Aug. 22, 1967 R. D. FOLLRATH 3,336,778

EDGE-FORMING APPARATUS AND METHOD

Filed June 8, 1964 3 Sheets-Sheet 1

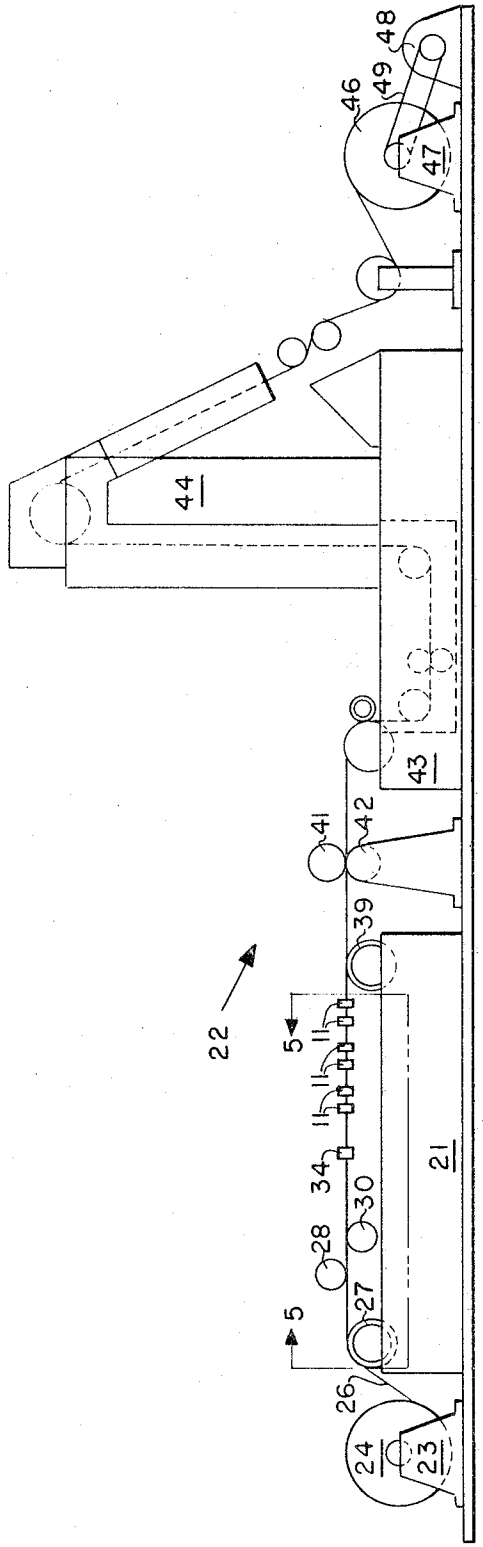

Fig. 4

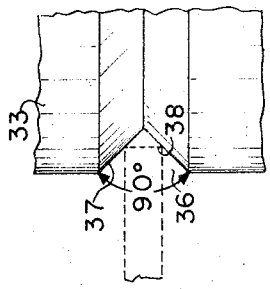

Fig. 3

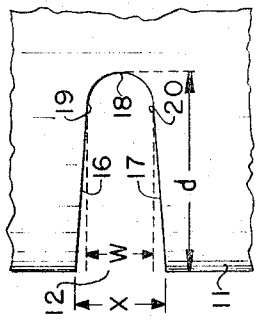

Fig. 2

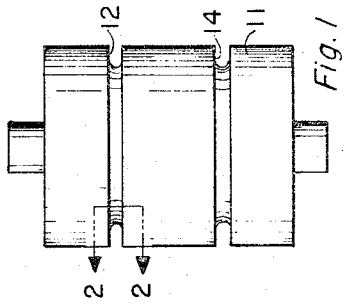

Fig. 1

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EDGE-FORMING APPARATUS AND METHOD

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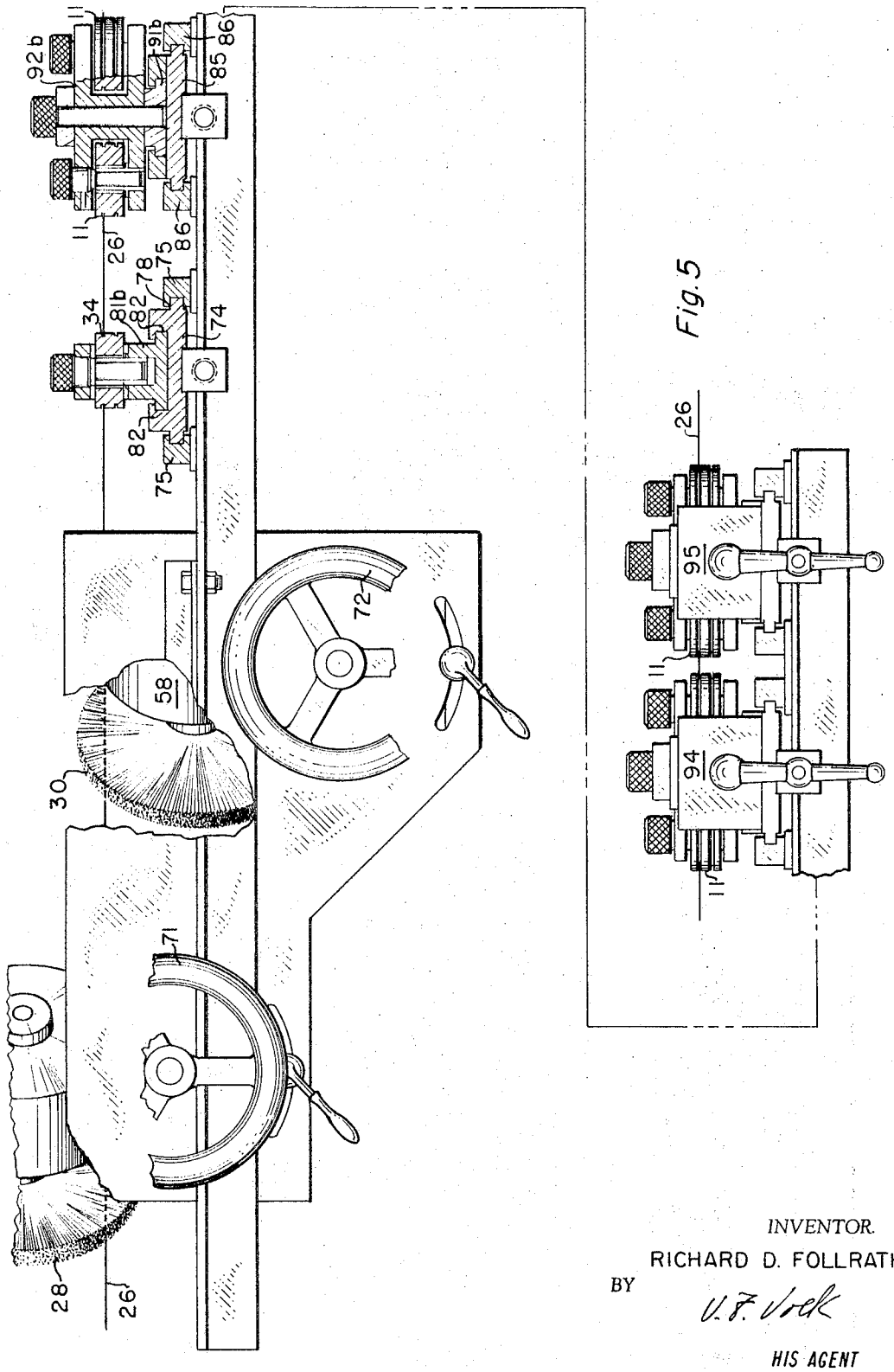

Fig. 5

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EDGE-FORMING APPARATUS AND METHOD

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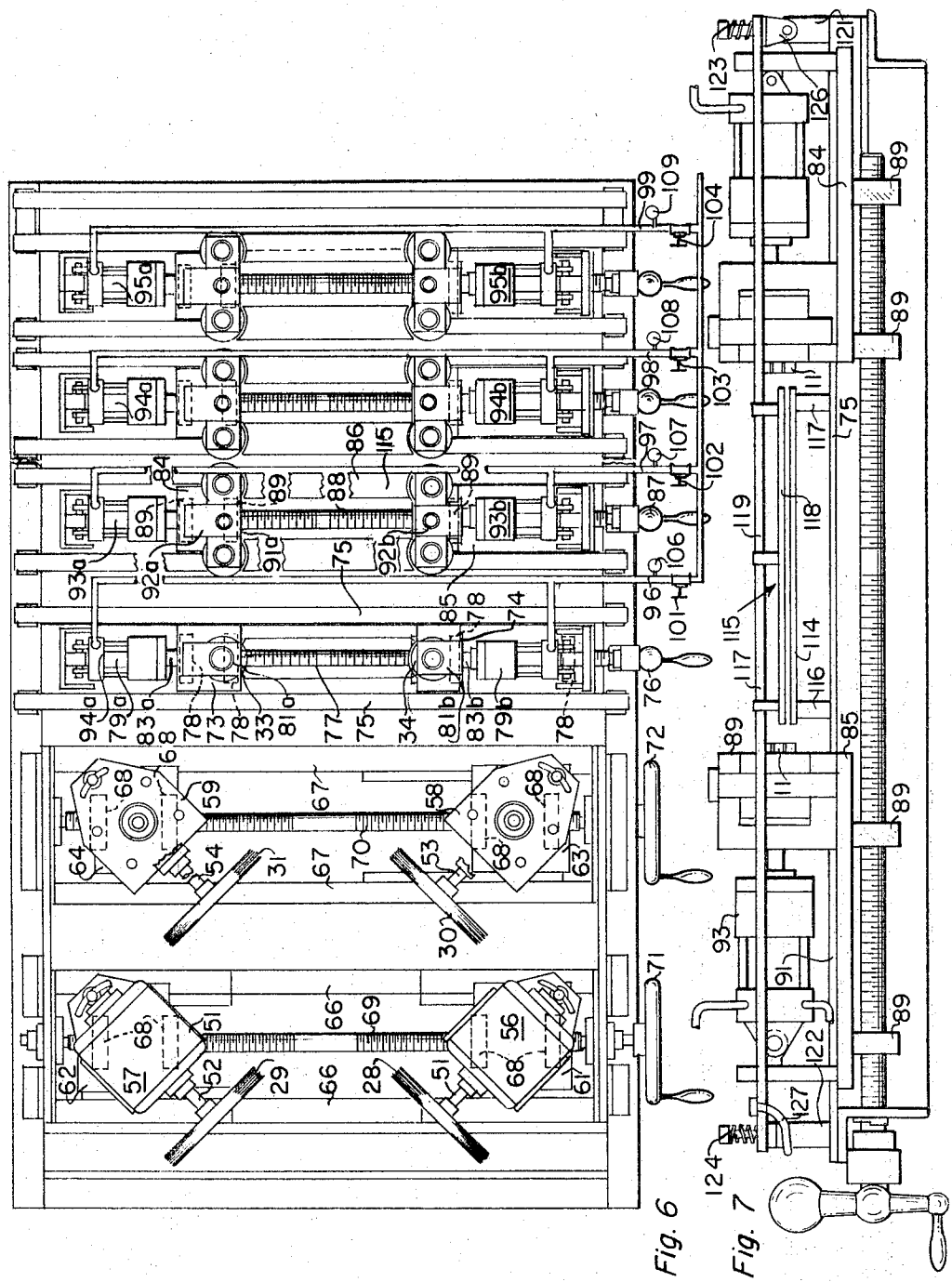

Fig. 6

Fig. 7

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3,336,778

EDGE-FORMING APPARATUS AND METHOD

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Filed June 8, 1964, Ser. No. 373,159
10 Claims. (Cl. 72—203)

My invention relates to edge-forming methods and apparatus and particularly to rolling rounded edges on electrical conductor strip.

In the manufacture of electrical apparatus employing induction coils, there has been an increasing commercial interest in forming such coils from flat strip conductors instead of using round or square magnet wire. When used in such coils the strip may be enamelled, it may merely be interleaved with a layer of insulating material such as paper, Mylar or other suitable dielectric, or the two insulating means may be combined.

The most troublesome portions of magnet strip coils are their edge portions, for, when the strip is formed, usually by slitting it from wide sheets, the edges are likely to be burred and sharp-cornered. For enamelled strip, the edge is the most difficult to cover uniformly with an insulating coat; the electrical stresses are most concentrated at the edges; and in the wound coils the edges remain exposed compared to the flat surfaces, each of which is protected by an adjacent outer winding of the coil.

I have found that the best magnet strip conductor is one in which the edge is fully formed, that is, the edge is rounded in a semicircle or similar curve that is tangent to, or blends continuously with, the flat sides of the strip. This is opposed to a mere rounding or "breaking" of the corners. However, when attempts were made to manufacture strip conductor on a commercial scale it was found that none of the known apparatus was capable of producing an acceptable product. The reasons for this may be that magnet strip is relatively wide and thin compared to strip that has previously been made with a rounded edge. The metals are soft, usually copper or aluminum, and cannot withstand much end thrust, and the required degree of reliability is very great.

In the practice of my invention I propose to economically produce electrical strip with fully formed edges.

I further propose to produce strip which is precisely dimensioned within close tolerances.

I further propose to produce strip in a process with high reliability.

The edges of metallic strip can be rounded by electrolytic erosion, grinding or skiving, etc., but I have found that edge rolling the strip is the most reliable and satisfactory process. In edge rolling, however, the strip is subjected to very high buckling pressures that tend not only to buckle the sheet but also to thicken the strip section adjacent to the edge rolls. I have found that known types of edge rolls do not perform satisfactorily, but that if the groove is cut in the roll in a manner not, to my knowledge, heretofore suggested, the resulting edge is fully formed and is free from irregularities, and the strip is free from pronounced thickening adjacent to the rolled edges. Whenever some slight thickening does occur it can be readily removed by a single pass through horizontal rolls mounted downstream of the edging rolls. I have discovered that an essential element for rolling satisfactory edge contours on electrical magnet strip is a very deep groove in the edging roll. This groove should have a depth at least 2½ times the thickness of the strip, and the depth may be as much as 8 times this thickness. The side walls forming the groove should be substantially straight in radial section and should taper outwardly only slightly so that the opening of the groove is no more than one or two mils wider than the groove at the beginning of the

bottom curvature. This curvature at the base of the groove is preferably semicircular or parabolic and should blend into the side walls without any sharp discontinuity.

Great precision is, of course, required of the grooves cut in the edging rolls, and it is preferable to grind in the grooves after the rolls are hardened. To control the shape and dimensions of the groove contour it is advisable to make wax or lead impressions of the groove which can be checked under a microscope.

I have found that a plurality of passes through my edging rolls are usually necessary to achieve a fully-formed edge. This is conveniently accomplished by mounting a plurality, such as six rolls per edge, in series. Before passing through these rolls the strip is advantageously treated by brushing the four corners of the edges to remove burrs and break the sharpness of the corners. Following this, and prior to entering the above-described grooved edging rolls, I further preform the edges by means of V-notched rolls. Here the notch has a 90° angle and the same roll can be used for strips of widely different gage. Each groove of the grooved rolls, however, can be used for only one gage of strip, but a plurality of different sized grooves can be cut into one roll, and the latter can be used for different strip gages by merely changing its vertical position.

The required precision of edge rolling is greater than theusual precision of slitting wide strips so that I prefer not to set my rolls in fixed positions and rely on the uniformity of the width of thestrip to seat it properly in the notch and grooves of the rolls. Rather, I mount one, or both, of each opposing pair of rolls to slide in the plane of the advancing strip, and I urge the rolls against the strip by the application of a constant force. As an urging means I have found it advantageous to use air or hydraulic cylinders. When this is done the magnitude of the force can easily be controlled by regulating the pressure. I have discovered that an apparatus having all the rolls on one side of the strip slidably mounted and the rolls on the opposite side fixedly mounted is satisfactory for running strip that is perfectly straight. When there is a possibility of the strip being cambered, however, as is frequently the case in commercial practice, I prefer to mount all the rolls slidably.

My apparatus for edge-forming metallic strip comprises means for paying off the strip and means for advancing it through the apparatus. The strip has square or angular corners, being most commonly slit from a wide sheet, and my apparatus comprises brushes mounted in the path of advance of the strip rotating against the corners so as to deburr and break them. It also comprises V-notched rolls mounted to rotate on axes normal to the advance of the strip wtih circumferential V-notches positioned to engage the edges of the strip and further break the corners. Edge-forming rolls are mounted in my apparatus also to rotate on axes normal to the advance of the strip. There are means mounting the V-notched and edge-forming rolls movably against the strip, and means, such as air cylinders, urging the movably mounted rolls against the strip. My edging roll for forming the edge of metallic strip has at least one circumferential edge-forming groove with side walls substantially straight in radial section, and a curvilinear bottom contour blending into the sidewalls. The grooves have depth to width ratios of at least 2.5 and the openings of the sidewalls forming the grooves do not exceed their separation at the circumferential lines where the bottom contour blends in, by more than about 2 mils.

A more thorough understanding of my invention can be gained from the appended drawing.

In the drawing:

FIGURE 1 shows a side view of an edging roll made to my invention.

FIGURE 2 shows an enlarged view of a groove in the roll of FIGURE 1.

FIGURE 3 shows an enlarged view of a V-notch in a roll used in my apparatus.

FIGURE 4 shows a side view of the apparatus of my invention.

FIGURE 5 shows a side view, partly in section, of the length 5—5 of FIGURE 4.

FIGURE 6 shows a plan view of the apparatus of FIGURE 5.

FIGURE 7 shows a front view of an element of the apparatus of FIGURE 4.

With reference to FIGURE 1 a cylindrical roll **11**, rotatable on a vertical axis, is ground or cut with a plurality of circumferential grooves **12, 14** of different widths to fit different gages of strip. Although I have shown two different sized grooves in my roll **11** it will be understood that the roll may have a single groove or it may have a plurality of grooves all the same size. In the latter case the grooves can be used consecutively as they become worn. In FIGURE 2 the groove **12** is shown on an enlarged scale and is seen to be formed of straight side walls **16, 17** and a curvilinear bottom contour **18**. The contour **18** is semicircular but it will be understood that other contours may also be used within the scope of my invention. The curvilinear bottom portion **18** is tangential to the walls **16, 17** at circumferential lines **19, 20**, respectively, and these lines mark the beginning of the curved portion of the groove **12**. Between the lines **19, 20** the groove **12** has a width *w* which is from 0 to about 1 mil thicker than the stock to be edge rolled, and the walls **16, 17** taper outwardly so that a width *x* at the opening of the groove is greater than the width *w*. The difference between the opening and the bottom widths is not great, however, being only about 1 or, at most about 2 mils.

The groove **12** has a depth *d* and the ratio *d/w* constitutes an important element of my invention. In the embodiment of FIGURE 2 *d/w* is equal to 3 and I have found that it should in no case be less than 2½ for the proper practice of my invention.

The grooved rolls such as the roll **11** are mounted on a bench **21** in an apparatus indicated generally by the numeral **22** (FIGURE 4). This apparatus comprises a pay-off stand **23** supporting a coil **24** of metallic strip **26** which is payed over a rubber-surfaced guide roll **27** to establish its elevation in passing through my apparatus. The strip **26** then passes under two brushes **28, 29** (FIGURE 6) and over two brushes **30, 31** which deburr the corners of the strip and also break the sharp angles of the corners. I prefer to employ fiber brushes such as the brushes made by the Osborn Manufacturing Company and sold under the trademark "Fascut." The preferred brushes are 8 inches in diameter and ½ inch wide and are rotated at high speed such as 3400 r.p.m., but it will be understood that it has been known to deburr metal edges by brushing and other known types of brushes and speeds of rotation can be used within the scope of my invention. A further description of the mounting of the brushes **28–31** is given hereinbelow with reference to a detailed description of FIGURES 5 and 6. On leaving the area of the brushes **30, 31** the strip **26** passes between two notched rolls **33, 34** in each of which is cut a V-notch **36** (FIGURE 3) formed by walls **37, 38** which are straight in radial section and meet at an angle of about 90°. By means of the notches **36** I preform the edges of my strip in preparation for full-forming by the grooved rolls **11**. Although I have shown a 90° notch **36** in my roll **33** (there is, of course, a similar notch in the roll **34**), I do not wish to be limited to this angle. It is also conceivable that my apparatus would be operable without the rolls **33, 34**. Omission of these rolls would, however, require additional rolls **11** to complete the edge forming in one pass. The rolls **33, 34** can be used with a wide range of metal gages whereas each of the rolls **11** must be changed, either by substituting another roll or by reversing the roll to position the other groove in line with the strip, whenever a different gage of strip is run through the apparatus. My apparatus **22** has six pairs of grooved rolls **11** mounted in tandem, and upon leaving the furthest downstream of these rolls with edges of the strip **26** fully formed, the strip passes over a second rubber-surfaced guide roll **39** and through a pair of flat rolls **41, 42** set at the precise strip gage. These flat rolls eliminate any slight thickening of the strip section. As stated hereinabove, it is a feature of my invention that the shape of the grooves cut in the rolls **11** serves to minimize thickening of the edges and the presence of the flat rolls **41, 42** are in the nature of a precaution to correct for any slight edge growth that may result. Upon leaving the flat rolls **41, 42** the strip **26** enters a known type of degreasing tank **43** and dryer **44** from which it is taken up into a coil **46** mounted in a stand **47** and driven by a motor **48** through a chain **49**.

Referring particularly to FIGURES 5, 6 and 7 the brushes **28–31** are mounted on respective shafts **51–54** of motors **56–59** mounted, in turn, on respective sliding platforms **61–64** which slide in pairs of greased rails **66—66, 67—67**.

Screw blocks **68** are fastened to the bottom of each of the platforms **61–64**. The screw blocks are threaded onto double pitch screws **69, 70** turned by respective hand cranks **71, 72**. By turning the cranks **71, 72** the positions of the brushes **28–31** can be adjusted horizontally to accommodate strips **26** of different widths.

The V-notched rolls **33, 34** are similarly mounted on sliding platforms **73, 74** slidable in rails **75—75** that can be adjusted by means of a crank **76**, screw **77**, and screw blocks **78**. However, as can best be seen in FIGURE 5 the rolls **33, 34** are mounted to slide relative to the platforms **73, 74** so that they can follow slight variations in the width of the strip when urged by air cylinders **79*a*, 79*b***. These may be true variations or effective variations due to a slight camber in the strip. For this purpose the rolls **33, 34** are mounted on second platforms **81*a*, 81*b*** slidable on the respective platforms **73, 74** within the gibs **82—82**. Pistons **83*a*** and **83*b*** of the cylinders **79*a*** and **79*b*** urge the platforms **81*a*** and **81*b*** toward each other with a constant, predetermined force. The grooved edging rolls **11** are similarly mounted except that each of the slidable platforms mounts two rolls instead of one. Thus for mounting the first four grooved rolls downstream of the V-notched rolls, platforms **84, 85** are slidable in rails **86—86** and are adjustable by means of a hand crank **87**, screw **88** and screw blocks **89**. Second platforms **91*a*** and **91*b*** slidably support opposing yokes **92*a*, 92*b*** for the rolls **11** and are urged toward each other by air cylinders **93*a*, 93*b***. The mounting of the additional 8 grooved rolls urged by air cylinders **94*a*, 94*b*, 95*a*, 95*b*** are substantially identical. It will be understood that although I have preferred, in the illustrated embodiments of my invention to apply a force to only one of each pair of opposing rolls all the rolls might be mounted to continuously follow variations in the width of the strip within the scope of my invention. The cylinders **79*a*, 79*b*, 93*a*, 93*b*, 94*a*, 94*b*, 95*a*, 95*b*** are fed by air lines **96–99** controlled by regulators **101–104** to supply a constant air pressure as indicated by air gages **106–109**. This pressure can be changed according to the thickness and hardness or toughness of the strip being processed.

During contact with the edging rolls, the strip is supported and held flat by means of a shoe assembly **115** shown in FIGURE 7. The shoes have been omitted from the other figures for the sake of clarity. The assembly **115** comprises a lower shoe **114** fixed to the rail **75** by means of posts **116, 117** and an upper shoe **118** fixed to a pair of rods **119** of which only one is visible in the drawing. The other rod and its supporting structure is symmetrically located on the other side of the platforms **84, 85** as seen in FIGURE 7. The rod **119** shown in the drawing is supported on brackets **121, 122** and urged against the said

brackets by compression springs **123**, **124**. The rod **119** is fastened to the bracket **121** by means of a hinge **126**, and to the bracket **122** by means of a latch **127**. This arrangement permits the upper shoe to be lifted out of the way for threading my apparatus. Although I have shown the shoe assembly associated with the platforms **84**, **85**, it will be understood that a similar shoe assembly is used to keep the strip flat between each set of edging rolls.

I have invented a new and useful apparatus and method for which I desire an award of Letters Patent.

I claim:

1. The method of edge-forming electrical conductor strip comprising the steps of:

(A) brushing the corners of said strip to deburr the same and break the sharp angle of said corners,

(B) rolling the edges of said strip in an approximately 90-degree V-notched roll to further shape said edges, and

(C) rolling the edges of said strip in rolls with curvilinear-bottomed grooves to fully form said edges,

(a) said grooves having a depth to width ratio of at least 2.5.

2. The method of edge-forming electrical conductor strip comprising the steps of:

(A) brushing the corners of said strip to deburr the same and break the sharp angle of said corners,

(B) rolling the edges of said strip in an approximately 90-degree V-notched roll to further shape said edges,

(C) rolling the edges of said strip in rolls with curvilinear-bottomed grooves to fully form said edges, said grooves having a depth to width ratio of at least 2.5, and

(D) flat rolling said strip.

3. Apparatus for edge-forming metallic strip comprising:

(A) means paying off a supply of said strip,

(B) means advancing said strip through said apparatus,

(C) edge-forming rolls mounted to rotate on axes normal to the advancing of said strip,

(D) circumferential edge-forming grooves in said rolls

(a) positioned to roll the edges of said strip,

(b) having a depth to width ratio of at least 2.5, and

(c) having a width no greater than about 1 mil in excess of the thickness of said strip,

(E) means mounting said rolls continuously movable with variations in the width of said strip,

(F) means urging said rolls against said strip at a pressure sufficient to round the edges of said strip but insufficient to thicken said edges, and

(G) means taking up said strip.

4. The apparatus of claim **3** wherein the urging means are air cylinders.

5. Apparatus for edge-forming metallic strip having angular corners comprising:

(A) means paying off a supply of said strip,

(B) means advancing said strip through said apparatus,

(C) brushes mounted in the path of advance of said strip, rotating against the corners of said strip to deburr and break said corners,

(D) edge-forming rolls mounted to rotate on axes normal to the advancing of said strip,

(E) circumferential edge-forming grooves in said rolls

(a) positioned to roll the edges of said strip,

(b) having a depth to width ratio of at least 2.5, and

(c) having a width no greater than about 1 mil in excess of the thickness of said strip,

(F) means mounting said rolls continuously movable with variations in the width of said strip,

(G) means urging said rolls against said strip at a pressure sufficient to round the edges of said strip but insufficient to thicken said edges, and

(H) means taking up said strip.

6. The apparatus of claim **5** wherein said urging means are air cylinders.

7. Apparatus for edge-forming metallic strip having angular corners comprising:

(A) means paying off a supply of said strip,

(B) means advancing said strip through said apparatus,

(C) brushes mounted in the path of advance of said strip rotating against the corners of said strip so as to deburr and break said corners,

(D) V-notched rolls mounted to rotate on axes normal to the advance of said strip,

(a) said rolls having circumferential V-notches positioned to engage the edges of said strip,

(b) said notches further breaking said corners,

(E) edge-forming rolls mounted to rotate on axes normal to the advance of said strip,

(F) circumferential edge-forming grooves in said edge-forming rolls,

(a) positioned to roll the edges of said strip,

(b) having a depth to width ratio of at least 2.5, and

(c) having a width no greater than about 1 mil in excess of the thickness of said strip,

(G) means mounting said V-notched rolls and said edge-forming rolls continuously movable with variations in the width of said strip,

(H) means urging said V-notched rolls and said edge-forming rolls against said strip, at a pressure insufficient to thicken said edges, and

(I) means taking up said strip.

8. The apparatus of claim **7** wherein the urging means are air cylinders.

9. An edging roll for forming the edge of metallic strip comprising:

(A) a cylindrical member rotatable about its longitudinal axis, and

(B) at least one circumferential edge-forming groove in said member,

(a) said groove having a substantially semicircular bottom contour, and

(b) said groove having a depth to width ratio of at least 2.5,

(c) said groove having a width not substantially greater than 1 mil in excess of the thickness of said strip.

10. An edging roll for forming the edge of metallic strip comprising:

(A) a cylindrical member rotatable about its longitudinal axis, and

(B) at least one circumferential edge-forming groove in said member,

(a) said groove having side walls substantially straight in radial section and a curvilinear bottom contour blending into said sidewalls at circumferential lines thereon,

(b) said groove having a depth to width ratio of at least 2.5,

(c) the opening of said sidewalls not exceeding their separation at said lines by an amount exceeding about 2 mils,

(d) said groove having a width not substantially greater than 1 mil in excess of the thickness of said strip.

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