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METHOD FOR MAKING MAGNETIC CORES

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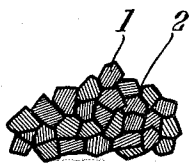


Fig. 1

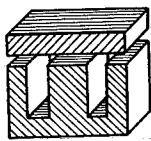


Fig. 3

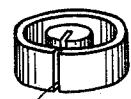


Fig. 4

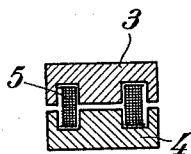


Fig. 5

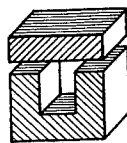


Fig. 2

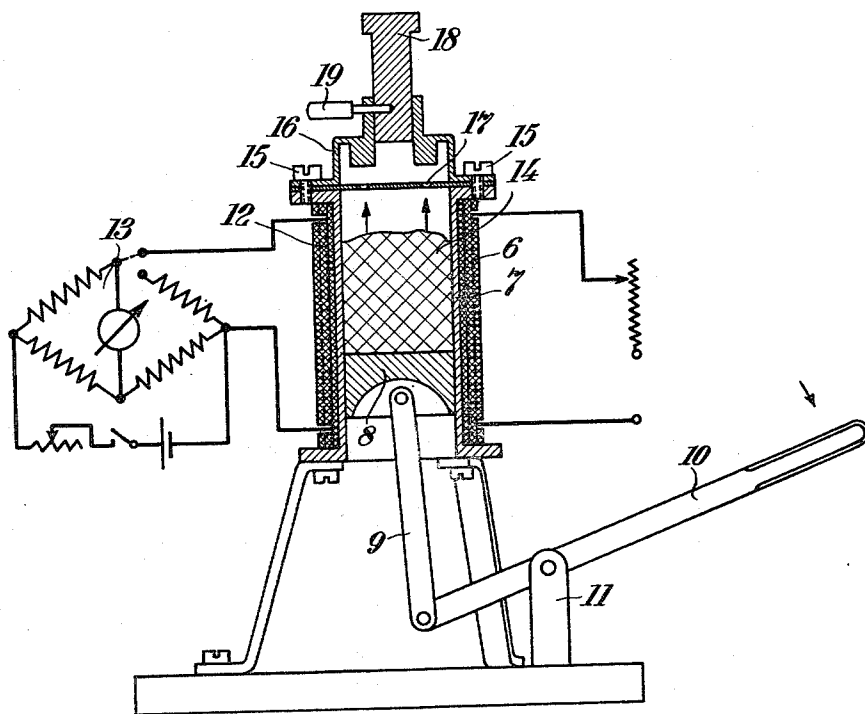


Fig. 6

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METHOD FOR MAKING MAGNETIC CORES

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5 Claims. (Cl. 175—21)

This invention relates to a method for making magnetic cores, more particularly magnetic cores for high frequency coils. It is the object of this invention to facilitate the manufacture of molded magnetic cores of magnetic powder. Another object of the invention is to reduce the manufacturing time and to make possible the manufacture of such cores in a continuous process by quantity production. Still another object is to render it possible to use cheap, irregular iron powder without reducing the efficiency of the core.

The method according to this invention comprises the steps of intimately mixing magnetic powder with a sufficient quantity of a thermoplastic insulating binder, extruding the heated mixture into the mold through restricted orifices, cooling the mixture in the mold and ejecting the solidified body from the mold.

I have already disclosed in my prior Patents Nos. 2,011,697 and 2,011,698 how to produce a uniform magnetic material of low losses at high frequency by depositing a mixture of magnetic material and insulating binder on a thin paper ribbon, superposing several of such deposited layers by compression and stamping the required core pieces from the sheet thus produced. Other methods involving the compressing of iron dust cores from a mixture of magnetic powder and insulating binder are also known. The method according to the present invention, however, is differentiated from the last mentioned prior art core compression method by rendering possible a quick mass production of cores with very uniform electrical and magnetic properties, accurate dimensions and even of complicated shape, because a great quantity of the magnetic material can be mixed and prepared in a large storage container, from which only a small quantity may be extruded into the mold through a perforated plate by exerting pressure upon the bulk of the magnetic mixture, and the portion of the magnetic mixture thus extruded can be solidified immediately and then ejected from the mold.

Molding processes of ordinary, non-magnetic thermoplastic materials by extrusion are known per se in the art. I have discovered, however, that in applying these known methods in a new field, namely, for the production of the above-described iron dust cores, a very essential property can be conveniently and cheaply imparted to these cores which property was not recognized, so far as I am aware, and in fact is not essential in the prior art use of this extrusion method for producing objects of non-magnetic thermoplastic

material mixtures. This property is the uniform density and mixture of the constituents throughout the molded body, which can be imparted to the product by extruding the plastic mixture through orifices into the mold. Iron dust cores, more particularly for use in high frequency broadcast receivers, must be of quite uniform density, and the magnetic material must be quite uniformly distributed throughout the core volume in order to obtain in all cores produced the same uniform good efficiency, especially low losses, and uniform permeability.

Even slight differences in the distribution of the magnetic powder within the binder may cause great differences in the permeability in different parts of the core. These essential properties were heretofore imparted to these cores to a certain extent by very special and tedious molding processes which made quantity production very difficult and very expensive. Especially was it difficult, if not impossible, to produce a large number of a given core form with the same uniform electric and magnetic properties, partly on account of the great differences in the specific weight between the iron powder and the plastic binder, the former being of the order of 7.7 and the latter of the order of 1—2. By my discovery that the extrusion process of a thermoplastic ferrous dust core mixture fulfills for each core of a given form the above stated requirements, I have overcome the heretofore existing great obstacles to cheap quantity production of these cores, and the mixture of constituents of such widely different specific weights, instead of separating during the extrusion as might be expected, becomes more uniform. I have found that by intimately mixing a sufficient quantity of insulating material and iron powder in the desired proportions, and by carefully selecting and keeping constant all the conditions influencing the extrusion process, it is possible to obtain cores of very good uniformity, electrically as well as mechanically.

When I refer in the specification and claims to "plastic state" or "plastic material", these terms should be understood in the conventional sense, namely to indicate any material which at the given temperatures is not of rigid shape, but can be easily deformed or molded, more particularly by these terms is understood a semi-liquid viscous or syrup-like condition of the material.

In this way, it is possible to produce cores in a continuous process by an automatic machine and to solidify said cores immediately by cooling. Instead of spherical particles of expansive carbonyl

iron, cheaper iron powder can be used which is obtained for instance by mechanical disintegration, grinding, reducing from oxides or hydrides or similar processes. Such particles should, however, be insulated additionally by separate insulating skins on each particle which may be produced by oxidizing which is preferably effected by gradually heating the powder to a temperature of 240 to 300° C. under continuous stirring in open air, until the yellow tempering color appears.

It is possible, by using a binder having a high softening or melting point respectively, to make cores in this way, the heat resistance of which is practically absolutely satisfactory (up to more than 100° C.). Cores of this kind have considerable mechanical strength. Various substances may be used as binder which are good insulators and have a high softening or melting point and are sufficiently thinly liquid to fill up the interstices between the magnetic particles. Care must be taken that no agents are applied which are detrimentally reacting with the iron powder. Paraffine, ceresine or other waxes may be used which, however, when employed alone, have a relatively low melting point. Natural or artificial resins of different composition (for instance colophony) which become liquid under heat, that is at temperatures of 80 to about 250° C., may be better suited. These resins may be used in pure state or with suitable additions such as small admixtures of paraffine and ceresine which make the matter more thinly liquid and elastic. Up to one twentieth by weight of ceresine or paraffine may be added to the resin, and one part by weight of this mixture may be mixed with 4 to 5 parts by weight of magnetic powder. In particular, so-called Cumaron resin, which is produced by polymerization of solvent naphtha and has a melting point up to 200° C. and more, is used with good success.

Pitches or asphalts may likewise be used, provided they are sufficiently thinly liquid. It is, however, advisable to add small quantities of sulphur (about 5%), thus increasing their melting point to more than 100° C.

Pure sulphur proved to be particularly suited. By mixing one part by weight of sulphur and 2.5 parts by weight of magnet powder at a temperature of 115 to 140° C. a core is obtained which is mechanically extremely hard and heat proof, having very low losses and a permeability between 10 and 13.

Favorable results were further obtained by using so-called solid chlorinated hydrocarbons (in particular naphthalenes) that is hydrocarbons the melting point of which is advanced by partly substituting the hydrogen by chlorine. Such substances, in particular those made of naphthalene, are very thinly liquid under heat, their softening point is almost identical to their melting point and they have high adhesive properties. This binder has high elasticity, while the electrical properties as regards insulation and losses are extremely favorable. As an example of mixture proportions one pound by weight of such chlorinated hydrocarbons should be mixed with about 3 to 4 parts by weight of magnet powder.

The above process is particularly suited if cheap material of non-spherical shape is used which is provided with an oxide skin.

The invention will be better understood by reference to the accompanying drawing in which:—

Fig. 1 shows the inner structure of a core made according to the invention,

Fig. 2 shows one type of core,

Fig. 3 shows another type and

Fig. 4 shows still another type of core.

Fig. 5 is a sectional view of a complete coil built up of two core halves as per Fig. 4.

Fig. 6 shows the principle of a machine for the continuous manufacture of cores according to the invention.

As shown in Fig. 1, the interstices between the magnetic particles 1 are perfectly filled up by the insulating binder 2, whereby metallic contact between the particles is prevented.

The complete core may be of any suitable shape. Fig. 2 shows a semi-shell core, Fig. 3 a shell-core or E-core, Fig. 4 one half of a so-called pot-core consisting of a cylinder which has an annular groove designed to take up the bobbin. This is more clearly shown in Fig. 5, in which 3 and 4 are two core halves and 5 is the bobbin accommodated in said annular groove.

To reduce eddy current, a radial air gap 20 may be arranged in the core as shown in Fig. 4.

To improve the electric properties of the core, in particular when using irregular, cheap iron powder, it is useful to mold the core under the influence of a strong magnetic field the direction of which corresponds to the direction of the high frequency field of the coil. To this effect, a magnetizing coil having the same dimensions as the high frequency coil may be fitted in the mold. Under the influence of this magnetic field, the magnetic particles are alined in the direction of the flux and, moreover, the distance between the particles in a plane, which is perpendicular to the lines of force, is increased due to the magnetic repulsion between the particles. In that way, the quantity of the expensive magnetic powder needed for a core may be reduced by 30% without reducing the permeability.

The advantage of the process according to the present invention consists in the fact that it permits the direct production of magnetic cores in a continuous process so as to meet the great demand of the radio industry for such magnet cores.

The principle of a machine for such continuous production is shown in Fig. 6. The piston 8 is located in a cylinder 7 heated by heating windings 6. By means of the lever device 9, 10, 11, the piston may be moved in the cylinder in the direction of the arrow. The temperature may be accurately measured by the measuring wire 12 and an electric temperature measuring arrangement 13. This accurate temperature measuring is of particular importance in case of sulphur cores. In the cylinder is the magnetic pulp 14. The mold plate 16 is arranged at the top of the cylinder and fixed by screws 15. The iron pulp 14 is pressed into the mold 16 through nozzles 17 by means of the piston 8. The mold is then cooled while its contents are kept under pressure and it is then removed from the cylinder. The core is hereafter ejected by the expulsion device 18, which, during the pressing, is maintained in a definite position by the pin 19. The plate 16, of course, may carry a greater number of hollow molds corresponding to the shape of core to be made, so that a greater number of cores may be produced in one operation. The mold may have double walls so as to be water cooled to accelerate the solidification of the core.

In order to increase the permeability of the core it may be useful to subject the finished core to a subsequent pressing process in a mold applying heat and pressure. Any surplus of binder may thus be expelled and the permeability will be increased accordingly. The expelled quantity of

binder may be caught by little sucking plates of blotting paper or by similar means. In that way, the permeability may be fairly increased without increasing the high frequency losses of the core.

- 5 Another modification of the present method consists in mixing the liquid insulating binder with a magnetic powder and molding the core at a lower temperature than that at which the insulating binder or the mixture of the powder and
10 binder respectively has a plastic consistency. This presents the advantage that the insulating and binding layer between the particles offers a greater resistance against piercing, thus rendering it possible to use higher pressure without
15 causing metallic contact between the particles.

I claim:—

1. A method of making magnetic high frequency cores, which comprises heating and intimately mixing magnetic powder and thermoplastic insulating binder, squirting a charge of the heated plastic mixture through a restricted aperture into a mold, solidifying the charge within the mold by cooling, and discharging the solid body from the mold.

- 25 2. A method of making magnetic high frequency cores, which comprises squirting a heated mixture of magnetic powder and thermoplastic insulating binder into a mold through a restricted aperture in the cover thereof, cooling the material in the mold to form a solid body, and discharging the solid body from the mold.

3. A method of making magnetic high frequency

cores, which comprises providing a heated supply of intimately mixed magnetic powder and thermoplastic insulating binder in a chamber fitted with a displacement piston, applying to a mold an apertured cover, applying the cover and
5 mold over an opening in a wall of the chamber, thereafter displacing a predetermined charge of the heated mixture from said chamber through the apertured cover into the mold by movement of said piston, cooling said charge within the mold
10 to form a solid body, and thereafter removing the cover and discharging the solid body from the mold.

4. A method of making magnetic high frequency cores, which comprises maintaining in
15 plastic state an intimate mixture of magnetic powder and thermoplastic insulating binder, displacing by pressure against the plastic mass a charge of said mixture through an apertured cover into a mold closed thereby, solidifying said
20 charge by cooling within said mold, removing said cover and discharging the solidified charge from said mold.

5. A process comprising intimately mixing magnetic powder and a thermoplastic insulating
25 binder while keeping the mass at the melting temperature of the binder, squirting the mixture so formed from a container into a mold while keeping the mixture at a temperature where the binder is plastic and solidifying the portion of
30 said mixture contained in the mold by cooling.

HANS VOGT.