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COLD ROLLED SILICON STEEL STRIP

Weston Morrill, Pittsfield, Mass., assignor to General Electric Company, a corporation of New York

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The present invention relates to cold rolled silicon steel strip and more particularly to cold rolling silicon steel strip at temperatures far below those heretofore employed in the production of such material. Processes heretofore employed in cold rolling silicon steel strip are set forth in the patent to Smith No. 1,915,766, June 27, 1933, and in the patent to Goss No. 1,965,559, July 3, 1934. While the Smith process usually employs only one cold reduction the process generally employed in the production of cold rolled strip for use in transformer cores is that disclosed in the Goss patent and comprises two cold rolling steps with intermediate normalizing at about 925° C. for a few minutes and, after the final cold reduction, a normalizing treatment at about 1100° C. in hydrogen for about four minutes.

It is one of the objects of the present invention to increase the permeability and reduce the total watt losses in cold rolled silicon steel strip.

In a process such as disclosed in the Goss patent, the first cold rolling reduces the silicon steel from about .080 inch to .030 inch and the second or final cold rolling effects a reduction from .030 inch to .011 inch. Although the rolling operation is generally designated "cold" rolling the temperature of the material during rolling is generally about 80° C. and in many cases well above 100° C.

I have found that if the cold rolling of silicon steel strip is carried out at lower temperatures, for example by maintaining the temperature of the steel within the range of 20° C. to —30° C. during the rolling operation, a considerable improvement is obtained both in the permeability and total watt losses of the steel. The following table shows the results of permeability tests on silicon steel strip containing 2.96% silicon which was given two cold reductions at temperatures of —30° C., 0° C., 100° C. and 200° C., with intermediate and final normalizing treatments as set forth above:

Rolling temperature	Maximum permeability
NORMALIZED AT 1100° C.	
—30° C.	16,060
0° C.	13,170
100° C.	10,780
200° C.	9,000

When the steel strip was thereafter given a stabilizing anneal at about 850° C. in hydrogen, the following results were obtained:

Rolling temperature	Maximum permeability
—30° C.	18,640
0° C.	18,540
100° C.	16,620
200° C.	12,980

These figures indicate clearly that the temperature at which cold rolled silicon strip is produced has an important bearing on the permeability of the rolled material. Rolling silicon steel strip at temperatures of about 20° C. or lower also effects a reduction of about 10 to 15% in the hysteresis loss in the steel at 15,000 B. Moreover the exciting current at 15,000 B. of material rolled at 0° C. is about one-half and the permeability about twice that of the material rolled at 100° C.

Still further improvement in the magnetic properties of the cold rolled steel may be obtained if the steel after being normalized as usual in hydrogen at about 1100° C. is normalized for a few minutes at about 800° C. in a strongly oxidizing atmosphere or is annealed for a few hours at about 850° C. in a mildly oxidizing atmosphere. The effect of these heat treatments is to stabilize the steel by reducing some of the carbon in the steel thereby eliminating the possibility of ageing. While the improvement in magnetic properties obtained by the re-normalizing treatment or subsequent anneal at 850° C. is particularly effective in silicon steel which has been rolled at temperatures between 20° C. and —30° C., this heat treatment is also effective in reducing the watt losses in any cold rolled silicon steel irrespective of the particular temperature employed in the cold rolling.

When more than one cold rolling step is employed the final cold rolling temperature appears to be more important than the temperature employed in the first cold rolling operation. The following table shows the effect on watt losses at 60 cycles and 10,000 B. and 15,000 B. obtained with 3% silicon steel strip cold rolled in two steps at temperatures of 80° C. Likewise the table shows the effect of two cold reductions at 0° C. and the effect of a first reduction at 80° C. and a second reduction at 0° C. In each case the first cold reduction was from .080 to .030 inch and the second cold reduction from .030 to .012 inch. In each case the strip was normalized at 925° C. for five minutes in a hydrogen atmos-

phere after the first cold reduction and was normalized at 1100° C. for three minutes in a hydrogen atmosphere after the second cold reduction.

First rolling	Second rolling	Watt losses	
		10,000 B.	15,000 B.
°C.	°C.		
80	80	.53	1.18
80	0	.48	1.08
0	0	.49	1.08

Where a cold reduction of the silicon steel strip is effected in one operation, as in Smith patent, the temperature for the cold reduction should be in the range of 20° C. to −30° C. for best results. Likewise, if two or more cold reductions are employed, as in Goss patent, it is essential that a temperature in the range of 20° C. to −30° C. be employed in the second or final cold rolling operation in order to obtain the best magnetic characteristics in the steel strip.

In addition to the improvement in permeability and watt losses which may be obtained by rolling silicon steel strip at very low temperatures, I have also found that silicon steel strip containing about 3% silicon rolls easier at 0° C. than the same material rolled at temperatures of −30° C., 100° C., 200° C. or 460° C. This latter result is of course contrary to what would be expected.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In cold rolling silicon steel strip, the step which comprises maintaining the temperature of the steel within the range of 20° C. to −30° C. during the rolling operation.

2. In cold rolling silicon steel strip, the step which comprises maintaining the temperature of the steel strip about 0° C. during the rolling operation.

3. In cold rolling silicon steel strip containing about 3% silicon, the steps which comprise effecting successive reductions of approximately 60 to 70% in the steel, the temperature of the steel being maintained within the range of 20° C. to −30° C. during each of said reductions.

4. In cold rolling silicon steel strip, the steps which comprise effecting successive reductions of approximately 60 to 70% in the steel, the temperature of the steel being maintained within the range of 20° C. to −30° C. during the final reduction.

5. In cold rolling silicon steel strip, the steps which comprise effecting successive reductions of approximately 60 to 70% in the steel, the temperature of the steel being maintained within the range of 0° C. to −30° C. during the final reduction.

6. In cold rolling silicon steel strip, the steps which comprise rolling the steel at a temperature in the range of 20° C. to −30° C. normalizing the steel at about 1100° C. and thereafter annealing the steel, the temperature of the steel being maintained within the said range during the rolling operation.

7. In cold rolling silicon steel strip, the steps which comprise rolling the steel at a temperature within the range of 20° C. to −30° C., normalizing the steel at about 1100° C. in a reducing atmosphere and thereafter heat treating the steel to reduce some of the carbon in the steel, the temperature of the steel being maintained within the said range during the rolling operation.

8. In cold rolling silicon steel strip, the steps which comprise rolling the steel at a temperature within the range of 20° C. to −30° C., normalizing the steel at about 1100° C. in a reducing atmosphere and renormalizing the steel for a few minutes at about 800° C. in a strongly oxidizing atmosphere, the temperature of the steel being maintained within the said range during the rolling operation.

9. In cold rolling silicon steel strip, the steps which comprise rolling the steel at a temperature within the range of 20° C. to −30° C., normalizing the steel at about 1100° C. in a reducing atmosphere and thereafter annealing the steel at about 850° C. for a few hours in a mildly oxidizing atmosphere, the temperature of the steel being maintained within the said range during the rolling operation.

WESTON MORRILL.