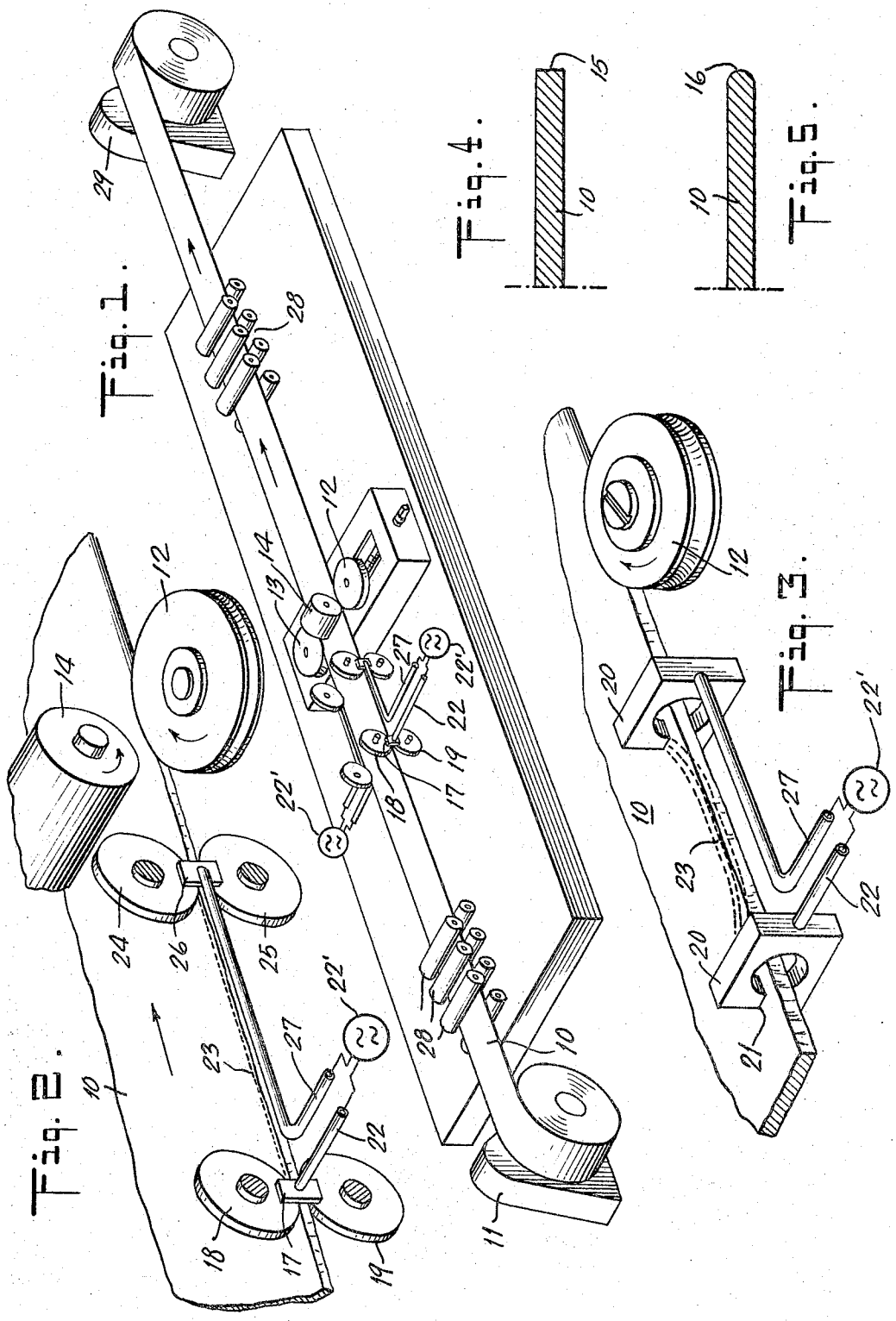
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EDGE CONDITIONING OF METAL STRIPS BY HIGH FREQUENCY RESISTANCE HEATING

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EDGE CONDITIONING OF METAL STRIPS BY HIGH FREQUENCY RESISTANCE HEATING

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This invention relates to methods and apparatus for rounding or otherwise conditioning the edges of metal strips and the like by the use of high-frequency resistance heating.

In the manufacture of metal strips for uses such as barrel hoops and steel strapping it is important that the edges of the stripping be free of sharp edges in order to prevent cutting or other injury. When metal strips are to be utilized for such uses as barrel hoops they are manufactured in relatively narrow strips ranging in width, for example, from approximately one to six inches. Since the edges of the strips must be free of sharp edges and preferably have a rounded mill edge, the ordinary steel strips are generally rolled hot in the narrow width desired in order to produce a steel strip with a rounded mill edge. Although the rolling of such relatively narrow strips on a hot mill is relatively expensive, it is done extensively today since no other practical method is known for conditioning the edges of the such narrow strips.

The reason that the edges of these metal strips are conditioned by rolling the narrow strip on a hot mill is that cold rolling of the edge generally results in thickening of the metal strip and also in deformation of the metal strip. It has also been found impractical to condition the edges of these narrow metallic strips by cutting tools since the use of cutting tools results in slivers and burrs and makes necessary the use of a secondary operation in order to produce a strip edge with a smooth finish. In addition, the use of cutting tools results in excessive breakdowns at accelerated speeds.

In accordance with the present invention the foregoing problems are overcome by providing a method and apparatus for conditioning the edges of metal strips that have been slit or rolled with uneven edges. In the preferred form of the invention a metal sheet approximately 25 to 50 inches wide is slit into multiple coils of proper width in order to form the metallic strips. The edges of these metal strips after slitting are uneven and it is desired to condition these edges in order to produce either a rounded edge or an edge with any other desired configuration. This is accomplished by heating the edges of the metal strip until the plastic range of the metal is reached, and then passing the metal strip past ironing rolls which form the edges of the metallic strip to any desired configuration, such as a full radius, chamfered or a combination of both a full radius and a chamfer. In order to heat the edges of the metal strips an in-line high-frequency contact resistance heating system is used in which in-line contacts are placed on the edges of the metallic strip prior to the time that the edges of the metallic strip are engaged by the ironing rollers. The ironing rollers are adjustable to the width of the metallic strip and apply pressure to the edges of the metallic strip such that while the edges of the metallic strip are in a plastic state the ironing or pressure applying rollers form the edge of the metal strip to any desired shape such as a full radius, a chamfer or a combination of either of these shapes.

Through the use of the present invention, it is possible to form coil widths to a particular size where it is impossible to cut off a small amount of metal from the edges of the metallic strip without distorting or deforming the metallic strip. This invention has particular advantage in the handling of wide strip sheets and coils.

In addition to the advantages of the invention enumerated above another advantage obtained by edge conditioning metallic strips in accordance with the present invention is that the edges of the metallic strips are blued because of being heated and oxidized while being treated in accordance with the present invention. The blueing acts as an anti-rust device and effectively reduces rusting. In the past the slitting of the steel sheets resulted in edges which were raw and devoid of oxide, which resulted in rusting if it was left in this condition for any appreciable length of time.

These and further objects and features of the invention will appear from a reading of the following detailed description of the invention, the description to be read in conjunction with the accompanying drawings which form a part of this specification and illustrate by way of example the presently preferred embodiment of the invention.

In the drawings:

FIGURE 1 is a perspective view of one embodiment of apparatus for practicing the edge conditioning of metallic strips in accordance with the present invention;

FIGURE 2 is a perspective view on an enlarged scale of the heating zone portion of FIGURE 1 and illustrating one embodiment or apparatus for heating the edges of metallic strips to the plastic range so the edges thereof can be formed to the desired configuration;

FIGURE 3 is a perspective view of an alternate embodiment of apparatus for practicing the present invention;

FIGURE 4 is a cross-section illustrating in general the condition of one edge of a metal strip before it has been conditioned in accordance with the present invention and

FIGURE 5 is a view similar to FIGURE 4 and illustrating one edge of a metallic strip after it has been conditioned in accordance with the present invention.

Referring now to the drawings and particularly to FIGURE 1 thereof metal stripping **10** is shown as being advanced in the direction indicated by the arrow from the uncoiler **11** and between a pair of pressure applying edge rollers **12** and **13** which condition or shape the opposed longitudinal edges of the metal stripping **10** in a manner to be presently described. The spacing between the edge rollers **12** and **13** is preferably adjustable in order to accommodate metal stripping of different widths. If desired, pressure rollers may be positioned between the edge rollers **12** and **13**, one pressure roller **14** being positioned to engage the upper surface of the metal stripping **10** and the other pressure roller (not shown) being positioned to engage the lower surface of the metal stripping **10**. The pressure rollers **14** maintain pressure on the upper and lower surfaces of the metal stripping **10** while passing between the edge rollers **12** and **13** and prevent the metal stripping from buckling due to the pressure exerted on the metal stripping **10** by the edge rollers **12** and **13**.

The function of the edge rollers **12** and **13** is to condition and shape the edges of the metal stripping **10** in order to remove any sharp edges and to form the edge of the metal stripping to the desired configuration. If the metal stripping has been formed by slitting a wide metallic strip into multiple coils of proper width, the edges **15** of the metallic strips **10** are generally jagged and uneven as illustrated in FIGURE 3.

The apparatus illustrated in the figures is adapted to roll the edges of the metal stripping **10** in order to form a rounded edge **16** on the metal strip **10** as illustrated in FIGURE 5. As best illustrated in FIGURE 2, the edge rollers **12** and **13** are shaped in such a manner as to roll the edges of the metal stripping **10** in order to produce the rounded edge **16** illustrated in FIGURE 5. It is to be understood, however, that the edge rollers

12 and 13 may be shaped in such manner as to impart to the edges 15 of the metal stripping 10 any desired configuration.

In order that the edge rollers 12 and 13 may condition and shape the edges of the metal stripping 10, it is necessary that the edges of the metal stripping 10 be heated until they are plastic just before the metal stripping 10 passes between the edge rollers 12 and 13. In accordance with the present invention the edges of the metal stripping 10 are heated by means of a high-frequency resistance heating method.

In operation of the invention heating current of radio frequency is brought from a suitable current source preferably to contacts engaging the longitudinal edges of the metal strip 10 before the strip 10 passes between the pressure rollers 13 and 14. In the preferred form of the invention it is desired that current be applied to the upper and lower edge surfaces of the metal stripping 10 in order to uniformly heat the edges thereof until they are plastic and thereby capable of being conditioned by the edge rollers 12 and 13.

One form of apparatus for applying current to the upper and lower edge surfaces of the metal stripping 10 is illustrated in FIGURES 1 and 2. This apparatus will be described with reference to one longitudinal edge of the strip 10 but it is to be understood that identical apparatus is positioned at the opposed edge. A pair of contact rollers 18 and 19 is positioned adjacent each opposed edge of the metal stripping 10 and in engagement with the upper and lower surfaces. The contact roller 18 is positioned such as to engage the upper edge portion of the metal stripping 10, and the contact roller 19 is positioned in vertical alignment below the contact rollers 18 in such manner as to contact the lower edge surface of the metal stripping as illustrated best in FIGURE 2. Current is applied to these rollers by reason of their engagement with a contact 17. If desired, rather than utilizing contact rollers 18 and 19, the contacts may take the form of the contacts 20 illustrated in FIGURE 3. These are formed with a slot 21 adapted to receive the longitudinal edge portions 15 of the metal stripping 10. The surfaces of this slot 21 are adapted to engage the upper and lower edge surfaces of the metal stripping and to apply the current thereto in a manner similar to the operation of contact rollers 18 and 19 in FIGURE 2.

In the practice of the present invention it is desirable to cool the contacts and this may be done by introducing a stream of water or other cooling fluid into and through each contact and then out through, for example, a tube 22 which may comprise also one of the current connections to a high-frequency generator schematically indicated at 22' as shown in FIGURES 1 and 2. From the contact rollers 18 and 19 high-frequency current flows along the upper and lower edge surfaces on one edge of the metal strip 10 in the direction of movement of the strip and following the path indicated by the dotted lines 23, the currents along the parallel paths on the upper and lower surfaces of the metal strip and along on the edge surface thereof merge at a second pair of contact rollers 24 and 25, which are engaged by a contact 26. The contact rollers 24 and 25 and the contact 26 may be identical to the contact rollers 18 and 19 and the contact 17. As illustrated in FIGURE 1 there are mating pairs of first and second contact rollers on either side of the metal stripping 10, each pair of contact rollers being in vertical alignment and adapted to engage the upper and lower surfaces of the metal strip adjacent the edges thereof.

As in the case of contact 17, the contact 26 is also preferably provided with cooling fluid conduits, for example, a water connection as at 27. The conduit 27 may also comprise one of the connections to the radio frequency current source and as indicated in detail in FIGURE 2 the conduit 27 is preferably located so as to

extend along the approaching longitudinal edge of the metal stripping 10 and closely adjacent the same for a considerable distance back towards contact 17 thus providing a return high-frequency connection so located as to tend strongly to concentrate the current flow closely along the edge surfaces of the metal strip 10, thereby causing such edge progressively and rapidly to be heated more and more all the way from contact 17 to contact 26. At the latter contact 26, which is just prior to the metal stripping 10 passing between the edge rollers 12 and 13, the edges of the metal stripping 10 have been heated to the plastic state so that they may be conditioned and formed by the edge rollers 12 and 13. As can be seen, therefore, the heating zone is positioned immediately before the metal stripping 10 passes between the edge rollers 12 and 13, the heating zone being present between the contacts 17 and 26.

The current used in the practice of the present invention is preferably of radio frequency, such, for example, as in the neighborhood of 100,000 cycles per second or up to 300,000 or 400,000 cycles or higher. With all such frequencies the slidable form of contact as illustrated in FIGURE 3, or roller contacts such as illustrated in FIGURES 1 and 2, may be used without resulting in arcing or sputtering difficulties. It has been found that metal stripping varying from approximately $\frac{1}{32}$ of an inch to $\frac{9}{16}$ of an inch in thickness may be edge conditioned in accordance with the present invention at speeds varying from 100 to 400 feet per minute. The power source can be a single high frequency generator to which two heating heads are attached, one for each side of the metal strip 10. Since the two sides of the metal stripping 10 are identical, control of the power source is relatively simple with a single oscillator.

In the practice of the present invention the heating and rolling of the edges of the metal stripping 10 may result in grain change and possible shortening or elongation. For this reason flattener rolls 28 may be positioned before and after the edge rollers 12 and 13. The stripping 10 is adapted to pass between the flattener rollers 28 which will take care of any shortening or elongation and remove any slight upset that may be occasioned in the metal stripping 10 by the edge rollers 12 and 13. After the metal stripping 10 has been treated in accordance with the present invention, it may be wound up on a coiler 29.

Although certain particular embodiments of the invention are herein disclosed for purposes of explanation, further modifications after study of this specification will be apparent to those skilled in the art to which the invention pertains. Reference should accordingly be had to the appended claims in determining the scope of the invention.

What is claimed and desired to be secured by Letters Patent is:

1. A method for conditioning the longitudinal edge of an elongated metal strip to remove irregularities therefrom and to reshape said edge to a desired configuration, said method comprising rapidly advancing said strip and bringing the edge thereof into contact with roller edge shaping means at an edge conditioning station, maintaining along on said edge of said strip at a heating station in advance of said edge conditioning station heating current of a frequency in the order of 100,000 cycles per second or higher, said current being conductively applied and being concentrated to flow in a single path along on said edge of the strip, said current being sufficient to bring said edge to a temperature rendering the metal thereof plastic at said conditioning station, and bringing said strip edge into contact under pressure with said roller edge shaping means at said edge conditioning station whereby said edge assumes the configuration of said roller surface.

2. A method for conditioning the longitudinal edge of an elongated metal strip to remove sharp portions or irregularities therefrom and to reshape said edge to a desired configuration, said method comprising rapidly advancing said strip and bringing the edge thereof into

contact with roller edge shaping means at an edge conditioning station, maintaining along on the edge of said strip at a heating station in advance of said edge conditioning station heating current of a frequency in the order of 100,000 cycles per second or higher by applying contacts connected to a source of such current to the edge of said strip at successive locations therealong while said strip is passing said heating station, said current being thus conductively applied and being concentrated on the edge surfaces of said metal strip, said current being sufficient to bring the edge of said strip to a temperature to render the metal thereof plastic at said edge conditioning station, and bringing said strip edge into contact under pressure with said roller edge shaping means at said conditioning station whereby said edge assumes the configuration of said roller surface.

3. A method for conditioning the longitudinal edges of an elongated metal strip to remove irregularities therefrom and to shape said edges to a desired configuration, said method comprising rapidly advancing said strip and bringing the edges thereof into contact with roller edge shaping means at an edge conditioning station, maintaining along the edges of said strip at a heating station in advance of said edge conditioning station heating current of a frequency in the order of 100,000 cycles per second or higher, said heating current being connected to said metal strip by applying at least two contacts connected to a source of such current to each longitudinal edge of said metal strip at opposite locations while said strip is in said heating station, maintaining one of said contacts on each edge further from the edge conditioning station than the other contact, said current being sufficient to bring the edges of said strip to a temperature sufficient to render the metal thereof plastic at said edge conditioning station, and bringing said strip edges into contact under pressure with said roller edge shaping means at said edge conditioning station whereby said edges assume the configuration of said roller surface.

4. A method for conditioning the longitudinal edge of an elongated metal strip to remove sharpness or irregularities therefrom and to reshape said edge to a desired configuration, said method comprising rapidly advancing said strip and bringing the edge thereof into contact with roller edge shaping means at an edge conditioning station, maintaining along said edge at a heating station in advance of said edge conditioning station heating current of a frequency in the order of 100,000 cycles per second or higher, said heating current being connected to said metal strip by applying at least two contacts connected to a source of such current to said edge while said strip is passing said heating station, maintaining at least one of said contacts on said edge further from the edge conditioning station than the other contact, the current being concentrated along on said edge between the contacts in engagement therewith by maintaining a lead connection to one of said contacts in a position extending along in closely spaced relation to said edge toward said other contact, said current being sufficient to bring the edges of said strip to a temperature rendering the metal thereof plastic at said edge conditioning station, and bringing said strip edge into contact under pressure with said roller edge shaping means at said conditioning station whereby said edge assumes the configuration of said roller surface.

5. A method for conditioning a longitudinal edge of an elongated metal strip to reshape said edge to a desired configuration, said method comprising rapidly advancing said strip and bringing the edge thereof into contact with roller edge shaping means at an edge conditioning station, maintaining along on said edge at a heating station in advance of said edge conditioning station heating current of a frequency in the order of 100,000 cycles per second or higher, said heating current being connected to said metal strip by applying at least two contact means connected to a source of such current to

the edge of the strip while said strip is passing said heating station, maintaining one of said contacts on said edge further from the edge conditioning station than the other contact, said contact means including a pair of rollers engaging the upper and lower surfaces of said strip adjacent said edge whereby flow of such heating current will be applied along on the upper and lower surfaces of the edge portions, said current being sufficient to bring the edge to a temperature rendering the metal thereof plastic at said edge conditioning station, and bringing said strip edge into contact under pressure with said roller edge shaping means at said edge conditioning station whereby said edge assumes the configuration of said roller surface.

6. Apparatus for conditioning a longitudinal edge of an elongated metal strip to reshape said edge to a desired configuration, said apparatus comprising a pair of squeeze rollers, at least one of said rollers being an edge shaping roller, means for rapidly advancing said strip and bringing the longitudinal edge thereof into contact with said edge shaping roller at an edge conditioning station, a source of heating current of a frequency in the order of 100,000 cycles per second or higher, contacts connected to said heating current source and applied successively to the longitudinal edge of said metal strip at a heating station in advance of said edge conditioning station, said heating current heating said edge to a temperature where it is plastic when said edge reaches said edge conditioning station, and said squeeze rollers being mounted on means permitting adjustment of the spacing therebetween whereby said plastic edge is brought into contact under pressure with said edge shaping roller in said edge conditioning station whereby said edge assumes the configuration of said roller surface.

7. Apparatus for conditioning a longitudinal edge of an elongated metal strip to reshape said edge to a desired configuration, said apparatus comprising a pair of squeeze rollers, at least one of said rollers being an edge shaping roller, means for rapidly advancing said strip and bringing the longitudinal edge thereof into contact with said edge shaping roller at an edge conditioning station, a source of heating current of a frequency in the order of 100,000 cycles per second or higher, first contact means engaging the longitudinal edge of said strip at or adjacent said edge conditioning station for applying current from one terminal of such heating current source to said edge, second contact means engaging the longitudinal edge of said strip in advance of said first contact and connected to the other terminal of said source, said contact means and said metal edge acting to complete a circuit with said current source, said circuit including a parallel current path along the edge of said metal strip and extending for at least a substantial portion of the distance between the two contact means, such current progressively heating said edge to a temperature where it is plastic when said edge reaches the edge conditioning station, and said squeeze rollers being mounted on means permitting adjustment of the spacing therebetween whereby said plastic edge is brought into contact under pressure with said edge shaping roller in said edge conditioning station whereby said edge assumes the configuration of said roller surface.

8. Apparatus for conditioning the longitudinal edges of an elongated metal strip to remove irregularities therefrom and to shape said edges to a desired configuration, said apparatus comprising a pair of spaced edge shaping rollers, means for rapidly advancing said strip and bringing the opposed longitudinal edges thereof into contact with said rollers at an edge conditioning station, a source of heating current of a frequency in the order of 100,000 cycles per second or higher, first contact means engaging each longitudinal edge of said strip at or adjacent said edge conditioning station for applying current from one terminal of such heating current source to said edges, second contact means engaging each longitudinal edge of said strip in advance of said first contacts and connected

to the other terminal of said source, said contact means and said metal edges acting to complete circuits with said current source, for progressively heating said edges to a temperature where they are plastic when said edges reach said edge conditioning station, each of said circuits including lead portions in closely spaced relation to one of said edges to concentrate said current along each longitudinal edge of said strip between said first and second contacts, and said edge shaping rollers being mounted on means permitting adjusting of the spacing therebetween whereby said plastic edges are brought into contact under pressure with said edge shaping rollers in said edge conditioning station whereby said edges assume the configuration of said roller surfaces.

9. Apparatus in accordance with claim **7** wherein restraining rollers are positioned between said squeeze rollers and in engagement with the upper and lower surfaces of said metal strip to prevent said strip from changing shape or buckling due to the pressure of said edge shaping rollers.

10. Apparatus in accordance with claim **7** wherein flattening rollers are positioned after said squeeze rollers, said metal strip being adapted to pass between said rollers to maintain the configuration of said strip.

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