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PROCESS FOR PRODUCING MAGNETIC BODIES

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This invention relates to magnetic bodies and particularly to processes for producing magnetic bodies of the type employing magnetic material in finely divided form, for example, magnetic dust cores for loading coils and the like.

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.

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 in 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 insulation between the magnetic particles so as to reduce eddy current loss in the core.

In the case especially when the magnetic material in the core made in the above described manner is a magnetic alloy including nickel and iron, it has been found desirable 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, to remove volatile constituents of the insulating material tending to impair its magnetic stability, and to fully develop the magnetic characteristics of the alloy. In general, the magnetic properties of the magnetic material improve correspondingly as the temperature of this annealing heat treatment increases. Most insulating materials start to deteriorate from an insulating standpoint when subjected to heat treatment, before the optimum value of annealing temperature for the magnetic material is reached, and the upper limit of the annealing temperature is therefore limited by the characteristics of the insulating material.

Heretofore, it has also been found desirable in order to obtain the best magnetic properties in magnetic bodies of the above described type to subject the magnetic particles before they have been compressed into their final form, to a preliminary annealing heat treatment at a high temperature, for example, in the manner disclosed and claimed in the U. S. patent to Karcher 1,669,665, issued May 15, 1928. Heretofore, it has been the practice to subject the finely divided magnetic materials to this preliminary annealing heat treatment before the insulation has been applied to their surfaces.

In accordance with the present invention it has been found that the magnetic and mechanical characteristics of magnetic bodies of the above described type may be improved, and the process of making them may be simplified, if the preliminary annealing heat treatment of the individual magnetic particles is carried out after the insulation has been applied to their surfaces, so that the insulating material is subjected also to heat treatment at a high temperature prior to the final annealing heat treatment of the compressed magnetic body.

The invention effectively increases for a given insulating material used, the permissible temperature of the final annealing treatment in the process of preparing magnetic bodies of the above described type, resulting in reduced magnetic losses for unit permeability.

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

In practicing the present invention, the magnetic material for the magnetic body or core 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 U. S. Patent 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 proportions, 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 alloy 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.

Up to this point, the process of making the magnetic bodies is the same as commonly practiced in the prior art. In the processes of the prior art, the magnetic dust particles thus obtained would be then submitted to the preliminary annealing heat treatment after which the insulating coatings would be applied to their surfaces. In the process of the present invention, however, the procedure is reversed, that is, the insulating coatings are first applied to the magnetic dust particles and then the insulated magnetic particles are subjected to the preliminary heat treatment at a suitable high temperature.

Any suitable insulating material and process for applying it may be used for insulating the individual magnetic dust particles in the process of the invention. Particularly good results have been obtained with the process of the invention using insulating materials and processes of insulating substantially as disclosed in Lathrop Patent 1,810,070, issued August 11, 1931, the copending applications of H. Lathrop, Serial No. 497,261, filed November 21, 1930 and Serial No. 548,404, filed July 2, 1931, or those of C. C. Neighbors, Serial No. 505,956, filed December 31, 1930 and 580,503, filed December 11, 1931.

The insulated magnetic dust particles are then annealed in a covered container at a temperature preferably of approximately 850° C. for about one hour or more.

A mass of the insulated magnetic particles is then placed in a mold and compressed under high pressures of approximately 200,000 pounds per square inch into core rings in well known manner. Following this step in the process, the core rings are subjected to heat treatment for several hours at as high a temperature as the insulating material will withstand in an annealing pot to reduce strains in the magnetic material tending to impair the magnetic characteristics of the core.

It was found that when any of the insulating materials and processes of insulating disclosed in the above mentioned patents and applications were employed, the process of the invention enabled the permissible core ring annealing temperature to be increased appreciably over the maximum core annealing temperature allowable when the processes of the prior art were used. Core ring annealing temperatures as high as 650° C. did not cause appreciable deterioration of the insulating materials in the completed cores.

A plurality of the rings so formed are then stacked coaxially to form a magnetic core on which the usual loading coil toroidal windings are wound. The number of rings used in a given core will depend upon the existing electrical characteristics of the telephone circuits with which the loading coils are to be associated.

A number of loading coil cores were made by the process of the invention similar to that described above in which the preliminary annealing heat treatment of the magnetic dust particles was carried out after said particles had been insulated, for comparison with other cores of similar construction made by a similar process but in which the preliminary annealing heat treatment of the magnetic dust particles was carried out prior to their insulation in the usual manner. Tests on the two lots of cores showed that the former for a given magnetic material and a given insulating material had much lower hysteresis loss for unit permeability than the latter, while the eddy current loss remained about the same. In most cases, it was found that with the process of the invention the hysteresis losses were reduced to approximately one-third those of the similar cores made by the processes of the prior art.

In addition to the above mentioned advantage of the process of the invention, it was found that it resulted in producing magnetic cores having better mechanical characteristics than cores produced by the processes of the prior art, probably due to the fact that substantially all volatile material in the insulating materials is driven off in the preliminary heat treatment of the insulated magnetic dust particles. Still another advantage of the process of the invention is that because the magnetic particles are insulated before the preliminary heat treatment, sinter-

ing of the magnetic particles in the annealing heat treatment is prevented and consequently less handling and mechanical working of the magnetic dust is required.

The obtaining of lower hysteresis loss for unit permeability by the use of the process of the invention is of economic importance since it will permit better transmission quality to be obtained in transmission lines with smaller sized loading coils.

It is understood 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. The process of making a low loss magnetic body from finely divided magnetic material of the type requiring heat treatment at a high temperature to properly develop its magnetic characteristics, and insulating material, which consists in first applying coatings of said insulating material to the individual particles of the magnetic material, then heat treating the insulated magnetic particles at a high temperature to anneal the magnetic material therein and to remove volatile constituents from the insulating coatings, compressing the resulting insulated particles into the desired form, and then heat treating the compressed body at as high a temperature as the insulating material will withstand without substantial deterioration from an insulating standpoint, to remove the strains produced in the magnetic material in the forming operation.

2. The process of making a magnetic body from finely divided magnetic alloy including nickel and iron, and an insulating and binding material, which consists in first applying coatings of the insulating and binding material to the individual alloy particles, then heat treating the insulated alloy particles at a high temperature to anneal the magnetic material therein, and to remove volatile constituents from the insulating coatings, compressing the resultant insulated alloy particles to produce a substantially homogeneous body in the desired form, and then heat treating the formed body at the highest temperature the insulating and binding material will withstand without substantial deterioration, to remove the strains produced in the magnetic material by the forming operation.

3. In the process of producing a magnetic body comprising finely divided particles of a magnetic alloy including nickel and iron and insulating material therebetween compressed into a substantially homogeneous mass and subsequently heat treated at a high temperature to anneal the magnetic alloy material, the method of effectively raising the permissible temperature of the final annealing heat treatment of the magnetic body and thus improving its magnetic characteristics which consist in subjecting the magnetic alloy particles and insulating material therebetween before their compression to a preliminary heat treatment at a high temperature in the neighborhood of 850° C. to anneal the magnetic material, and to remove volatile constituents of the insulating material.

In witness whereof, I hereunto subscribe my name this 28th day of April, 1932.

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