes of the wiper bar, and wherein one machined portion of the upper surface is at an angle of approximately 5° relative to a plane extending from the slot, and a second machined portion is at an angle of approximately 12° relative to the plane extending from the slot.

10. The wiper bar of claim 9 including a third machined portion extending perpendicular to the one machined portion and the second machined portion.

11. The wiper bar of claim 10 wherein the third machined portion is at an angle of approximately 2° relative to the plane extending from the slot.

12. A wiper bar comprising means for holding a workpiece along at least two dimensional surfaces thereof, and workpiece forming means mounted on the wiper bar in alignment with the holding means which act upon one of the dimensional surfaces of the workpiece, and means for moving at least one of the workpiece forming means out of such alignment by a pivotal movement of the at least one workpiece forming means about at least one other workpiece forming means.

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