United States Patent

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[54] **REMOVABLE ROLL APPARATUS FOR ROLLING THE EDGES OF STRIP METAL**
2 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **72/40,** 72/199, 72/238
[51] **Int. Cl.** **B21b 45/00,** B21b 31/08
[50] **Field of Search** 29/18; 72/40, 199, 225, 234, 241, 242, 243, 246, 238

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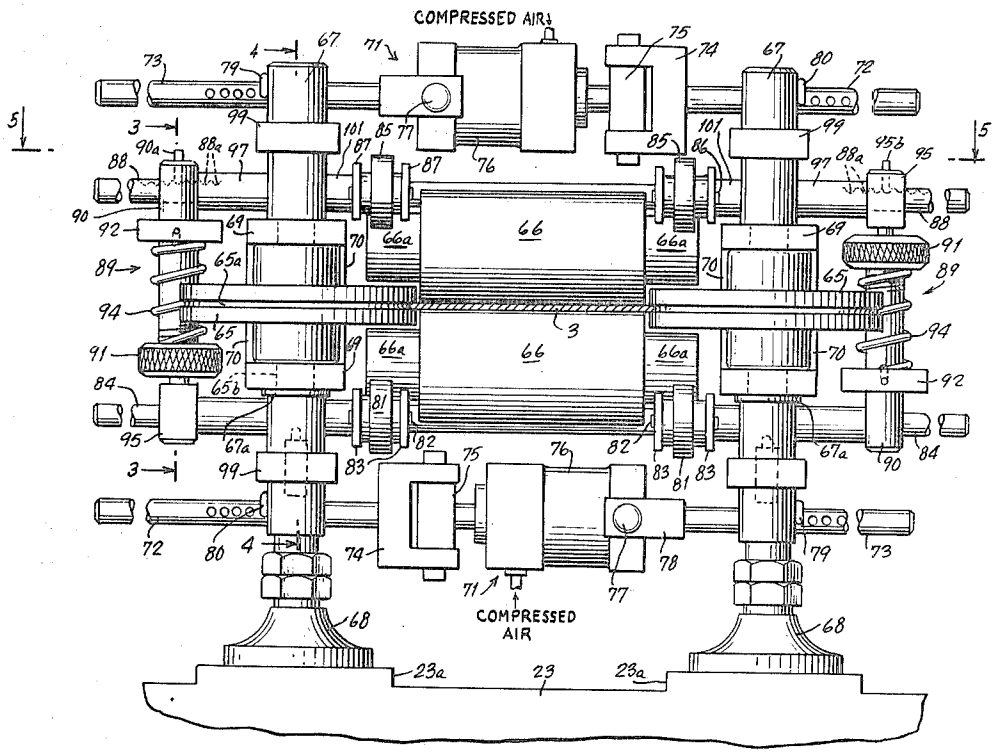
ABSTRACT: Apparatus for rounding the edge of an elongated strip of metal, e.g., aluminum. The edge is rounded by rolling and cleaning techniques. Edge forming rolls rotate on vertical axes and have round grooves which receive an edge of the strip. Edge thickness control rolls overlap the edges of the 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 the 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.



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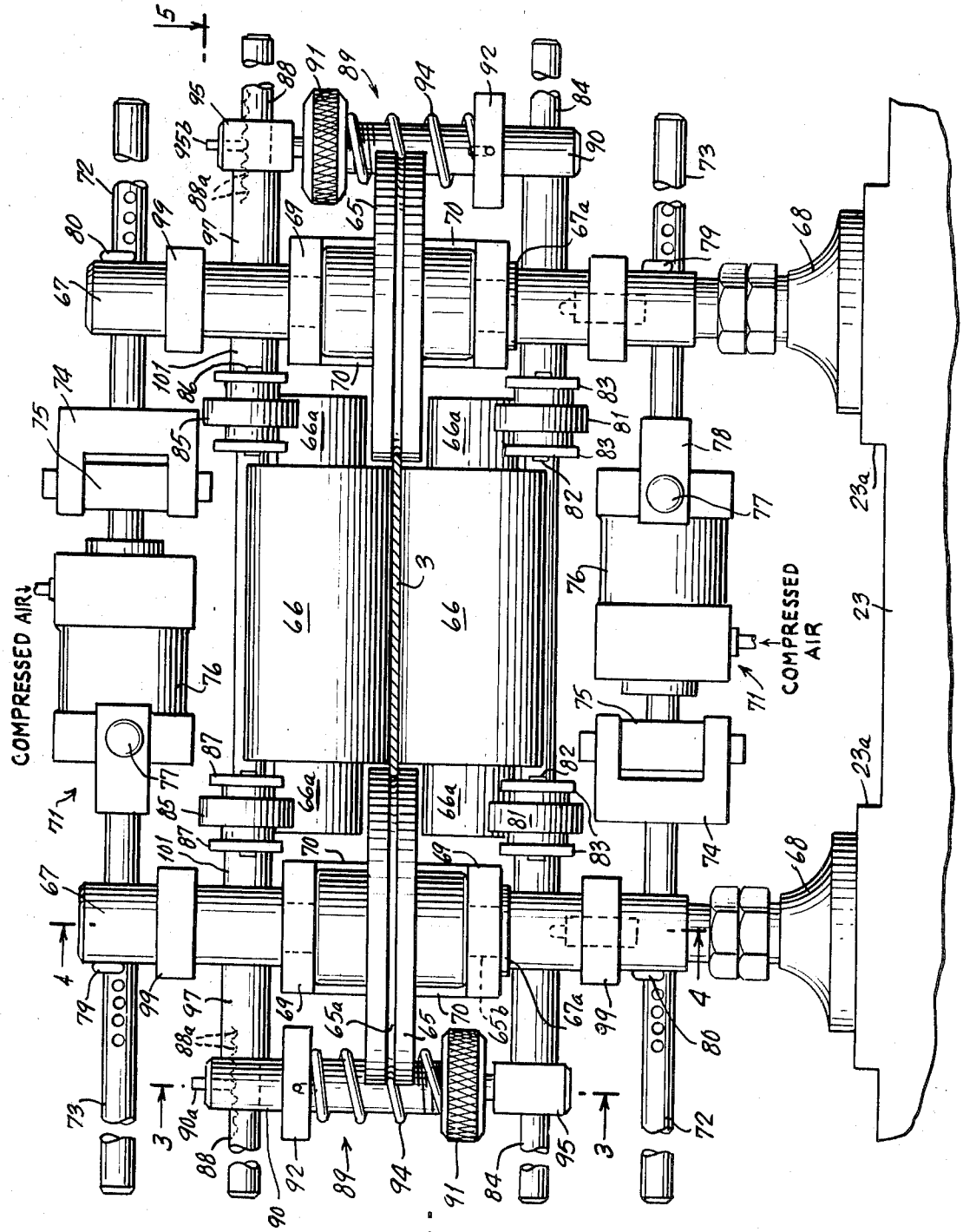

Fig. 1.

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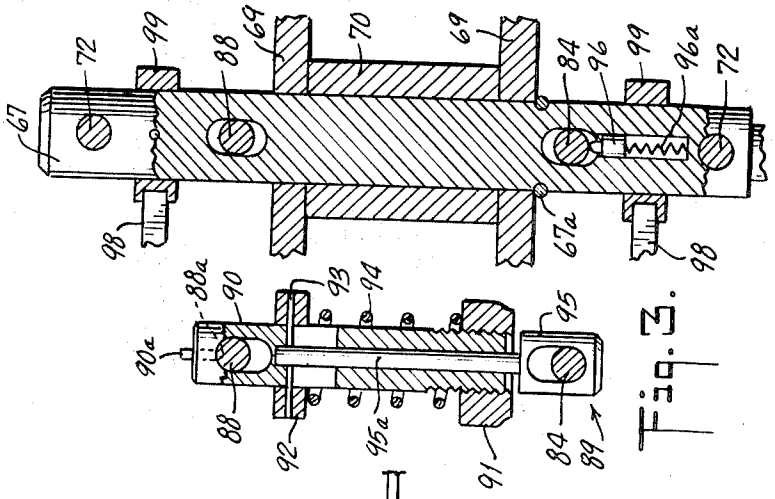

Fig. 4.

Fig. 3.

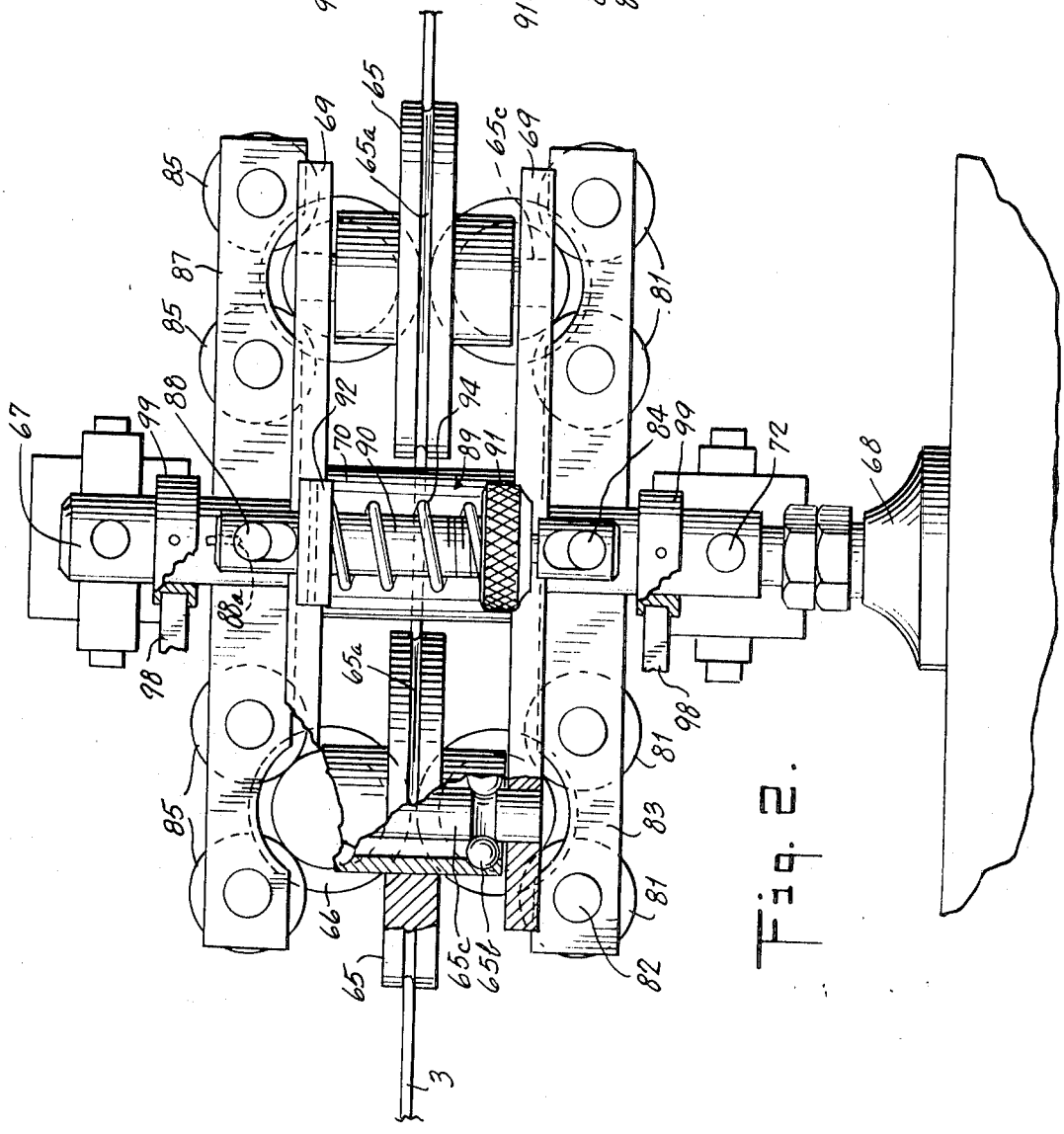

Fig. 2.

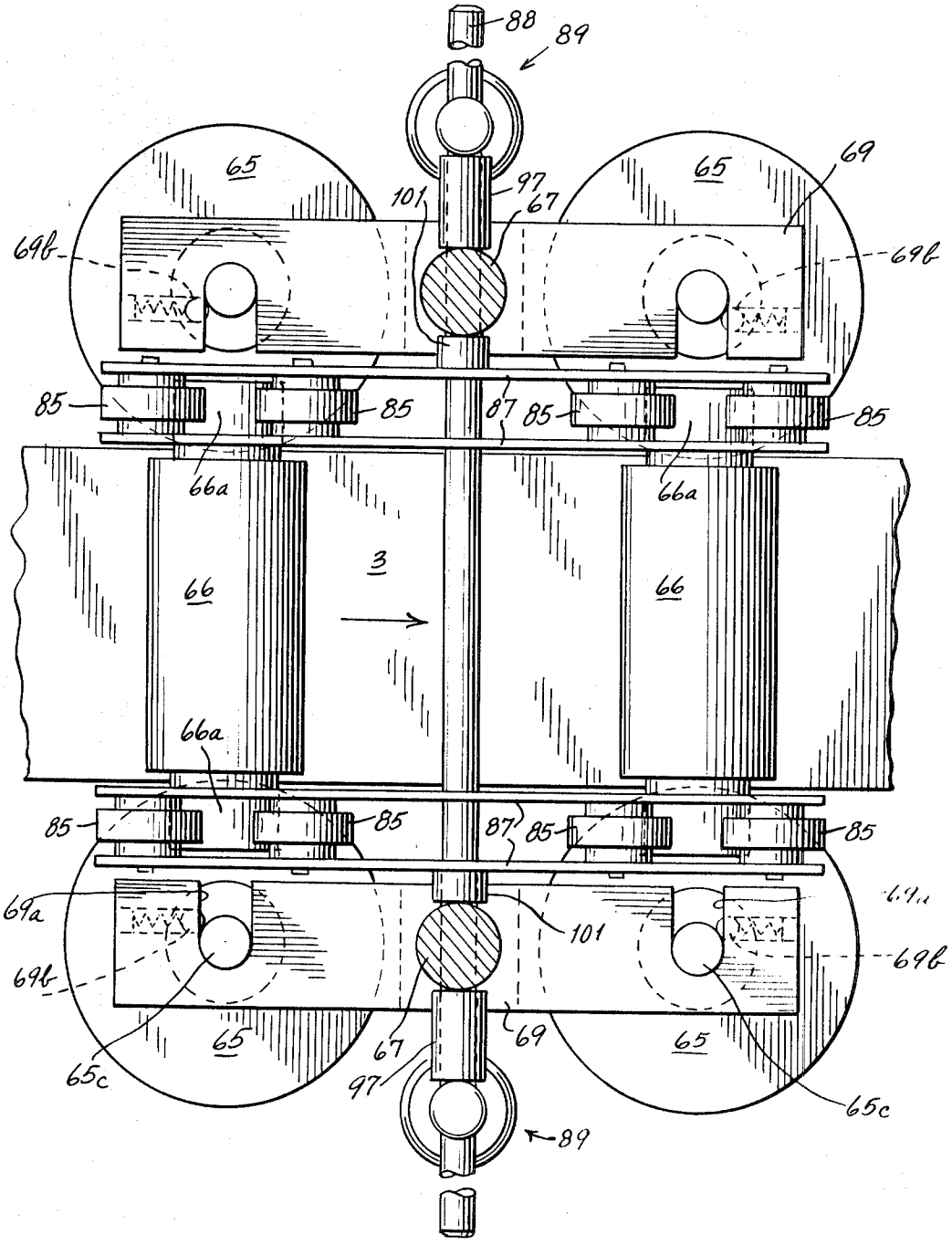

Fig. 5.

REMOVABLE ROLL APPARATUS FOR ROLLING THE EDGES OF STRIP METAL

CROSS-REFERENCE

This application is a division of my copending application Ser. No. 632,758, filed Apr. 21, 1967, for ROLLING APPARATUS FOR ROUNDING THE EDGES OF STRIP METAL, now U.S. Pat. No. 3,479,852, issued Nov. 25, 1969.

BACKGROUND OF THE DISCLOSURE

This 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 groove 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.

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 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 antibuckle 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.

FIG. 1 is a view, partly in section and partly in elevation showing the edge-forming rolls and antibuckle rolls;

FIG. 2 is a side elevational view of the apparatus of FIG. 1;

FIG. 3 is a sectional view taken along the line 3—3 of FIG. 1;

FIG. 4 is a sectional view taken along the line 4—4 of FIG. 1;

FIG. 5 is a sectional view taken along the line 5—5 of FIG. 1.

DESCRIPTION OF THE INVENTION

FIGS. 1A, 1B and 2

A complete edge-forming roll assembly is illustrated in FIGS. 1 and 2. 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 antibuckle rolls 66, one above and one below the strip. The antibuckle rolls 66 are provided with projecting hubs 66*a* at their ends. The entire assembly including four edge-forming rolls 65 and four antibuckle rolls 66 is mounted onto 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. 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 the beam. Another beam 69 rests on the top of the spacer 70. The beam 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 the ends of the arbors 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. 1, 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 motors **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 position. 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 antibuckle roll **66** has its hubs supported by engagement with four backup rolls **81**, each of which is rotatable on an antifriction 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 backup rolls **81** for both of the antibuckle 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 antibuckle rolls **66** are supported by engagement with the strip and hence by the lower antibuckle rolls **66** located immediately below them on the opposite side of the strip. The upper antibuckle rolls are retained in position by backup rolls **85** which engage their hubs **66*a***. Each roll **85** turns on an antifriction 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 through and beyond the columns **67**, similar to the rod **84**.

The ends of the rods **8** and **84** are yieldably connected by a spring mechanism **89** best seen in FIG. **3**. 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 is 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 **95** engages rod **84** and that the upper end of the 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. **4**) 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**, backup rolls **81** and **85**, and antibuckle rolls **66**, if floating in that it is spring supported and hence does not exert any 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 antibuckle 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. **5**) 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. **1** are shown as being reversed from the parts of the corresponding assembly **89** at the left-hand side of FIG. **1**. 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 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 antibuckle 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 antibuckle 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 backup rolls **81** and **85** to separate sufficiently so that the antibuckle roll may be removed.

After the antibuckle 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 antibuckle rolls may be readily removed for repair or replacement with rolls of a different contour. Different sets of antibuckle 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 column **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.

We claim:

1. Apparatus for rolling strip metal, comprising:

a. a pair of edge-forming rolls adapted to engage opposite edges of a moving metal strip;

b. means for supporting said edge-forming rolls;

c. opposed upper and lower antibuckle rolls adapted to engage the flat surfaces of the strip between the edge forming rolls, each said antibuckle roll having projecting hubs at its ends;

d. upper and lower sets of backup rolls, each set of backup rolls engaging the hubs of one antibuckle roll, said sets of backup rolls and the opposed antibuckle rolls cooperating to retain the antibuckle rolls in place;

e. upper and lower rigid means supporting the respective sets of backup rolls, and in which the respective sets of backup rolls are journaled;

f. a stationary support;

g. means, including yieldable means, resting on said stationary support and supporting said lower rigid means; and

h. means, including spring means, connecting said upper and lower rigid means, said spring means biasing said lower rigid means upwardly and said upper rigid means downwardly;

i. said spring means and said yieldable means cooperating to bias said rigid means toward one another and thereby to bias each set of backup rolls into engagement with its antibuckle rolls, and to bias the two antibuckle rolls toward engagement with one another, said spring means and said yieldable means being movable against their respective biases to permit removal of either antibuckle roll, in the absence of a strip between the antibuckle rolls.

2. Apparatus for rolling strip metal, comprising:

a. a pair of edge-forming rolls adapted to engage opposite edges of a moving metal strip;

means for supporting said edge-forming rolls;

c. a pair of antibuckle rolls adapted to engage the flat surfaces of the strip between the edge-forming rolls;

d. two sets of backup rolls, one for retaining each of the antibuckle rolls in place;

e. spring means connecting the two sets of backup rolls, said spring means being yieldable to permit removal of either antibuckle roll;

wherein the improvement comprises:

f. said supporting means including, for each edge-forming roll:

1. an arbor on which the edge-forming roll is rotatably mounted, said arbor extending in both directions beyond the edge-forming roll;

2. support means for the arbor including:

i. a pair of beams, one at each of the arbor and extending transversely thereof, said beams having recesses on the side facing the antibuckle rolls so that the arbor can be moved into and out of said recesses only from that direction; and

ii. spring detent means in said recesses to hold said edge-forming rolls in place therein;

3. said antibuckle rolls being effective to hold the edge-forming rolls in place, so that after the antibuckle rolls are removed, the edge-forming rolls may be removed by compressing the spring detent means.