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Tomita

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[54] **LAMINATED MAGNETIC COIL MATERIALS**

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[52] **U.S. Cl.** **336/196,** 29/605, 29/609, 148/31.55, 156/89, 156/187, 156/280, 161/196, 161/213, 336/200, 336/213, 336/219, 336/223

[51] **Int. Cl.**.....**C04b 35/00,** H01f 27/30

[58] **Field of Search** 161/196, 213, 165; 156/184, 156/185, 187, 280, 89; 117/230, 234, 236, 240, 94, 97, 127, 129, 135.1, 105; 148/6, 100, 101, 113, 122, 31.5, 31.55; 29/605, 609; 336/221, 222, 225, 200, 219, 223, 196, 213

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Primary Examiner—Robert F. Burnett
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[57] **ABSTRACT**

A laminated magnetic material composed of thin rolled sheet of magnetic alloy having a thickness of less than 25 microns and a glassy material formed on at least one surface of the thin rolled sheet of magnetic alloy, wherein the sheet of magnetic alloy and the glassy material are wound and laminated alternately and each of the layers of magnetic alloy is secured to the adjacent layer interposed by an electric insulator.

2 Claims, 8 Drawing Figures

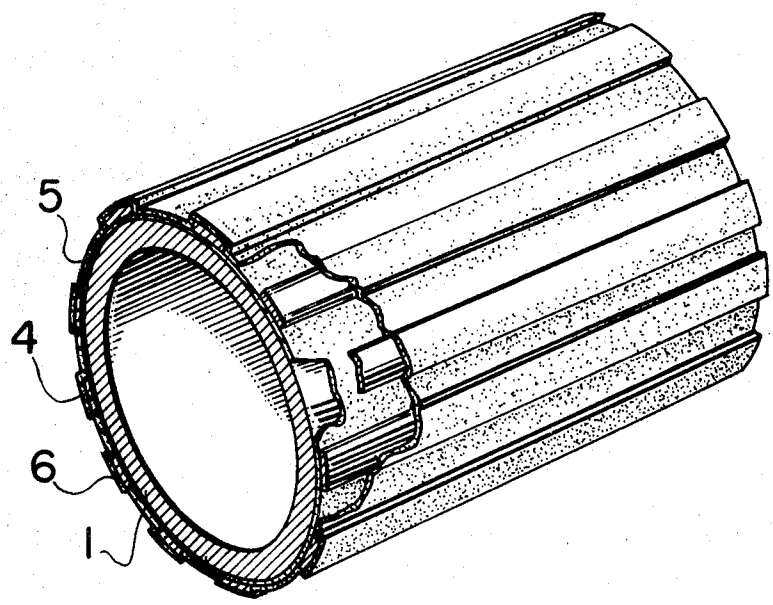


FIG. 1

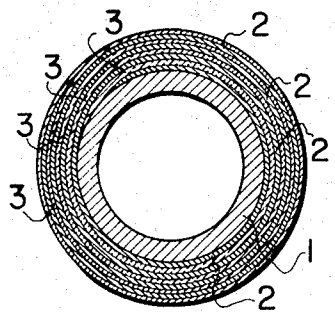


FIG. 2

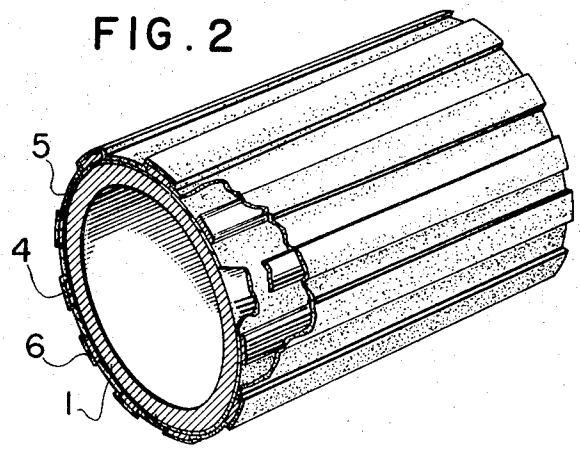


FIG. 3

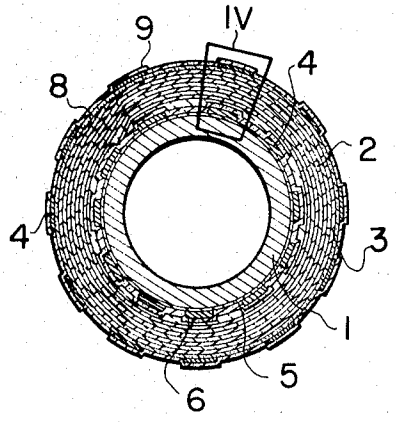


FIG. 4

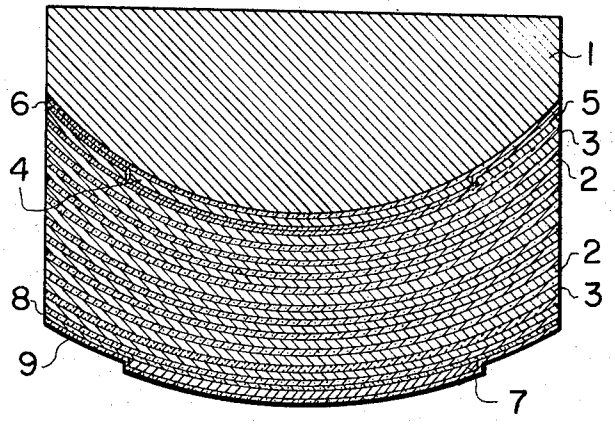
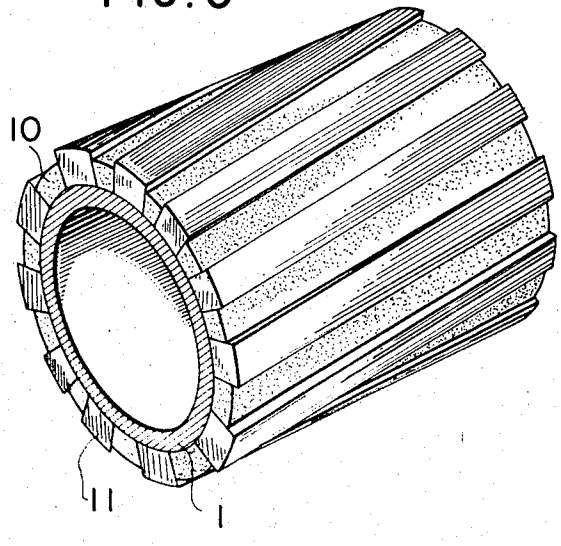


FIG. 5



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FIG. 6

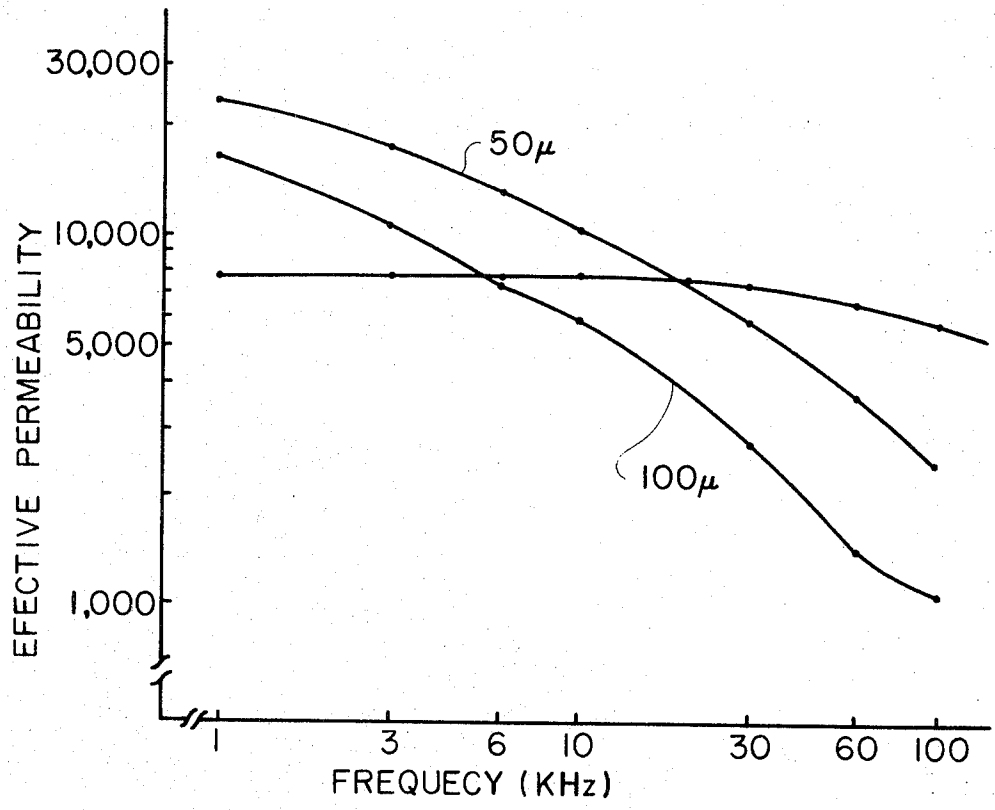


FIG. 7

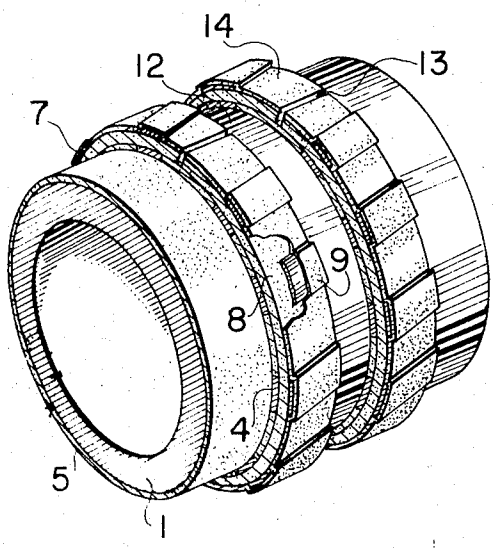
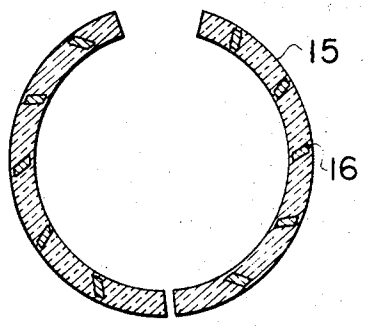


FIG. 8



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LAMINATED MAGNETIC COIL MATERIALS

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

The invention relates to a magnetic core composed of thin rolled sheet of high permeability magnetic alloy having a thickness of less than 25 microns and a method of manufacturing the same.

2. DESCRIPTION OF THE PRIOR ART

There are two types of magnetic cores known in the art, those which are made of magnetic alloys having a high permeability such as silicon steel or permalloy, and those which are made of an oxide magnetic material, namely, ferrite.

With regard to the methods of manufacturing magnetic cores of high permeability magnetic alloy, a stamped-core method, a toroidaly wound-core method and a dust core method are generally known. In the method of making a stamped-core, a thin sheet of magnetic alloy is first punched to form a sheet of desired shape and then a number of punched sheets are treated for electric insulation and laminated to a predetermined thickness. While in the toroidaly wound-core method, a thin sheet of magnetic alloy is wound toroidaly after treatment for electric insulation. The dust core method is the one, in which powder of magnetic alloy is mixed with a binder of an electrically insulating property and then this mixture is molded. On the other hand sintering of ferrite is usually applied in a method of forming ferrite cores. However, magnetic cores formed by pitching powder of magnetic alloy with a binder of an electrically insulating property are not used widely due to their inferior magnetic properties. Generally, stamped-cores or toroidaly wound-cores are used with admiration.

However, in practice it has been impossible to form stamped cores or toroidaly wound-cores employing a sheet of magnetic alloy having a thickness of less than 25 microns and therefore, an improvement in the frequency characteristics in these magnetic cores has been limited. In other words since a permeability under alternating current conditions is inversely proportional to the square of the thickness of sheet theoretically, the frequency characteristics can be improved by making the thickness of the sheet as thiner as possible. The thickness of the sheet which has been employed for making conventional stamped cores or toroidaly wound-cores, however, has been limited technologically resulting in a limitation in the frequency characteristics. The reasons why the thickness of the sheet of magnetic alloy has been limited are based on the following facts: First, stamped cores are manufactured by laminating a sheet of magnetic alloy after punching by a press machine and applying an electrically insulating treatment. In this punching work, the accuracy of punching depends on the ratio of the gap between the male and female patterns and the thickness of the sheet of magnetic alloy, and so greater the ratio the higher the accuracy of the work. In fact, punching works have been performed with relatively good accuracy where the thickness of the sheet of magnetic alloy is not less than 25 microns. However, where the thickness is less than 25 microns the edge of the punched sheet does not have an acute angle and in addition, since the reforming work is difficult technically, this method has been unpracticable where a thickness of the sheet is less than

25 microns. Secondly, toroidaly wound-cores are manufactured by winding a sheet of magnetic alloy spirally, after a treatment for electrical insulation. In this method where the sheet of magnetic alloy is too thin, the lamination work is impossible and eventhough the sheet were laminated, the shape of the core thus formed would be deformed. It has been found also that these defects are produced when the thickness of the sheet of magnetic alloy is less than 25 microns.

On the other hand, although those magnetic cores formed by sintering a ferrite material present a frequency characteristics of the ferrite material itself and no influences due to the forming work are observed, ferrite cores have not only such disadvantages that a magnetic flux density is small as compared with high permeability alloys but also cores themselves are fragile mechanically.

By these reasons mentioned above, if it is possible to form a magnetic core with much thiner sheet of high permeability magnetic alloy the frequency characteristics of magnetic core would be improved in a great extent. Furthermore, according to the present technique of rolling work, since it is possible to roll a sheet of magnetic alloy as thin as 1 micron, if it becomes possible to form magnetic cores with such an extremely thin sheet of magnetic alloy an increase in permeability would be far greater.

In conventional stamped cores or toroidaly wound-cores, magnesium oxide (MgO) or aluminum oxide (Al_2O_3) is employed as an electric insulator. However, since these kind of electric insulators are not adhesive and they are not secured between the laminated layers, these insulators are subjected to be broken away from the layers in time. Therefore, if it is possible to make an electric insulator to be secured to the sheet of magnetic alloy in such laminated condition, then a magnetic core of high reliability would be realized.

SUMMARY OF THE INVENTION

A primary object of the present invention is to provide a laminated magnetic material composed of extremely thin sheet of high permeability magnetic alloy.

A further object of this invention is to provide a laminated magnetic material in which a high permeability magnetic alloy and an electric insulator are laminated securely and are formed in a desired shape.

A still further object of this invention is to provide a laminated magnetic material provided with coils.

A still further object of this invention is to provide a laminated magnetic material on which a plurality of elements, such as a plurality of cores or magnetic heads, are formed.

A still further object of this invention is to provide a method of manufacturing a laminated magnetic material composed of very thin sheet of high permeability magnetic alloy.

A still further object of this invention is to provide a method of manufacturing a laminated magnetic material provided with coils.

This invention relates to a laminated magnetic material composed of very thin sheet of high permeability magnetic alloy and a method of making the same.

The laminated magnetic material according to the present invention is characterized in that it is composed of substantially very thin sheet of magnetic alloy with

high permeability wound spirally, and that a glassy material is formed interposing between the layers of magnetic alloy, the glassy material being adhered to the adjacent sheet of magnetic alloy.

In such a structure, the glassy material does not break away and even an extremely thin magnetic alloy can be formed into a toroidaly wound-core.

In order to improve a permeability of the laminated magnetic material which is used for A.C. equipment, the thiner the sheet of magnetic material the better.

Although it has been impossible to press or to wind the sheet of magnetic alloy having a thickness less than 25 microns, by applying a particular method according to this invention it has become possible to manufacture a laminated magnetic material of such a structure described above.

The method according to this invention is such that a glassy film is formed on the sheet of high permeability magnetic alloy, and the sheet of magnetic alloy is wound and laminated around a support base of non-magnetic material so that the sheet of magnetic alloy and the glassy film are laminated alternately, and then the laminated body is heated to a temperature higher than the softening point of the glassy material so as to make the layers of the laminated body fused and united. In this method, even with a very thin sheet of magnetic material any deformation of the thin sheet is effectively prevented.

The glassy material employed in this invention for electric insulation provides a good adhesive property advantageously as compared to magnesium oxide or aluminum oxide. This glassy material may be formed by a high frequency sputtering technique easily. In such cases where the glassy material formed on the sheet of magnetic alloy contains bubbles in itself, it is apt to be broken away from the sheet of magnetic alloy resulting in a deterioration of the electrical characteristics. Therefore, it is preferable to heat the laminated body after forming the glassy film to a temperature higher than the softening point of the glassy material and to remove the bubbles from the glassy material.

On the other hand, where work strains are caused in the magnetic alloy due to the works such as rolling work, the permeability decreases in a great extent. For this reason annealing is usually applied after the work so as to remove the work strain. This annealing is generally performed by heating after laminating the sheet of magnetic alloy and the electric insulator alternately, to a temperature higher than the recrystallization point of the magnetic alloy and then by cooling it in a furnace.

Therefore, where the glassy material has a softening point lower than the annealing temperature, the glassy material might be fell-out from the layer between the layers of magnetic material. It is desirable, therefore, to use such a glassy material which is softened at the annealing temperature and further to softening treatment simultaneously with the annealing treatment. By applying the both softening and annealing treatments simultaneously, another advantageous effect may be obtained, in which, where the sheet of magnetic material is covered with a glassy material only on one surface thereof, the glassy material is not adhered to the other surface of the sheet and no adhesive action is effected thereto. However, upon applying the annealing treatment, since the glassy material is subjected to be softened at the same time, the glassy material is fused to the other surface of the sheet of magnetic material on which surface the glassy material was not deposited originally. As a result, a laminated magnetic material is formed with each layer securely adhered to the other. In such case, where a glassy material is formed on both surfaces of the sheet, before applying an annealing treatment each glassy film on one sheet of magnetic material is not adhered to the adjacent glassy film of the other sheet, however these two glassy films can be fused and adhered in the process of annealing treatment.

In order to increase a adhesiveness of the glassy material, it is preferable to form a film of oxide preliminary over the surface of the magnetic alloy. This film of oxide favorably improves the electric insulation of the glassy material. The formation of the film of oxide may be carried out by heating the magnetic alloy in the atmosphere of oxygen.

It will be readily convinced that the laminated magnetic material hereinbefore mentioned has a remarkable frequency characteristics due to the fact that the thickness of the sheet of magnetic material has been reduced in a great extent. Further, for the purpose of utilizing the laminated magnetic material as a part of some electrical equipment, it is desirable that the laminated magnetic material thus formed is provided with a coil wound thereof. Accordingly it is very useful to manufacture such laminated magnetic material. A method according to this invention is directed to eliminate the process of winding coil conductors around the laminated magnetic material. Furthermore, it is so designed as to utilize the nonmagnetic support base which is used only in a process of lamination to reinforce the mechanical strength of the laminated magnetic material. To achieve these requirements, in the present invention predetermined number of coil conductors are disposed on the surface of the support base of non-magnetic material along the longitudinal direction of the support base insulated electrically from the base with an insulator, and outside these coil conductors sheet of high permeability magnetic alloy and glassy film are wound alternately one after the other thus forming a lamination, and following this process outside this laminated magnetic material the same number of coil conductors as those disposed before are disposed longitudinally insulated electrically from the sheet of magnetic material, and then coil conductors disposed inside and outside the laminated magnetic material are bridged so as to allow a current to flow through the coil conductors successively. Thus, the coil winding process, which is performed after the laminating process and is a troublesome work has been eliminated according to this invention. Any material having a high electrical conductivity, for example a copper, is suitable for coil conductors. These coil can be deposited on the nonmagnetic support base by means of evaporation, in which a masking plate may be used to define the intended portions on which the evaporation is not applied. In such instances where the support base is made of an electrically conductive material, it is necessary to form an electric insulating film over the surface of the nonmagnetic support base for the purpose of providing electrical insulation

between any two of the coil conductors. Since this insulating film is not subjected to be wound as is the case with the glassy material formed on the sheet of magnetic alloy, a high cohesiveness is not required, therefore any suitable material other than glassy material may be employed.

The coil conductors disposed on the support base are also insulated electrically from the sheet of magnetic alloy, accordingly, where the glassy material formed thereon is facing the coil conductors, the glassy film may be utilized as an electric insulator therebetween. However, where the glassy material is not so formed as to face the coil conductors, an electric insulator must be formed on the coil conductors.

In order to perform the bridging work for the coil conductors disposed inner and outer surfaces of the laminated magnetic alloy, such particular designing considerations with respect to the direction of the coil conductors to be disposed are desirable. For example, where the predetermined number of coil conductors are disposed on both inner and outer surfaces of the cylindrical support base of non-magnetic material along the axis of the support base, the coil conductors disposed on the outer surface of the cylindrical support base are arranged in such a manner that each of the outer coil conductors is extended from one end of the corresponding inner conductor to the other end of the adjacent inner conductor, in other words the outer coil conductors are skewed along the axis of the cylindrical support base by one pitch, or the interval of the conductors.

It is also necessary that where the outer and inner coil conductors are to be bridged, both end surfaces of the cylindrically shaped laminated magnetic material must be covered with an electric insulator, otherwise a current would flow through the bridge to the laminated magnetic material resulting in a malfunction of the magnetic core. The electric insulator for this purpose may be obtained by depositing a conventional electric insulator film, for example by a high frequency sputtering technique.

The bridging of the both outer and inner coil conductors are carried out easily by an evaporation technique in the same way as the forming of the coil conductors, or instead of this way soldering of a conductor strip to both ends of the coil conductors may also be applied.

When the laminated magnetic material thus formed is applied for multi-elements purpose, the processes for mounting a plurality of elements on the laminated magnetic material would be eliminated and consequently the structure of the manufactures would be much simplified. These requirements are also satisfied in this invention by utilizing the non-magnetic support base effectively. For this purpose, the laminated material and coil conductors are grooved together circumferentialy so that the bottom of the groove reaches at the electric insulator film deposited on the surface of the non-magnetic support base. The number and the width of the grooves are arbitrary selected according to the number of the elements required. Following to the forming of the grooves bridging of the outer and inner coil conductors are naturally carried out.

Among magnetic alloys, permalloy are more suitable than silicon-steel for such a purpose where an excellent frequency characteristics is required, because the former has a higher permeability than the latter.

The laminated magnetic material according to this invention are used advantageously for cores or cores with coils to be used in various parts and equipments. In addition, it is also applicable for magnetic recording heads by forming an air gap on the portion of the laminated magnetic material.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a cross sectional view illustrating a structure of a laminated magnetic material in which a sheet of high permeability magnetic alloy having a glassy film deposited on the surface thereof is wound around a support base of non-magnetic material.

FIG. 2 is a perspective view which shows a disposition of coil conductors on a support base of nonmagnetic material.

FIG. 3 is a cross-sectional view which shows coil conductors disposed on both outer and inner surfaces of a laminated magnetic material.

FIG. 4 shows the section IV of FIG. 3 in detail.

FIG. 5 is a perspective view which illustrates a bridging of outer and inner coil conductors.

FIG. 6 is a graph illustrating a variation in an effective permeability with frequency.

FIG. 7 is a perspective view illustrating a formation of a multi-elements magnetic recording heads.

FIG. 8 shows a ring of glassy material which is employed for bridging coil conductors, which conductors are disposed on outer and inner surfaces of a laminated magnetic material.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiment 1

The present invention is primarily directed to provide a laminated magnetic material with excellent frequency characteristics. Accordingly, a rolled sheet of 11 weight % Fe-83 weight % Ni-6 weight % V alloy, having a thickness of 10 microns was employed as a sheet of high permeability magnetic alloy. This sheet of magnetic alloy was covered with a glassy film at first and then it was laminated on a support base of nonmagnetic material. The sheet of Fe-Ni-V alloy was 20 mm in width and 410 mm in length. A mixture of magnesium fluoride (MgF_2) and glass of low melting point with softening point of about 550°C was selected for a glassy material.

Prior to the forming of a glassy film, the surface of Fe-Ni-V alloy was cleaned by applying a pickling treatment, and then it was heated in the atmosphere of oxygen in order to form a thin film of oxide on the surface of the alloy. Following to these processes, a mixture of magnesium fluoride and low-melting point glass was deposited on one surface of the sheet of Fe-Ni-V alloy to a thickness of about 2 microns by high frequency sputtering. The sheet of Fe-Ni-V alloy was then wound around a stainless steel tube in such a manner that the glassy film always appears outside during the winding process. The tube of stainless steel (SUS 52) was 13 mm in outer diameter, 11 mm in inner diameter and 30 mm in length and the surface thereof was smoothed. The number of layers formed by the laminated sheet of Fe-Ni-V alloy was ten and the remnant of the sheet was cut and removed. In this case, the inner surface of the stainless steel tube had been screwed beforehand in

order to remove the tube by pulling out of the laminated magnetic material easily after completion of the lamination process.

Following the winding process, it was heated to a temperature higher than the softening point of the glassy material, for example to a temperature of about 700°C. Due to this heat treatment the glassy material was melted and fused to the adjacent sheet of Fe-Ni-V alloy securely and consequently the laminated magnetic material united solidly was formed. FIG. 1 shows the laminated magnetic material formed as before indicated and numeral 1 represents a stainless steel tube, 2 is a sheet of Fe-Ni-V alloy and 3 is a glassy film. After the laminating process the stainless steel tube was removed from the laminated magnetic material by pulling the shaft which had been screwed in the tube. The laminated magnetic material had no indication of deformation and it was formed in the cylindrical shape with uniform inner diameter along its axis. The laminated magnetic material composed of the sheet of high permeability magnetic alloy which sheet having a thickness of less than 25 microns was thus realized, and since the electric insulator film is firmly secured to the sheet of magnetic alloy in this invention, a good electric insulation properties as well as a long life have been achieved successfully.

Embodiment 2

It is indeed very desirable for applying a laminated magnetic material to some parts and equipments in practical use, if coil conductors are provided on the laminated magnetic material. In this embodiment, the stainless steel tube 1 was not removed but it was utilized for disposing coil conductors on the tube, because the tube remained unremoved was not harmful for practical use, but on the contrary it was useful in some cases to improve a mechanical strength. In this embodiment, the dimensions of the tube 1 was the same as Embodiment 1. Prior to the disposition of coil conductors, silicon oxide (SiO_2) was deposited on the surface of the tube by high frequency sputtering to a thickness of 2 microns so as to provide an electric insulator between the tube 1 and coil conductors. To obtain an insulator film of uniform thickness the tube was rotated at a constant speed on the axis by driving a shaft screwed in the tube. Then, coil conductors were deposited on the surface of the stainless tube 1 along the axis. The coil conductors deposited by vacuum evaporation were ten conductors with equal intervals, and each conductor was so designed as to have a thickness of 3 microns and a width of 1.5 mm. Accordingly, the portions on which the evaporation was not intended to be applied were covered with a masking plate. The vacuum evaporation was carried out by a high frequency heating technique in a vacuum of 1×10^{-5} mm Hg, and an evaporation temperature was at about 1,500°C.

Following to the deposition of the coil conductors by evaporation, a film of silicon oxide was formed over the whole surface by high frequency sputtering. FIG. 2 shows coil conductors deposited on the surface of the stainless steel tube 1, and numeral 4 represents a coil conductor, 5 is a film of silicon oxide formed on the surface of the stainless steel tube 1, and 6 is a film of silicon oxide formed on the coil conductor 4 after completion of the deposition of the coil conductors.

For a high permeability magnetic alloy material to be used, a sheet of 11 weight % Fe-83 weight % Ni-6 weight % V alloy with a thickness of 10 microns was employed. AT first, a thin film of oxide was formed on the sheet of magnetic alloy and then a glassy material which is a mixture of magnesium fluoride and low melting point glass with softening point of about 550°C was formed to a thickness of 2 microns by a high frequency sputtering technique. The width and length of the sheet of Fe-Ni-V alloy was the same as embodiment 1. The sheet of composite magnetic material formed as described before was wound around the stainless tube 1. The number of layers was 10. Upon completion of the winding process, it was heated to a temperature of about 700°C, and each glassy material was fused and secured to the adjacent glassy material. Since the recrystallization temperature of the Fe-Ni-V alloy is about 600°C, an annealing was also progressed together with the softening of the glassy material. Silicon oxide was then deposited on the surface of the laminated magnetic material to a thickness of 2 microns and further the coil conductors were evaporated thereon to a thickness of 3 microns, and in addition silicon oxide was deposited further thereon. These deposition processes are the same as those in which silicon oxides 5 and 6 were deposited on the stainless tube 1 and the coil conductors 4 was deposited by evaporation. The coil conductors were disposed so that each conductor extends from one end of the corresponding inner coil conductor 4 to the other coil conductor end of the adjacent inner coil conductor. FIG. 3 shows a cross section of the laminated magnetic material provided with coil conductors, those members 1 to 6 are explained referring to FIGS. 1 and 2, and in which numeral 7 designates a coil conductor disposed on the laminated magnetic material, 8 is a film of silicon oxide formed between the laminated magnetic material and coil conductors, and 9 is a film of silicon oxide formed over the coil conductor 7. FIG. 4 shows an expanded section A of FIG. 3 and illustrates a construction in detail.

After completion of the disposition of coil conductors 4 and 7 on both surfaces of the laminated magnetic material, both end surfaces of the laminated magnetic material was covered with silicon oxide to a thickness of 5 microns by a high frequency sputtering technique, and then both corresponding conductor ends of coil conductors 4 and 7 were bridged by evaporating a copper so as to complete a coil winding.

FIG. 5 shows a connection by bridging outer coil conductor 7 and inner coil conductor 4, in which 10 is a film of silicon oxide formed on the end surface of the laminated magnetic material, and 11 is a copper foil evaporated.

Table 1 illustrates a D.C. magnetizing characteristics of the laminated magnetic material manufactured according to this invention. A D.C. magnetizing characteristics is not influenced by a thickness of the sheet of magnetic alloy, but substantially effected by a composition of materials of the core as well as manufacturing processes. Table 1 shows in what degree the magnetic core made of laminated magnetic superior in D.C. magnetizing characteristics to the ferrite cores and dust cores.

The ferrite core was made by sintering Mn-Zn ferrite (a composite of MnO, ZnO, and Fe_2O_3) in the shape of ring of inner diameter of 12 mm, outer diameter of 15 mm, and a hight of 3 mm, while the dust core was made by molding a powder of 11 weight % Fe-83 weight % Ni-6 weight % V alloy with a binder in the shape of ring of the same size as the ferrite core mentioned above.

TABLE 1

Characteristics

Core	B_{10} k gauss	B_1 k gauss	Br/B_{10} %	Hc Oe	μo	μm
This invention		6.0	6.4	70 0.08	20,000	12,000
Ferrite core	3.9	2.8		54 0.30	2,500	3,200
dust core	6.2	1.3		7 0.70	220	280

Where, B_{10} is a flux density when a magnetic field intensity H is 10 oersteds B_1 is a flux density when a magnetic field intensity H is 1 oersted, Br is a remanent flux density, Hc is a coercive force, μo is a initial permeability, and μm is a maximum permeability.

For magnetic cores with suitable properties, magnetic flux density and permeability are required to be great, whereas a coercive force must be small. The laminated magnetic material of Fe-Ni-V alloy is superior to the both ferrite cores and dust core in view of the required properties.

FIG. 6 shows a variation in effective permeability of laminated magnetic materials with frequency. In which 100μ and 50μ represent cores made of the sheets having a thickness of 100 microns and 50 microns respectively. These two cores are formed at first by punching a rolled sheet of 11 weight % Fe-83 weight % Ni-6 weight % V alloy in the shape of ring of an outer diameter of 35 mm, inner diameter of 25 mm, and then by laminating to five layers interposing an electric insulator between the layers of magnetic alloy.

Generally a permeability of magnetic core tends to decrease with higher frequency. Therefore, if such a core, which has a high frequency and the permeability does not decrease with respect to the frequency increase, is achieved it would be obvious that the core provides an excellent properties. The magnetic core made of laminated magnetic material according to this invention was proved to be the one which meets those requirements completely.

Embodiment 3

For the purpose of applying the laminated magnetic material in embodiment 2 to a magnetic head for a magnetic tape with twenty tracks, a groove 12 was formed circumferentially as deep as the bottom of the groove reaches at the silicon oxide film formed on the stainless steel tube 1 as shown in FIG. 7, and a gap 13 was made on the portion where no coil conductors were deposited. The width of the track 14 and the interval of tracks (or the width of the groove) were 0.5 mm. These cutting works and machine works were carried out by means of electron beam.

Prior to the connection of the outer and inner coil conductors 4 and 7 of each track for making a complete coil winding, end surfaces of the laminated magnetic material exposed by the grooving were covered with silicon oxide to a thickness of 5 microns by a high frequency sputtering technique.

Then a glass plate 15 having a number of copper foils 16 evaporated on both surfaces thereof and which glass plate being formed in the shape of ring divided into two parts as shown in FIG. 8, was inserted into the grooved portion. The glass plate 15 is made of borosilicate glass having a softening point of about 750°C, and its shape is formed as the inner surface fits the bottom surface of the groove 12. On both end surfaces of the glass plate 15, a number of copper foils 16 is evaporated to a thickness of 5 microns in such a manner that the copper foils bridge the outer and inner coil conductors 4 and 7 of the track 14 and completes the coil winding upon inserting the glass plate into the groove 12. The width of the glass plate 14 including the thickness of the copper foil 16 was selected to be 0.40 mm.

After inserting the glass plate 15 into the groove 12, the coil conductors 4 and 7 were connected to the evaporated copper foil 16 respectively with Sn–Pb solder.

With respect to the magnetic head manufactured as described hereinbefore, a dielectric strength of coil, an allowable current of coil, and magnetic characteristics at the frequency of 100 KH_Z were measured, those results of the measurement are shown in Table 2.

TABLE 2

Dielectric strength of coil	About 80V
Allowable current of coil	About 60 mA
Total magnetic flux (coil current is 60 mA)	2.4 maxwell
Rectangular ratio	64%
Coercive force	0.08 Oe
Effective permeability (coil current 10 mA)	6,500

Various characteristics shown in Table 2 were proved to be entirely sufficient for magnetic head for practical use.

Further, since the effective permeability at the frequency of 100 KH_Z of a stamped core formed by laminating a rolled sheet of 11 weight % Fe-83 weight % Ni-6 weight % V alloy (a thickness of 100 microns) together with an electric insulator film were about 800, it was proved that the effective permeability of the core according to this invention is as great as eight times of the stamped core mentioned above.

I claim:

1. A laminated magnetic material having a coil comprising,

a non-magnetic support base,

an electric insulator film formed on the surface of said support base,

a plurality of inner coil conductors disposed on said insulator film along the longitudinal direction of said support base,

a rolled sheet of high permeability magnetic alloy, said sheet of magnetic alloy having a thickness of less than 25 microns,

a glassy material formed on at least one surface of said sheet of magnetic alloy, said sheet of magnetic alloy and said glassy material being wound and laminated alternately and crossing said inner coil conductors,

a plurality of outer coil conductors disposed on an electric insulator film forced on said wound and laminated body, and

a plurality of conductor foils bridging said outer and inner coil conductors disposed on both outer and inner surfaces of said laminated body, wherein each layer of said wound and laminated body is secured to the adjecent layer and interposed by an electric insulator.

2. A laminated magnetic material having a coil according to claim 1 wherein said wound and laminated body and said coil conductors disposed on the outer and inner surfaces of said wound and laminated body are divided by a groove crossing said coil conductors to form divided sections, and

a plurality of copper foils are disposed on each end surface of said divided sections exposed by said groove and said copper foils form bridge connections between said outer and inner coil conductors.

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