

UNITED STATES PATENT OFFICE

2,531,445

MANUFACTURE OF MAGNETIC BODIES
FROM COMPRESSED POWDERED MA-
TERIALSWilliam Edward Laycock, London, England, as-
signor to International Standard Electric Cor-
poration, New York, N. Y.No Drawing. Application December 19, 1946, Se-
rial No. 717,330. In Great Britain November
23, 1945

3 Claims. (Cl. 252-62.5)

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This invention relates to the manufacture of magnetic bodies from compressed powdered materials.

The principal object of the invention is to effect a reduction in the energy losses in such bodies.

In an article in the Bell System Technical Journal, volume 15 (1936), entitled "Magnetic Measurements at Low Flux Densities" it is shown (page 49) that the losses in a coil core are represented by an equation

$$\frac{R}{L} = \mu(aBm + c)f + \mu ef^2$$

wherein R is the resistance in ohms due to core and winding only and L is the inductance in henries due to core and residual air space only.

The terms on the right hand side of this equation may be considered as different loss coefficients, and as proportional to constants K_1 , K_2 and K_e where

$$K_1 = \mu c \times 10^3$$

$$K_2 = \mu a \times 10^3 + K_e = \mu e \times 10^6$$

where μ is the permeability of the body, a is the hysteresis resistance coefficient, c is the residual resistance coefficient and e is the eddy current resistance coefficient of the core, as defined in the aforesaid article. K_1 is known as the residual loss coefficient, K_2 the hysteresis co-efficient and K_e the eddy current coefficient.

The present invention has for its principal object to effect a reduction in the hysteresis co-efficient K_2 more particularly, though not exclusively, in magnetic bodies that are used in carrier current transmission systems, especially at high frequencies. The presence of the hysteresis loss coefficient K_2 causes the generation of harmonic voltages and thus a reduction thereof means a reduction of the intermodulation between different channels of transmission, and a simplification of circuit problems arising from resistances which vary with energy level. The present invention has also been found to provide some reduction in the residual loss coefficient K_1 .

The eddy current coefficient K_e is solely dependent on the particle size of the magnetic powder and providing the particles are adequately insulated from one another it cannot be altered for a given particle size. Hence for a given particle size the only variables that can be altered are K_1 and K_2 .

According to the present invention the hysteresis loss coefficient is reduced considerably be-

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low values previously attained by the use of silica sol as a primary insulating layer for the magnetic particles.

It is preferable to use as a secondary insulating layer applied outside the primary insulating layer a hard dense non-plastic insulant such as titanium dioxide.

The best results have been obtained by the use of an insulation that consists of three layers applied successively to the particles the first comprising silica sol, the second magnesium hydroxide and the third titanium dioxide. The use of the titanium dioxide forms the subject matter of our co-pending Application No. 717,329, filed December 19, 1946.

It is believed that these results may be explained on the theory that the minimum hysteresis coefficient is obtained when the magnetic particles have been subjected to the maximum plastic deformation without the particles having been brought into contact with one another. Silica sol forms a primary insulating layer which has the property of flowing under the pressure which is used to compress the particles into core form whilst retaining an enveloping insulating film over each particle.

The plastic deformation takes place under the pressure used for the purpose of compressing the insulated magnetic particles into a solid body and an annealing of the solid body is necessary to cause re-crystallisation in the magnetic material. The greater the plastic deformation the lower the re-crystallisation temperature for a given magnetic material and the greater is the freedom from strain in the magnetic material, which is well known to be desirable.

The primary layer of silica sol is of such a character that minimum volumetric change occurs during subsequent processes so that the magnetic particles are not in a state of strain after heat-treatment. Moreover silica sol has a low power factor and this assists in lowering the K_2 constant.

The following description relates to embodiments of the invention in which the magnetic particles consist of an alloy containing 78%-83% nickel, 16%-19% iron and up to 4% molybdenum and are of such size as to pass a 400 mesh screen. When such particles are to be compressed into bodies for use with carrier currents the amount of insulation used is normally such that the permeability of the finished core is about 14.

The best results hitherto with cores of permeability 14 made from powder of the above composition and fineness have been obtained by

means of insulation consisting of colloidal clay, such as kaolin, magnesium hydroxide and sodium silicate as described and claimed in British specification No. 438,803, with the addition of a small percentage of a phenol formaldehyde resin according to British application No. 16407/44. The insulated particles are pressed into cores under a pressure of 45 tons per square inch and then annealed in an inert atmosphere at 630° C. for 40 minutes.

The properties obtained from the finished cores are a permeability of 14, $K_2=0.10$, $K_1=2.70$ and $K_e=0.07$. In the following examples the cores are manufactured in the same manner save for the nature of the insulation used.

Example 1

100 parts of the magnetic dust are thoroughly mixed with 10 parts of silica sol; and the mixture dried at 50° C. and passed through a 120 mesh sieve. The insulated dust that passes the sieve is thoroughly mixed with 2½ parts of magnesium hydroxide in aqueous suspension. The resulting mixture is evaporated at 130° C. to dryness with continuous mixing and screened through a 30 mesh sieve. The material passing the sieve is compressed into a core which has a permeability of 14.05 and a K_2 of 0.07.

Example 2

Same as Example 1 except that 5 parts of magnesium hydroxide are used. The permeability is decreased to 10.9 and the K_2 also increased to 0.11.

It appears that there is an upper limit to the quantity of magnesium hydroxide that can be used without unduly increasing the factor K_2 .

Example 3

100 parts of magnetic dust are mixed with 10 parts of silica sol, dried at 50° C. and passed through a 120 mesh sieve. 1.25 parts of magnesium hydroxide in aqueous suspension are thoroughly mixed with the material passing the sieve and the mixture evaporated to dryness at 130° C. 4.6 parts of titanium dioxide are dry mixed therewith and the result screened through a 30 mesh sieve. Cores made from this compressed material have a permeability of 13, a factor K_2 of 0.064; a factor K_1 of 1.2 and a factor K_e of 0.06.

The use of titanium dioxide is described and claimed in our co-pending application No. 717,329 of even date herewith.

The results obtained by Example 3 are considered to be the best obtained for a permeability in the neighbourhood of 14, as all loss factors show some decrease, and that in the factor K_2 showing a 40% decrease.

The following examples relate to cores intended for use at still higher frequencies than the foregoing and thus intended to have a permeability in the neighbourhood of 6.

Example 4

100 parts of magnetic dust are thoroughly mixed with 10 parts of silica sol, dried at 50° C. and screened through a 120 mesh sieve. The material passing the sieve is mixed with 5 parts of magnesium hydroxide in water suspension and the mixture dries at 130° C. The dried material is thoroughly mixed with 6 parts of magnesium oxide powder and 2 parts of a phenol formaldehyde resin. This mixture is heated at 40° C. for

half an hour and screened through a 30 mesh sieve. The material passing the sieve is compressed into cores. The permeability is 6.9 and the factor K_2 0.062.

Example 5

Same as Example 4 as regards the first two coatings. The dried mixture with magnesium hydroxide is mixed with 15 parts of titanium dioxide and 2 parts of a phenol formaldehyde resin. The mixture is passed through a 30 mesh sieve, semi-cured at 40° C. and the material passing the sieve compressed into cores. The permeability was 5.8 and the factor K_2 was 0.046. The factor K_1 was 2.0 and K_e was 0.045 thus showing a decrease in all three loss factors compared with normal type insulation.

One method of preparing the silica sol was to hydrolyse a commercial form of silicon ester in methylated spirits by means of hydrochloric acid solution (0.5 N in distilled water). In the following claims this type of silica sol is referred to as acid hydrolyzing silicon ester which will be understood by those skilled in the art to which this invention relates as being that type of substance produced by acid hydrolysis of an alkyl orthosilicate, for instance ethyl orthosilicate, hydrolyzed with methyl alcohol or a similar lower alcohol containing an aqueous acid solution.

What is claimed is:

1. Method of manufacturing a body having low hysteresis loss factor from compressed insulated magnetic particles of high permeability which comprises first insulating the particles with a primary insulating layer consisting of an acid hydrolyzed silicon ester, subsequently insulating the particles with at least one further layer of insulation comprising an intermediate layer of at least one substance chosen from the class consisting of magnesium oxide and magnesium hydroxide, and an outermost layer comprising titanium dioxide, compressing the particles so insulated into core form to cause plastic deformation of the magnetic particles and then annealing the finished core to recrystallise the magnetic particles.

2. A magnetic body composed of magnetic particles insulated from one another by a plurality of separately applied individually distinct layers of insulation compressed into a solid body in which the outermost layer comprises titanium dioxide an underlying intermediate layer comprises magnesium oxide and the inner layer comprises an acid hydrolyzed silicon ester.

3. A magnetic body composed of magnetic particles insulated from one another by a plurality of separately applied layers of insulation on said particles compressed into a solid body, said layers comprising titanium dioxide as the outermost layer, silica sol as the innermost layer and magnesium hydroxide as the intermediate layer.

WILLIAM EDWARD LAYCOCK.

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Certificate of Correction

Patent No. 2,531,445

November 28, 1950

WILLIAM EDWARD LAYCOCK

It is hereby certified that error appears in the above numbered patent requiring correction as follows:

In the grant, line 16, strike out "of Seventeen years"; same line, after "grant" insert *until November 23, 1965*; in the heading to the printed specification, line 11, before "3 Claims" insert *Section 1, Public Law 690, August 8, 1946. Patent expires November 23, 1965*;

and that the said Letters Patent should be read as corrected above, so that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 1st day of May, A. D. 1951.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.

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