June 6, 1967 G. A. BAKER 3,323,342

METHOD AND MEANS FOR SMOOTHING EDGES OF STRIP MATERIAL

Filed March 31, 1965 2 Sheets-Sheet 1

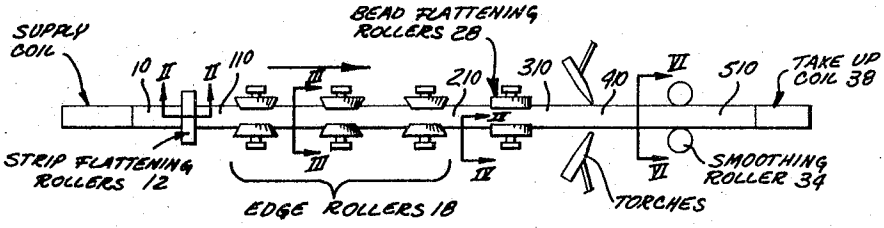


FIG. 1

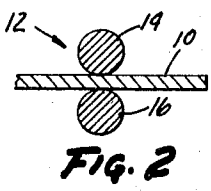


FIG. 2

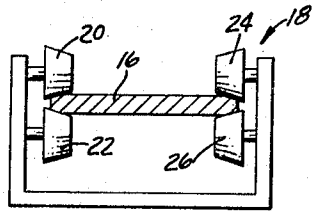


FIG. 3

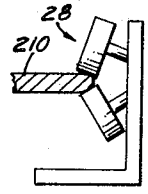


FIG. 4

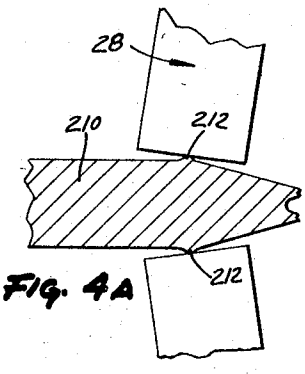


FIG. 4A

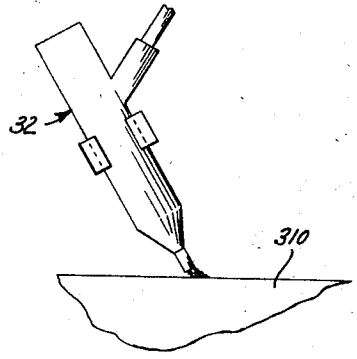


FIG. 5

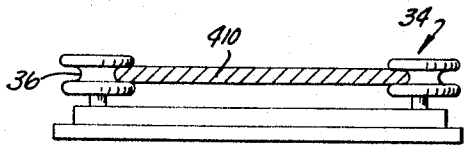


FIG. 6

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METHOD AND MEANS FOR SMOOTHING EDGES OF STRIP MATERIAL

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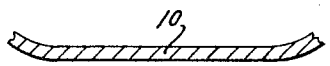


FIG. 7.

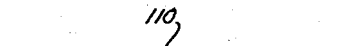


FIG. 7A.

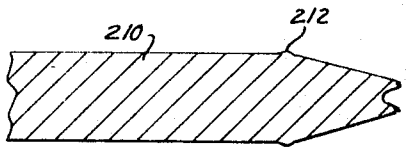


FIG. 7B.

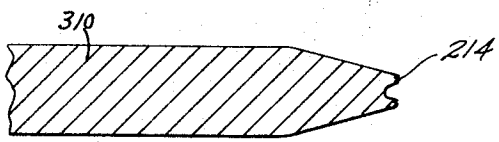


FIG. 7C.

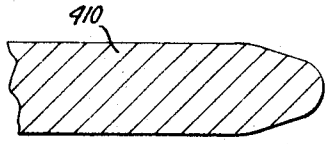


FIG. 7D.



FIG. 8.

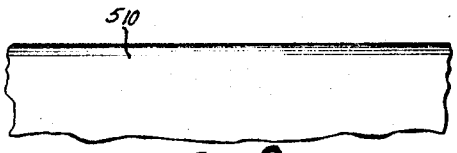


FIG. 8a.

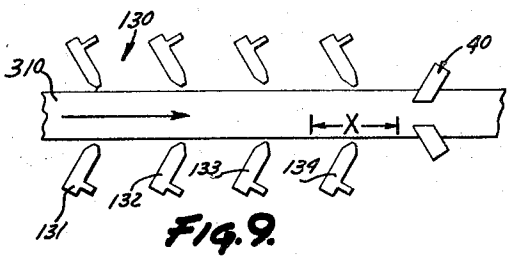


FIG. 9.

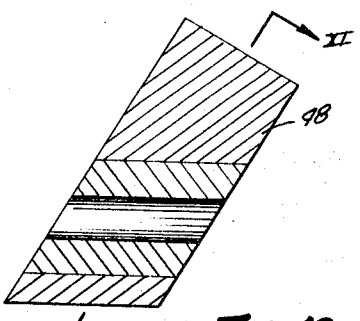


FIG. 10.

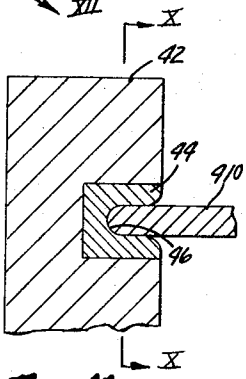


FIG. 11

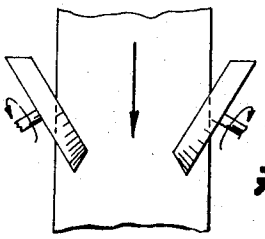


FIG. 12

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METHOD AND MEANS FOR SMOOTHING EDGES OF STRIP MATERIAL

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Filed Mar. 31, 1965, Ser. No. 444,273
11 Claims. (Cl. 72—200)

This invention relates to the treating and conditioning of metal, and more particularly to a method and a means for smoothing, shaping, and treating the edges of metal strips, particularly long thin ribbon-like strips such as are stored in large coils.

Certain manufacturing operations require large quantities of thin metal strips for the making of different products. This is particularly true in the manufacturing of certain electrical coils and transformers, in which long, continuous lengths of such strips are tightly coiled to form windings. Probably the most typical metal used for this purpose is aluminum. Strips of this metal having desired widths are usually provided by slitting several narrow coils from a wide coil of stock of a desired thickness. In accordance with modern automated volume-production techniques, the metal strips are formed in the following manner. The coils of the sheet metal are wound from a supply reel to a take-up reel over a plurality of slitting knives. These pass through the metal and divide the single wide sheet into a desired number of narrower strips at very high rates of speed.

This slitting of the sheet stock produces jagged side extremities on each resulting strip. These jagged edges render the strips unsatisfactory for their intended purpose. In the making of transformers or coils, the metal strips are given a coating of a suitable insulating material, such as by anodizing or by applying a film of plastic substance such as epoxy, in order to prevent the different turns in each winding from shorting out against each other. However, when the edges of the winding material are not completely smooth they are not satisfactory since in use even slight irregularities will produce uneven films of the coating applied or will puncture the coating of insulation to cause serious electrical difficulties and early failure of the coil or winding. The sharply jagged edges produced by slitting the rolls of sheet rock are consequently entirely unsuitable, and the strips must in some way have their edges rounded and smoothed before they can be used.

The metal-working craft in general has developed limited skills for smoothing various metal surfaces in a variety of ways, including the jagged edges of the slit aluminum stock. These techniques have not been satisfactory when applied to the thin ribbon material used in transformer windings. Further, the problem is not merely one of smoothing these edges, but of doing it at a high rate of speed, so that the end result is an economically feasible operation. Accordingly, until the present time no completely satisfactory method has been provided.

The basic approach has been to pass the strip of material over or through various rollers and combinations of rollers. While this has readily produced a uniform flatness and has further effected a general smoothing of the sides of the strips, the sides have nonetheless retained sharp lateral irregularities and consequently have for the most part been unsatisfactory in usage. Even in those cases where reasonably smooth edges have been obtained, the rolling technique normally leaves a ridge of displaced metal which interferes with the proper winding of the transformer. Thus, it has heretofore been necessary to exercise considerable additional time-consuming care in smoothing these edges in order to produce

a functionally suitable product. This has naturally been the source of considerable additional expense.

It is therefore a primary objective of the present invention to provide a method and a means for treating the jagged edges of such strip material while the strip is being moved at a high rate of speed in a manner which continuously produces a completely smooth edge surface which is also straight and linear over the length of the strip. The process of the present invention is one which is executed continuously as the strip of metal is moved from a supply coil to a take-up coil, and it is completely automatic once set into operation.

The foregoing desirable features and advantages, together with others of an equally desirable nature, will become increasingly clear to those skilled in the appropriate art upon a thorough consideration of the following specification and its appended claims, when taken in conjunction with the illustrative drawings setting forth preferred embodiments thereof.

In the drawings:

FIG. 1 is a schematic plan view of the complete apparatus for performing the novel method;

FIG. 2 is an enlarged fragmentary side elevational view of the strip flattening rollers taken along the plane II—II of FIG. 1;

FIG. 3 is an enlarged fragmentary sectional elevational view, taken along the plane III—III of FIG. 1, illustrating the edge rollers;

FIG. 4 is an enlarged fragmentary sectional elevational view of the bead-flattening rollers, taken along the plane IV—IV of FIG. 1;

FIG. 4A is a further enlargement of FIG. 4, showing specific details thereof;

FIG. 5 is an enlarged fragmentary plan view depicting one of the torches shown in FIG. 1 in operation;

FIG. 6 is an enlarged sectional elevational view of the smoothing rollers taken along the plane VI—VI of FIG. 1;

FIG. 7 is an enlarged transverse sectional view of the metal strip before entering the rollers of FIG. 2;

FIG. 7A is an enlarged transverse sectional view of the metal strip after the same has passed through the rollers of FIG. 2 but before it has entered the rollers of FIG. 3;

FIG. 7B is an enlarged, fragmentary, transverse sectional view of the metal strip after the same has passed through the rollers of FIG. 3 but before it has passed through the rollers of FIG. 4;

FIG. 7C is an enlarged, fragmentary, transverse sectional view of the metal sheet after it has passed through the rollers of FIG. 4;

FIG. 7D is an enlarged, fragmentary, transverse sectional view of the metal strip after the same has passed the torches of FIG. 5;

FIG. 8 is an enlarged fragmentary plan view of the metal strip of FIG. 7D before passing through the smoothing rollers of FIG. 6;

FIG. 8A is a fragmentary plan view of the metal strip of FIG. 8 after the same has passed through the smoothing rollers of FIG. 6;

FIG. 9 is a plan view of another embodiment of the torch section of the apparatus, including a different smoothing apparatus;

FIG. 10 is an enlarged, sectional, side-elevational view of the smoothing apparatus of FIG. 9, taken along the plane X—X of FIG. 11, with the metal strip removed;

FIG. 11 is a fragmentary, sectional end elevational view, taken through the plane XI—XI of FIG. 10, showing also the shaping of the metal strip; and

FIG. 12 is a plan view of a presently known form of shaping roller, shown for purposes of comparison.

Stated in brief, the present invention provides a sequence of operations which are carried out as a metal strip is moved at high speed from a supply coil of strip material to a take-up coil. This sequence is as follows. The strip first passes through a preliminary mechanical shaping operation which includes first flattening rollers, then edge rollers, and finally bead flattening rollers. This provides a tapered edge with a channeled, jagged and irregular margin. The strip is then passed between torches which heat the irregular margin edges of the strip to the temperature where the metal is flowable. As the strip passes through and beyond the torches, its heated edge flows slightly and assumes a rounded and smooth configuration but with small lateral undulations. Finally, the strip is passed through a pair of smoothing rollers which draw the strip to eliminate the undulations, giving it a completely uniform width throughout its entire length. Following this, the finished smooth and straight strip is wound upon the take-up coil.

Referring now in more detail to the drawings, the basic sequence of operations is seen in FIG. 1, where the different parts have been labeled. The strip-flattening rollers **12** seen at the left of this figure constitute the first step in the operation, and it is through these rollers that the strip of metal **10** first passes in its newly-slit and jagged condition. The strip-flattening rollers **12** are seen in FIGS. 2 to be a pair of horizontally disposed cylindrical rollers **14** and **16**. These rollers are securely mounted a predetermined distance apart which corresponds to the nominal thickness of the strip **10**. Further, the rollers extend a brief distance beyond each side of the metal strip, and consequently as the latter is drawn continuously between them all edge-curling tendencies are removed and the strip emerges flat.

The strip of metal **10** is then drawn through several sets of edge rollers such as are indicated at **18**. These rollers are illustrated in more detail in FIG. 3, where each set of them is seen to include a first pair of vertically-aligned rollers **20** and **22** positioned at one side of the strip **10**, and a second such pair of rollers **24** and **26** at the other side of the strip opposite the first pair. As is seen from the drawings, the plane of each of the edge rollers **18** is in alignment with the longitudinal axis of the metal strip. Further, their rolling surfaces are bevelled at a predetermined angle so that as the edge of the metal strip passes between each pair of the rollers, it is rolled into a similarly bevelled configuration at both its upper and its lower surfaces.

After the metal strip has initially been slit, it has the general cross-sectional shape shown in FIG. 7. Both edges of the strip are turned upward by the slitting knives, and the edges are sharp and jagged. After passing through the strip-flattening rollers **12**, the strip has the flat configuration shown at **110** in FIG. 7A. As it is drawn through the edge rollers **18**, the metal strip is given the double-bevelled configuration noted above, and it appears in the form shown at **210** in FIG. 7B. It is here to be noted that the beveling action of the edge rollers creates a bead **212** of material at the beginning of the bevel. The edge rollers also create a grooved channel depression **214** along the edge of the strip **210** due to the action of these rollers in deforming the corners of the strip outwardly as the edges are smoothed.

The parallel alignment of the edge rollers **18** with the metal strip is to be noted particularly. Previous methods of mechanically smoothing such strips utilized similar rollers, but positioned them so that their plane of rotation was at an acute angle relative to the longitudinal axis of the metal strip, as is illustrated in FIG. 12. This type of alignment imparted a very harsh rolling action to the metal strip, since the turning force imparted to the rollers by the motion of the metal strip necessarily included both longitudinal and transverse components. As a result of the latter, slippage and friction between the rollers and the strip was inevitable and this caused an abrading

contact between the roller and the strip which actually removed metal from the latter. Moreover, in practice, this arrangement tended to remove more metal from one face of the strip than from the other, and therefore a non-uniform edge resulted. Furthermore, the angle of alignment of these rollers produced a rotational movement which acted to knead the metal toward the center of the strip where it tended to ball up ahead and at one side of the roller. These undesirable results had to be removed by additional separate operations.

In contrast to this, the present alignment of the edge rollers with the strip eliminates the abrading contact between strip and roller, and produces a smooth and continuous surface configuration without loss of metal and with substantially complete uniformity on each side of the strip.

After leaving the edge rollers **18** in the form shown in FIG. 7B, the metal strip **210** passes through the bead-flattening rollers **28**. These rollers are shown in FIGS. 4 and 4A, where it may be seen that they are similar to the edge rollers discussed previously. They are somewhat narrower, however, and more significantly, their rolling surfaces are not bevelled but are flat. The rollers **28** operate in vertical alignment with each other at each side of the metal strip, and they are aligned directly over the beads **212** shown in FIG. 7B and seen also in FIG. 4A. They are so arranged that their contact with the strip is limited to that necessary to flatten this bead. After being drawn between these rollers, the strip emerges with the shape shown at **310** in FIG. 7C, the beads which previously were present having now been smoothly blended into the remaining portion of the strip by the action of the bead-flattening rollers. Consequently, most of the surface configuration of the strip **310** in FIG. 7C is smooth and continuous, except for the groove or channel **214** which remains as yet undisturbed. The two tips which form the groove **214** are quite thin and therefore readily heat to a flowable temperature.

The metal strip **310** passes from the bead-flattening rollers next before oppositely disposed torches **30**, which are directed generally toward the edges of the strip and specifically at the grooved extremity **214** thereof. The purpose of the torches is to heat the edge margins of the strip in the vicinity of the groove to a temperature at which the metal at the edges of the strip become flowable. In this state, the metal forming the groove **214** flows smoothly together and attains the configuration shown at **410** in FIG. 7D. That is, the end extremity of the strip flows into a smooth curve. The groove and the jagged tips adjacent the groove are eliminated. The position of the torches **30** relative to the edge of the metal strip is shown in more detail in FIG. 5, where a single torch **35** is shown disposed at approximately forty-five degrees from the longitudinal axis of the strip.

The precise extent of heating effected by each torch is clearly a somewhat critical matter, since if the temperature of the metal is raised above that at which it is flowable only, it will exceed the desired plastic or flowable state and enter the liquid phase. If this occurs, the edge of the strip will merely melt away and the desired configuration will be lost. On the other hand, if the degree of heating is inadequate, the desired flowing of the metal to smoothly fill the groove **214** and shape the edge will not occur. The amount of heat necessary to produce the desired result will of course vary with differences in the kind and thickness of metal being treated. The speed at which the strip is drawn past the torches will materially affect the degree of heating which can be effected by each torch.

The preferred type of torch is one utilizing an electrical arc, and preferably is of the "Heliarc" variety in which a jet of inert gas such as helium or argon surrounds the arc to shield the point of heating and protect the hot, flowable metal from oxidation. In actual practice, however, certain applications may indicate the practicability of

other types of torches, such as for example those utilizing gases such as oxygen and acetylene.

After the moving strip of metal **410** has been smoothly shaped by the action of the torches, the cross-sectional configuration of its edge is quite satisfactory. However, it is observed that over a length of the strip its smooth edge will nonetheless have certain gentle longitudinal undulations, such as are shown in FIG. 8. These longitudinal irregularities are undesirable, since they adversely affect the performance and response of a transformer, and in its most desired form the winding material should have absolutely straight, linear edges.

Accordingly, the strip **410** is next drawn between a pair of smoothing rollers **34** (FIG. 1). The smoothing rollers are more distinctly shown in FIG. 6, where they are seen to be a pair of horizontally-rotatable pulley-like rollers having a rounded, concave annular shaping surface **36** formed generally centrally about each. The strip **410** has its opposite edges lying within the shaping surfaces **36** of smoothing rollers **34**, and the rollers are positioned a distance apart whereby they exert a slight drag upon the moving metal strip. These rollers flatten out the undulations of the side surfaces, and as the metal strip passes beyond the smoothing rollers it is in the form shown at **510** in FIG. 8A, wherein both its sides are straight and completely linear. At this stage the complete smoothing and shaping operation is finished, and the resulting strip is wound upon the take-up coil shown as **38** in FIG. 1.

It will be apparent that the process just described is based upon the underlying principle of completely shaping the edges of the metal strip in the desired manner while constantly moving the strip from one coil to another. Thus, to achieve maximum efficiency and practice the process in the most rewarding manner, the speed at which the metal strip is moved should be maximized. Previously, such speeds were very low, but by utilizing the present method to its fullest extent, speeds of up to fifty feet per minute appear to be completely feasible, and indeed this figure may be greatly exceeded under certain optimum conditions. In maximizing the speed of the operation, it becomes impossible to effect proper heating with a single pair of torches as shown in FIG. 1. This problem is overcome by the use of a plurality of torches **130** (FIG. 9). These are oriented as substantially the same angle as the single pair of torches **30** described previously. In this situation each of the torches on one side of the metal strip **310** is calculated to heat a given portion of the strip a fraction of the total amount required. Thus, the heating effect of the torches is cumulative. In FIG. 9 for example, the distance along the edge of the metal strip designated "X" will have been successively heated by torches **131**, **132**, **133**, and **134**. When it leaves the proximity of the final torch and enters the smoothing device **40**, it is heated to the proper flowable state.

The smoothing device **40** of FIG. 9 is a further embodiment of the basic concept of smoothing side undulations of the metal strip into straight edges. The device **40** consists of a pair of wiping dies. One of the dies in the pair **40** is shown at **42** in FIGS. 10 and 11. As there shown, the die **42** preferably has an insert **44** of a very hard and durable material such as silicon carbide, and the insert has a precisely-formed shaping orifice **46** which is directly analogous to the rounded, concave shaping surface **36** in the smoothing rollers **34** described previously. As shown in FIG. 9, the dies **40** are preferably positioned at an angle to the moving metal strip so that their inner edges angle toward the oncoming strip (i.e., opposed to the direction of its motion). Thus, any bead of metal formed by these dies is urged outwardly toward the edge of the work where it is stripped from the metal. The dies **40** are positioned in firm sliding contact with the edges of the strip at the desired width thereof and must firmly withstand the forces created by the frictional wiping with which they smooth out the side undulations from the hot, plastic edges of the strip. The angular orientation noted helps them to better withstand these forces while properly performing the intended function.

Having now fully described the structure of preferred embodiments of the apparatus for performing the present novel method, and having further shown the operation of this structure and the performance of the method itself, persons skilled in the art to which it pertains will recognize that certain modifications and variations may be made in specific details of the invention without departing from its underlying spirit. Accordingly, all such variations and modifications are to be considered a part of the invention and included in the scope of the claims appended herebelow, unless these claims by their language expressly state otherwise.

I claim:

1. A method of automatically smoothing the edges of a long, thin, continuous strip of metal, comprising the steps of: continuously moving the strip lengthwise; heating the edge margins of the moving strip to a flowable state; and while so heated allowing said edge margins to flow together in a smoothly rounded edge configuration.

2. The method of claim **1** wherein said edges are rolled and drawn while still somewhat flowable to eliminate undulations.

3. The method of claim **1** wherein said strip is subjected to the additional step of drawing said strip through a pair of stationary shaping dies to give the edges a smoothly rounded configuration; orienting the shaping dies to urge any bead of excess metal outwardly away from the strip and removing said bead from the strip.

4. A method of smoothing the edges of a thin, ribbon-like strip of metal comprising the steps: continuously moving the strip lengthwise at a uniform speed; forming the edge margins of the strip into an outwardly tapered configuration; heating said tapered edges to a temperature at which the metal is flowable; and flowing the metal into a smoothly rounded edge configuration.

5. The method recited in claim **4**, wherein the strip is subjected to the additional steps of: drawing said strip while heated to a flowable state through a pair of stationary shaping dies and wiping any excess metal repositioned by said dies outwardly away from the strip and stripping it from the edges of said strip.

6. The method recited in claim **4**, wherein the strip is subjected to the additional steps of: applying the heat to said strip progressively by passing said strip successively through the heating zones of a plurality of torches.

7. A method of smoothing the edges of a thin, ribbon-like strip of metal comprising the steps: continuously moving the strip lengthwise at a uniform speed; rolling each of the top and bottom edge margins of the strip outwardly into a double-sided tapered configuration defining a channel-shaped groove therebetween; heating the said groove-defining edges to a temperature at which the metal is flowable; and flowing the metal into the groove to form a single smoothly rounded edge configuration at each side of the strip.

8. Apparatus for automatically smoothing the edges of long, thin, ribbon-like strips of metal, comprising: means for continuously and steadily moving separate strips lengthwise from a supply of same to a take-up device; mechanical pressure apparatus for forming the edge margins of the strip into an outwardly tapered configuration as the strip is so moved; torch means positioned on opposite sides of the moving strip and directed at its tapered edges; said torch means arranged to heat the said edges to a flowable state wherein irregularities flow together and assume a smooth character; and shaping and straightening means positioned at opposite sides of said strip for linearly straightening the smoothly flowed edges as the strip is moved.

9. The automatic smoothing apparatus of claim **8**, wherein said shaping and straightening means is a pair of oppositely-disposed horizontally-rotating rollers having a

rounded, concave annular shaping surface for receiving the edges of the moving strip and rolling the strip into a uniform width throughout its length.

10. The automatic smoothing apparatus of claim 9, wherein said shaping and straightening means is a stationary wiping die having oppositely-disposed concave shaping die surfaces for receiving the edges of the moving strip and wiping any excess metal repositioned by said dies outwardly away from the strip and stripping it from edges of the strip.

11. The apparatus of claim 8, wherein said torch means includes a plurality of individual torches arranged in succession at either side of the moving strip; each of said

torches arranged to heat the portion of the strip edge in proximity therewith a predetermined fraction of the total temperature required to render that portion flowable in the time during which the portion continues in proximity with the torch while the strip is moved past the torches, whereby the said edges are progressively heated to a flowable state by the entire succession of torches.

No references cited.

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