Nov. 6, 1962 B. F. HART ETAL 3,062,267

METHOD AND APPARATUS FOR HELICALLY WINDING STRIP MATERIAL

Filed Dec. 8, 1959 2 Sheets-Sheet 1

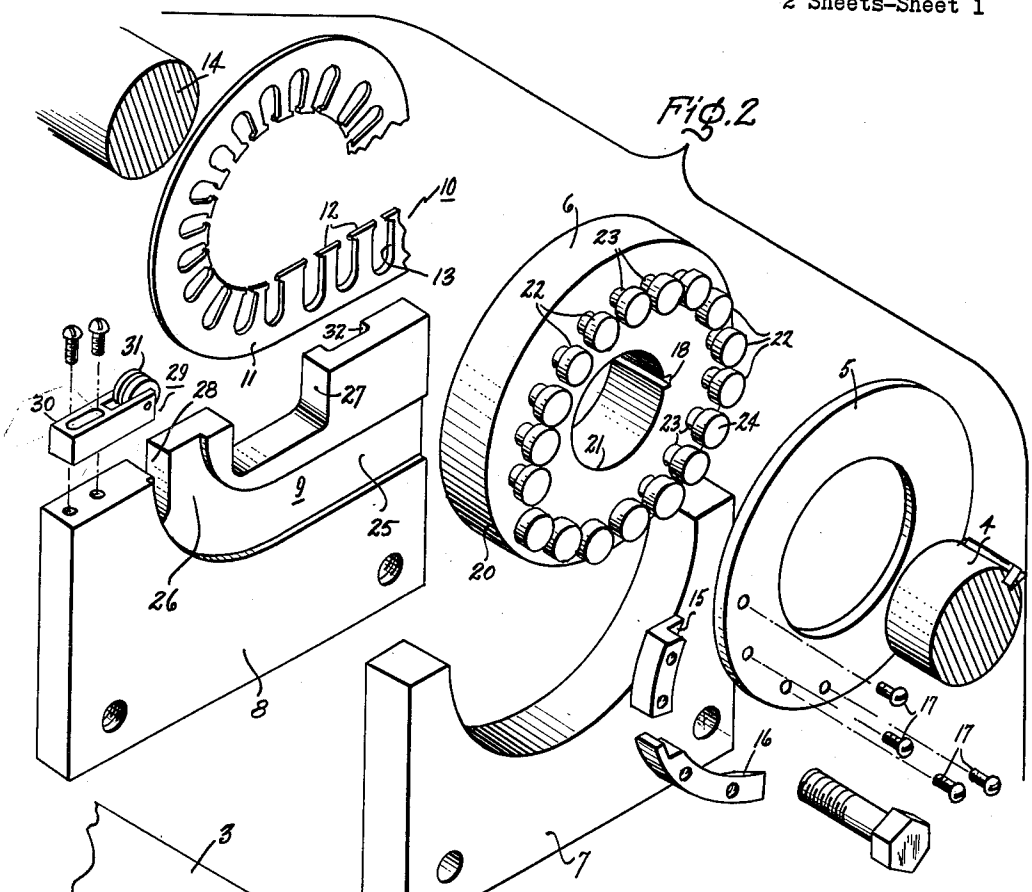


Fig. 2

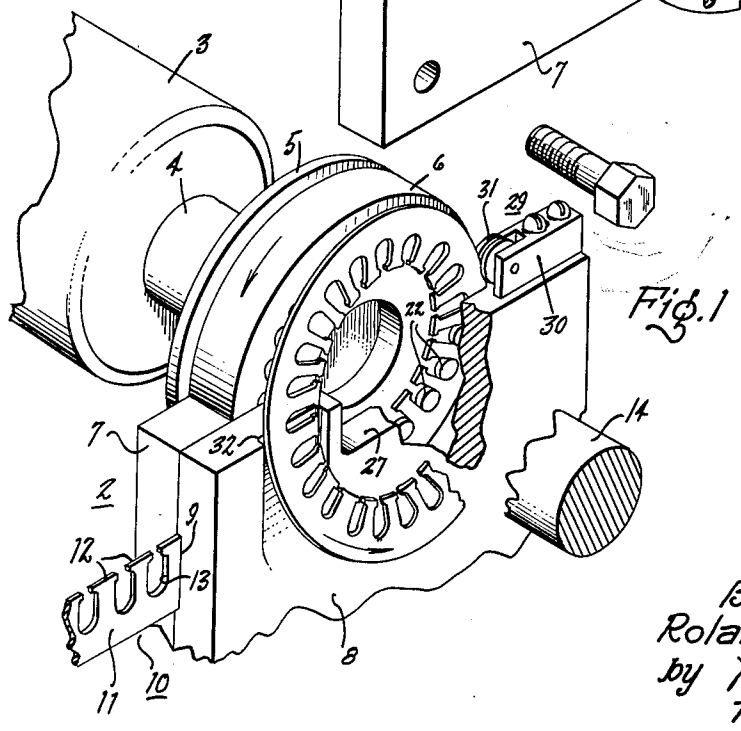


Fig. 1

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Fig. 5

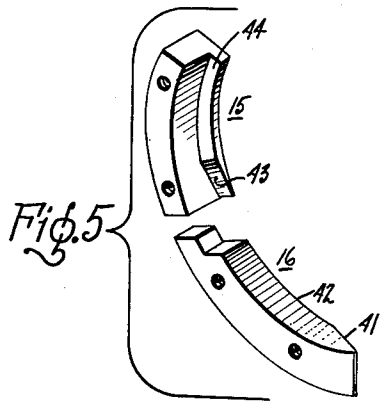


Fig. 4

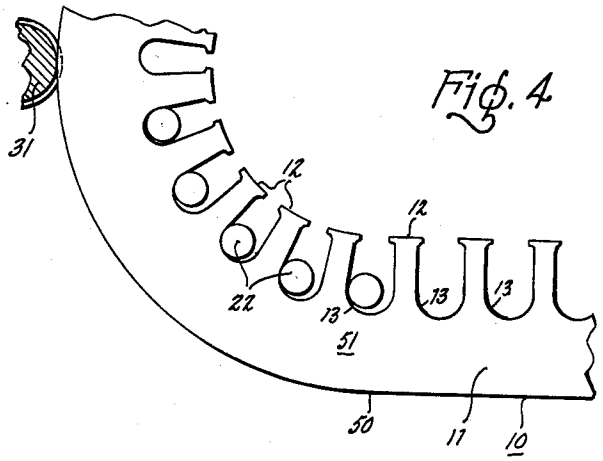
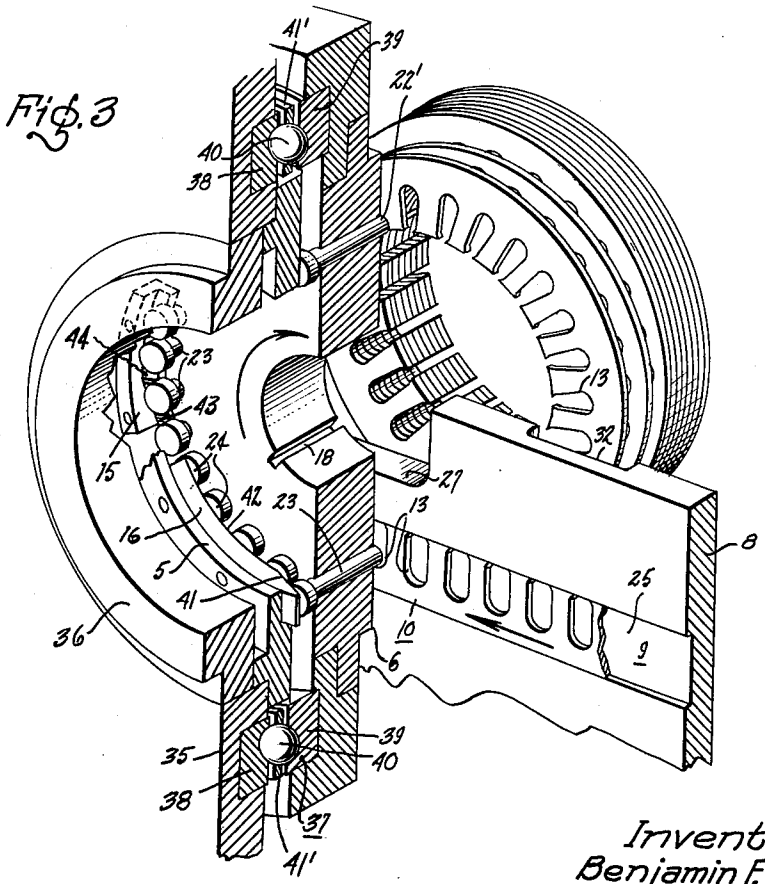


Fig. 3



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METHOD AND APPARATUS FOR HELICALLY WINDING STRIP MATERIAL

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15 Claims. (Cl. 153—64.5)

This invention relates to a method and apparatus for helically winding a continuous thin metal strip, and more particularly, to a method and apparatus for helically winding a continuous thin metal strip with the planar surface of the strip being substantially normal to the axis of the helix for forming laminated electromagnetic core constructions.

Heretofore, the most common method for fabricating laminated motor stators has been to stamp discs from sheets of metal such as core iron or silicon steel. These discs are usually annular in shape with suitable notches or winding slots provided along the inner periphery thereof. The discs are suitably stacked and compressed to a desired height and some form of fastening means is utilized to connect the laminations into a single structure. The notches in the discs are aligned so that electrical coils may be set therein. A fabrication process of this type entails a great amount of waste, especially of sheet material between adjacent disc stampings and in the center portion of each disc.

It has been previously suggested that such stator constructions be fabricated from a continuous strip of metal, the strip to be initially notched to provide the ultimate core construction with slots for the electrical windings. The strip is helically wound with the notches in the strip being in alignment to form an entire stator construction from a single strip of material. To so helically wind a strip into a cylindrical structure that has a solid outer periphery, the strip is continuously compressed between tapered rollers to stretch the periphery and give the material an arcuate form. Unfortunately, it has been found that metal such as core iron is not a sufficiently homogeneous material for such use and also that the pressures exerted by the rollers cannot always be maintained sufficiently uniform. As a result, the strip, while being shaped into helical form, stretches irregularly in response to the pressure applied and also stretches irregularly because of the non-homogeneous character of the material. The result of this difficulty in winding the material is manifested in misalignment of notches in the strip.

Another problem presented by this prior process results from the outer periphery of the metal strip being compressed between tapered rollers. The material at the area of compression has a taper and, therefore, the strip does not have a uniform thickness. The outer portions of each turn of the strip, when compressed against one another, will be spaced from each other. As a result, the end product is unsuitable for use since the notches are misaligned and the edges are spaced.

The chief object of the present invention is to provide an improved method and apparatus for helically winding thin strip material.

Another object is to provide an improved method and apparatus for helically winding strip material while maintaining the thickness of the strip substantially uniform during winding.

A still further object is to provide an improved method and apparatus for uniformly winding a helical strip with spaced notches to form the stator of an electric motor having the layers of strip define spaced slots in the stator.

These and other objects of my invention will become more apparent from the following description.

In accordance with the present invention a continuous thin metal strip is wound into a helical form by successively engaging the thin strip at spaced points, urging the strip in an arcuate path, and compressing the strip as it passes in the arcuate path to maintain the thickness of the strip substantially uniform as the strip achieves an arcuate form.

Another feature of the invention is an apparatus for winding a thin metal strip into a helical form, including means defining an arcuate path having predetermined width, means for passing a thin strip having a thickness greater than the width of the arcuate path through the arcuate pat hwhereby the strip is compressed and emerges from the path with an arcuate shape and a substantially uniform thickness. "Winding thin strip in a 'helical' form" as used herein designates winding the strip with the flat planar portion of the strip lying substantially normal to the axis of the helix.

The invention will be more clearly understood from the detailed description of preferred embodiments described in the accompanying drawings, in which

FIGURE 1 is a perspective view of an apparatus employing the present invention;

FIGURE 2 is an exploded perspective view of the apparatus shown in FIGURE 1;

FIGURE 3 is a sectional view of another embodiment of the invention;

FIGURE 4 is a fragmentary view of a strip of material being bent in an arcuate form by being engaged by a plurality of pins;

FIGURE 5 is a perspective view of a cam construction utilized to actuate the pins shown in FIGURE 4.

In FIGURE 1 there is shown an apparatus 2 which includes a suitable prime mover 3 which drives a shaft 4. Shaft 4 extends through a stationary cam plate 5 and is connected to a rotatable member 6. Cooperating with rotatable member 6 are a back-up plate 7 and a winding shoe 8 which may be bolted together. A continuous strip of annealed core iron is introduced into a slot 9 defined by the walls of back-up plate 7, winding shoe 8 and rotatable member 6. The strip of material 10 comprises a solid portion 11 having suitable teeth 12 extending therefrom with suitable indentations or notches 13 extending therebetween. The strip is introduced through slot 9 and is formed into an arcuate shape by winding about an arbor 14 in a manner to be more fully described hereinafter.

After the strip achieves its arcuate form, it is supported by the arbor 14. If desired, this arbor may be provided with suitable splines (not illustrated) which fit into one or more of the notches in strip 10 to align the strip for further fabrication into a completed stator.

In FIGURE 2 there is shown an exploded view of the apparatus in FIGURE 1. Driving shaft 4 passes through the opening in cam plate 5. This cam plate is an annular, flat member adapted to have mounted thereon cam members 15 and 16 by means of bolts 17. The function of these cam members is to engage indexing pins 22 mounted on rotatable member 6. The construction and action of cam members 15 and 16 is more fully described hereinafter.

Rotatable member 6 is an annular member having a central opening defined by cylindrical surface 21. The outer periphery of member 6 is defined by cylindrical surface 20. The inner cylindrical surface 21 has provided therein a suitable keyway 18 and, by means of a suitable key, shaft 4 is connected to rotatable member 6.

Annularly disposed about the opening defined by cylindrical surface 21 are a plurality of holes in which are reciprocally mounted indexing pins 22. These pins each comprise a shank portion 23 and a head portion 24, the shank portion being adapted to reciprocate within the holes in rotatable member 6. The head portion of each

pin is arranged to engage cam members 15 and 16 which impart reciprocating motion to the pin. When a pin 22 is fully urged into its opening in member 6 by engaging cam 16, a portion of the shank portion extends beyond the opposite surface of rotatable member 6. In this position the extending pin 22 engages the edge of a notch 13 in strip 10 for a predetermined interval after which the cam 15 withdraws the pin from the strip. The extending pins 22 follow an arcuate path, carrying therewith a section of strip 10. Driving shaft 4 extends through the opening defined by surface 21 in rotatable member 6 and, if desired, may be attached to an arbor 14 by suitable means (not illustrated).

Back-up plate 7, as previously noted, is bolted to winding shoe 8 in a manner to define slot 9 therebetween. Slot 9 includes a straight portion 25 and an arcuate portion 26 defined by the recess in the winding shoe and the face of rotatable member 6. The width of slot 9 is slightly less than the thickness of the strip stock being supplied. In the case of strip stock having a thickness of .025 inch, the width of the slot may be .023 inch, for example.

The winding shoe 8 is provided with a suitable indentation 27 for arbor 14 and a recess portion 32 which is adapted to provide clearance for the strip after it has been bent more than 270°. Another slot 28 is also provided, into which extends a diameter controlling device 29 comprising a block 30 having rotatably mounted thereon a roller 31. Roller 31 may be adjustably mounted by means (not illustrated) to engage the outer arcuate periphery of the strip and thereby control its diameter. The roller by engaging the edge of the strip creates a bias thereon and imparts a set to the material which upon release of the bias controls the arcuate edge of the strip.

FIGURE 3 illustrates another embodiment of the invention shown in FIGURES 1 and 2. This view which is in perspective and partially in section, illustrates the action of cams 15 and 16 relative pins 22 and the relation of pins 22 with respect to notches 13 of strip 10. A stationary member 35 is provided having mounted therein a collar 36. Adjacent collar 36 and mounted in the opening in support 35 is cam plate 5 having cams 15 and 16 attached thereto. The rotatable member 6 in this embodiment is rotatably mounted on support 35 by means of ball bearing construction 37. The bearing 37 comprises a first race 38 which is mounted in the support 35 and a second race 39 which is mounted in the rotatable member 6. A plurality of balls 40 adapted to rotate in these races are suitably spaced from one another by means of a spacer member 41'.

An enlarged view of cam member 15 and 16 is shown in FIGURE 5. The member 15 is provided with a beveled surface 43 which acts on the underside of head 24 adjacent shank 23 of pins 22. By referring to FIGURE 3, it can be seen that this surface 43 retracts pins 22 from strip 10. A planar arcuate surface 44 is provided adjacent surface 43 to maintain the pins in this retracted position. Cam member 16 has a beveled surface 41 which is adapted to engage the top portion of heads 24 of pins 22 to urge the pins forward to penetrate the space between the teeth 12 in the strip 10. A planar arcuate surface 42 maintains pins 22 in the position of penetration caused by the surface 41.

In FIGURE 3 it can be seen that the lower most pin 22 is in the process of being urged into a notch 13 in strip 10 as rotatable member 6 turns in the direction indicated. The pin is fully extended into the notch to permit the pin to engage the strip, and after rotation of approximately 45° the pin is retracted by the cam member 15. In their upper most position, the pins, as shown by the pin 22' in FIGURE 3, no longer engage the strip 10.

In FIGURE 4 there is shown a fragmentary view of a strip during the process of being wound into an arcuate shape. The five pins 22 are in strip engaging positions. The lower most pin is beginning to penetrate the strip 10, whereas the upper most pin is in the process of being retracted. In this view, the action of the roller 31 is shown, biasing the edge of the strip to control the arcuate edge thereof.

Considering the operation of the apparatus and referring to FIGURE 1, initially strip 10 is passed into slot 9. The strip prior to this has been suitably notched to provide the indentations 13 which will later form the slots wherein the windings for the motor or generator are to be fitted. After the notches have been placed in the strip, the material, if desired, may be suitably annealed to suitably soften the material to facilitate the bending of the strip. The material as it enters slot 9, because of the width of the slot being less than that of the material, is slightly compressed. To facilitate the feeding of the strip into the slot, the slot may be provided with a slight taper to a width greater than the strip thickness.

Referring to FIGURE 3, the material is advanced in the slot 9 until it reaches the area of pins 22. At this initial point of contact with rotatable member 6, the pins are in a retracted position. The lower most pin 22 has its head portion 24 beginning to engage surface 41 of cam 16. As the pin continues to rotate, surface 41 causes the pin to pass into notch 13 and engage the edge of the tooth 12. The pin 22 is maintained in this penetrating position by means of surface 42 of cam 16. As member 6 rotates, successive pins are passed into the notches 13 to engage the edges of adjacent teeth 12 and cause the strip to follow the strip in the arcuate path scribed by the pins.

If desired a suitable lubricant may be utilized during the bending operation to lubricate the surfaces of the strip, to cool the strip and to flush particles from the apparatus such as annealing scale.

It will be appreciated that as a strip of material is bent by the action of the pins, there is a tendency of the material to buckle. However, since the material is restrained between the surface of winding shoe 8 and the adjacent surface of rotatable member 6, this is not possible. There is, therefore, a tendency for the outer fibers of the strip to be placed into tension and the inner fibers to be placed into a compressive state. The compressive forces do not achieve any magnitude because they are relieved by the toothed construction of the strip. The effect is that the extremities of teeth 12 are urged into closer proximity to one another.

Normally, as a result of these bending forces, there will be a decrease in the thicknes sof the material in the solid portion 11 (FIGURE 4), specifically at the periphery 50. At the intermediate portions 51, this stretching effect may change to compression and at the base of the teeth there is a thickening of the material because of the compression due to bending.

As previously mentioned, it is desirable to maintain the thickness of the strip substantially uniform. To achieve this in the present invention the retaining surfaces of the slot 9 create compressive forces acting on the surfaces of the strip causing material flow in the strip. Compression is initially caused by passing the strip into slot 9, which has a smaller width than the strip thickness. It has been found that during the winding operation, this compression plus the restrain of the walls of the slot causing further compression of the strip causes material in the area of the base of teeth 12 to flow radially outward, and there is a displacement of material from point 51 toward edge 50. By this means, the thickness of the strip is maintained substantially uniform.

In FIGURE 4 it will be noted that the size of the initial slot 13 is diminished, both in width and in shape, during the winding operation. Initially, there is ample room for pin 22 to fit into the slot. However, after rotation of approximately 45°, it can be seen that this space becomes more and more restricted, and there is almost a tendency of the opposite edges of the notch to engage the pin.

Referring to FIGURE 3, it can be seen that at this point that surface **43** (FIGURE 5) of cam member **15** engages the underside of head **24** of pin **22**. Surface **43** retracts pin **22** from engagement with strip **10**. As the rotatable member continues to rotate, surface **44** of cam member **15** assures that the pin is in a retracted position where it will remain while it makes a complete revolution and again comes into engagement with cam member **16**.

After strip **10** passes diameter controlling device **29**, which by its biasing action controls the arcuate edge of the strip, the strip begins to helically wind about arbor **14**, and in order to provide clearance for the strip so wound, recess **32** is provided in the winding shoe. If desired, a suitable spline construction may be provided on arbor **14** for the purpose of aligning the notches in the strip.

A typical stator construction formed by the present invention may utilize strip stock .025 inch in thickness having a width of 1¼ inches to form stators having an outside diameter of 5 inches and a width of 1 to 3 inches.

The present invention provides a method and apparatus which engages thin strip material at spaced points causing it to achieve an arcuate form and, simultaneously the application of compressive forces on the strip causes a flow of material to maintain the thickness of the strip material substantially uniform. It will be appreciated that this invention is capable of applications other than formation of laminated stators, such as in the construction of heat exchangers.

While there has been described a preferred embodiment of the present invention, it will be appreciated that the invention is not limited thereto, but that various modifications may be made without departing from the scope of the appended claims.

What we claim as new and desire to secure by Letters Patent of United States is:

1. In a method for helically winding a metal strip having a succession of openings therein, the steps which consist of passing pins through the openings in the strip to engage the wall of the openings in the strip, moving the pins in an arcuate path thereby urging the strip in an arcuate path, and compressing the strip between an angularly movable surface and an angularly stationary surface as it passes in the arcuate path to maintain the thickness of the strip substantially uniform as the strip achieves an arcuate form.

2. The method according to claim 1 further comprising the step of engaging the outer periphery of the strip to maintain the diameter of the arcuate form of the strip substantially constant.

3. In a method for helically winding a thin metal strip having a succession of openings with the flat surface thereof lying in a plane substantially normal to the axis about which the strip is to be wound the steps which consist of passing pins through the openings in the strip, causing the pins to engage the edges of the openings in the strip, passing the pins in an arcuate path while in engagement with the strip edges and concurrently applying a compressive force to the strip in an angular vicinity of said engagement thereby causing the strip to assume a substantially uniform arcuate form, removing the pins from engagement with the strip and discontinuing the compressive force after the strip has moved a predetermined angular distance, and engaging the outer periphery of the strip angularly beyond the application of the compressive force on the strip to maintain the diameter of the arcuate form of the strip substantially constant.

4. A method for forming a helix from an elongated relatively thin strip material having a solid portion and spaced apart notches adjacent at least one edge thereof comprising successively placing a plurality of angularly and individually movable members into the notches in engagement with the strip, driving said strip through a confined arcuate path by concurrent angular movement of said members causing said strip to assume an arcuate form, and removing said members from engagement with the strip after the members have been in engagement therewith through an angle not substantially in excess of 45°.

5. A method for forming a helix from an elongated relatively thin strip material having a solid portion and spaced apart notches adjacent at least one edge thereof comprising successively placing a plurality of individually reciprocable members into the notches in engagement with the strip, driving said strip through a predetermined confined arcuate path by concurrent angular movement of said members while simultaneously applying a compressive force to the solid portion for the confined arcuate path thereby causing said strip to assume an arcuate form, and removing said members from engagement with the strip and discontinuing the compressive force after the strip has been driven through said predetermined arcuate path.

6. In a method for helically winding a metal strip having a series of openings the steps which consist of successively passing a plurality of reciprocable elements in the openings, engaging the edges of the openings with the elements, passing the elements in an arcuate path to urge the strip in an arcuate path and compressing the strip as it passes in the arcuate path to substantially maintain the thickness of the strip uniform as it assumes an arcuate form.

7. The method according to claim 6 in which the elements engage the strip for approximately 45°.

8. In an apparatus for forming a helix from an elongated relatively thin strip of material having spaced apart slots adjacent one edge thereof, driving means including a rotatable member and a plurality of spaced apart elements adapted to enter the slots and to engage a strip, means for rotating said member and moving said elements in an angular path of travel, means for moving said elements indvidually into and out of the strip slots as said elements respectively travel through an angular path not substantially in excess of 45°, and means for compressing said strip against said rotatable member while said elements engage the strip thereby driving the strip in a predetermined confined arcuate path and forming said strip into a helix.

9. In an apparatus for forming a helix from an elongated relatively thin strip of material having spaced apart slots adjacent one edge thereof, driving means including a rotatable member and a plurality of spaced apart pins carried by said member, said rotatable member and pins being movable relative to one another and rotatable together as a unit, means for successively moving said pins individually into and out of the strip slots while being moved in an angular path of travel by said rotatable member, and means for compressing the strip against said rotatable member when said pins are in engagement with the strip thereby driving the strip in a predetermined confined arcuate path and forming the strip into a helix.

10. In an apparatus for forming a helix from an elongated relatively thin strip of material having spaced apart slots adjacent one edge thereof, driving means including a plurality of spaced apart reciprocably mounted elements arranged in a circle and adapted to enter the slots to engage the strip, means for reciprocating said elements into and out of the strip slots while concurrently moving said elements in an angular path of travel, thereby driving the strip in a predetermined confined arcuate path and forming said strip into a helix, and means for engaging the radially outer periphery of the strip angularly beyond the position at which the elements are moved out of the strip slots to maintain the diameter of the arcuate edge of the strip substantially constant.

11. In an apparatus for winding a thin strip having spaced apart openings in a helical path, a combination of

means defining an arcuate path having a width less than the thickness of the strip, means for passing the strip through the arcuate path, said latter means comprising a rotatable member and a plurality of pins reciprocally mounted on said member for engaging the edges of the openings as the strip moves through at least a portion of the arcuate path, and stationary cam means for selectively reciprocating the pins whereby the pins engage a strip during a portion of its travel through the arcuate path, the strip emerging from the path with an arcuate shape and a substatnially uniform thickness.

12. The apparatus according to claim 11 further comprising means for engaging the edge of the arcuate strip to substantially maintain the outer diameter of the arcuate strip substantially constant.

13. In an apparatus for winding a thin metal strip in a helical path, the combination of a rotatable member, a plurality of annularly displaced pins reciprocally mounted in the rotatable member adapted to engage the strip of thin material, a stationary cam adapted to move the pins to engage the edges of spaced openings in the thin strip, means for compressing thin material as it is urged in the arcuate path, means to rotate the rotatable member and to move said pins in an arcuate path thereby urging the strip to pass said arcuate path, said pins disengaging the thin strip prior to its discharge from the arcuate path.

14. In an apparatus for winding a thin metal strip having a plurality of spaced notches in a helical path, the combination of means defining a slot having parallel planar walls, said slot having a straight portion and an arcuate portion and being adapted to compress the notched strip which is supplied to the slot, a rotatable member, a plurality of reciprocally mounted pins carried by said rotatable member, said pins being adapted to extend into a portion of said slot to engage the walls of

the notches in said strip, and means for rotating the rotatable member to urge the strip into the arcuate portion of the slot whereby the strip as it passes through the arcuate portion of the slot is further compressed causing the metal of the strip to flow toward the outer peripheral edge of the strip to maintain the thickness of the strip substantially uniform as the strip achieves an arcuate form.

15. In an apparatus for winding a thin metal strip having a plurality of spaced notches in a helical path, the combination of means defining a slot having parallel planar walls, said slot having a straight portion and an arcuate portion and being adapted to compress the notched strip which is supplied to the slot, a rotatable member, a plurality of reciprocally mounted pins carried by said rotatable member, means for rotating the rotatable member, cam means for reciprocally moving said pins to extend the pins into the arcuate portion of the slot, said pins being adapted to engage the walls in the notches in the strip whereby rotation of the rotatable member urges the strip into the arcuate portion of the slot, the strip as it passes through the arcuate portion of the slot being further compressed causing the metal of the strip to flow toward the outer peripheral edge of the strip to maintain the thickness of the strip substantially uniform as the strip achieves an arcuate form.

References Cited in the file of this patent

UNITED STATES PATENTS

1,920,154	Carlson	July 25, 1933
1,920,155	Fisher	July 25, 1933
1,970,536	Mansur	Aug. 14, 1934
2,290,594	Platt	Jan. 12, 1960