

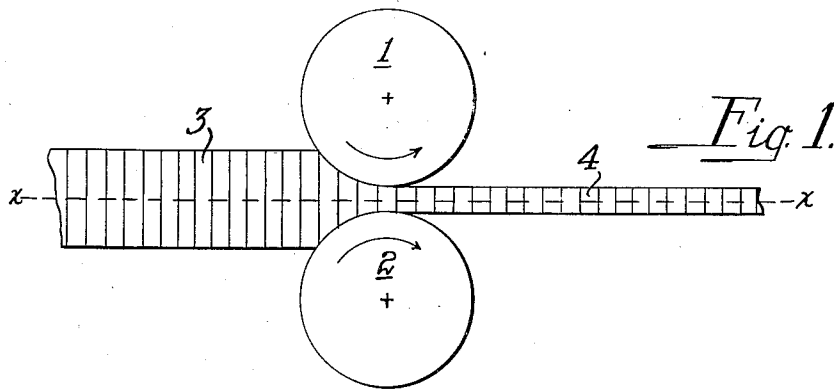
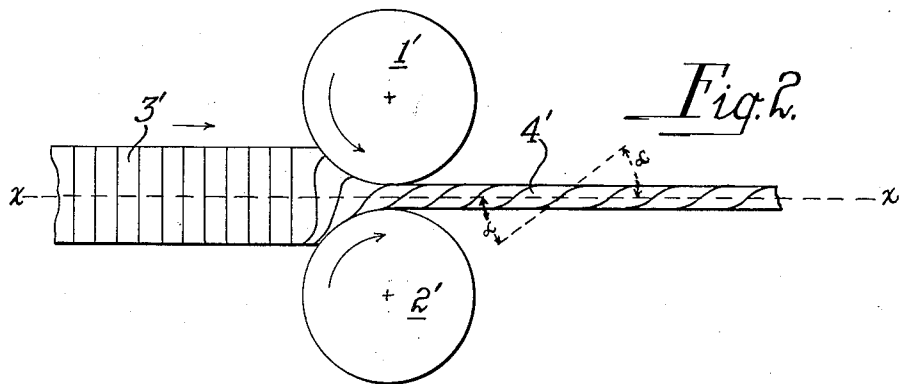
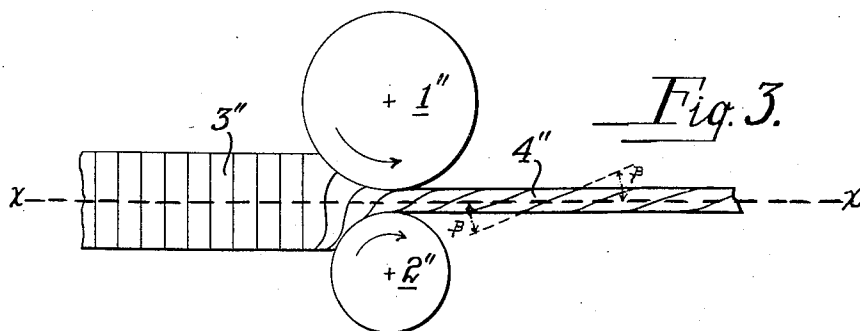
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TREATMENT OF ELECTRICAL SHEET STEELS

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TREATMENT OF ELECTRICAL SHEET STEELS

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This invention relates to the treatment of electrical sheet steels and particularly to a method of finishing silicon steel sheets to reduce watt loss.

Electrical sheet steels, as manufactured by the various mills, have hitherto been of known relatively poor and unimproved quality and the industry has apparently had to make the best of the recognized unfavorable situation.

According to the Epstein test, the present highest quality silicon alloy electrical steel checks around .70 to .75 watt loss per pound of metal while lower grades by the same test check around .80 to .88 watt loss.

Such steel is commonly classified as Grade A, Grade B and Grade C according to watt loss per pound and most mills turn out about 25% Grade A, 25% Grade B and 50% Grade C. Some more favored mills are able to produce 50% Grade A and 50% Grade B with the practical elimination of Grade C.

It is realized that Grade B steel and even more so Grade C steel represents a loss and it would be highly desirable to eliminate both Grade B and Grade C and to raise the quality of Grade A.

It is, therefore, an object of my invention to eliminate Grades B and C as far as possible and to improve the quality of Grade A.

It is an object of my invention to produce a Supergrade A steel of reduced watt loss per pound with the practical elimination of Grades B and C.

Another object is to treat silicon steel sheets to a reducing step between rolls having different surface speeds.

A further object lies in suitably controlling the temperature of such reducing step.

Other and further objects will be pointed out hereinafter or will be apparent as the description proceeds.

For the purpose of illustratively explaining certain features of my invention, a suitable drawing has been added. Figure 1 is a diagrammatical side view showing ordinary rolls in operation. Figure 2 is a like view but shows the effect of increasing the speed of one of the rolls in accordance with one aspect of my invention; and, Fig. 3 is a diagram-

matical sectional view showing the effect of employing rolls of different diameters while at the same time maintaining them at a like speed of rotation in accordance with another aspect of my invention.

In the various figures somewhat similar elements will be given the same reference numerals, and be distinguished from the others by "prime" suffixes. In the figures, upper and lower rolls 1 and 2, respectively, form a path in which the metal shape 3 is reduced to form the shape 4. Since the speed ratio of both rolls in the illustration of Figure 1 is one to one (1:1) and they are of like diameter, the orientation of crystals before rolling (see 3) is similar to the orientation after rolling (see 4). That is, when two rolls of the same diameter are driven at the same rotative speed, or when two rolls of different diameters are driven at rotative speeds which represent a function of the ratio between diameters, the metal shape 3 is, in general, only subjected to a strain. By "strain" it is meant that the metal is subjected to vertical pressure and mainly to the forces of compression. As a result, the orientation of crystals is changed very little, if any, by the roll pass (see numeral 4).

On the other hand, if the speed of one roll, 1' of Fig. 2, is given a ratio of say two to one (2:1) to the other roll 2', one face or side of the metal while being rolled and compressed is, in addition, subjected to a "stressing" force. In other words, the faster roll 1' tends to press one surface of the metal forward at a higher rate of speed than the slower roll 2', resulting in a multiplication of varied types of forces produced upon the shape being rolled. In using the term "stressing" I particularly wish to bring out subjecting the crystals of the metal to both tensile and compressive stresses and more particularly to the former and to the latter when so applied as to be conducive of the former. As a result, the rolling action upon the metal sheet, or the like, causes a slippage between the crystals after they have cooled down from the rolling heat and at the time they are allowed to freeze into position.

The same effect may be accomplished, as

seen in Figure 3, by providing rolls of different diameters, say of a ratio of three to one (3:1). This effect is obtained if the axial speed of both rolls 1'' and 2'' is maintained at the same value. Of course, if the roll diameters of Fig. 3 had the same ratio as the speed of the rolls of Fig. 2, the same angle representing the orientation of crystals would result.

Due to the speed ratio maintained between the surface of one roll and the surface of another, the pressure of one roll, as influencing the crystalline structure of the metal being rolled, is advanced with respect to the pressure of the other roll. As a result, the metal is not only reduced (see 4' and 4''), but, in addition, subjected to a tensile force making an angle α (see Figure 2) or an angle β (see Figure 3) with the axis of the metal $x-x$. Of course, the greater the speed ratio, or the advanced push of one roll, the greater will be the tensile force and the off-vertical displacement of the crystals of the metal.

As is well known to the art, for many purposes, the layout represented by Fig. 3 is more efficient than that shown in Fig. 2. For, the sharper and smaller the rolls, the greater is the horizontal component available for extending the bar or sheet in the direction of its length, and the smaller the proportion of power expended in extending the bar laterally to its length. Small rolls are, therefore, found to require less power to draw out a bar, doing so more quickly and causing less spreading in the operation than large rolls; this means there is more pressure per unit of surface if a small roll is applied. But questions of strength prevent full advantage being taken of this fact.

I have more or less arbitrarily selected the angular range of from 45° to 65° as representative of advantageous angles of metal flow. As seen in Figure 2, the angles α , and as seen in Figure 3, the angles β , are illustrative of such. In other words, they represent the angles formed between the normal axis $x-x$, of the metal being rolled and the axis of the orientation of crystals or of metal flow. Although I have found this range very effective, yet I do not wish to limit my application to such, since it has been employed merely for the purpose of explanation; other suitable angles may also be effective.

Present practice in manufacturing silicon alloy steels is one of indefinite control. This is clear from the fact that three different grades are obtained from heating, rolling and annealing under supposedly and apparently similar conditions. Like causes produce like results and variable products confirm variable control.

The best electrical quality of silicon alloy steel is obtained in direct proportion as the grain structure is strained or so relatively located that the crystal is in position favor-

able to slip. Such condition destroys the "at rest" structure and the equilibrium of the positive ions of the atom. Uniform pressure combined with counter-stress forces results in the distortion of crystal structure and prevents the rotation of the crystal into an equilibrium position as in part occurs in present rolling practice. Pressure and heat are of significant importance to give sufficient structural strength to overcome internal stress and the plasticity sufficient to weaken the crystal cleavage planes, allowing definite slip by definite, though minute, movement, all the while holding the displacement until "frozen" in the stressed relations. Annealing partly or completely normalizes these strains depending upon the degree and uniformity of temperature and the duration of the annealing.

Certain premises are set up, on the basis of which, the present invention is unusually and unexpectedly efficient. Electrical steels must have definite orientation of grain structure as well as uniform strain after the anneal. The critical point between these two attributes, that is, the balance between them, determines the degree or amount of watt loss. In a fine grain steel, adjustment of grain and the beginning of stress is not detectable until elongation of approximately 8%. Extreme elongation of 50% or more produces a grain relatively unfavorable to stress or crystal slip and, therefore, many metals will harden by proportional elongation and the higher Brinell values result in part by the grain adjusting itself to positions unfavorable to further slip. At about 70% elongation of the more ductile metals, rupture will occur and thus the maximum or limit of crystal slip is indicated.

According to the present invention, a good silicon alloy is rolled, preferably in packs, to about one gauge heavy (#28 U. S. S.). The alloy is reheated at approved temperatures, as per curve chart, say up to 1500° or 1600° F. and then given two passes on an Otte compound stressing mill with (balance screw and stress levers) the same side of the sheet always to the same side of the roll, the rolls being driven at different surface speeds or being of different diameters and with a counter-pressure at 45° to 65° to the line of metal flow. The Otte stressing mill consists of two rolls either of different diameters driven at the same speed, or of the same diameters driven at different speeds, so as to give a different peripheral speed for each roll. The sheets rolled in a mill of this kind receive a different amount of work by each roll, which would tend to stress the sheet. It has been found that by using a set up of this kind that the flow lines of the sheet have a different direction than when two rolls of the same diameter and driven at the same speed are used. By proper reg-

ulation of the speed of the two rolls, or by proper regulation of the diameters the direction of these flow lines can be made to assume angles of 45° and 65° to the axis of the sheet. When such a condition in the mill is obtained it has been found that the pressure is exerted at these angles. The action of the stressing mill, by virtue of the different peripheral speeds of the two rolls, is a kneading action which breaks up the structure of the metal and introduces desirable stresses. The next step is an immediate passing through straightening rolls, preferably with the sheet temperature about the point of recalescence, that is, around 800° to 900° F. Annealing at about 1550° F. follows.

The cost per ton to roll and anneal under the above process will not vary appreciably from the cost of manufacturing the low grades of electrical steels as made today.

The above is intended to be illustrative and not limitative and I may vary the details and application of the invention considerably without departing from its spirit and scope. It is to be understood that the amount of normal pressure, secondary stress, the angle of counterpressure, area of metal stressed at normal pressure under rolls, temperature of rolling and annealing are all subject to variation as dictated or warranted by proper and good practice. The mills may be of two, three, and/or four roll high units and charts and temperature curves may be used or made for plainness and simplicity.

What I claim as new and desire to secure by Letters Patent is:

1. In a process of the character described, the steps of finishing silicon steel sheets at about the temperature of recalescence and subjecting the opposite sides of such sheets to rollers having unequal effective surface speeds.

2. In a process of the character described, the steps of heating a silicon steel sheet to a temperature not lower than the ordinary reheating temperature and in passing the reheated sheet between reducing rolls which cause, to opposite sides of the sheet, unequal forward slippage resulting in differential elongation in opposite sides of the sheet.

3. In a process of the character described, the step of stressing unequally the opposite sides of a sheet of silicon steel undergoing final mechanical reduction.

4. In a process of the character described, the step of simultaneously subjecting the opposite sides of a sheet of silicon steel to rolls imparting unequal stresses thereto during the final mechanical reduction of the sheet.

5. The process of treating electrical silicon alloy steels for reducing the watt loss which includes the steps of rolling the alloy to gauge, reheating to 1500 to 1600° F., passing through a roll pass and subjecting the

steel to a stressing pressure for orienting the crystals at angles of 45° to 65° to the axes of the steel, straightening at 800° to 900° F., and annealing at about 1550° F.

6. A process of treating silicon steel to reduce its watt loss including the steps of rolling the steel to gauge, reheating it, stressing its opposite sides unequally, and thereafter straightening and annealing.

7. A process of treating silicon steel to reduce its watt loss including the steps of rolling the steel to gauge, reheating it to about 1500-1600° F., stressing it unequally on opposite sides, straightening it at about 800-900° F., and annealing at about 1550° F.

8. A process of treating silicon steel to reduce its watt loss including the steps of rolling the steel to gauge, reheating it, passing it through a compound stressing mill to impart unequal stresses to opposite sides of the steel, straightening the so stressed steel and then annealing it.

9. A process of treating silicon steel to reduce its watt loss including the steps of rolling the steel to gauge, reheating it, passing it at least twice in the same relation through a compound stressing mill to impart unequal stresses to opposite sides of the steel, straightening the same and annealing it.

10. In a process of the character described, the steps of finishing silicon steel sheets at about the temperature of recalescence and subjecting such sheets to such mechanical working that the metal flow at the surface of one side of each sheet adjacent the line of greatest reduction is retarded with relation to the metal flow at the surface of the other side of the same sheet adjacent said line of greatest reduction.

11. The process of treating silicon steel comprising rolling it to gauge, reheating it, subjecting it to the action of a compound stressing mill to impart a counterpressure of 45° to 65° to the line of metal flow, straightening at about the temperature of recalescence and annealing.

In testimony whereof, I have hereunto subscribed my name this 26th day of September, 1929.

OTHO M. OTTE.