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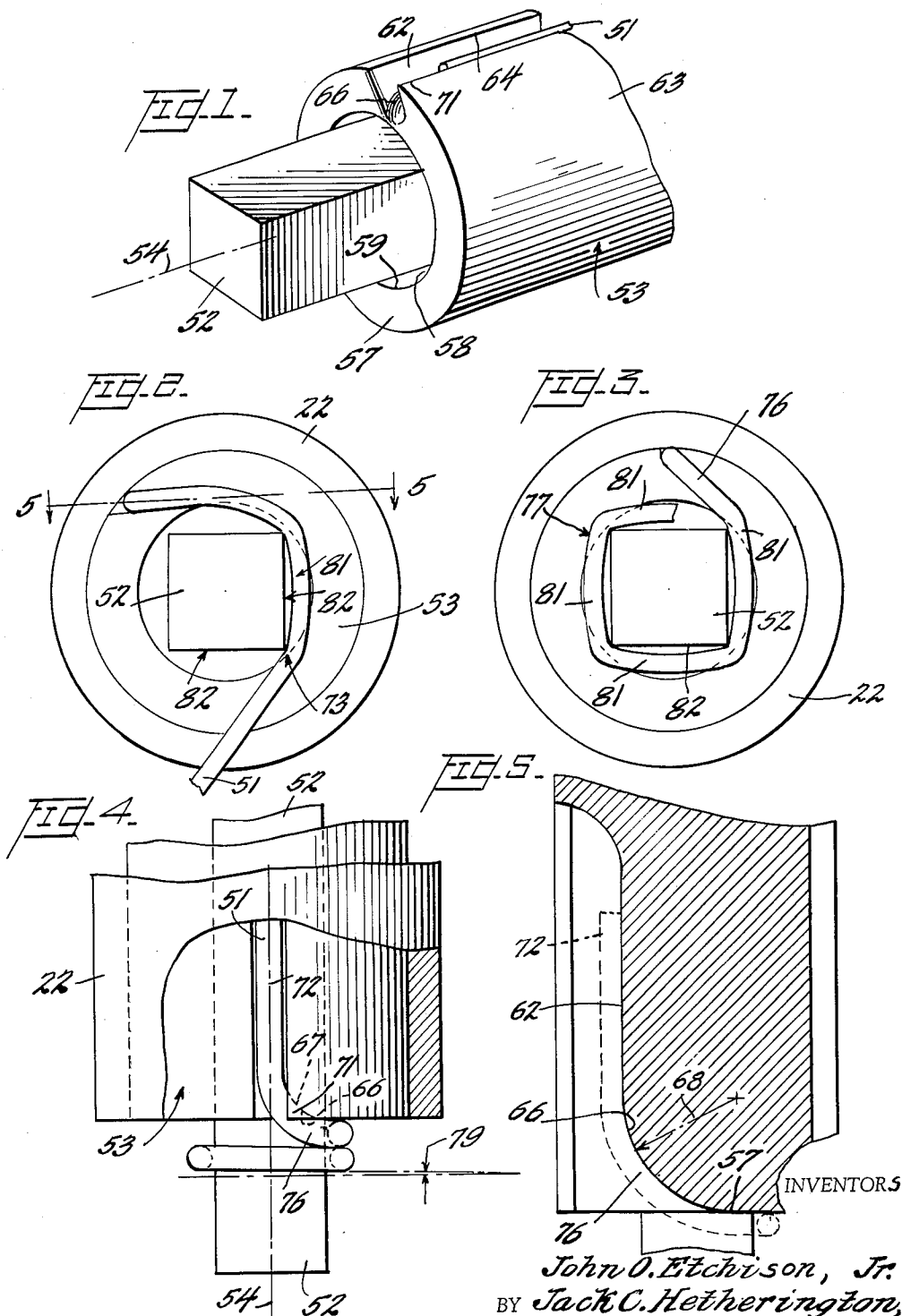
J. O. ETCHISON, JR., ETAL

3,213,894

METHODS OF AND APPARATUS FOR CONNECTING A STRAND AND
AN ELONGATED MEMBER AND METHODS OF
MANUFACTURING SUCH APPARATUS

Filed Oct. 15, 1962

3 Sheets-Sheet 1



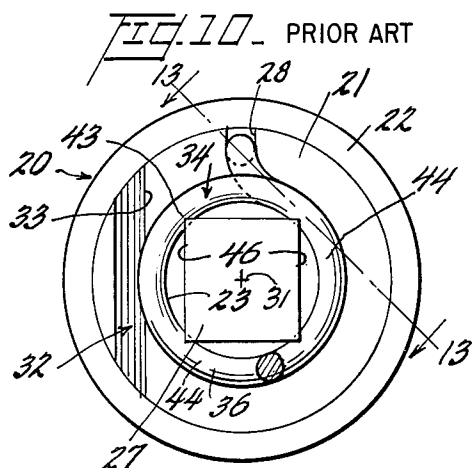
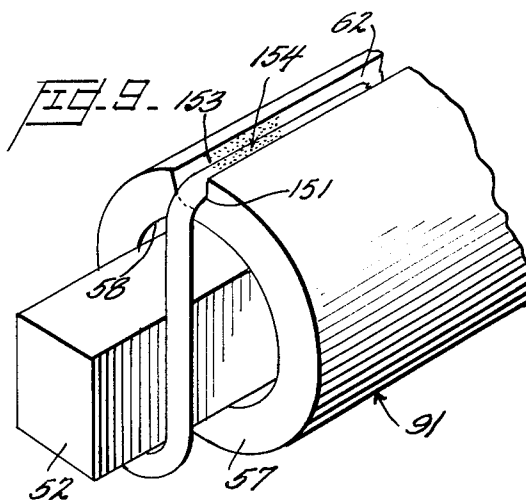
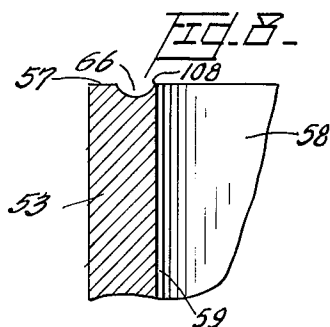
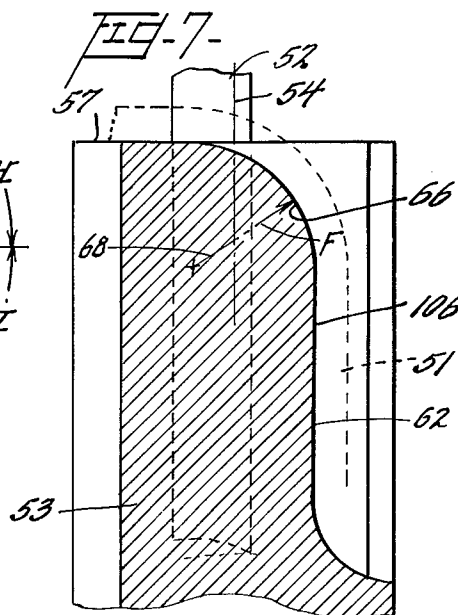
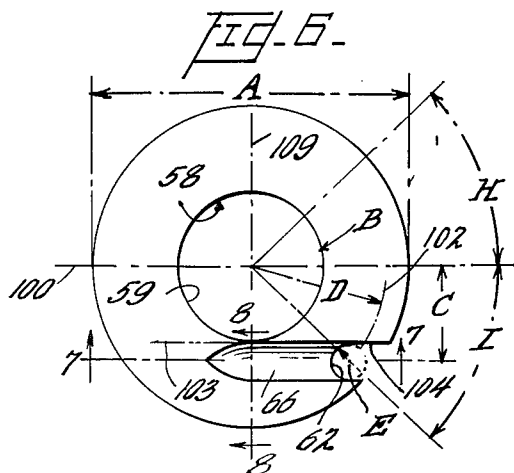
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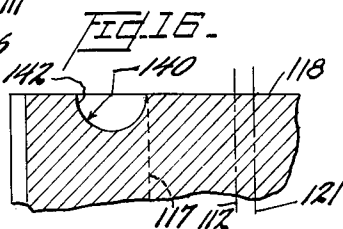
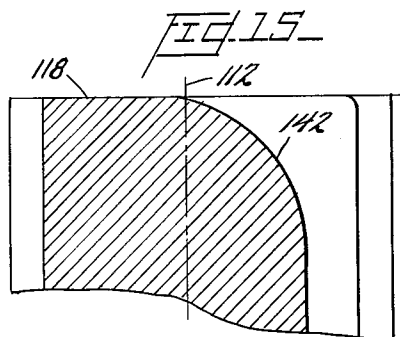
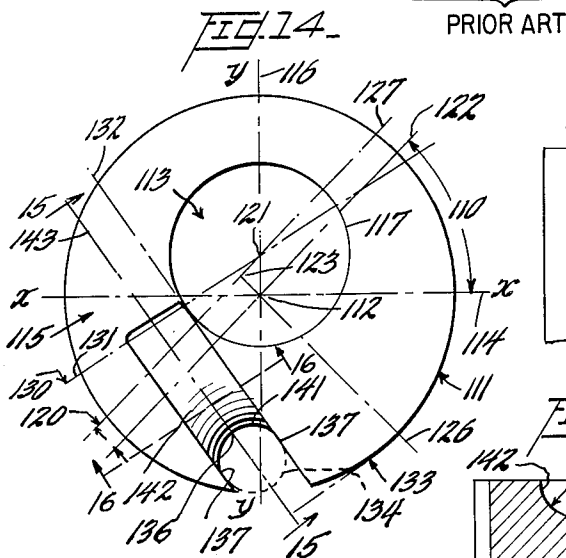
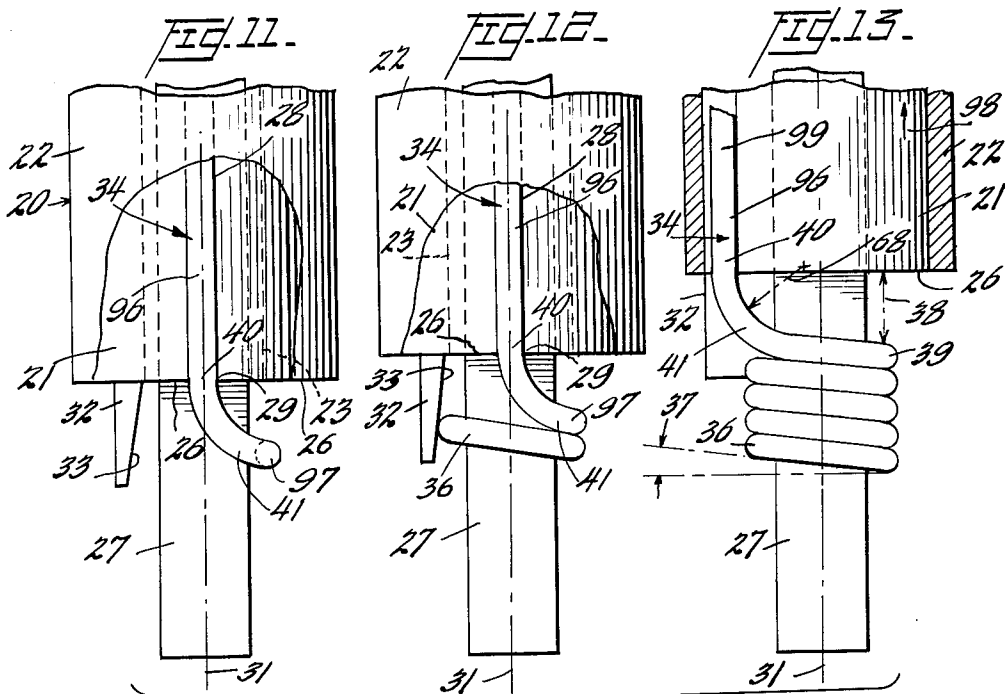
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METHODS OF AND APPARATUS FOR CONNECTING A STRAND AND AN ELONGATED MEMBER AND METHODS OF MANUFACTURING SUCH APPARATUS

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This invention relates to methods of and apparatus for connecting a strand and an elongated member and to methods of manufacturing such apparatus. More particularly, this invention relates to methods of and apparatus such as a bit for wrapping wire strand on a terminal, and to methods for manufacturing such apparatus.

In the manufacture of electrical units, it is sometimes necessary to connect strands to elongated members. More particularly, in the manufacture of electrical units such as printed circuit boards, telephone terminal banks used in the communications field, etc., it is necessary to wrap strands such as electrically conductive filaments, wire, or metal terminals, extending from a component, onto elongated terminals mounted on the printed circuit board, terminal bank, etc. to mechanically and electrically connect the strand to the terminal.

In the past, apparatus for connecting a strand and an elongated member such as a terminal, has included a generally cylindrical bit having a longitudinal recess extending from an end surface into the bit for receiving the terminal. Such prior apparatus has also been provided with a longitudinal groove machined in the outer peripheral surface of the bit. The longitudinal groove intersects and forms a corner with the end surface to direct strand onto the terminal during a wrapping operation.

In the use of such prior apparatus, a tubular sleeve is mounted over the bit and the bit and the sleeve are mounted on a rotary spindle. The bit is placed over the terminal so that the terminal extends into the longitudinal recess. A strand, such as wire, is fed into the groove with an end portion thereof extending out of the groove and temporarily secured to the terminal. To commence wrapping, the spindle is driven for rotating the bit and the sleeve so that the longitudinal groove rotates around the terminal. As the bit rotates, the wire advances out of the longitudinal groove in the direction of the axis of the terminal. The axially advancing wire is engaged and thrust transversely to the axis of the terminal by the corner of the longitudinal groove and is thereby wrapped in the form of convolutions onto the terminal. As the convolutions are wrapped, the last-wrapped convolution urges the bit off the terminal in opposition to a force—known as “the back force”—that is applied to the bit through the spindle.

Two principal criteria have been established for determining the quality of wrapped connections between wires and terminals. First, the connection must not advance axially relative to the terminal during a “strip” test wherein measured forces are applied to the wire in the direction of the axis of the terminal. Secondly, the wire must not break or fail during an “unwrap” test wherein the wire is unwound from the terminal.

Testing connections wrapped by the prior bits in view of these criteria, indicates that significant problems accompany the use of the prior bits. More particularly, the tests indicate that the back force applied to the bit must be carefully regulated because increases in the back force cause the wire to be wrapped too tightly on the terminal. When the wire is wrapped too tightly on the terminal, the corners of the terminal bite into the wrapped

convolutions to such an extent that the connection fails the “unwrap” test.

Accordingly, prior efforts have been directed toward decreasing the back force in an attempt to preclude failures during the “unwrap test.” When the back force is significantly reduced, it has been found that the prior bits wrap convolutions having a nearly perfect circular configuration. As a result, only four small points of each circular convolution of wire contact the terminal, rendering the connection likely to fail the “strip test.” To increase the amount of contact between the wire and the terminal by means other than varying the back force, projections are generally formed on the end surface of prior bits. These projections are provided with what is known as wiping surfaces, which rotate with the bits, engaging and pressing the wrapped convolutions of wire onto the terminal. The wiping surfaces are effective to force the wire against the corners of the terminal and increase the amount of contact between the wrapped wire and the terminal. However, experience indicates that the wiping surfaces, by impressing the circular convolutions of wrapped wire onto the terminal, create cuts in the circular convolutions of wire which appear to be additional causes of failures during the “unwrap” test.

Additionally, as a result of the tests made in view of the above-mentioned criteria on connections wrapped by the prior bits, it is believed that the corners of the prior bits, formed by the intersection of the longitudinal grooves and the end surfaces, work-harden the wire and render the wire subject to cracking as it is wound onto the sharp corners of the terminal. Failures are believed to occur during the “unwrap” test because of this work-hardening and cracking. Also, the friction that occurs at the corners during the work-hardening is believed to cause erosion of the corner and consequent roughening and scratching of the surface of the wire. Because of the erosion of the corner, the average life of such wrapping bits has been found to be only six to seven days, during which an approximate average of only 6,000 connections have been wrapped. The eroded bit must be reworked to make the corner smooth, or if the erosion is too severe, the bit discarded.

Problems have also arisen in attempting to prevent such wear and erosion of the corner of the longitudinal groove. Hardening processes, such as carbonizing, which have been performed at the corner, have been ineffective to significantly increase the life of the bit, while rendering such bits extremely costly. Accordingly, excessive bit reworking and replacement is necessary, rendering the use of such prior wrapping bits very expensive.

Research has been conducted to determine the source of the above-mentioned problems in an endeavor to provide a simple and inexpensive wrapping bit having characteristics of long life and freedom from the above-mentioned problems and limitations. During such research, close examination has been given to the details of the wire wrapping operation. In this examination, it has been discovered that the axial and transverse components of motion of the wire advancing out of the longitudinal groove, resolve according to the characteristics of the wire so that the wire assumes an arcuate path between the corner of the longitudinal groove and a first point of contact with the terminal. More particularly, it has been discovered that the wire naturally assumes an arcuate path which has a predetermined radius of bend, which is hereinafter termed the “natural bending radius” of the wire.

As a result of the discovery of this natural bending radius, the source of the limitations and problems attendant use of the prior bits has, for the first time, been discovered. Thus, it has been found that by providing, at a predetermined location on the bit, an arcuate strand

forming surface having the natural bending radius of a strand to be wrapped, the problems attendant prior bits are reduced to insignificant proportions. Moreover, connections wrapped by bits provided with such forming surfaces, withstand extraordinarily high forces during the "strip" test, while passing the "unwrap" test.

Significantly, experiments conducted with bits manufactured according to the principles of this invention, indicate that the bits are capable of wrapping acceptable connections for at least seventy-two working days without showing signs of wear or erosion. Also, it has been determined that back force is not critical to the wrapping of acceptable connections with the bits of the present invention, and that less marring of the wire is evident because of the natural flow of wire around and in continuous contact with the forming surface of the bits of the present invention.

No less important, it has been found that bits embodying the principles of the present invention wrap connections which are highly stable. That is, four convolutions of a six convolution wrapped connection may be unwrapped from the terminal before the remaining two convolutions will rotate relative to the terminal. Furthermore, simple and inexpensive techniques may be employed to manufacture the present bits from inexpensive stock material, rendering costly material and hardening operations unnecessary.

An object of the present invention is to provide new and improved methods of and apparatus for connecting a strand and an elongated member.

Another object of the present invention is to provide a simple and inexpensive apparatus and method of manufacturing such apparatus for wrapping wire strand onto a terminal.

Still another object of the present invention is to provide new and improved wire wrapping facilities for producing a connection between a wire and a terminal wherein the quality of the connection is significantly increased.

An additional object of this invention resides in the provision of an apparatus and methods of making such apparatus for wrapping wire strand onto a terminal wherein the apparatus is provided with characteristics of long life and freedom from limitations and problems attendant prior wrapping apparatus.

A further object of this invention resides in a wire provide a wire guide groove having a radius corresponding to the natural bending radius assumed by the wire during wrapping.

A still further object of this invention is to provide an elongated wire wrapping facility having an end surface and a longitudinal groove for supplying wire along an arcuate surface that undercuts the periphery of the facility wherein the surface is provided with a predetermined radius and formed tangent to the groove and the end surface.

A related object of this invention resides in the provision of a universal bit for wrapping wires having various diameters wherein the bit is provided with a wire forming surface for engaging an entire section of the wire that naturally assumes a predetermined curved configuration during wrapping onto a terminal.

With these and other objects in view, the present invention contemplates apparatus such as a bit for connecting a strand and an elongated member such as a terminal according to one method of the present invention. The bit is provided with a flat end surface and a recess extending from the end surface into the bit for receiving the terminal. A longitudinal groove machined in the peripheral surface of the member extends toward the end surface. A strand forming surface is formed in the bit tangent to both the recess and the end surface and extends arcuately under the periphery of the bit into tangential intersection with the groove. The arcuate configuration of the strand forming surface corresponds to

the natural bending radius assumed by the strand during wrapping.

Additionally, with the foregoing objects in view, the present invention contemplates a method of manufacturing apparatus, such as a bit, for wrapping strand onto a terminal wherein the strand during the wrapping naturally assumes a curved configuration having a predetermined natural bending radius. A workpiece, such as a bit blank, is provided with an end surface, a terminal receiving recess extending from the end surface, and a longitudinal groove formed in the periphery of the blank and terminating at the end surface. The natural bending radius of the strand is determined. Then a strand forming surface is formed in the bit blank tangent to both the recess and the end surface and extending arcuately into tangential intersection with the longitudinal groove. The arcuate configuration of the surface is formed in conformity with the natural bending radius of the strand.

A complete understanding of this invention may be had by reference to the following detailed description when read in conjunction with the accompanying drawings illustrating preferred embodiments thereof, wherein:

FIG. 1 is a perspective view of an apparatus of the present invention manufactured according to one method of this invention for wrapping strands such as wire onto terminals according to another method of this invention, showing a bit provided with an arcuate strand guideway having a radius conforming to the natural bending radius of the strand;

FIG. 2 is an elevational end view of the bit shown in FIG. 1 illustrating the bit rotating to advance a strand through the guideway and onto a terminal received in a recess provided in the bit;

FIG. 3 is a view similar to FIG. 2 showing a convolution of strand wrapped in a generally square configuration on the terminal upon further rotation of the bit;

FIG. 4 is a plan view of the bit shown in FIG. 1 illustrating a longitudinal groove formed in the bit tangent to the arcuate guideway for guiding a strand to the arcuate guideway during a wrapping operation;

FIG. 5 is a cross-sectional view taken on line 5—5 of FIG. 2 showing a forming surface of the strand guideway having the natural bending radius of the strand and formed tangent to the end surface of the bit and tangent to the strand groove;

FIG. 6 is an end view of the bit shown in FIG. 1 provided with reference letters designating various dimensions of the bit;

FIG. 7 is a cross sectional view taken on line 7—7 of FIG. 6 showing the strand guideway having the natural bending radius of the strand and formed tangent to the end surface of the bit and tangent to the strand groove in conjunction with additional reference letters indicating additional dimensions of the bit;

FIG. 8 is a cross sectional view taken on line 8—8 of FIG. 6 illustrating the transverse configuration of the forming surface of the strand guideway;

FIG. 9 is a perspective view of a bit blank which may be employed in practicing the method of the present invention to manufacture a wrapping bit having the strand forming surface shown in FIG. 7;

FIG. 10 is an end view of a prior bit illustrating the generally circular configuration of convolutions of wire wrapped by the prior bit in conjunction with sharp corners of the terminals which project into the inner surfaces of the convolutions of the wire;

FIG. 11 is a plan view of the prior wrapping bit shown provided with a longitudinal groove forming a corner at the intersection thereof with an end surface of the prior bit in conjunction with a projection having a wiping surface for pressing the convolutions of wire into the terminal;

FIG. 12 is a plan view of the prior bit similar to FIG. 11 showing convolutions of wire wrapped on the terminal

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while determining the natural bending radius of the wire;
 FIG. 13 is a cross sectional view of the prior bit taken along line 13—13 of FIG. 10 illustrating the spacing of the end surface of the prior bit from the wrapped convolutions of wire in conjunction with the natural bending radius of the wire;

FIG. 14 is an end view of another embodiment of the present invention showing a universal bit for wrapping various strands having different diameters onto a terminal and illustrating a terminal receiving recess formed eccentrically with respect to the center of the universal bit;

FIG. 15 is a cross sectional view taken on line 15—15 of FIG. 14 showing a strand forming surface formed with the natural bending radius provided in the universal bit; and

FIG. 16 is a cross sectional view taken on line 16—16 of FIG. 14 showing the transverse configuration of the strand forming surface provided on the universal bit.

Prior wrapping tool

A description of and the significant advantages of the present invention may best be appreciated by referring first to FIGS. 10 and 11, wherein a prior or standard wire wrapping tool 20 is shown including a shaft or bit 21, which is sometimes referred to as a spindle or wrapping head. The prior bit 21 is received in a sleeve 22 for rotation therewith under the action of a motor (not shown). The bit 21 is provided with a central recess 23 extending axially from an end surface 26 (FIG. 11) for receiving a terminal 27 having a longitudinal axis 31. A groove 28 extending from the end surface 26 is formed in the periphery of the bit 21. A corner 29 (FIG. 11) is formed by the intersection of the groove 28 and the end surface 26. A projection 32 extending from the end surface 26 adjacent to the corner 29 is provided with a sloped wiping surface 33.

In the operation of the prior bit 21, the terminal 27 is inserted in the recess 23, whereafter a length of strand, such as wire 34, is inserted in the groove 28. One end of the wire 34 is then temporarily secured to the terminal 27. The sleeve 22 and the bit 21 are then rotated as a unit relative to the terminal 27. Upon rotation of the bit 21 and the sleeve 22, the wire 34 advances out of the groove 28 parallel to the axis 31 of the terminal 27 and is directed by the corner 29 in a path that is transverse to the axis 31. The wire 34 advances in the transverse path and is wrapped on the terminal 27 in the form of helical convolutions 36 having a helix or lead angle 37 (FIG. 13) and a generally circular configuration (FIG. 10).

During the wrapping operation, the end surface 26 of the prior bit 21 is spaced by a distance 38 from the last wrapped convolution 39 of wire 34 as shown in FIG. 13. Additionally, the corner 29 at the intersection of the longitudinally groove 28 and the end surface 26 engages a section 40 of the wire 34 which is advancing in a direction parallel to the axis 31 and which is remote from the last wrapped convolution 39. An arcuate or transverse section 41 of the wire 34 is not engaged by the prior bit 21, but is free and advances transversely onto the terminal 27 without additional guiding forces being applied thereto by the prior bit 21.

Referring in detail to FIG. 10, the helical convolutions 36 wrapped by the prior bit 21 are shown having the generally circular configuration when viewed along the axis 31 of the terminal 27. The wiping surface 33 of the projection 32 has engaged and pressed the wrapped convolutions 36 against the corners 43 of the terminal 27 so that the corners cut into the wire 34 to increase the amount of contact between the wire and the terminal. The wiping surface 33 may also have been effective to press arcuate sections 44 of the wrapped convolution 36 toward the sides 46 of the terminal 27 as the wire 34 is forced against the corners 43 of the terminal. Thus the

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wiping surface may have been effective to partially deform the circular configuration of the wrapped convolutions 36.

Square wrap bit

Attention is now directed to FIG. 1 wherein there is shown an apparatus constructed according to the principles of the present invention for connecting a strand 51, such as an electrically conductive filament, wire, etc., and an elongated member 52, such as a terminal. The apparatus includes an elongated, generally cylindrical, "square-wrap" bit 53 having a central longitudinal axis 54. A recess 58 having a generally cylindrical wall 59 extends from a flat end surface 57 parallel to the axis 54 into the bit 53 for receiving the terminal 52. A longitudinal groove 62 is formed in the outer peripheral surface 63 of the bit 53 and extends from the end surface 57 in the direction of the axis 54. The longitudinal groove 62 is formed so that the surface 64 thereof has an arcuate cross-section. Adjacent to the intersection or junction of the longitudinal groove 62 and the end surface 57, there is provided a wrapping section or a strand forming surface 66, etc., that extends arcuately from the longitudinal groove into intersection with the end surface 57. The arcuate configuration or contour of the forming surface 66 is formed in conformity with and congruent to the natural bending radius 68 (FIGS. 5 and 7) of the strand 51 that is to be wrapped and connected to the terminal 52.

Considering the forming surface 66 in further detail by reference to FIGS. 1 and 4, provision of the forming surface 66 in the bit 53 is shown to be effective to form an arcuate or curvilinear slot or guideway 67 having the arcuate forming surface 66 as a lower surface. The forming surface 66 and the guideway 67 undercut the periphery 63 of the bit 53 and form a lip 71. More specifically, and now referring also to FIGS. 5 and 6, the forming surface 66 is shown formed tangent to both the end surface 57 and the wall 59 (FIGS. 1 and 6) of the cylindrical recess 58 and extends into tangential intersection with the longitudinal groove 62.

In operation, the bit 53 is enclosed in the tubular sleeve 22 (FIGS. 2-4) that is provided with an inside diameter equal to the outside diameter of the bit 53. The terminal 52, which may be mounted against rotation on a support (not shown), and the enclosed bit 53 are moved axially relative to each other to insert the terminal 52 in the cylindrical recess 58. Next, a length 72 (FIGS. 4 and 5) of the wire 51 is inserted through the guideway 67 around the forming surface 66 for advancement axially into the longitudinal groove 62. A trailing end 73 (FIG. 2) of the wire 51 is then temporarily secured to the terminal 52 and the bit 53 and the sleeve 22 are rotated relative to the terminal. As shown in FIGS. 2 and 4, as the bit 53 and the sleeve 22 rotate, the wire 51 advances through the longitudinal groove 62 toward the forming surface 66 and the terminal 52 in the direction of the longitudinal axis 54 of the bit. A section 76 (FIGS. 3-5) of the axially advancing wire 51 is engaged by the forming surface 66 and is thrust thereby transversely to the axis 54 of the bit into a predetermined arcuate configuration. The transversely thrust arcuate section 76 of wire 51 advances around and in continuous contact with the forming surface 66 into contact with the flat end surface 57 (FIG. 5). The wire 51 advances along the flat end surface 57 onto the terminal 52 in the form of generally "square" convolutions 77 of wire as shown in FIG. 3. The engagement of the end surface 57 with the wire 51 as the convolutions 77 are wrapped, is effective to urge the bit 53 off the terminal 52 at a uniform rate so that the convolutions 77 of wire are connected to the terminal at uniform helix angle 79 (FIG. 4).

By maintaining control of the transversely advancing section 76 of wire 51 just prior to the contact of the wire with the terminal 52, the forming surface 66 is effective to form the convolutions 77 in the generally "square"

shape or configuration. Thus, as shown in FIG. 2, a first section 81 of the wire has been laid nearly parallel to one side 82 of the terminal 52. Referring to FIG. 3, a complete convolution 77 of wire wrapped by the bit 53 is shown having four such sections 81 which are wrapped closely parallel to the sides 82 of the terminal 52 and thus assume the generally "square" configuration.

The present invention includes a method of manufacturing the bit 53 for wrapping the wire 51 onto the terminal 52. The method utilizes the characteristic which the wire 51 has during wrapping of naturally assuming an arcuate configuration having the natural and predetermined bending radius 68 (FIGS. 5 and 7). The method includes the steps of providing a bit blank 91 (FIG. 9) having the flat end surface 57, the longitudinal groove 62 formed in the periphery thereof, and the recess 58 for receiving the terminal 52 which is to be provided in the bit 53. The method further includes the step of forming in the bit blank 91 a surface, such as the strand forming surface 66 shown in FIGS. 1 and 7, that extends arcuately from the longitudinal groove 62 into intersection with the end surface 57. The arcuate contour of the surface 66 conforms to the predetermined natural bending radius 68 of the wire 51.

Considering in further detail the strand forming surface 66, attention is now directed to FIGS. 11, 12 and 13 for a description of a method for determining the natural bending radius 68 (FIG. 13) of the wire 51 (FIG. 1) or wire 34 that is to be wrapped by the bit 53 provided with the forming surface 66.

Initially, as shown in FIG. 11, the terminal 27 is inserted into the recess 23 of the prior bit 21 which has been enclosed by the sleeve 22. A first length 96 of wire 34 is inserted into the longitudinal groove 28 of the prior bit 21. A second length 97 of the wire 34 extending from the groove is temporarily secured to the terminal 27.

The bit 21 and sleeve 22 are then rotated relative to the terminal 27 as shown in FIG. 12 to wrap the convolutions 36 of wire onto the terminal. Before all of the first length 96 of wire 34 has been wrapped onto the terminal 27, for example, when four convolutions 36 have been wrapped on the terminal, the rotation of the bit 21 and the sleeve 22 is suddenly stopped. As shown in FIG. 13, the bit 21 and the sleeve 22 are then moved in the direction of the arrow 98 to expose the first length 96 of wire which extends in a path 99 parallel to the terminal 27. Also exposed, is the section 41 of the wire 34 which extends from the parallel path 99 arcuately onto the terminal. The radius 68 (FIG. 13) of the arcuate section 41, which is the natural bending radius of the wire 34, is then measured and recorded.

The above steps are repeated for each wire 34 or 51 of various types and gages of wire that are to be wrapped, and the respective natural bending radius 68 is formed on one of the bits 53 of the present invention.

The natural bending radius 68 determined by the above method may be provided on the bit 53 according to the following detailed description when considered in conjunction with FIGS. 6, 7, and 8. The description refers to certain dimensions of the bit 53 by means of reference letters A through I.

Referring first to FIG. 6, letter A represents the outside diameter of the bit 53. Letter B represents the diameter of the cylindrical recess 58. The bit 53 of this example is provided with a longitudinal groove 62 having a radius E formed in the periphery of the bit 53 at an angle I and a distance C from the X axis 100. The center of the longitudinal groove 62 also intersects a circular line 102 having a radius D. In this location, a line 103 drawn parallel to the X axis 100 and tangent to the wall 59 of the cylindrical recess extends into tangential engagement with a wall 104 of the longitudinal groove 62.

As shown in FIG. 7, the forming surface 66 is formed tangent to the lower surface 106 of the longitudinal groove 62 and is provided with a radius F which is the

natural bending radius 68 of the wire 51 to be wrapped onto the terminal 52. The arcuate forming surface 66 extends parallel to the line 103 as viewed in FIG. 6 and tangentially intersects the flat end surface 57 of the bit as shown in FIG. 7. As shown in FIG. 8, the forming surface 66 tangentially intersects the end surface 57 and forms a wall 108 between the arcuate surface 66 and the wall 59 of the cylindrical recess 58.

Another aspect of the present invention contemplates a method of connecting the strand or wires 51 and the elongated member or terminal 52. More particularly, the method of connecting the wire 51 and the terminal 52 is effective to wrap the wire onto the terminal according to the principles of the present invention. The method utilizes the characteristics of the wire 51, set forth above, of naturally assuming during wrapping a predetermined arcuate path having the natural bending radius 68 (FIGS. 5 and 7). In the practice of the method for connecting the wire 51 and the terminal 52, the wire is advanced in the direction of the axis 54 of the terminal. The advancing wire 51 is engaged and thrust or directed transversely to the axis 54 to form the section 76 (FIG. 3-5) having the predetermined arcuate configuration of the natural bending radius 68. The section 76 of the wire 51 is then guided by continuously contacting the wire along the natural bending radius to wrap the wire onto the terminal 52.

Another aspect of the present invention contemplates the provision of a universal "square" wrap bit 111 that is adapted to wrap various gages and types of wire 51 onto the terminals 52. Referring to FIGS. 14, 15 and 16, the universal bit 111 is shown generally cylindrical in configuration and has a central longitudinal axis 112 defined by the intersection of X and Y axes 114 and 116 respectively. A cylindrical recess 117 is formed through the end surface 118 of the bit 111 eccentrically with respect to and on one side 113 of the longitudinal axis 112. The center 121 of the recess 117 may be located by passing a line 122 through the longitudinal axis 112 of the bit at an angle 110 such as 45° measured from the X axis 114. A distance 120 such as 0.010 of an inch is then marked on a line 126 that is drawn perpendicular to the 45° line 112 and passes through axis 122. The point defined by the intersection of the parallel line 127 (drawn parallel to line 122) and the Y axis 116 is the center 121 of the cylindrical recess 117.

A wire guide groove may be located on the other side 115 of the axis 112 by drawing a line 131 through the center 121 of the recess 117 at an angle 130 such as 35° measured from line 127. A line 132, drawn perpendicular to the line 131 and tangent to the recess 117, extends across the end surface 118 of the bit into intersection with the periphery 133 of the bit. A circle 134 having a diameter equal to the largest diameter of wire 51 to be wrapped is positioned tangent to the line 132 and the periphery 133 of the bit 111. A section 136 of the circle which extends between points 137 indicates the lower surface of the longitudinal wire guide groove 141 that extends in an axial direction in the periphery 133 of the bit 111. As shown in FIG. 16 a universal wire forming surface 142 is provided with the same transverse diameter 140 as the diameter of the wire guide groove 141. As viewed in FIG. 16, the universal wire forming surface 142 is centered on a line drawn parallel to the line 132 (FIG. 14) and extends arcuately into tangential intersection with both the end surface 118 of the bit 111 and the wall of the recess 117. Universal bits 111 constructed according to the present example have successfully wrapped wires 51 having such various diameters as 0.016, 0.020 and 0.025 of an inch according to the wrapping operation described above for the bit 53 of the present invention.

In accordance with the method contemplated by the present invention for manufacturing a bit 53 (FIG. 1) for wrapping wire 51 onto a terminal 52, the bit blank

91 shown in FIG. 9 is enclosed with the tubular sleeve 22 shown in FIG. 4, and a terminal 52 is inserted into the longitudinal recess 58. A length of wire 51 is inserted into the longitudinal groove 62 and the bit blank 91 and the sleeve 22 are rotated relative to the terminal 52 to advance the length of wire 51 from the groove around a corner 151 that forms the intersection between the longitudinal groove 62 and the end surface 57 and onto the terminal 52. The wire forming surface 66 shown in FIG. 7 may be provided in the bit 91 by applying an abrasive compound 153, such as diamond lapping compound number 40-W-30, sold under trademark "Hyprez," to the advancing wire 51 and the longitudinal groove 62 at a point 154. The compound 153 is effective to form the surface 66 (FIG. 7) in the bit blank 91 in conformity with the natural bending radius 68 (FIG. 7) of the wire 51. Alternatively, and in accordance with the method of making bits 53 contemplated by the present invention, the abrasive coating 153 may be provided on the periphery of the wire 51 for forming the wire forming surface 66 in the bit blank 91 as the wire is wrapped onto the terminal 52.

According to a preferred method of manufacturing the bit 53 (FIG. 1) from a generally cylindrical bit blank 91 according to the principles of the present invention, the bit blank 91 (FIG. 9) is provided with the longitudinal recess 58 and the longitudinal groove 62 extending toward the flat end surface 57. The preferred method includes the provision of the prior bit 21 (shown in FIGS. 11-13) having the end surface 26. The prior bit 21 is also provided with the longitudinal recess 23 extending from the end surface 26 and the longitudinal groove 28 intersecting the end surface to form the corner 29. A portion of the terminal 27 is enclosed by inserting the terminal into the recess 23 of the prior bit 21, and the first length 96 of wire 34 is inserted into the longitudinal groove 28. The second length 97, which is the leading end of the wire 34, extends out of the longitudinal groove 28 and is temporarily secured to the terminal 27. The standard bit 21 and the terminal 27 are rotated relative to each other to advance a portion of the first length 96 of the wire 34 through the longitudinal groove 28, around the corner 29 and onto the terminal 27. The relative rotation between the bit 21 and the terminal 27 is suddenly interrupted so that a portion of the first length 96 of the wire 34 remains in the longitudinal groove. The portion of the first length 96 that advanced from the groove 28 extends in the arcuate path naturally assumed by the wire 34 as it advances around the corner 29 toward the terminal 27. The radius of the arcuate path naturally assumed by the wire, i.e., the natural bending radius 68 of the wire 34 is then measured (FIG. 13). An arcuate surface 66 provided with the natural bending radius 68 of the arcuate path of the wire 34 is then formed in the bit blank 91 tangent to both the groove 62 and the recess 58 of the bit blank 91 as shown in FIGS. 6 and 7.

Although the bits 53 have been described in conjunction with terminals 52 having a square cross-section, it is to be understood that the bits 53 successfully wrap convolutions 77 of wire on terminals having rectangular cross-sections.

It is to be understood that the above-described arrangements are simply illustrative of the application of the principles of this invention. Numerous other arrangements may be readily devised by those skilled in the art which will embody the principles of the invention and fall within the spirit and scope thereof.

What is claimed is:

1. In a device for winding strand onto an elongated member,
 - a bit means having a groove for maintaining the strand in an axial path, and
 - means formed in said bit means for directing the strand from said axial path in an arcuate path congruent to the natural bending radius of the strand onto said

elongated member, said means having an effective surface corresponding to said arcuate path so that said surface continuously engages the strand advancing in the arcuate path.

2. In a wrapping bit for providing a square-wrap coil of filament on a terminal having a square cross-section wherein the filament assumes a predetermined configuration during wrapping onto said terminal, said configuration being congruent to the natural bending radius of the filament;

an elongated member having a flat end surface, a peripheral groove for receiving said filament, and a recess for receiving said terminal; and

means formed in the member tangent to said flat end, the base of said groove, and said recess for defining an arcuate guideway having said predetermined configuration to form said square-wrap coil during said wrapping.

3. In a bit for wrapping metal strand onto an article;
 - an elongated member having a transverse end surface, a shank section, and a wrapping section terminating at the transverse end surface; said wrapping section being provided with a peripheral groove and an arcuate slot tangent to said groove and said end surface, said arcuate slot having a configuration congruent to the natural bending radius of the metal strand.

4. In a bit for wrapping wire onto a terminal,

a cylindrical member having an end surface and a cylindrical recess extending from said end surface into the member, said member being provided with a wire guide groove having a first axially extending section provided with a first guide surface and a second transverse section having a second guide surface, said second guide surface having a radius equal to the natural bending radius of the wire and being formed tangent at one end to said first guide surface and tangent at the other end to both the end surface and said cylindrical recess.

5. In a device for wrapping a strand onto a terminal, said strand having a characteristic of naturally assuming a predetermined natural bending radius during wrapping, a bit provided with a longitudinal axis and an end surface transverse to said axis,

means formed in the bit along said axis for receiving said terminal,

means formed in the periphery of said bit parallel to said axis for supplying strand to be wrapped onto said terminal, and

means including an arcuate surface undercutting the periphery of said bit, said arcuate surface having said predetermined natural bending radius of the strand and formed tangent to both the strand supplying means and to said end surface.

6. In a tool for connecting a wire and a terminal, a bit for winding the wire on the terminal upon relative rotation between the bit and the terminal,

said bit comprising a rod-like member having an end surface and a longitudinal recess extending from said end surface into the member for receiving the terminal, said member having a longitudinal groove formed in the periphery surface of the member and extending from said end surface, said member being provided with a guideway extending from said groove and terminating at said surface tangent to said recess and said end surface, said guideway being provided with an arcuate bottom surface having a radius substantially equal to the natural bending radius of the wire.

7. In a tool for wrapping a substantially square coil of strand onto a terminal having a substantially square cross-section,

a bit having a longitudinal axis for wrapping said coil upon rotation of said bit on said axis relative to said terminal, said bit comprising a generally cylindrical member having an end surface formed transversely

to said axis, said member also having a longitudinal groove extending from said end surface in the outer periphery thereof for guiding said strand, said end surface having a curvilinear groove originating tangent thereto and extending congruent to the natural bending radius of said strand into said member into tangency with said longitudinal groove, and a lip formed in said member overhanging and curvilinear groove for guiding said strand from the longitudinal groove into the curvilinear groove to lay a substantially straight length of said strand on each side of said terminal and form said square coil.

8. In a universal device for individually winding strands having large and small diameters onto an elongated member;

universal bit means having a central longitudinal axis and a recess formed parallel with and eccentric to said axis for receiving said elongated member, said bit means having a longitudinal groove for individually maintaining a strand in a path parallel to said axis; and

means formed in said bit means for individually directing a strand from said parallel path in an arcuate path congruent to the natural bending radius of the strand onto said elongated member, said means having an effective surface corresponding to said arcuate path so that said surface continuously engages a strand advancing in the arcuate path, said surface having an arcuate configuration extending transversely to said arcuate path for receiving a strand having a large diameter.

9. In a universal wrapping bit for providing square-wrap coils of various filaments having different diameters on terminals having square cross-sections wherein the filaments assume a predetermined configuration congruent to their respective natural bending radii during wrapping on said terminals;

an elongated member having a flat end surface, a central longitudinal axis, a peripheral groove provided on one side of said axis for individually receiving said various filaments, a longitudinal recess formed through said end surface parallel to and on a side of said axis opposite to said one side for receiving said terminals, and

means formed in the member tangent to said flat end, the base of said groove, and said recess said means defining an arcuate guideway for guiding the filaments in their respective natural bending radii to form said square-wrap coils during said wrapping.

10. The method of manufacturing a bit for wrapping wire onto a terminal, said wire having a characteristic of naturally assuming during said wrapping an arcuate bend congruent to the natural bending radius of said wire, comprising the steps of:

providing a bit blank having an end surface, a longitudinal groove formed in the periphery thereof, and a recess for receiving said terminal, and abrading in said bit blank an arcuate surface having said natural bending radius tangent to said recess, said end surface and said groove.

11. A method of manufacturing a bit for winding a solderless connection between a connecting wire and a terminal wherein fabricating steps are performed on a bit blank having an end surface, a longitudinal recess extending from the end surface, and a longitudinal groove formed in the periphery and terminating at said end surface; said steps including

moving the terminal and the bit blank relative to each other to insert the terminal in the recess;

inserting a length of connecting wire into the groove; rotating the bit and the terminal relative to each other to advance the length of wire from the groove and wind the wire on the terminal, and

applying an abrasive compound to the advancing wire and the groove adjacent to the end surface to form

said bit having a wire guideway conforming to the natural bending radius of the wire.

12. A method of manufacturing a wire winding bit from a generally cylindrical blank having an end surface, a longitudinal groove formed in the periphery thereof and terminating at an opening in said end surface, and an axially extending recess; which comprises the steps of enclosing the blank;

moving the enclosed blank and a terminal relative to each other to insert the terminal in the recess;

providing an abrasive coating on the periphery of a length of wire;

feeding a length of the coated wire into the groove; and

rotating the enclosed blank and the terminal relative to each other to advance the coated wire out of the groove, through said opening, and onto the terminal to abrade and form in said blank a guideway having a wire guide surface conforming to the natural bending radius of the wire.

13. A method of manufacturing a winding bit from a generally cylindrical blank having a longitudinal recess and a longitudinal slot extending toward an end surface wherein a standard bit having an end surface is provided with a longitudinal recess extending from the end surface and a longitudinal groove terminating in a chamfered edge joining the end surface; which method comprises the steps of

inserting the terminal into the recess of the standard bit;

inserting a length of wire into said groove;

rotating the standard bit and the terminal relative to each other to advance a first length of the wire through said groove, around the chamfered edge, and onto the terminal;

interrupting said relative rotation so that a second length of the wire remains received in said groove and said first length of the wire extends in an arcuate path congruent to the natural bending radius of the wire from said groove toward the terminal;

measuring said natural bending radius of said arcuate path, and

forming an arcuate surface having a radius conforming to said natural bending radius tangent to the slot and the recess of the blank.

14. The method of manufacturing a bit for wrapping wire onto a terminal, said wire having a characteristic of assuming an arcuate path congruent to the natural bending radius of said wire during winding thereof on said terminal, comprising the steps of

providing a bit blank having an end surface, a recess for receiving the terminal, and a longitudinal groove formed in the periphery thereof and extending from said end surface, the junction of said end surface and said groove forming a corner;

enclosing said bit blank within a sleeve to form a guideway with said groove;

moving the terminal into the recess,

feeding an indeterminate length of wire through said guideway,

securing a leading end of said wire to said terminal, rotating said bit blank and said sleeve relative to the terminal to advance the wire through the groove and around said corner on the terminal, and

stopping said rotation upon said wire eroding said corner to form an arcuate surface congruent to the natural bending radius of said wire.

15. The method of wrapping a strand onto an elongated member, said strand having characteristics of naturally assuming a predetermined curved path corresponding to the natural bending radius of said strand during said wrapping, said method including the steps of advancing said strand in the direction of the axis of said elongated member,

directing said advancing strand transversely to said axis

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to form a section of said strand into said predetermined curved path, and
engaging the entire length of said section to guide and wrap the wire in said path onto said elongated member.

16. The method of wrapping a wire onto a terminal having a longitudinal axis, wherein said wire assumes a predetermined arcuate path having a natural bending radius during said wrapping, which method comprises the steps of

advancing the wire in the direction of the axis of said terminal,
engaging and thrusting the advancing wire transversely to said axis into said predetermined path corresponding to said natural bending radius of the wire, and
guiding said transversely thrust wire by continuously

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contacting the wire along said natural bending radius to wrap the wire onto said terminal.

References Cited by the Examiner

UNITED STATES PATENTS

2,783,816	3/57	Wolf	153—67
2,885,764	5/59	Shulters et al.	242—7
3,006,563	10/61	Bos et al.	242—7

FOREIGN PATENTS

537,333	10/52	Canada.
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OTHER REFERENCES

IBM Technical Disclosure Bulletin, vol. 4, No. 8, January 1962, page 12.

CHARLES W. LANHAM, *Primary Examiner.*

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,213,894

October 26, 1965

John O. Etchison, Jr., et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 46, after "wire" insert -- wrapping bit and methods of manufacturing the bit to --; column 5, lines 55 and 56, for "longitudinally" read -- longitudinal --; column 11, line 8, for "and" read -- said --; line 23, for "ar" read -- an --; column 12, line 34, for "chamfered" read chamferred --.

Signed and sealed this 19th day of July 1966.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

EDWARD J. BRENNER

Commissioner of Patents