

84 -M

May 15, 1928.

J. W. ANDREWS

MAGNETIC MATERIAL

Filed April 24, 1926

1,669,644

Fig. 1.

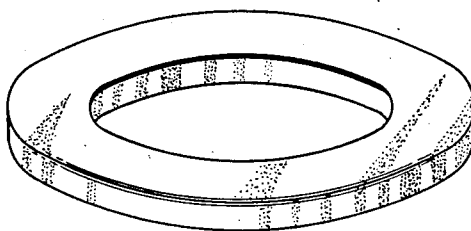
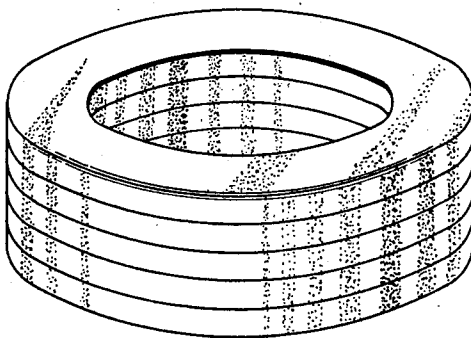


Fig. 2.



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

106-84M

Patented May 15, 1928.

1,669,644

# 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 24, 1926. Serial No. 104,482.

This invention relates to magnetic materials and magnet cores, and more especially to magnet cores for inductance units to be used in telephone circuits and their method of production.

The principal object of the invention is the production of a magnetic element possessing to a high degree those electrical, magnetic and physical characteristics which make it highly desirable in electrical signaling apparatus, particularly in apparatus employed in circuits carrying currents of high frequencies.

In accordance with one embodiment, the present invention contemplates the construction of magnet cores of a magnetic material reduced to a finely divided form combined with a suitable insulating material and bound in a compact mass by a suitable binding material. More specifically, the invention contemplates the formation of 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 enveloped with a primary coating of an insulating material such as sodium silicate or chromic acid, the coated particles are then treated with a binding medium such as a synthetic resin and the insulated particles are formed into cores at a temperature and under a pressure sufficient to form the material into a homogeneous solid.

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 elements of magnetic particles of many forms.

In carrying out the present invention, the magnetic material is prepared in the following manner: The magnetic material em-

ployed 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 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 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, and since the disintegration of the material takes place mainly at the crystal boundaries, small crystals are highly desirable 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 200 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 at a temperature of approximately 400° C. to 900° C. 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 in the following manner: A thin solu-

tion of sodium silicate is prepared and the powdered permalloy dust is added to this solution, the amount of dust being determined by the permeability desired and the particular use to which the finished cores are to be put. To insure complete coating of the particles, the dust is thoroughly mixed with the sodium silicate solution by thoroughly stirring by hand or by rolling in a revolving drum, and the temperature of the mixture is maintained at about  $100^{\circ}\text{C}$ . until all of the water has evaporated. The dry coated dust particles are then mixed with about 5% of a partially cured synthetic resin in the form of a very fine powder and the mixture placed in a ring die where the resin is cured by means of pressure low enough not to greatly distort any of the individual dust particles and a temperature of approximately  $165^{\circ}\text{C}$ ., and the material is formed into rings or cores. 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 insulator to the insulated dust before it is pressed into rings. The rings are removed from the presses and a plurality of rings thus formed are then 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 circuit with which the inductance units are to be associated.

It is advantageous to form the rings or cores under a low pressure because it is then unnecessary to heat treat them after they are pressed into shape. Pressing the rings under high pressures tends to distort the individual dust particles beyond their elastic limit and as a result the hysteresis losses are increased and the permeability is decreased in the finished rings, thereby necessitating annealing the rings after pressing to restore their desirable magnetic properties. Since when the rings are pressed under low pressure, the individual particles are not distorted and the rings retain their desirable magnetic properties, subsequent annealing is unnecessary.

Although the permalloy particles have been described as being coated with a solution of sodium silicate and the coated particles treated with a synthetic resin it is, of course, to be understood that other insulators, such as chromic acid or a mixture of chromic acid and sodium silicate, may be used to coat the particles or the dust may be insulated by superficially oxidizing it by heating in air, and other binding materials, such as natural resin, plaster of Paris, or lead oxide and glycerine, may be substituted for the synthetic resin and still produce

cores which are satisfactory from both a magnetic and electrical standpoint. Also other magnetic materials, such as finely divided electrolytic iron may be substituted for the nickel iron alloy with satisfactory results.

By using an alloy of the proportions stated in the preceding paragraph and by following the foregoing method of insulating the individual alloy particles and forming 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 desirable permeability with equal or less total losses than units 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 consisting of finely divided particles of a nickel iron alloy, an insulating coating on the particles, and an infusible, insoluble binding material holding the particles in a compact mass.
2. As a new article of manufacture, a magnetic substance consisting of finely divided particles of a nickel iron alloy, an insulating coating of sodium silicate, and a binder of a synthetic resin holding the particles in a compact mass.
3. As a new article of manufacture, a magnetic substance consisting of finely divided particles of an alloy comprising more than 25% nickel and the remainder principally iron, an insulating coating of sodium silicate on the particles, and a binder of a synthetic resin holding the particles in a compact mass.
4. As a new article of manufacture, a magnetic substance consisting of particles of a magnetic material, and an insulator composed of sodium silicate and a synthetic resin separating the particles.
5. As a new article of manufacture, a magnetic substance consisting of particles of a magnetic alloy comprising more than 25% nickel and the remainder principally iron, and an insulator composed of sodium silicate and a synthetic resin separating the particles.
6. The method of making magnetic structures, which consists in enveloping finely divided particles of a nickel iron alloy with a coating of an insulating material, and treating a mass of such insulated particles with a phenolic condensation product to bind them together.
7. The method of making magnetic structures, which consists in enveloping finely divided particles of an alloy comprising more than 25% nickel and the remainder principally iron with an insulating coating of

sodium silicate, and binding a mass of such insulated particles together with a synthetic resin.

8. The method of making magnetic structures, which consists in reducing an alloy comprising more than 25% nickel and the remainder principally iron to finely divided particles, heating the particles, reducing the resulting product to finely divided particles, enveloping the particles with an insulating coating of sodium silicate, and binding a mass of such insulated particles together with a synthetic resin:

9. The method of making magnetic structures, which consists in enveloping particles of a magnetic material with a coating of an insulating material, adding a synthetic resin to a mass of such insulated particles, and treating the mass at a temperature and under a pressure sufficient to cause a transformation of the resin to form a homogeneous solid.

10. The method of making magnetic structures, which consists in enveloping finely divided particles of a ferrous magnetic material with an insulating coating of sodium silicate, adding a synthetic resin to a mass of such insulated particles, and treating the mass at a temperature and under a pressure sufficient to cause a transformation of the resin to form a homogeneous solid.

11. The method of making magnetic structures, which consists in reducing an alloy comprising more than 25% nickel and the remainder principally iron to finely divided particles, heating the particles, reducing the resulting product to finely divided particles, enveloping the particles with an insulating coating of sodium silicate, adding a synthetic resin to a mass of such insulated particles, and treating the mass at a temperature and under a pressure sufficient to cause a transformation of the resin to form a homogeneous solid.

12. The method of making magnetic structures, which consists in treating a mass of magnetic particles in finely divided form with a phenolic condensation product, and subjecting said treated mass to heat and pressure to form a homogeneous solid and to cure said phenolic condensation product.

13. The method of making magnetic structures, which consists in treating a mass of magnetic particles in finely divided form with a partially cured phenolic condensation product, and subjecting said treated mass to heat and pressure to form a homogeneous solid and to completely cure said phenolic condensation product.

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

JOHN WENDELL ANDREWS.