No. 839,060. PATENTED DEC. 18, 1906.

G. S. DUNN.

MACHINE FOR BENDING METAL STRIPS EDGEWISE.

APPLICATION FILED NOV. 16, 1905.

6 SHEETS—SHEET 1.

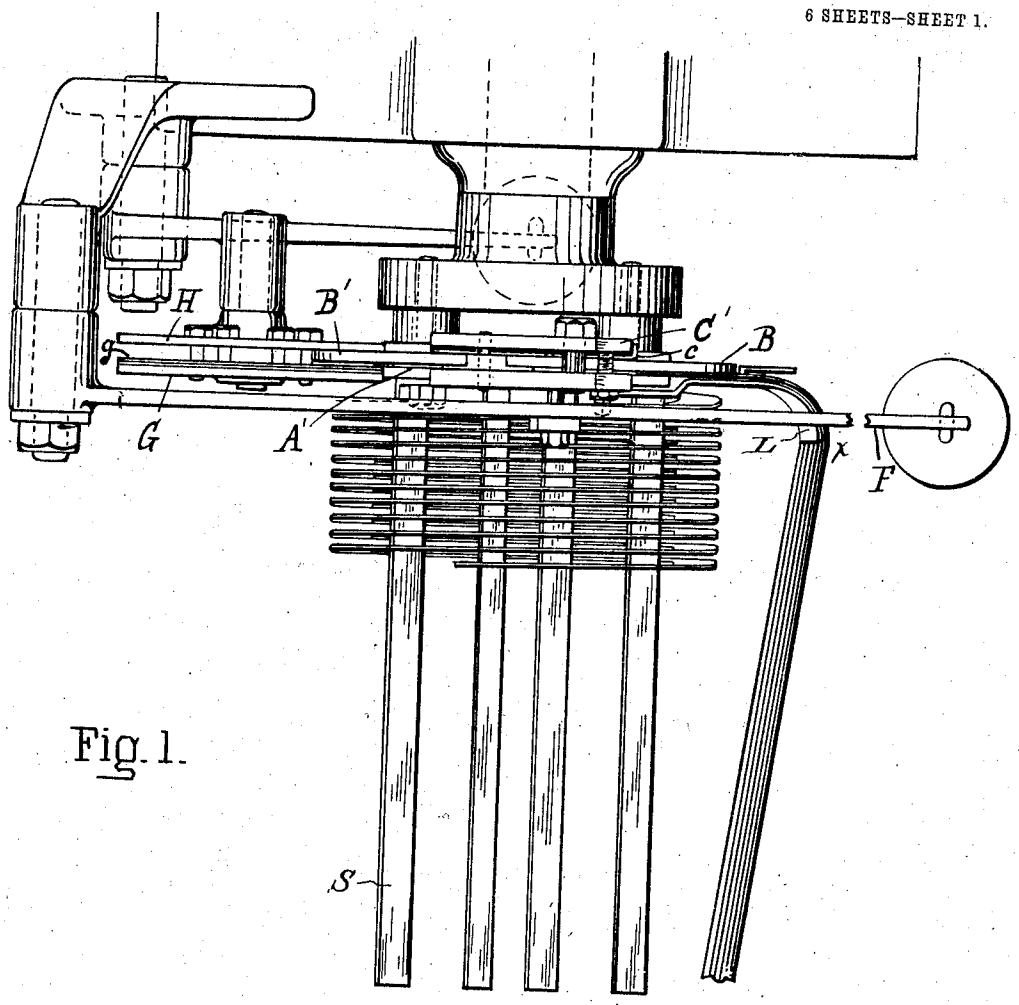
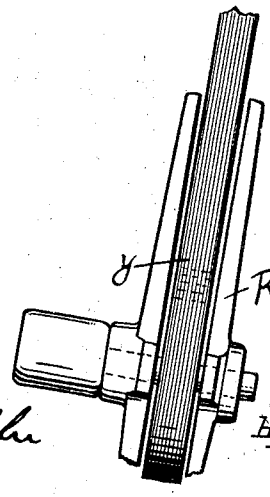


Fig. 1.



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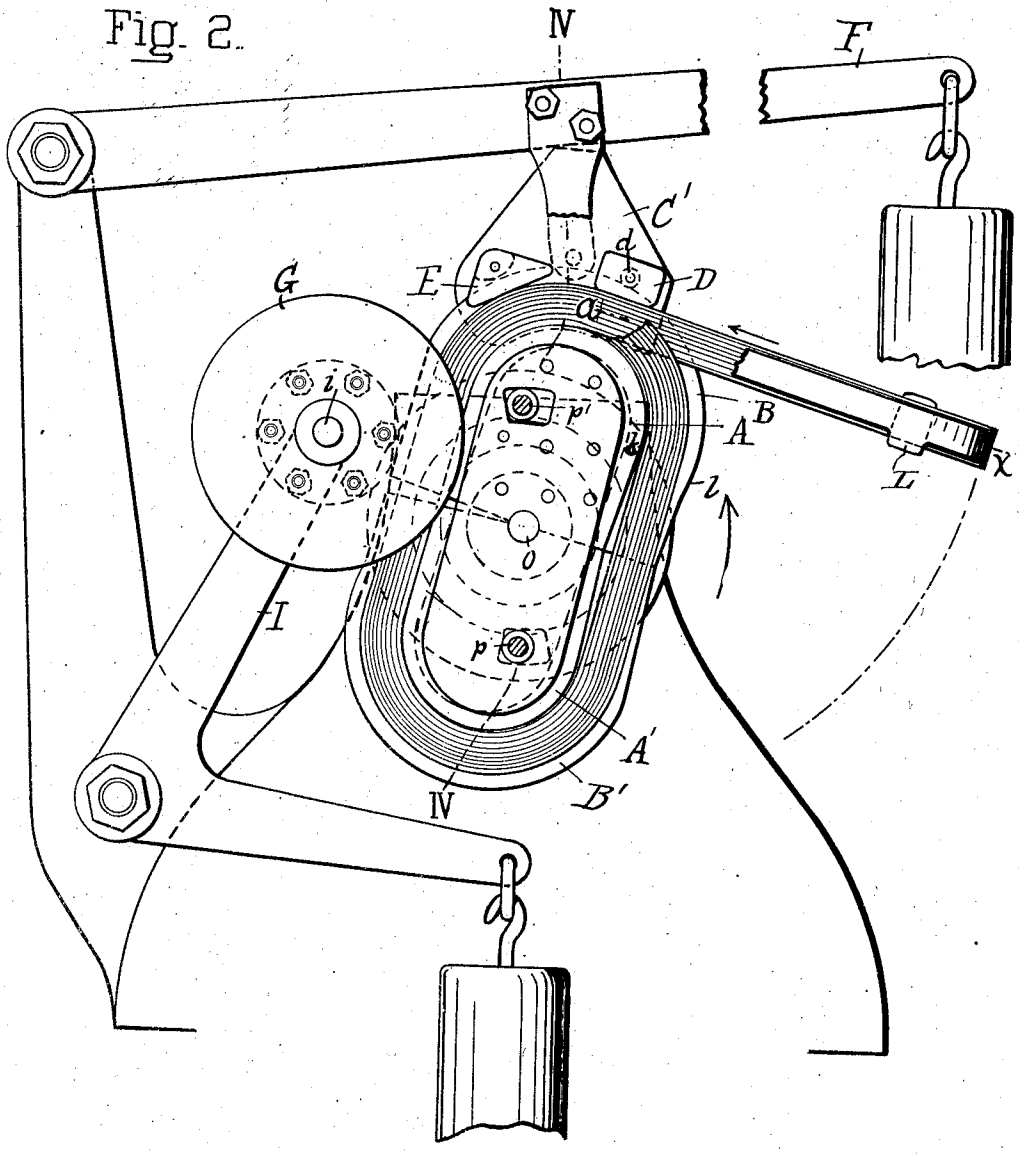
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6 SHEETS—SHEET 2.

Fig. 2.



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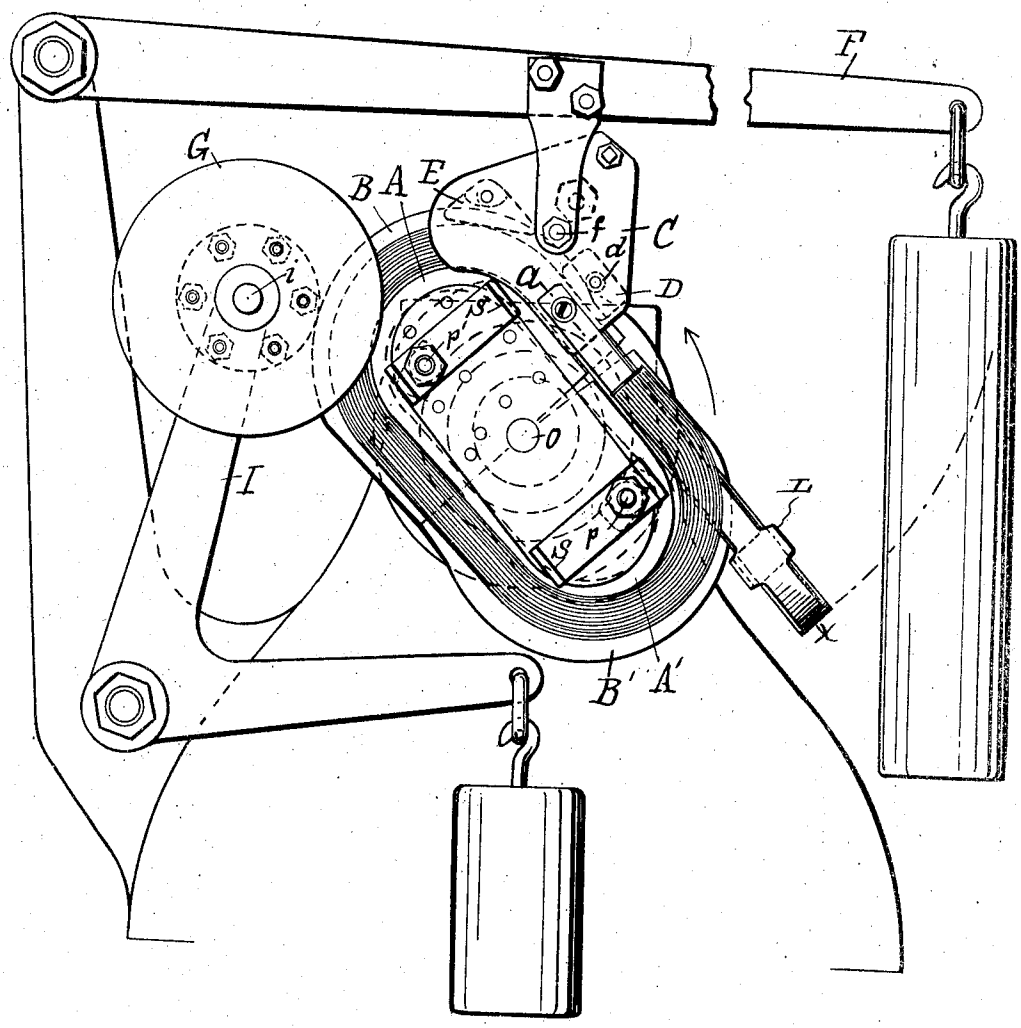
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6 SHEETS—SHEET 3.

Fig. 3.



Witnesses:

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6 SHEETS—SHEET 4.

Fig. 4.

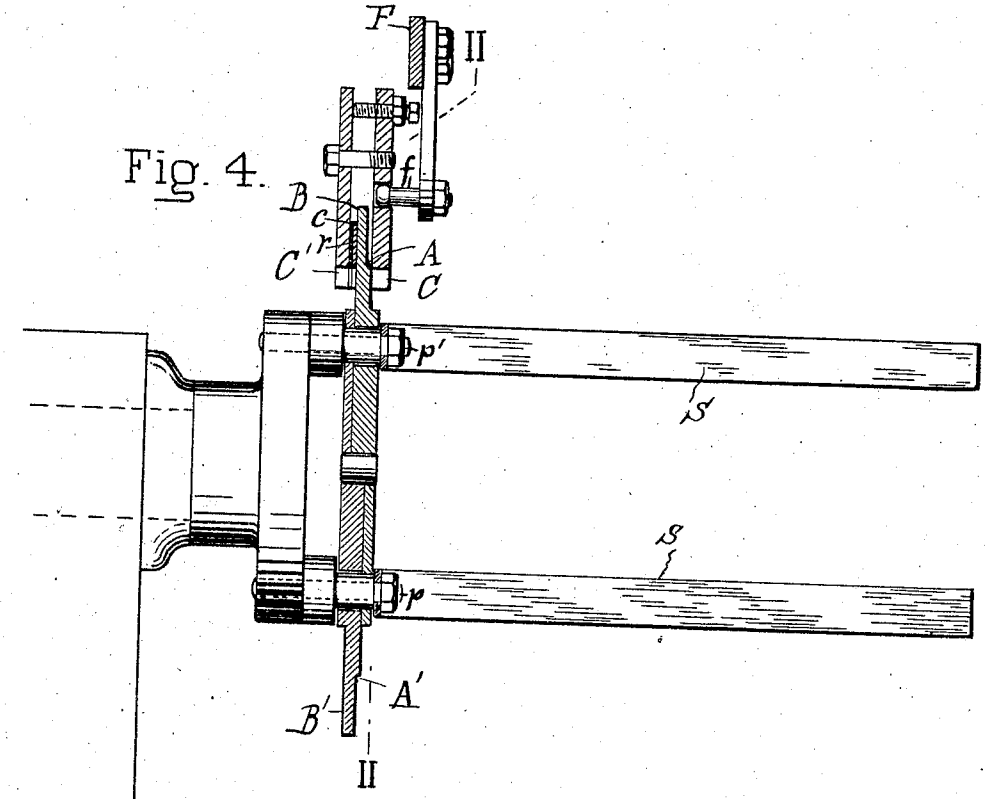
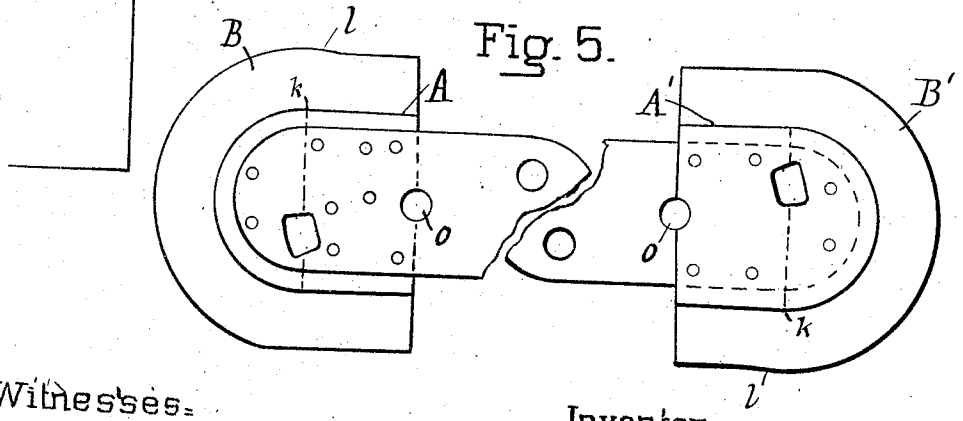


Fig. 5.



Witnesses:

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6 SHEETS—SHEET 5.

Fig. 6.

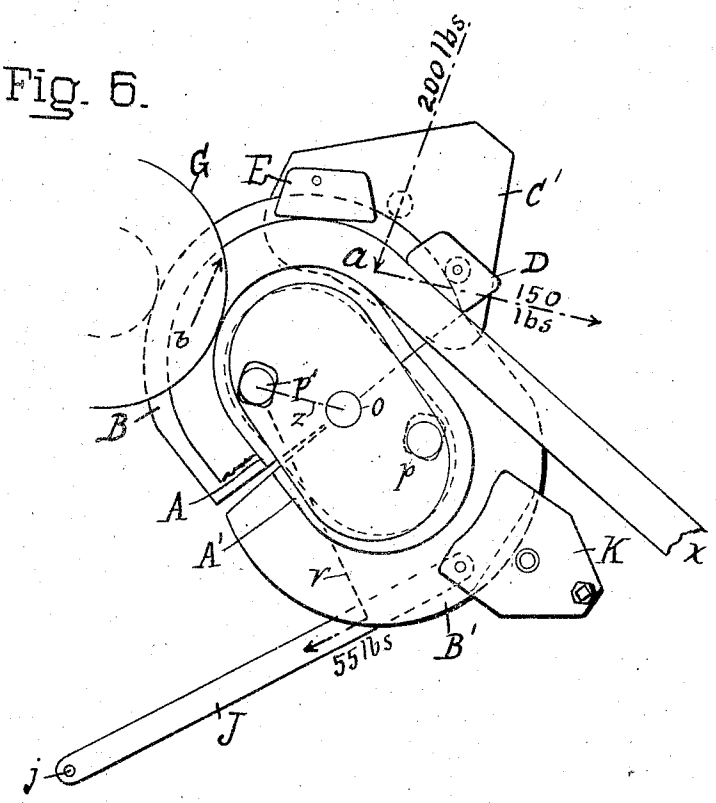
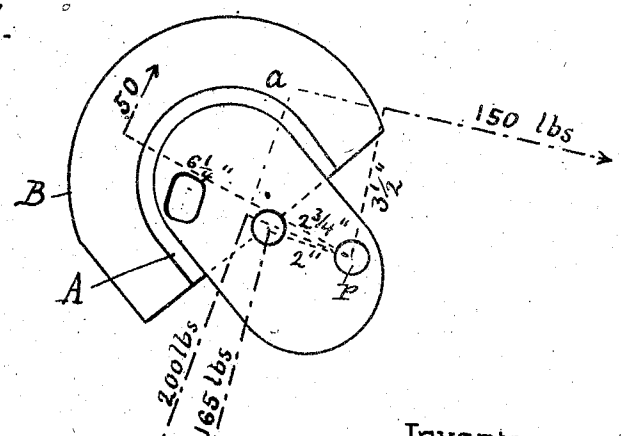


Fig. 7.



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6 SHEETS—SHEET 6.

Fig. 8.

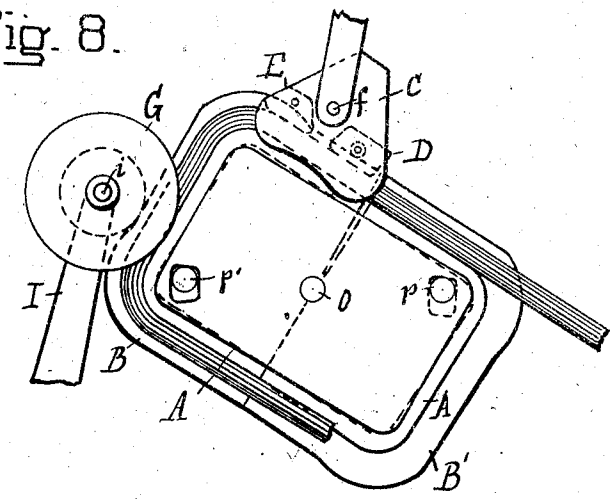
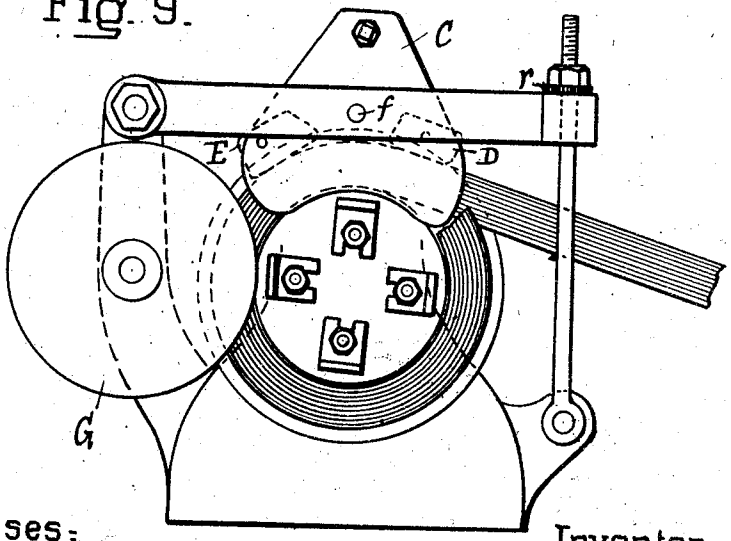


Fig. 9.



Witnesses:

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UNITED STATES PATENT OFFICE.

GANO S. DUNN, OF EAST ORANGE, NEW JERSEY, ASSIGNOR TO CROCKER-WHEELER COMPANY, OF AMPERE, NEW JERSEY, A CORPORATION OF NEW JERSEY.

MACHINE FOR BENDING METAL STRIPS EDGEWISE.

No. 839,060. Specification of Letters Patent. Patented Dec. 18, 1906.

Application filed November 16, 1905. Serial No. 287,721.

To all whom it may concern:

Be it known that I, GANO S. DUNN, a citizen of the United States of America, and a resident of East Orange, county of Essex, and State of New Jersey, have invented certain new and useful Improvements in Machines for Bending Metal Strips Edgewise, of which the following is a specification.

My invention relates to apparatus for coiling edgewise thin copper strips, including as the most difficult type of coil those having convolutions of elongated form with straight sides joined by arcs of circles and other forms not truly circular.

The object of the invention is to produce a machine by which such coils may be formed, having curved parts with an inside radius as short as twice the width of the strip or even less and in which the width of the strip may be many times the thickness of the strip (the important range in practice running from twenty to one hundred times.) Strips with a thickness of twelve one-thousandths of an inch and the width of over an inch have been coiled by the apparatus illustrated, and this is not the limit of its capacity.

My invention consists in certain apparatus pertaining to this art of winding flat strips edgewise, all of which is completely described and illustrated herein; but it will facilitate the understanding of the invention to state briefly some of its general characteristics.

The machine is a low-tension winding-machine. It operates without the necessity of attaching an end of the strip to or of winding the strip about the mandrel for the purpose of anchoring it, and no material tension is applied to the strip as it approaches the point of bending. The bending is effected by a pressure applied to the edges of the strip at three places, by the mandrel and two shoes, the shoes pressing against the outer edge and the mandrel pressing against the inner edge at a point between the two shoes, which hold the strip against the bending pressure. The shoes have contacts as straight of edge as the straightest part of the exterior bounding-line of the proposed coil, and the shoes are so mounted that the contact edges are independently adjustable to the edge of the strip. The strip is pulled through the bending instrumentalities by a rotary friction-clamp.

When the machine is organized for winding non-circular coils, the mandrel is built of relatively movable sections, whereby the strip is overwound to correct for the spring-back in the metal, so that the coil is in its final shape when it leaves the mandrel. The machine has a non-reciprocating rotary mandrel and a two-shoe bending device and when organized for winding non-circular coils provision is made for proper tangential delivery of the strip to the mandrel.

In the accompanying six sheets of drawings, which form a part of this application, Figure 1 is a plan view of a machine embodying my invention and constructed for the formation of elongated coils. Fig. 2 is an end elevation of the machine with the rotating parts in section on the line II II of Fig. 4 and in position for bending over one of the curved ends. Fig. 3 is an end elevation of the machine with the rotating part at the point in its revolution where the strip winds from one of the curved ends onto one of the straight sides, and the two parts of the mandrel are shifted with respect to each other as compared with their relation to each other in the preceding figure to allow for the overwind. Fig. 4 is a side elevation of the machine with the pressure-lever bending-saddle and forming-mandrel in section on the line IV IV of Fig. 2. Fig. 5 shows face views of the two parts of the forming-mandrel. Fig. 6 is a front elevation of a forming-mandrel and directly coöperating parts for less elongated coils in position just preceding shift of the two parts to allow for the overwind, together with arrows which indicate the intensity and direction of the forces acting on the parts of the mandrel to cause it to shift. Fig. 7 is a strain diagram showing the turning moments of the forces referred to the point of pivotal support of one of the parts of the mandrel. Fig. 8 shows a forming-mandrel and directly coöperating parts for the formation of rectangular coils with rounded corners. Fig. 9 shows my invention adapted to the formation of circular coils.

Briefly stated, the coiling apparatus comprises a rotary mandrel which is revolved about a fixed axis and a bending-saddle which is pressed toward one side of the

mandrel. The strip to be coiled is fed between the saddle and the mandrel in a direction which must be about tangent to the surface of the latter at the point of entrance under the saddle. In case a non-circular mandrel is employed the saddle has a radial movement to and from the mandrel-axis and also a considerable rocking movement to preserve its alinement with or substantially tangential relation to the portion of the mandrel against which it rests as the mandrel is revolved. These movements are independent of each other. They follow the rotation of the mandrel and are set up thereby. In consequence of this construction the strip leads into the coiling apparatus along a line which is not only constantly varying in its distance from the axis of rotation of the mandrel, but which oscillates through a considerable angle. A portion of this movement will be apparent by comparing the directions *x*....*a* along which the strip passes to the coiling apparatus while this apparatus is in the positions illustrated in Figs. 2 and 3, respectively. The strip is conveniently supplied from a reel R, and it is necessary first to lead this strip to the shifting-point *x* and in such manner that it will be permitted to take the proper tangential direction. To effect this, it is first bent flatwise and led around an arc which is preferably about and slightly more than a right angle, (but which may be considerably less,) and then conducted to the bending apparatus. This turn in direction is defined by a guide L, which is pivoted in the apparatus and has considerable angular movement during the operation of the machine, as can be seen by comparing the positions of the end of the guide in Figs. 2 and 3, and the reel is preferably so located that the point *y* of delivery of the strip is about on a line with the approximate center of the curved path of the end of the guide. One result of this location is that the end of the guide throughout its extent of movement will remain at about the same distance from the point of delivery, and the strip between the reel and guide will not at any time be slackened by the angular movement of the guide. Another and more important result of the location of the reel above indicated is avoidance of any tendency to edgewise bending by reason of the shifting of the direction of entry of the strip under the bending-saddle. This is obviously attainable in other ways. This guide, though important, is not essential, particularly with thin strips. The guide is made as short as possible to keep down the range of movement of its outer end, but it must be long enough to hold the strip as it approaches the machine out of the way of the spool which holds the formed coils.

The winding apparatus has a revoluble forming-mandrel which may be conveniently mounted on the face-plate of a lathe. It consists when used for non-circular coils of two parts A A', which have a slight movement with respect to each other. The parts taken together have a contour approximately the same as that desired for the interior of the coils and a face the width of which is slightly less than the thickness of the strip to be coiled. The forming-mandrel has a single flange in two parts B B', each part being integral with one of the parts of the mandrel and supporting the mandrel part.. This is important, as the machine is intended for coiling thin strips of copper. The forming-mandrel is the slight shoulder at the side of the flange. It is slightly less than the thickness of the strip. The two flange parts and mandrel parts taken together constitute what may be termed a "single-flanged forming-mandrel." The strip of copper to be coiled is laid with one edge against the forming-face of the mandrel and one side against the flange of the mandrel and is snugly held by a pair of clamps C C', between which is the strip of copper and the flange of the mandrel, so that the sides of the strip are closely confined on the one side by one of the clamps and on the other side by the flange. The bending is effected by a leading shoe D, a following shoe E, and the mandrel in coöperation and takes place where the strip is snugly confined on the sides between one of the clamps and the flange. Both of the shoes are pivoted between the clamps and have straight contacting faces which contact with the edge of the strip. The shoes are slightly thinner than the copper strips, so that they will not be clamped when the clamps are adjusted to confine the strip snugly.

The strip is confined on its sides throughout the portion between the shoes, (where the bending chiefly takes place,) and also for a short distance in advance of the leading shoe and in the rear of the following shoe (where there is also some flow of metal or tendency to flow from the bending.) In order to avoid excessive friction and resistance to the passage of the strip, only the area of flow of metal is so confined.

The clamp and shoes together constitute what may be termed a "bending-saddle." This saddle is held down against the edge of the copper strip by means of a weighted lever F. A pin *f*, projecting from the lever, enters a hole situated about midway between the pivotal points of the shoes so as to fairly equalize the pressure between the shoes. The adjustment is such that the leading shoe will not crush the strip down into contact with the mandrel at a point directly under it, but will effect the principal bending at a point between the leading shoe and the following shoe. In this way the bending is effected with less severe pressure

between the shoe and the edge of the strip than would be necessary to force the strip entirely down to the mandrel under the shoe, which with thin strips would result in upsetting the edge of the strip. This pressure may be adjusted in the weight applied to the lever; but it is usually preferable to have an excess of pressure and to hold the shoe at a slightly greater distance from the mandrel than the width of the strip, particularly at the curved parts of the mandrel. I effect this by a roller *d* on the pin with the leading shoe, the roller resting on the edge of the flange of the mandrel. This edge is shaped to act as a cam which holds the leading shoe at such a distance from the mandrel when bending over the curved portions of the mandrel that the strip will not be forced entirely down to the mandrel directly under the leading shoe.

The curved parts of the cam are carried at *l l* beyond the points *k k*, where the curved arcs join the straight sides of the mandrel and the strip winds from the curved arcs onto the straight sides. The rear shoe has the important function of holding the strip against the straight sides of the mandrel while the succeeding curved portions are being started, and thereby preventing the bending strains in the strip at the curved portions from being communicated to the straight portions and causing them to bow. In order to secure a uniform distribution of pressure against the sides of the strip where the bending takes place, one of the clamps C′ is faced with a piece of sheet metal *c*, which is backed with a sheet of rubber fiber or other elastic material *r*. The distribution and adjustment of pressures above indicated results in coils wherein the turns are of substantially uniform width and thickness throughout.

The strip has a traveling anchorage to the mandrel by means of a rotary clamp or pinch wheel consisting of two circular flanges G H, between which the strip and the flange of the mandrel pass immediately after emerging from between the clamps of the saddle. These flanges are drawn together by bolts, and one of them is preferably faced with an annular sheet *g*, backed with rubber, fiber, or other elastic material to distribute the pressure more uniformly. The pinch-wheel revolves on a pin *i* on the end of a weighted lever I, by which it is held in engagement with the strip and flange. The friction between the strip and the flange of the mandrel on the one side and between the strip and the flange of the pinch-wheel on the other side holds the strip from slipping with respect to the mandrel and puts a sufficient tensile strain upon the strip to draw it under the saddle. Through this tensile strain the friction on the strip from passing under the parts which contact with the edge is overcome, and the friction from contact with the parts which confine the sides of the strip at the point of bending is also overcome. It is necessary that the effect of the latter friction be mitigated or the combined resistance will exceed the tensile strength of the strip or the holding power of the pinch-wheel. The friction against the sides where the bending takes place may be analyzed into two components. First, there is friction arising from the linear movement of the strip. This friction is only on the side of the strip which is against one of the clamps of the saddle. Opposed thereto on the opposite side is the flange of the mandrel, which has a linear movement with the strip and neutralizes any tensile stress from the linear friction on the opposite side. Second, there is friction from the transverse movement of the strip radially to the mandrel in being brought down into contact. This friction is only on the side of the strip against the flange of the mandrel. Opposed thereto, on the opposite side, is one of the clamps of the saddle with respect to which the strip has very little transverse movement and which about equalizes any resistance from the transverse friction on the opposite side.

In bending a copper strip to a mandrel in the manner indicated there is a spring-back or unwind amounting to from one to three per cent. of the arc and an enlargement of about half of a per cent., so that to produce a semicircular bend with a given interior diameter the mandrel should be about half of one per cent. smaller, and the curvatures of the arcs should exceed the required arcs from one to three per cent. and in the examples illustrated should exceed a semicircle by about one and one-half degrees. It is manifestly impossible to join the ends of two such arcs with straight tangent lines in a rigid plane structure. The difficulty is overcome by me by making the mandrel in two parts. Each part has an arc of one hundred and eighty-one and one-half degrees, with straight sides tangent to the ends of the arcs in the examples, in which it is required to wind coils with each convolution consisting of two semicircular arcs joined by straight sides. In the example in which it is required to wind coils having rectangular convolutions the sides of which are joined by ninety-degree arcs each part of the mandrel has two arcs of about ninety-one degrees joined by a straight tangent line and with straight tangent sides at the other ends of the arcs. In both sets of examples the two parts of the mandrel are each supported from a pin *p p′*, which projects from the face-plate of the spindle and engages a hole in a projecting arm P of the one mandrel part and passes through a slot in the other mandrel part. The two mandrel parts are hinged to each other at the middle point *o* of the mandrel and have a slight relative movement equal to

the overwind, so that the adjoining straight sides of the two parts on either side of the mandrel can be brought into alinement. This movement or flop of the two parts is made at each half-revolution just in advance of the laying of the strip on the side, the parts of which are brought into alinement by the resultant action of several forces.

In the form illustrated in Fig. 6 the flop of the mandrel takes place when in the course of a revolution it reaches about the position illustrated. The forces acting on the mandrel to cause it to flop are the weighted lever bearing on the saddle and acting at the point *a* and a drag K, which is a clamp applied to the flange of the mandrel and anchored through a link J at a fixed point *j*. The former force may be about two hundred pounds and the latter force about fifty-five pounds under the conditions shown. Adversely-acting forces are the reaction of the pinch-wheel, which may be fifty pounds acting at *b*, and the reaction of the saddle, which may be one hundred and fifty pounds acting at *a*. These forces act directly upon the mandrel part A through its flange B, except the drag, which acts on the mandrel part A′ concurrently with the action of the other forces on the part A and indirectly through the pin connection *o* on the mandrel part A, where, by reason of the three-to-one ratio of the lever-arms *v* and *z*, the force of the drag is three times as much. The turning moments of these forces acting on the mandrel part A to turn it about the pin *p* are the products of the forces with their lever-arms, as indicated in Fig. 7, and the algebraic sum with the forces adjusted, as indicated, results in the required counter-clockwise movement of the mandrel part A about its pivot-point *p*. The principal adversely-acting turning moment is the reaction of the saddle, and to reduce this as much as possible its lever-arm is shortened by locating the pivot-point *p* above the line of symmetry of the mandrel part. With the more elongated mandrel of Figs. 1 to 5 this lever-arm is much shorter and this adverse turning moment is so much reduced that a drag is not necessary. The strip after passing the pinch-wheel meets the saddle and falls away from the face of the mandrel, so that it does not interfere with the flop of the mandrel nor get in the way of the feeding-guide. The finished convolutions are received on a skeleton spool consisting of parallel prongs S S, which are supported from the ends of the pins *p p′*, which extend from the face-plate of the spindle. This part of the apparatus is of inexpensive construction and may be used with different mandrels. Neither is it necessary to have a separate pinch-wheel or saddle for each particular variety of coil.

As indicated above, one of the features of the machine which enables me to operate at tensions readily opposed by a pinch-wheel is that the strip is inclosed at the point of bending between a stationary wall and a flange which travels with the mandrel and the strip, thereby helping it along.

It will be clear that many changes may be made without departing from the spirit of my invention.

The methods herein described are claimed in a divisional application of this application, filed by me November 28, 1906, Serial No. 345,463.

Having now described my invention and the best way known to me of practicing it, what I claim, and desire to secure by Letters Patent of the United States, is—

1. In a machine for winding flat strips edgewise, the combination of a non-circular rotary mandrel and a forming-saddle with reciprocating and rocking movements which are independent of each other and follow the rotation of the mandrel, substantially as described.

2. In a machine for winding flat strips edgewise, the combination of a non-circular rotary mandrel and a forming-saddle with reciprocating and rocking movements which are independent of each other and follow the rotation of the mandrel, the saddle having two shoes, substantially as described.

3. In a machine for winding flat strips edgewise, the combination of a non-circular rotary mandrel, a forming-saddle with reciprocating and rocking movements which are independent of each other and follow the rotation of the mandrel, and two shoes mounted upon the saddle having independent rocking movements, substantially as described.

4. In a machine for winding flat strips edgewise, the combination of a non-circular rotary mandrel, a forming-saddle with reciprocating and rocking movements which are independent of each other and follow the rotation of the mandrel, and two shoes provided with straight faces and mounted on the saddle, substantially as described.

5. The combination of a mandrel about which a strip is to be bent edgewise, a single flange for the mandrel, means for revolving the mandrel, a bending-saddle provided with a shoe contacting with the edge of the strip for bending the strip to the curved parts of the mandrel, a clamp for engaging one side of the strip and confining it against the flange of the mandrel, and a rotary clamp for clamping the bent strip to the mandrel as it emerges from under the saddle, substantially as described.

6. The combination of a mandrel about which a strip is to be bent edgewise, means for revolving the mandrel, a bending-saddle provided with a shoe contacting with the edge of the strip, the point of contact of the shoe with the edge of the strip being in ad-

vance of the point at which the bending is effected, and means independent of the strip for positioning the shoe, substantially as described.

7. The combination of a mandrel about which a strip is to be bent edgewise, a cam, means for revolving the mandrel and cam, a bending-saddle provided with a shoe contacting with the edge of the strip and a part guided by the cam whereby the point of contact of the shoe with the edge of the strip is maintained in advance of the point at which the bending is effected, substantially as described.

8. The combination of a mandrel about which a strip is to be bent edgewise, means for revolving the mandrel, a bending-saddle provided with a leading shoe and a following shoe contacting with the edge of the strip, and means for maintaining the point of contact of the leading shoe with the strip in advance of the point at which the bending is effected, substantially as described.

9. The combination of a mandrel about which a strip is to be bent edgewise, a cam, means for revolving the mandrel and cam, a bending-saddle provided with a leading shoe and a following shoe contacting with the edge of the strip and a part guided by the cam whereby the point of contact of the leading shoe with the strip is maintained in advance of the point at which the bending is effected, substantially as described.

10. The combination of a mandrel about which a strip is to be bent edgewise, a single flange for the mandrel, means for revolving the mandrel, a bending-saddle provided with a shoe contacting with the edge of the strip for bending the strip to the curved parts of the mandrel and a clamp for engaging one side of the strip and confining it against the flange of the mandrel, means for maintaining the point of contact of the shoe with the edge of the strip in advance of the point at which the bending is effected, and a rotary clamp for clamping the bent strip to the mandrel as it emerges from under the saddle, substantially as described.

11. A mandrel consisting of a plurality of parts about which a metallic strip is to be bent into non-circular coils in which the curvatures of the forming-surfaces of the several parts aggregate more than a whole circle, the parts being pivoted so as to have an angular movement with respect to each other, substantially as described.

12. A mandrel consisting of two parts about which a metallic strip is to be bent into an elongated coil with straight parallel sides in which the curvature of the forming-surface of each part exceeds a semicircle, and the two parts have an angular movement with respect to each other by which the adjoining surfaces of the parts may be brought into alinement on either side, substantially as described.

13. The combination with a two-part mandrel, of a rotary part having a fixed axis for revolving the mandrel, eccentrically-positioned pivots connecting the mandrel parts with the rotary part, and pivot connections between the parts of the mandrel, substantially as described.

14. The combination of a mandrel about which a strip is to be bent edgewise into non-circular coils, means for revolving the mandrel, a pivoted bending-saddle, means for holding the saddle in contact with the strip during the revolution of the mandrel, a guide supported from the saddle for turning the direction of the strip and guiding it to the entrance between the saddle and mandrel, and a point of delivery for the strip located about on a line with the center of the curved path of the guide, substantially as described.

15. In a machine for winding flat strips edgewise, the combination of a mandrel rotating on a fixed axis, a two-shoe bending-saddle, a traveling friction-clamp, substantially as described.

16. In a machine for winding flat metallic strips edgewise, to form non-circular coils, the combination of a mandrel rotating on a fixed axis and consisting of a plurality of parts which may be shifted to change the outline of the mandrel, a two-shoe bending-saddle, and a traveling friction-clamp, substantially as described.

17. In a machine for winding flat strips edgewise to form non-circular coils, the combination of a mandrel rotating on a fixed axis, a two-shoe bending-saddle, an angularly-shifting guide for the tangential delivery of the strip to the mandrel, and means located at a suitable point for delivery of the strip to the guide, substantially as described.

Signed by me in the borough of Manhattan, New York city, New York, this 14th day of November, 1905.

GANO S. DUNN.

Witnesses:
THOMAS EWING, Jr.,
SAMUEL W. BALCH.