United States Patent [19]

Withrow

[11] **3,828,599**

[45] **Aug. 13, 1974**

[54] **APPARATUS AND METHOD FOR LEVELING METAL STRIP**

[75] Inventor: **David A. Withrow**, Willoughby, Ohio

[73] Assignee: **Production Machinery Corporation**, Mentor, Ohio

[22] Filed: **Aug. 27, 1973**

[21] Appl. No.: **391,559**

Related U.S. Application Data

[63] Continuation of Ser. No. 196,985, Nov. 9, 1971, abandoned.

[52] **U.S. Cl.** **72/163**, 72/245

[51] **Int. Cl.** **B21d 1/05**

[58] **Field of Search** 72/160, 163, 248, 246, 72/236, 162, 201

[56] **References Cited**

UNITED STATES PATENTS

1,519,657	2/1924	Biggert, Jr.	72/245
3,031,872	5/1962	Kusters	72/245 X
3,492,850	2/1970	Groppins	72/162 X
3,561,241	2/1971	Blain	72/201
3,605,470	9/1971	Polakowski	72/163

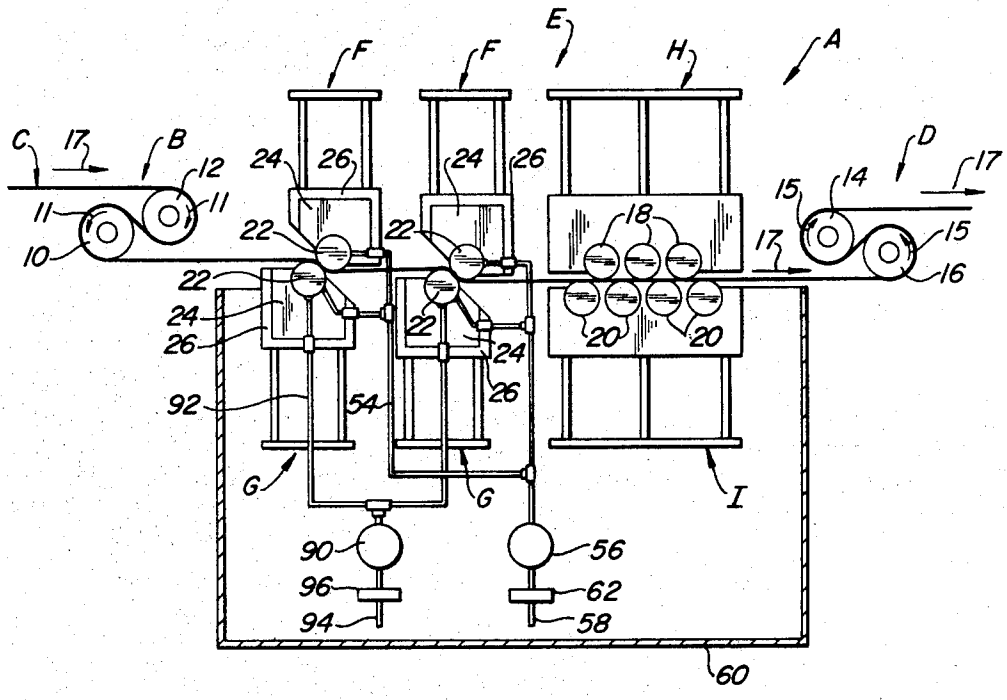
Primary Examiner—Milton S. Mehr

Attorney, Agent, or Firm—Meyer, Tilberry & Body

[57] **ABSTRACT**

An apparatus and method for leveling elongated metal strip includes pulling means for pulling the strip under tension in a longitudinal direction and flexing means for imparting flexing forces to the strip. The flexing means includes fluid pressure means for producing the flexing forces.

3 Claims, 6 Drawing Figures



PATENTED AUG 1 3 1974

3,828,599

Fig 1

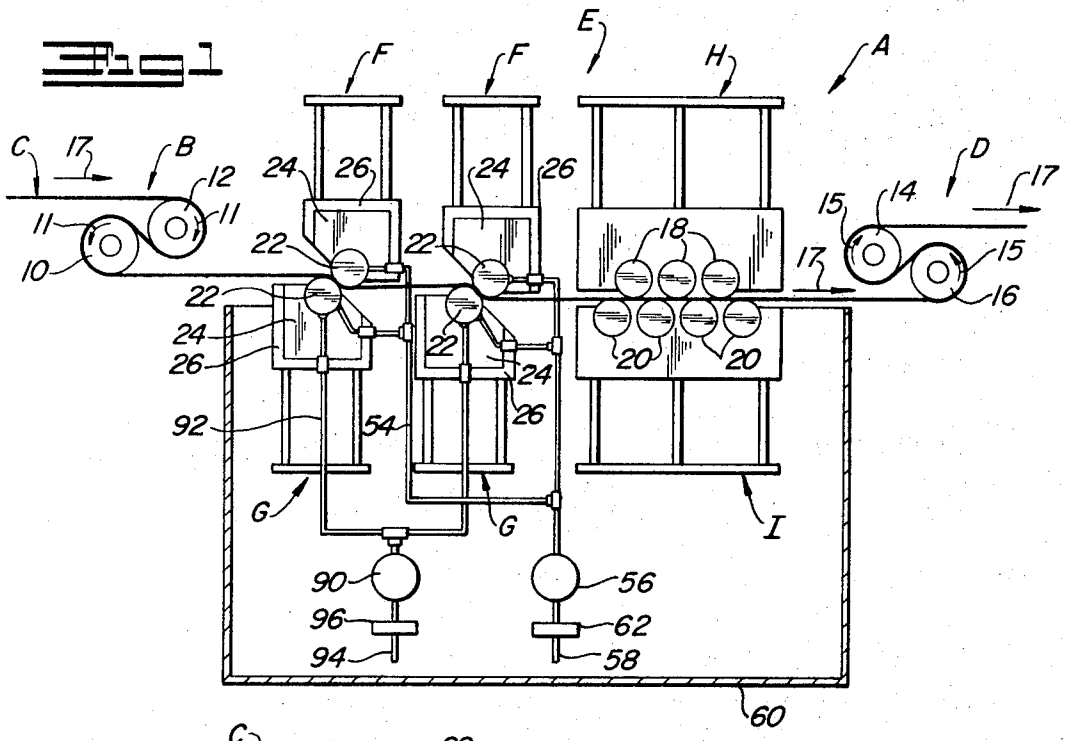
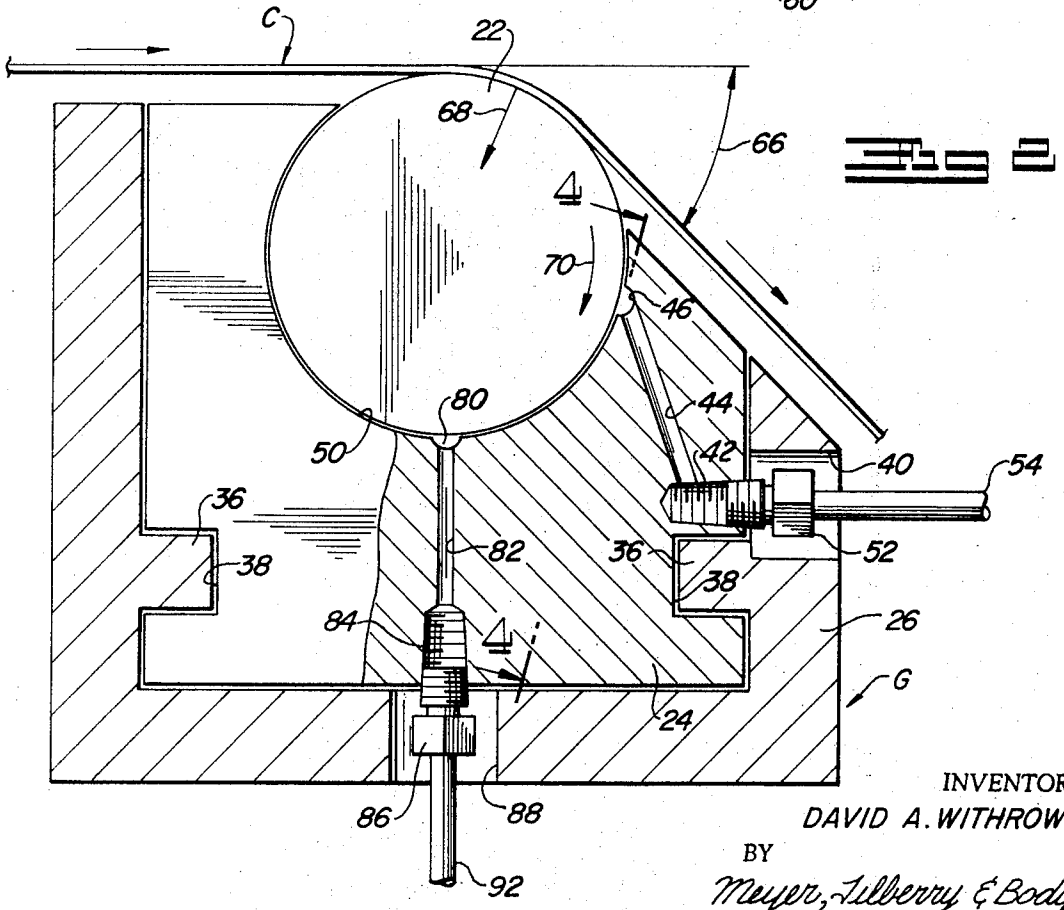


Fig 2



INVENTOR.
DAVID A. WITHROW
BY
Meyer, Tilberry & Body
ATTORNEYS

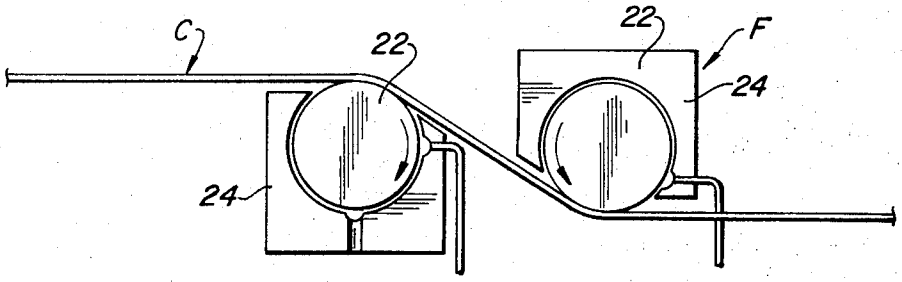


Fig 3

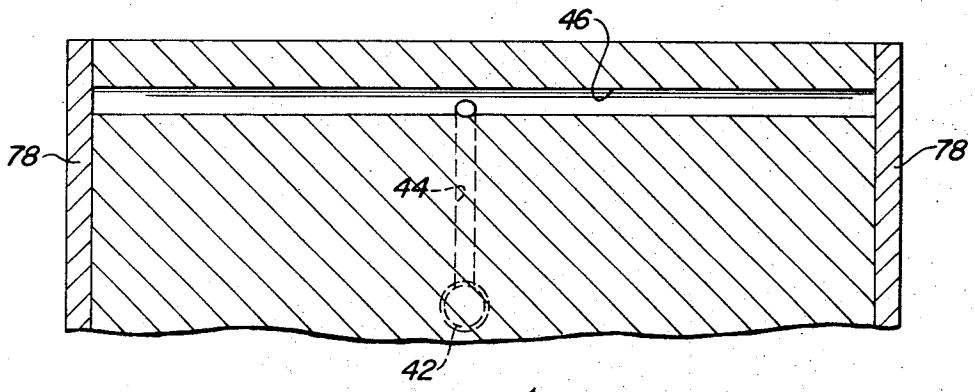


Fig 4

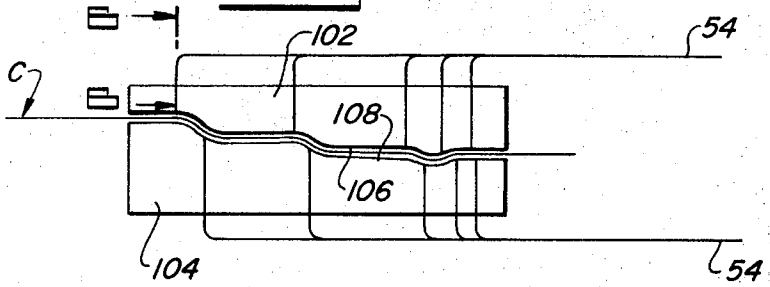


Fig 5

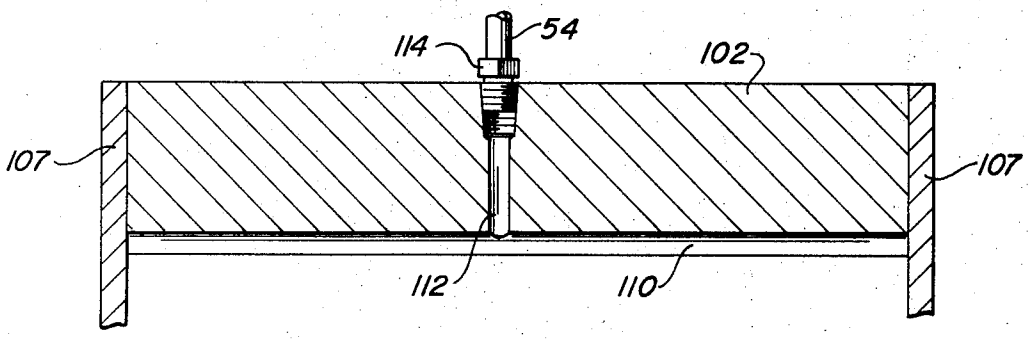


Fig 6

INVENTOR.
DAVID A. WITHROW
BY
Meyer, Tilberry & Body
ATTORNEYS

APPARATUS AND METHOD FOR LEVELING METAL STRIP

This is a continuation, of application Ser. No. 196,985 filed Nov. 9, 1971, now abandoned.

BACKGROUND OF THE INVENTION

The present invention pertains to the art of leveling elongated metal strip, and more particularly to leveling such strip by the application of tensioning and flexing forces.

Elongated metal strip produced in a mill commonly has wrinkles, wavy edges and other imperfections. It is common to remove such imperfections by applying tension to the strip while passing the strip through staggered rolls. The combination of tension and flexing around the rolls stretches the strip beyond its yield point which permanently elongates the strip to remove the imperfections.

The rolls used for flexing the strip are preferably of small diameter to reduce the tension required for inducing permanent elongation. The rolls extend completely across the width of the strip and are normally supported in end bearings. When small diameter rolls are used, the tension in the strip tends to deflect the rolls. However, if the work rolls are allowed to deflect, the quality of strip flattening will be seriously reduced. Conventional apparatus employs a large number of segmented backup rolls deployed along the length of the work rolls to minimize deflection of the work rolls. The requirement for a large number of backup rolls makes such apparatus very expensive. Furthermore, the backup rolls tend to emboss the work rolls after a period of under tension.

It is a principle object of the present invention to provide an improved apparatus and method for leveling metal strip.

It is also an object of the present invention to provide an apparatus for leveling metal strip which uses a fluid film bearing.

It is another object of the present invention to provide an apparatus and method for leveling metal strip in a manner which is more economical and simpler than existing apparatus and methods.

It is an additional object of the present invention to provide an apparatus and method for leveling metal strip in a manner which eliminates stripping of the strip.

It is a further object of the present invention to provide an improved apparatus and method for leveling metal strip in a manner which provides enclosed support for the flex rolls to eliminate critical speed vibration of the flex rolls in high speed applications.

DESCRIPTION OF THE DRAWINGS

The invention may take form in certain parts and arrangements of parts, certain preferred embodiments of which will be described in this specification and shown in the accompanying drawings which form a part hereof.

FIG. **1** is a side elevational view of an apparatus for leveling strip and having the improvement of the present invention incorporated therein;

FIG. **2** is a partial cross-sectional elevational view of one lower bending roll unit in FIG. **1**;

FIG. **3** is a simplified side elevational view showing the improved arrangement of the present invention;

FIG. **4** is a cross-sectional elevational view looking in the direction of arrows **4—4** of FIG. **2**;

FIG. **5** is a side elevational view similar to FIG. **3** and showing another embodiment of the present invention; and

FIG. **6** is a cross-sectional elevational view looking in the direction of arrows **6—6** of FIG. **5**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, wherein the showings are for purposes of describing certain preferred embodiments of the invention only and not for purposes of limiting same, FIG. **1** shows an apparatus A for flattening or leveling metal strip. A drag bridle B includes rotatably driven rolls **10** and **12** through which metal strip C is trained as shown. A pull bridle D includes rotatably driven rolls **14** and **16** through which strip C is also trained. Rolls **10** and **12** of drag bridle B are driven in the direction of arrows **11** at a lower speed than rolls **14** and **16** of pull bridle D which are driven in the direction of arrows **15** so that strip C is under considerable tension as it moves in the direction of arrows **17** and is elongated by the tensioning and flexing forces applied by apparatus A. It will be recognized that FIG. **1** is a simplified showing of a leveling apparatus and that additional components may be located between bridles B and D. For example, additional drag and pull bridles may be provided, as well as a temper mill and pre-flex unit. Such arrangements are conventional and have been omitted for simplicity of description.

In accordance with one arrangement, flexing means E is positioned between bridles B and D for imparting flexing forces to strip C. Flexing means E bends strip C as it passes therethrough. Flexing means E is designed to bend the metal back and forth in small radius bends. Flattening or leveling can be accomplished only by stressing the metal beyond its elastic range in order to produce permanent set. Therefore, the bends produced in passing through flexing means E are necessarily of small radius.

In accordance with one arrangement, flexing means E includes upper bending roll units F and lower bending roll units G. Flexing means E may also include an upper roll unit H having rolls **18** staggered with respect to rolls **20** in lower roll unit I. Rolls **18** and **20** may be positioned to provide vertually no flexing of strip C and simply serve to flatten the strip. Roll units F, G, H and I may be adjustably positioned for vertical and lateral adjustment in a known conventional manner for properly positioning the rolls.

Each upper bending roll unit F includes a roll **22** extending completely across the entire width of strip C and rotatably journaled in bearing journal **24** mounted in bearing journal carrier **26.** Each lower bending roll unit G includes an elongated roll **22** extending completely across the width of strip C and rotatably journaled in bearing journal **24** carried by bearing journal carrier **26.**

In accordance with one arrangement, each bearing carrier **26** of lower bending roll units G includes a pair of oppositely disposed longitudinally extending keys or projections **36** received in keyways or longitudinal grooves **38** in bearing journal **24.** Bearing carrier **26** is provided with an enlarged bore **40** therethrough in alignment with a threaded bore **42** in bearing journal **24.** An inclined hole **44** in bearing journal **24** intersects

threaded bore **42** at one end and longitudinal arcuate grooe **46** at its other end. Arcuate portion **50** in bearing journal **24** is approximately **230** degrees and lies on the circumference of a circle. In one arrangement, arcuate portion **50** lies on the circumference of a circle whose diameter is around 2.502 inches and roll 22 has a diameter of around 2.500 inches. In other words, there is around two-thousandths clearance between the outer periphery of roll **22** and arcuate portion **50** of bearing journal **24.** A nipple **52** extends through bore **40** in bearing carrier **26** and is threaded into threaded bore **42** in bearing journal **24.** Nipple **52** is connected through conduit **54** with the output end of a hydraulic pump **56** having an intake **58** positioned in sump **60** and connected with pump **56** through filter **62.**

In one arrangement, strip C is in contact with the outer periphery of roll **22** over an arc of around **45** degrees so that strip wrap angle **66** is **45** degrees. With this wrap angle, and a tension in strip C of around **800** pounds per inch of width of roll **22,** the resultant load indicated by numeral **68** on roll **22** is around 500 pounds per inch of width. Oil having a viscosity of 10–100 centipoises is supplied by pump **56** to groove **46** at a pressure of **30-40** pounds per square inch. Oil then flows at a rate of around **1**/10th gallon per minute when roll **22** has a width of around **60** inches. As strip C travels through apparatus A, roll **22** rotates in the direction of arrow **70** on a fluid film which develops between its outer periphery and arcuate portion **50** of bearing journal **24.** An induced load carrying film is created between the periphery of roll **22** and arcuate portion **50** when roll **22** rotates under applied load **68.** For the values previously given, a frictional torque of around 2.5 inch pounds per inch of width for roll **22** is developed during rotation thereof. As shown in FIG. **4,** end plates **78** may be secured to bearing journal **24.** The distance across the oppositely facing surfaces of plates **78** is slightly greater than the width of roll **22.** Lubricant flowing into the end clearances also provides a fluid film thrust bearing. If desired, the ends of roll **22** and plate **78** may be stepped or provided with spiral intake grooves to develop a better hydrodynamic fluid pressure.

On bottom bending roll units G, it is also possible to provide an additional longitudinal groove **80** extending along arcuate portion **50** of bearing journal **24.** Groove **80** is connected by hole **82** with threaded bore **84** receiving nipple **86** extending through bore **88** in bearing carrier **26.** Nipple **86** is connected with a higher pressure pump **90** through conduit **92.** High pressure pump **90** has its inlet **94** positioned in sump **60** through filter **96.** During line stops, when strip C is not moving, a suitable valve in conduit **92** may be opened and pump **90** energized to pump lubricating fluid into the space between arcuate portion **50** and roll **22** so that roll **22** will not seat during strip stoppage.

It will be recognized that upper bending roll units F are provided with lubrication in a manner described with reference to lower bending roll units G. Lubricant is supplied to both upper and lower rolls **22** immediately adjacent the area where the periphery of rolls **22** first enter arcuate portions **50** in their direction of rotation. This insures efficient development of a load carrying fluid film.

Instead of having a self-acting fluid bearing formed by hydrodynamic effect, it will be recognized that additional ports may be provided to arcuate portion **50** for external pressure generation of the fluid film by hydrostatic effect. In place of hydrostatic or hydrodynamic effect for producing the film it will also be recognized that pneumodynamic or pneumostatic lubrication may also be provided. The self-acting hydrodynamic bearing described with internal pressure generation is the preferred embodiment.

It is also possible to provide upper bending roll units F with a high pressure inlet as described with reference to lower bending roll units G so that upper rolls **22** will not be forced upward and seat under the force of strip C acting thereagainst during strip stoppage.

As shown in FIG. **3,** strip C also makes arcuate contact with upper roll **22** over an angle of around **45** degrees. Upper roll **22** is laterally displaced from lower roll **22** and positioned vertically downward so that strip C is sharply bent as it passes through upper and lower rolls **22.** The peripheral portions of rolls **22** define flexing surface means which extend traversely of strip C on opposite sides thereof. The arrangement described relys upon viscosity and pressures of the load bearing film to supply the flexing forces which bend strip C.

In accordance with another arrangement, as shown in FIGS. **5** and **6,** a pair of upper and lower flexing members **102** and **104** are positioned on opposite sides of strip C. Flexing members **102** and **104** replace bending roll units F and G of FIG. **1.** Each flexing member **102** and **104** is formed with a stepped or radiused surface **106** and **108** facing the opposite sides of strip C. Stepped surfaces **106** and **108** define a tortuous path through which strip C is alternately flexed in one direction, then the other. Each stepped surface **106** and **108** is formed with longitudinally extending grooves **110** connected through holes **112** with nipples **114.** Nipples **114** are connected through conduits **54** with pump **56** of FIG. **1.** The spacing between stepped surfaces **106** and **108** may be around four-thousandths greater than the thickness of strip C. The supply of lubricant between stepped surfaces **106** and **108,** and the opposite sides of strip C, develops a fluid film sliding bearing so that strip C is flexed as it slides along the fluid film through the tortuous path provided by stepped surfaces **106** and **108.** End plates **107** may be secured to flexing members **102 0**and **104.** The distance between the opposite facing inner surfaces of end plates **107** is slightly greater than the width of strip C.

It will be recognized that it is possible to use many different liquid lubricants including water in the arrangement described, and that wipers and splash guards may be provided for removing lubricant from strip C after it has passed through flexing means E and returning the lubricant to sump **60.**

The improved roll mounting arrangement of the present invention is capable of use in many applications other than tension leveling of metal strip. For example, it may be used for metering lubricant or a coating onto strip material. The improved roll mounting arrangement may be used in any application requiring extremely low friction, such as a cage for a roller bearing or as a substantially frictionless fulcrum. The roll mounting arrangement is also useful in application where roll speeds are high and stability is essential.

Although the invention has been described with respect to certain preferred embodiments, it will be recognized that obvious alterations and modifications will occur to others skilled in the art upon the reading and understanding of this specification. The present inven-

tion includes all such equivalent alterations and modifications and is limited only by the scope of the claims.

Having thus described my invention, I claim:

1. In an apparatus for leveling an elongated metal strip having a given width including means for pulling said strip under tension along a generally longitudinal path, first and second generally cylindrical rolls extending transversely across said strip and on opposite sides of said path, each of said rolls having a cylindrical outer surface concentric to a longitudinally extending axis, and means for rotatably supporting each of said first and second rolls for rotation about said axes and in contact with said strip to define a flexing pattern for said strip as it moves along said path, the improvement comprising: said roll supporting means each including a cylindrical recess extending parallel to said roll axis and having a fixed inner cylindrical surface generally matching said outer cylindrical surface of one of said rolls, said inner cylindrical surface being substantially less than 360° to expose a position of said one roll and being slightly larger than said outer cylindrical surface to define an elongated arcuate space extending along said one roll and having first and second circumferentially spaced ends, said space having a generally uniform radial thickness determined by the difference in the size of said inner and outer cylindrical surfaces, said one roll being driven with respect to said inner cylindrical surface in a direction extending from said first circumferentially spaced end of said space to said second circumferentially spaced end of said space, and means for continuously forcing a fluid into said space adjacent said first circumferentially spaced end whereby said fluid is dynamically forced along said space by rotation of one roll in said recess.

2. The improvement as defined in claim 1 including means for selectively forcing a fluid into said space at a position between said circumferentially spaced ends to apply a force between said inner and outer cylindrical surfaces.

3. In an apparatus for leveling an elongated metal strip having a given thickness and width including means for pulling said strip under tension along a generally longitudinal path, and first and second generally fixed elements positioned on opposite sides of said path and extending transversely across said strip, each of said elements having means for defining a flexing pattern for said strip as it moves along said path, the improvement comprising: a first undulating surface on said first fixed element, a second undulating surface on said second fixed element and matching said first undulating surface, said first and second surface defining an undulating recess extending across said path a distance greater than the width of said strip and having a generally uniform thickness slightly greater than the thickness of said strip, first means for continuously forcing a liquid into said recess between said first surface and said moving strip and second means for continuously forcing a liquid into said recess between said second surface and said strip whereby said strip is supported on liquid as it is pulled through said undulating recess.

* * * * *