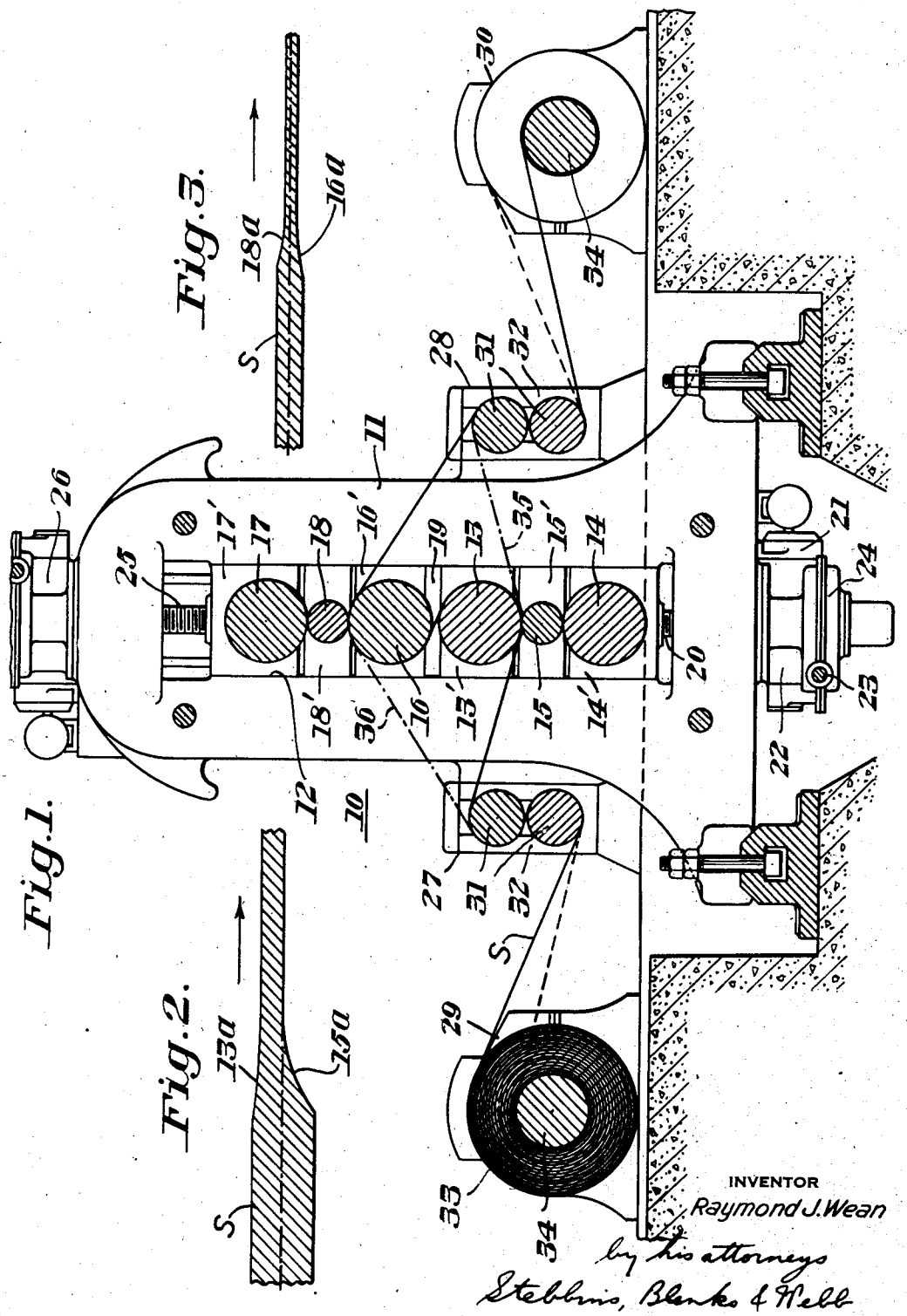
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METHOD AND APPARATUS FOR ROLLING STRIP

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METHOD AND APPARATUS FOR ROLLING STRIP

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This invention relates to the rolling of metal strip and, in particular, to the cold reduction of strip by passing it through a plurality of roll stands successively.

Metal strip is commonly reduced to final gauge by cold rolling it progressively in a plurality of 4-high mills or by repeated passes back and forth through a single stand reversing 4-high mill. Tension is usually applied to the strip as it emerges from the rolls and back tension may also be applied to the strip as it enters the rolls. The deformation of the material thus accomplished results from the combined effect of the tension applied to the strip and the compression exerted by the work rolls in the plane containing their axes, and is in the nature of a uniform displacement by extrusion or flow of the grains, both sides or surfaces of the strip being deformed approximately equally.

I have invented a novel method and apparatus for cold rolling metal strip whereby one side or surface of the strip is deformed to an extent greater than the other in passing through one stand of rolls and the other side or surface is deformed to an extent greater than the first-mentioned side in passing through a succeeding stand of rolls. I employ a plurality of 3-high roll stands, each of which has a middle roll smaller in diameter than the outer rolls. The strip is entered between the rolls so that in the first pass, one side of the strip engages the middle roll and, in the next pass, the other side of the strip engages the middle roll. I also maintain tension on the strip entering and leaving the mill. By this method, I work the two sides or surfaces of the strip alternately and obtain a somewhat angular flow of the metal which results in what I elect to designate "angular re-orientation." The product of this method, when tested parallel and transverse to the direction of rolling, exhibits characteristics more nearly equal than the product of conventional rolling methods.

My invention also has a special application to the removal of "set" which is the transverse curvature sometimes exhibited by cold-rolled strip. For this purpose I subject the material to a pass between the rolls of a 3-high stand with the concave side of the strip in contact with the small middle roll whereby that side is deformed more than the other side, thus leaving the strip in a final shape which is more nearly level.

The apparatus which I prefer to employ includes a mill comprising a pair of spaced housings having a plurality of 3-high roll stands journaled therein. The rolls of the several stands have their axes substantially in the same vertical plane. I also provide strip-tensioning means and a coiler on each side of the mill. By this arrangement, the strip may be passed back and forth through the mill successively until it has been reduced to the desired final gauge.

Further novel features and advantages of the invention will become apparent during the following complete description and explanation which refer to the accompanying drawing illustrating the apparatus and procedure of a preferred embodiment and practice. In the drawing,

Figure 1 is a central vertical section through a mill and associated apparatus, adapted for carrying out the method of my invention;

Figure 2 is a sectional view to enlarged scale, through a piece of strip illustrating the reduction produced by passing it through the first 3-high roll stand; and

Figure 3 is a similar view illustrating the reduction effected on passing the strip through the second stand.

Referring in detail to the drawing, a rolling mill 10, as illustrated therein, comprises spaced housings 11, each having a window 12 adapted to receive bearing chucks in which are journaled the rolls of at least two 3-high roll stands. One 3-high stand of rolls includes outer rolls 13 and 14 and a middle roll 15. Another stand includes outer rolls 16 and 17 and a middle roll 18. The rolls have necks journaled in chucks designated by the same reference numeral as the rolls with a prime affixed. Spacer blocks 19 are disposed between the chucks 13' and 16'. The chucks of the rolls forming the lower stand are supported by screws 20 operated by a motor 21 having a built-in speed reducer 22. The reducer 22 drives a shaft 23 having worms thereon meshing with worm wheels disposed in cases 24 and threaded on the screws. The chucks of the rolls forming the upper stand are held in proper relation by screws 25 actuated by mechanism indicated at 26, similar to that just described.

The middle rolls 15 and 18 of the two 3-high stands are quite small compared to the outer rolls. In the illustrated embodiment, for example, the middle rolls have a diameter about one-half that of the outer rolls. While the ratio of the diameters of the middle and outer rolls need not fall within any specific limits, the middle roll should have a diameter which is small compared to that of the outer rolls or, at least, to the diameter of the outer roll with which the

strip is in contact. While it is not necessary that the outer rolls of the stands be of the same diameter, this is usually convenient from the operating standpoint.

Tension-roll stands 27 and 28 are mounted on opposite sides of the mill and coilers 29 and 30 are disposed beyond the tension-roll stands. The latter are composed of a pair of rolls 31 journaled in spaced housings 32. The rolls are preferably arranged to be driven by any suitable means and are also provided with means for applying braking action. The driving and braking may conveniently be combined by providing an electric motor for driving the rolls and utilizing regenerative braking. The coilers 29 and 30 are likewise provided with suitable driving motors and braking means.

In utilizing the apparatus described above for rolling strip according to the method of my invention, I take the outer end of a coil of strip 33 disposed, for example, on the mandrel 34 of coiler 29 and pass it around the lower roll 31 of tension stand 27, thence between the rolls of said stand and around the upper roll thereof. I then thread the leading end of the strip between the rolls 13 and 15, thence around the roll 13, between it and the roll 16 and thence around the latter and between it and the roll 18. I then lead the strip around the upper roll of tension stand 28, between the two rolls thereof and around the bottom roll, and thence to the mandrel of coiler 30.

With the screws 20 and 25 adjusted to give the desired drafts on the strip as it passes between the rolls of the two 3-high stands successively, I drive the coiler 30 and the tension rolls 28. The coiler 33, now serving as an uncoiler, and the rolls of tension stand 27 are retarded to provide the desired tension on the strip entering the first or lower stand of reducing rolls.

The rolls of the two 3-high stands are preferably driven by any suitable means, conveniently by separate motor drives with speed-control means so that the rolls of the second stand may be driven at a peripheral speed sufficiently greater than that of the rolls of the first stand so as to maintain tension on the strip between the two stands, despite the elongation resulting from the reduction in the first stand. The tension stand 28 and the coiler 30 maintain forward tension on the strip emerging from the second stand.

It will be noted that, under the conditions described, the bottom side or surface of the strip designated S will be engaged by the small or middle roll of the first stand, while the upper side or surface of the strip will be engaged by the middle roll of the second stand. This causes the two sides or surfaces of the strip to be deformed alternately or, at least, causes one surface to be deformed much more than the other, in each of the two passes. This results from the relative diameters of the rolls engaging the strip in each of the two passes.

Figure 2 illustrates on an enlarged scale the reduction of the strip effected on passing through the first stand. As clearly shown in Figure 2, the reduction in the original thickness of the strip is effected principally in the portion of the strip thickness below the median plane between the upper and lower surfaces. In other words, the two sides of the strip are deformed along the curvature of the rolls 13 and 15, the deformation curves being designated 13a and 15a. The action of the rolls, because of their different diameters, seems to be analogous to the action of a hammer and anvil, the small roll performing the function of the hammer and the large roll that of the anvil.

Figure 3 illustrates the reduction effected in the second pass. As there shown, the upper surface of the strip is deformed along the curve 18a, corresponding to the curvature of roll 18, to a greater extent than the deformation along the curve 16a corresponding to the curvature of roll 16. In the second pass, therefore, it is the portion of the strip above the median plane of the entering material in which the principal reduction is effected. The alternate deformation of the two sides or surfaces of the strip causes angular plastic flow of the metal resulting in angular reorientation of the grains. This tends to prevent the occurrence of preferred orientation to a marked extent, leaving the material with more nearly uniform characteristics parallel and transverse to the direction of rolling than in the case of strip rolled by conventional methods and apparatus. The method of my invention apparently results in an angular displacement of successive layers of the original material caused by working each of the two surfaces successively to a greater extent than the opposite surface. The direction of relative slippage between the several planes is reversed in passing through the two stands successively.

After substantially the full length of the strip in the coil has been passed through the two stands, the mill is reversed, as well as the functions of the tension stands and the coilers. The strip is then subjected to a second pass through the two stands successively under tension as described before. It will be evident that the rolls of the lower stand must be driven, on the reverse pass, at a speed higher than that of the rolls of the upper stand, in order to maintain the desired tension on the strip between the stands. The strip is again reduced by successive deformations effected principally in the two sides thereof as previously described. Rolling of the strip in opposite directions is continued until it has been reduced to the desired final gauge.

My invention also contemplates subjecting cold-rolled strip to one or more passes through a single stand of rolls to remove "set" therefrom. This "set" is a transverse curvature which sometimes characterizes cold-rolled material. To remove it, I pass the strip between the upper roll 13 and the middle roll 15 of the lower stand, as indicated by a chain line 35, or between the lower roll 16 and the middle roll 18 of the upper stand, as indicated by chain line 36, depending on the direction of the "set." The strip should be started through the mill so that the concave surface will be engaged by the small roll and thereby subjected to greater deformation than the other surface, in accordance with the explanation given above. This tends to remove the curvature and deliver the strip in a shape more nearly approaching a flat or level condition. Usually a relatively light reduction in a single pass will suffice to remove the "set."

It will be apparent from the foregoing explanation that my invention is characterized by numerous advantages. The most important has already been mentioned, viz., the production of material having more or less uniform characteristics parallel and transverse to the rolling direction. The preferred embodiment of the apparatus, including two 3-high roll stands in the same housings, is obviously capable of producing a much greater reduction than a single 4-high

roll stand. Two mills, such as that shown in Figure 1, for example, will effect a reduction equivalent to that produced by three 4-high roll stands but will cost much less than the latter. It is possible, of course, to employ a mill such as that illustrated in connection with one or more 4-high stands.

While the invention has been described with particular reference to the cold reduction of metal strip, it may also be utilized for temper rolling material such as tinplate stock while still in strip form.

A further advantage of the invention is that the strip is wrapped around one of the larger outer rolls of each stand through an angle of more than 180°, which results in a frictional grip on the material whereby it may be subjected to substantial tensions without slippage.

Although I have illustrated and described but a preferred embodiment and practice of the invention, it will be recognized that changes in the construction and procedure disclosed may be made without departing from the spirit of the invention or the scope of the appended claims.

I claim:

1. In a method of flattening cold-rolled strip having a "set" or transverse curvature, the steps including cold-reducing the strip by passing it through a 3-high rolling mill having a middle roll smaller than the outer rolls, and starting the strip through the mill so that the concave surface thereof is engaged by the middle roll.

2. In a method of flattening cold-rolled strip having a "set" or transverse curvature, the steps including cold-rolling the strip and deforming the concave surface thereof more deeply than the convex surface.

3. In a method of rolling strip, the steps including cold-reducing it progressively in a plurality of 3-high roll stands disposed one above the other, each having a middle roll smaller than the outer rolls, and passing the strip between the middle roll of one stand and the outer roll thereof adjacent the other stand, then between the middle roll of the other stand and the outer roll thereof nearer the first-mentioned stand.

4. The method defined by claim 3 characterized by maintaining the strip in contact with the outer rolls engaged thereby throughout about 180° of their circumference.

5. A mill for reducing strip comprising a pair of spaced housings having windows therein, two stands of three rolls each having their necks disposed in said windows with their axes substantially in vertical alinement, chucks slidable in said windows adapted to receive said necks, and spacers between the chucks in which the necks of the top roll of the lower stand and the bottom roll of the upper stand are journaled, said spacers being movable relative to said housings with said last-mentioned chucks.

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