Sept. 30, 1958 G. STANIUS 2,854,056

METHOD OF TREATING METAL STRIP FOR THE FORMATION OF VENETIAN BLIND SLATS AND THE LIKE

Filed Dec. 8, 1951 2 Sheets-Sheet 1

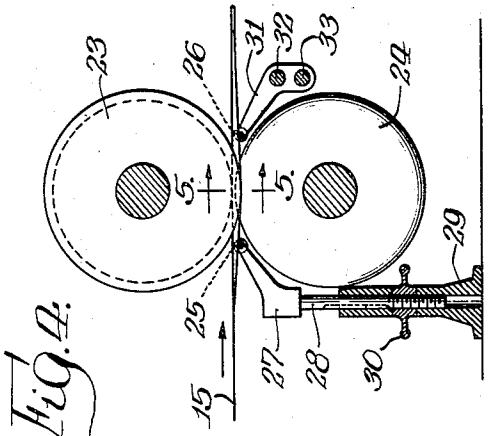


Fig. 4.

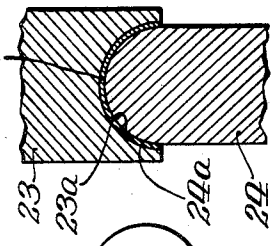


Fig. 5.

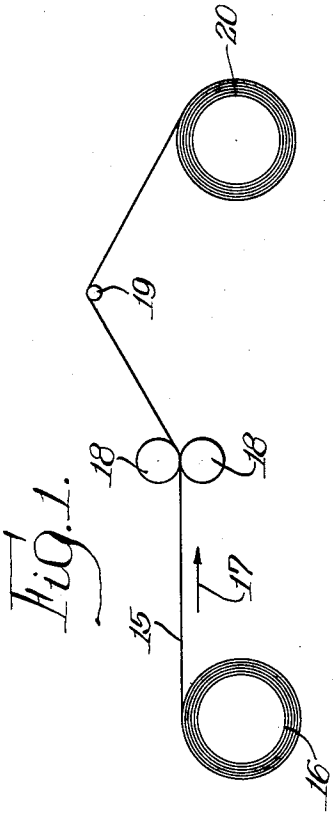


Fig. 1.

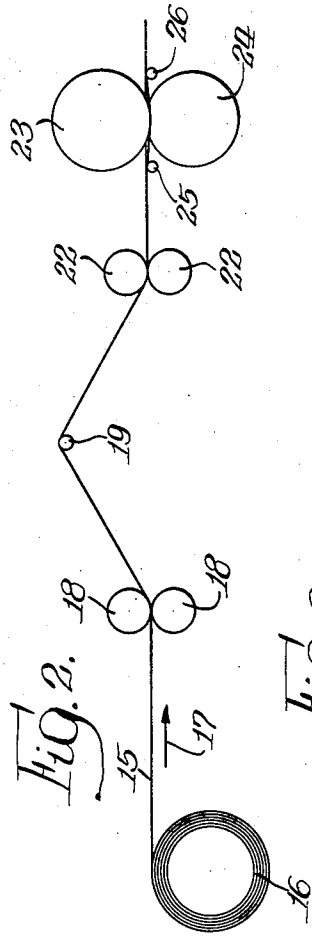


Fig. 2.

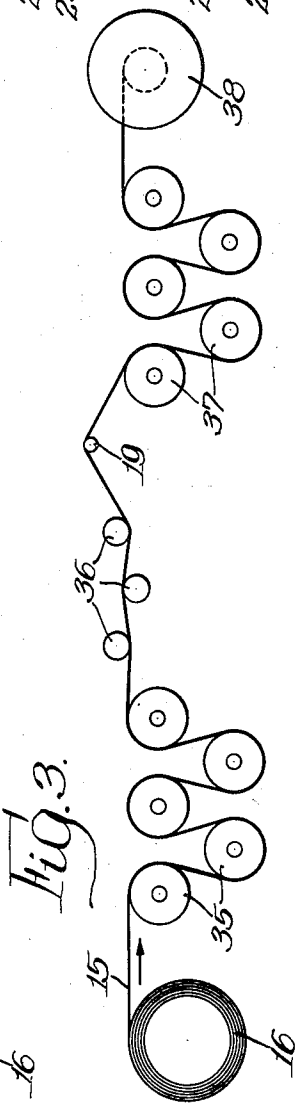


Fig. 3.

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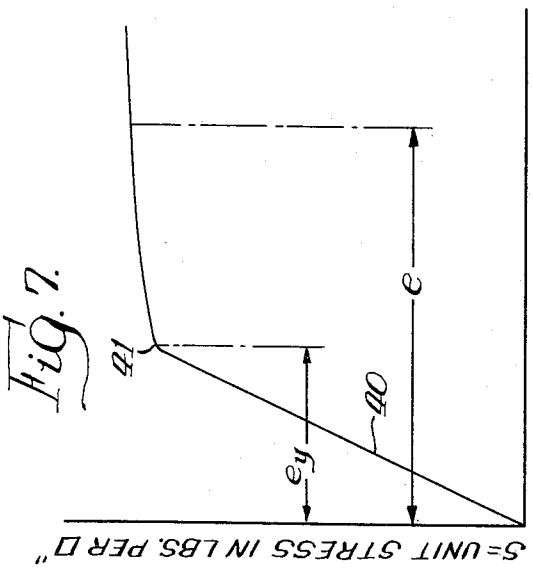


Fig. 7.

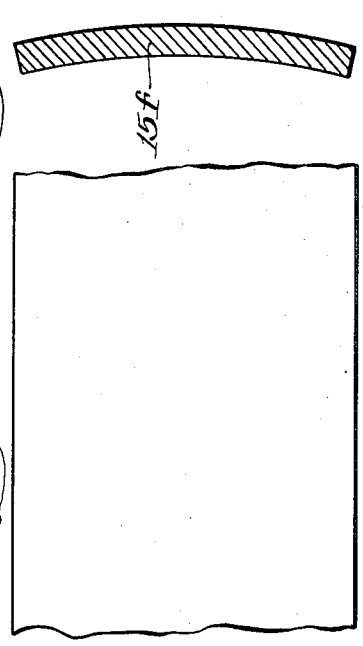


Fig. 10.

Fig. 9.

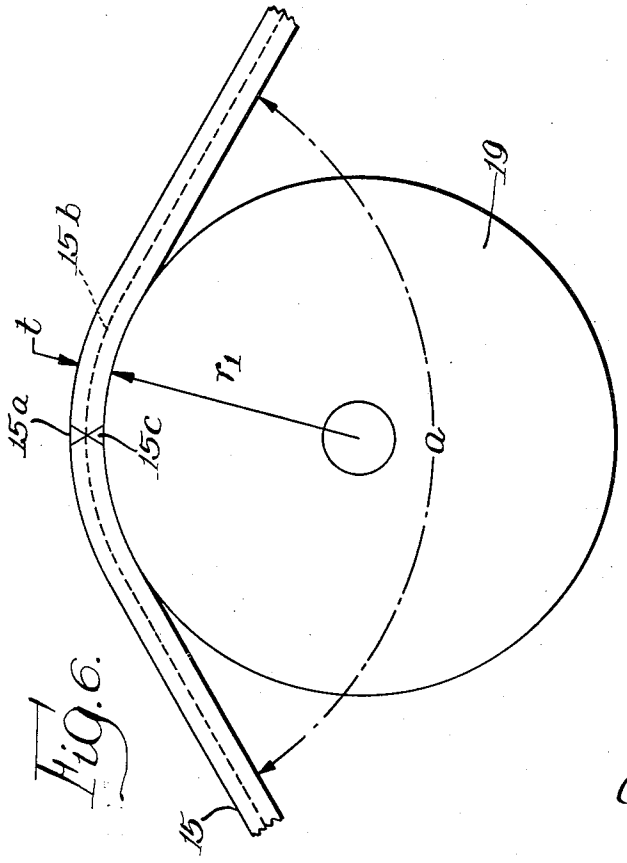


Fig. 6.

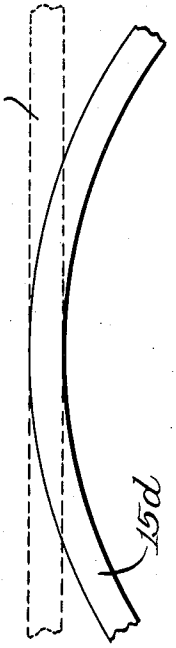


Fig. 8.

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2,854,056

METHOD OF TREATING METAL STRIP FOR THE FORMATION OF VENETIAN BLIND SLATS AND THE LIKE

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Application December 8, 1951, Serial No. 260,745

3 Claims. (Cl. 153—54)

This invention relates to improvements in methods of forming metal Venetian blind slats and the like and its purpose is to provide an improved method for carrying on in a continuous process successive operations which produce, from strip steel or other thin metal, straight resilient slats of curved or other nonplanar cross section.

The manufacture of Venetian blind slats from strip steel or other strip metal has presented a problem. In order that the slats may be formed of thin and hard resilient metal, it is desirable to impart a transverse curvature to the metal strip so that it will have sufficient stiffness to prevent sagging due to its own weight and, in order that the completed Venetian blind will be attractive in appearance and convenient to operate, it is essential that the slats be longitudinally straight and parallel to each other. The production of longitudinally straight and transversely curved slats of thin resilient metal cannot be accomplished with certainty by running ordinary commercial strip steel through forming rolls to impart a transverse curvature thereto because such commercial strip material is not perfectly flat but has present therein irregularities in contour and variations in internal stresses such that the formed strip produced by the forming rolls is usually not longitudinally straight and its edges are not always parallel to each other.

This difficulty has been solved by the invention described and claimed in United States Letters Patent No. 2,294,434, granted September 1, 1942, on an application of Allen B. Wilson. In said Letters Patent there is disclosed a method and apparatus for treating the thin resilient hard metal strip by a two stage process in the first of which the intermediate portion is stressed longitudinally beyond its elastic limit so that it is permanently stretched, while in the second stage the metal strip which is so stretched in its intermediate portion has its edge portions stretched longitudinally until all portions of the strip have been stretched longitudinally to substantially the same extent. During the stretching operation the strip is transversely formed and the result is a final product which is transversely curved and longitudinally straight with parallel edges. Thus, by the method just described, the irregular, uncertain and unknown conditions which exist in the commercial metal strip at the beginning of the process are removed and there is established a known condition in the metal strip which may be successfully treated in the second stage of the process.

The present invention involves the discovery that the variations and inequalities in internal stresses which normally exist in thin resilient commercial strip steel and the like may be removed and a known condition of internal stresses created by bending the strip throughout its width about a relatively small radius, whereby the portion of the metal adjacent one surface of the strip is progressively stretched longitudinally throughout its width beyond the elastic limit or yield point and the portion adjacent the opposite surface is compressed throughout its width an equal amount, or less, depending upon the tension in the strip, following which the metal strip so treated may be subjected to a second stage operation like that of said Letters Patent with the resulting production of a slat which is transversely curved and longitudinally straight. By varying the tension in the metal strip during the bending thereof in the first stage of this improved process, the relative depth of the zones of the longitudinal stretching and longitudinal compression may be varied with a corresponding variation in the amount of edge stretching which may be required in the second stage of the operation in order to produce a straight slat. Thus, by a novel mode of operation requiring only very simple apparatus and only a moderate degree of tension in the strip, the metal strip may be prepared for the second stage operation. Other objects of the invention relate to various features of the improved method and to the structure of the improved apparatus, all of which will appear more fully hereinafter.

The nature of the invention will be understood from the following specification taken with the accompanying drawings in which several embodiments of the improved apparatus and one example of the improved method of forming Venetian blind slats are illustrated. In the drawings,

Figure 1 shows a somewhat diagrammatic side elevation of a simple arrangement which may be employed for carrying out the first stage of the process;

Fig. 2 is a diagrammatic side elevation similar to that of Fig. 1 but showing the apparatus for effecting the first stage of the process connected in operative relationship to apparatus for performing the second stage of the process during which the metal strip is transversely formed and has its edge portion stretched longitudinally;

Fig. 3 is a diagrammatic side elevation of a somewhat more elaborate form of apparatus which may be employed in carrying out the first stage of the improved process;

Fig. 4 shows an enlarged side elevation of the forming rolls and supporting rolls which may be employed in practicing the second stage of the process;

Fig. 5 shows a partial vertical section through adjacent portions of the forming rolls illustrated in Fig. 4;

Fig. 6 shows an enlarged side elevation of the roll, shown in any one of Figs. 1, 2 or 3, over which the metal strip is drawn to effect the longitudinal stretching of the strip adjacent one surface and the compression of the metal of the stress adjacent its opposite surface;

Fig. 7 shows a curve which represents the relationship between the elongation of the metal and the stresses imposed upon it when operating below and above the elastic limit thereof;

Fig. 8 shows an enlarged side elevation of a portion of the metal strip after it has passed over the roller shown in Fig. 6, illustrating the tendency of the strip to assume a longitudinal curvature;

Fig. 9 shows a plan view of the portion of the metal strip illustrated in Fig. 8 after it has been flattened from the curved state which it naturally assumes; and

Fig. 10 shows a cross sectional view of the strip illustrated in Fig. 9, showing the arcuate transverse formation which is imparted to the strip by the action of flattening it from the curved condition shown in Fig. 8.

In Fig. 1 there is shown a simple form of apparatus for bending the metal strip during its longitudinal movement to remove the irregularities and variations in the internal stresses which exist in some commercial strip steel with the resulting creation of a known condition of internal stresses which may be subsequently dealt with in a predetermined manner when completing the operation of forming a Venetian blind slat which has a curved cross section and is longitudinally straight. As there shown, the commercial strip steel 15 is drawn from a

supply reel **16** and is moved in the direction of the arrows **17** between two guide rolls **18** which contact the upper and lower sides of the strip. If desired, the lower roll **18** may be omitted. From these guide rolls, the metal strip is directed upwardly and in contact with the top portion of a bending roll **19**. From the roll **19** the strip is inclined downwardly and is wound upon a winding reel **20** which may be power driven to supply the power which is required to pull the strip from the reel **16** through the rolls **18** and over the bending roll **19**. The rolls **18** and **19** are cylindrical in form and one of the rolls **18** may preferably be provided with end flanges to prevent lateral displacement of the metal strip during its travel. The rolls **18** and **19** are preferably mounted on anti-friction bearings so that they rotate freely. A brake may be applied to the supply reel **16** in order to maintain a taut condition of the metal strip **15** as it passes over the bending roll **19**, but the change in the internal stresses of the metal is brought about primarily by its bending action in passing over the bending roll **19** rather than by the tension in the strip. The tension in the strip must be sufficient to maintain the strip in a taut condition as it passes over the bending roll **19** but is not required for stretching the strip. The tension exerted on the strip by pulling it over the roll should preferably be substantially uniform and the amount of tension will determine the position of the neutral zone **15*b*** between the portion of the strip which is stretched longitudinally and the portion which is compressed longitudinally in passing over the bending roll. By increasing the tension exerted on the strip by external means, the neutral zone may be caused to move toward the roll and a greater proportion of the strip will be longitudinally stretched.

The result of drawing the metal strip endwise over the bending roll **19** is illustrated somewhat diagrammatically in Fig. 6 where a portion of the metal strip is shown in conjunction with a side elevation of the roll **19**. As the strip **15** passes over the roll **19** the outer portion of the strip is stretched or elongated as indicated diagrammatically by the portion of triangular cross section **15*a*** which lies on the outside of a longitudinal neutral zone represented by the dotted line **15*b***. At the same time that this stretching of the outer portion of the metal strip takes place, there is a compression of the portion of the strip which is between the neutral zone **15*b*** and the surface of the roll **19** as indicated diagrammatically by the area of triangular cross section shown at **15*c*** in Fig. 6. This action takes place progressively with a resulting longitudinal stretching of all portions of the metal strip which are on the outside of the neutral zone **15*b*** and a compression of all portions of the metal strip which are on the inner side of that zone so that the condition of internal stresses and irregularities in the metal which existed as it came from the supply reel is corrected and a newly created and known condition of internal stress is brought about. After passing over the bending roll **19** the metal strip when released naturally assumes the arcuate condition shown by full lines at **15*d*** in Fig. 8. This condition, which is commonly known as "bundle curve," is a condition of internal stresses which gives to the strip a normal tendency to coil upon itself in a longitudinal direction.

If the metal strip having the longitudinal curvature illustrated in Fig. 8 were flattened out by causing it to assume the longitudinal shape illustrated by the dotted lines **15*e*** in Fig. 8, longitudinal compressive stresses would be set up in the top portion of the metal strip and longitudinal tensile stresses would be set up in the lower or underlying portion of the strip. These opposing compressive and tensile stresses which are set up in the strip by flattening it to the condition shown by dotted lines in Fig. 8 give rise to transversely acting compressive stresses in the upper portion of the strip and to transversely acting tensile stresses in the lower portion of the strip. These transversely acting compressive stresses are opposed to each other and the transversely acting tensile stresses are similarly opposed to each other and they will relieve themselves by imparting to the metal strip a transverse curvature which is shown at **15*f*** in Fig. 10. It is this metal strip which has a normal longitudinal curvature after passing the bending roll and which has a slight transverse arcuate form when its longitudinal curvature is removed, which constitutes the product of the first stage of the process and this strip may then be acted upon by the second stage of the process to impart to the strip a permanent transverse curvature and the longitudinal straight form which is desirable in the finished slat.

In Fig. 1 of the drawings, the metal strip **15** which has been operated upon by the bending roll **19** to produce the condition which has just been described is wound upon a reel **20** and may thereafter be treated by the second stage of the process to produce the finished slat material. In Fig. 2, the strip **15** passing from the supply reel **16** is carried through the guide rolls **18** and over the bending roll **19** from which it is carried between two guide rolls **22** and thence between two forming rolls **23** and **24**, one of which is power driven for the purpose of withdrawing the metal strip from the reel **16** and imparting a longitudinal movement thereto. The upper forming roll **23** has a concave peripheral surface **23*a*** which is adapted to cooperate with the convex peripheral surface **24*a*** of the lower forming roll **24** to impart a transverse curvature to the metal strip **15** as it passes between them. The curvature of the surfaces **23*a*** and **24*a*** is such that the metal strip is stressed transversely beyond its elastic limit and thus retains a permanent transverse curvature which is desirable in the finished slat. The metal strip is supported in advance of the forming rolls by a supporting roll **25** and is supported immediately following the forming rolls by a supporting roll **26**. These supporting rolls are arranged in close proximity to the forming rolls and the roll **25** is capable of adjustment vertically while the roll **26** is preferably mounted for lateral adjustment transversely of the strip. As the metal strip passes through the forming rolls **23** and **24** with its edge portions bent downwardly to conform to the curvature of the forming roll **24**, the edge portions of the strip are compelled to pass through paths which are of greater length than that followed by the intermediate portion of the strip, thus resulting in a longitudinal stretching of the edge portions of the strip, as described in said Wilson Letters Patent. By regulating the elevation of the supporting roll **25** the degree of longitudinal stretching of the edge portions of the strip may be regulated to insure the straightness of the strip as it emerges from the second stage of the process. For this purpose, the supporting roll **25** may be mounted on a bracket **27** carried by an adjusting screw **28** mounted in a standard **29** and operated by an adjusting nut **30**, whereby the elevation of the bracket **27** may be varied. In order to correct for possible lateral curvature of the strip which causes it to twist as it emerges from the forming rolls **23** and **24**, the supporting roll **26** may be adjusted laterally of the strip **15** and for this purpose the roll **26** may be mounted upon a bracket **31** which is positioned to slide upon a horizontal rod **32** as shown in Fig. 4. An adjusting screw **33** may be used to vary the position of the bracket **31** on the rod **32** as more fully described in said Letters Patent.

In Fig. 3 of the drawings, there is shown a modified arrangement of the apparatus for carrying out the first stage of the process according to which the metal strip **15** passing from the reel **16** is carried in zigzag fashion around a series of power driven friction rolls **35** which withdraw the strip from the reel and advance it toward the point where it passes through a series of straightening rolls **36** which tend to minimize irregularities and any variable internal stresses in the strip and to remove any transverse curvature or camber in the strip according

to the method which is more fully described in the United States Letters Patent of Chester M. MacChesney, No. 2,140,533, dated December 20, 1938. The use of the straightening rolls **36** may be necessary only when the commercial strip is highly irregularly stressed and the desirability of using these rolls may be conveniently determined by running through a test piece of the strip metal without the roll **36** and thereby finding out whether a satisfactory product can be produced. After passing through the straightening rolls **36**, the metal strip passes over the bending roll **19** previously described and is then carried through another series of power driven friction rolls **37** which are similar in size and shape to the rolls **35** and which perform the function of drawing the strip through the straightening rolls **36** and over the bending roll **19**. Upon emerging from the friction rolls **37**, the strip which has thus completed the first stage of the process is wound upon a winding reel **38** and may be stored in a coil in preparation for subsequent treatment by the second stage of the process.

In carrying on the process of the present invention hard strip steel having considerable resiliency is preferably employed and good results have been obtained when using comparatively thin metal, preferably having a thickness of about 0.008 inch. However, good results can be obtained with metal thicknesses of from about 0.006 inch to about 0.012 inch and it is believed that satisfactory results could also be obtained with metal thicknesses somewhat above or below this range. To effect the longitudinal stretching of one side of the strip and the compression of the opposite side, to bring about a known condition of the stresses in the metal, the bending roll **19** should have a radius r_1 such that the bending of the metal as it passes over the roll will set up stresses beyond the elastic limit of the metal. If in Fig. 7, the ordinates s be taken to represent the unit stress in pounds per square inch imposed upon the metal and the abscissae e be taken to represent the unit strain, that is, the inches of elongation per inch of length of the specimen, then the curve **40** shows the variation in the unit strain with changes in the stress to which the metal is subjected and the point **41** on the curve represents the elastic limit or yield point of the metal. The values represented by the curve **40** may be determined by test for any given metal. In the case of hard resilient strip steel commonly employed in the manufacture of thin resilient Venetian blind slats the value of the unit strain e_y at the yield point **41**, is approximately 0.0036 inch per inch, a value which may be determined by experiment. When bending a metal strip around a bending roll, such as the roll **19**, the unit strain e satisfies the equation:

$$e=\frac{t}{2r_1} \tag{1}$$

in which t represents the thickness of the metal strip in inches and r_1 is the radius of the roll **19** in inches. The derivation of this equation will now be set forth.

Upon referring to Fig. 6, it is apparent, from purely geometrical observation, that

$$e=\frac{2\pi(r_1+t)-2\pi\left(r_1+\frac{t}{2}\right)}{2\pi\left(r_1+\frac{t}{2}\right)} \tag{2}$$

which equation may be reduced to the following form:

$$e=\frac{t}{2r_1+t} \tag{3}$$

For all practical purposes, where the value of the thickness t of the strip is very small as, for example, on the order of 0.008 inch preferably employed for Venetian blind slat material, Equation 3 may be modified to read:

$$e=\frac{t}{2r_1} \tag{4}$$

which is the same as Equation 1 above.

From Equation 4 the value of r_1 may be derived as follows:

$$r_1=\frac{t}{2e} \tag{5}$$

For the purpose of determining the value of r_1 just at the yield point, that is, the radius of the bending roll which will cause stretching of the metal strip just at the yield point, the value of the yield point strain e_y may be substituted for e in Equation 5 with the following result:

$$r_1=\frac{t}{2e_y} \tag{6}$$

For practical purposes Equation 6 may be modified to include a constant C_1 as follows:

$$r_1=C_1\frac{t}{2e_y} \tag{7}$$

C_1 is a constant, determined by experiment, which is less than the integer 1 and it is included in the equation to insure a value of r_1 small enough so that when the metal strip is bent around the bending roll **19**, it will be stretched sufficiently beyond the yield point adjacent the outer convex surfaces of the strip and compressed an equal amount beyond the yield point adjacent the inner concave surface of the strip. C_1 may be considered a factor of safety which compensates for ordinary inherent physical variations in the metal strip such as in its yield point or thickness.

If the strip steel has a thickness of 0.008 inch and e_y be 0.0036 and C_1 be taken as 0.5, then r_1 will be 0.555 inch. There is thus determined the radius of the roll **19** which will effect the stretching of the outer portion of the metal strip and the compression of the inner portion as it passes over the roll, with the resulting setting up of residual strains of known character in the metal. To obtain this effect, the parts of the metal strip on opposite sides of the roll, as viewed in Fig. 6, must be relatively inclined. The best value of this angle a between these portions of the strip may best be determined by experiment but must be such that in operation the Equation 1 above will be satisfied. In practice, it is found that if the angle a be about 120° or less, satisfactory results are obtained.

It is also important that the rolls over which the strip passes following the roll **19** be of such radius that they will not remove the residual strains which have been induced by the bending roll. According to the equation previously employed the radius r_2 of the rolls **37**, for example, will be

$$r_2=C_2\frac{t}{2e_y} \tag{8}$$

where C_2 is a factor of safety determined by experiment and of such value, greater than the integer 1, that the metal strip in being bent around the rolls **37** will operate below the elastic limit represented by the point **41** on the curve **40**.

Thus, if t be 0.008 inch and e_y be 0.0036 inch and C_2 have the value 4, the radius r_2 of the rolls **37** will be 4.444 inches.

If the first stage of the operation be carried on with the form of apparatus shown in Fig. 3 it is desirable also that the straightening rolls **36** be of such size as to set up substantially uniform longitudinal strains in the metal strip during the straightening process. If r_3 be taken as the radius of a roll **36** and the same Equation 8 be employed with a constant C_3 sufficiently small to insure an operation slightly above or beyond the yield point **41**, it may be calculated that, with t and e_y having the same values as before, r_3 should be 1.000 inch if C_3 be taken as 0.9.

As heretofore indicated, the product which is produced by flexing the metal strip over the bending roll **19** is naturally bowed in a longitudinal direction and, if flattened longitudinally as shown by dotted lines in Fig. 8,

it acquires a transverse curvature as represented diagrammatically in Fig. 10. The effect of running this strip endwise through the forming rolls is to lessen the longitudinal curvature and to impart transverse curvature to the strip with the resulting creation of a balance of the stresses in the strip such that it is longitudinally straight and transversely arcuate. Actually, the strip after passing through the first stage is longitudinally curved downwardly due to the bending moment created by longitudinally stretching the upper surface portion and longitudinally compressing the lower surface portion of the strip in the first stage. After passing the strip through the second stage of the process, the edge portions are stretched in an amount which decreases progressively from the outer edges of the strip toward its center, thus leaving the central portions of the strip with a residual portion of the total bending moment created by the first stage. At the same time, the edge stretching creates a new bending moment which is opposed to the first stage bending moment and, with the proper amount of edge stretching, this opposed bending moment will equal the residual portion of the first stage bending moment. Therefore, since the stresses and moments in the strip are balanced, it is transversely arcuate and longitudinally straight. This formed material may be wound into coils or cut to length to form slats of the desired dimensions. If it is wound into coils, it will assume its straight form due to its own resiliency when unwound and may then be cut into slats of the desired length.

In connection with the operations which have been described above, it will be noted that the metal strip produced by the first stage process, i. e., that which has the longitudinal curvature, must be fed into the second stage forming rolls **23** and **24** with the outer convex surface directed upwardly, as in Fig. 8, if the male forming roll **24** is the bottom roll, as shown in Figs. 4 and 5, in order to remove the longitudinal curvature during the second stage operation.

Although several arrangements of apparatus embodying the present invention and one example of the improved method have been shown and described by way of illustration it will be understood that the invention may have various embodiments and be practiced in various ways within the scope of the appended claims.

I claim:

1. The method of treating a substantially flat metal strip which comprises the steps of running the strip endwise over and in contact with a substantial portion of a surface which is curved longitudinally of the strip about a radius determined by the equation

$$r_1=\frac{t}{2e_y}$$

in which r_1 is the said radius, t is the thickness of the strip and e_y is the unit strain of the metal at the yield point, maintaining the strip in a taut condition as it passes over said surface, thereby effecting the longitudinal stretching of the portion of the strip adjacent one surface thereof while compressing longitudinally of the strip the metal adjacent the opposite surface thereof, imparting to the strip a transversely bowed cross section, and stretching longitudinally the edge portions of the strip sufficiently to cause the bowed strip to become longitudinally straight.

2. The method of treating a substantially flat metal strip which comprises the steps of running the strip endwise over a surface which is curved longitudinally of the strip about a radius determined by the equation

$$r_1=\frac{t}{2e_y}$$

in which r_1 is the said radius, t is the thickness of the strip and e_y is the unit strain of the metal at the yield point, maintaining the strip in a taut condition as it passes over said surface, maintaining a relative inclination of the portions of said strip in advance of and following said surface, thereby effecting the longitudinal stretching of the portion of the strip adjacent one surface thereof while compressing longitudinally of the strip the metal adjacent the opposite surface thereof, imparting to the strip a transversely bowed cross section, and stretching longitudinally the edge portions of the strip sufficiently to cause the bowed strip to become longitudinally straight.

3. The method of treating a substantially flat metal strip which comprises the steps of running the strip endwise over and in contact with a substantial portion of a surface which is curved longitudinally of the strip about a radius determined by the equation

$$r_1=C_1\frac{t}{2e_y}$$

in which r_1 is the said radius, t is the thickness of the strip, e_y is the unit strain of the metal at the yield point and C_1 is a constant less than the integer 1, maintaining the strip in a taut condition as it passes over said surface, thereby effecting the longitudinal stretching of the portion of the strip adjacent one surface thereof while compressing longitudinally of the strip the metal adjacent the opposite surface thereof, imparting to the strip a transversely bowed cross section, and stretching longitudinally the edge portions of the strip sufficiently to cause the bowed strip to become longitudinally straight.

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