Oct. 31, 1961 J. N. WOGNUM ET AL 3,006,401

APPARATUS FOR CONDITIONING METAL STRIP HAVING NON-UNIFORM STRESSES THEREIN

Filed Oct. 23, 1957 5 Sheets-Sheet 1

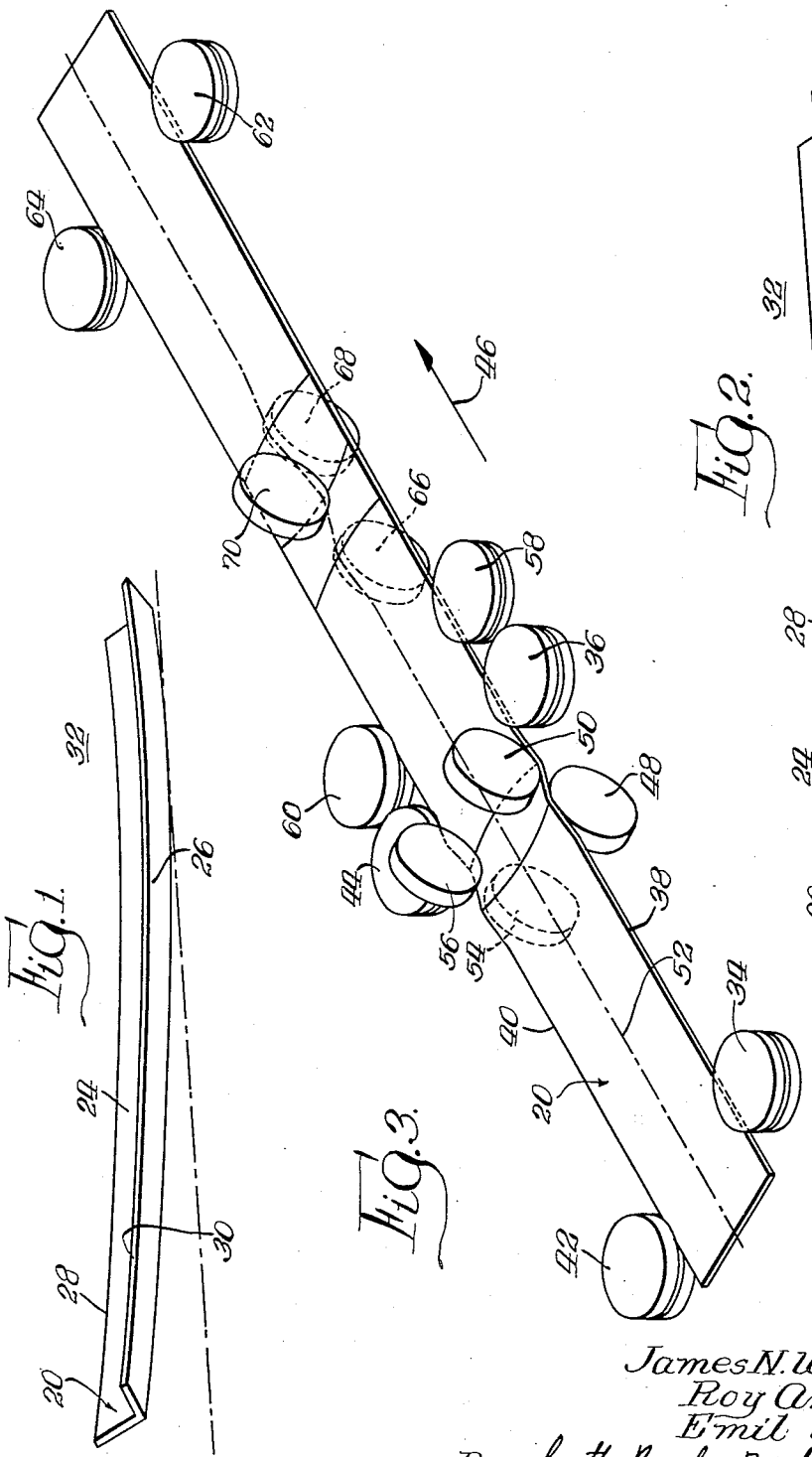


Fig. 3.

Fig. 1.

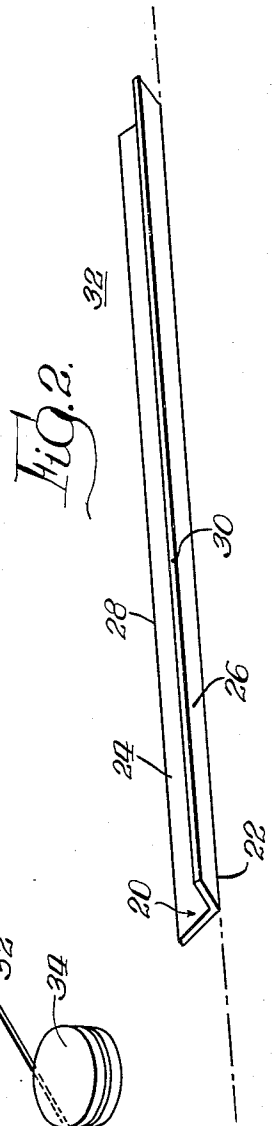


Fig. 2.

INVENTORS.
James N. Wognum,
Roy A. Moody,
Emil Simich
By Smith, Brangley, Baird & Clayton
Attys

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Filed Oct. 23, 1957 5 Sheets-Sheet 2

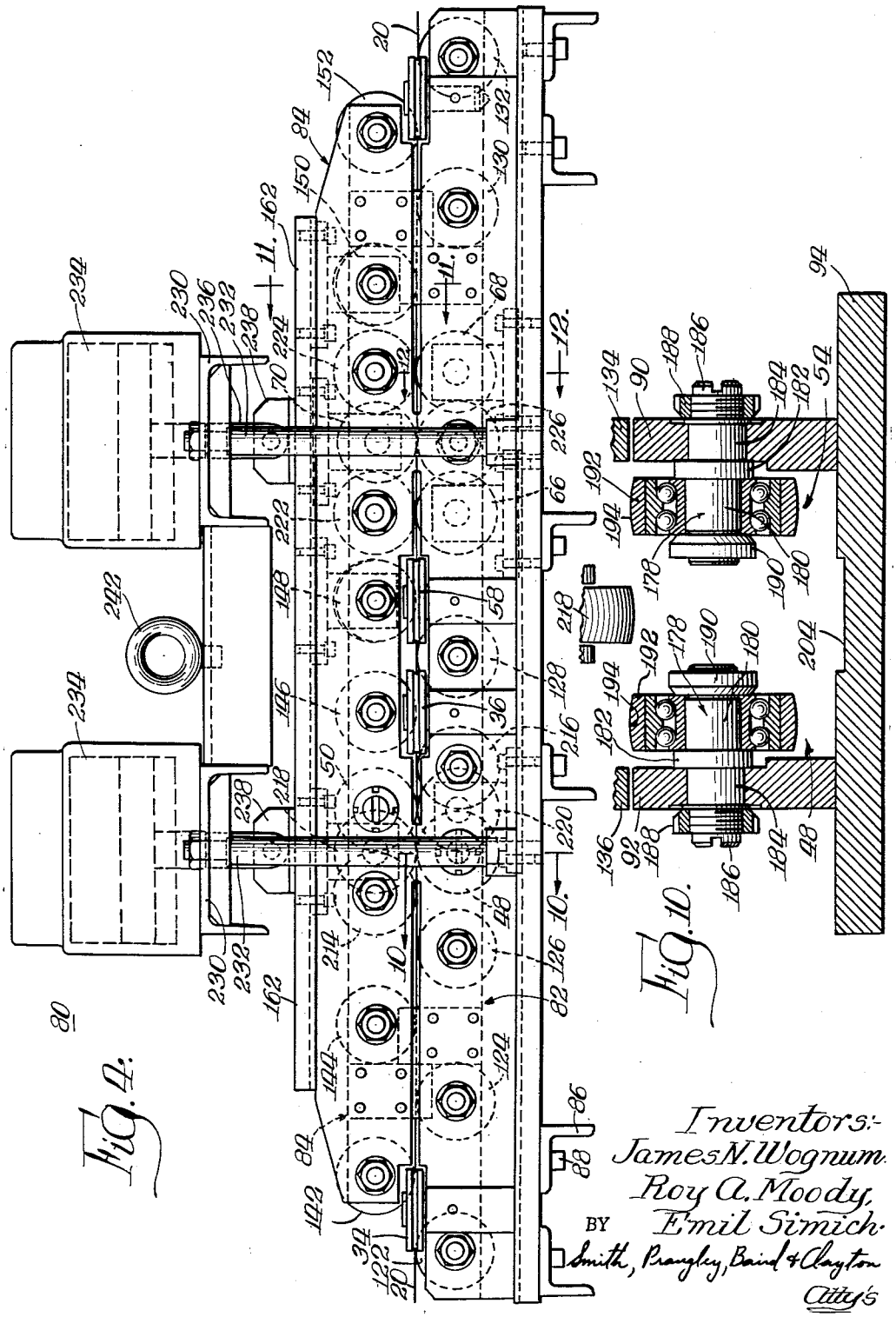


Fig. 4.

Fig. 10.

Inventors:-
James N. Wognum
Roy A. Moody
Emil Simich
BY Smith, Brayley, Baird & Clayton
Attys

Oct. 31, 1961 J. N. WOGNUM ET AL 3,006,401

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Filed Oct. 23, 1957 5 Sheets-Sheet 3

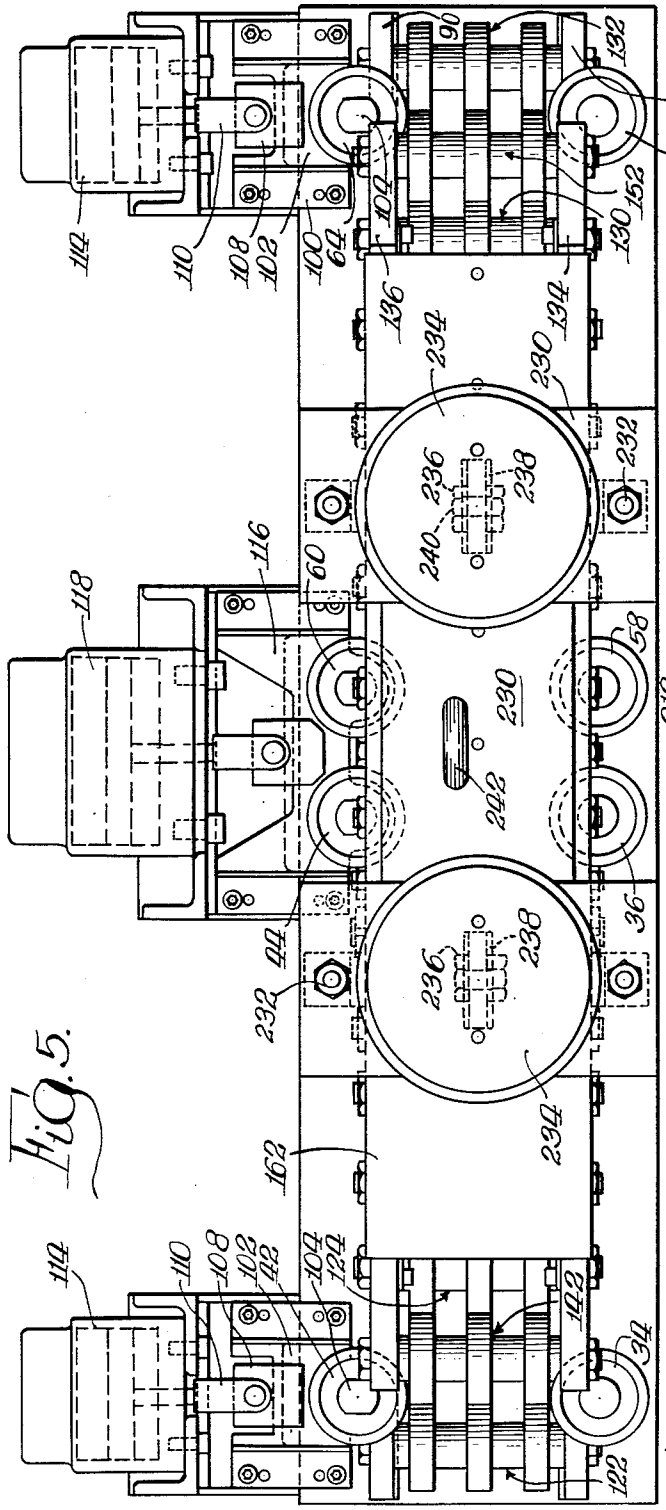


Fig. 5.

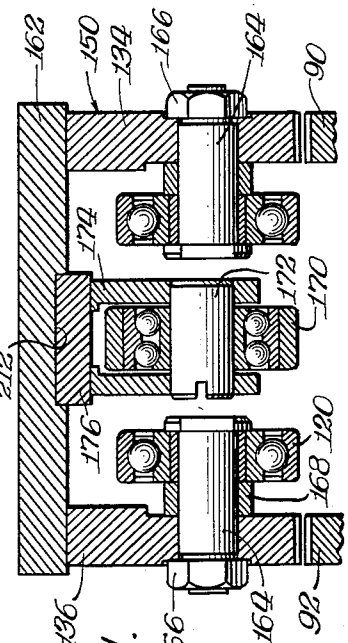


Fig. 11.

Inventors:-
James N. Wognum
Roy A. Moody,
Emil Simich
BY
Smith, Pranglay, Baird & Clayton
Attys.

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Filed Oct. 23, 1957 5 Sheets-Sheet 4

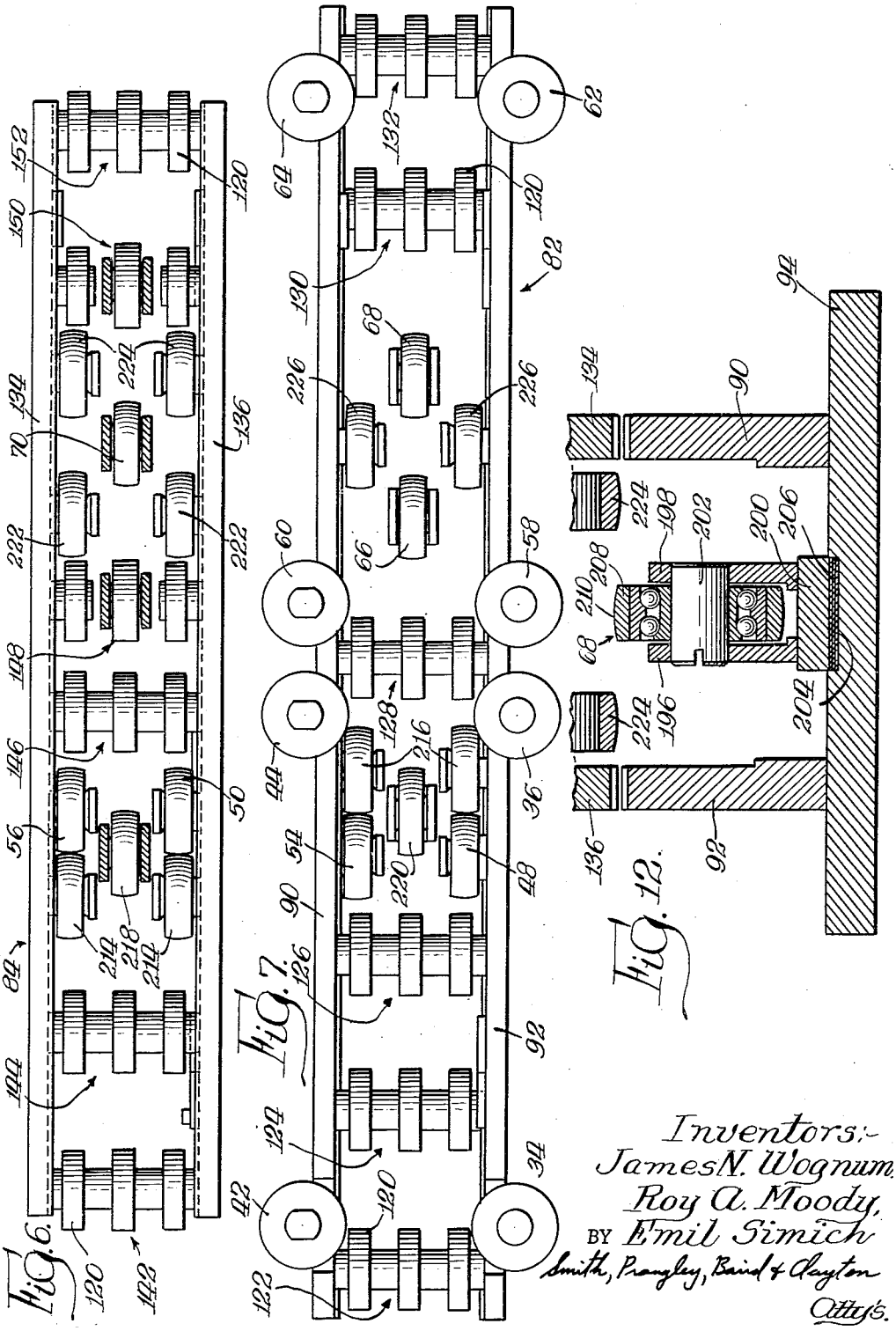


Fig. 6.

Fig. 7.

Fig. 12.

Inventors:-
James N. Wognum
Roy A. Moody,
BY Emil Simich
Smith, Prangley, Baird & Clayton
Atty's.

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Filed Oct. 23, 1957 5 Sheets-Sheet 5

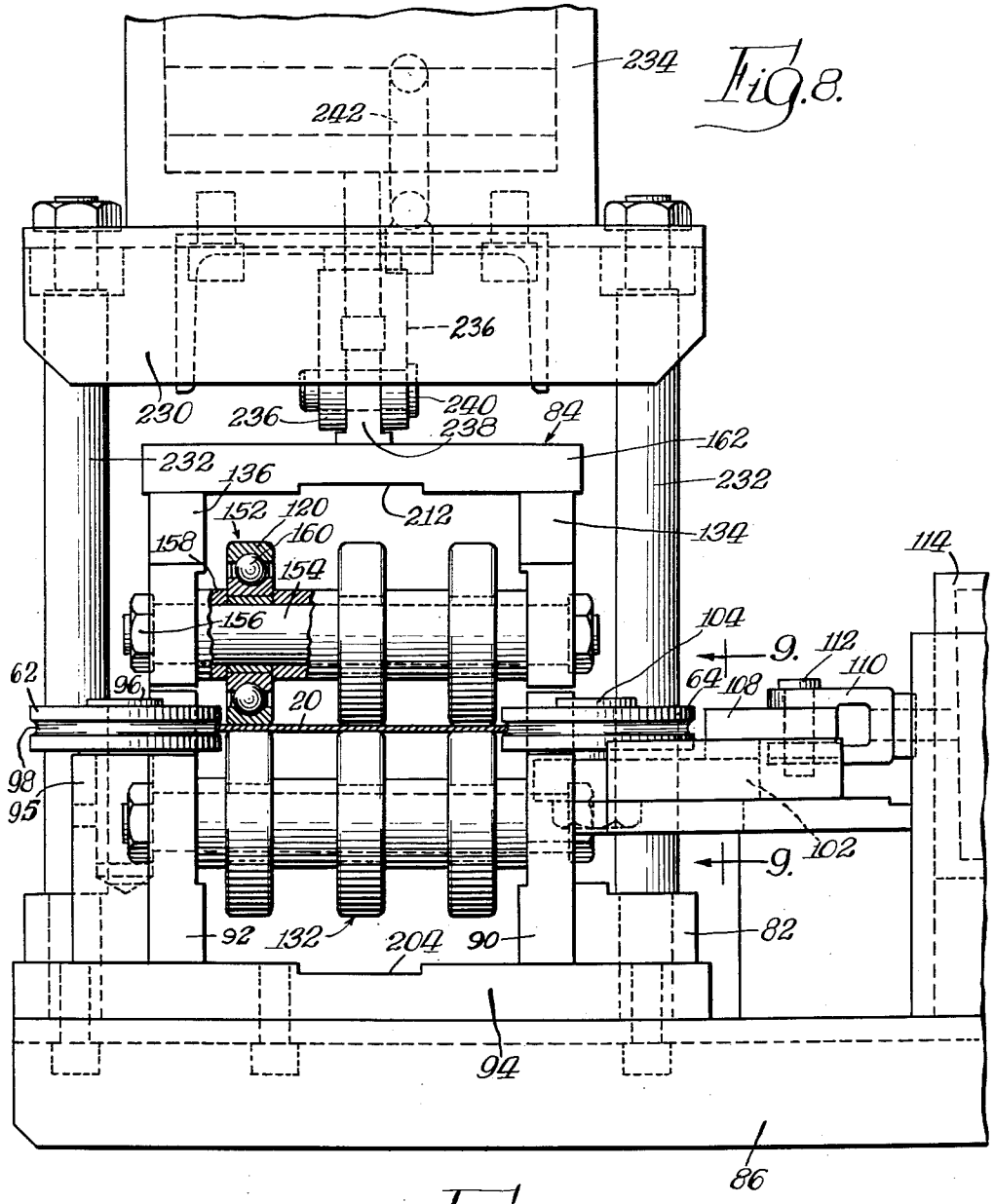


Fig. 8.

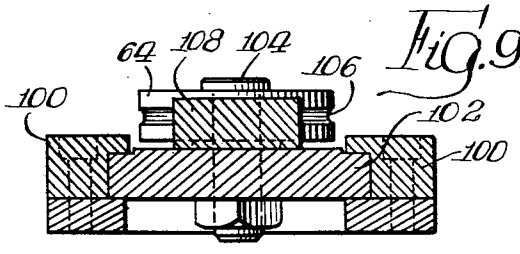


Fig. 9.

Inventors:-
James N. Wognum
Roy A. Moody
Emil Simich
BY
Smith, Pringley, Baird & Clayton
Attys.

United States Patent Office 3,006,401 Patented Oct. 31, 1961

3,006,401

APPARATUS FOR CONDITIONING METAL STRIP HAVING NON-UNIFORM STRESSES THEREIN

James N. Wognum, Roy A. Moody, and Emil Simich, Chicago, Ill., assignors to Acme Steel Company, Chicago, Ill., a corporation of Illinois

Filed Oct. 23, 1957, Ser. No. 691,978
4 Claims. (Cl. 153—93)

This invention relates to an improved method and apparatus for conditioning strip metal such as steel and the like, to redistribute therein non-uniform internal stresses whereby to produce a straightened longitudinally flat strip.

During the formation of strip metal such as strip steel, non-uniform internal residual stresses will ordinarily be produced therein even though great care is taken in the manufacture of the strip. In certain instances, the non-uniform internal stresses may actually produce physical deformation of the strip, such as lateral curvature known as "chamber," and in those instances in which there is no visible deformation of the strip while in its flat state, there still may be non-uniform internal stresses or islands of stresses therein which will cause the strip to take undesired curvatures or other shapes when the strip is later worked or formed. These internal stresses or islands of stresses may be produced during the rolling of the metal, as the result of uneven rolling pressures, or may be produced by unequal stresses set up in the metal during a slitting operation, or during annealing and coating operations.

Although methods and apparatus have been devised heretofore to condition strip metal, these prior methods and apparatus have had certain disadvantages. Some of the prior strip straighteners and conditioners are very large and require operating power of an amount which prohibits their use except in special instances. Others of the prior devices also have been wasteful of the strip in that substantial portions at the lead end and at the trailing end of the strip could not be worked. Expensive and cumbersome hold back rolls and puller rolls furthermore were required on other devices in order to produce the high externally applied tension in the strip necessary to render those particular devices operative. In certain instances heretofore the strip has been worked only on the edges thereof in an effort to remove lateral curvature or camber but this has often produced islands of stresses longitudinally of the strip which deformed the strip when it is folded along a longitudinal fold line. The products produced by certain of these prior machines do not have a sufficient consistency in the internal stress patterns thereof to permit folding and forming along longitudinal lines, such folding often providing distorted products.

Accordingly, it is an important object of the present invention to provide an improved apparatus for producing a straightened longitudinally flat metal strip having therein a substantially uniform internal stress pattern throughout its length.

In conjunction with the foregoing object, it is another object of the invention to provide an improved apparatus which produces a straightened flat strip that can be subsequently formed into a multi-planar strip that will also be longitudinally straight.

Another object of the invention is to provide an apparatus, of the type set forth, in which non-uniform internal stresses or islands of stresses are redistributed longitudinally of the strip whereby to produce a strip that can be subsequently formed into multi-planar shapes which will be true and which will not be deformed by non-uniform internal stresses or islands of stresses within the strip.

Yet another object of the invention is to provide an apparatus of the type set forth which do not require the hold back and puller rolls that have been necessary in

certain methods and apparatus used heretofore for similar purposes.

Yet another object of the invention is to provide an apparatus by which a longitudinal portion of a strip having non-uniform stresses therein will have parts thereof worked, so as to distribute the non-uniform stresses throughout the longitudinal portion and produce a strip in which the stresses are substantially uniform throughout.

Still another object of the invention is to provide an apparatus of the type set forth for producing a strip having a pattern of residual stresses therein such that the strip is sufficiently consistent in its internal stress pattern to be readily usable in forming operations wherein the strip is folded or formed along a longitudinal line thereof.

Yet another object of the invention is to provide an apparatus of the type set forth in which end scrap of a strip is substantially reduced as compared with prior methods and apparatus.

These and other objects and advantages of the invention will be better understood from the following description when taken in conjunction with the accompanying drawings. In the drawings, wherein like reference numerals have been utilized to designate like parts throughout:

FIG. 1 is a perspective view showing the longitudinally curved shape which a metal strip may take, when folded along a longitudinal line, as a result of non-uniform internal stresses in the strip prior to its folding, the stresses in this particular case causing the strip to bow longitudinally upwardly;

FIG. 2 is a view similar to FIG. 1 showing a strip conditioned by the present invention in the flat and thereafter folded in a manner similar to FIG. 1 and illustrating the resultant longitudinally straight piece achieved by redistributing the non-uniform stresses or islands of stresses in the flat strip by means of the present invention;

FIG. 3 is a schematic view in perspective of an apparatus embodying the principles of the present invention;

FIG. 4 is a side elevational view of an apparatus made in accordance with and embodying the principles of the present invention;

FIG. 5 is a plan view of the apparatus of FIG. 4;

FIG. 6 is a plan view, with certain portions broken away, of an upper roll carriage of the apparatus, illustrating the disposition of the rolls thereon;

FIG. 7 is a plan view of a lower roll carriage of the apparatus, illustrating the disposition of the rolls thereon;

FIG. 8 is an end view of the exit end of the apparatus of FIGS. 4 and 5, with certain portions broken away;

FIG. 9 is a fragmentary enlarged view in vertical section through the support for one of the edge pressure rolls, substantially as seen in the direction of the arrows along the line **9—9** of FIG. 8;

FIG. 10 is an enlarged view in vertical section through the edge stretching rolls mounted on the lower carriage, substantially as seen in the direction of the arrows along the line **10—10** of FIG. 4;

FIG. 11 is an enlarged fragmentary view in vertical section through certain of the positioning rolls mounted on the upper carriage, substantially as seen in the direciton of the arrows along the line **11—11** of FIG. 4 and illustrating the construction and mounting of the rolls; and

FIG. 12 is an enlarged fragmentary view in vertical section illustrating the construction and mounting of one of the center stretching rolls, substantially as seen in the direction of the arrows along the line **12—12** of FIG. 4.

The present invention and the treatment provided thereby may be applied to a strip which has internal stresses therein sufficient to cause external deformation such as "camber" and it may be applied to a strip which is flat but has non-uniform internal stresses or islands of stresses therein. The method and apparatus may be utilized in conditioning a wide variety of sizes of strip but certain

important advantages of the invention are more fully realized when working on relatively heavy steel strip. For purposes of illustration, the invention will be described later as applied to a steel strip approximately four inches wide and having a thickness of about 0.1 inch. Such a strip is available as cold rolled and slitted stock rolled into coils. An important use of such strip is to provide angle members by folding the strip along a longitudinal line whereby to provide angularly disposed flanges extending along the longitudinal axis of the strip.

In producing such angle pieces, the coiled strip is normally folded by a rolling operation to provide a cross section such as that illustrated in FIGS. 1 and 2 of the drawings. If there are no substantial non-uniform internal stresses in the strip, a part having the straight longitudinal form illustrated in FIG. 2 will be produced. More specifically, the strip, which is generally designated by the numeral **20**, has been folded along a longitudinally extending line **22** to provide a pair of angularly disposed flanges **24** and **26**. As illustrated in FIG. 2, the longitudinally extending edges **28** and **30** of the resultant angle piece **32**, are parallel to each other and to the fold line **22** and are straight. However, if the strip **20** has substantial non-uniform internal stresses therein at the time it is folded, they may exhibit themselves by causing the portion of the strip along the fold line **22** to be longer or shorter relative to the edges **28** and **30**. If the material along the fold line **22** is longer than the edges **28** and **30**, the resultant angle piece will be bowed as illustrated in FIG. 1 of the drawings. Conversely, if the material along the fold line **22** is shorter relative to the edges **28** and **30**, then the angle piece will be bowed in the opposite direction. Combinations of these deformations of the piece may be encountered in untreated or unconditioned stock and, instead of merely being bowed, more complex twisting or skew deformations of the piece may be obtained.

Machines and methods have been available heretofore to treat such strip material whereby to remove or redistribute the stresses therein before forming. However, as has been explained above, such machines have had certain disadvantages and, accordingly, are used only in certain special circumstances.

The form of machine used for folding a strip **20** into the shape **32** may contain a set of straightening rolls which sometimes can straighten a piece that is bow-shaped like that in FIG. 1 so that it will be substantially straight like the piece of FIG. 2. However, the use of such straightening rolls has not been satisfactory. The amount of working of the formed piece required to obtain a straightened piece will vary according to the stress distribution within the original strip. Accordingly, it has been found that frequent and repeated adjustment of such straightening rolls has been required heretofore, and this has seriously limited production. By means of the present invention, on the other hand, strip **20** can be continuously conditioned to redistribute the stresses therein prior to folding, whereby substantially to eliminate the need for adjusting the straightening rolls in the machinery for forming the piece **32**. As a result, a substantial increase in production efficiency and a substantial increase in the utilization of the forming machinery is realized.

The method and apparatus of the present invention are both diagrammatically illustrated in FIG. 3 of the drawings. In order to obtain the desired conditioning of the strip **20**, it is necessary, in accordance with the present invention, to establish a datum path therefor and thereafter to work longitudinal sections or elements of the strip while holding the adjacent sections in the datum path. To this end, a plurality of edge engaging rolls and a plurality of vertical positioning rolls is provided. For the purpose of simplicity, the vertical positioning rolls in FIG. 3 have been omitted, but it is to be understood that they are disposed throughout the non-worked areas of the strip **20** and are urged against the surface of the strip whereby to provide a vertically oriented datum path.

At least three horizontal path determining rolls are required along each edge of the strip **20**. A set of edge engaging rolls along one edge of the strip **20** is mounted so that the rolls rotate upon fixed axes, and a set of rolls along the other edge of the strip **20** is mounted on axes which can be shifted and be yieldingly urged toward the other edge engaging rolls. In the present instance, four edge engaging rolls have been provided along each edge of the strip **20**. A first pair of edge engaging rolls **34** and **36** is provided which engage one edge **38** of the strip **20**, the rolls **34** and **36** being free to rotate upon vertical axes and the axes being fixed. The edges of the rolls **34** and **36** are grooved to provide peripheral contact with the edge **38** and to provide a certain amount of vertical positioning control immediately adjacent to the edge of the strip. Disposed opposite the rolls **34** and **36**, and contacting the other edge **40** of the strip, there is a pair of rolls **42** and **44**. The rolls **42** and **44** are also mounted to rotate upon vertical axes, but the axes of these rolls are mounted for movement toward and away from the axes of the rolls **34** and **36** whereby to apply substantial transverse pressure to the strip **20**. Each of the rolls **42** and **44** also is provided with a circumferential groove so that a certain amount of vertical positioning control is imparted to the strip as well as horizontal positioning control.

As illustrated schematically in FIG. 3, two pairs of work rolls engage and stress the material of the strip adjacent to its edges **38** and **40**. One pair of the work rolls **48** and **50** works the material adjacent to the edge **38** by bending that portion of the strip first about a portion of the periphery of the roll **48**, then about a portion of the periphery of the roll **50** as the strip advances in the direction of the arrow **46**, and also by forcefully deflecting the area being worked out of the predetermined datum path, thereby causing that portion to follow a longer path than that through which moves the center portion of the strip indicated by the dashed line **52**. Simultaneously with the working of the edge portion **38**, the edge **40** of the strip is worked by a pair of work rolls **54** and **56** which are disposed so that the edge portion **40** is first bent around a portion of the periphery of the roll **54** to cause working, and then is bent in the opposite direction around a portion of the roll **56** as the strip advances. Each of these bending operations works the edge portion **40** of the strip, and working is also caused by the fact that this edge portion, like the edge portion **38**, is deflected out of the predetermined datum path so that it is forced to follow a longer path than the center portion of the strip. The work rolls **54** and **56** are located directly opposite the work rolls **48** and **50**, respectively, so that the working of the opposite edge portions of the strip is accomplished simultaneously and symmetrically. This is of importance because it avoids the tendency that would arise for the strip to want to camber laterally first in one direction and then in the other if one set of the edge working rolls were located ahead of the other set on opposite sides of the strip.

The combined stresses applied to the strip in each area being worked must, in the present invention, be greater than the elastic limit of the material so that plastic working takes place. By study of FIG. 3 of the drawings, it will be understood that the tensional force applied to each area of the edge of the strip being worked, is the resultant of: (*a*) the stress produced by bending or flexing the strip about the surface of the work rolls, which are of relatively small diameter; (*b*) the stress produced by deflecting the work area out of the datum path of the strip, so that it is required to follow a path longer than that followed by adjacent areas of the strip which remain in the datum path; and (*c*) the tension produced in the strip by the relatively small pulling force provided by any suitable device for

pulling or advancing the strip through the present apparatus. A further tensional force may be applied to the area being worked in cases where the strip, as it enters the apparatus, has a natural lateral camber. For example, if the strip being fed into the apparatus of FIG. 3 has a natural camber toward the right, the fact that the several edge engaging rolls **34**, **36**, **42** and **44**, and other like rolls that will be referred to later, cooperate to confine and hold the strip straight against its tendency to camber, would itself produce a state of some tension in the edge portion **38** of the strip. This tension, of course, would be in addition to the tensional forces (*a*), (*b*) and (*c*) mentioned above, that are applied to the area being worked by the rolls **48** and **50**. If the strip, on the other hand, had a natural camber to the left, the confining and holding of the strip straight against that camber would produce some tension in the edge portion **40** which would be in addition to the tensional forces (*a*), (*b*) and (*c*) applied to the edge portion **40** in the area of the work rolls **54** and **56**.

The amount of force required to advance the strip through the present machine is relatively small so that the tensional force referred to above as item (*c*) is quite small. On the contrary, the working of the edge portions of the strip, and the working of the center portion thereof which will be referred to later, is primarily produced by the forces (*a*) and (*b*). The diameters of the work rolls **48**, **50**, **54** and **56**, as well as the center portion work rolls later discussed, are proportioned to the thickness of the strip being worked and the physical properties thereof so that the flexure of the metal about the surfaces of these rolls will alone produce stresses exceeding the elastic limit of the material of the strip. Thus, the addition thereto of any tensional stress greater than zero will produce substantial plastic stretching of the area being worked and, in the present invention, that additional force is provided primarily by the item (*b*) above, that is, by the deflection of the work area out of the datum path so that it must follow a path longer than adjacent portions that are retained in the datum path, in combination with the holding of the adjacent longitudinal section of the strip in a datum path as will be explained hereinafter. Study of FIG. 3 will reveal to anyone acquainted with well-known principles of force mechanics that the tensional forces produced in the working area of the strip by forcing it to follow a longer path than that followed by the adjacent portions, will necessarily be counteracted by compression forces set up in the portions of the strip adjacent the tensioned ones. These adjacent portions therefore act in the nature of a strut, and the term "strut" will hereafter be used in this specification and in the claims in that sense.

The portion of the strip held in the datum path adjacent to the point of working will serve as a strut, as just stated, whereby to support the area being worked and to aid in redistributing the stresses in the strip longitudinally thereof as the work area progresses longitudinally along the strip. Accordingly, areas of high compression or high tension in the strip have the stresses therein redistributed longitudinally in a continuous manner by working portions of the strip plastically while maintaining adjacent portions of the strip in the datum plane to act as a support or strut for the area being worked. After working has taken place and after working has taken place and after the strip has advanced beyond the work point, the unworked area held in the datum plane will be placed under tension and, accordingly, will apply to the edge portion which has been stretched by working, a force tending to contract the edge portion whereby to aid in redistributing any residual internal stresses originally present in the work area longitudinally of the strip.

In connection with the matter of confining the strip laterally within the predetermined datum path, it is contemplated that it would be possible to use the edge engaging rolls **34**, **42**, **36** and **44** in combination with only one further set of edge engaging rolls, thus to provide three rolls along each edge of the strip **20**, but for purposes of convenience two additional sets of rolls instead of one have been provided. More specifically, a third set of rolls **58** and **60** has been provided to engage the edges of the strip **20** beyond the rolls **36** and **44** and another set of edge engaging rolls **62** and **64** has also been provided at the outlet end of the center working section. The rolls **58** and **62** are mounted with their axes of rotation stationary in a manner like, and for the same reasons, as the rolls **34** and **36**. The axes of rotation of the rolls **60** and **64**, on the other hand, are mounted for movement toward and away from the axes of the opposing edge engaging rolls **58** and **62** and substantial pressure is applied thereto by means later disclosed. The force applied to the rolls **60** and **64** should be equal to that applied to the rolls **42** and **44** and may be 760 pounds when straightening a strip having the dimensions set forth above.

After the edges of the strip **20** have been worked, the center portion of the strip is worked by means of a pair of lower work rolls **66** and **68** and a cooperating upper work roll **70** positioned to engage the strip **20** at a point spaced between the points of engagement of the lower work rolls **66** and **68**. The rolls **66**, **68** and **70** cause the center **52** of the strip **20** to be bent or flexed around peripheral portions thereof and to travel through a longer path than the edges thereof whereby to stress and work the center of the strip by applying thereto the same forces discussed above. The stress applied by means of the center working rolls is preferably of the same order as that applied by the edge working rolls and may be determined in the same manner previously discussed with respect to the edge working rolls.

Non working rolls, which are omitted in FIG. 3 for the sake of simplicity, are positioned adjacent to the center working rolls **66**, **68** and **70** to hold the edge portions of the strip **20** in the predetermined datum path immediately adjacent to the areas being worked by the center working rolls. Since the center working rolls are so proportioned with respect to the dimensions and the physical properties of the strip **20** that the strip at the point of working is stressed beyond the elastic limit by the bending or flexing of the strip about the surfaces of the rolls alone, the strip is worked plastically by the deflection of the center portion of the strip out of the datum path, in the same manner discussed above with respect to the edge rolls. The center rolls are stretching and deflecting the material out of the datum plane and, accordingly, in order to maintain the balance of forces transverse of the strip, the adjacent edge portions of the strip will be placed under compression. The edge portions of the strip **20** therefore react as struts against the forces applied to the center portion being worked, whereby to distribute the stresses longitudinally of the strip **20**.

During working by both the edge working rolls and the center working rolls, the strip **20**, as previously suggested, is held in a predetermined horizontal path by the various edge engaging rolls. As a result, any camber initially in the strip will be relieved and removed. More specificially, any edge portion of the strip **20** which is shorter than the opposite edge portion (thus tending to produce camber in a strip) will automatically be worked more than the opposite longer edge portion. Accordingly, the original internal stresses tending to produce camber in the strip **20** will be removed and the strip straightened laterally due to the resultant urging of the movable edge engaging rolls **42**, **44**, **60** and **64** toward the stationary edge engaging rolls **34**, **36**, **58** and **62** which provide an edge datum line.

It has previously been pointed out that adjacent longitudinal sections of the strip alternately or sequentially serve as struts and then as areas being worked by the work rolls. It is contemplated that as many work rolls

may be used across a strip as is required to produce a usable consistency of internal stresses in the strip **20**. In general, the longitudinal sections of working will be alternated with longitudinal sections serving as struts and held in the datum path by suitable rolls adjacent the work rolls. The necessary radius of the work rolls to impart to the strip sufficient flexing or bending so as to exceed the flexure elastic limit can be calculated from the dimensions of the strip **20** and the physical properties thereof, including the elastic limit or yield point. It is possible to operate the device so that the yield point or elastic limit is barely exceeded at the point of working. However, in most instances the flexing of the sheet will be sufficient to substantially exceed the yield point. It further is to be noted that each section of the strip is first flexed in one direction and then in the other direction so that the stresses adjacent to both flat surfaces of the strip and extending toward the center thereof are worked and redistributed. Because of the flexing of the material beyond the yield point thereof, very little force need be applied to the strip **20** to move it longitudinally in the direction of the arrow **46** and still obtain the desired working thereof.

There is shown in FIGS. 4 through 12 of the drawings a machine which specifically embodies the principles of the invention which have been discussed above with respect to FIG. 3. For purposes of clarity the various edge engaging rolls and the various working rolls described above with respect to FIG. 3 have had the same reference numerals applied thereto in FIGS. 4 through 12. Referring particularly to FIGS. 4 and 5 of the drawings, the conditioning machine has been generally designated by the numeral **80** and includes a lower carriage generally designated by the numeral **82** and an upper carriage generally designated by the numeral **84**. The lower carriage **82** is suitably supported by a frame which includes a plurality of transversely extending angle iron frame members **86**. The carriage **82** is bolted to the angle iron frame members **86** by means of bolts **88**. As may be best seen in FIG. 7 of the drawings, the lower carriage **82** includes a pair of longitudinally extending side members **90** and **92** (see FIG. 8 also) which are mounted upon a bottom plate **94**.

The stationary edge engaging rolls **34**, **36**, **58** and **62** are all mounted on the side member **92**. The mounting and construction of each of these side rolls is identical and, accordingly, the mounting structure for each of these rolls will be supplied with the same reference numerals. Referring to FIGURE 8, it will be seen that the side member **92** is provided with embossments **95** each of which has a vertically extending bore therein which receives a vertically extending shaft **96** for an associated edge engaging roll. The edge engaging roll is provided with a circumferentially extending groove **98** which extends around the periphery thereof and has a part-circular configuration. These side engaging rolls are free to rotate about the shafts **96** but the axis of rotation of each is fixed with respect to the side member **92**.

The movable side engaging rolls **42** and **64** have the same construction and accordingly only the specific construction of the side engaging roll **64** will be described with special reference to FIGS. 5, 8 and 9 of the drawings. Like reference numerals are applied where appropriate to the like parts of the other movable side engaging roll. Mounted on the frame members **86** there is a pair of guides **100** which receive therebetween a movable slide **102**. Mounted on the slide **102** there is a vertically disposed shaft **104** which rotatably receives the movable edge engaging roll such as the roll **64**. The roll **64** and the other movable edge engaging rolls are also provided with a circumferentially extending groove **106** around the periphery thereof which is concavely shaped as is illlustrated in FIGS. 8 and 9.

Also mounted on and attached to the slide **102** there is an arm **108** which extends laterally outwardly therefrom and is received between the ends of a bifurcated connector **110**. A pin **112** extends through aligned apertures in the arms of the connector **110** and the arm **108**, and the connector **110** is in turn connected to the movable piston rod of an air motor **114** which is also mounted on the frame members **86**. When air is supplied to the air motor **114** through suitable lines (not shown) the slide **102** is moved to the left, as viewed in FIG. 8, whereby the edge rolls engage the strip **20** and yieldingly urge it against the opposite stationary edge engaging roll such as the roll **62** in FIG. 8.

The edge engaging rolls **44** and **60** are mounted similarly to the edge engaging roll **64** described above. More specifically, the rolls **44** and **60** are mounted on a common slide **116** similar to the slide **102** and are moved simultaneously by a single air motor **118**. Since two rolls are mounted on a single slide **116**, the pressure exerted by the motor **118** is preferably double that exerted by each of the motors **114** which are each used to position only a single edge engaging roll.

The strip **20** is guided into the machine and guided during working thereof, with respect to the vertical and in a predetermined datum path between the work stations, by a plurality of conveying rolls **120**. As may be best seen in FIG. 7 of the drawings, there is disposed on the lower carriage **82** a plurality of the rolls **120**. Preferably the rolls **120** are mounted in groups of three and the groups of rolls **120** are disposed along the carriages **82** and **84**. The first group or set **122** of the rolls **120** on the lower carriage **82** is disposed at the input side of the conditioner and contacts the strip **20** before it engages the side rolls **34** and **42**. A second set **124** of the rolls **120** engages the strip after it passes beyond the rolls **34** and **42** and a second set **126** similarly engages the strip immediately before contact with the edge working rolls **48**, **50**, **54** and **56**. Another set **128** of the rolls **120** engages the strip **20** between the set of edge rolls **36—44** and the next pair of edge rolls **58—60**. After the strip **20** passes the center working rolls, it engages still another set **130** of the rolls **120** and a final set **132** of the rolls **120** engages and guides the strip **20** after it passes the edge engaging rolls **62** and **64**.

The upper carriage **84** includes a pair of longitudinally extending frame members **134** and **136** on which are mounted the work rolls **50**, **56** and **70**, together with suitable guide rolls. More specifically, a plurality of the guide rolls **120** is provided, these guide rolls being mounted in sets of three each. The first set **142** of the guide rolls **120** is provided between roll sets **122** and **124** at the input end of the machine. The second set **144** is provided, and contacts the strip **20**, between the sets **124** and **126**. A set **146** is provided in substantial alignment with the side engaging rolls **36** and **44** and a similar set **148** is provided between the side engaging rolls **58** and **60**. The roll sets **150** and **152** are provided adjacent to the exit end of the machine.

The construction and mounting of the roll sets **122** through **132**, **142**, **144**, **146** and **152** are substantially the same and detailed description, accordingly, will be given only of the set **152** by reference to FIG. 8 of the drawings wherein certain details of construction and mounting are given. Like reference numerals have been applied to the other sets where applicable.

Referring then to FIG. 8, it will be seen that the rolls **120** of the roll set **152** are supported upon the frame members **134** and **136** by means of a shaft **154** which extends through aligned apertures in the frame members **134** and **136**. The ends of the shaft **154** are threaded and receive nuts **156** to mount the shaft **154** upon the frame members. Spacers **158** are provided between each pair of rolls **120** and between the outermost rolls **120** and the adjacent frame member. Each roll **120** is provided with inner and outer races between which are disposed ball bearings **160** to provide for free rotation of the outer race which is in contact with the strip **20**. It further is

to be noted that the external peripheral surface of the roll **120** is cylindrical in form as indicated by shading in FIG. 8.

The mounting of the roll sets **148** and **150** is different from that described above with respect to roll set **152**. The constructions of the roll sets **148** and **150** are substantially identical to each other and, accordingly, only the construction and mounting of the roll set **150** will be described in detail with special reference to FIG. 11 of the drawings.

Referring to FIG. 11, it will be seen that the side members **134** and **136** are interconnected at the top thereof by a plate **162** which extends for a substantial distance along the frame members **134** and **136**, as may be best seen in FIG. 5 of the drawings. Each of the outermost rolls **120** in the roll set **150** is mounted independently of the other rolls on the frame members **134** and **136**. More specifically, a headed bolt **164** is provided which extends through an opening in the center of the roll **120** and through an aperture in the associated frame member. The outer end of the bolt **164** is threaded and receives thereon a retaining nut **166**. Preferably, a spacer **168** is provided between the associated frame member and the roll **120** to provide for proper lateral placement of the roll **120**.

The center roll of the set **150** is larger in diameter and has a double ball bearing structure and, accordingly, the numeral **170** has been applied thereto. The roll **170** is suported upon a shaft **172** which is in turn received in and supported by a pair of downwardly extending plates **174** connected at their upper ends by a plate **176** that is in turn mounted on the plate **162**. The two lower edge working rolls **48** and **54** are mounted on the lower carriage **82** and the upper pair of edge engaging work rolls **50** and **56** is mounted on the upper carriage **84**.

The construction and mounting of the lower edge working rolls **48** and **54** is best illustrated in FIG. 10 of the drawings. It will there be seen that each roll is mounted upon the side members **90** and **92** of the lower carriage **82**. More specifically, each roll is provided with a shaft generally designated by the numeral **178** which has a first cylindrical portion **180** received within an opening in the inner race of the associated roll. A second cylindrical portion **182** is provided adjacent to the cylindrical portion **180** and is formed integrally with a third cylindrical portion **184** which is mounted on and received in an aperture in the associated frame member. The axes of the cylindrical portions **180** and **184** are eccentrically positioned so that vertical adjustment of the position of the associated roll can be obtained by rotation of the cylindrical portion **184** within the associated frame member. To this end the outer end of the shaft **178** is provided with a slot **186** to facilitate turning thereof. The outwardly directed end of the shaft **178** is threaded to receive a retaining nut **188** and the opposite end is also threaded to receive a retaining nut **190**.

As illustrated, the rolls **48** and **54** are of the double ball bearing race type. A tire **192** is provided for each roll and the outer surface thereof which contacts the steel strip **20** is convexly curved or crowned as at **194**. The upper edge working rolls **50** and **56** are constructed and mounted in a manner similar to the lower rolls **48** and **54** described above.

The construction and mounting of the center working rolls **66**, **68** and **70** can best understood by reference to FIG. 12 of the drawings. The mounting and construction of the lower center working rolls **66** and **68** is identical and, accordingly, only the construction and mounting of the roll **68** will be described in detail by a reference to FIG. 12 of the drawings. Referring to that figure, it will be seen that a mounting frame is provided including a pair of upstanding sides **196** and **198** which are interconnected at their lower ends by a plate **200**. A shaft **202** is received in aligned apertures in the sides **196** and **198** to receive thereon the inner race of the roll **68**. There is formed in the bottom plate **94** a rectangular groove **204** which has a width such as to receive the plate **200** therein. The position of the periphery of the roll **68** is adjustable with respect to the bottom of the groove **204** by means of suitable shims **206**. A tire **208** is provided as the bearing surface for the roll **68** and the surface thereof is convexly curved or crowned as at **210** to provide the strip engaging surface.

The center working roll **70** is similarly constructed and mounted and is adjustably mounted on the plate **162** within a groove **212** (FIGS. 8 and 11) formed therein and is adjustable by means of shims like shim **206** (FIG. 12).

In addition to the rolls described above, other rolls are provided immediately adjacent to the various work rolls. These rolls are specifically adapted to hold the sections of the strip immediately adjacent to the strip sections being worked, in the datum path or plane, whereby to provide the supporting struts described above. The struts support and apply longitudinal stresses to the sections being worked to redistribute the stresses therein longitudinaly. More specifically, a pair of edge engaging guide rolls **214** is provided on the upper carriage **84** to engage the strip immediately before it engages the working rolls **48** and **54** (see FIG. 6). A similar pair of rolls **216** is provided on the lower carriage **82** to engage the strip immediately after it has passed the edge working rolls **50** and **56** (see FIG. 7). In addition, a center engaging roll **218** is provided to engage the upper surface of the strip in substantial alignment with the lower edge working rolls **48** and **54** and disposed inwardly therefrom, and a similar roll **220** is provided on the lower carriage **82** to engage the lower side of the strip in the center thereof while the strip is in engagement with the upper edge working rolls **50** and **56**.

Similarly, additional rolls are provided about the center working rolls **66**, **68** and **70**. A pair of rolls **222** is provided to engage the upper surface of the strip while the strip is being worked by the lower working roll **66**. Another pair of rolls **224** engages the upper surface of the strip in alignment with the lower center working roll **68**. A third pair of rolls **226** engages the lower surface of the strip **20** while the center of the strip is being worked by the center working roll **70**.

Each of the rolls **214**, **216**, **222**, **224** and **226** is constructed and is mounted in a manner similar to the rolls **48** and **54**, as is best illustrated in FIG. 10 of the drawings, the only difference in the mounting being that the shafts **178** for the non-working rolls are formed straight instead of eccentric, i.e., the cylindrical portions **180** and **184** have the axes thereof in horizontal alignment. The non-working roll **218** is mounted in a manner substantially identical with the roll **170** illustrated in FIG. 11 and has a curved or crowned strip engaging surface thereon. The roll **220** is mounted substantially like the roll **68** illustrated best in FIG. 12 of the drawings but is not provided with the adjusting shims **206**.

Means are provided accurately to position the upper carriage **84** vertically with respect to the lower carriage **82**. To this end an upper support plate **230** has been provided and is supported upon the lower carriage **82** by means of four upstanding bolts **232**, whereby fixedly to position the support plate **230** with respect to the lower carriage **82**. Mounted on the support plate **230** there is a pair of hydraulic motors **234** which are preferably air actuated and are provided with downwardly directed piston rods carrying bifurcated connectors **236** thereon. Upstanding ears **238** are fixedly attached to the upper surface of the plate **162** and extend upwardly between the ends of the bifurcated connectors **236**. A bolt **240** extends through aligned apertures in the connector **236** and the associated ear **238**.

Each of the motors **234** is provided with suitable connections (not shown) to air under pressure. When air is applied to the motor **234**, the pistons therein are ex-

tended downwardly to apply pressure on the plate **162** and to force the upper carriage **84** downwardly toward the lower carriage **82**. When conditioning a strip having the dimensions set forth above, a high pressure, for example, 2500 pounds may be applied by each of the motors **234**. When it is desired to feed a new strip into the machine **80**, the piston rods of the motors **234** are retracted to raise the upper carriage **84** to facilitate insertion of the strip between the carriages **82** and **84**. When it is desired to disassemble the upper carriage **84** from the lower carriage **82**, this can be accomplished by removing the bolts **232** and lifting the upper support plate **230** by means of an eye bolt **242** provided for that purpose and mounted on the plate **230**.

The operation of the machine **80** is as follows. The piston rods of the motors **234** are retracted to raise the upper carriage **84** away from the lower carriage **82**, and the free end of the strip **20** is then threaded into position in the machine. During the threading it is desirable to retract the piston rods of the motors **114** and **118**. The motors **234** are then operated under the operating force of approximately 2500 pounds each, the motors **114** are operated under a force of 760 pounds and the motor **118** is operated under a force of approximately 1520 pounds, whereby to apply substantially 760 pounds to each of the side edge engaging rolls **44** and **60**.

As the strip **20** is thereafter fed or pulled through the machine by any suitable means, the various rolls will function in the manner which has been described heretofore. The result will be to redistribute all non-uniform internal stresses or islands of stresses throughout the strip whereby to provide a more uniform stress condition therethrough as has been described above with respect to FIG. 3 of the drawings.

It will be seen that there has been provided a method and apparatus which fulfill all of the objects and advantages set forth above. Although one preferred embodiment of the invention has been shown and described for purposes of illustration, it is to be understood that various changes and modifications can be made therein without departing from the spirit and scope of the invention. Accordingly, the invention is to be limited only as set forth in the following claims.

We claim:

1. Apparatus for conditioning an elongated metal strip comprising guide means for supporting a strip along a predetermined datum path, means for deflecting the edge sections of the strip extending in the direction of the datum path first in one direction and then in the other direction out of the datum path to work the strip plastically substantially throughout the thickness thereof, means to hold the center section of the strip in the datum path at points disposed transversely of said edge section deflecting means, means for deflecting the center section of the strip at a point disposed along the datum path from said edge section working means to deflect the strip out of the datum path in one direction and then in the other direction to work the center section of the strip plastically substantially throughout the thickness thereof, and means for holding the edge sections of said strip in the datum path transversely adjacent to said center section deflecting means.

2. Apparatus for conditioning an elongated metal strip comprising guide means to support a strip for longitudinal movement along a predetermined planar datum path, means for deflecting the longitudinal edge sections of the strip out of the datum path, means to hold the center longitudinal section of the strip in the datum path adjacent to and disposed transversely with respect to said edge section deflecting means, means for deflecting the center section of the strip out of the datum path at a point disposed longitudinally away from said edge section deflecting means, and means for holding the edge sections of the strip in the datum path transversely adjacent to the said center section deflecting means.

3. Apparatus for conditioning an elongated metal strip comprising guide means to support a strip for longitudinal movement along a predetermined planar datum path, means for deflecting the longitudinal edge sections of the strip out of the datum path, means for holding the longitudinal section of the strip intermediate said edge sections in the datum path adjacent to and disposed transversely with respect to said edge section deflecting means, means for deflecting said intermediate section of the strip out of the datum path at a point disposed longitudinally away from said egde section deflecting means, and means for holding the edge sections of the strip in the datum path transversely adjacent to said intermediate section deflecting means.

4. Apparatus for conditioning an elongated metal strip comprising guide means to support a strip for longitudinal movement along a predetermined planar datum path, means for deflecting out of the datum path a pair of laterally spaced apart longitudinally extending sections of the strip, means for holding the longitudinal section of the strip intermediate said pair of sections in the datum path adjacent to and disposed transversely with respect to said deflecting means, means for deflecting said intermediate section of the strip out of the datum path at a point disposed longitudinally away from said first mentioned deflecting means, and means for holding said laterally spaced apart pair of sections in the datum path transversely adjacent to said intermediate section deflecting means.

References Cited in the file of this patent

UNITED STATES PATENTS

1,040,378	Parmelee	Oct. 8, 1912
1,562,916	Rendleman	Nov. 24, 1925
1,584,499	Zachuber	May 11, 1926
1,587,357	Allen	June 1, 1926
1,839,251	Norton	Jan. 5, 1932
1,914,439	Langford	June 20, 1933
2,090,706	Sheperdson	Aug. 24, 1937
2,095,733	Coryell	Oct. 12, 1937
2,168,435	Bond	Aug. 8, 1939
2,213,507	Ungerer	Sept. 3, 1940
2,305,793	Puppe	Dec. 22, 1942
2,333,282	Wilson	Nov. 2, 1943
2,355,448	Kratz	Aug. 8, 1944
2,441,648	Senard	May 18, 1948
2,600,442	Stanius	June 17, 1952
2,638,143	Maust	May 12, 1953
2,792,049	Peebles	May 14, 1957