Nov. 25, 1969 L. J. CONRAD ET AL 3,479,852

ROLLING APPARATUS FOR ROUNDING THE EDGES OF STRIP METAL

Filed April 21, 1967 10 Sheets-Sheet 1

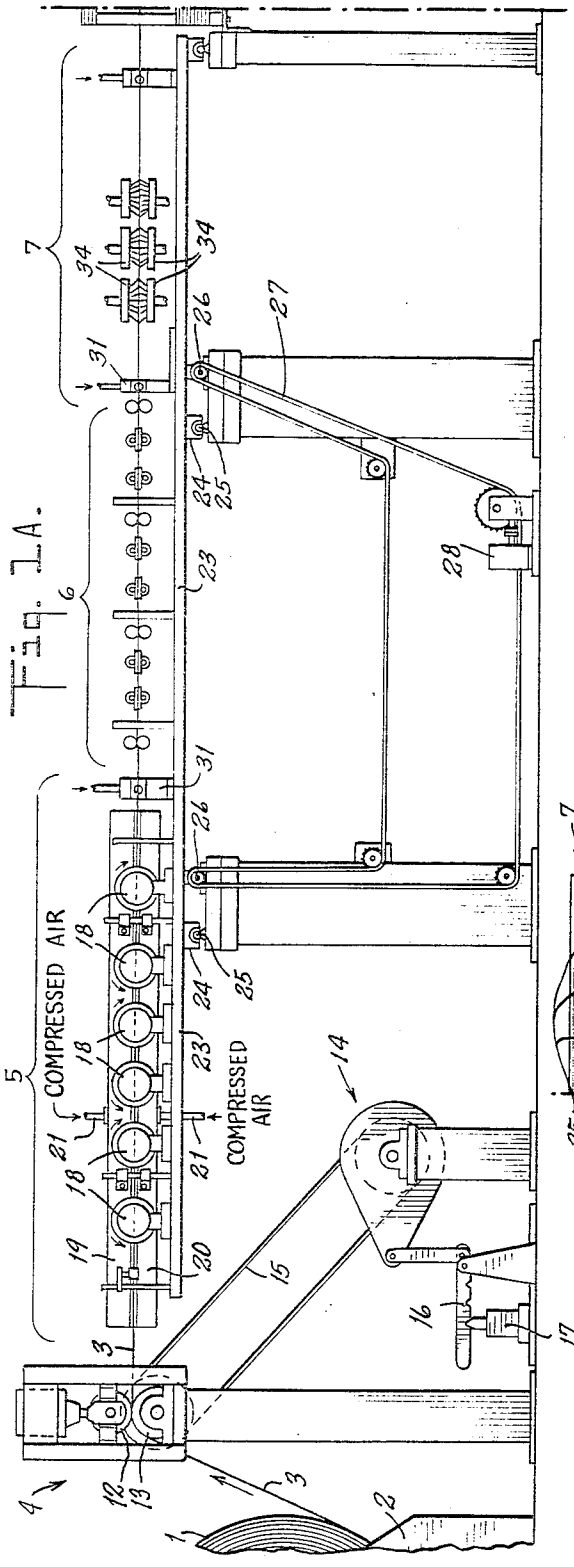


Fig. 1A.

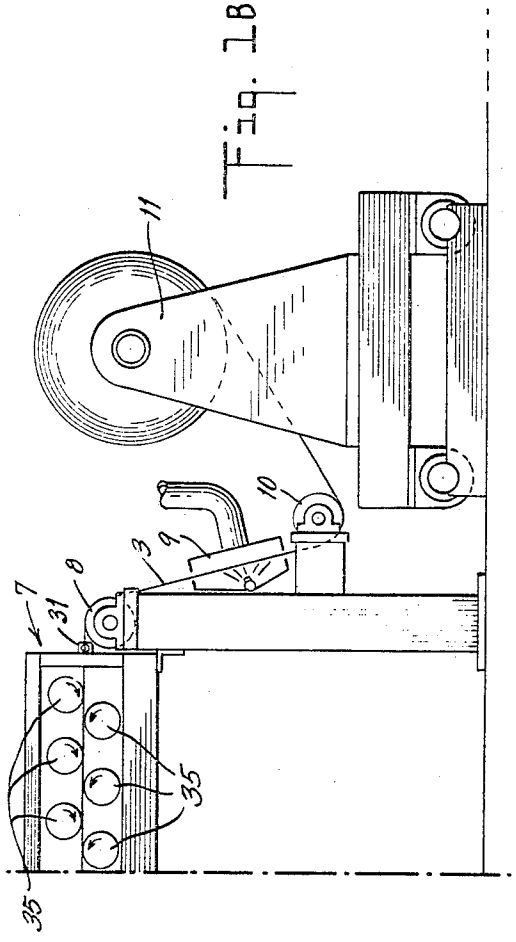


Fig. 1B.

INVENTORS
LUCAS J. CONRAD
JOHN R. EVERHART
BY Lester N. Clark
ATTORNEY

Nov. 25, 1969 L. J. CONRAD ET AL 3,479,852

ROLLING APPARATUS FOR ROUNDING THE EDGES OF STRIP METAL

Filed April 21, 1967 10 Sheets-Sheet 2

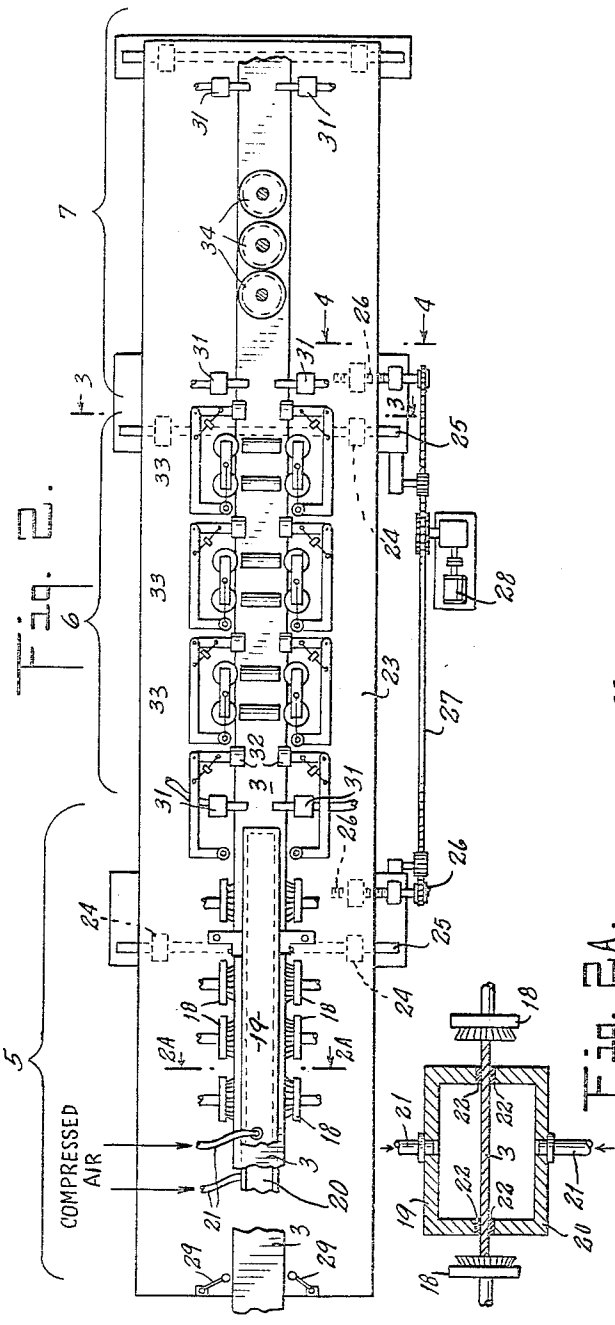


Fig. 2.

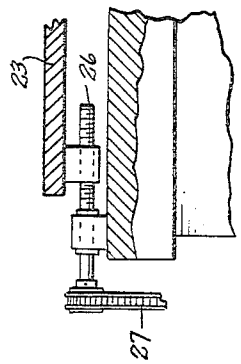


Fig. 4.

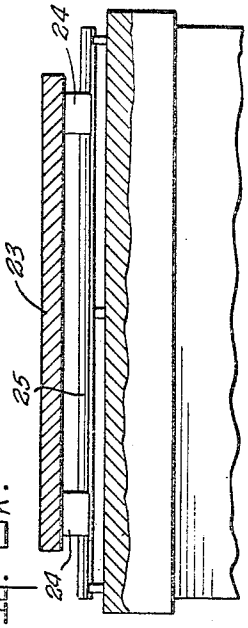


Fig. 3.

Fig. 2A.

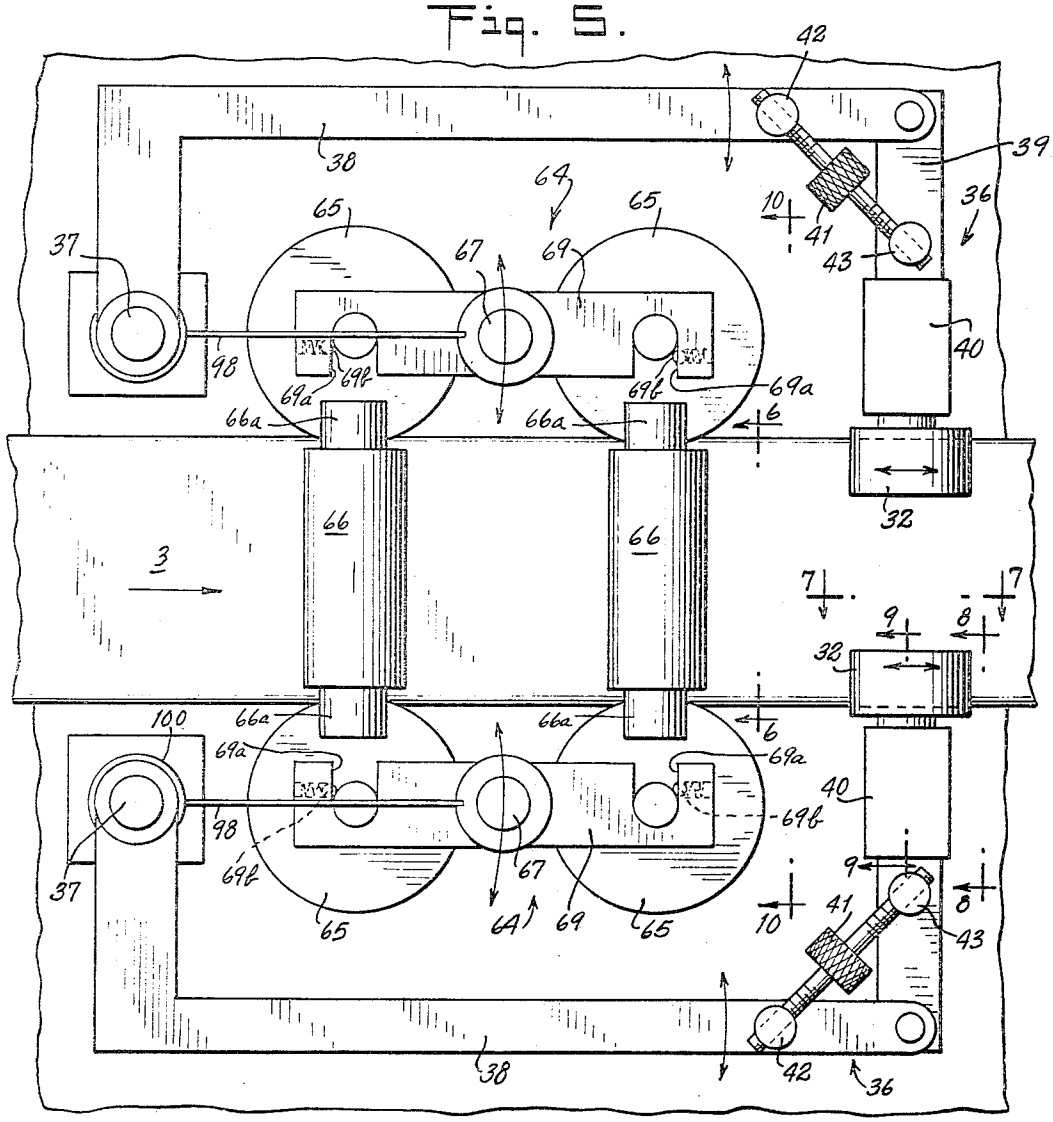
INVENTORS
LUCAS J. CONRAD
JOHN R. EVERHART
BY Lester H. Clark
ATTORNEY

Nov. 25, 1969 L. J. CONRAD ET AL 3,479,852

ROLLING APPARATUS FOR ROUNDING THE EDGES OF STRIP METAL

Filed April 21, 1967 10 Sheets-Sheet 5

Fig. 5.



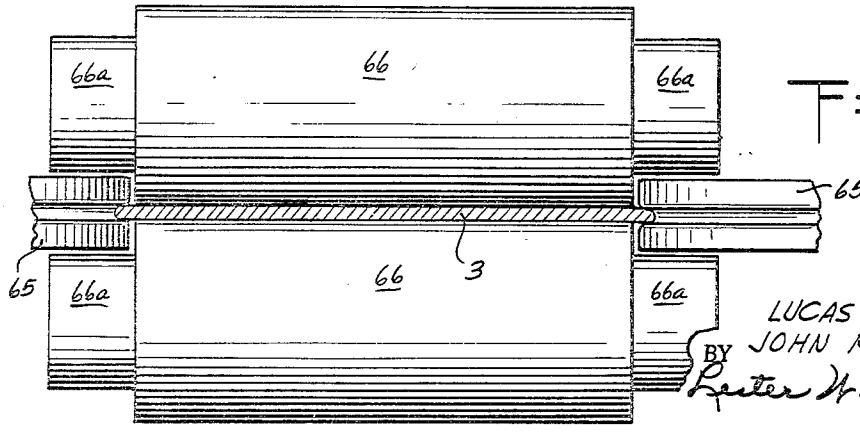


Fig. 6.

INVENTORS
LUCAS J. CONRAD
JOHN R. EVERHART
BY Lester H. Clark
ATTORNEY

Nov. 25, 1969 L. J. CONRAD ET AL 3,479,852

ROLLING APPARATUS FOR ROUNDING THE EDGES OF STRIP METAL

Filed April 21, 1967 10 Sheets-Sheet 4

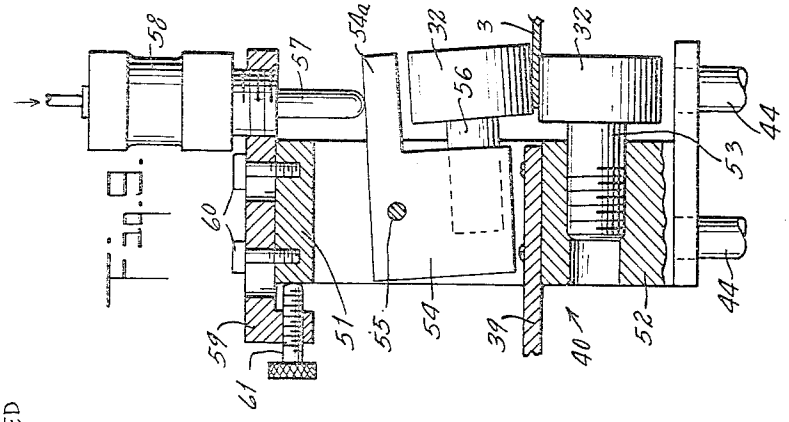


Fig. 6.

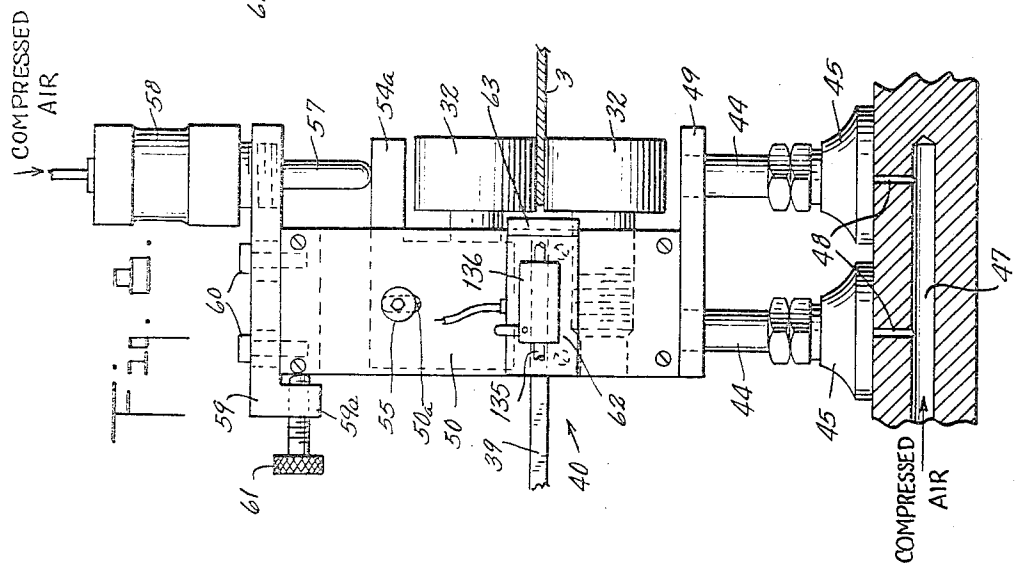


Fig. 6.

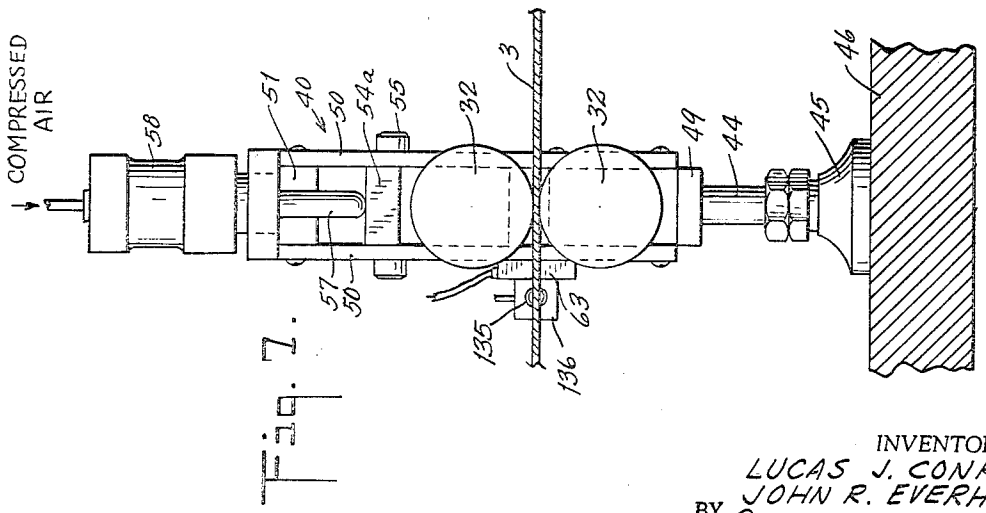


Fig. 7.

INVENTORS
LUCAS J. CONRAD
JOHN R. EVERHART
BY Lester H. Clark
ATTORNEY

Nov. 25, 1969 L. J. CONRAD ET AL 3,479,852

ROLLING APPARATUS FOR ROUNDING THE EDGES OF STRIP METAL

Filed April 21, 1967 10 Sheets-Sheet 5

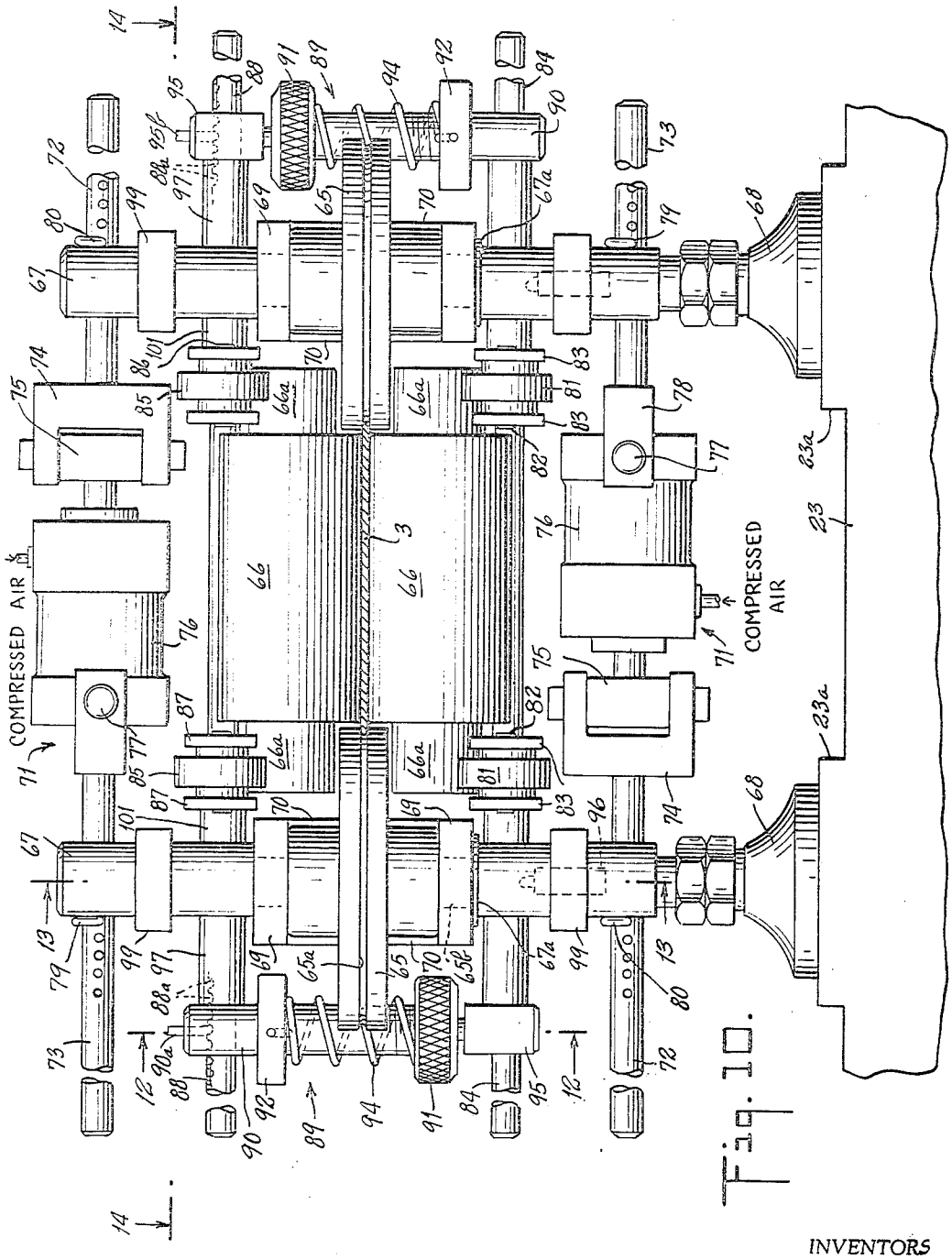


Fig. 10.

INVENTORS
LUCAS J. CONRAD
BY JOHN R. EVERHART
Lester H. Clark
ATTORNEY

Nov. 25, 1969 L. J. CONRAD ET AL 3,479,852

ROLLING APPARATUS FOR ROUNDING THE EDGES OF STRIP METAL

Filed April 21, 1967 10 Sheets-Sheet 6

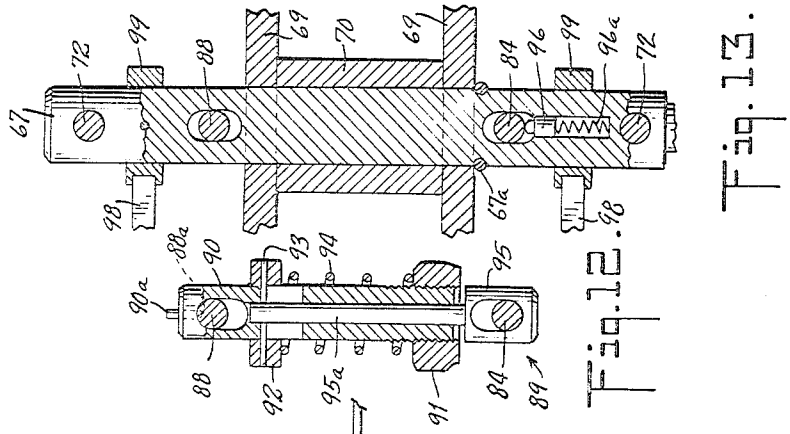


Fig. 12.

Fig. 13.

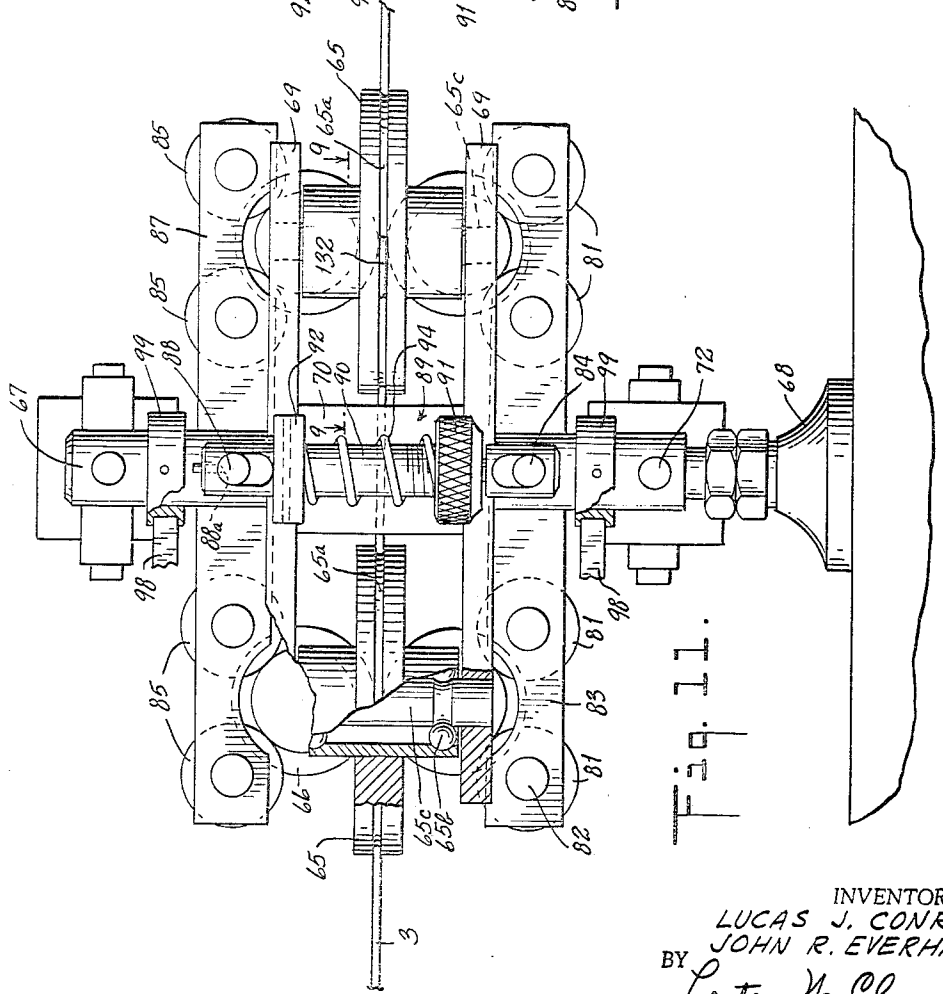


Fig. 11.

INVENTORS
LUCAS J. CONRAD
JOHN R. EVERHART
BY Lester N. Clark
ATTORNEY

Nov. 25, 1969 L. J. CONRAD ET AL 3,479,852

ROLLING APPARATUS FOR ROUNDING THE EDGES OF STRIP METAL

Filed April 21, 1967 10 Sheets-Sheet 7

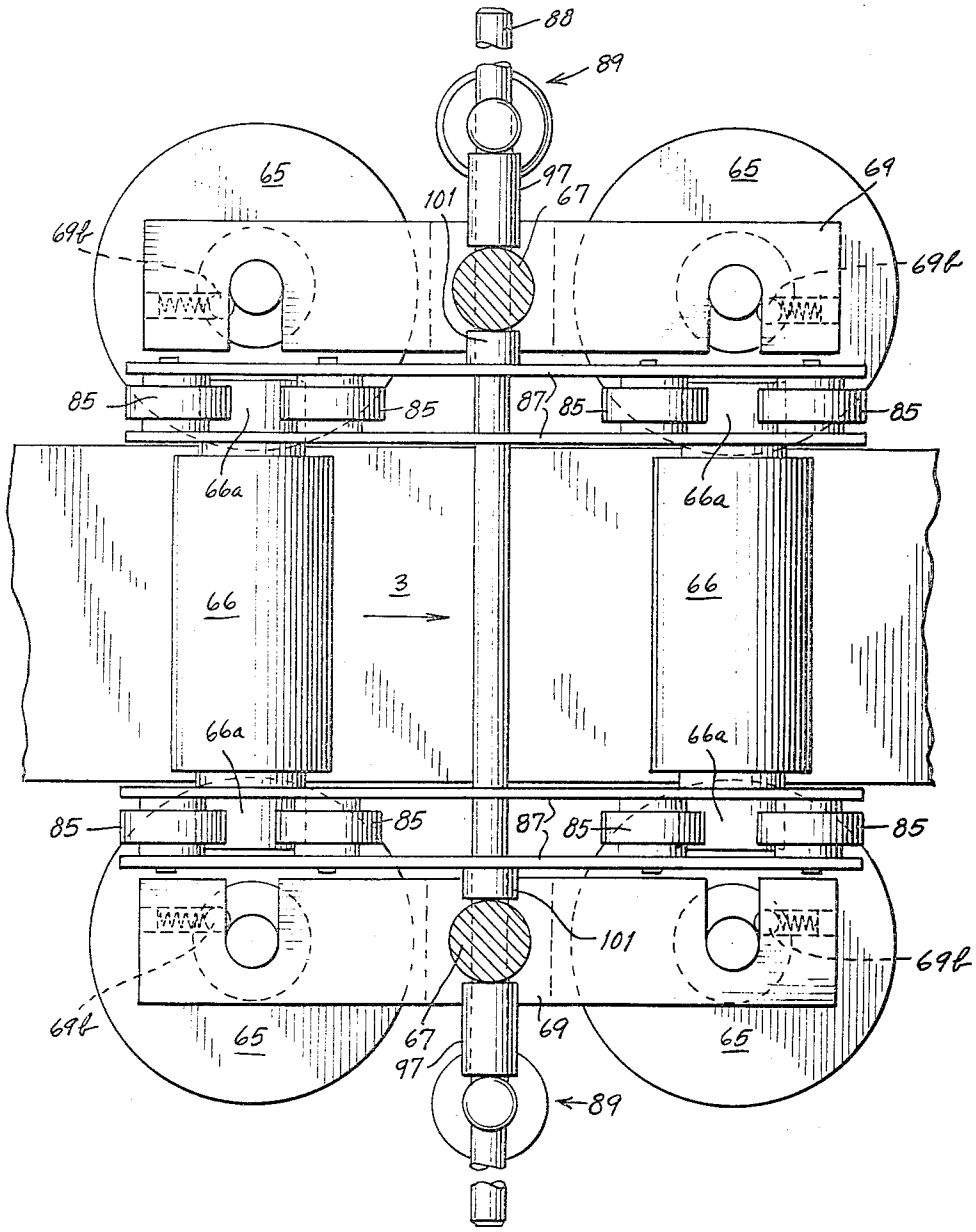


Fig. 14.

INVENTORS
LUCAS J. CONRAD
JOHN R. EVERHART
BY Lester W. Clark
ATTORNEY

Nov. 25, 1969 L. J. CONRAD ET AL 3,479,852

ROLLING APPARATUS FOR ROUNDING THE EDGES OF STRIP METAL

Filed April 21, 1967 10 Sheets-Sheet 8

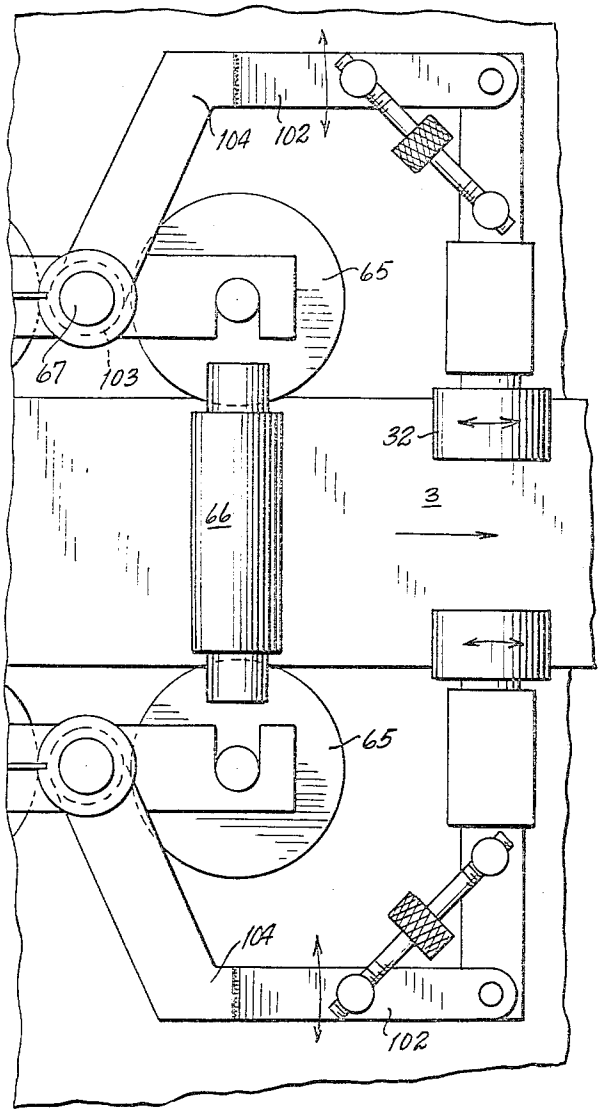


Fig. 15.

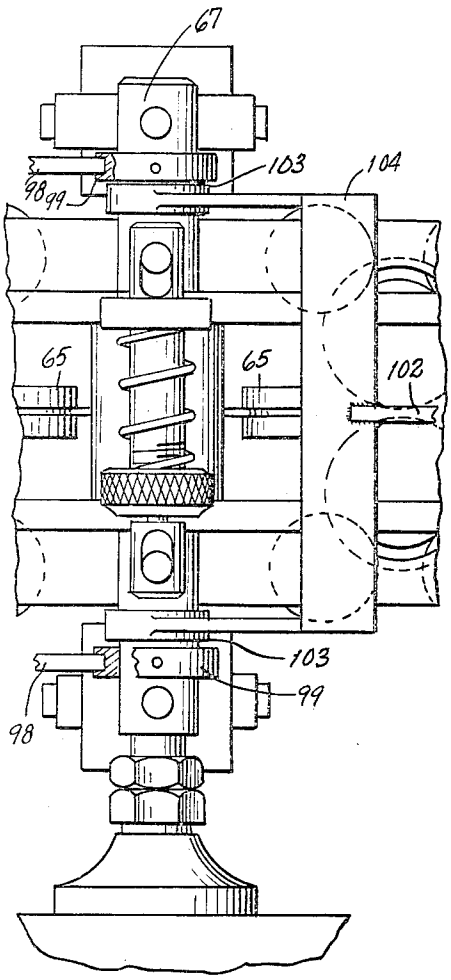


Fig. 16.

INVENTORS
LUCAS J. CONRAD
JOHN R. EVERHART
BY Lester H. Clark
ATTORNEY

Nov. 25, 1969 L. J. CONRAD ET AL 3,479,852

ROLLING APPARATUS FOR ROUNDING THE EDGES OF STRIP METAL

Filed April 21, 1967 10 Sheets-Sheet 9

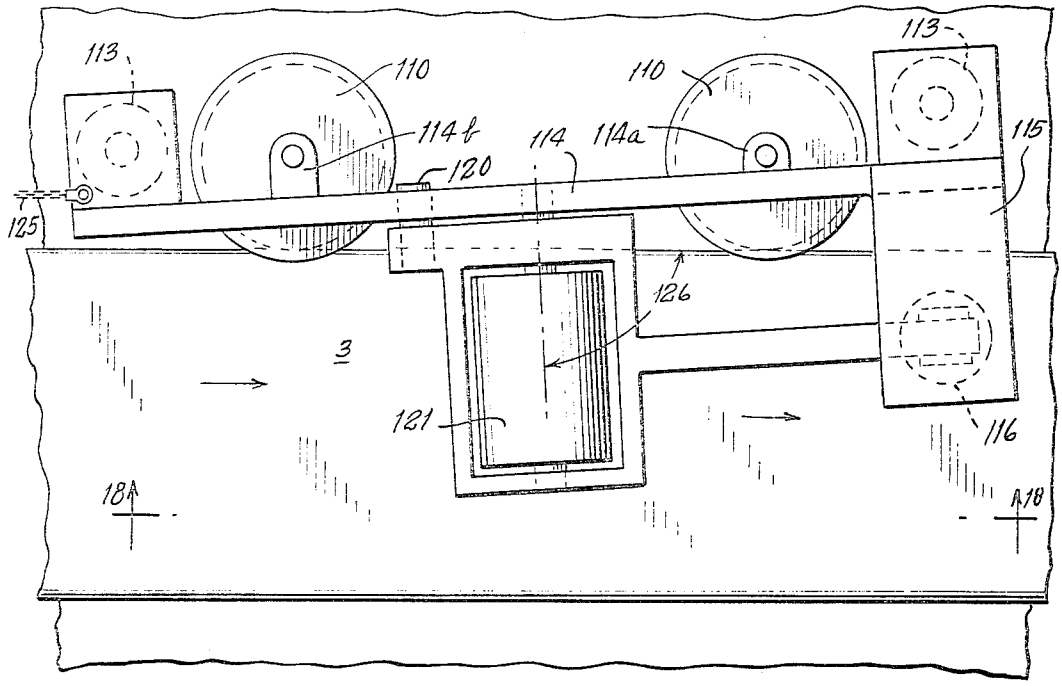


Fig. 17.

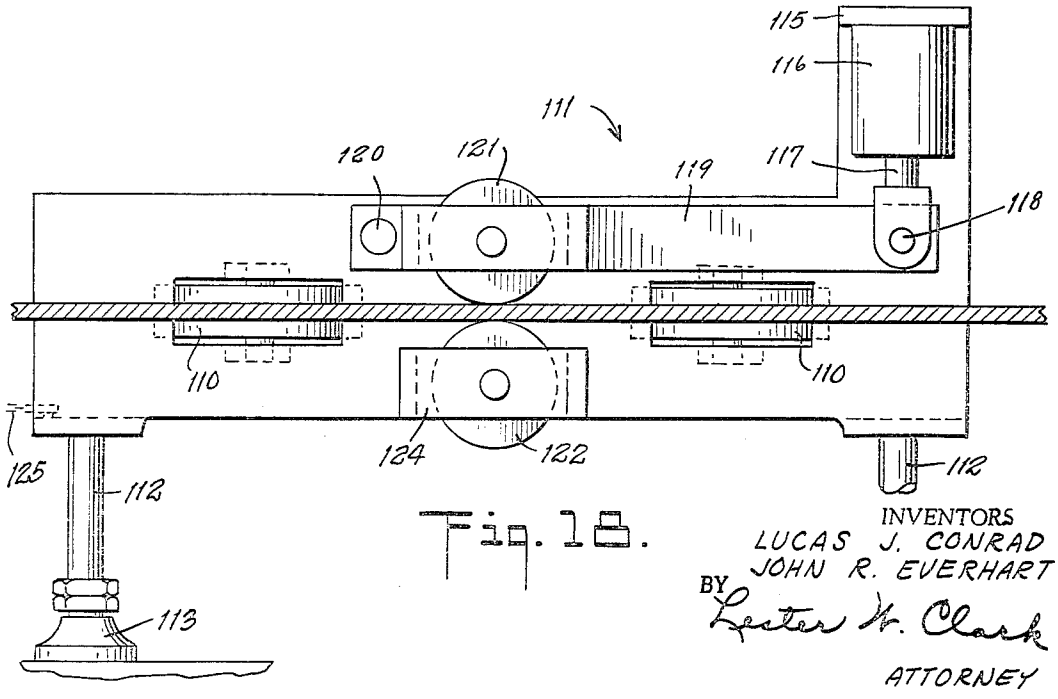


Fig. 18.

INVENTORS
LUCAS J. CONRAD
JOHN R. EVERHART
BY Lester W. Clark
ATTORNEY

Nov. 25, 1969 L. J. CONRAD ET AL 3,479,852

ROLLING APPARATUS FOR ROUNDING THE EDGES OF STRIP METAL

Filed April 21, 1967 10 Sheets-Sheet 10

Fig. 19.

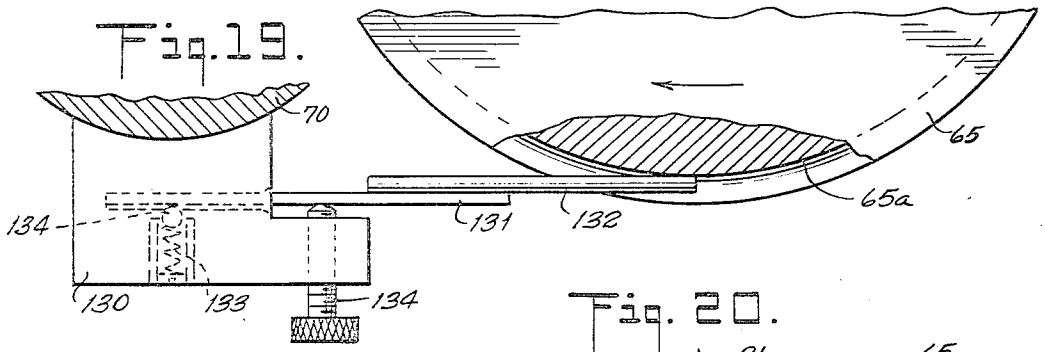


Fig. 20.

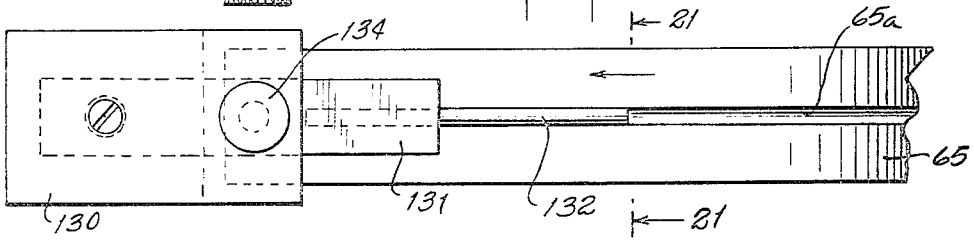


Fig. 22.

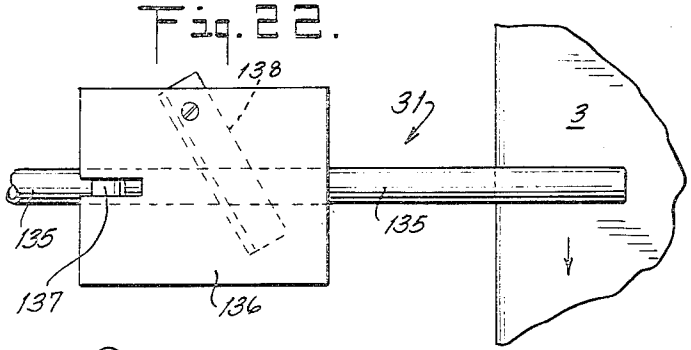


Fig. 21.

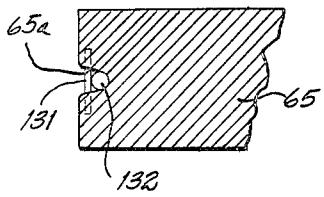
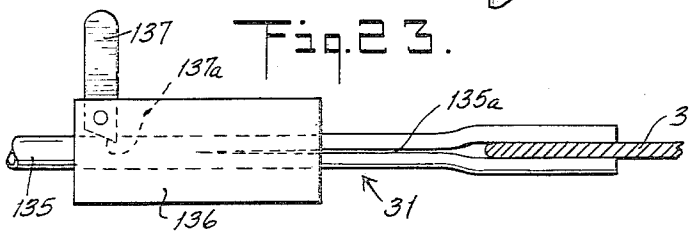


Fig. 23.



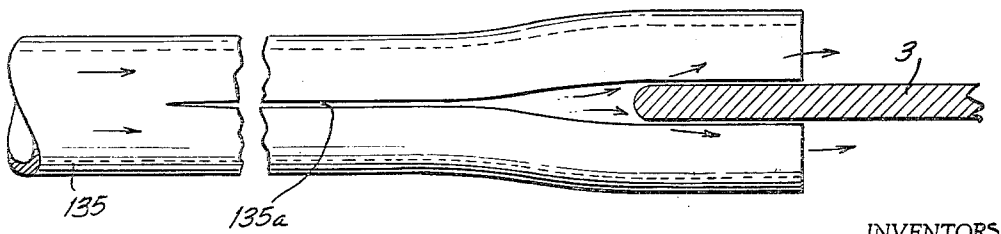


Fig. 24.

INVENTORS
LUCAS J. CONRAD
JOHN R. EVERHART
BY Lester N. Clark
ATTORNEY

United States Patent Office 3,479,852
Patented Nov. 25, 1969

3,479,852

ROLLING APPARATUS FOR ROUNDING THE EDGES OF STRIP METAL

Lucas J. Conrad and John R. Everhart, Winston-Salem, N.C., assignors to Archer Products, Incorporated, Winston-Salem, N.C., a corporation of Delaware

Filed Apr. 21, 1967, Ser. No. 632,758
Int. Cl. B21d 55/00; B21b 45/02, 13/10
U.S. Cl. 72—40 31 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus for rounding the edge of an elongated strip of metal, e.g., aluminum. The edge is rounded by rolling and cleaning techniques. Edge forming rolls rotate on vertical axes and have round grooves which receive an edge of the strip. Edge thickness control rolls overlap the edges of the strip and engage the marginal flat surfaces thereof. The edge thickness control rolls are mounted on caster supports so that their axes of rotation tend to assume directions at right angles to the motion of the strip. Both edge forming rolls and the edge thickness control rolls are rotated only by their contact with the moving strip. Rolls are readily demountable. Supports allow rolls to follow lateral movements of strip without stressing it.

The cleaning techniques employed include brushing and cleaning with a stream of compressed air. One set of brushes rotates about horizontal axes and engages the edges of the strip. Between these brushes, the strip passes between upper and lower plenum chambers, which are supplied with compressed air and are effective to hold the middle of the strip against buckling. The fluid cleaning apparatus comprises a tube having an open end and diametrically opposite slits through which the edge of the material passes. Compressed air is supplied to the hose and blows away any splinters or particles clinging to the edges. The compressed air cleaning is employed after the rolling or brushing operation. A final cleaning station includes one set of brushes rotatable about vertical axes and engaging the flat surface of the strip and a second set of brushes rotatable about horizontal axes and also engaging the flat surface.

BACKGROUND OF THE DISCLOSURE

The invention is particularly useful for rounding the edges of flat strips or foils of aluminum which are intended to be used as electrical windings or capacitors. Such strips or foils are commonly first manufactured by cutting or slitting a wider strip or sheet, and have sharp corners at their edges resulting from the cutting or slitting operation. They may also have occasional slivers or small particles clinging to their edges.

The strip is either interleaved with an insulating material such as paper, or the strip may be coated with an insulating material before it is wound into a coil. A clean, smoothly contoured edge is required to prevent puncture of the insulation by burrs, slivers, etc., to maintain purity of cooling and/or insulating fluid where a fluid cooled winding is used, and to attenuate corona discharge. In those cases where a liquid insulating coating is applied, a smooth curved surface facilitates a more uniform coating, since if the strip has a sharp corner, the surface tension of the liquid film will reduce the thickness of the coating at that corner.

The prior art teaches the use of edge forming rolls having rounded grooves engaging the edge of a strip of metal and effective to produce a round contour on the strip. Such rolls, if employed according to the teachings of the prior art, are effective to form the edges, but have

a tendency to produce ridges in the flat surfaces of a strip at a point adjacent the edges. Furthermore, the prior art edge forming rolls have a tendency to squeeze the strip laterally, thereby causing it to buckle in the middle. While this is not important in dealing with strips of substantial thickness and materials of substantial strength, e.g., steel, it presents difficulties when dealing with weaker metals such as aluminum.

SUMMARY OF THE INVENTION

The invention comprises means defining a path for moving strip material, and edge rolling and edge cleaning means mounted to cooperate with a strip moving along that path. A strip moving through the apparatus disclosed herein first encounters an edge cleaning station, where the edges of the strip are brushed by a series of brushes rotating about horizontal axes aligned with the strip, with successive brushes turning in opposite directions. In order to prevent the lateral force of the brushes from buckling the strip, the central portion of the strip passes between the upper and lower plenum chambers which are maintained under pressure, preferably by means of compressed air.

After passing the edge brushing station, the strip passes between two fluid edge cleaners, which comprise tubes or hose slit at their open end so that the edge passes through the slits. The tubes are supplied compressed air, which issues in a high velocity stream so that any particles clinging to the edges are blown away.

The strip next passes to a rolling station where it encounters a first set of edge thickness control rolls. These rolls engage the flat surfaces of the strip and overlap the edges thereof. They are mounted on a caster support and are driven only by contact with the strip, so that their axes of rotation tend to assume positions at right angles to the strip.

Following the edge thickness control rolls, the strip passes through three sections of the rolling station, each section comprising two sets of edge forming rolls followed by a single set of edge thickness control rolls similar to the first one. Upon leaving the rolling station, the strip passes another fluid edge cleaning station, similar to the one at the end of the edge brushing station. The strip next passes through a final cleaning station where it first encounters a set of brushes rotating on vertical axes and engaging the flat surfaces of the strip. This is followed by another fluid edge cleaning and finally by another set of brushes rotating on horizontal axes and engaging the upper and lower flat surfaces of the strip.

One of the principal features of the invention is the edge thickness control rolls and their caster mount. These rolls are effective to eliminate ridges formed by the edge forming rolls and to reduce minor variations in thickness of the strip.

Another feature of the invention is the mounting of the edge forming rolls so that they are urged against the edges of the strip only under light pressure, and so that if the strip moves laterally a short distance the edge forming rolls move with it without substantial change in the force applied to the strip by the edge forming rolls. This force is determined by a parallelogram linkage including pneumatic motors in two of the links, which motors determine the forces applied to the edges of the strip by the edge forming rolls. Each pair of opposed edge forming rolls is associated with a pair of antibuckle rolls which effectively prevents the force applied by the edge forming rolls from buckling the strip in the middle.

The edge forming rolls, the anti-buckle rolls and their supports are so constructed that they can be readily removed and replaced. Furthermore when a strip is fed into the apparatus, its leading edge is self-threading both

through the edge forming rolls and the edge thickness control rolls.

A wire doctor blade is provided for each edge forming roll, for the purpose of cleaning slivers, oxide deposits and the like from the bottom of the edge forming grooves in the roll.

DRAWINGS

FIGS. 1A and 1B, taken together with the left end of FIG. 1B placed at the right end of FIG. 1A, form a fragmentary, somewhat diagrammatic elevational view of an edge rolling apparatus constructed in accordance with the invention, with many parts omitted for the sake of clarity;

FIG. 2 is a plan view of the apparatus of FIG. 1A;

FIG. 2A is a sectional view taken along the line 2A—2A FIG. 2;

FIG. 3 is a sectional view taken on the line 3—3 of FIG. 2;

FIG. 4 is a sectional view taken on the line 4—4 of FIG. 2;

FIG. 5 is a plan view on an enlarged scale showing the edge forming rolls and the edge thickness control rolls in one section of the rolling station of FIGS. 1A and 2. Some parts have been omitted for the sake of clarity;

FIG. 6 is a further enlarged view showing the positional relationship between the edge forming rolls and the anti-buckle rolls, when a strip is passing through the rolls;

FIG. 7 is a view taken along the line 7—7 of FIG. 5, showing an elevational view of the edge thickness control rolls;

FIG. 8 is a view taken along the line 8—8 of FIG. 5, showing a side view of the edge thickness control rolls of FIG. 7;

FIG. 9 is a cross-sectional view taken along the line 9—9 of FIG. 5, showing further details of the support for the edge thickness control rolls;

FIG. 10 is a sectional view taken along the line 10—10 of FIG. 5, showing the edge forming rolls and anti-buckle rolls, but with parts supplied which are omitted in FIG. 5;

FIG. 11 is a side elevational view of the apparatus of FIG. 10;

FIG. 12 is a sectional view taken along the line 12—12 of FIG. 10;

FIG. 13 is a sectional view taken along the line 13—13 of FIG. 10;

FIG. 14 is a sectional view taken along the line 14—14 of FIG. 10;

FIG. 15 is a fragmentary view similar to a portion of FIG. 5, showing a modification;

FIG. 16 is a fragmentary view similar to a portion of FIG. 11, but illustrating the modification of FIG. 15.

FIG. 17 is a fragmentary view similar to FIG. 5, showing still another modification;

FIG. 18 is an elevational view of the apparatus of FIG. 17;

FIG. 19 is a view taken along the line 19—19 of FIG. 11, illustrating the doctor blade mechanism;

FIG. 20 is an elevational view of the doctor blade mechanism of FIG. 19;

FIG. 21 is a sectional view taken along the line 21—21 of FIG. 20;

FIG. 22 is a plan view on an enlarged scale showing one of the fluid edge cleaning units;

FIG. 23 is an elevational view of the fluid edge cleaning unit of FIG. 22;

FIG. 24 is a fragmentary view similar to a portion of FIG. 23, but on an enlarged scale.

DESCRIPTION OF THE INVENTION

FIGS. 1A, 1B and 2

These figures illustrate somewhat diagrammatically, a complete edge rounding apparatus in accordance with the invention.

A coil 1 of strip aluminum is mounted on a supply reel 2 (shown as a fragment at the left end of FIG. 1A). The aluminum passes as a strip 3 from the supply reel 2 to a pinch roll stand 4 of conventional construction, which regulates the tension in the strip. From the pinch roll stand 4, the strip 3 passes through a first cleaning station 5, a rolling station 6, and a final cleaning station 7, which is divided in the illustration between FIGS. 1A and 1B. From the final cleaning station, as seen in FIG. 1B, the strip 3 passes over a guide roll 8, and thence through an oil spray system 9 and over another guide roll 10 to a take-up reel 11, which is driven by a motor (not shown). That motor is the only drive for the moving strip, and all rolls are rotated only by their contact with the moving strip.

The principal features of novelty of the present invention are in the roll station 6 and in the cleaning stations 5 and 7. The other parts of the apparatus will be only briefly described.

The pinch roll stand 4 comprises a rubber faced roll 12 and a steel faced roll 13. The strip 3 is pinched between the two rolls. The steel faced roll drives a pneumatic, water cooled brake generally indicated at 14, the drive being through pulleys and a belt 15. The brake torque is adjustable by means of a bell crank lever 16, which acts on a pneumatic load cell 17. The longitudinal tension on the strip 3 as it passes through the cleaning station 5, the rolling station 6 and cleaning station 7 may be set and controlled by the brake 14.

The strip 3 passing through the cleaning station 5 passes between opposed rows of rotary brushes 18 turning on horizontal axes extending at right angles to the direction of movement of the strip. Between the brushes, the central portion of the strip passes between upper and lower plenum chambers 19 and 20 which are connected by suitable conduits 21 to a source of compressed air. The edges of the plenum chambers where they contact the strip 3 are faced with nylon or other suitable material as shown at 22 so that the chambers do not mar or scratch the strip surface. Air is continuously leaking between the strip and the facings 22.

The entire cleaning and rolling apparatus shown in FIG. 1A, including the precleaning station 5, the rolling station 6 and that part of the final cleaning station 7 which appears in FIG. 1A, is mounted on a platform 23 having on its under surface downwardly projecting saddles 24 which rest on laterally extending rails 25. The platform 23 may be driven along the rails by means of a pair of lead screws 26 (FIGS. 2 and 4) which are driven by a chain 27 connected through suitable drive mechanism to a reversible motor 28. The motor 28 is controlled by edge feelers 29, which appear at the left end of FIG. 2. The feelers 29 normally have a small clearance from the edge of the strip. If either feeler is contacted by the strip edge, a lateral movement of the strip is indicated, since the strip is of substantially constant width. The contacted feeler 29 actuates the motor 28, to drive the lead screws 26 in a direction to terminate contact between the edge of the strip and the feeler 29, whereupon operation of the motor is discontinued. Thus, the entire cleaning stations and the rolling station are moved laterally and kept in alignment with the strip, so that substantially no stress can be placed on the strip due to a change in its lateral position.

At the end of the cleaning station 5, the strip passes between two opposed fluid operated edge cleaners 31, which are described in detail in connection with FIGS. 22 to 24 below.

In the rolling station 6, the strip first passes between a pair of edge thickness control rolls 32 and thence passes through three rolling station sections, each indicated by numeral 33, one of which is shown in detail in FIGS. 5 to 14.

Upon entering the final cleaning station 7, the strip first passes through a second pair of fluid operated cleaning devices 31 (see FIGS. 22 to 24) and then passes between an array of rotary brushes 34, rotating on vertical axes.

One set of brushes **34** is located above the strip and the other set below the strip. After passing the brushes **34**, the strip passes another pair of fluid operated cleaning devices **31** and thence passes into the final section of the cleaning station **7**, which appears in FIG. 1B and consists of upper and lower sets of brushes **35** rotating on horizontal axes and engaging the flat surfaces of the strip.

After leaving the final cleaning station **7**, the strip passes another fluid-operated cleaning device **31**, and then over guide roll **8**, through oil spray system **9**, and over guide roll **10** to take-up reel **11**.

EDGE THICKNESS CONTROL ROLLS
FIGS. 5 and 7–9

The edge thickness control rolls **32** are mounted in vertically opposed pairs, one pair being best seen in FIGS. 7 to 9. Furthermore, each vertically opposed pair is located directly opposite a similar pair on the other edge of the strip (see FIG. 5). The edge thickness control rolls are supported on caster mountings. More specifically, each pair of edge thickness control rolls **32** is supported on a frame generally indicated at **36** which is in turn mounted for movement about a pivot **37** whose vertical pivot axis is located upstream of the path of strip movement from the rolls **32**. As best seen in FIG. 5, each frame **36** includes an arm **38** having a right angle elbow. The left end of each arm **38**, as it appears in FIG. 5, is journaled for rotation on one of the pivots **37**. The other end of the arm **38** is pivotally connected to a link **39**, which extends from arm **38** toward the strip **3**. As its end nearest the strip, the link **39** is fixed to a carriage **40** which rotatably supports the rolls **32**. A turnbuckle **41** connects pivot posts **42** and **43** fixed respectively on the arm **38** and the link **39**. The operation of the turnbuckle changes the angle between arm **38** and link **39** and hence effectively changes the lateral positions of rolls **32** at which they rotate about axes perpendicular to the direction of strip movement. Consequently, the turnbuckles **41** may be used as adjustments either to accommodate strips of different widths or to vary the amount of overlap of the rolls **32** over the marginal edges of the strip **3**.

One of the carriages **40** is illustrated in FIGS. 7 to 9. The carriage **40** is supported on a pair of vertical posts **44** having feet **45** of substantial horizontal extent, and resting on an underlying plate **46**. Within the plate is a manifold or passage **47** communicating with branch passages **48** which terminate at the upper flat surface of the plate **46**, upon which the feet **45** rest. Compressed air is supplied continuously to the passage **47** and flows out under the feet **45**, thus providing an air bearing upon which the carriage **40** may be moved laterally freely in the event any lateral force is applied to it through the strip **3**. The air bearings thus allow the frames **36**, and the rolls **32** supported thereby, to move on their pivots **37** with little or no friction, so that the rolls **32** always turn at right angles to the motion of the strip, and hence exert no lateral force on the strip.

The carriage **40** comprises a base plate **49** fixed to the tops of the columns **44**. Extending upwardly from the base plate **49** are a pair of side plates **50** connected at their upper ends by a top plate **51**. A block **52** is mounted between the side plates **50** below the strip **3** and is apertured to threadedly receive an arbor **53** on which the lower edge thickness control roll **32** is rotatably mounted by a roller bearing (not shown). A block **54** is fixed on a retainer pin **55** which extends through vertical slots **50***a* in the side plates **50**. The block **54** carries an arbor **56** on which the upper edge thickness control roll **32** is mounted by means of a roller bearing (not shown). The block **54** is provided with a laterally projecting arm **54***a* at its upper end which extends into the path of movement of a thrust rod **57** operated by a pneumatic cylinder **58** or other suitable motor means. The cylinder **58** is mounted on a horizontal plate **59** attached by screws **60** extending through slots in the plate **59** to the top plate **51** of the carriage. The plate **59** is provided at its left-hand end as seen in FIGS. 8 and 9, with a downwardly projecting finger **59***a* through which is inserted an adjusting screw **61** having a knurled head and cooperating at its opposite end with the top plate **51**. The lateral position of the pneumatic motor **58** may be adjusted by loosening the locking screws **60** and then operating the adjusting screw **61**, after which the screws **60** are again tightened. This changes the line of action of rod **57** relative to the edge of the strip **3**.

The particular position of rod **57** is to be selected with a view to several variables. Any strip which has been cut had a ridge of material along its edge, and the height of that ridge is one of the more important variables to be considered. Other variables are the location of the ridge, i.e., its spacing from the edge, the air pressure to be used in the cylinder **58**, and the desired contour of the edge. Another factor is whether the roll **32** is engaging the strip along the full width of the roll, or only part of it. In some cases it may be desirable to change this setting so as to produce a tapered edge, as shown in an exaggerated fashion, in FIG. 9. In other cases, it may be desired to make the marginal surfaces of the strip **3** substantially flat, as shown in FIG. 8. By controlling the pressure in the pneumatic cylinder **58**, the force tending to squeeze the edge thickness control rolls **32** together may be regulated. The slots **50***a* allow freedom of vertical movement of the upper roll **32**, so as to accommodate minor variations in thickness of the edge without introducing substantial stresses in the strip **3**. In other words, the squeezing force exerted by cylinder **58** is not dependent on the position of the piston in the cylinder. The slots **50***a* allow the rolls **32** to separate or to move together without changing that force.

Mounted on one of the plates **50**, as best seen in FIGS. 7 and 8, is a switch **62** having an actuator plate **63** adapted to be engaged by the edge of the strip **3** if a severe condition of misalignment between the strip and the rolling apparatus occurs. The switch **62** is connected in an electrical circuit (not shown) which is effective to shut down the drive motor for the take-up reel **11** in the event that such a misalignment occurs.

EDGE FORMING ROLL ASSEMBLY
FIGS. 5 and 10–14

A complete edge forming roll assembly is illustrated in FIGS. 10 and 11, and is shown with certain parts omitted at **64** in FIG. 5. The edge forming roll assembly **64** comprises four edge forming rolls **65**. One pair of edge forming rolls is located on each side of the strip **3**. The rolls of each pair are spaced apart along the direction of movement of the strip. Furthermore, each pair is directly opposite the pair of edge forming rolls on the other side of the strip. Each edge forming roll is provided with a central groove **65***a*, which is contoured to produce a desired contour on the edge of the strip **3**.

In the edge rolling apparatus of the prior art, the successive edge forming rolls encountered by the strip are commonly given progressively varying contours, so that the first edge forming roll encountered by the strip has a contour only slightly different from that of the square cornered strip which approaches it, while the contour of the last edge forming roll is that of the final edge desired. In apparatus constructed according to the present invention, it is preferred to give all the rolls **65** the same contour, i.e., all the grooves **65***a* will have the contour of the final desired edge. If the grooves are so contoured, then the edge will enter the groove of the first roll less deeply and the grooves of the subsequent rolls more deeply, and will fully engage the bottom of the last groove. The varying depth of penetration of the edge into the groove is accommodated by the yieldable mounting of the rolls, as described more fully below.

Between each set of laterally opposed edge forming rolls, there are mounted a pair of anti-buckle rolls **66**, one above and one below the strip. The anti-buckle rolls **66**

are provided with projecting hubs 66*a* at their ends. The entire assembly including four edge forming rolls 65 and four anti-buckle rolls 66 is mounted on two columns 67 located on opposite sides of the strip. The bottom of each column is provided with a foot 68 and rests upon an air bearing similar to that disclosed in the case of the foot 45 in FIG. 8. Each column 67 is provided with a groove to receive a split ring 67*a* on which rests a horizontal beam 69 extending along the path of movement of the strip 3. A tubular spacer 70 encircles the column 67 above the beam 69 and rests on that beam. Another beam 69 rests on the top of the spacer 70. The beams 69 have recesses 69*a* on their inner faces, near their ends. Each roll 65 is force fitted on the outer race of a roller bearing 65*b*, whose inner race is fixed on an arbor 65*c*. The ends of the arbors 65*c* are received in the recesses 69*a*, and are retained there by spring-loaded ball detents 69*b*.

The columns 67 are interconnected near their lower end by a horizontal transverse link 71, best seen in FIG. 10, and including a pair of rods 72 and 73 slidably received in apertures in the columns 67. At the inner end of the rod 72 is mounted a yoke 74 carrying a pivot pin 75 to which is attached the piston rod of a pneumatic cylinder 76. The other end of cylinder 76 is attached to another pivot pin 77 extending at right angles to the pivot pin 75 and carried by a yoke 78 fixed on the inner end of the rod 73. It may be seen that the yokes 74 and 78 and the pivot pins 75 and 77 provide a universal joint connection between the rods 72 and 73, accommodating any misalignment which may occur between those rods.

The upper ends of the columns 67 are connected by another transverse horizontal link 71, whose components are exactly the same as those of the lower link 71 just described, except that the upper link 71 is rotated through an angle of 180° about a central vertical axis, so that the left end of the upper link is the same as the right end of the lower link, and vice versa. Further description of the upper link 71 is considered unnecessary. Movement of the rods 73 with respect to the columns 67 is limited by a fixed pin 79. The position of the rods 72 with respect to their associated columns 67 is determined by pins 79 and 80, any of which may be inserted in any one of a number of holes on the rod 72 or 73 to vary the maximum spacing between the columns 67, which may be necessary to accommodate strips 3 of different widths.

The columns 67, the transverse links 72, and their connections provide a parallelogram linkage supporting the edge forming rolls 65. The force acting on the edges of the strip through the edge forming rolls 65 is determined by the pressure of the air supplied to the pneumatic motor 76, and may be regulated as desired. It may be observed that the parallelogram linkage allows separation of the columns 67 which may be required on account of minor variations in the width of the strip. If such variations occur, the strip can readily push the columns 67 apart to the limits determined only by the strokes of the pistons in the cylinders 76. Furthermore, because of the nature of the pneumatic cylinders 76, the force which they exert is not dependent upon their positions. In other words, the same force is exerted on the edges of the strip when the cylinders are pushed apart, as when they are together, as long as the limits of travel of the pistons within the cylinders is not exceeded. The expected variation in the width of the strip is only a fraction of an inch, which is much less than the stroke of the pistons employed.

The lower anti-buckle roll 66 has its hubs supported by engagement with four back-up rolls 81, each of which is rotatable on an anti-friction bearing carried by an arbor 82 extending between a pair of beams 83. The beams 83 extend longitudinally of the path of strip movement and provide supports for back-up rolls 81 for both of the anti-buckle rolls located under the strip 3. The beams 83 are pivotally mounted at their center on a transverse rod 84 which extends entirely across the rolling station from one side to the other and projects through and beyond the columns 67.

The upper anti-buckle rolls 66 are supported by engagement with the strip and hence by the lower anti-buckle rolls 66 located immediately below them on the opposite side of the strip. The upper anti-buckle rolls are retained in position by back-up rolls 85 which engage their hubs 66*a*. Each roll 85 turns on an anti-friction bearing carried by an arbor 86 having its ends fixed in a pair of parallel beams 87. The beams 87 are pivotally mounted on a transverse rod 88 which extends transversely of the path of strip movement and beyond the columns 67, similar to the rod 84.

The ends of the rods 88 and 84 are yieldably connected by a spring mechanism 89 best seen in FIG. 12. As shown in that figure, the lower rod 84 extends through a vertically elongated slot in a link 95 having an upwardly extending projection 95*a* of considerably smaller diameter. A sleeve 90 encircles the projection 95*a* and is provided at its upper end with a vertically elongated slot to receive the upper transverse rod 88. A knurled collar 91 is threaded on the outside of the sleeve 90 near its lower end. Another collar 92 encircles the sleeve 90 near its upper end, and is connected by a pin 93 to the upper end of the projection 95*a*. The pin 93 extends through slots in the sleeve 90, so that it is free to move vertically with respect to that sleeve. A coil spring 94 is retained in compression between collars 91 and 92. It may be seen that the coil spring 94 forces the collars 91 and 92 apart, and thereby ensures that the lower end of the slot in the link 89 engages rod 84 and that the upper end of its slot in the sleeve 90 engages rod 88. The spring 94 thus exerts a force tending to bias the two rods 84 and 88 toward each other, and thereby determines the amount of squeezing force applied by the rolls 66 to the moving strip. This force may be adjusted by rotating the knurled collar 91.

The lower rod 84 is mounted on a piston 96 (FIG. 13) supported by a spring 96*a* located in a recess at the center of the column 67. Thus, the whole assembly, including the rods 84 and 88, back-up rolls 81 and 85, and anti-buckle rolls 66, is floating in that it is spring supported and hence does not exert and downward force on the strip 3.

Alternatively, instead of the springs 96*a*, pneumatic pressure may be applied under the piston 96 to counterbalance the weight of the anti-buckle rolls 66 and their supporting structure.

Springs 94 control the squeezing or pinching force which the upper and lower rolls 66 exert against the strip 3.

On the rod 88, there are provided spacer sleeves 101 (FIG. 14) between each of the outer beams 87 and the adjacent column 67. Another set of spacer sleeves 97 is provided on the rod 88 between the columns 67 and the spring assemblies 89. Similar spacer sleeves 101 and 97 are provided on the rod 84.

The parts of the spring assembly 89 at the right-hand side of FIG. 10 are shown as being reversed from the parts of the corresponding assembly 89 at the left-hand side of FIG. 10. In particular, the knurled collar 91 is below the spring 94 at the left-hand side and is above the spring 94 at the right-hand side. The particular orientation of these assemblies 89 is not critical. Either end of either assembly may be the upper end. The assemblies 89 may be held in place on the rods 84 and 88 by means of pins 90*a* and 95*b*, passing through central bores in the sleeve 90 and link 95, and having their ends received in recesses 88*a* in the rod 88.

The entire assembly comprising the edge forming rolls 65 and their associated anti-buckle rolls 66 and their support parts is movable laterally freely on the air bearings provided underneath the feet 68. The assembly is restrained against lateral movement only by a set of elongated leaf springs 98, seen in FIG. 5 and fragmentarily in FIG. 11, each of which connects a collar 99 fixed on one of the posts 67 to a similar collar on a vertical post 100 which supports one of the pivots 37 of the edge thickness control rolls 32. Thus, if the strip 3 moves laterally, the

entire assembly will float laterally with it on the air bearings under the feet **68**. The leaf springs **98** are substantially elongated and provide little or no resistance to lateral movement of the roll assembly within a substantial range. The lateral movement of the assembly is limited by the point at which the feet **68** start to move off shoulders **23***a* (FIG. 10) formed on the supporting plate **23**. When such a movement of the feet **68** takes place, the feet **68** are tilted slightly and the air bearing effect is lost at the edge over which the foot is passing. There results an automatic braking which stops the lateral movement of the feet before a substantial fraction of the foot area has passed beyond the shoulder **23***a*.

Although the feet **68** are shown in the drawings as being supported on a flat plate **23** which extends across the entire width of the strip, it is usually preferable to mount the feet **68** on elongated rails extending the full length of the rolling and cleaning stations **5**, **6** and **7** and connected by cross-bars at spaced points along their length. Such an arrangement allows ready change of the apparatus from one strip width to another by simply changing from one set of cross-bars to another. Nevertheless, in the interests of simplifying the drawings, the embodiment illustrated is shown with a single solid plate **23**.

The rolls in the apparatus illustrated may be readily removed and replaced without taking the entire apparatus apart. When there is no compressed air supplied to the cylinders **76**, the columns tend to tilt and assume unusual angles. The other parts also tend to take up slack positions, and the whole assembly appears rather loose-jointed. However, as soon as air is supplied to the cylinders **76**, the edge forming rolls **65** are moved inwardly until they abut against the ends of the anti-buckle rolls **66** and the whole assembly takes up a more erect posture, substantially as shown in the drawings.

In order to remove the rolls for replacement, it is desirable to have no strip in the apparatus. Each anti-buckle roll **66** can be removed simply by pulling it lengthwise of the path of strip movement, away from its supporting column **67**. The spring units **89** allow the back-up rolls **81** and **85** to separate sufficiently so that the anti-buckle roll may be removed.

After the anti-buckle rolls are moved, then the edge forming rolls are held in place only by the spring detents **69***b*. The edge forming rolls can then be pushed inwardly toward the path of strip movement, and the spring detents will retract to allow the ends of the arbors **65***c* to pass. The spring detents **69***b* are not relied upon to hold the edge forming rolls in place during operation, as the strip is then in position, and constitute the principal means of performing that function.

Thus, it may be seen that either the edge forming rolls or the anti-buckle rolls may be readily removed for repair or replacement with rolls of a different contour. Different sets of anti-buckle rolls **66** may be required for substantially different strip widths.

In the case of narrow strips, there may not be room enough between the columns **67** to accommodate the pneumatic cylinders **76**. In that event, the pneumatic cylinder may be linked to rods such as rods **72** and **73**, outboard of the columns **67**, rather than inboard. One of the cylinders should then be placed at one side of the strip and the other at the opposite side. The general effect and operation would be the same.

While the apparatus shown has two pairs of edge-forming rolls **65** in the assembly **64**, it could alternatively be built with only one pair of opposed edge-forming rolls, or with any other convenient number of such pairs.

FIGS. 15 and 16

These figures illustrate a modification of the apparatus illustrated in FIGS. 5 and 11, particularly with respect to the location of pivot of the caster mounting for edge thickness control rolls **32**. In FIG. 5, that caster mounting includes an arm **38** which is attached to a fixed pivot **37**. In FIG. 15, the arm **38** of FIG. 5 is replaced by a shorter arm **102** which, as best seen in FIG. 16, terminates at its pivot end in a yoke **104** which is connected to a pair of collars **103** rotatably mounted on the column **67**.

The arrangement shown in FIGS. 15 and 16 has the advantage that the edge thickness control rolls **32** are moved laterally with the strip concurrently with the movement of the post **67**.

FIGS. 17 and 18

These figures illustrate a modified form of mounting for edge forming rolls **110**, which are similar to the edge forming rolls **65**, described above. The rolls **110** are journaled on an elongated carriage **111**, which comprises an elongated beam **114** supported on a pair of columns **112** provided with feet **113** which cooperate with air bearings in their supporting surfaces as described in connection with the feet **45** of FIG. 8.

The beam **114** has outwardly extending projections **114***a* and **114***b* in which the rolls **110** are journalled. At the downstream end of the beam **114**, there is provided a flange **115**, extending over the strip **3** and supporting a pneumatic cylinder **116**. The piston rod **117** of the cylinder **116** is connected by a pivot **118** to one end of a lever **119** whose opposite end is pivoted at **120** on the beam **114**. Near the pivot **120**, the lever **119** has formed thereon a frame in which is received a caster roll **121**, rotatable on an arbor supported by the lever **119**. An opposing caster roll **122** is located under the strip **3** and is journaled in a fixed frame **124** attached to the beam **114**.

The carriage **111** is restrained against longitudinal movement of the strip **3** by means of a flexible line or cable **125** attached at any convenient point on the carriage **123** and sufficiently elongated so that it exerts no substantial lateral force on that carriage. The other end of cable **125** is attached to any suitable fixed support which serves as a pivot for carriage **123**. The axes of the caster rolls **121** and **122** meet the edge of the strip at an angle **126** which is slightly less than 90°. Thus the upstream end of the cable **125** defines the pivot axis of a caster mount for rolls **121** and **122**. The caster rolls **121** and **122** tend to drive the edge forming rolls **110** toward the strip **3**, and thus determine the force applied by the edge forming rolls to the strip. A similar set of edge forming rolls is usually provided at the opposite edge of the strip. Thus the net lateral force on the strip due to the edge forming rolls is balanced.

While the caster rolls **121** and **122** are shown as not overlapping the edge of the strip, they could be extended to overlap the edge, and then could be made to perform an edge thickness control function similar to that performed by the edge thickness control rolls **32** of FIGS. 5 to 9.

The carriage **111** may alternatively be used to support tool means other than the rolls **110**. The tool means may engage the strip at some predetermined lateral distance from the edge. Different tool means may be located on the carriage **111** at opposite edges of the strip to apply substantially different treatments to those opposite edges.

FIGS. 19 to 21

These figures illustrate a doctor blade mechanism which may be employed with any of the edge forming rolls illustrated, for example, the edge forming rolls **65** of FIGS. 10 and 11. Attached to a suitable support, which may be the spacer sleeve **70** of FIG. 10, is a block **130** apertured to receive a leaf spring **131** on which is mounted, as by welding or soldering, a length of wire **132** having a contour which substantially matches that of the bottom of the groove **65***a* in the roll **6**. A spring **133** acts through a ball detent **134** to hold the plate **131** in place in a recess in the block **130**. A knurled thumb screw **134** acts on the plate **131** and controls the pressure of the wire **132** against the bottom of the groove **65***a*. As the roll **65** rotates, the

wire rides in the bottom of the groove and cleans out any material which may be deposited there, including slivers, oxide deposits and the like.

FIGS. 22 to 24

These figures illustrate in detail the fluid pressure cleaning device shown at **31** in FIGS. 1A and 2.

The device **31** consists of a tube **135**, such as a flexible hose, extending through an aperture in a suitable fixed support **136**, which may be mounted on the support for the edge thickness control rolls **32**, as shown in FIG. 7. The open end of the hose is slit at opposite locations, as shown at **135***a*. The slits are preferably, but not necessarily, diametrically opposed. The open end of the hose is spread apart so that the opposite halves overlap the marginal edge of the strip **3**. Air at high velocity is supplied through the tube **135** and passes out through the open end of the tube, and also between the walls of the tubes and the surfaces of the strip **3**. The result is that a high velocity stream of air flows over the marginal and edge surfaces of the strip **3**, thereby cleaning any loose materials which may be clinging to those surfaces. The support **136** is provided with a lever arm **137** pivotally mounted on the support and having a wedge-shaped end **137***a* extending into the aperture through which the tube passes and adapted to engage and hold the tube **135** against movement. The support **136** is also provided with a fixed knife blade **138** which spans the aperture through which the tube **135** is threaded. As the slit end of the tube wears away, additional lengths of tube can be pushed through the support **136**. As the tube is so pushed, the knife **138** slits the tube **135** and prepares it for engagement with the strip **3**.

The apparatus of FIGS. 22 to 24 may be used to supply cleaning fluids other than air. Furthermore, the apparatus may be used to supply fluids carrying abrasive particles, or fluids which act on the metal strip by virtue of their own chemical properties, as chemical machining fluids, etching fluids, and the like.

Although the invention has been described in connection with the edge contouring of strip aluminum, many features thereof are useful in the rolling of other metals, and some features are useful in processes other than edge contouring, such as cleaning, abrading, chemical machining, etc.

While we have shown and described certain preferred embodiments of our invention, other modifications thereof will readily occur to those skilled in the art, and we therefore intend our invention to be limited only by the appended claims.

What is claimed is:

1. Apparatus for rolling strip metal, comprising:
(a) means defining a path of movement for longitudinally moving metal strip; and
(b) a pair of rolls;
wherein the improvement comprises:
(c) frame means spanning one edge of the path of strip movement and supporting the rolls for rotation about spaced axes substantially parallel to the strip so that the rolls engage opposite surfaces of the strip; and
(d) pivotal support means for said frame means having a pivot axis perpendicular to the plane of the strip and spaced longitudinally of the strip from the rolls in the direction from which the strip approaches the rolls;
(e) said pivotal support means and said frame means cooperating to provide a caster support for said rolls so that when the rolls are driven by the moving strip, they are driven toward an angular position on said pivotal support means in which the horizontal axes are at right angles to the direction of strip movement.

2. Apparatus as defined in claim **1**, in which said pivotal support means comprises:
(a) a support for the frame means movable transversely of the path of strip movement;
(b) means to limit said transverse movement; and
(c) means restraining the frame means against longitudinal movement with the strip.

3. Apparatus as defined in claim **2**, in which said longitudinal restraining means comprises:
(a) a pivot mounted on a fixed member; and
(b) an arm connecting the pivot to the frame means.

4. Apparatus as defined in claim **2**, in which said longitudinal restraining means comprises:
(a) a fixed support located upstream of the path of strip movement from the frame means; and
(b) a flexible line connecting a fixed support and said frame means.

5. Apparatus as defined in claim **2**, in which said support comprises:
(a) a vertically extending post carrying said frame means and having a horizontally extending foot at its bottom;
(b) means having a generally planar surface supporting said foot; and
(c) pneumatic pressure supply means including a conduit through said planar surface means and opening on said planar surface to supply air under pressure between said surface and said foot, so that the foot floats on an air bearing.

6. Apparatus as defined in claim **1**, in which said frame means includes pneumatic means for forcing said rolls toward one another to squeeze the strip between them.

7. Apparatus as defined in claim **6**, in which said frame means includes:
(a) a lever extending longitudinally of the strip;
(b) means on said lever rotatably supporting one of said rolls; and
(c) said pneumatic means comprises a cylinder and piston operatively connected to said lever.

8. Apparatus as defined in claim **1**, in which said rolls overlap an edge of the strip, and engage opposite marginal surfaces thereof.

9. Apparatus as defined in claim **8**, in which:
(a) said frame means includes a pivotal mount for one of said rolls having a pivot axis parallel to the plane of the strip.

10. Apparatus as defined in claim **9**, including:
(a) pneumatic motor means on said frame means for forcing said rolls together; and
(b) means for varying the position of said pneumatic motor means with respect to said pivot axis.

11. Apparatus as defined in claim **8**, including means for varying the position of said rolls transversely of the strip to vary the extent of the overlap between the rolls and the strip.

12. Apparatus as defined in claim **1**, including tool means carried by said frame means and adapted to engage said strip.

13. Apparatus as defined in claim **12**, in which said tool means comprises edge forming roll means.

14. Apparatus as defined in claim **1**, including:
(a) a pair of edge engaging rolls carried by said frame means and adapted to engage an edge of said strip;
(b) said pair of edge engaging rolls being arranged on the frame means to limit the movement thereof on said pivotal support means to a position in which the axes of said surface engaging rolls make an angle less than a right angle, with the direction of strip movement, so that the driving of said surface engaging rolls toward said right angle position is effective to hold said edge engaging rolls against the edge.

15. Apparatus for rolling strip metal, comprising:
(a) means defining a path of movement for longitudinally moving metal strip;
(b) at least one roll adapted to engage the strip;
(c) supporting means for the roll allowing limited

frictionless movement of the roll transversely of the direction of movement of the strip; and

(d) means restricting the supporting means against movement in the direction of the strip motion;

wherein the improvement comprises:

(e) means yieldably urging the roll toward a predetermined position of alignment with respect to the strip.

16. Apparatus as defined in claim **15**, in which said supporting means comprises:

(a) axle means supporting said roll for rolling engagement with one of the flat surfaces of the moving strip, said roll being driven only by its contact with the strip; and

(b) pivot means for the supporting means having a pivot axis perpendicular to the plane of the strip and upstream of the strip from the roll;

(c) said axle means and said pivot means cooperating to provide a caster support which yieldably urges the roll toward an angular position on the pivot in which its axis of rotation on the axle means is at right angles to the direction of strip movement.

17. Apparatus as defined in claim **15**, in which:

(a) said roll is one of a pair of edge thickness control rolls adapted to engage the opposite surfaces of the strip adjacent an edge thereof; and

(b) said supporting means incudes:

(1) frame means spanning one edge of the path of strip movement and supporting said rolls for rotation about spaced axes substantially parallel to the strip so that the rolls engage opposite surfaces of the strip; and

(2) pivotal support means for said frame means having a pivot axis perpendicular to the plane of the strip and spaced upstream of the strip from the rolls;

(c) said frame means, said rolls, said pivotal support means cooperating with the strip to caster the rolls so that they are yieldably urged by the motion of the strip toward a position in which their axes of rotation are at right angles to the direction of strip movement.

18. Apparatus as defined in claim **15**, in which said roll is an edge forming roll adapted to rollingly engage and shape an edge of the strip.

19. Apparatus as defined in claim **18**, in which said yieldable urging means includes pneumatic motor means on said roll with a predetermined force independent of the position of the roll.

20. Apparatus as defined in claim **19**, in which:

(a) said roll is one of a pair of edge forming rolls engaging opposite edges of the strip;

(b) said supporting means includes:

(1) a pair of bearing means respectively supporting said edge forming rolls; and

(2) a pair of vertically extending posts, one supporting each of said bearing means;

(c) said yieldably urging means comprises a pair of transverse expandable link means, one connecting the upper ends of said posts and the other connecting the lower ends of said posts, said link means cooperating with said posts to form a parallelogram linkage; and

(d) two yieldable biasing devices, one connected in each of said transverse link means, and both acting in a direction to move the posts toward each other.

21. Apparatus as defined in claim **19**, in which said supporting means for said edge forming roll includes:

(a) a vertically extending post having a horizontally extending foot at its bottom;

(b) means having a generally planar surface supporting said foot; and

(c) pneumatic pressure supply means including a conduit through said planar surface means to supply air under pressure between said surface and said foot, so that the foot floats on an air bearing.

22. Apparatus as defined in claim **20**, including:

(a) a pair of opposed anti-buckle rolls engaging the flat surfaces of said strip between said edge forming rolls;

(b) each of said anti-buckle rolls having projecting hubs at the ends thereof;

(c) back-up rolls engaging said projecting hubs; and

(d) means mounted on said posts and carrying said back-up rolls.

23. Apparatus as defined in claim **22**, in which said means carrying said back-up rolls includes yieldable means providing an upwardly acting force on said rolls, so that the rolls are floating and apply a minimum of vertical force to said strip.

24. Apparatus as defined in claim **22**, including means for applying a biasing force to the opposed anti-buckle rolls, in a direction tending to move them toward each other.

25. Apparatus as defined in claim **22**, in which:

(a) each of said posts carries two pairs of edge forming rolls, and those ends of two pairs of anti-buckle rolls which are located at one side of the strip; and

(b) said means carrying said support rolls comprises two pairs of pivoted beams supporting said support rolls.

26. Apparatus as defined in claim **17**, in which:

(a) the edge forming roll has a groove adapted to receive an edge of the strip, said groove having a contour of semi-circular cross-section at the bottom thereof; and

(b) doctor blade means for cleaning said groove, comprising:

(1) a wire of generally cylindrical cross-section; and

(2) means supporting said wire with an end thereof riding in the groove at a locality spaced from said edge.

27. Apparatus for rolling strip metal, comprising:

(a) means defining a path of movement for longitudinally moving metal strip; and

(b) an edge forming roll having a groove adapted to receive and form an edge of the strip;

wherein the improvement comprises:

(c) a pair of edge thickness control rolls adapted to engage and overlap the opposite marginal flat surfaces of the strip downstream from the edge forming roll; and

(d) caster support means for said edge thickness control rolls having a pivot axis perpendicular to the plane of the strip from the edge thickness control rolls.

28. Apparatus as defined in claim **27**, including:

(a) support means for the edge forming roll allowing limited frictionless movement of the edge forming roll transversely of the direction of movement of the strip;

(b) means restraining the support means against movement in the direction of strip motion; and

(c) common fixed pivot means for said restraining means and said caster support means.

29. Apparatus as defined in claim **27**, including:

(a) support means for the edge forming roll allowing limited frictionless movement of the edge forming roll transversely of the direction of movement of the strip;

(b) means restraining the support means against movement in the direction of strip motion; and

(c) pivot means for said caster support means mounted on said supporting means and movable therewith transversely of the strip.

30. Apparatus as defined in claim **27**, including:

(a) support means for the edge forming roll allowing limited frictionless movement thereof transversely of the direction of movement of the strip;

(b) means restraining the support means against movement in the direction of strip motion; and

in which:

(c) said caster support means comprises a carriage spanning one edge of the path of strip movement; and

(d) said edge forming roll is mounted on the carriage and limits movement of the carriage toward the center of the strip;

(e) said edge thickness control rolls are mounted on the carriage with their axes intersecting the edge of the strip at an angle slightly smaller than a right angle so that the edge control rolls are yieldably urged by the motion of the strip toward the center line thereof and are effective to hold said edge forming roll against the edge of the strip.

31. Apparatus as defined in claim **27**, including an edge cleaner located downstream from the edge thickness control rolls and comprising:

(a) a flexible cylindrical tube having an open end and opposed slits in the tube extending longitudinally thereof from the open end and adapted to receive an edge of the strip;

(b) means supporting the tube adjacent said path of movement with the slits aligned with said path;

(c) means supplying cleaning fluid through said tube.

References Cited

UNITED STATES PATENTS

1,955,503	4/1934	King	29—18
2,168,435	8/1939	Bond	72—246 X
2,348,283	5/1944	Dolan	72—246

MILTON S. MEHR, Primary Examiner

U.S. Cl. X.R.

29—17; 72—1, 234, 246

PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,479,852 Dated November 25, 1969

Inventor(s) Lucas J. Conrad and John R. Everhart

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 3, line 57, "19-19" should be -- 9-9 --.
Col. 6, line 12, "had" should be -- has --.
Col. 10, line 35, "123" should be -- 111 --;
line 38, "123" should be -- 111 --;
line 71, "6" should be -- 65 --;
line 73, "134" should be -- 134a --.

SIGNED AND
SEALED
AUG 18 1970

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents