March 2, 1965 R. K. HOLTZ 3,171,464

METHOD OF FLATTENING METAL STRIP OR SHEET

Filed Sept. 4, 1962

2 Sheets-Sheet 1

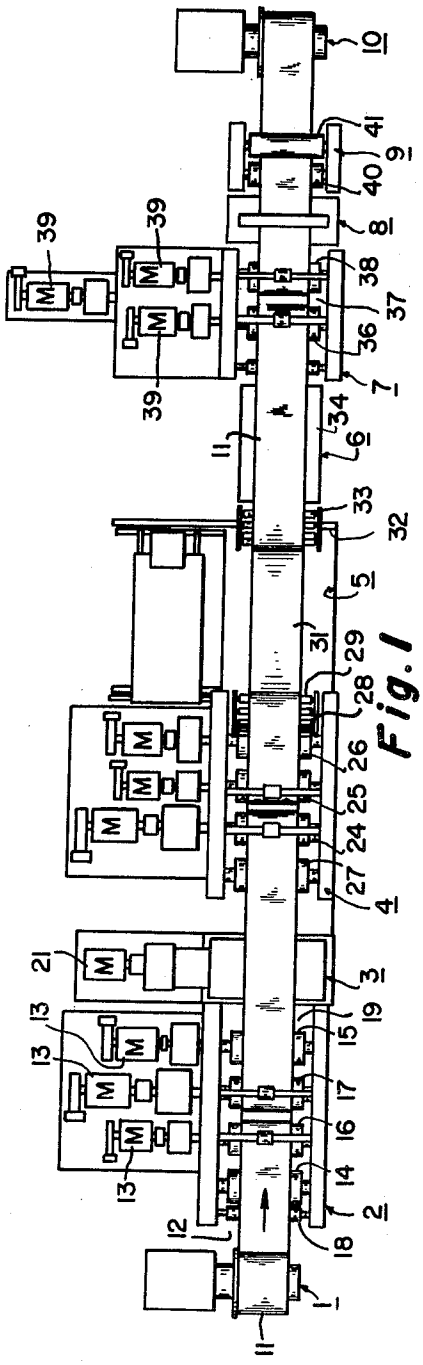


Fig. 1

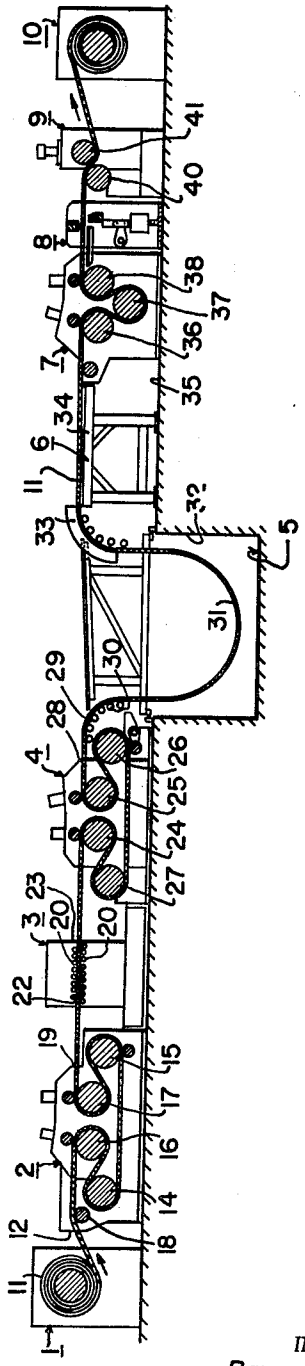


Fig. 2

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2 Sheets-Sheet 2

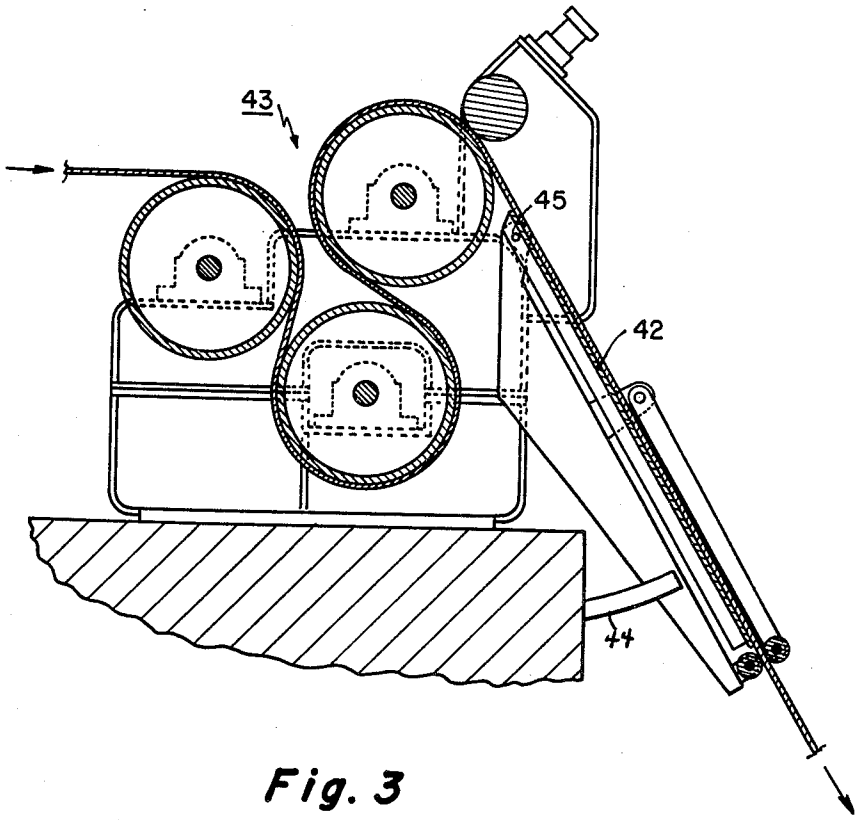


Fig. 3

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METHOD OF FLATTENING METAL STRIP OR SHEET

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9 Claims. (Cl. 153—86)

This invention relates to a method of flattening nonferrous and ferrous metal strip or sheet, particularly aluminum, copper, brass and carbon and alloy steel cold rolled strip and sheet in gauges about 0.040" and lighter and in almost any width.

Ability to produce metal strip and sheet, particularly in large coils, with a high degree of flatness widthwise throughout substantially their length and in some cases, substantially perfect flatness, has been a problem for some time. Many fabricators of metal parts and metal articles require flat sheet and strip in order to meet specification and produce a high quality article.

Heretofore, some rolled strip or sheet has been passed through roller levelers wherein it is flexed alternately between the work rolls of the levelers to flatten same but these levelers have not been wholly successful for flattening the lighter gauges such as those 0.040" and thinner which are more difficult to roll flat than the heavier gauges. Furthermore, flattening the lighter gauges on a roller leveler is more difficult than flattening the heavier gauges for the lighter gauges are less prone to assume a radius of bend defined by the diameter of the work rolls of the leveler and by the positions of the upper work rolls relative to the lower work rolls.

In roller levelling strip and sheet, the material is bent by the work rolls about its neutral axis where a zero bending stress is maintained. At the radii of the bends in the strip where yield stress is encountered in the outside fibers of the strip (tensile stress on the outside surface and compression stress on the inside surface of the bend), a stress distribution results which decreases in a straight line relationship from the tensile yield value at one outside fiber through zero at the neutral axis to the compressive yield value at the other outside fiber. Decreasing the radius of the bend causes the yield stress to penetrate below the outside fibers or surfaces of the strip and increases the amount of metal thicknesswise which has been stressed beyond the yield point. However, two factors limit the amount one can decrease the radius of the bends which, in turn, limit from a practical standpoint the effectiveness of a roller leveler on light gauge materials. The first factor is that as the work roll diameters and center-to-center spacing thereof are decreased to effect a smaller bend radius, the leveler becomes mechanically weaker and unsuited for flattening the heavier gauges. Accordingly, the gauge range which can be accommodated by a given leveler is limited and the machine is not attractive to a customer who is not able to justify purchase on a basis of light gauges alone.

The second factor is that the lighter gauges being less rigid than the heavier gauges tend not to assume the radius of the bends governed by the work roll diameter and center-to-center spacing thereof.

Application of tension to the strip while it traverses a roller leveler overcomes mechanical limitations of design of the leveler by inducing an additional stress to the strip which, when added to the stress generated by bending of the strip around a portion of the work rolls of the leveler, has the same effect as decreasing the bend radius. Also, tension increases the apparent rigidity of the metal strip and insures that it conforms to the work roll radius of the leveler during flattening and improves the effectiveness of the leveler adjustments. This tension is applied longitudinally of the strip and substantially in the direction of the path of travel of the strip through the roller leveler.

The amount of tension used for flattening a particular strip or sheet is determined by taking into account stress/strain characteristics of the metal and the relationship between the gauge of the metal to be flattened and the work roll diameter of the roller leveler.

To achieve a high degree of flatness in the strip, adequate inspection, preferably continuous inspection, of the strip issuing from the tension leveling part of the apparatus is highly important to afford an opportunity to regulate positions of the work rolls of the leveler and amounts of tension applied to the strip and thereby correct unflattened portions or segments of the strip. Additionally, the strip should be at zero tension during inspection because if the material is not quite flat, a small amount of tension therein may make the strip appear to be flat.

My invention provides a method of flattening metal strip and sheet in long continuous lengths wherein the strip is subjected to tension during flattening and then is made available at substantially zero tension for substantially continuous inspection, after which it is wound into a coil or cut to length. Specifically, my method for flattening strip or sheet comprises passing a continuous length of the strip along a path of travel through a roller leveler and through a first means for engaging the strip and operable to place a forward tension thereon. A forward tension is placed upon the strip while passing it through the roller leveler and to the first means after which it is advanced from the first means further along the path of travel and conveyed over an inspection table and to a second means for engaging the strip and moving it over the inspection table. This second means is operated relative to the first means so that the strip is under substantially zero tension during its travel over the inspection table. Then the strip is further advanced from the second means and wound into a proper coil while subjecting it to tension which assists to produce the neat coil.

The second means is operated relative to the first means so as to produce a loop in the strip between the first means and the inspection table or between the inspection table and it.

To place a back tension on the strip on the entry side of the roller leveler, I pass the strip through a third means positioned in advance of the entry end of the roller leveler and so operate this third means relative to the roller leveler and/or the first means that the strip is subjected to back tension between the third means and the roller leveler.

My apparatus for flattening metal strip and sheet comprises a roller leveler positioned for receiving the strip from a feed means and a first tension means on the exit side of the roller leveler and in tandem therewith so that the strip travels through the roller leveler and the first tension means sequentially. This first tension means is operable for generating a forward tension on the strip between the roller leveler and it. On the exit side of the first tension means is an inspection table for travel of the strip thereover. A second tension means is on the exit side of the inspection table for engaging the strip and advancing it over the inspection table. This second tension means is operable relative to the first tension means so that the strip is under substantially zero tension in its travel over the inspection table.

Between the exit end of the first tension means and the entry end of the inspection table is a pit for receiving a loop in the strip. This pit may also be located between the inspection table and the second tension means.

On the exit side of the second tension means is a winding reel for winding the strip into the coil and for placing a tension on the strip between the second tension means and the reel to produce the proper coil.

Between the feed means and the roller leveler is a third tension means for engaging the strip and for travel of the strip therethrough. This third tension means is operable relative to the roller leveler and/or the first tension means for generating a back tension in the strip between the roller leveler and it.

In the accompanying drawings I have shown a preferred embodiment of my invention in which:

FIGURE 1 is a plan view of apparatus for effecting flattening of metal strip and sheet and on which I practice my method for flattening the strip and sheet;

FIGURE 2 is a side elevation view of the apparatus of FIGURE 1; and

FIGURE 3 is a side elevation view of a three-roll bridle and a sloping inspection table which can be used in the apparatus of FIGURE 1.

Referring to FIGURES 1 and 2, my flattening apparatus comprises a feed or payoff reel **1**, a first bridle **2**, a roller leveler **3**, a second bridle **4**, a pit **5**, an inspection table **6**, a third bridle **7**, a shear **8**, a deflector roll assembly **9**, and a winding reel **10**. The foregoing elements are in alignment and arranged in tandem so that strip passes sequentially through each from the payoff reel **1** through to the winding reel **10**.

The payoff reel **1** mounts a coil of metal strip **11** and delivers same to the entry end **12** of the first bridle **2** which comprises four rolls horizontally mounted, three of which are driven by motors **13**. The rolls of the first bridle are arranged substantially in tandem with the two end rolls **14** and **15** of the four being slightly below the two center rolls **16** and **17**. The strip enters the first bridle over a billy roll **18** and travels around the left center roll **16** which is motor driven, then around the left end roll **14** which is an idler one, next beneath the two center rolls **16** and **17** and around the right end roll **15**, motor driven, from which it goes around the right center roll **17** and then passes over the exit end **19** of the first bridle into the roller leveler **3**.

This roller leveler **3** is of conventional construction and, therefore, further description thereof is deemed unnecessary other than to point out that it has work rolls **20** which are driven by a motor **21**, which form a labyrinth path of travel **22** therethrough and which alternately flex the strip to flatten same.

From the exit end **23** of the roller leveler, the strip advances into the second bridle **4** whose construction is substantially the same as the first bridle. This second bridle likewise has three motor driven rolls **24**, **25** and **26** and one idler roll **27** and the path of travel of the strip through the second bridle is the same as the path of travel through the first bridle.

The driven rolls **24**, **25** and **26** of the second bridle are so powered by the motors connected thereto that they generate a forward tension upon the strip in its travel from the first bridle through the roller leveler to the second bridle. A conventional electric control (not shown) effects operation of the second bridle to provide this forward tension.

The driven rolls **15**, **16** and **17** of the first bridle are so powered by the motors **13** relative to the roller leveler and/or the second bridle that they produce a back tension upon the strip in its travel from the first bridle to the roller leveler. The electric control brings about operation of the first bridle to obtain this back tension.

On the exit end **28** of the second bridle is a first roller conveyor **29** comprising a plurality of idler rolls **30** which form an arcuate path of travel for the strip extending from a horizontal plane to a vertical plane which leads into the pit **5**.

In the pit, the strip forms a loop **31** which lies in a substantially vertical plane disposed substantially parallel to the path of travel of the strip through the apparatus.

On the exit end **32** of the pit is a second roller conveyor **33** substantially the same as the first roller conveyor with its idler rolls arranged to form an arcuate path of travel for the strip leaving the pit so that it is guided from a vertical plane into a horizontal plane for advancement to the inspection table.

The second roller conveyor directs the strip onto the inspection table **6** which comprises a bed **34** disposed horizontally to the surface of the level **35** on which the apparatus is located. This bed preferably is precisely flat to provide a proper reference for determining the degree of flatness in the strip.

From the exit end of the inspection table the strip travels into the third bridle **7** which comprises three rolls **36**, **37** and **38** rotatably driven by motors **39**. These three rolls of the third bridle are arranged in a V configuration with the entry roll **36** being disposed above the center roll **37** and the exit roll **38** likewise disposed above the center roll. The strip travels around the inside of entry roll **36**, then around the bottom roll **37** and up and around and over the inside of the exit roll **38**.

The rolls of the third bridle **7** are so powered by the motors **39** relative to the second bridle that they produce the loop **31** in the strip in the pit and assure that the strip is under substantially zero tension during its travel across the inspection table. The conventional electric control regulates operation of the third bridle relative to the operation of the second bridle **4** to form the loop in the pit **5** and present the strip at substantially zero tension in its travel across the inspection table **6**.

From the third bridle the strip progresses through a shear **8** which crops off ends of the coil should such cropping be required.

Next, the strip travels through a deflector roll assembly **9** which comprises two rolls **40** and **41** positioned so that their axes of rotation lie in a plane disposed diagonally to the path of travel of the strip through the apparatus. The rolls are adjacent one another whereby the strip travels over an upper surface of the lower roll **40** and across an under surface of the upper roll **41** and then onto the winding reel **10**.

The winding reel is driven by a motor (not shown) which generates a tension in the strip between the third bridle and the reel so that the strip can be wound into a neat coil.

In order to present the strip for inspection at substantially zero tension, it is highly desirable that the loop **31** be formed in order to isolate the tension leveling apparatus (the first and second bridles and the roller leveler) from the rewind apparatus (the third bridle, deflector roll assembly and the rewind reel). Additionally, the loop permits use of different amounts of tension for flattening than for rewinding the strip into a coil.

While non-flatness of a strip's edges is best judged by conveying it over a flat horizontal surface, non-flatness in the center portion of the strip is best judged on a substantially vertical strip pass line such as an egress portion of the strip as it issues from the loop. Accordingly, the loop performs a function of placing the strip in a good position for inspection of central portions of the strip.

When flattening light gauges such as 0.010" and thinner, the weight of the strip in the loop, which may be of considerable depth for various reasons such as the speed of operation of the apparatus, can produce a sufficient tension to obscure irregularities in flatness of the strip and prevent adequate inspection when the light strip is conveyed across a horizontal inspection table. Additionally, friction between the strip and the table also obscures the irregularities. Under such conditions, a downwardly sloping inspection table **42** (FIGURE 3) on the exit side of a three-roll second bridle **43** and at the entrance to the loop is preferable since such a table can be

tilted to the exact angle required to minimize the effects of compressive feeding forces, table friction and gravity all of which affect each other. An arm 44 connected to the lower end of the table 42 enables it to be tilted about its pivot mounting 45 to a given angle and thereby present light gauge strip at substantially zero tension for inspection.

The amount of tension which effects flattening of the strip during its travel through the roller leveler in most cases is not the same as the amount of tension employed to rewind the strip into a coil. To flatten the strip in its travel through the roller leveler, I employ an amount of tension which places it under a stress sufficient to assist the roller leveler in effecting flattening. For example, about 100 pounds of tension per inch of strip width has been found satisfactory for some light gauge materials.

The amounts of tension employed to wind the strip into a proper coil is in no way related to that required for tension leveling. Handling and use requirements of the coils determine the amount of tension used for winding the strip into these coils.

Conventional pinch roll stands driven by conventional motors can be substituted for one or more of the bridles in my apparatus and perform the same functions therein as the bridles.

While I have shown and described preferred embodiments of my invention, it is understood that it may be otherwise embodied within the scope of the following claims.

I claim:

1. In a method of flattening metal strip or sheet the invention comprising passing a continuous length of said strip along a path of travel through a roller leveler and then through a first means for engaging said strip and operable to place a forward tension thereon, placing a forward tension upon said strip during passing same through said roller leveler and through said first means, advancing said strip from said first means further along said path of travel and conveying same over an inspection table and to a second means for engaging said strip and moving same over said inspection table, operating said second means relative to said first means so that said strip is under substantially zero tension during its travel over said inspection table.

2. The invention of claim 1 characterized by advancing said strip from said second means and winding same into a coil.

3. In a method of flattening metal strip or sheet, the invention comprising passing a continuous length of said strip along a path of travel through a first means for engaging said strip and advancing same to a roller leveler, then passing said strip through said roller leveler and next through a second means for engaging said strip and operable to place a forward tension thereon, placing a back tension upon said strip during passing same from said first means to said roller leveler, placing a forward tension upon said strip during passing same through said roller leveler and to said second means, advancing said strip from said second means further along said path of travel and conveying same over an inspection table and to a third means for engaging said strip and moving same over said inspection table, operating said third means relative to said second means so that said strip is under substantially zero tension during its travel over said inspection table.

4. The invention of claim 3 characterized by so operating said third means relative to said second means as to produce a loop in said strip between said second means and said inspection table, said loop lying in a substantially vertical plane disposed substantially parallel to said path of travel.

5. The invention of claim 4 characterized by advancing said strip from said third means and subjecting same to tension while winding it into a coil.

6. In a method of flattening metal strip or sheet wherein the strip is passed along a path of travel through a roller leveler and then through a first means for engaging said strip and operable to place a forward tension thereon and wherein a forward tension is placed upon said strip during passing same through said roller leveler and to said first means, the invention comprising advancing said strip from said first means further along said path of travel and conveying same over an inspection table and to a second means for engaging said strip and moving same over said inspection table, operating said second means relative to said first means so that said strip is under substantially zero tension during its travel over said inspection table.

7. The invention of claim 6 characterized by advancing said strip from said second means and subjecting same to tension while winding it into a coil.

8. The invention of claim 6 characterized by so operating said second means relative to said first means as to produce a loop in said strip between said first means and said inspection table, said loop lying in a substantially vertical plane disposed substantially parallel to said path of travel.

9. The invention of claim 6 characterized by so operating said second means relative to said first means as to produce a loop in said strip between said inspection table and said second means, said loop lying in a substantially vertical plane disposed substantially parallel to said path of travel.

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