

Patented Feb. 4, 1941

2,230,228

UNITED STATES PATENT OFFICE

2,230,228

MANUFACTURE OF MAGNETIC CORES

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No Drawing. Application January 6, 1940,
Serial No. 312,686

14 Claims. (Cl. 175-21)

This invention relates to the manufacture of magnetic cores, and more particularly to the manufacture of insulated dust type magnetic cores in which small insulated particles of magnetic material are compressed into a body.

An object of this invention is the provision of improved methods for producing insulated dust type magnetic cores having substantial mechanical strength and magnetic properties established within desired limits.

In the manufacture of insulated dust magnetic cores it is customary to pulverize a magnetic metal or alloy into small particles, coat the particles with a combination insulation and binder, and then form the coated particles into a body at high pressure. Cores of this type are used in a variety of apparatus and different core properties are required for different fields of service. The effective permeability of the core is nearly always important and in many instances it is desirable to produce cores having an effective permeability rating established accurately within predetermined and narrow limits. The effective permeability of these cores is influenced by the spacing of the particles, other factors being equal, and in some cases the permeability can be regulated by incorporating a particle spacing agent or filler in the core. These fillers should be chemically inert, non-metallic and non-magnetic.

Kaolin and colloidal clay are generally suitable for this purpose. These materials can be incorporated in the core by dry mixing them with the coated particles and then pressing the mixture in the usual manner, provided that the magnetic particles are relatively coarse and that the proportion of filler is small. However, this procedure is not suitable when very small magnetic particles, such as 300 or 400 mesh or smaller, or a large proportion of filler are used for the cores. Under either of these conditions a dry mixture of particles and kaolin or colloidal clay is very fluffy and difficult to handle without the loss of some of the filler material and consequent disruption of the proper ingredient proportion balance. When attempts are made to press the dry mixture in a die cavity, the fluffy material tends to blow past the forming member before any compacting is accomplished. Also, the spacing material tends to segregate, with the result that the magnetic properties of the core are not uniform and soft spots are formed by the accumulated filler. These soft spots are deficient in mechanical strength and usually produce cracks in the core during the pressing or assembly operations.

In accordance with one embodiment of the present invention, a core containing magnetic particles smaller than 400 mesh in size can be produced with a high degree of mechanical

strength and a uniform effective permeability rating accurately established at predetermined values. The small magnetic particles are first coated with a primary insulation-binder comprising a magnesium hydroxide, sodium silicate and talc. The coated particles are then combined with dry kaolin and colloidal clay in an enclosed mixing apparatus and stirred for a definite period, after which a solution of sodium silicate and magnesium hydroxide in water is added thereto. The resultant mass is stirred until it forms into small balls or spheres, which are heat treated, pulverized into relatively coarse particles and finally compressed into the core structure. The resultant core is strong, free from cracks, and has uniform properties throughout, due to the distribution and treatment of the spacing agent in the core body.

This procedure is suitable for making high-quality cores from a variety of magnetic materials and can be adapted to the manufacture of cores from various metals and alloys. The invention is particularly adapted for use with nickel-iron alloys of the permalloy type and the following detailed description is directed primarily to the production of cores from this type of alloy.

The magnetic particles used in these cores can be prepared by any suitable method. One process for producing nickel-iron magnetic alloy particles is fully described in Patent 1,669,649, issued May 15, 1928 to C. P. Beath and H. M. E. Heinicke.

In manufacturing the particles into cores, the particles are initially provided with a primary insulating coating. This coating and its application is disclosed in my Patent No. 2,105,070, which issued January 11, 1938. As stated in that patent, this coating comprises magnesium hydroxide (milk of magnesia), sodium silicate, and talc and is preferably applied in several layers. For the first layer a solution is made of water, magnesium hydroxide and sodium silicate. The magnetic particles are thoroughly mixed with this solution, after which the coated particles are heated to a temperature between 275° F. and 300° F. to evaporate the water and form an initial set in the insulating material so that it will not be redissolved in the application of subsequent coatings. The second layer is applied by immersing the particles in a similar solution to which talc has been added. The particles are then again heated and two additional layers may be applied in the same manner, making a total of four layers in all. The ingredient proportions are modified for the various coatings, as explained in the patent, and the amount of insulating material is adjusted in accordance with the fineness of the particles and resultant particle surface area to be covered.

In the second process step the coated particles are dry mixed with a filler or particle spacing agent. As stated above kaolin and colloidal clay are suitable for this purpose, and a mixture containing about equal parts of the kaolin and colloidal clay gives excellent results. The quantity of mixture to be added depends upon the permeability desired in the completed core and must be carefully measured. In general, the quantity of kaolin-clay may be equal to from 4% to 20% of the total weight of the coated magnetic particles, the core permeability being reduced as the quantity of filler is increased.

In the dry mixing operation, the particles, kaolin and colloidal clay are placed in a closed tumbling barrel of the usual type and tumbled until the materials are thoroughly commingled. A tumbling period of about ten minutes, with the barrel closed, is usually adequate, but the operation should be continued until a portion of the kaolin-clay mixture is coated on the particles and the remainder is dispersed throughout the particle mass.

In the third process step a solution is added to and combined with the mixture of particles and spacing agent. This solution is made by dissolving sodium silicate and magnesium hydroxide in distilled water. The exact quantity and proportions of these ingredients will depend largely upon the nature and the quantity of particle spacing agent present. In making cores of 400 mesh dust containing a quantity of 50-50 kaolin-clay equal to 4% of the dust weight, good results were obtained with the following solution:

	Weight—Wet basis— per cent of total particle weight
Sodium silicate.....	75
Magnesium hydroxide.....	1.25
Distilled water.....	3.50
Total.....	5.50

In one type of core the filler weight is equal to 6% of the particle weight and the following solution is employed in that construction:

	Weight—Wet basis— per cent of total particle weight
Sodium silicate.....	1.2
Magnesium hydroxide.....	2.0
Distilled water.....	3.5
Total.....	6.7

For cores made of 400 mesh dust and a 50-50 kaolin-clay filler equal to 20% of the total particle weight the following solution is employed:

	Weight—Wet basis— per cent of total particle weight
Sodium silicate.....	3.70
Magnesium hydroxide.....	6.30
Distilled water.....	3.50
Total.....	13.50

The proper quantities of sodium silicate and magnesium hydroxide to be used with other proportions of filler can be determined by interpolation of the ranges given in the above tables. The quantity of water remains constant and the other ingredient proportions are varied with the filler content. Thus, the solution weight will be 5.5% of the particle weight when 4% filler is used

and 13.5% of the particle weight when 20% filler is used.

The solution is poured over the dry mixture in the tumbling barrel and time is allowed for the solution to become absorbed. The barrel is then rotated and the wet mass is worked with a scraping tool. As the tumbling or mixing progresses, the wet mass forms into bodies or spheres of increasing size. After about ten minutes of tumbling, these spheres or balls attain a diameter around one inch and they are then removed from the barrel.

In the next operation, the spheres are placed in a ventilated oven while wet and then heat treated therein. The spheres are first heated at a temperature between 140° F. and 160° F. for about two hours and then, without intermediate cooling, they are heated at a temperature of between 175° F. and 195° F. for an additional period of about two hours. In one satisfactory process the spheres are heated at around 150° F. for about two hours and then heated at around 186° F. for about two hours. At the end of this heat treatment the spheres are dry and hard and they can be stored, preferably in covered containers, in this condition for an indefinite period.

In the next operation, the heat treated spheres are ground or pulverized by means of any suitable apparatus, into relatively coarse particles. The grinding is continued only until the particles will pass through an 80 mesh screen and it is desirable for as many of the particles as possible to approximate this maximum size.

The coarse particles are next pressed into core bodies by the usual methods. In this operation the coarse particles are placed in a die cavity and then compressed by means of a member which is forced into the cavity. Very high pressures, around 250,000 pounds per square inch of forming member surface, are employed to compress the member into a unitary body of desired configuration.

With the above described process a high percentage of particle spacing agent can be incorporated effectively in the core to provide wide flexibility in adjustment of core permeability. The magnetic properties of the core are uniform because the spacing agent is dispersed uniformly throughout the core structure. All of the spacing agent can be incorporated efficiently and effectively in the core and, consequently, the permeability values of the core can be controlled within narrow limits. The coarse particles produced from the spheres bond readily in the pressing operation and the resultant cores have high mechanical strength to withstand the handling and stresses to which they are subsequently subjected. Because segregation of the spacing agent is prevented, the formation of soft spots and the tendency for the cores to crack is avoided.

Although the above description covers a specific embodiment of the invention that is adapted to one type of core structure, these procedures can be used in making cores of various magnetic metals and alloys and modifications of these methods are feasible. In place of the kaolin-colloidal clay combination other materials that are chemically inert, non-metallic and non-magnetic can be employed as fillers if they do not introduce a factor that is deleterious to core quality. The kaolin and clay gives good results partly because of the particle size distribution resulting from this combination and any substituted material should preferably have a similar particle size range. For the solution that is added to the

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particle-filler mixture it is possible to use other metallic hydrates, such as hydrates of bismuth, aluminum, zinc and cadmium, in place of the magnesium compound. Also, other alkali metal silicates, such as potassium silicate, can be substituted for the sodium silicate.

While the use of the specifically disclosed materials is preferred, certain modifications can be made therein with satisfactory results, and it is to be understood that the invention is limited only by the scope of the appended claims.

What is claimed is:

1. In a method of making a magnetic core, the steps of coating finely divided particles of magnetic material with insulation, dry mixing a measured quantity of the coated particles and an agent for separating the particles, adding a liquid solution of a metallic hydrate and a silicate to the commingled particles and separating agent, mechanically mixing the resultant mass until it forms into small bodies, heat treating said bodies, pulverizing the heat treated bodies into relatively coarse particles, and forming said particles into a core.

2. In a method of making a magnetic core, the steps of coating finely divided magnetic particles with insulation, dry mixing the coated particles with kaolin and colloidal clay, adding to the dry mixture a solution of a metallic hydroxide and an alkali metal silicate, mechanically mixing the resultant mass until it forms into small bodies, heat treating said bodies, pulverizing the heat treated bodies into relatively coarse particles, and compressing the coarse particles into a core.

3. In a method of making a magnetic core, the steps of coating finely divided magnetic particles with insulation, dry mixing the coated particles with a chemically inert material for spacing the particles; adding to the dry mixture a solution of a metallic hydroxide and an alkali metal silicate, mechanically mixing the resultant mass until it forms into small bodies, heat treating said bodies, pulverizing the heat treated bodies into relatively coarse particles, and forming said coarse particles into a core.

4. In a method of making a magnetic core, the steps of coating finely divided magnetic particles with insulation, dry mixing the coated particles with a chemically inert material for separating the particles, adding to the dry mixture a solution comprising water, magnesium hydroxide and sodium silicate, mechanically mixing the resultant mass until it forms into small bodies, heat treating said bodies, pulverizing the heat treated bodies into relatively coarse particles, and forming the coarse particles into a core.

5. In a method of making a magnetic core, the steps of coating finely divided magnetic particles with insulation, dry mixing the coated particles with a chemically inert material for separating the particles, adding to the dry mixture a solution comprising water, magnesium hydroxide and sodium silicate, mechanically mixing the resultant mass until it forms into small spheres, heating the spheres at a temperature between 140° and 160° F., subsequently heating the spheres at a temperature between 175° F. and 195° F., pulverizing the heat treated spheres into relatively coarse particles, and compressing the coarse particles into a core.

6. In a method of making a magnetic core, the steps of coating finely divided magnetic particles with insulation, dry mixing the coated particles with kaolin and colloidal clay, adding

to the dry mixture a solution comprising water, a metallic hydroxide and an alkali metal silicate, mechanically mixing the resultant mass until it forms into small spheres, heating the spheres at a temperature between 140° and 160° F. for about two hours, subsequently heating the spheres at a temperature between 175° F. and 195° F. for about two hours, pulverizing the heat treated spheres into relatively coarse particles, and compressing the coarse particles into a core.

7. In a method of making a magnetic core, the steps of dry mixing finely divided and coated particles of magnetic material with kaolin and clay, the total weight of the kaolin and clay being equal to from 4% to 20% of the weight of the coated particles, adding to the commingled particles, clay and kaolin a solution comprising water, magnesium hydroxide and sodium silicate, the total weight of added solution being from 5.5% to 13.5% of the weight of the coated particles, mechanically mixing the combined particles with the agent and solution until the mass forms into small spheres, heat treating said spheres, pulverizing the heat treated spheres into relatively coarse particles, and compressing the coarse particles into a core.

8. In a method of making a magnetic core, the steps of dry mixing finely divided and coated particles of magnetic material with a material for separating the coated particles, said separating material comprising kaolin and colloidal clay in about equal proportions and the total weight of the material being from 4% to 20% of the weight of the coated particles, adding to the dry mixture a solution comprising water, magnesium hydroxide and sodium silicate, mechanically mixing the resultant mass until it forms into small spheres, heating said spheres at a temperature between 140° F. and 160° F., subsequently heating the spheres at a temperature between 175° F. and 195° F., pulverizing the heat treated spheres into relatively coarse particles, and compressing the coarse particles into a core.

9. In a method of making a magnetic core, the steps of dry mixing finely divided and coated particles of magnetic material with a material for separating the coated particles, said separating material comprising kaolin and colloidal clay in about equal proportions and the total weight of the material being from 4% to 20% of the weight of the coated particles, adding to the dry mixture a solution comprising water, magnesium hydroxide and sodium silicate, mechanically mixing the resultant mass until it forms into small spheres, heating said spheres at a temperature around 150° F. for about two hours, subsequently heating the spheres at a temperature around 186° F. for about two hours, pulverizing the heat treated spheres into relatively coarse particles, and compressing the coarse particles into a core.

10. In a method of making a magnetic core, the steps of dry mixing finely divided and coated particles of magnetic material with a material for separating the coated particles, said separating material comprising kaolin and colloidal clay in about equal proportions and the total weight of the material being from 4% to 20% of the weight of the coated particles, adding to the dry mixture a solution comprising water, magnesium hydroxide and sodium silicate, the total weight of the solution being from 5.5% to 13.5% of the weight of the particles, mechanically mixing the resultant mass until it forms into small spheres, heating said spheres at a temperature between

140° F. and 160° F., subsequently heating the spheres between a temperature of 175° F. and 195° F., pulverizing the heat treated spheres into relatively coarse particles, and compressing the

5 coarse particles into a core.

11. In a method of making a magnetic core, the steps of dry mixing finely divided and coated particles of magnetic material with a material for separating the coated particles, said separating
10 material comprising kaolin and colloidal clay in about equal proportions and the total weight of the material being about 4% of the weight of the coated particles, adding to the dry mixture a
15 solution comprising water, magnesium hydroxide and sodium silicate, the weight of said solution being about 5.5% of the weight of the particles, mechanically mixing the resultant mass until it
20 forms into small spheres, heating said spheres at a temperature between 140° F. and 160° F., subsequently heating the spheres between a temperature of 175° F. and 195° F., pulverizing the
heat treated spheres into relatively coarse particles, and compressing the coarse particles into
a core.

12. In a method of making a magnetic core, the steps of dry mixing finely divided and coated particles of magnetic material with an agent for
separating the particles, said separating agent comprising dry kaolin and colloidal clay in about
30 equal proportions and the total weight of the agent being from 4% to 20% of the weight of the coated particles, adding to the dry mixture a solution comprising a quantity of water equal
to 3.5% of the particle weight, a quantity of
35 magnesium hydroxide equal to from 1.25% to 6.30% of the particle weight, and sodium silicate equal to from .75% to 3.70% of the particle weight, mechanically mixing the resultant mass
until it forms into spheres around one inch in
40 diameter, heating said spheres, pulverizing the heat treated spheres into relatively coarse particles, and compressing said relatively coarse particles into a core.

13. In a method of making a magnetic core, the steps of dry mixing finely divided and coated
45 particles of magnetic material with an agent for

separating the particles, said separating agent comprising dry kaolin and colloidal clay in about
equal proportions and the total weight of the agent being equal to 6% of the weight of the
5 coated particles, adding to the dry mixture a solution comprising a quantity of water equal to 3.5% of the particle weight, a quantity of magnesium hydroxide equal to 2% of the particle weight, and sodium silicate equal to 1.2% of the
10 particle weight, mechanically mixing the resultant mass until it forms into spheres around one inch in diameter, heating said spheres at a temperature between 140° F. and 160° F. for two hours, subsequently heating said spheres at a
15 temperature between 175° F. and 195° F., pulverizing the heat treated spheres into relatively coarse particles, and compressing said relatively coarse particles into a core.

14. In a method of making a magnetic core, the steps of coating finely divided particles of a
20 nickel-iron magnetic alloy with a mixture of magnesium hydroxide, sodium silicate and talc, combining the coated particles with an agent for separating the particles, said separating agent comprising dry kaolin and colloidal clay in about
25 equal proportions and the total weight of the agent being equal to about 6% of the weight of the coated particles, dry mixing the particles and agent until a portion of the agent is coated on the particles and the remainder is dispersed
30 through the particle mass, adding to the dry mixture a solution comprising a quantity of water equal to 3.5% of the particle weight, a quantity of magnesium hydroxide equal to 2% of the particle weight, and a quantity of sodium silicate
35 equal to 1.2% of the particle weight, mechanically mixing the resultant mass until it forms into spheres around one inch in diameter, heating said spheres at a temperature around 150° F. for about two hours, subsequently heating the
40 spheres at a temperature around 186° F. for about two hours, pulverizing the heat treated spheres into relatively coarse particles, and compressing said relatively coarse particles into a
core.

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