

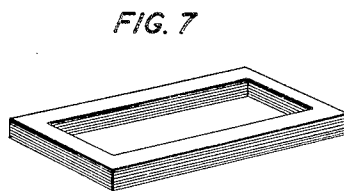
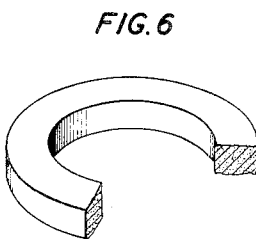
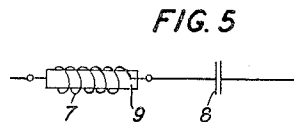
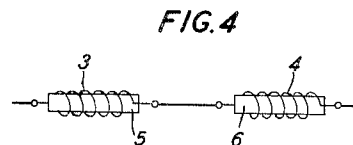
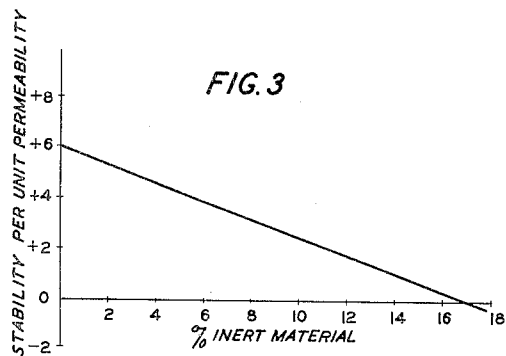
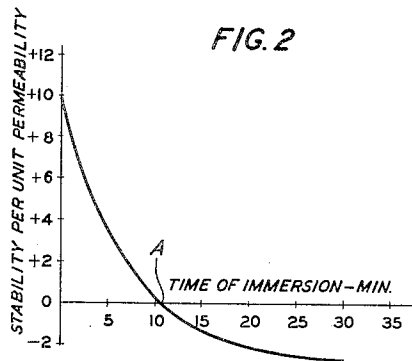
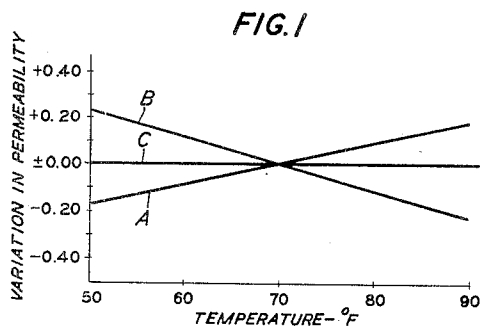
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2,191,151

MAGNETIC CORE WITH CONSTANT PERMEABILITY

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2,191,151

MAGNETIC CORE WITH CONSTANT PERMEABILITY

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3 Claims. (Cl. 175—21)

This invention relates to inductive devices and more particularly to the cores of such devices which comprise magnetic material and insulating material.

5 Among the magnetic materials used in electrical apparatus are certain alloys of the magnetic metals. One of these alloys which has found rather extended use is that known as permalloy which is composed mainly of nickel and iron to which small quantities of other materials may be added for various purposes.

10 The desirable qualities of the alloy noted has caused its use in high quality telephone circuits. It has been found, however, that with varying temperatures the permeability of this alloy varies, thereby changing the characteristics of the apparatus of which it forms a part.

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

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

25 These objects are attained in accordance with this invention by mixing with the alloy, material which is substantially non-conductive electrically and inert magnetically but which has a larger coefficient of thermal expansion than the alloy.

30 The invention will be better understood from the following description and attached drawing forming a part thereof in which:

35 Fig. 1 is a graph showing the variation in permeability with change in temperature for certain magnetic specimens;

40 Fig. 2 is a graph showing the variation of stability with the length of time of immersion of a magnetic sample in an inert material;

45 Fig. 3 is a graph showing the variation in magnetic stability with varying amounts of a different inert material;

Figs. 4 and 5 show applications of the invention; and

Figs. 6 and 7 show forms into which the magnetic material may be pressed.

50 Referring now to Fig. 1 the curve A shows the variation of permeability expressed in per cent of the permeability at the reference point of 70° F., with change in temperature for a core of compressed permalloy having a composition of 82 per cent nickel, 16 per cent iron and 2 per cent

molybdenum. This alloy was prepared in accordance with U. S. Patent 1,669,649 issued to Beath and Heinicke May 15, 1928, and was ground to a powder of sufficient fineness to pass a 400 mesh screen. This powder was mixed with sufficient inert refractory insulating material in accordance with U. S. Patent 1,943,115 issued to W. C. Ellis June 9, 1934, to give the compressed and annealed toroidal core a permeability of 13.5. It will be noted from this curve that at 50° F. the permeability varies from that at 70° F. by about -0.18 per cent; at 60° F. by about -0.09 per cent; at 80° F. by about +0.09 per cent, etc. In the range of temperature shown in the curve this core has a positive permeability temperature coefficient, that is, the permeability increases with increasing temperature, the rate being about 90 parts per million per degree Fahrenheit.

20 A core having a permeability which varies with temperature is, of course, undesirable in many instances since such a core will cause the coil with which it is associated to have an inductance which varies with temperature. A coil of this type when included in a high quality telephone transmission line adversely affects the transmission characteristics of the line.

25 It is, therefore, of considerable value to have a core which has a constant temperature permeability characteristic and such a core may be attained by mixing with the material constituting the core an inert material having a coefficient of thermal expansion substantially greater than that of the main core material. The main core material for purposes of this specification includes the magnetic material, the insulating material, and the binding material if any is used. The main core material above described has a coefficient of cubical expansion of about 35×10^{-6} .

30 One such inert material which has given satisfactory results in this connection is Superla Wax which is a highly refined hydrocarbon wax prepared in accordance with U. S. Patent 1,735,555 to Wendt and Banta, dated November 12, 1929. This wax exists in the solid state in the temperature range of interest, that is, from 55° F. to 95° F. and in this range has a coefficient of cubical expansion of the order of 500×10^{-6} .

35 In experiments involving the addition of Superla Wax to the magnetic material previously described, it was found more convenient to express the relationship existing between the permeability of a core and varying quantities of added Superla Wax by relating the permeability or the change thereof to the time of immersion 55

of the core in the molten wax since the amount of Superla Wax added to the core is proportional to the time of immersion. This relationship is shown graphically in Fig. 2 where the ordinates of the curve represent per cent stability of the core per unit permeability and the abscissae represent time of immersion measured in minutes. By the term "stability" as used here is meant the change in inductance of a coil in parts per million per degree Fahrenheit. To facilitate comparison with cores of different permeabilities the stability is divided by the permeability of the cores to be compared.

From Fig. 2 it will be seen that the curve crosses the zero stability line at point A representing a time of immersion of approximately eleven minutes. This means that a core of the material previously defined when immersed in molten Superla Wax for eleven minutes and then cooled will have substantially constant permeability with varying temperature. Such a core may be represented by curve C of Fig. 1 which shows a zero change in permeability with change in temperature.

Fig. 2 shows the time of immersion at atmospheric pressure. In actual practice the immersion would probably be carried out at a pressure less than atmospheric and the time of immersion would thereby be considerably shortened. For example, for saturation with Superla Wax at atmospheric pressure a time of immersion of about two hours is required, whereas in a vacuum the time of immersion for saturation does not exceed thirty minutes.

The behavior of a core of the material as defined hereinbefore when saturated with Superla Wax is shown by curve B of Fig. 1. From this curve it will be noted that a saturated core has a decreasing permeability with increasing temperature, the decrease being about 115 parts per million per degree Fahrenheit, that is, saturation over-compensates.

Another inert material which has been found to give favorable results is fluorspar. Fig. 3 shows how different amounts of fluorspar mixed with the main core material affects the permeability of a core. Fluorspar has a coefficient of cubical expansion of about 60×10^{-6} . From the curve it is seen that with a fluorspar content of about 17 percent of the main core material, a substantially constant permeability core is attained with change in temperature. Also it will be noted that over-compensation will be obtained if more than 17 per cent is used.

As specific examples of the use of this invention reference is had to Figs. 4 and 5. Fig. 4 illustrates an electric circuit comprising two inductive devices such as retardation coils 3 and 4 having cores 5 and 6. Sufficient inert material may be mixed with the magnetic alloy powder of core 5 of coil 3 to give it a negative permeability temperature characteristic (that is, over-compensate) which will effectively balance or neutralize the positive permeability temperature characteristic of core 6 of coil 4.

In Fig. 5 there is illustrated a circuit comprising an inductance device 7 and a capacitance device 8. In this case the core 9 of device 7 may be made to have either a positive or negative permeability temperature characteristic to compensate for the variations of capacitance with changing temperature of the device 8.

For example if the core 9 should have a negative permeability temperature characteristic (decreasing permeability with increase in tempera-

ture) in order to compensate for a positive temperature characteristic of condenser 8, the core 9 may be immersed in molten Superla Wax for a period substantially greater than eleven minutes when carried on at atmospheric pressure, the time of the immersion being chosen that the resulting variable temperature characteristic for core 9 neutralizes the variable temperature characteristic of condenser 8. On the other hand if core 9 should be given a positive permeability temperature characteristic the time of immersion in Superla Wax at atmospheric pressure should be chosen at the proper value less than eleven minutes.

The cores of inductance devices 3, 4 and 7 may be of the toroidal form as illustrated in Fig. 6 or the laminated form of Fig. 7. If temperature compensation with a refractory inert material is desired the proper portion of inert material is added to the magnetic material powder before the powder is compressed to give the resultant core the particular permeability temperature characteristic required. However, if an inert material of low melting point such as Superla Wax is to be used for temperature compensation the immersion in the molten material may take place after the core material has been compressed to its final shape.

It is to be understood that whereas certain specific materials have been mentioned as causing the results described, the invention is not to be limited thereto but is to be limited only as defined in the appended claims.

What is claimed is:

1. A compressed and annealed magnetic core comprising finely divided magnetic particles of an alloy comprising nickel and iron in which the nickel content is more than 80 per cent of the nickel iron content, a layer of insulating material surrounding each of said particles and substantially insulating each particle from every other particle, said insulated particles having a permeability which increases with increase in temperature over a certain range, and means for compensating in part at least for said change in permeability with temperature, said means comprising a substantial amount of fluorspar incorporated in said core between said particles.

2. A temperature compensated and compressed magnetic core consisting of finely divided magnetic particles of a single alloy comprising nickel and iron in which the nickel content is more than 80 per cent of the nickel iron content, a layer of insulating material surrounding each of said particles and substantially insulating each particle from every other particle, said insulated particles normally having a permeability which increases with increase of temperature over the range from 50° F. to 90° F., and a temperature stabilizing material dispersed between said insulated particles consisting of a magnetically inert substance differing in composition from said insulating material and having a thermal coefficient of expansion considerably higher than said magnetic particles, the exact proportion of stabilizing material to magnetic material in the core being so chosen that the resulting core has a substantially constant permeability over said temperature range.

3. A compressed magnetic core in accordance with claim 2 in which said temperature stabilizing material comprises a hydrocarbon wax.

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