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UNITED STATES PATENT OFFICE

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MAGNETIC MATERIAL

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The present invention relates to magnetic material and more particularly to nickel-iron alloys and to a method for treating such alloys so as to obtain therein desirable magnetic qualities, such as low total watt loss, when employed as the core material of constant potential power transformers.

In my copending application, Serial No. 290,889, filed July 6, 1928, I have disclosed a nickel-iron alloy having a low total watt loss. The method for obtaining the product disclosed in my prior application consists briefly in melting nickel and iron in certain proportions in an atmosphere substantially free from nascent nitrogen, rolling the alloy into sheet form and annealing the sheets in a non-oxidizing atmosphere at temperatures varying from about 1200 to 1300° C. When subjected to the above process, the annealed alloy has a hysteresis loss that is less than .23 watts per pound and when in sheets about 14 mils thick a total watt loss that is less than .4 watts per pound when tested at B = 10,000 gausses and at 60 cycles.

The heat treatment employed in my prior process involves the use of relatively high temperatures which are always expensive and usually inconvenient. It is one of the objects of the present invention to provide a relatively low temperature process for producing a nickel-iron alloy which in sheet form has an unusually low total watt loss and which is suitable for use as a core material for distribution transformers and the like. Other objects will appear hereinafter.

According to the present invention, my improved alloy consists of about 40 to 50% nickel and about 60 to 50% iron. Ordinarily, in manufacturing the alloy electrolytic nickel may be employed with iron which may contain a relatively small amount of impurities, for example about .05 carbon and less than .02 sulphur. If the iron contains a greater amount of these impurities, it is refined to approximately the above composition. The materials comprising the alloy are preferably melted either in an open hearth furnace or in an induction furnace and in an atmosphere substantially free from nascent nitrogen. A reducing atmosphere, for example hydrogen, may be employed in the melting furnace although a vacuum or other non-oxidizing environment may be employed if desired. It will usually be found more advantageous to employ an induction furnace rather than an open hearth furnace, since the former permits more accurate control of the atmosphere employed, for example hydrogen or vacuum.

The resulting ingot is heated to a temperature of about 1200° C. passed through a bar mill and cut into sheet bars. These bars are then heated to a temperature of about 1100° C. and rolled on a sheet mill into sheets about 14 mils thick. The final or finishing pass through the sheet mill is of considerable importance. For best results, the finishing pass should be made with the sheets heated to a temperature of about 600° to 700° C. and should effect a reduction of about 5 to 10% but preferably 5 to 7% in the thickness of the material.

When the sheets have been reduced to the desired thickness, i. e. about 14 mils, they are annealed, preferably in a hydrogen atmosphere or in a non-oxidizing environment at a temperature which may vary from about 900° C. to about 1100° C. When hydrogen is employed as the gaseous atmosphere it should preferably be dry, free from oxygen, and flow slowly through the furnace. With a temperature of about 900° C. the annealing period may be from about 5 to about 10 hours although generally not more than 6 hours will be required. With a temperature such as 1100° C. the annealing period will be appreciably shorter, for example one to two hours.

At the end of the annealing period, it is desirable for best results that the sheets be cooled down to about 600° C. at a rate which exceeds normal furnace cooling, (i. e. about 1.5° C. per minute) but at a rate less than 100° C. per minute. The preferred rate of cooling is from 60 to 80° C. per minute. The sheets are then cooled slowly from 600° in air to room temperature.

The product obtained by the above process when in sheets about 14 mils thick has generally a total watt loss which is less than

.3 watts per pound when tested at 10,000 gausses and 60 cycles and a hysteresis loss which may be in the neighborhood of .15 or under.

Satisfactory results may be obtained with a composition consisting of about 46% nickel and about 54% iron. If desired, a small amount of manganese or silicon, preferably manganese, up to about 3% may be added to the nickel iron alloy in order to reduce the eddy current losses in the sheet material. The addition of manganese or silicon in amounts up to 3% does not materially affect the hysteresis loss. More than 1% of manganese or silicon however adversely affects permeability at working densities. A composition consisting of about 45% nickel, about 1% manganese and about 54% iron when treated as hereinbefore described gives generally the lowest hysteresis and eddy current losses consistent with a high permeability at working densities, i. e. 10,000 to 15,000 gausses at 60 cycles. A low sulphur content, for example less than .02%, is desirable in order to obtain the best results.

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

1. The method of making a nickel iron magnetic alloy which comprises melting the materials comprising the alloy, rolling the alloy into sheets, annealing the sheets at a temperature between about 900° C. and 1100° C. and cooling the sheets to about 600° C. at a rate greater than 1½° per minute but less than 100° C. per minute.

2. The method of making a magnetic alloy which comprises melting about 40% to about 50% nickel with about 60% to about 50% iron, rolling the resulting alloy into sheet form and annealing the sheets in a non-oxidizing environment at a temperature between about 900° C. and 1100° C. and cooling the sheets to about 600° C. at a rate varying from about 60° to 80° per minute.

3. The method of making a nickel iron magnetic alloy which comprises melting about 40% to 50% nickel with about 60% to 50% iron, rolling the alloy, while heated at an elevated temperature, into a sheet about 14 mils thick, the temperature of the sheet being between 600° C. and 700° C. during the finishing pass through the sheet mill, and annealing the sheet in a non-oxidizing environment at a temperature varying from about 900° C. to 1100° C.

4. The method of making a magnetic alloy which comprises melting about 40% to 50% nickel with about 60% to about 50% iron, rolling the alloy at an elevated temperature into sheets having a thickness of about 14 mils, the finishing pass through the sheet mill being made with the sheets heated to a temperature between 600° C. and 700° C. and effecting a reduction of about 5% to 10% and annealing the sheet material in a non-oxidizing environment at a temperature varying from 900° C. to 1100° C.

5. The method of making a magnetic alloy which comprises melting about 40% to 50% nickel with about 60% to 50% iron in a non-oxidizing environment, rolling the alloy into sheets having a thickness of about 14 mils, the finishing pass through the sheet mill being made with the sheets heated to a temperature between 600° C. and 700° C. and effecting a reduction of about 5% to 10% in thickness, annealing the sheet material in a hydrogen atmosphere at temperatures varying from about 900° C. to 1100° C. and cooling the sheets to about 600° C. at a rate of about 60° C. to 80° C. per minute.

6. The method of making a magnetic alloy which comprises melting about 40% to 50% nickel and about 60% to 50% iron in an atmosphere substantially free from nascent nitrogen, rolling the resulting ingot into bars and then into thin sheets about 14 mils thick, the finishing pass on the sheet mill effecting a reduction of 5% to 10% in the thickness of the material, the sheets being heated to a temperature between 600° C. and 700° C. annealing the sheets in a non-oxidizing environment at a temperature varying from about 900° C. to 1100° C. and cooling the sheets to about 600° C. at a rate greater than 1½° C. per minute but less than 100° C. per minute.

7. A constant potential transformer having a laminated core, said laminations consisting substantially of 40% to 50% nickel and from 60 to 50% iron, said laminations, when substantially 14 mils thick, having a total watt loss less than .3 watts per pound when tested at 10,000 gausses and 60 cycles.

8. A laminated magnetic core material consisting substantially of 40 to 50% nickel and from 60 to 50% iron, said laminations when substantially 14 mils thick having a total watt loss less than .3 watts per pound when tested at 10,000 gausses and 60 cycles.

9. A nickel iron magnetic alloy in sheet form, said alloy when in sheets 14 mils thick having a total watt loss less than .3 watts per pound and a hysteresis loss of .15 watts per pound or less when tested at 10,000 B and 60 cycles.

In witness whereof, I have hereunto set my hand this 10th day of June, 1930.

WILLIAM E. RUDER.