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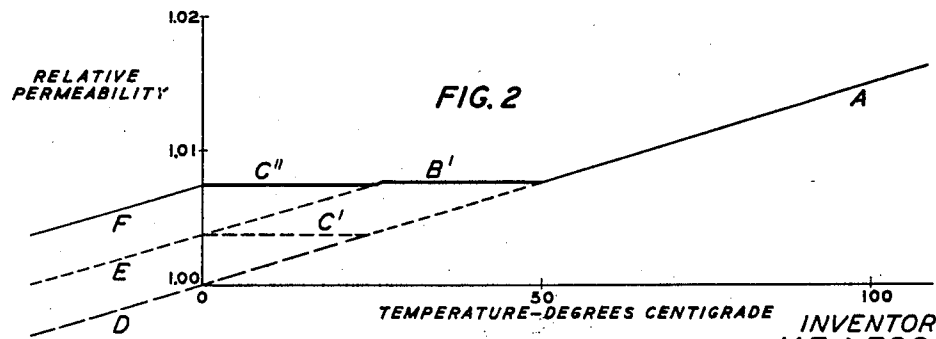
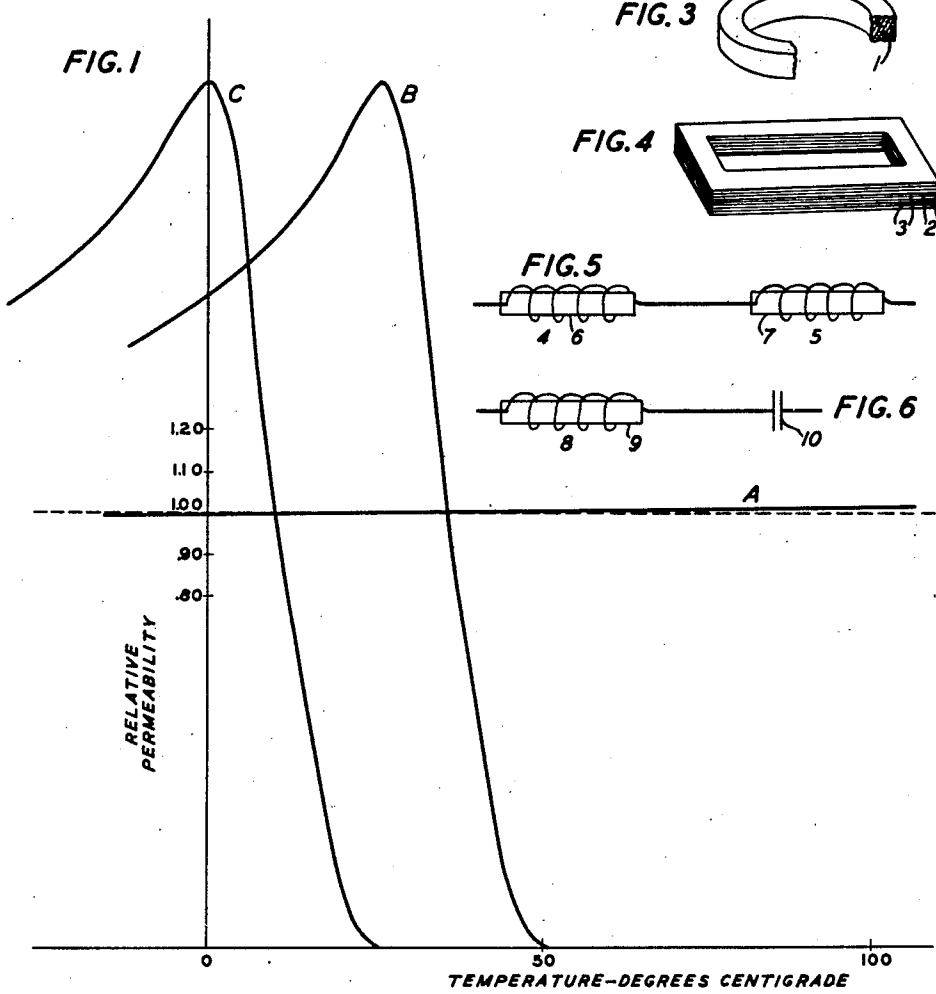
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MAGNET BODY AND PROCESS OF MAKING THE SAME

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MAGNET BODY AND PROCESS OF MAKING THE SAME

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5 Claims. (Cl. 175-21)

This invention relates to magnetic bodies of the type employing magnetic material in finely divided form, such as dust or laminations, and to methods of producing such bodies.

This application is a continuation of the co-pending U. S. application of V. E. Legg, Serial No. 685,656, filed August 18, 1933.

Magnetic bodies comprising compressed finely divided magnetic material in the form of dust or assembled thin laminations of magnetic material are extensively used as cores for loading coils, filter coils, transformers and similar transmission apparatus in telephone circuits. The transmission characteristics of such apparatus are subject to variations due to changes in permeability of the cores with temperature under service conditions, which variations are especially objectionable in the case of high quality circuits.

An object of the invention is to stabilize the permeability of a magnetic body over a desired temperature range.

Another object is to produce such variations of permeability with temperature in a magnetic core for an inductance coil in an electrical circuit as to neutralize or reduce the effects of variations in permeability with temperature of a core for another coil in the circuit, or of variations with temperature in the characteristics of other apparatus in the circuit.

These objects are attained in accordance with the invention by utilizing in a magnetic body or core a magnetic material having a negative permeability-temperature coefficient over a certain temperature range, or by utilizing therein proper proportions of magnetic materials having opposing permeability-temperature characteristics so as to produce the required stabilization or neutralization or variation over the desired temperature range. In one embodiment, a magnetic core

having a substantially constant relative permeability over a desired temperature range is produced by forming the core from a mixture of dust of a normal magnetic material having a positive permeability-temperature coefficient, with

proper proportions of dust of magnetic material having a negative permeability-temperature coefficient over that temperature range. In the case of laminated magnetic bodies or cores, stabilization of permeability over a desired temperature range is attained by providing an occasional lamination of magnetic material having a negative permeability-temperature coefficient over that temperature range with other laminations of magnetic material having a positive permeability-temperature coefficient.

The exact nature and advantage of the invention will be better understood from the following detailed description thereof when read in connection with the accompanying drawing in which:

Figs. 1 and 2 show curves illustrating the process of invention; and

Figs. 3 to 6 show different applications of the invention.

Magnetic materials having positive permeability-temperature coefficients commonly used in magnetic devices are (1) iron, (2) nickel, (3) cobalt, (4) permalloys, i. e., alloys of iron and nickel or iron and nickel alloyed with moderate amounts of chromium, copper, manganese, molybdenum, tungsten, vanadium, etc., (5) permisvars, i. e., alloys of iron, nickel and cobalt or iron, nickel and cobalt alloyed with the above mentioned addition agents.

In practicing the invention it has been found best to select for the negative coefficient materials used as stabilizers those whose non-magnetic points occur somewhat above the desired temperature range. Although the use of such material has been suggested for temperature control circuits, fire alarms, etc., the decline of permeability from a maximum as temperature increases has generally been considered too abrupt for practical use. However, this very steepness of the permeability-temperature curves makes such materials useful for stabilizers in magnetic cores, since only a small amount added to a core will suffice to neutralize the small positive permeability-temperature coefficient of the principal core material.

Magnetic materials having negative permeability-temperature coefficients with non-magnetic points in the room temperature range consist of almost any of the above mentioned materials with increased amounts of non-magnetic components. Thus, an alloy comprising 12.5 per cent by weight molybdenum, 80 per cent nickel, 0.5 per cent manganese and 7 per cent iron becomes non-magnetic in the room temperature range. Also an alloy comprising 30 per cent by weight copper, 60 per cent nickel and 10 per cent iron has a non-magnetic point in the room temperature range. Small changes in the percentage of non-magnetic component in the alloy can be made to adjust the non-magnetic point to any desired temperature.

The curves of Figs. 1 and 2 serve to illustrate the process of the invention. In these curves temperature in degrees centigrade is plotted as abscissae and relative permeability as ordinates.

Curve A of Fig. 1 shows the change of relative permeability with temperature over a temperature range including room temperatures of a magnetic material A comprising 2 per cent by weight of molybdenum, 80 per cent nickel and the rest mainly iron. It will be noted that for this material the permeability gradually increases over the room temperature range. Curve B of Fig. 1 shows the change of relative permeability with temperature over a temperature range including room temperatures of an alloy material B comprising 12.5 per cent by weight, molybdenum, 80 per cent nickel and the rest mainly iron. It will be noted that for the second material the permeability decreases sharply over the room temperature range, the material becoming non-magnetic at about 50 degrees centigrade. Curve C of Fig. 1 shows the change of relative permeability with temperature over a temperature range including room temperatures of an alloy material C comprising 13 per cent by weight molybdenum, 80 per cent nickel and the rest mainly iron. It will be noted that for the third material the permeability also decreases sharply in the room temperature range, the material going non-magnetic at about 25 degrees centigrade.

It would appear from the curves of Fig. 1 that the admixture of proper amounts of the negative coefficient material B or C, or B and C, with a larger quantity of the positive coefficient material A would produce a combination material having a relative permeability which is substantially constant over the entire room temperature range. Experiments have indicated that this result may actually be obtained in practice as indicated by the curves of Fig. 2 which in order to illustrate the invention more clearly have been plotted on a larger scale than the curves of Fig. 1.

Referring to Fig. 2 the line A—D is the permeability-temperature curve for the alloy material A unstabilized. If the proper percentage of the material B is admixed with the principal material A, the relative permeability-temperature curve for the resultant material will follow the line AB'E. If the proper percentage of the material C is admixed with the principal material A, the relative permeability-temperature curve for the resultant material will follow the line AC'E. If the proper percentages of the two materials B and C are admixed with the principal material A, the relative permeability-temperature curve for the resultant material will follow the line AB'C'F.

As indicated by the curves of Fig. 2, stabilization is achieved over a temperature range of a location depending upon the material added, and to an extent depending upon (1) the extent of the negative relative permeability-temperature coefficient range of the added material and (2) the number of stabilizing materials added which stabilize successive temperature ranges. Other factors affecting the extent of stabilization are the foreign materials in the composite magnetic body or core, e. g. the insulation between the magnetic particles, diluting materials, such as kaolin, etc. In the case illustrated in Fig. 2 where proper percentages of both the material B and the material C were added to the principal material A, as indicated by the line AB'C'F, the relative permeability of the composite material would be approximately stabilized over the temperature range 0-50 degrees centigrade.

The invention is of particular application to

magnetic cores for loading coils, transformers and retardation coils used in electrical circuits and subject to variations in temperature in service. For example, as indicated in Fig. 3, a compressed magnetic dust core part for a loading coil, having substantially constant permeability over a desired temperature range may be produced by using as the magnetic material therein a mixture of dust of a magnetic material having a positive permeability-temperature coefficient over that temperature range with sufficient dust of a magnetic material having a negative permeability-temperature coefficient over the same temperature range. A laminated magnetic core for a transformer, as indicated in Fig. 4, which will have zero or a very small change in permeability over a range of temperatures which will be encountered in service would comprise a plurality of laminations of a magnetic material having a positive permeability-temperature coefficient over that range and a sufficient number of laminations of a magnetic material having a negative permeability-temperature coefficient over that temperature range.

In another embodiment of the invention as indicated in Fig. 5, in an electrical circuit comprising a plurality of inductive devices, for example, retardation coils 4 and 5, sufficient magnetic material having a negative permeability-temperature coefficient over a given range of temperatures would be used in the magnetic core 6 for the coil 4 as to give a net negative coefficient for the core 4 sufficient to balance out effectively the positive permeability variations of the unstabilized core 1 for the coil 5 over the given range of temperatures.

In still another application of the invention, as indicated in Fig. 6, in an electrical circuit comprising a plurality of reactive elements, for example, a retardation coil 8 having a magnetic core 9, and a condenser 10, sufficient negative permeability-temperature coefficient magnetic material would be used in the core 9 to make the variation in inductance of the coil 8 with temperature compensate effectively for the variations in the value of the condenser 10 with temperature over the range of temperatures to which the reactive elements would be subjected in service.

As examples of stabilization of permeability with temperature in accordance with the methods of the invention, the following experimental data obtained by the applicant may be cited.

A magnetic dust core in which the magnetic dust material comprised an alloy containing approximately 2 per cent by weight of molybdenum, 80 per cent nickel and the rest mainly iron, and without the addition of stabilizing materials, was found to have a relatively permeability-temperature coefficient of approximately $+200 \times 100^{-6}$ per degree centigrade, over the room temperature range. A second dust core made by substantially the same process and with the same molybdenum-nickel-iron alloy as specified for the first core except for additions by mixing before insulation of 0.25 per cent of a stabilizer comprising dust of an alloy containing 12.5 per cent by weight molybdenum, 80 per cent nickel and the rest mainly iron, and 0.25 per cent of a second stabilizer comprising dust of an alloy containing approximately 13 per cent by weight molybdenum, 80 per cent nickel and the rest mainly iron, was found to have a permeability-temperature coefficient of approximately $+50 \times 10^{-6}$, over the room temperature range.

Another dust core made by a similar process but in which 0.50 per cent of each of the above-described stabilizers was added to the molybdenum-nickel-iron alloy dust comprising the particular percentages specified above for the first core, by mixing before insulating, was found to have a permeability-temperature coefficient of about -250×10^{-6} . It is apparent from these results that the addition of some intermediate quantities of these stabilizers would produce a core having approximately zero permeability-temperature coefficient, and that a non-stabilized core having a permeability-temperature coefficient of say $+200 \times 10^{-6}$ may be used together with an over-stabilized core of say -250×10^{-6} permeability-temperature coefficient, and the relative cross-sectional areas of the cores adjusted so as to obtain zero coefficient for the combination.

In the above mentioned experimental cores the material used for insulating the magnetic dust particles was chromic acid, sodium silicate and talc as disclosed in Andrews et al. Patent No. 1,669,643, issued May 15, 1928, and the process of preparing the cores was substantially as described in that patent, but similar results may be obtained where other insulating materials and other processes of preparing the cores are used. The perfection of neutralization in accordance with the method of the invention depends upon the proper selection of neutralizing compositions, the percentages thereof, the insulation, and of course, the heat treatment of the magnetic materials in the core. Extreme refinement of neutralization can be effected by using small percentages of a number of stabilizers with successively higher non-magnetic points.

The scope of the invention is indicated by the appended claims.

What is claimed is:

1. A temperature stabilized magnetic body comprising a mixture of finely divided magnetic material and finely divided stabilizing alloy containing approximately 12 to 13 per cent by weight molybdenum, 80 per cent nickel and 7 per cent iron, the stabilizing alloy comprising from 0.25 to 1.00 per cent by weight of the mixture.

2. A temperature stabilized magnetic body comprising a mixture of finely divided magnetic material and stabilizing material, the stabilizing material comprising from 0.25 to 1.00 per cent by weight of the mixture and consisting of finely divided particles of one or more alloys containing

approximately 12 to 13 per cent by weight molybdenum, 80 per cent nickel and 7 per cent iron, said magnetic material consisting of an alloy containing approximately 2 per cent by weight molybdenum, 80 per cent nickel and 18 per cent iron.

3. A magnetic body having substantially constant permeability over the room temperature range comprising a mixture of finely divided magnetic material and finely divided stabilizing material, the stabilizing material comprising approximately 0.5 per cent by weight of the mixture and consisting of equal parts of two alloys, one containing approximately 12.5 per cent by weight molybdenum, 80 per cent nickel and 7.5 per cent iron and the other containing approximately 13 per cent molybdenum, 80 per cent nickel and 7 per cent iron, the magnetic material comprising an alloy containing approximately 2 per cent by weight molybdenum, 80 per cent nickel and 18 per cent iron.

4. The process of producing a temperature stabilized magnetic core which consists in mixing together finely divided magnetic material and finely divided stabilizing material constituting approximately 0.5 per cent by weight of the mixture and consisting of one or more alloys containing approximately 12 to 13 per cent molybdenum, 80 per cent nickel and 7 per cent iron, insulating the finely divided particles in the mixture from each other, forming a mass of the insulated particles into the desired core form, and heat treating the resulting core to improve its magnetic characteristics.

5. A temperature stabilized magnetic body formed by mixing finely divided nickel-iron alloy having a positive permeability-temperature coefficient over a range of temperatures to be encountered in service, with approximately 0.5 per cent by weight of finely divided stabilizing material consisting of a plurality of alloys having different negative permeability-temperature coefficients over respectively different portions of said temperature range, each alloy containing molybdenum as a constituent, the number of alloys, the amount of molybdenum in each and the exact proportion of stabilizing material to magnetic material in the mixture being so chosen as to produce in the magnetic body a substantially continuous and uniform stabilization of permeability over said range of temperatures.

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