May 28, 1929. H. H. LOWRY 1,714,683

ELECTRICAL INSULATION

Filed Aug. 26, 1927

FIG. 1.

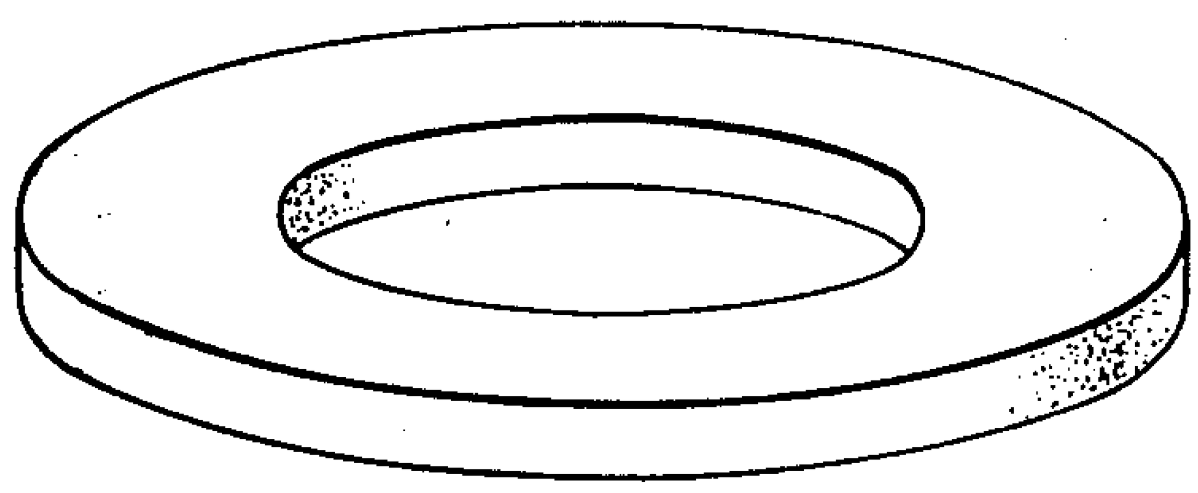
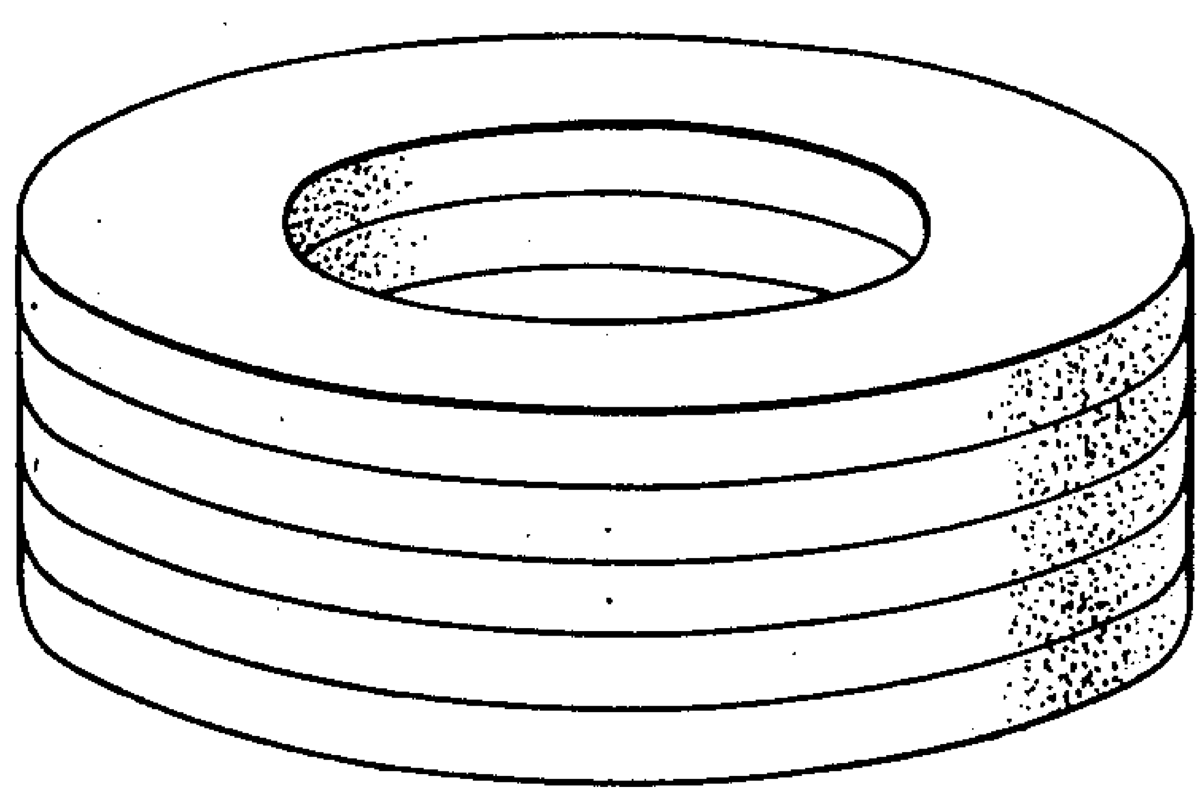


FIG. 2.



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UNITED STATES PATENT OFFICE.

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ELECTRICAL INSULATION.

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This invention relates to electrical insulation, and particularly to the insulation of magnetic particles used in the manufacture of magnetic cores for loading coils and the like.

Magnetic cores made from finely divided particles of magnetic material and pressed together, so-called magnetic dust cores, are being extensively used as cores for loading coils which are inserted in telephone lines to improve their transmission characteristics. To obtain the required electrical and magnetic properties, and sufficient mechanical strength in such cores, it has been found to be desirable to construct them by applying very high pressures, in the neighborhood of 200,000 pounds per square inch to the magnetic particles to form them into a homogeneous mass. In the case, especially, of cores made from magnetic alloys containing nickel and iron, it is desirable to subject the cores made in this manner to a subsequent heat treatment at a very high temperature to improve the magnetic properties of the magnetic material, and remove the strains produced therein due to the high pressures used, which has the tendency to reduce the desirable electrical and magnetic properties of the alloy in the core, which are otherwise obtainable. It has also been found to be desirable to insulate the magnetic particles from each other to reduce eddy current losses in the completed core.

In general, an insulating material to be suitable for insulating finely divided magnetic particles in cores requiring the mechanical and thermal treatment described above must be one which will have sufficient strength to withstand the shears encountered in the pressing operation, which will have an extraordinary resistance to decomposition by heat, i. e., a low dissociation pressure, and which will satisfactorily adhere to the magnetic particles so as to give a uniform distribution of the insulation throughout the core and satisfactory coherence between the insulated particles in the pressed core. In general, it has been found that those insulating materials which are thermally most stable and are otherwise satisfactory for the purpose lack the quality of adherence to the magnetic particles, that is, they do not serve as binding materials also, and it has been necessary to add binding materials to the insulating materials to remedy this difficulty. These additional binding materials may not contribute to the insulation, and may introduce variations which may adversely affect the electrical and magnetic properties of the final core or make necessary a more complicated and expensive treatment in manufacturing the core. For example, finely ground, fused silica, SiO_2, on account of its combination of excellent insulating properties and extremely low dissociation pressures at the temperatures used for annealing nickel-iron alloy materials in making magnetic cores for loading coils, has been suggested as an insulating material for the magnetic particles, but is not satisfactory for this purpose when used alone due to lack of the quality of adherence referred to, its use resulting not only in a non-uniform distribution of the insulation between the dust particles but also in a lack of coherence of the insulated dust in the completed core. When this material has been used for insulation in magnetic dust cores it has been necessary, therefore, to combine this insulating material with another material to serve as a binder.

In accordance with the present invention, it has been found that if hydrated silica, made chemically so as to be in a very finely divided state, is utilized for insulating the magnetic particles in magnetic cores, insulating coatings may be produced thereon which combine the excellent electrical insulating properties and the extremely low dissociation pressures at high temperatures characteristic of SiO_2, with the quality of adherence so that, when the particles are pressed into a core, the insulation is uniformly distributed throughout the core and the insulated particles cohere satisfactorily. It has been found that magnetic cores so insulated are mechanically very strong, and have such electrical and magnetic properties including a high permeability and low hysteresis and eddy current losses as to make them particularly suitable as cores for loading coils.

Briefly, the process of making cores in

accordance with the invention comprises mixing the finely divided magnetic particles and the finely divided hydrated silica in proper proportions, evaporating the mixture to dryness to form adherent insulating coatings on the particles, applying a high pressure to the coated particles to form them into a solid, homogeneous mass, and subsequently heating the compressed mass to improve the magnetic properties of the magnetic material.

The invention will be clear from the following more detailed description when read in connection with the accompanying drawing, in which Fig. 1 is a perspective view of a magnetic ring produced in accordance with the invention, and Fig. 2 illustrates a plurality of such rings stacked to form a magnetic core such as is used in connection with loading coils.

In carrying out the present invention the magnetic material is preferably prepared from an alloy containing nickel and iron. A preferred form of alloy contains 78-1/2% nickel and 21-1/2% iron. For a description of this and other alloys which may be used as core material, reference is made to the patent to G. W. Elmen, No. 1,586,884, issued June 1, 1926. Obviously, alloys other than those described in that patent may also be used. The magnetic alloy, which may be in slab form, is reduced to a finely divided state, such as dust, in any well known manner as by crushing in a hammer mill or other suitable reducing apparatus and subsequently rolling in a ball mill. The dust material thus obtained is sieved, and the portion passing through a 120 mesh sieve is suitable for magnetic core purposes. The magnetic dust is insulated in accordance with the invention as will be described below, and is then pressed into core form.

The insulation for the magnetic dust comprises hydrated silica chemically made so as to be in an extremely finely divided state. A preferable way of producing it is by causing silicon tetra-chloride in vapor form to react with steam. The reaction is as follows:

$$SiCl_4+3H_2O=SiO(OH)_2+4HCl.$$

The combined vapors are allowed to react and condense to form a colloidal suspension which comprises aggregates of the hydrated silica in a solution of hydrochloric acid, the latter of which may be removed by suitable chemical means. The hydrated silica may be obtained chemically in other ways for example, by treating sodium silicate with hydrochloric acid, or other acid.

Before utilizing the hydrated silica for insulating the nickel-iron alloy dust, it is desirable to grind the colloidal suspension in a colloidal mill to separate the colloidal aggregates. The resulting product, which is of more or less gelatinous nature, and the nickel-iron alloy particles are then mixed in suitable proportions, and the mixture then evaporated to dryness. An adherent insulating coating is thus produced on the magnetic particles. This coating is SiO_2, as the hydrated silica on heating loses its water of hydration.

A mass of the coated particles is then placed in a mold and compressed into a core ring, such as is shown in Fig. 1, with a pressure of approximately 200,000 pounds per square inch. The compression of the particles into a homogeneous solid core necessarily produces strains in the magnetic dust. To remove these strains, the compressed core rings are put in an electric furnace and given a heat treatment, the temperature of the heat treatment being so regulated as to give the required magnetic properties to the magnetic material.

The insulation obtained in the manner described withstands without deterioration the high pressures and high temperatures used in the process of making the cores, and, moreover, causes the insulated dust particles to cohere after pressing so as to produce cores that are mechanically very strong. The difference in behavior of the insulation thus made and that of ground fused silica may be explained by the extremely fine subdivision of the former, which is characteristic of most materials made in the vapor state, and by its hydration.

A plurality of rings thus formed are stacked coaxially to form a complete core, as shown in Fig. 2, which may be employed as a loading coil by applying thereto, the usual toroidal winding, the number of rings in the core depending upon the existing electrical characteristics of the telephone circuit with which the loading coils are to be associated.

It has been found that in the case of a magnetic core made of alloy particles comprising 78-1/2% nickel and 21-1/2% iron the best results from a magnetic and electrical standpoint are obtained when the relative proportions of the hydrated silica and the nickel-iron alloy dust are so selected that the insulation obtained in the completed core comprises 2 to 8% by volume of the completed core, a proportion of 6% being preferable, and when the core is annealed after the pressing operation at a temperature ranging from 500° C. to 600° C. for an hour. Core rings made up in this manner give a permeability of approximately 75 and very low hysteresis and eddy current losses. For a detailed account of the heat treatments which may be employed with nickel-iron alloy structures, to obtain various characteristics, reference is made to G. W. Elmen Patents Nos. 1,586,884 and 1,586,889, issued June 1, 1926.

While the invention has been described with respect to the insulation of a magnetic dust which requires a heat treatment to fully develop the magnetic properties of the magnetic material, the invention is not limited to this particular aspect. The hydrated silica insulation may be advantageously employed in other forms of metallic structures which are subject to compression or heat treatment, or both, and the invention is only to be limited within the scope of the appended claims.

What is claimed is:

1. The method of producing a permanent electrical insulation on a metal structure which will withstand without deterioration exposure to mechanical stress and high temperatures, which comprises applying finely divided hydrated silica to the surface of said structure, and applying heat thereto to form an adherent coating of silica on said surface.

2. The method of producing a permanent electrical insulation on a metal structure which will withstand exposure to high pressure and high temperature, which comprises chemically combining a silicon compound with another chemical compound which will react therewith to produce finely divided hydrated silica, applying said hydrated silica to the surface of said structure and applying heat thereto to form an adherent coating of silica thereon.

3. A magnetic structure comprising magnetic material in a finely divided state, and a coating comprising a single chemical compound having good electrical insulating and adhesive properties on each of the particles of said material, said coating being such as to retain its adhesive and insulating qualities when said magnetic structure is subjected to great mechanical stress and heat treatment at high temperatures to improve its mechanical, electrical and magnetic properties.

4. A magnetic structure in accordance with claim 3 and in which said coating is obtained by chemically combining a chemical compound containing silicon with another chemical compound to produce hydrated silica, coating said particles with said hydrated silica and applying heat thereto.

5. A magnetic structure in accordance with claim 3 and in which said coating comprises silica in extremely finely divided form produced by mixing said particles with hydrated silica chemically obtained by combining a silicon compound in the vapor state with water, and evaporating the mixture to dryness.

6. A magnetic structure comprising magnetic material in a finely divided state, and adherent, electrically insulating coatings on the particles of said material, the coated particles being compressed into a homogeneous solid under high pressures, said magnetic material being such as to require a heat treatment at high temperatures to improve its magnetic properties after being subjected to said high pressures, said coating comprising a single chemical compound having good insulating properties and low dissociation pressures at said high temperatures, and in such form as to bind said particles firmly together at said high pressure and temperatures.

7. A magnetic structure in accordance with claim 6 and in which said chemical compound comprises silica in extremely finely divided form produced by vaporizing a silicon compound and chemically combining said compound with another chemical compound to produce hydrated silica which is applied to said particles prior to compressing them to form said solid.

8. A magnetic structure in accordance with claim 6 and in which said coatings were produced by mixing said magnetic particles, prior to pressing them to form a solid, with hydrated silica, obtained by combining a vaporized silicon compound with water vapor, and evaporating the mixture to dryness.

9. A magnetic structure in accordance with claim 6 and in which said magnetic material comprises an alloy containing nickel and iron and said coatings comprise finely divided silica obtained by vaporizing a silicon compound.

10. A magnetic structure comprising an alloy containing nickel and iron in finely divided form, adherent insulating coatings on the particles of said alloy, the coated particles being compressed under high pressure to form a homogeneous solid, said coatings comprising silica in extremely finely divided form produced by combining a silicon compound with another chemical compound which will react therewith to produce hydrated silica which is mixed with said alloy particles prior to forming said solid.

11. A magnetic structure in accordance with claim 10 in which said alloy comprises at least 78 per cent nickel, and in which said insulating comprises 2 to 8 per cent by volume of said magnetic structure.

12. The method of making a magnetic dust structure which comprises mixing a mass of magnetic dust particles with hydrated silica obtained in extremely finely divided form by chemical means, applying heat to the mixture to form an insulating coating of silica on said particles, subjecting the coated particles to high pressure to form a homogeneous solid, and thereafter heating said solid to high temperatures to improve its magnetic properties.

13. The method of electrically insulating magnetic dust particles for use in magnetic dust core structures, which comprises mixing said particles with hydrated silica in extremely finely divided form produced by chemical means, and applying heat to the mixture to form adherent insulating coatings on said particles.

14. The method of making magnetic struc-

ture suitable as cores for loading coils which comprises combining silicon tetrachloride in vapor state with steam to form hydrated silica in finely divided form, mixing in predetermined proportions said hydrated silica with an alloy in finely divided form containing nickel and iron, drying the mixture, subjecting the mass to high pressure to form a homogeneous solid, and heat treating said solid at a high temperature to improve its magnetic properties.

In witness whereof, I hereunto subscribe my name this 24th day of August A. D., 1927.

HOMER H. LOWRY.