

106. COMPOSITIONS,
COATING OR PLASTIC

Cross Reference

Examiner

84 M

May 15, 1928.

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J. W. ANDREWS
MAGNETIC MATERIAL

Filed April 17, 1926

Fig. 1.

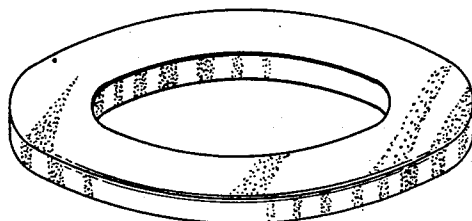
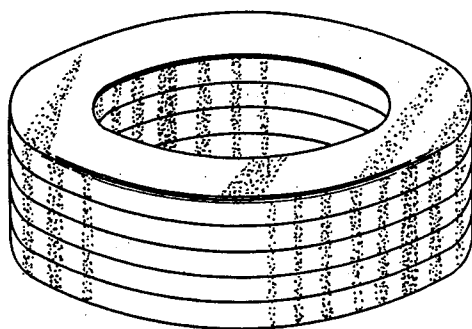


Fig. 2.



Inventor
John W. Andrews
by *H. K. H. H. H.* Att'y.

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UNITED STATES PATENT OFFICE.

JOHN WENDELL ANDREWS, OF CHICAGO, ILLINOIS, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

MAGNETIC MATERIAL.

Application filed April 17, 1926. Serial No. 102,728.

This invention relates to magnetic materials and magnet cores, and more especially to magnet cores for loading coils for telephone circuits, and their method of production.

The principal object of the invention is the production of a magnetic element having low losses and a relatively high permeability to enable a given inductance to be obtained from a minimum amount of material and possessing to a high degree those electrical and magnetic characteristics which make it highly desirable in electrical signalling apparatus, particularly in loading coils for telephone circuits.

In accordance with one embodiment, the present invention contemplates the construction of magnet cores of an alloy including nickel and iron in finely divided form, heat treated to have a higher inherent magnetic permeability and lower inherent hysteresis loss than iron and combined with a suitable insulating material. More specifically, the invention contemplates the formation of the magnet cores of a nickel iron alloy in finely divided form in which the proportions of its constituents are more than 25% of nickel and the remainder principally iron, and in a form which has proven satisfactory, the nickel content being approximately 78½% of the whole. The metal particles are treated with a solution of an acid and an alkali whereby the alloy particles are given a primary insulating coating, after which the particles are dried and thoroughly mixed with dry acid and a filler until they have received a secondary insulating coating. The particles are then heated to increase the resistance of the final cores after which they are compressed into cores of the desired shape and size. The cores so formed are finally heat treated to the optimum temperature for the particular alloy of which the cores are constructed to stabilize the insulator and to give a high permeability and low hysteresis and eddy current losses.

It is believed that the invention will be clearly understood from the following detailed description of one embodiment thereof and from the accompanying drawing, in which

Fig. 1 is a perspective view of a section of a loading coil core made in accordance with the present invention, and

Fig. 2 shows a plurality of these sections assembled to form a completed core.

It will be understood, however, that this is merely illustrative and the invention is not limited to the production of this form of core but is adapted to the production of cores of magnetic particles of many forms.

In carrying out the present invention, the magnetic material is prepared in the following manner: The magnetic material employed is preferably prepared from a nickel iron alloy commonly referred to as "permalloy" which is treated in a manner more fully described in the copending application of C. P. Beath and H. M. E. Heinicke, Serial No. 101,179, filed April 10, 1926, to reduce the alloy to a finely divided form. Experience has proven that where low eddy current losses are desired it is essential that the particles be of small size and preferably of such size that all of the particles will readily pass through what is generally known as a 120 mesh screen and a large percentage pass through a 200 mesh screen. According to one embodiment of the invention, the alloy is prepared by melting approximately 78½ parts of nickel and 21½ parts of iron in an oxidizing atmosphere and pouring the resulting alloy into a mold. When prepared according to the foregoing process, the resulting alloy will be exceedingly brittle and is therefore particularly adapted to be reduced to a finely divided or dust form from which the finished cores are molded.

After the brittle ingots are obtained they are successively passed through progressively reducing hot rolls which form the alloy into flat slabs approximately one-quarter of an inch thick. By the hot rolling process the size of the crystalline structure is materially reduced, which since the disintegration of the material takes place mainly at the crystal boundaries, is essential in order to have a satisfactory yield of dust. The rolled slabs are broken into short pieces and are then crushed in a jaw crusher, hammer mill, or any other suitable type of apparatus in which a further reduction occurs. The material after being passed through the jaw crusher is subsequently rolled in a ball mill until it is reduced to a fine dust. The dust is sieved through a 120 mesh sieve and any residue is remelted and the forego-

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ing operation is repeated to again reduce the material to a finely divided form. Prior to the addition of the insulating material, the finely divided particles of the nickel iron alloy are annealed in a closed container at a temperature of approximately 750° C. to 980° C., the temperature of about 925° C. having proven to be one which produces very satisfactory results. It is then necessary to again reduced the annealed alloy which is now in the form of a cake to a finely divided form, after which it is mixed with the insulator.

According to one form of the invention, the insulator for the primary coating of the dust particles is prepared by mixing the ingredients in approximately the following proportions: $1\frac{1}{4}$ parts of dry silicic acid to 1 part of water glass, having approximately the following percentages of active silica and of base, SiO_2 , 32.6%; Na_2O , 20.4%, sufficient water to make a rather dilute solution being added to the ingredients. This solution is thoroughly mixed and the permalloy particles added to the solution, the amount of the permalloy particles added being determined by the permeability desired and the particular use to which the finished cores are to be put. The entire mass is then boiled to dryness accompanied by constant stirring to prevent caking and to insure a thorough primary coating of the individual dust particles. The dry coated particles are then placed in a revolving drum and dry silicic acid and ferric oxide in the ratio of 1 part of silicic acid to $1\frac{1}{2}$ parts of ferric oxide are added to give the particles a secondary insulating coating. This mixture is tumbled in the drum to thoroughly mix the ingredients until the dust particles assume a uniform red color which, since the ferric oxide is red, indicates that they are thoroughly coated with the secondary insulator. Following this step the coated dust particles are placed in a furnace in which they are heated at the optimum annealing temperature of approximately 468° C. in order to increase the resistance of the finished rings, and cooled. The dry insulated dust particles are then in a form suitable for pressing into cores or rings which are preferably formed with a pressure of approximately 200,000 pounds per square inch. A high pressure is used in forming the rings in order to increase their density, since it has been found that the permeability of the rings increases with increased density. Finally the cores are transferred to an annealing furnace where they are annealed at a temperature of from 480° C. to 950° C. A few test rings may be made of dust insulated in the above manner and their permeability measured. Should their permeability be too low, it may be increased by the addition of a predetermined amount of uninsulated dust

to the insulated dust before it is pressed into rings.

A plurality of rings thus formed are stacked coaxially to form a core on which the usual toroidal winding is applied, the number of such rings used depending upon the existing electrical characteristics of the telephone circuit with which the loading coils are to be associated.

Although the permalloy articles have been described as being insulated by coating them with a solution of water glass and silicic acid in definite proportions and by tumbling them with silicic acid and ferric oxide in a definite ratio, it is, of course, to be understood that the proportions of the ingredients may be varied without departing from the spirit and scope of the invention. Also other acids than silicic may be used with satisfactory results, among these being antimonious, arsenous, arsenic, molybdic, tungstic, antimonous, and phosphoric, and the water glass and ferric oxide may likewise be replaced with other alkalies, such as sodium metasilicate and sodium zincate, and fillers, such as stannic oxide, manganese dioxide and cupric oxide, and still produce cores which are satisfactory from both an electrical and magnetic standpoint.

By using an alloy of the proportions stated in the preceding paragraphs and by following the foregoing method of insulating the individual alloy particles and compressing the particles into cores or rings, magnet cores or rings are produced which have an extremely high permeability with a minimum amount of material employed. By the use of such cores or rings, inductance units having the same permeability with equal or less hysteresis and eddy current losses as cores constructed according to previously known methods, but with much less core volume and much less coil volume, are available.

What is claimed is:

1. As a new article of manufacture, a magnetic substance composed of particles of a magnetic material, a primary insulating coating of silicic acid and water glass, and a secondary insulating coating of silicic acid and ferric oxide separating the particles.

2. As a new article of manufacture, a magnetic substance composed of particles of a magnetic material, a primary insulating coating consisting of $1\frac{1}{4}$ parts of silicic acid and 1 part water glass, and a secondary insulating coating consisting of 1 part silicic acid and $1\frac{1}{2}$ parts of ferric oxide separating the particles.

3. As a new article of manufacture, a magnetic substance composed of particles of a magnetic material, and an insulating material consisting of an acid, an alkali, and a filler separating the particles.

4. As a new article of manufacture, a

magnetic substance composed of finely divided particles of a magnetic alloy of nickel and iron, and an insulating material consisting of silicic acid, water glass, and a filler separating the particles.

5 5. As a new article of manufacture, a magnetic substance composed of finely divided particles of a magnetic alloy composed of more than 25% nickel and the remainder principally iron, and an insulating material consisting of silicic acid, water glass, and ferric oxide separating the particles.

10 6. As a new article of manufacture, a magnetic substance composed of finely divided particles of a magnetic alloy composed of more than 25% nickel and the remainder principally iron, and an insulating material consisting of $2\frac{1}{4}$ parts of silicic acid, 1 part of water glass, and $1\frac{1}{2}$ parts of ferric oxide separating the particles.

15 7. The method of making magnetic structures, which consists in coating particles of a magnetic material with an insulating material, consisting of an acid, an alkali and a filler, and forming a mass of such insulated particles into a homogeneous solid.

20 8. The method of making magnetic structures, which consists in coating particles of a magnetic material with an insulating material, consisting of silicic acid, water glass and ferric oxide, and forming a mass of such insulated particles into a homogeneous solid.

25 9. The method of making magnetic structures composed of an alloy, which consists in reducing the alloy to finely divided particles, heating the particles, again reducing the product so obtained to finely divided particles, coating the particles with an insulating material comprising silicic acid, water glass and ferric oxide, and forming a mass of such insulated particles into a homogeneous solid.

30 10. The method of making magnetic structures composed of an alloy, which consists in reducing the alloy to finely divided particles, heating the particles, again reducing the product so obtained to finely divided particles, coating the particles with an insulating material comprising silicic acid, water glass and ferric oxide, heating the insulated particles, and forming a mass of such insulated particles into a homogeneous solid.

35 11. The method of making magnetic structures composed of an alloy, which consists in reducing the alloy to finely divided particles, heating the particles, again reducing the product so obtained to finely divided particles, coating the particles with an insulating material comprising silicic acid, water glass and ferric oxide, heating the insulated particles, forming a mass of such insulated

particles into a homogeneous solid, and heating the solid mass to a high temperature.

40 12. The method of making magnetic structures composed of a nickel iron alloy, which consists in reducing the alloy to finely divided particles, heating the particles and again reducing the product so obtained to finely divided particles, coating the particles with an insulating material comprising silicic acid, water glass and ferric oxide, heating the insulated particles, forming a mass of such insulated particles into a homogeneous solid, and heating the solid mass to a high temperature.

45 13. The method of making magnetic structures composed of an alloy of more than 25% nickel and the remainder principally iron, which consists in reducing the alloy to finely divided particles, heating the particles and again reducing the product so obtained to finely divided particles, coating the particles with an insulating material comprising silicic acid, water glass and ferric oxide, heating the insulated particles, forming a mass of such insulated particles into a homogeneous solid, and heating the solid mass to a high temperature.

50 14. The method of making magnetic structures, which consists in enveloping finely divided particles of a nickel iron alloy with a primary coating of an insulating material consisting of silicic acid and water glass, enveloping the coated particles with a secondary coating of an insulating material composed of silicic acid and ferric oxide, and forming a mass of such insulated particles into a homogeneous solid.

55 15. The method of making magnetic structures, which consists in enveloping finely divided particles of a magnetic alloy comprising more than 25% nickel and the remainder principally iron with a primary coating of an insulating material consisting of $1\frac{1}{4}$ parts silicic acid and 1 part water glass, enveloping the coated particles with a secondary coating of an insulating material composed of 1 part silicic acid and $1\frac{1}{2}$ parts ferric oxide, heating the insulated particles, forming a mass of such insulated particles into a homogeneous solid, and heating the solid mass to a high temperature.

60 16. A magnetic structure comprising a magnetic material in finely divided form, and an insulating material coating the particles comprising an acid as the principal constituent.

65 17. A magnetic structure comprising a magnetic material in finely divided form, and an insulating material coating the particles comprising an acid and a filler.

In witness whereof, I hereunto subscribe my name this 31st day of March A. D., 1926.

JOHN WENDELL ANDREWS.