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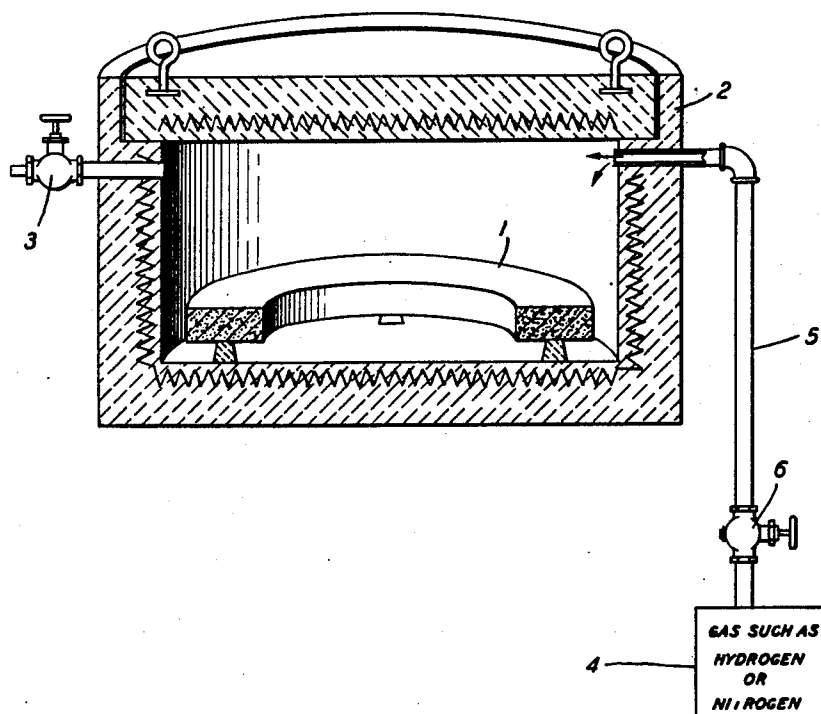
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PROCESS OF PRODUCING MAGNETIC BODIES

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PROCESS OF PRODUCING MAGNETIC BODIES

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This invention relates to magnetic bodies and particularly to magnetic bodies in which the magnetic material is in finely divided form, such as magnetic cores for loading coils and the like.

An object of the invention is to improve the magnetic, electrical and mechanical characteristics of magnetic bodies of the type employing magnetic material in finely divided form, for example, magnetic dust cores for loading coils.

Magnetic cores made from finely divided magnetic material, so-called "magnetic dust cores", are being extensively used in loading coils which are inserted in telephone lines to improve their transmission characteristics. Such cores are usually constructed by subjecting the finely divided particles of the magnetic material and electrically insulating and binding material between the magnetic particles to extremely high pressures in the neighborhood of 200,000 lbs. per square inch. The high pressures are utilized to form the component materials into a substantially homogeneous mass in the desired core form, and to give sufficient mechanical strength to the completed core. The electrically insulating material serves to reduce eddy current losses in the completed core.

In the case especially where the magnetic material in the core made in the above described manner is a magnetic alloy including nickel and iron, it is desirable to subject the core to a subsequent heat treatment at a high temperature to remove the strains introduced in the magnetic material by the pressing operation tending to impair the magnetic properties of the magnetic alloy in the core, and to fully develop the magnetic characteristics of the alloy. In general, the magnetic properties of the magnetic material improve correspondingly as the temperature of the annealing heat treatment increases. It has been found that most

insulating materials which are otherwise satisfactory for use as insulation between the magnetic particles of such cores as described above, start to deteriorate from an insulating standpoint before the optimum annealing temperature for the magnetic material is reached, and it is therefore necessary to limit the temperature of the annealing heat treatment in order that the insulation may not be damaged. The best magnetic properties for the magnetic cores are therefore not obtained.

In accordance with the invention, the process of making magnetic bodies of the above mentioned type is improved by carrying out the final annealing heat treatment in a gas such as nitrogen or hydrogen. It has been found that the presence of the nitrogen or hydrogen gas during the heat treatment effectively increases the breakdown temperature of the insulating material enabling the heat treatment to be carried to higher temperatures than otherwise could be used without deleteriously affecting the electrical insulation. This enables magnetic bodies to be produced having lower core losses for a given high value of permeability than would otherwise be obtained.

The exact nature of the invention and its advantages will be brought out in the following detailed description thereof when read in connection with the accompanying drawing, the single figure of which illustrates diagrammatically a step in the process of producing a magnetic core for a loading coil which embodies the invention.

The magnetic material for a loading coil core is preferably prepared in the following manner:

The magnetic metals, for example, nickel and iron, in proportions depending upon the desired percentage composition of the alloy, are first melted in small lots in a suitable furnace, a small amount of iron sulphide being preferably added to each melt to em-

brittle the resulting alloy sufficiently so that it may be easily reduced to finely divided form by mechanical methods. The resulting alloy is then poured into a mold to form an ingot. To produce a fine grain structure in the alloy material in which the individual crystals are approximately the size desired for the finished dust particles, the hot ingots are successively passed through progressively reducing rolls to decrease the cross-section of the ingots to the required size, the final roll being preferably effected at approximately the temperature at which the alloy ceases to be malleable, after which the rolled material is quenched in water at a temperature below that at which it loses its malleability. The resultant ingots are broken into short pieces and the pieces crushed in a rock crusher, hammer mill, or other suitable apparatus, after which the crushed material is pulverized by rolling in a ball mill for several hours. After several hours of rolling the resulting dust is sieved through a 120 mesh sieve and that portion which will not pass through the sieve is returned to the ball mill for further rolling, this process being repeated until a sufficient quantity of the fine dust is obtained. Prior to the addition of the insulating material the finely divided particles of the alloy are annealed in a closed container at a temperature of approximately 750° C. to 980° C., a temperature of about 925° C. having proven to be one which produces very satisfactory results. It is then necessary to again reduce the annealed alloy which is now in the form of a cake to a finely divided form after which it is mixed with the insulating material.

Preferably the annealed magnetic particles are insulated with the chromic acid-water glass-talc composition in the manner disclosed in detail in U. S. Patent to Andrews-Gillis No. 1,669,643, issued May 5, 1928, although the process of the invention is applicable as well when other insulating materials capable of withstanding heat treatment at high temperatures are used. The insulated particles are then formed into core rings at a pressure of approximately 200,000 lbs. per square inch in an hydraulic press.

The compressed core rings are then annealed in accordance with the method of the invention. As indicated in the single figure of the drawing, the core rings 1 are inserted in a suitable electric furnace 2 from the interior of which air preferably has been previously removed through the valve 3. An atmosphere of substantially pure hydrogen or nitrogen gas is then provided in the interior of the furnace supplied, for example, from the gas container 4 through the inlet pipe 5. The gas pressure in the interior of the furnace may be regulated to the desired degree by means of the valve 6 in the inlet pipe 5. The pressed core rings are then annealed for a short time in this gaseous atmosphere

at a temperature above that at which the insulating material would ordinarily deteriorate. When the chromic acid-water glass-talc insulation is used, the heat treatment preferably is at a temperature of about 660° C. for about one-half hour. The rings are then allowed to cool in the furnace. The rings are removed from the furnace and then, if necessary, they are boiled in water to remove any soluble substances of the insulating materials and dried at a temperature approximately 100° C.

A plurality of rings thus formed are then stacked coaxially to form a core on which the usual toroidal winding is applied, the number of such rings used depending upon the existing electrical characteristics of the telephone circuit with which the loading coils are to be associated.

A number of loading coil cores were made up by a process similar to that described above in which the final annealing heat treatment was carried out in the usual manner in air at the highest temperature which the insulation ordinarily would stand without deterioration, and were compared with other cores of similar construction made by the same process, but in which the final heat treatment was carried out in the manner of the invention in substantially pure hydrogen or nitrogen gas instead of air and at the higher temperature. Tests on the two lots of cores showed that the latter for a given magnetic material and a given insulating material had a much higher permeability and much lower hysteresis losses for unit permeability than the former while the eddy current losses remained about the same. Certain of the cores tested in which the magnetic material comprised finely divided magnetic alloy containing approximately 77½ to 78% nickel, 13 to 17% iron, 1 to 4% molybdenum and 4 to 7½% copper, and the insulating material comprised the chromic acid-water glass-talc insulation such as disclosed in Andrews et al. Patent 1,669,643, issued May 15, 1928, and in which the cores were subjected to annealing heat treatment at a temperature approximately 650° C. for about ½ hour in substantially pure nitrogen or hydrogen gas, were found to have from 25 to 35% higher permeability and 40 to 50% lower hysteresis losses for unit permeability than similar cores which had been annealed in air at approximately the highest temperature which the insulating material would stand, (500° C.) for ½ hour.

Cores made from other magnetic materials and other insulating materials gave similar improved results when the annealing heat treatment was carried out in the hydrogen or nitrogen gas at higher temperature. In each case, it was found that the temperature of the annealing heat treatment could be raised appreciably without deterioration of

the insulation in the core if it was subjected to the annealing heat treatment in the hydrogen or nitrogen gas instead of in air, and that a corresponding improvement in the magnetic characteristics of the final core was obtained.

The invention is not limited to magnetic bodies composed of the particular magnetic materials and insulating materials specified above, which were given by way of example only, for it is believed that the invention is applicable to magnetic bodies utilizing any kind of magnetic material and any insulating materials if the optimum temperature of the heat treatment to obtain the best magnetic characteristics is higher than that which the insulating materials will withstand without deterioration.

What is claimed is:

1. A method of improving the magnetic characteristics of a magnetic body comprising finely divided magnetic material and electrically insulating material therebetween, which consists in subjecting the body to heat treatment at a high temperature above the temperature at which the insulating material when heated in air will deteriorate, in a gas of such characteristics as to effectively increase the break-down temperature of the insulating material to a value above said high temperature, and thereafter cooling said body.

2. The process of making a magnetic body having high permeability and low hysteresis and eddy current losses, which consists in insulating finely divided particles of a magnetic alloy including nickel and iron with an electrically insulating material which will deteriorate from an insulating standpoint when subjected to heat treatment in air at a temperature above a certain value, compressing the insulated magnetic alloy particles into a substantially homogeneous body of the desired form, and heat treating the compressed body at a given high temperature above said certain value in a gas having such characteristics as to effectively raise the breakdown temperature of said insulating material to a value above said given high temperature, and thereafter cooling said body in said gas.

3. The method of claim 1 and in which said gas comprises substantially pure hydrogen.

4. The method of claim 1 and in which said gas comprises substantially pure nitrogen.

5. The method of claim 1 and in which said magnetic material comprises a magnetic alloy including nickel and iron, and said high temperature of said heat treatment is greater than 500° C., said insulating material being one which would normally deteriorate from an insulating standpoint at a temperature below said high temperature when heated in air.

6. The process of claim 2 and in which said gas comprises substantially pure hydrogen.

7. The process of claim 2 and in which said gas comprises substantially pure nitrogen.

8. The process of claim 2 and in which said gas comprises substantially pure hydrogen, and said insulating material comprises an acid, an alkali and a filler.

9. The process of claim 2 and in which said insulating material comprises chromic acid, sodium silicate and talc, said gas comprises substantially pure hydrogen and said heat treatment is at a temperature above 500° C.

In witness whereof, I hereunto subscribe my name this 20th day of January, 1931.

GUSTAF W. ELMEN.