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ROLLING OF THIN GAUGED MATERIAL

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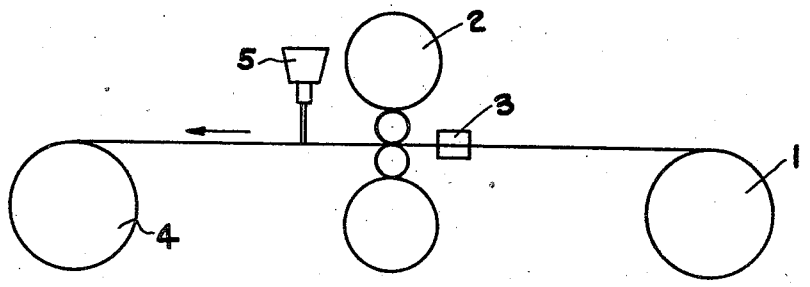


FIG 1

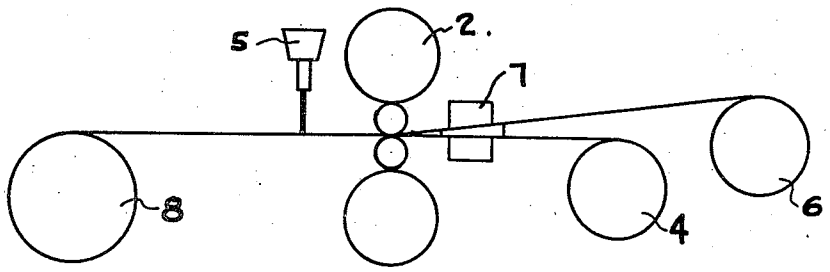


FIG 2

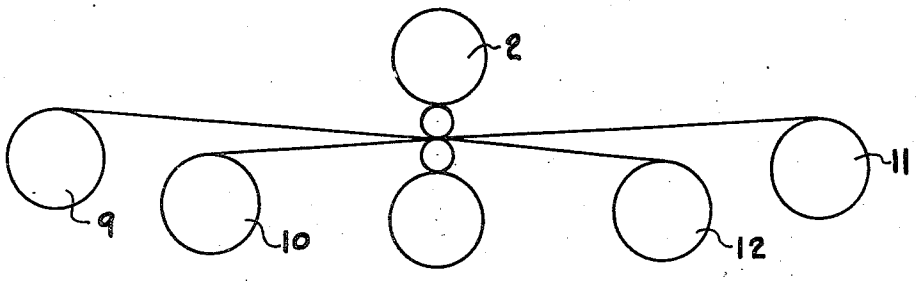


FIG 3

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ROLLING OF THIN GAUGED MATERIAL

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2 Claims. (Cl. 80—60)

1

There is an increasing demand for very thin gauge ferrous strip materials where the gauge itself must be accurate and where the cross-sectional contour of the rolled piece must be substantially uniform, i. e., not characterized by such gauge variations as a high crown in the center. Hitherto it has been possible to make such strips in comparatively narrow widths on very rigid narrow mills usually of the 4-high type, or on certain special kinds of mills, such as the mill set forth in United States Letters Patent to Sendzimir, No. 2,170,732, where the strain of the working rolls is transmitted by rotating elements to rigid beams extending in the direction of the axis of the rolls. For many uses it is undesirable or uneconomical to produce the material in narrow widths, and as to the special beam backed mills they are not generally available as yet.

While our invention is not confined to this field of utility, we may mention that it is being presently used for the formation of wide but very thin silicon steel strip .003 inch or less in thickness. Such exceedingly thin silicon steel strip has come to be of commercial importance for the manufacture of certain types of high frequency transformer cores and for other special uses. It may be noted also that silicon steel by reason of its tendency to hardness and brittleness is a difficult material to cold roll. We shall describe our invention in an exemplary embodiment having to do with the manufacture of thin silicon steel strip of the character to which reference has just been made, but it will be understood that it may be used in other fields of utility.

As is well known, in the cold rolling of wide strip there is, as respects any given metal of any given metallurgical characteristics in any given mill, a gauge limit below which cold rolling will not be effective, due largely to the spring of the rolls. This phenomenon is not entirely confined to cold rolling mills of course, and just as pack rolling is practiced in hot mills, attempts have been made to send two or more superposed sheets through cold mills so that the additive gauges or thicknesses of the several sheets will give a workpiece well above the minimum gauge for reduction. This procedure involves certain special difficulties of its own which do not require discussion here; but it is in no event productive of strip. In the making of metal foils, two or more strips have in instances been run simultaneously through a foil mill with the production of very thin material. These practices, however, have not resulted in the provision of a mode of operation or mechanism whereby thin, wide, hard metal strips could be produced with great accuracy on standard rolling equipment, even with the addition of extra reels and the like; but it is a fundamental object of our invention to provide such a mode of operation.

2

It is an object of our invention to provide means and a method whereby a hard metal strip of a gauge conveniently produced by conventional cold rolling operations can be carried down in a single pass to gauges in the neighborhood of .003 inch or less with great accuracy.

It is an object of our invention to provide a means and method for doing this wherein the additional materials employed, themselves become useful for reduction in a similar manner to the same or similar light gauges in subsequent operations.

It is an object of our invention to provide a mode of proportionally rolling a combined workpiece through the use of tension wherein tension is correlated not only to the strengths of the workpiece portions but also to the proportional reductions accomplished.

It is an object of our invention to provide a mode of treatment, preparation, combination and rolling for a composite workpiece with equipment which may not be characterized by a plurality of reels or coilers on both sides of the mill and wherein discrepancies in the initial length of concurrently coiled workpieces may be compensated in ways hereinafter set forth. These and other objects of our invention which will be set forth hereinafter or will be apparent to one skilled in the art upon reading these specifications, we accomplish by that certain mode of operation and with those apparatus modifications of which we shall now describe certain exemplary embodiments. Reference is made to the drawings which form a part hereof in which:

Figure 1 is a diagrammatic representation of a step of preparing a strip surface for combination with another strip.

Figure 2 is a diagrammatic showing, serving to illustrate the step of producing a matched or composite coil and the step of rolling that coil when the mill is reversed.

Figure 3 is a diagrammatic representation of the passage of a plurality of strips simultaneously through a rolling mill wherein the entering and leaving tension on each strip can be separately controlled.

In an exemplary procedure under our invention, and using the exemplary equipment hereinafter set forth, we first prepare two strips of silicon steel of different gauges, one of the strips being .019 inch in thickness and the other being .005 inch in thickness. These strips will be of sheet width, say 24 inches or more depending, of course, on the available equipment for producing them and the width of the mill to be used for affecting reduction to very thin gauges in accordance with the teachings of our process. The strips will be long enough to give the mill a good

productive capacity—a coil of the heavier material may weigh 6000 lbs. or more.

The strips themselves may be made by any of the current strip processes. Ordinarily these will comprise the forming of slabs from ingots, the hot rolling of the slabs to intermediate gauge strips and the cold rolling of the strips singly to the gauges desired, with such annealings and pickling between the other steps as may be a part of good rolling procedure, or as may be dictated by some special initial or ultimate qualities of the material. For example, there are a number of recognized processes for the production of silicon steel which (usually in connection with a final heat treatment) are relied upon to impart particular magnetic or other qualities to the material. These will not be herein discussed. They are applicable to and may be practiced in connection with the novel steps of our invention which will be set forth; but they form no limitation thereon.

The thinner of the two strips, especially if its thickness is such as cannot conveniently be made by ordinary cold rolling processes, may be formed as an incident to our process as will be explained.

The two strips—in the exemplary embodiment having respectively gauges of .019 and .005 inch—have surfaces which are clean, i. e., free from scale, though not necessarily free from a thin uniform oxide film, and are preferably, though not necessarily, in annealed condition. The softer the material, the easier it is to work; but the nature and character of the annealing operation, if any, does not form a limitation upon our procedure and may be such as is essentially dictated by other desired characteristics, e. g., the magnetic properties where silicon steel is the material worked upon. Bright annealing of cold rolled stock will in the preparation of our starting pieces usually render a pickling unnecessary. It is not necessary that out starting materials have what is known as a cold rolled surface, but in many instances this is helpful.

As shown in Figure 1, we may take a coil of open annealed silicon steel stock of .019 gauge, say 25 inches slit width, as at 1, and pass it through a mill 2, having an emery cloth wiper diagrammatically indicated at 3. The emery cloth is located on the top side only with a felt drag on the bottom. The emery cloth flattens small projections and cleans the top surface which is later to come in contact with the lighter gauge strip, and in instances is helpful. It is not necessary. But precautions should be taken that at least the contacting surface of the strip is suitably clean, and the procedure just described is one way of doing this. Any projections on the surface of heavy strip that is to be in contact with light gauge strip will punch holes in thin strip when the two strips are given the reducing pass. Also it is advisable that the coil be carefully rewound as at 4 with even tension.

While we have spoken of passing the strip through the mill 2, this is essentially a matter of convenience, for no pressure is applied to the mill, and the mill at this time is doing no work. Rewinding and tensioning equipment which does not include a mill could be employed, if available, for this step and the next succeeding one; but the steps may be carried on with conventional equipment as described.

A light stream of palm oil is preferably applied to the surface of the strip before recoiling as diagrammatically indicated at 5.

The coil 4 is now brought around to the entering side of the mill (Figure 2). A coil of open annealed .005 inch silicon steel, preferably slit to 24 inches in width, is placed on another reel as at 6, and the two strips are run through a double felt wiper as at 7. A double wiper is important, for we have found that if two different gauges are matched, using one wiper only through which they concurrently pass, there will be variable friction between the two contacting surfaces caused by non-uniformity of tensions between the pay-off reels and the wiper, mill or recoiler. This not only produces a tendency for the lighter gauge material to run off to the side but also gives a combined coil in which the tensions are not uniform.

The two strips from coils 4 and 6, passing through the mill 2, are wound together to form a matched coil 8. In this operation constant tension is maintained between the .005 coil and the wiper and between the .019 coil and the wiper. Once again no pressure is applied to the mill, and it is doing no work. A small stream of palm oil is preferably played on the two strips as they are wound together. This operation also could be performed on apparatus that did not include a rolling mill.

It will have been noted that the thinner strip is preferably somewhat narrower than the thicker strip. This is not absolutely essential but is helpful in matching the strips and in producing a combined rolling piece.

Further, in our exemplary procedure the mill 2 is now reversed and driven under screw pressure, the matched strips being withdrawn from the combined roll 8 and separately recoiled as at 4 and 6. Power is separately applied to the tension coilers on which coils 4 and 6 are positioned, and to the mill and to the reel or coiler which is paying off the combined strip from the coil 8. During the rolling operation the double drag 7 will, of course, be removed. An entering drag may be employed if desired but is not necessary, because back tension can be exercised by the coiler holding coil 8. In an exemplary operation, with 1200 amperes pull on the mill, at a speed of 150 feet per minute, with a back tension produced by applying 350 amperes to the coiler holding the combined coil 8 and with forward tension produced by applying 150 amperes to the coiler holding coil 4, we have concurrently reduced the .005 inch strip to a gauge of .003 inch and the .019 inch strip to .010 inch. During this rolling operation, power will be applied to the coiler holding coil 6, but the power so applied need be only sufficient to assure tight and even coiling. The two strips are rewound separately as indicated, the movement of material being to the right in Figure 2 and opposite to its direction of motion during the preceding step of forming the combined coil 8. In the particular operation, on the particular mill and with the workpieces which we have described, it is necessary that the tension on the coiler 6 be very light during rolling, that is to say, just enough to keep the strip between the mill 2 and the coiler 6 from becoming slack and to permit tight and even coiling as aforesaid. The power figures which we have given are thus exemplary for the particular illustrative procedure which we have outlined.

In our operation the thinner strip is being passed through the mill under tension riding on the heavier strip which is also under tension.

The particular procedure which we have outlined is exemplary only and is not limiting. It is important that the wall thickness of the heavier strip be initially at least three times as thick as that of the thinner strip where two strips only are being concurrently rolled from a matched coil as at 8 containing both strips. In the particular exemplary illustration, the two strips were in a similar annealed condition and therefore of a similar softness. But, it will be obvious that where two strips are concurrently wound upon a single coil, that strip which is radially the outermost in each convolution will be the longer. One would expect in the decoiling of a matched coil to encounter a progressive slackness of the outermost strip when the innermost is maintained under tension. In our rolling process this does not occur however; and the compensation appears to take place in the bight of the rolls. We have indicated that we apply power to the coiler containing coil 8, and while we have not separately measured the tension in the thinner and thicker strips, the fact is that the combined strips decoil as though they were one, and without either separation or slackness.

It may be noted from the example given above that the percentage reduction made in each strip is not the same. The .005 strip has been reduced to .003, while the .019 strip has been reduced to .010. The tensional conditions were not in this instance the same on the two strips, either in the absolute sense or in proportion to their finished gauges.

The peculiar behavior of the matched strips is not readily explainable under ordinary rolling concepts, for as will be evident from the specific example shown, it seems to involve certain obvious inconsistencies. We do not attempt to explain them. We do know, however, that it is possible to carry a heavier strip through the mill under controlled tension and at the same time to cause a lighter strip to ride through the mill and be concurrently reduced under the same or different tensional conditions; that aside from such variables as may be introduced by composition of the two strips or divergent degrees of hardness, it is possible to control within limits wide enough for operability the relative percentages of reduction by controlling the tensional conditions on each strip, and further that where two strips have been wound upon the same reel or coiler and are concurrently paid therefrom under tension, that by controlling the tension on the thicker of the strips, the two strips may be caused to pay off and roll as one, where the materials are the same and of similar hardness, and where the gauges are roughly in the proportions of those set forth and the tensions are roughly in the proportions of those set forth. With other ratios of starting gauges it may be found necessary to control the tension of both pieces on the outgoing side of the mill at such substantial values as will have a definite effect upon the reduction of each strip. All other conditions being equal, a substantial variation of the tensional conditions on either or both strips will vary the relative percentage of reduction of the strips during their passage through the mill. As might be expected, variations in total tensions will likewise produce variations in total or combined reduction.

An advantage of the process set forth in the exemplary embodiment is that it may be practiced with cold rolling mills which have a pay-off reel and a tension reel on one side of the mill and one tension reel on the other side. Mills so equipped

exist, and in any event the addition of one tension reel to one side of the mill is not a matter of exorbitant capital outlay. But where, to a mill having but one tension reel on each side it is possible to add one or more additional tension reels on each side, the step of producing a matched coil can be eliminated. We have found it possible, as shown in Figure 3, to roll through the mill 2 separately strips from coils 9 and 10, rewinding them separately as at 11 and 12. While we have shown the rolling of two separate strips in Figure 3, three or more strips may be concurrently rolled; where the strips are decoiled from and recoiled upon separate coiling devices to which controlling power may be separately applied, it then becomes possible in the light of our teachings to control the relative percentages of reduction attained in separate strips of the same or different starting gauges to produce the same or different finished gauges within a fairly wide range. It will be understood, of course, that the thinner the finished gauge of the material, the less absolute tension it can stand in proportion to its width. When working with exceedingly thin materials or materials which are brittle in their nature or for any other reason cannot support a heavy tension when they have attained finished gauge, the indicated procedure is that of rolling a light strip with a heavy one under such conditions that the heavy tension may be applied to the heavy strip, while the light strip on the exit side of the mill need not be tensioned beyond that value which it can support or which is necessary for the production of a suitable coil. For reasons which are not clearly understood, the tension on one of the strips being concurrently rolled affects the rolling of the other strip. When speaking of tension generally, we include back tension as well as forward tension where both are not employed. Operations under our invention, however, may include the elimination of forward or back tension on one or more of the strips.

Where two strips are matched and coiled on a single coiler as described in the exemplary embodiment, the factor of the different effective lengths of the two strips as they approach the mill introduces a restrictive factor. Slackness is ordinarily not desired in one of the strips as it enters the mill. The compensation which has been described thus dictates either a considerable disparity in the initial gauges of the strip or a considerable disparity in forward tension on the two strips, or both.

The character of the metal being rolled is also a factor in determining what can be done, as to procedure, and what need be used, as to equipment. We have applied the principles of this invention to the rolling of very thin stainless steel strip, the strip being of the familiar 18–8 variety, as well as in the rolling of other chromium or stainless steels. Stainless steel is again a hard material which is difficult to reduce to thin gauges; but unlike silicon steel it is not brittle and will withstand greater tensions for the same thicknesses.

In an exemplary procedure for the combined rolling of stainless strip, we start with two coils both having a thickness of .007 inch, and being in an annealed state. As has already been described in connection with Figure 2, the two strips are combined on the coiler 8. The wiper indicated at 7 is used to clean the mating surfaces of the two strips. It will be noted that in this exemplary embodiment the strips are of the same gauge; and they may also be of the same width.

During the rolling operation the strips are decoiled together from the coil 8 and passed through the mill 2; but instead of being separately coiled as at 4 and 6 (which also of course may be done), we have found that the combined strips may be wound together on a single tension coiler. During the mill pass the strips are each reduced from .007 inch to .005 inch in thickness. The two strips are not only concurrently decoiled from coil 8 and passed through the mill as a unit, but are concurrently recoiled onto the same coiler, as for example at 4. This is of advantage where equipment is available consisting of a suitable mill with one tension coiler on each side. The stainless steel has very high tensile strength so that even at the light gauges it will withstand comparatively high tensions developed in the coilers supporting coils 8 and 4. In fact, the tensile strength of the stainless steel is usually as much as two or three times the tensile strength of silicon steel strip, gauge for gauge.

The strips decoil and recoil as a unit and without separation providing the forward and back tensions are properly correlated to the total reduction and the strength of the strips, the compensation again appearing to occur in the bight of the rolls. The back tension on the outer strip is presumably less on the entering side of the mill while on the exit side of the mill the outer strip presumably sustains the greater part of the forward tension. Yet in the particular exemplary procedure the percentage reduction in each strip is the same.

After the concurrent recoiling during rolling, the two strips of stainless steel may be separated from each other on a different unit, and each strip may be given a light, single skin pass to obtain a high surface finish as discussed hereinafter.

There are certain advantages derivable from concurrently rolling two strips of different starting gauge. In the exemplary embodiment the .019 material is accurately reduced to .010 inch. This is a convenient intermediate gauge for further single strand cold rolling operations such, for example, as may result in the provision of .005 strip. Also, our invention is not confined to the rolling of two strips concurrently or to the rolling of gauges such as those set forth in the exemplary embodiment. The operation may be so carried on that while a coil of finished light gauged material is made in each mill operation under our invention, one at least of the heavier strips is reduced to such a gauge that it can be employed as the lightest strip in a subsequent repetition of our process. Thus it will be seen that the cold rolling accomplished during our process on the heavier strip or strips is not lost as mechanical work but simply forms one of the stages of reduction of such strips incident to reducing them to final gauge. Needless to say, the thicker strip or strips employed in our process may be re-annealed before further processing and will usually be re-annealed.

The skilled roller familiar with his equipment will be able to determine a range of initial thicknesses for composite workpieces to be rolled in an efficient manner on his mill. From this he will be able to devise suitable composite workpieces apportioning to each part its percentage of the total or combined gauge so that within the limits of the tensional variations which he can produce with his equipment, he can control the relative percentages of reduction to give him his desired finished gauges. It will, of course, be understood that our process is applicable to

the simultaneous production of finished products of different gauges. Thus, if finished silicon steel is desired in gauges of .010 and .003 inch, the specific example which we have given is effective in the simultaneous production of finished silicon steel in two different but equally accurate gauges.

Our invention is not limited to the concurrent rolling of strips of the same composition, but within reasonably wide limits may be applied to the concurrent rolling of dissimilar metals, due allowance being made for such differences as may exist in their softness and rollability.

Where two strips are employed, one surface of each at the conclusion of our process will have an "open" surface rather than a cold rolled surface. Where more than two strips are employed, an intermediate strip or strips will have no cold rolled surface at all. For many uses the absence of a cold rolled surface is not objectionable; but it can in any event be remedied by giving to the finished strips separately a "skin" or surfacing pass in a cold mill, which is one producing no elongation but merely compressing and smoothing the surface of the stock.

Modifications may be made in our invention without departing from the spirit of it.

Having thus described our invention, what we claim as new and desire to secure by Letters Patent is:

1. A process of producing thin wide strip material which comprises cleaning the surface of a plurality of strips, one at least being of heavier gauge than another, winding said strips into a composite coil under equal tension, withdrawing said strips together from said composite coil, passing said strips through a rolling mill and concurrently reducing them, separately coiling said strips on the exit side of said mill and applying forward tension at least to said heavier strip.

2. A process of producing thin wide strip material which comprises cleaning the surface of a plurality of strips, one at least being of heavier gauge than another, winding said strips into a composite coil under equal tension, withdrawing said strips together from said composite coil, passing said strips through a rolling mill and concurrently reducing them, separately coiling said strips on the exit side of said mill and applying forward tension to both strips, the forward tension applied to said heavier strip being greater in amount than the tension applied to a lighter strip, and controlling the tensional relationship in such manner as to avoid slackness in any of the strips as they enter the mill and in such manner as to maintain a fixed relationship of proportional reductions in the strips.

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