Dec. 11, 1945. M. AMIDON ET AL 2,390,863

METHOD OF MAKING ELECTROMAGNETIC CORES

Filed Oct. 9, 1941

FIG. 1

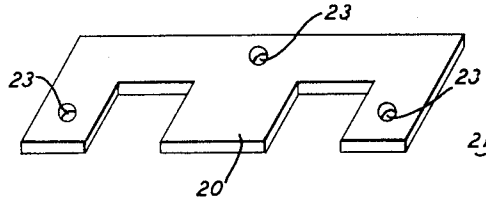


FIG. 2

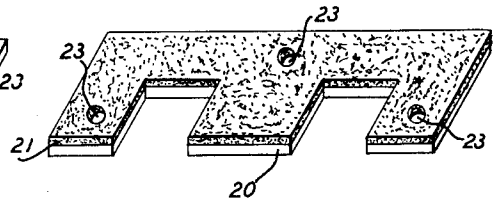


FIG. 3

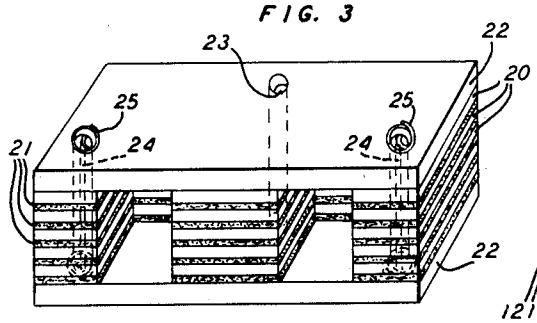


FIG. 4

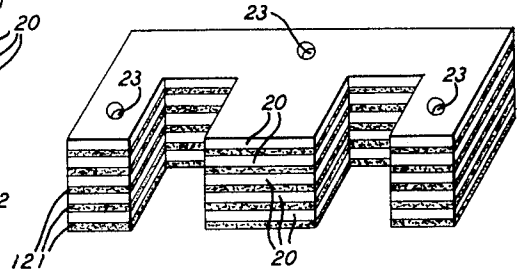
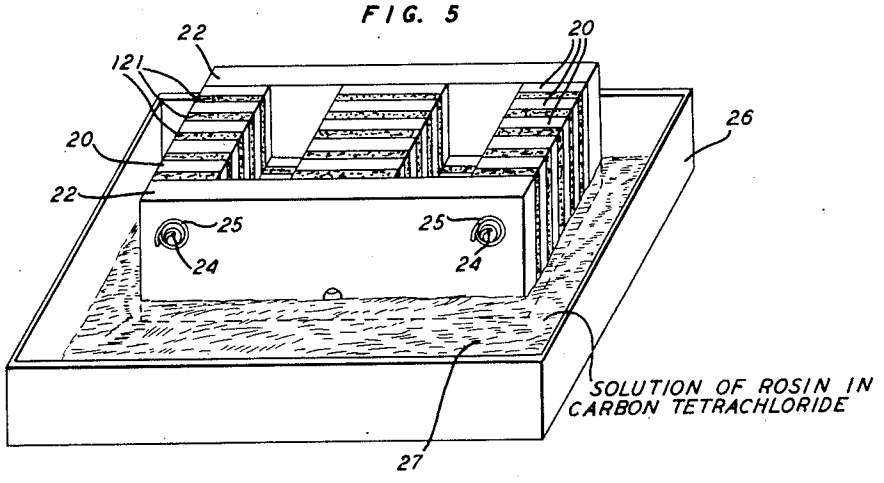


FIG. 5



INVENTORS
M. AMIDON
H. E. THORNTON

BY

E. R. Moulton
ATTORNEY

Patented Dec. 11, 1945 2,390,863

UNITED STATES PATENT OFFICE

2,390,863

METHOD OF MAKING ELECTROMAGNETIC CORES

Merle Amidon, Elizabeth, and Harry E. Thornton, Plainfield, N. J., assignors to Western Electric Company, Incorporated, New York, N. Y., a corporation of New York

Application October 9, 1941, Serial No. 414,288

1 Claim. (Cl. 175—21)

This invention relates to a method of making an electromagnetic core, and more particularly to a method of making an electromagnetic core, comprising a pile of laminations of magnetic material each having on one face thereof an adherent coating of electrically insulating mineral material.

There are instances in the electrical arts where it is desirable to produce magnetic cores for electromagnets, electromagnetic coils, transformers, and the like, consisting essentially of thin sheets of laminae of magnetic material, e. g. iron, silicon steel, various nickel-iron alloys, and the like, piled into stacks and having intercalated layers or sheets or coatings of material neither electrically or magnetically conductive, to minimize the occurrence of eddy currents or other parasitic effects.

An object of the present invention is to provide an improved method of producing an improved core of the general type described, the method being simple, rapid and inexpensive in operation, and the core laminae being effectively, durably and inexpensively insulated from each other in the stack.

In one embodiment the invention may be illustrated in a method comprising steps of heating a sheet of magnetic material to about 225° F., spraying one face of the hot sheet with a suspension of powdered mica in a vehicle consisting of water and polyvinyl alcohol, drying out the coating by expulsion by the heat of the hot sheet of water but not polyvinyl alcohol from the coating, forming laminae of identical size and shape from the coated sheet, and heating a stacked pile of the laminae to about 1900° F. to expel the polyvinyl alcohol and cause the powdered mica to cement the laminae together.

Other objects and features of the invention will appear from the following detailed description of one embodiment taken in connection with the accompanying drawing in which the same reference numerals are applied to identical parts in the several figures and in which

Fig. 1 is a view in perspective of a single blank lamina;

Fig. 2 is a similar view of a coated lamina;

Fig. 3 is a similar view of a stack of coated laminae bundled ready for annealing;

Fig. 4 is a similar view of the annealed stack ready for use; and

Fig. 5 is a similar view of the bundled and annealed stack being subjected to auxiliary treatment.

In the illustration of the invention herein disclosed, laminae **20** of suitable magnetic material are formed, e. g. by punching from sheets. These are then washed, cleaned or degreased in any suitable fashion, if necessary. The clean laminae are then spread on a suitable support (not shown), e. g. a sheet of wire mesh, and sprayed with a composition consisting essentially of 2.5 parts by weight of mica powder suspended in a solution of 0.75 part by weight of rosin in about about 96.25 parts by weight of carbon tetrachloride. Instead of the rosin solution in carbon tetrachloride above described, a solution of about 1% of dibutyl phthalate in carbon tetrachloride may be used as the vehicle for the mica suspension. The mica powder is preferably a muscovite mica ground to a 325 mesh finesss. This composition is sprayed to yield a residual film **21** of solids about 0.001 inch thick. Such a sprayed coating dries practically immediately at room temperatures and adheres firmly enough to the laminae to admit of handling with moderate care.

Such coated laminae are next stacked, as shown in Fig. 3, so that the laminae are intercalated regularly by their coatings, i. e. the laminae proper and their coatings alternate regularly throughout the stack; and temporary end members **22** of substantially the same gross dimensions are placed at the ends of the stack. These end members are of any suitable rigid and refractory material which will protect the stack of laminae against undue strains and accidental injury during the next steps of the procedure. The members **22** may preferably be of ceramic or the like material, e. g. porcelain or Lavite. The laminae and the end members are provided with aligned perforations **23**, to be used later for rivets to hold the stacked cores together. At this juncture, however, they are used to receive wires **24** passed through them and suitably twisted at their ends, as shown at **25**, to hold the stack and its protective end members together sufficiently firmly to exert a gentle pressure of the laminae on each other.

Such stacked and wired lamina bundles are annealed at a suitable temperature and for a suitable time and then cooled. The annealing temperatures are ordinarily, for the magnetic materials here in question, of a range upward of 1900° F. The coating **21** on each lamina before annealing, the carbon tetrachloride having evaporated, consists of about 10 parts of mica powder cemented in place with about 3 parts of rosin. During the annealing, the rosin is wholly consumed or driven off. After annealing, the

coatings 21 are found to consist wholly of mica residue, quite firmly adherent to the surface on which it was originally deposited, and lightly adherent to the next lamina above. The adherence to its original base is quite surprisingly firm. The reason for this is not known. Microscopic investigation and study have not been made to determine this. To the naked eye or through an ordinary loupe, the coating looks like an extremely fine grained sandpaper, and evidently has not been completely, or even to any material degree, melted. Undoubtedly the water of crystallization or molecular water of the mica has been driven off; and it is believed that the adhesion of the coating is due to some degree of fritting. The presence of the rosin or some equivalently acting material is preferable; for the adhesion of the mica is not always, though usually, complete in its absence. The difference, in the annealed bundle, of the adhesion to the surface on which the mica was sprayed and to the merely juxtaposed surface of the next lamina is striking; and if the laminae are forcibly separated there is no visible coating carried off by the superimposed lamina nor any visible loss of coating by the base lamina.

On removing the wires 24 and protective members 22, the bundle as shown in Fig. 3 is sufficiently self-coherent for careful handling in further operations, if any, of winding coils thereon or the like.

The procedure as thus far described is complete and successful with laminae of 45% nickel and 55% iron, or of 3.8% molybdenum, 78.8% nickel and 17.7% iron, the alloys known respectively as 45% permalloy and as molybdenum permalloy. It is not always satisfactory in the case of laminae of chrome permalloy (type composition: 3.8% chromium, 78.8% nickel and 17.7% iron), as the adhesion is sometimes insufficiently good for practical use.

Preferably, however, the blank, cleaned and degreased laminae may also be preheated to about 225° F. and sprayed with a suspension of about 2.5 parts of the mica powder in a solution of one part of polyvinyl alcohol in 99 parts of water instead of with the mica-rosin-carbon tetrachloride mixture. The remainder of the procedure is then as before. In this case, should chrome permalloy show a tendency toward too slight adhesion of the coating, the chrome permalloy laminae may be presprayed with a 4% water solution of boric acid, or, in some instances, boric acid may be added in like proportion to the vehicle of the mica suspension, and good results are achieved.

It is also found that in some cases when molybdenum permalloy is in question, a more uniform coating is obtained by using about 0.5 part powdered talc and 2.0 parts powdered mica in place of 2.5 parts of mica.

As a commercial continuous process, to be carried out largely mechanically, the method may be slightly modified as follows: The permalloy stock in a continuous ribbon, strip or sheet is cleaned with steam, degreased with a suitable solvent (e. g. trichlorethylene), preheated to about 225° F., sprayed with the above described 4% boric acid solution in the case of chrome permalloy only, sprayed with the above described suspension of mica in water and polyvinyl alcohol (mica and talc in the case of molybdenum permalloy), dried and rolled up for storage. The sprayed and dried coating thus produced is sufficiently coherent and adherent to endure such handling with reasonable care and without material damage. Indeed, such coated ribbons, strips or sheets may themselves be an object of the invention as a completed article of commerce produced by a manufacturer of metal and sold to a wholly independent manufacturer of electrical apparatus.

Such coated ribbon, strip or sheet may be fed through an ordinary punch press or like apparatus in the usual way to produce directly therefrom the coated laminae shown in Fig. 2; and the coating is sufficiently adherent and coherent for this to be done. The coated laminae thus produced are then stacked, bundled and annealed as before.

It is to be noted that a bundle of laminae, stacked, wired and annealed, need not be limited in size to the number of laminae intended to form a single core only. To reduce the number of handlings necessary to produce a considerable number of core stacks, especially those of relatively few laminae each, the sprayed and dried laminae may be stacked in bundles each equivalent to several future cores, wired and annealed. Separation of the bundled laminae after annealing is then possible because of the fact noted above that the sprayed and dried mica coating after annealing adheres so firmly to the surface on which it was sprayed and so lightly to the opposed surface of the next lamina, that separation is easily accomplished with the fingers only without damage to the coating, despite the fact that the adherence is sufficient to allow the de-wired bundle or fractions thereof to be handled as units, with reasonable care. On the other hand, should the laminae of a bundle become misplaced relatively to each other during wiring and annealing, the adhesions may be broken and the component laminae of a stack re-aligned without harm or loss of electromagnetic efficiency.

In some instances it may be desired to increase the adhesion of the coatings to the juxtaposed laminae where some rougher handling of the stacks is inevitable. In such case, the bundled, wired, annealed and cooled laminae, before the wires are removed, may be placed with the laminae standing on edge, as shown in Fig. 5, in a tray, tank or other suitable container 26 in which is a shallow layer of a solution of about 0.75 part rosin in about 95–100 parts carbon tetrachloride. The layer of solution need ordinarily be only deep enough to thoroughly wet the bottom face of the bundle, e. g. an eighth inch deep or so. By capillary attraction, the solution is drawn up between the opposed laminae and coatings, wetting their entire surfaces and appearing visibly at the top edges usually within one minute. Upon then removing the bundle from the solution, drying and removing the wires, the cohesion of the laminae is found to be considerably enhanced by the rosin thus introduced and deposited. Instead of the rosin solution a solution of about 1% dibutyl phthalate may also be employed for this operation, and in some instances this is preferable to the rosin solution.

Other substances than rosin or dibutyl phthalate dissolved in carbon tetrachloride or than vinyl alcohol dissolved in water may be used as the vehicle in which to suspend the ground mica for spraying the raw coating on the magnetic material. But such substances must preferably be such as will substantially entirely disappear during the annealing, and particularly such as will not leave a residual tar or coke deposit in the mica coat. The substances specified above are

preferred for the reason that they have this character. A suitable spray suspension for the purpose, so far as is at present known, must consist essentially of powdered mineral, comprising ground mica as its principal ingredient, suspended in a vehicle consisting of a suitable volatile liquid carrying a small proportion of a dissolved adhesive, preferably organic or non-mineral in nature, which is completely driven off at the annealing temperature without residue. For optimum results there will be about 2 to 3 parts by weight of mineral powder (mostly mica) suspended in about 95 to 105 parts by weight of volatile liquid solvent in which ½ to 1½ parts by weight of the expellable adhesive are dissolved. For work at room temperature the solvent will preferably be a highly volatile one, e. g. carbon tetrachloride, trichlorethylene, benzene, or the like; while, if the magnetic material to be sprayed is preheated, as described in one case above, some less volatile solvent, e. g. water, may be preferable.

The embodiments disclosed above are illustrative and may be modified and departed from variously without departing from the spirit and scope of the invention as pointed out in the appended claim.

What is claimed is:

The method of making electromagnetic cores which comprises steps of heating a sheet of magnetic material to about 225° F., spraying one face of the hot sheet with a suspension of powdered mica in a vehicle consisting of water and polyvinyl alcohol drying out the coating by expulsion by the heat of the hot sheet of the water but not the polyvinyl alcohol from the coating, forming laminae of identical size and shape from the coated sheet, and heating the stacked pile of laminae to about 1900° F. to expel the polyvinyl alcohol and cause the powdered mica to cement the laminae together.

MERLE AMIDON.
HARRY E. THORNTON.