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MAGNETIC MATERIALS AND METHODS OF
MAKING SUCH MATERIALSJohn W. Andrews, Westfield, N. J., assignor to
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7 Claims. (Cl. 75—22)

This invention relates to magnetic materials and methods of making such materials.

Objects of the invention are to provide magnetic materials having good magnetic properties and effective and efficient methods of making such materials.

In accordance with one embodiment of the invention from 5% to 20% of copper is alloyed with nickel and iron to produce a magnetic material having a high resistivity and a fine crystal structure which facilitates pulverizing the material for compressed dust cores.

Other objects and advantages will appear as the description proceeds.

15 In carrying out the present invention, a magnetic material is compounded from nickel, iron and copper to produce an alloy containing from 60% to 85% nickel, 5% to 20% copper, and the balance substantially iron. Even though the nickel and iron are relatively pure, the nickel usually contains some sulphur and the iron contains fractional percentages of carbon, manganese, silicon, sulphur, and phosphorus, and the total cobalt content from the nickel and iron usually runs in the neighborhood of .75%. The nickel, iron and copper are melted together under a covering of lime and fluorspar slag to which iron oxides are added either in the form of Fe_2O_3 or Fe_3O_4 . The iron oxide tends to oxidize impurities and gases in the molten alloy and during this oxidation the brittleness of the alloy changes from a state in which it is too ductile or tough to a state in which it is too brittle. Ferro-manganese is then added to the melt in order to return the alloy to the proper degree of brittleness and the manganese also appears to control the effectiveness of the sulphur content in addition to its action as a deoxidizing agent. Obviously other methods of oxidizing the molten bath may be used as the bubbling or blowing of oxygen or air through the bath, and other decarburizing agents such as aluminum, silicon, chromium or magnesium may be used.

45 The alloy thus prepared is cast into ingots which are rolled while hot until the material breaks into fragments which are quenched to produce a fine crystalline structure. The addition of the copper to the nickel-iron alloy produces an extremely fine crystalline structure which is very desirable since the disintegration of the material takes place at the crystal boundaries and consequently the smaller the size of the crystals, the finer the size of the dust which can be produced from the product. The fragments of magnetic material thus produced are reduced

to a finely divided form or dust in a hammer mill or other suitable reducing apparatus and subsequently pulverized in an attrition mill.

The dust from the attrition mill is sifted and passed through a fine mesh sieve. In some cases a 300 mesh sieve is used. The dust is then subjected to a heat treatment at a temperature from 1400° F. to 1600° F. or higher to remove the strains introduced into the magnetic material by the grinding operation. A small quantity of finely pulverized and roasted magnesium silicate or talc is mixed with the magnetic particles during the heat treatment to prevent sintering. The particles are then insulated with an insulating composition comprising .066% magnesium hydroxide, .32% sodium silicate, and .93% talc by weight of the magnetic material. This insulation is applied in a water solution and is preferably applied in several coatings. After the dust has been insulated, the magnetic material is formed into cores by subjecting it to a pressure in the neighborhood of 200,000 pounds per square inch. During the application of this pressure, the magnetic particles are again subjected to strains which impair the magnetic properties thereof and, therefore, the cores are again subjected to an annealing heat treatment by heating the cores, preferably in a hydrogen atmosphere, to a temperature from 1000° F. to 1200° F. In this heat treatment the insulating material also appears to become fully cured.

In the preferred form of the invention an alloy is used containing 69% to 74% of nickel and from 10% to 15% of copper and the balance substantially iron. It appears that the nickel, iron and copper form a ternary alloy in which the three components are in solid solution, which has a markedly higher resistivity than any of the components.

Two important factors in the reduction of losses in magnetic cores are the resistivity of the magnetic particles and the size of the particles since both of these factors tend to reduce eddy current losses. The addition of the copper to the nickel-iron alloy improves both of these factors. With the higher percentages of copper the metal tends to become more ductile and if substantially more than 20% of copper is used, the alloy becomes too ductile to pulverize. It also appears that the inductance stability of the alloy decreases at the higher copper values.

It will be understood that the nature and embodiments of the invention herein described are merely illustrative and that many changes and modifications may be made therein without de-

parting from the spirit and scope of the invention.

What is claimed is:

1. A magnetic core of finely divided and insulated magnetic particles compressed to form a core, the magnetic particles comprising a pulverized nickel-iron alloy containing from 5% to 20% copper, 60% to 85% nickel, and the balance mainly iron.
2. A method of making magnetic material, comprising adding an embrittling agent to a molten charge of nickel, iron, and copper, casting an ingot, rolling the ingot to break it into fragments, pulverizing the fragments to produce particles having a high resistivity and fine crystal size, and uniting the particles to form a core.
3. A method of making a magnetic core, which comprises compounding a nickel-iron alloy containing from 5% to 20% of copper, embrittling the alloy, pulverizing the embrittled alloy to produce magnetic particles having a high resistivity and fine crystal size, and uniting the particles to form a core.
4. A method of making a magnetic core, which

comprises compounding a molten alloy of substantially 60% to 85% nickel, 5% to 20% copper, and the balance substantially iron, oxidizing the alloy, casting the alloy into ingots, hot rolling the alloy to break it into fragments, and forming a core from the material.

5. A magnetic core of finely divided and insulated magnetic particles compressed to form a core, the magnetic particles comprising a nickel-iron alloy containing from 10% to 15% copper, 60% to 85% nickel and the balance iron.

6. A magnetic core of finely divided and insulated magnetic particles compressed to form a core, the magnetic particles comprising an alloy of 69% to 74% nickel, 10% to 15% copper, and the balance substantially iron.

7. A method of making magnetic cores of the kind composed of pulverized and compressed nickel iron alloy which comprises the steps of adding between 5% and 20% of copper to the nickel and iron in order to decrease the crystalline size before pulverizing it, and then working the alloy to pulverize it.

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