A plurality of identical ferromagnetic sheets are stamped or punched from a larger sheet of silicon-alloy steel. A finely divided powder of an inert bond inhibitor and spacer is mixed with the oil applied to the sheets during the stamping operation, or is applied to the sheets before or after stamping. The coated sheets are thereafter stacked and fastened together and heated to a temperature sufficient to anneal them and to form an insulating oxide layer on the sheets.
METHOD OF MAKING AN ELECTROMAGNETIC-SHEET STACK

FIELD OF THE INVENTION

The present invention relates to a method of making a sheet stack for use with an electromagnetic coil.

BACKGROUND OF THE INVENTION

The field or stator element of a motor, transformer, choke, meter movement, relay, magnetic-field detector or the like is usually formed from a multiplicity of similar laminations or sheets produced by stamping. These sheets are secured together in a stack by weldment beads, spot welds, straps or by means of rivets or bolts, after which the assembled stack is submitted to a heat-treatment operation (annealing) which improves its magnetic properties.

It is known to heat treat the individual sheet prior to formation of the stack for decarbonization or to form oxide layers thereon. When the sheets are treated separately however, fabrication costs become unacceptably high. When they are treated together as a random pile they often fuse together so that nonuniform decarbonization and formation of oxide layers results, there being minor differences in the characteristics of inner and peripheral portions of the sheets.

OBJECTS OF THE INVENTION

It is therefore an object of the present invention to provide an improved sheet stack for cooperation with an electromagnetic coil.

Another object of my invention is to provide an improved method of making such a stack.

Yet another object of the invention is to provide a method of making an improved sheet stack wherein the electromagnetic properties of the finished product are excellent.

SUMMARY OF THE INVENTION

The above objects are attained according to the present invention in a sheet stack whose individual sheets are coated during production with an inert bond inhibitor.

According to the principles of the present invention, therefore, the thin sheets or lamella of sheet iron, sheet steel or a steel-alloy sheet of silicon steel, as commonly used to produce the stator or field member of an electromagnetic device, are stamped or punched from a larger sheet and are geometrically identical, the sheets being stacked in coextensive relationship after the application of an inert antibonding spacing substance uniformly to the surfaces of the sheets. The stack, which is mechanically fixed in the final configuration of the magnetic body by rivets, bolts, weld seams, clamps or straps, is then annealed in an oxidizing atmosphere at a temperature and for a period sufficient to cause oxide layers to form on the spacedly juxtaposed surfaces of the adjoining sheets, the spacing material permitting the oxidizing furnace gases to pass between the sheets.

Surprisingly, when one or both surfaces of such stamped or punched sheets are coated substantially uniformly with an aerosol silicon oxide, talc or metal soap just sufficient to ensure a uniform distribution of this material, the spacing layer is sufficiently porous to allow access to the metal surfaces of the oxidizing furnace gases so that the oxidation of the sheets is effected continuously and uniformly in spite of the presence of the spacer particles. The latter are, as noted, chemically inert and physically inert with respect to the composition of the plate and the heat treatment. Thus the silicon dioxide or talc powder does not bond to the metal surfaces or to the oxide layers formed thereon, nor does it chemically react with either the furnace gases or the metals. As a consequence, the oxide layers, which are produced in situ in the furnace, form the permanent insulating and isolating layers without bonding of portions of the sheets together as has hitherto interfered with the uniformity of oxidation. Of course, the furnace atmosphere, annealing temperatures, depth of the formed oxide layer may conform to the state of the art and I may mention German published Application No. 1,433,744 in this regard.

The term "sheet" is used herein in the sense of the art, namely, to define generally C-shaped, E-shaped, D-shaped, T-shaped and I-shaped thin magnetic members which are joined together in stacks to form stators for electrodynamic devices or the cores of such devices as chokes, transformers and induction coils.

According to another feature of this invention the inhibitor is applied to the sheets as a finely divided aerosol powder. In this manner the hot gas of the furnace penetrates between the sheets to thoroughly decarburize the sheets even at their centers and otherwise ensure uniform heating.

DESCRIPTION OF THE DRAWING

The above and other objects, features, and advantages of the present invention will become more readily apparent from the following description, reference being made to the accompanying drawing in which:

FIG. 1 is a perspective view of a stack according to the present invention;

FIG. 2 is a section taken along line II-II of FIG. 1 drawn to a greatly enlarged scale; and

FIG. 3 is a largely diagrammatic view illustrating the method according to the present invention.

SPECIFIC DESCRIPTION

FIGS. 1 and 2 show a stack 4 formed of a plurality of identical sheets 1 held together by rivets 5. Each sheet 1 is separated from the neighboring sheet 1 by a layer of inhibitor 3 enabling oxide coatings 2 to form on the confronting faces of the sheets 1. In this manner each sheet 1 is effectively insulated from the other sheets so that losses due to eddy currents are held to a minimum.

As seen in FIG. 3 such a stack is produced by first stamping out the elements 1 from a sheet 6 at a stamping station 7. Oil mixed with the inhibitor 3 in powdered form is fed to the stamping device from a supply 8.

Downstream of the station 7 further aerosol-form inhibitor may be sprayed onto the individual stamped sheets 1 at a coating station 9, whereupon the stack is fastened together at a stacking station 10. An oven 11 is employed to heat treat the stack 4 for annealing and decarburization, and finally the stack 4 as shown in FIG. 2 is allowed to cool at 12.

The temperature to which the stack 4 need be heated and the rate at which it should be cooled depend on just what magnetic properties are supposed to be imparted to it. This temperature need merely be sufficient, for the present purposes, to form the coatings 2 as, for ex-
ample, vitreous or glass-like layers of microscopic thickness; the temperature should also be below that at which the applied spacing layer is broken down.

The inhibitor is, as stated above, a very finely divided powder which does not react with the sheets. The following products have utility as inhibitors according to the present invention, silicon dioxide (particularly with silicon-steel alloys); metallic soaps, talc, and other heat-resistant fine powders. As described above, these powders may be mixed with the stamping oil, or they may be blown over the stamped sheets, or both methods may be combined.

The sheets themselves may be made of magnet steel, soft iron, a silicon-steel alloy, or the like, as well known in the transformer art.

Within the annealing decarburizing furnace 11, the stack 4 of silicon-steel sheets is exposed to oxidizing gases at the annealing temperature to form the oxide layers 2 along the spacedly juxtaposed surfaces of the sheets. The spacing between the sheets can be of the order of 1 to 10 microns and will, of course, depend upon the layer of the particles introduced at 3 as the spacing layer. Where stamping oil serves as the medium for coating the surfaces of the sheets with the spacing material, it is preferred to use a stamping oil which is decomposed in the annealing furnace or evaporates prior to annealing. The oxide layers may have thicknesses of the order of microns and are found to be highly satisfactory as insulating layers between the sheets. They do not interfere with advantageous magnetic properties and, in fact, have been found to enhance certain of them. When the stack is removed from the furnace, it requires no further treatment before use although the entire stack may be encased in a housing or potted in an insulating mass.

SPECIFIC EXAMPLES

EXAMPLE I

A plurality of C-shaped sheets to be used for a clock-motor field yoke are stamped from previously degreased of a soft silicon-alloy steel sheet 1 mm thick. A layer of aerosol-fine silicon dioxide powder <10 μ up to 20 μ thick is dusted on the top of each sheet and the sheets are stacked and riveted together to form the shaped stack in its final configuration. Thereafter the sheets are heated to 1,500°F for one-half hour in a stream of air and allowed to cool in the furnace also in art. Oxide layers are formed on the juxtaposed but spaced surfaces of the plates.

The steel-sheet material may consist of 30 to 40 percent by weight cobalt, 1 to 24 percent by weight silicon, 0 to 3 percent by weight chromium, 0.4 to 0.8 percent by weight carbon, 0 to 9 percent by weight tungsten, the balance iron.

EXAMPLE II

The process described in Example I is carried out except that the layer, composed of talc, is applied in the stamping lubricant which is evaporated in the annealing oven during the initial phases of the treatment. In Example I and in Example II, stable oxide layers of a thickness of 1 to 10 microns are formed uniformly on the spacedly juxtaposed surfaces of the sheets.

I claim:

1. A method of making an electromagnetic sheet stack for cooperation with an electromagnetic coil comprising the steps of:

stamping a multiplicity of ferromagnetic congruent sheets from a larger plate and coating said sheets with a film of oil and talc constituting a bond inhibitor in the stamping process,

stacking said sheets with the talc bond inhibitor and oil between them and mechanically fixing the oil-coated and talc-coated sheets of the stack together in their ultimate structural relationship; and

heating the stack of coated oil-coated and talc-coated sheets to anneal said sheets in a furnace atmosphere simultaneously forming insulating oxide layers on juxtaposed surfaces of said sheets of the stack separated by said talc bond inhibitor.

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