106. COMPOSITIONS, COATING OR PLASTIC

CROSS REFERENCE

Examiner

84-M

Patented Jan. 9, 1934

1,943,115

UNITED STATES PATENT OFFICE

1,943,115

ELECTRICAL INSULATION FOR MAGNETIC BODIES

William C. Ellis, Malverne, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

No Drawing. Application May 24, 1933 Serial No. 672,643

8 Claims. (Cl. 175—21)

This invention relates to electrical insulation and particularly to the electrical insulation of finely divided magnetic material in magnetic bodies, such as magnetic cores for loading coils and the like.

The object of the invention is to improve the magnetic, electrical and mechanical characteristics of magnetic bodies of the type employing magnetic material in finely divided form.

Magnetic cores, made from finely divided magnetic material, so-called magnetic dust cores, are extensively used for the loading coils which are inserted in telephone lines to improve their transmission characteristics. Such cores are usually constructed by subjecting magnetic dust particles and an insulating and binding material between the magnetic particles to extremely high pressures in the neighborhood of 200,000 lbs. per square inch, so as to form the component materials into a substantially homogeneous mass in the desired core form, and to give sufficient mechanical strength to the completed core. The insulation between the magnetic particles is provided, in general, for the purpose of reducing eddy current losses in the core.

In the case especially where the magnetic material in a core made in the above described manner is a magnetic alloy including nickel and iron, it has hitherto been found desirable to subject the core to a subsequent heat treatment at a high temperature to remove the strains introduced in the magnetic material by the pressing operation, which tend to impair the magnetic properties of the magnetic alloy in the core. It is desirable, therefore, that the insulating material used in the core be such as will bind the magnetic materials firmly together, and such as will withstand without deterioration the high pressures and temperatures to which it will be subjected during the construction of the core. It is desirable also that the insulating material in the core be such as will not deteriorate under the conditions to which the loading coils are subjected in service.

In accordance with the invention it has been found that magnetic cores having extremely good magnetic, electrical and mechanical characteristics may be produced by use of insulating and binding material comprising colloidal clay, milk of magnesia and sodium silicate.

Other objects and the advantages of the invention will become apparent from the following detailed description thereof.

In practicing the present invention, the magnetic material is preferably prepared from a brittle alloy containing nickel and iron, with or without the addition of other constituents, and commonly known as "permalloy." The alloy may be prepared in the manner described in Patent No. 1,669,649 issued May 15, 1928 to C. P. Beath and H. M. E. Heinicke, wherein approximately 81 parts of nickel and 19 parts of iron and other magnetic materials are melted together in an oxidizing atmosphere and the resulting alloy poured into a mold. The alloy thus prepared is rolled while still hot into relatively thin slabs which are quenched rapidly in water to produce a fine crystalline structure which is desirable since the disintegration of the material takes place at the crystal boundaries and consequently the smaller the size of the crystal the finer the dust which can be produced therefrom. The slabs of alloy material so produced are then broken into short pieces and the pieces reduced to more finely divided form in any suitable manner, for example, by crushing in a rock crusher, hammer mill or other suitable apparatus, after which the crushed material is reduced to dust in an attrition or ball mill. The resulting dust is then sifted and the portion passing through a 120 mesh sieve is suitable for use as core material. That portion which will not pass through the 120 mesh sieve is returned to the ball or attrition mill for further rolling or grinding, this process being repeated until a sufficient quantity of the very fine dust is obtained. Prior to the addition of the insulating material, the finely divided particles of the alloy so obtained are annealed in a closed container at a temperature of aproximately 885 degrees C. The annealed dust is removed from the container in the form of a cake which is reduced to a powder of suitable fineness by crushing and grinding or rolling, and sifting through a 120 mesh sieve. The annealed dust is then insulated with the insulating material of the invention in the manner described below.

A typical insulation in accordance with the insulating material of the invention in the manner described below.

A typical insulation in accordance with the invention would have the following weights of insulating material per 100 grams of magnetic dust material:

	Grams
Colloidal clay	0.77
Sodium silicate	0.64
Milk of magnesia	2.11

The relative proportions of insulating and magnetic dust materials used may vary somewhat from these values depending upon the fineness of the dust, the kind of magnetic material used therein and the final core characteristics desired. Experiments indicate that for the best results in the production of cores for loading coils for low frequency telephone circuits, the amounts of the component insulating materials would be within the following limits: Colloidal clay, 0.1 to 1.1 grams, sodium silicate, 0.1 to 1.3 grams and milk of magnesia, 0.25 to 6.3 grams per 100 grams of magnetic dust.

In applying the insulation, the colloidal clay is first preferably mixed with magnetic dust either dry or in a water suspension. The milk of magnesia is added to the mixture in a water suspension formed by diluting the commercial product which comprises 32 to 40 grains of magnesium hydroxide, $Mg(OH)_2$, per fluid ounce. A 50 per cent solution of sodium silicate preferably having a silicate to soda ratio of about 1.6 although other ratios have been found to give good results also, is added to the mixture in a dilute water solution. The additional water is provided to insure complete mixing. Usually about 20 cc of liquid per 100 grams of dust is sufficient. The mixture is then evaporated to a condition of complete dryness with constant stirring to prevent caking and to insure a thorough coating of the individual dust particles. To obtain complete drying of the magnetic material, it may be desirable to apply heat thereto at a temperature of 120° C. or higher for a short time.

The insulation may be applied all at one time or in stages, so as to obtain several layers of the same insulating materials on the magnetic particles, in the manner disclosed, for example, in the patent to Lathrop 1,857,201, issued May 10, 1932. Three stages of insulation have been found to give very good results.

A variation of the multiple-coat method of insulating disclosed in the Lathrop patent has been found to be particularly suitable with the colloidal clay—milk of magnesia—sodium silicate insulation. According to this variation, one half of the total amount of colloidal clay and all of the milk of magnesia and sodium silicate is used for applying the insulating coatings to the magnetic dust particles by the multiple-coat method, and then the coated magnetic particles are mixed with the remaining half of the colloidal clay and the mixture compressed to form the core part. For example, where the insulating coatings are applied in three stages and the proportions of the insulating material are as given above, the procedure is as follows:

With every 100 grams of magnetic dust particles, 0.13 gram of colloidal clay, dry or in a water suspension, is first mixed; then 0.70 gram of the milk of magnesia in dilute water suspension and 0.21 gram of sodium silicate in dilute water solution are added to the mixture. The resulting mixture is then evaporated to a condition of complete dryness with constant stirring to apply the first insulating coating to the magnetic dust particles. The coated magnetic particles are then mixed with an additional 0.13 gram of colloidal clay, an additional 0.70 gram of milk of magnesia in a dilute water suspension and an additional 0.21 gram of sodium silicate in a dilute water solution are added thereto and the whole evaporated again to dryness with constant stirring to form the second layer of insulation on the magnetic dust particles. Then the resulting coated magnetic dust particles are mixed with 0.13 gram of colloidal clay, the remaining 0.70 gram of milk of magnesia in a dilute water suspension and the remaining 0.21 gram of sodium silicate in dilute water solution are added to the mixture and the whole evaporated to dryness to form the third layer of insulation on the magnetic particles.

The magnetic dust particles insulated in the above described manner are then mixed with 0.38 gram of colloidal clay, placed in a mould and compressed into core parts under a pressure of approximately 200,000 pounds per square inch. The core parts are then transferred to an annealing furnace where they are annealed at a high temperature preferably in hydrogen or in an inert atmosphere to relieve the internal stresses set up in the material by the pressing operation, thereby producing a core having low hysteresis loss. Where the annealing heat treatment is carried out in air, the core parts are preferably subjected to a temperature of approximately 500° C. for about 45 minutes. When the annealing heat treatment is carried out in hydrogen which enables higher annealing temperatures to be used, the core parts are preferably subjected to a temperature of approximately 650° C. for about 60 minutes. The usual loading coil toroidal windings are wound on the single core parts thus produced or on a plurality of said core parts stacked coaxially. The number of core parts used in a given core will depend upon the existing electrical characteristics of the telephone circuit with which the loading coils are to be associated.

A large number of core parts made by the above described methods and in which the magnetic material is an alloy containing approximately 81 per cent nickel, 17 per cent iron and 2 per cent molybdenum were tested by well known methods and found to have permeabilities ranging from 120 to 160 and sufficiently low hysteresis and eddy current losses as to be satisfactory for use as cores in coils for loading voice frequency telephone circuits.

The colloidal clay—milk of magnesia—sodium silicate insulation of the invention is also suitable for use in magnetic dust cores for coils employed for transmitting higher frequency signal currents, for example, carrier frequency and radio frequency signal currents. As the proportions and kinds of magnetic metals used in the magnetic alloy dust, the fineness of the dust and the pressures and the temperatures of the annealing heat treatments in the process for producing such cores may be different from those used in the case of cores for low frequency coils, different amounts and relative proportions of the constituent materials in the insulation than those specified above may be required for the best results.

It is to be understood that the invention is not limited to the particular magnetic materials and the specific proportions of the magnetic and insulating materials, above mentioned, which were given by way of example only, but that it is of a generic nature applicable to all magnetic materials and to various proportions of the constituent insulating materials. It is to be understood also that the method of applying the insulating material may be varied somewhat from that described above without departing from the spirit of the invention which is limited only within the scope of the appended claims.

What is claimed is:

1. A magnetic body comprising finely divided particles of a magnetic material and insulation between the particles produced by mixing the

106. COMPOSITIONS, COATING OR PLASTIC
84
CROSS REFERENCE
Examiner

magnetic particles with colloidal clay, milk of magnesia and sodium silicate in a volatile liquid and evaporating the mixture to dryness.

2. A magnetic body comprising finely divided particles of a magnetic alloy including nickel and iron and insulation between the alloy particles produced by mixing with the alloy particles colloidal clay, milk of magnesia and sodium silicate in water and evaporating the mixture to dryness, the whole compressed into a substantially homogeneous solid. and thereafter heat treated at a high temperature to improve the magnetic characteristics of the alloy.

3. A magnetic body comprising finely divided particles of a magnetic alloy comprising approximately 81 per cent nickel, 17 per cent iron and 2 per cent molybdenum, and insulation between the alloy particles formed by mixing with said alloy particles and water approximately 0.77 gram of colloidal clay, 2.11 grams of commercial milk of magnesia and 0.64 gram of a 50 per cent solution of sodium silicate for each 100 grams of alloy particles, and evaporating the mixture to dryness, the whole compressed into a substantially homogeneous solid and subsequently annealed in an inert gas at a temperature of approximately 650° C. for about sixty minutes.

4. The process of making a magnetic body which consists in mixing finely divided magnetic material with colloidal clay, milk of magnesia and sodium silicate in a volatile liquid, evaporating the mixture to dryness to form insulating coatings on the magnetic particles, subjecting a mass of the insulating particles to high pressure to form it into a substantially homogeneous solid in the desired shape, and then heat treating the solid to improve the magnetic properties of the magnetic material therein.

5. The process of making a magnetic body which consists in first mixing finely divided magnetic material with colloidal clay, mixing the resultant mixture with milk of magnesia and sodium silicate in a volatile liquid, evaporating the whole to dryness while stirring to form insulating coatings on the magnetic particles, subjecting a mass of the insulated particles to high pressure in a mold to produce a substantially homogeneous solid in the desired form, and heat treating the solid to improve the magnetic properties of the magnetic material therein.

6. The process of making a magnetic body having high permeability and low hysteresis and eddy current losses which consists in mixing with each 100 grams of finely divided particles of a magnetic alloy comprising approximately 81 per cent nickel and 19 per cent other magnetic material, principally iron, approximately 0.38 gram of colloidal clay, 2.11 grams commercial milk of magnesia and 0.64 gram of a 50 per cent solution of sodium silicate having a silicate to soda ratio of approximately 1.6, evaporating the mixture to dryness while stirring to produce insulating coatings on the individual magnetic particles, mixing the coated particles with approximately 0.38 gram of colloidal clay for each 100 grams of alloy, compressing the resulting mixture to form the component materials into a substantially homogeneous solid and subsequently heat treating said solid in an inert gas at a temperature of approximately 650° C. for about one hour to improve the magnetic characteristics for the alloy material therein.

7. The process of making a mechanically strong magnetic body having high permeability and low hysteresis and eddy current losses which consists in mixing with each 100 grams of finely divided magnetic alloy comprising approximately 81 per cent nickel, 17 per cent iron and 2 per cent molybdenum, approximately 0.13 gram of colloidal clay, 0.70 grams of commercial milk of magnesia and 0.21 gram of a 50 per cent water solution of sodium silicate in a volatile liquid and evaporating the mixture to dryness while stirring to form a first insulating coating on the magnetic particles, repeating this insulating process to produce on the insulated magnetic particles a second and a third insulating coating each comprising the same kind and amount of insulating materials as in the first coating, then mixing the insulated magnetic particles with approximately 0.39 gram of colloidal clay, subjecting a mass of the resulting mixture in a mold to a high pressure in the neighborhood of 200,000 pounds per square inch to form the component materials into a substantially homogeneous solid in the desired form and subjecting said solid to an annealing heat treatment in an inert gas at a temperature of approximately 650° C. for about sixty minutes to improve the magnetic characteristics of the magnetic alloy material therein.

8. A magnetic core comprising finely divided particles of a magnetic alloy comprising approximately 81 per cent nickel and 19 per cent other magnetic metals principally iron, and insulation between the particles formed by mixing with said alloy particles and water from 0.1 to 1.1 grams colloidal clay, from 0.1 to 1.3 grams of a 50 per cent solution of sodium silicate having a silicate to soda ratio of approximately 1.6, and from 0.25 to 6.3 grams of commercial milk of magnesia for each 100 grams of alloy particles, and evaporating the mixture to dryness, the whole compressed into a substantially homogeneous solid and subsequently annealed at a high temperature to improve the magnetic characteristics of the alloy material therein.

WILLIAM C. ELLIS.