

May 15, 1928.

1,669,646

A. F. BANDUR

MAGNETIC MATERIAL

Filed April 17, 1926

Fig. 1.

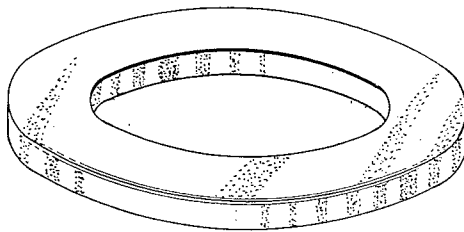
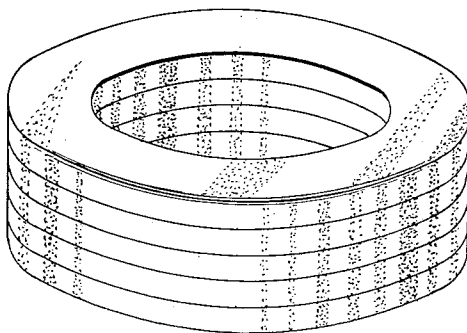


Fig. 2.



Inventor
Adolf F. Bandur
by *H. Hattis*
Att'y.

UNITED STATES PATENT OFFICE.

ADOLPH FRANCIS BANDUR, OF BERWYN, 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. 102,731.

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 signaling 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, combined with a suitable insulating material and heat treated to have a higher inherent magnetic permeability and lower inherent hysteresis loss than iron. 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 mixture of a flux, such as boric acid and kaolin in colloidal suspension, whereby the alloy particles are individually insulated after which they are compressed into cores of the desired shape and size. The cores are then impregnated with a solution of zinc hydroxide, are heated to expel moisture and finally are heat treated to the optimum temperature for the particular alloy of which the cores are constructed to stabilize the insulator and to give the required permeability, low hysteresis losses and high specific resistance, hence, low eddy current losses of the rings.

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 "perm-alloy" 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 while hot through progressively reducing 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 foregoing 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 reduce 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 dust particles is prepared by mixing the ingredients in the following manner: One part of kaolin is thoroughly dissolved in three parts by weight of water by heating to approximately 95° C. and stirring thoroughly until it forms a thin homogeneous colloidal mass. To this is added a quantity of a flux such as boric acid equal to four per cent by weight of kaolin to lower the fusion temperature and to increase the adhesive quality of the kaolin, the boric acid preferably being dissolved in the hot distilled water in which the kaolin is mixed. The powdered permalloy dust is added to this mixture, the amount of dust being determined by the permeability desired and the particular use to which the finished cores are to be put. The dust is thoroughly mixed with the kaolin solution by thoroughly stirring by hand or by rolling in a revolving drum, the temperature of this mixture being maintained at about 100° C. until all of the mechanically held water is removed. The dried 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.

The pressed rings are impregnated in a solution of zinc hydroxide containing an excess of ammonia for a period of from two to six minutes, depending on the size of the core, in order to allow the insulator to redistribute itself around the individual dust particles. The zinc hydroxide thus added decomposes at the high temperature of the subsequent annealing process and forms an oxide coating on the particles. The rings are then dried in the open at 100° C. for several hours to remove the hygroscopically held water and ammonia, after which they are placed in an oven and heated at approximately 290° C. for several hours, to reduce the amount of chemically combined water. After the rings are dried, they are annealed preferably in closed pots at the optimum annealing temperature of approximately

675° C. to partly fuse the kaolin and to give the rings the greatest permeability possible consistent with low core losses. 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 or dust which has a light coating of insulation 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 particles have been described as being insulated with a solution of boric acid and colloidal kaolin in definite proportions, 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 flux materials, such as borax, common salt or magnesium sulphate may be substituted for the boric acid to lower the fusion temperature of the kaolin.

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 extremely desirable electrical characteristics with a minimum amount of material employed. By the use of such cores or rings, inductance units having a higher 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, and an insulating material consisting of kaolin and a flux separating the particles.

2. As a new article of manufacture, a magnetic substance composed of particles of a magnetic material, and an insulating material consisting of one part kaolin and 4/100 parts boric acid separating the particles.

3. As a new article of manufacture, a magnetic substance composed of particles of a magnetic alloy of nickel and iron, and an insulating material consisting of kaolin and boric acid separating the particles.

4. As a new article of manufacture, a magnetic substance composed of finely divided particles of an alloy of nickel and iron, and an insulating material consisting

of 1 part kaolin and 4/100 parts boric acid separating the particles.

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 kaolin and boric acid separating the particles.

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 1 part kaolin and 4/100 parts boric acid separating the particles.

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

8. The method of making magnetic structures composed of an alloy, which consists in reducing the alloy to finely divided particles, coating the particles with an insulating material of kaolin and boric acid, and forming a mass of such insulated particles into a homogeneous solid.

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 kaolin and boric acid, and forming a mass of such insulated particles into a homogeneous solid.

10. The method of making magnetic structures composed of an alloy, which consists in reducing the alloy to finely divided particles, heat treating the particles, reducing the product so obtained to finely divided particles, coating the heat-treated particles with an insulating material comprising kaolin and boric acid, forming a mass of such insulated particles into a homogeneous structure, drying the structure and heating it to a high temperature to improve its magnetic properties.

11. The method of making magnetic structures composed of a nickel iron alloy, which consists in reducing the alloy to finely divided particles, heat treating the particles, reducing the product so obtained to finely divided particles, coating the heat-treated particles with an insulating material comprising substantially 1 part kaolin and 4/100 parts boric acid, and forming a mass of such insulated particles into a homogeneous structure.

12. 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, heat treating the particles, reducing the product so obtained to finely divided particles, coating the heat-treated particles with an insulating material comprising kaolin and boric acid, and forming a mass of such insulated particles into a homogeneous structure.

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, heat treating the particles, reducing the product so obtained to finely divided particles, coating the heat-treated particles with an insulating material comprising kaolin and boric acid, forming a mass of such insulated particles into a homogeneous structure, drying said structure, and subjecting it to heat treatment at a high temperature.

14. 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, heat treating the particles, reducing the product so obtained to finely divided particles, coating the heat-treated particles with an insulating material comprising substantially 1 part kaolin and 4/100 parts boric acid, forming a mass of such insulated particles into a homogeneous structure, drying the structure, and heating it to a high temperature to improve its magnetic properties.

15. The method of making magnetic structures, which consists in treating particles of a magnetic alloy with a solution of zinc hydroxide so as to form an oxide coating on the particles.

16. The method of making magnetic structures, which consists in treating particles of a magnetic alloy with a solution of zinc hydroxide, heating the particles so treated to a high temperature to decompose the zinc hydroxide and form an oxide coating on the particles.

17. The method of making magnetic structures composed of finely divided particles of a nickel iron alloy, which consists in treating the particles with a solution of boric acid and kaolin, forming the particles into rings, impregnating the rings with a solution of zinc hydroxide, and decomposing the zinc hydroxide to form an oxide coating on the particles.

18. The method of making magnetic structures from finely divided magnetic material, comprising coating the individual particles with an insulating material which retains its insulating properties at temperatures up to at least 800° C., compressing the insulated particles into a homogeneous solid, and thereafter heating said solid to a tempera-

ture between 450° C. and 800° C. and cooling, to restore the magnetic properties lost in the pressing operation.

19. The method of making magnetic structures from magnetic material in a finely divided form, which consists in heat treating the particles of magnetic material at a high temperature, coating the particles with an insulator which retains its insulating properties at high temperatures, compressing the coated particles into a homogeneous solid, and thereafter heat treating the particles at a temperature to impart thereto the desired magnetic properties.

20. The method of making magnetic structures from a magnetic material of nickel and iron in a finely divided form, which consists in heat treating the particles at a high temperature to prepare them for subsequent operations, coating the particles with an insulating material, and compressing the

coated particles into a homogeneous solid.

21. The method of making magnetic structures from a magnetic material of nickel and iron in a finely divided form, which consists in heat treating the particles at a temperature approximately 750° C. to 980° C. to prepare them for subsequent operations, coating the particles with an insulating material, and compressing the coated particles into a homogeneous solid.

22. The method of making magnetic structures from a magnetic material in a finely divided form, which consists in coating the particles with an insulator, adding thereto uninsulated particles to control the resulting permeability, and compressing the mass into a homogeneous solid.

In witness whereof, I hereunto subscribe my name this 1 day of April A. D., 1926.

ADOLPH FRANCIS BANDUR.