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PROCESS FOR INSULATING MAGNETIC BODIES

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The invention relates to magnetic bodies and particularly to methods of producing magnetic bodies of the type employing finely divided magnetic material.

An object of the invention is to improve the magnetic and mechanical characteristics of magnetic bodies of the type employing magnetic material in finely divided form, for example, magnetic dust cores for loading coils.

Magnetic cores made from finely divided magnetic material, so-called magnetic dust cores, are being extensively used for the loading coils which are inserted in telephone lines to improve their transmission characteristics. Such cores are usually constructed by subjecting the finely divided particles of the magnetic material and a non-magnetic material between the magnetic particles, to extremely high pressures in the neighborhood of 200,000 pounds per square inch. The high pressures are utilized to form the component materials into a substantially homogeneous mass of the desired core form, and to give sufficient mechanical strength to the completed core. The non-magnetic material is of such nature as to serve as a binder, and also as an insulation between the magnetic particles to reduce the eddy current loss in the completed core. In the case especially where the magnetic material in the core made in the above described manner is a magnetic alloy including nickel and iron, it is desirable also to subject the core to a subsequent annealing 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, and to fully develop the magnetic characteristics of the alloy. It is desirable therefore that the insulating material have such characteristics and be applied in such manner to the dust particles that it will withstand without deterioration the heat treatment and mechanical operations utilized in producing the core.

A method commonly used for applying the insulating material to the magnetic particles in the process of making loading coil cores is to mix the magnetic dust with the insulating material in powder form in a volatile liquid, such as water, and then to subject the mixture continuously to heat with constant stirring until the volatile constituents have been evaporated and the magnetic particles have been coated with the insulating material. Usually the magnetic dust and insulation mixture is evaporated to dryness within a short time of the order of an hour after the volatile liquid is added thereto. The coated magnetic particles are then compressed under high pressures into the desired core form and the resulting cores are given a subsequent annealing heat treatment to improve their magnetic characteristics.

In accordance with one embodiment of the present invention, magnetic cores made by the general process described above may be improved from a magnet standpoint if the following changes are made in the method of insulating. After the volatile liquid has been added to the magnetic dust and insulation mixture and the mass has been heated for a short time with continuous stirring to start the process of evaporation, the heating and stirring are discontinued and the moist mixture allowed to stand in this state for a period of time long in comparison with the usual total evaporating time after which the heat is again applied and the mixture evaporated to dryness. This modified treatment results in improved magnetic properties, especially a lowering of the eddy current loss in the final core.

The exact nature and advantages of the invention will be better understood from the following detailed description.

In practicing the present invention, the magnetic material for the magnetic body or core is preferably prepared from a brittle allow 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 United States Patent No. 1,669,649 issued May 15, 1928, to C. P. Beath and H. M. E. Heinicke, wherein the magnetic metals including nickel and iron in proper porportions depending upon the desired percentage composition of the alloy are melted together

in an oxidizing atmosphere, the resulting alloy being poured into a mold.

The ingots so obtained, while still hot, are successively passed through progressively reducing rolls to decrease their cross-section to the required size, the final roll being preferably effected at approximately the temperature at which the alloy ceases to be malleable, after which the rolled material is quenched in water at a temperature below that at which it loses its malleability. This mechanical treatment is for the purpose of producing a fine crystalline structure in the alloy which is desirable since the disintegration of the material takes place at the crystal boundaries, and consequently the smaller the size of the crystals in the alloy material, the finer the magnetic dust which can be produced therefrom. The resultant ingots are broken into short pieces and the pieces reduced to finely divided form in any suitable manner, for example, by crushing in a rock crusher, hammer mill or other suitable apparatus, and pulverizing the crushed material by rolling in an attrition or ball mill for several hours. After rolling, the resulting dust is sieved through a 120-mesh sieve and that portion which will not pass through the sieve is returned to the ball mill for further rolling, this process being repeated until a sufficient quantity of the fine dust is obtained. The fine dust so obtained is then annealed in a closed container at a temperature of approximately 885° C. The annealed dust is removed from the container in the form of a cake which is reduced to a powder by crushing in a rotary crusher and subsequently grinding in an attrition or ball mill. The ground dust is again sifted through a 120-mesh sieve and the dust passing through the sieve is then mixed with a suitable insulating composition.

The method of insulating the annealed magnet dust particles in accordance with the invention will be described for the case where the insulating composition comprises talc, kaolin, sodium silicate, a water-soluble organic acid, for example, tartaric acid and water as disclosed in the copending application of C. C. Neighbors, Serial No. 505,956, filed December 31, 1930, although the process of the invention is applicable as well when other insulating materials capable of withstanding without appreciable deterioration heat treatment at high temperatures are used.

The permalloy dust and the insulating composition preferably in the proportions specified in the above mentioned copending application, are thoroughly mixed. Heat is then applied to the mixture to start the process of evaporation, the heating being continued with constant stirring until the mixture is reduced to a plastic moist mass. The heating is then discontinued and the moist mass allowed to stand for a long period of time ranging from 4 to 24 hours before heat is again applied and the evaporation to dryness completed to coat the magnetic particles with the insulating material. In the commerical manufacture of magnetic dust cores, it is desirable, of course, for reasons of economy that the total evaporation time be reduced to the shortest possible period that will produce good results. Experience indicates that an average period of about 18 hours for the time which the moist mixture is allowed to stand without application of heat, gives the final core sufficiently good magnetic properties.

It is, of course, apparent that the general method of insulating, above described, may be modified to some extent within the scope of the invention. For example, similar results may be obtained by allowing the wet mixture to stand for an appreciable time before heat is applied or by applying the heat thereto at intervals allowing it to stand for an appreciable period between the applications of heat, in which case the total time of standing may be greater or less than the times specified above.

The insulated dust is then sifted through a 16-mesh sieve, then placed in a mold 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 in air or hydrogen to relieve the internal stresses set up by the pressing operation thereby producing a core having a high permeability and low hysteresis loss. If the insulating material used is that disclosed in the above mentioned patent application to Neighbors, the annealing temperature used is preferably about 565° C., but may be as high as 620° C. If the former temperature is used, the core parts are preferably raised to that temperature in about eleven minutes and maintained at such temperature for about three minutes. If higher annealing temperatures are used, the time should, of course, be proportionately shortened, and vice versa.

One or more core parts thus formed are then stacked to form a core to which the usual toroidal winding is applied to form a loading coil, the number of core parts used in each core depending upon the electrical characteristics of the circuit with which the loading coil is to be associated.

A number of loading coil cores were made by a process similar to that described above in which the "delayed evaporation" method of insulation was used for comparison with other cores of similar construction made by the same process but in which the insulation process was carried out in the usual manner without delaying the evaporation to dryness. Tests on the two lots of cores showed that the former for a given magnetic material and a given insulating material had much lower eddy current losses for unit permeability

than the latter, while the hysteresis losses remained about the same. In the case of certain cores in which the magnetic material comprised finely divided magnetic alloy containing approximately 64 per cent nickel, 17 per cent iron and 15 per cent molybdenum, and 4 per cent of a fourth metal, and the insulating material comprised the tartaric acid-sodium silicate-talc-kaolin insulation such as disclosed in the above mentioned Neighbors patent application, it was found that a delay of approximately eighteen hours in the evaporation of the insulation and dust mixture in the process of insulation, reduced the eddy current loss to less than one-half that of similar cores made by the standard process in which the evaporation to dryness after the liquid part of the insulation had been added to the mixture of magnetic dust and insulating material lasted only about forty-five minutes.

It is understood that the invention is not to be limited to the exact embodiments above described, but only within the scope of the appended claims.

What is claimed is:

1. In the process of making a magnetic body comprising finely divided magnetic particles insulated from each other by insulating material, the method of insulating the magnetic particles which consists in mixing said magnetic particles with the insulating material in finely divided form, in a volatile liquid, allowing the mixture to stand for a time long in comparison with the time which would be required to evaporate said mixture to dryness with the continuous application of heat, and then evaporating the mixture to dryness with the application of heat to form adherent coatings of said insulating material on said particles.

2. In the process of making a magnetic body comprising finely divided magnetic particles insulated from each other by insulating material, the method of insulating the magnetic particles which consists in mixing said particles with said insulating material in finely divided form, in a volatile liquid, allowing the mixture to stand for several hours, and then evaporating the mixture to dryness with the application of heat to form adherent coatings of said insulating material on said magnetic particles.

3. In the process of making a magnetic body comprising finely divided magnetic particles insulated from each other by insulating material which consists in mixing said particles with the insulating material in powdered form in a volatile liquid, partially evaporating said mixture with the application of heat, then removing the heat and allowing the mixture to stand exposed to the atmosphere for several hours, and then applying heat to the moist mixture to evaporate it to dryness so as to form adherent coatings of the insulating material on the magnetic particles.

4. The process of producing a magnetic body having low eddy current loss from finely divided magnetic material and an insulating composition comprising a water-soluble organic acid, sodium silicate, finely divided ceramic material and water, which consists in thoroughly mixing said magnetic material and insulating composition, applying heat to the resulting mixture until it has been reduced to a moist mass, allowing said mass to stand in the moist state from four to twenty hours, then heating the mixture to dryness, compressing the resulting product into the desired form, and annealing the formed product at a high temperature to develop the magnetic characteristics of the magnetic material.

In witness whereof, I hereunto subscribe my name, this 29th day of June, 1931.

CONRAD D. OWENS.