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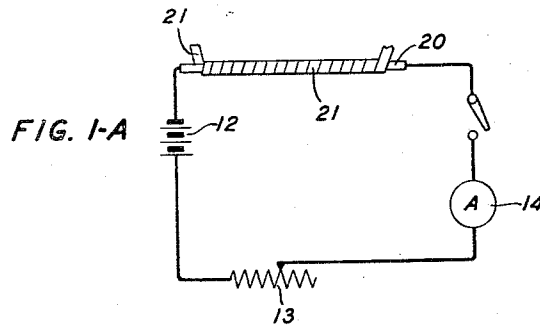
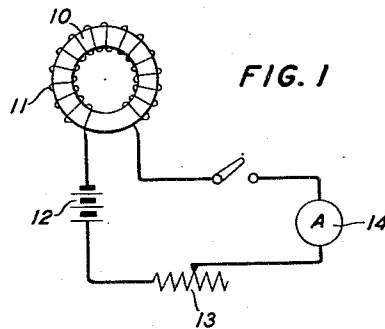
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1,848,364

TREATING MAGNETIC MATERIALS

Filed March 2, 1931

3 Sheets-Sheet 1



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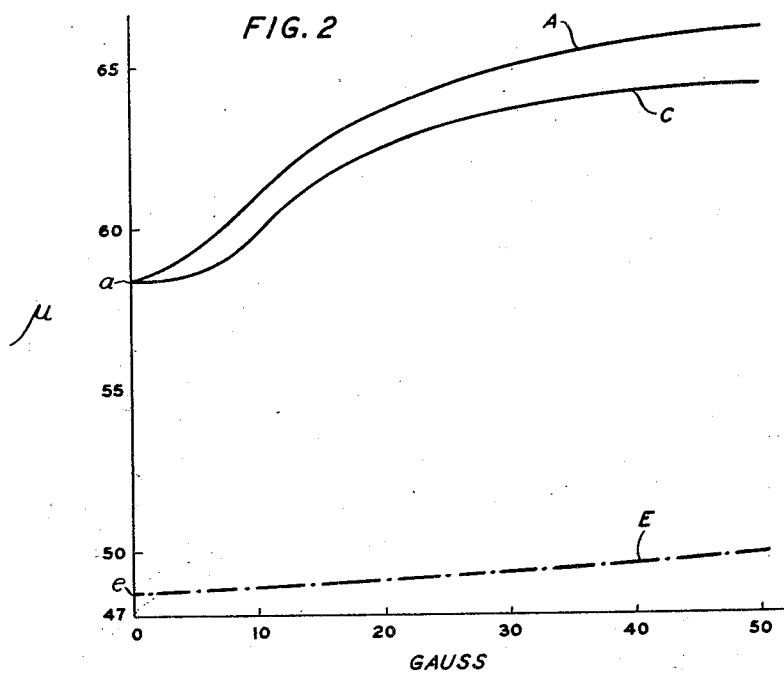
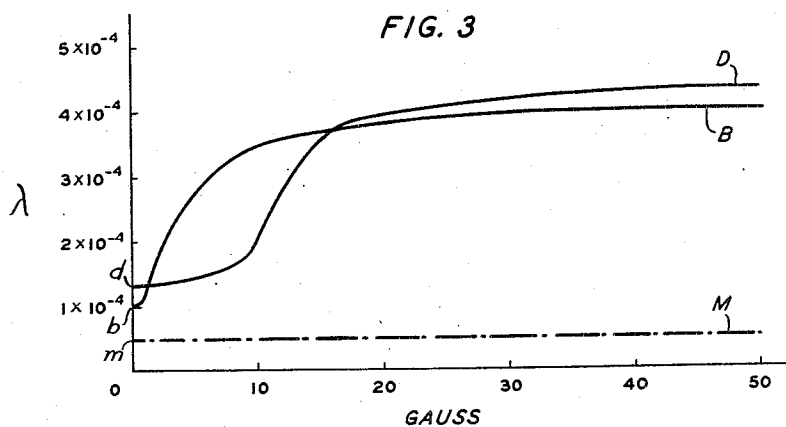
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3 Sheets-Sheet 2



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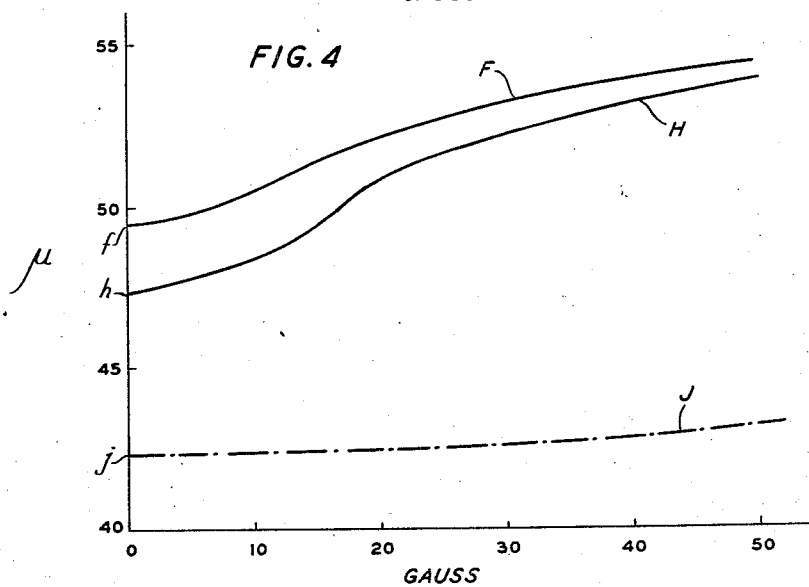
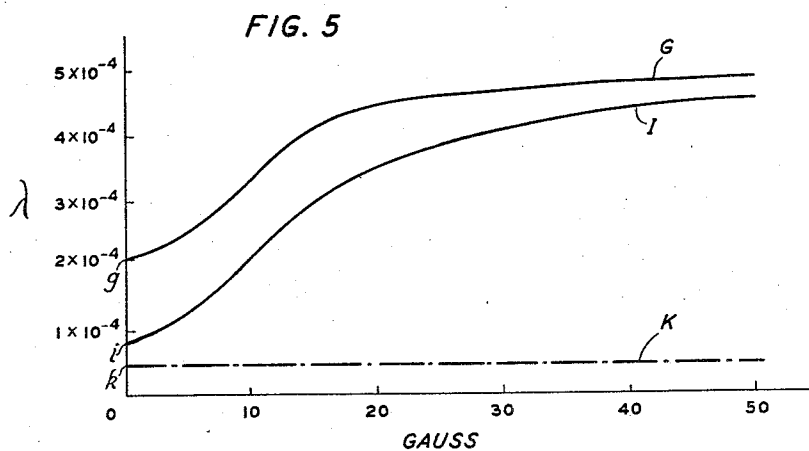
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TREATING MAGNETIC MATERIALS

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3 Sheets-Sheet 3



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TREATING MAGNETIC MATERIALS

Application filed March 2, 1931. Serial No. 519,400.

The present invention relates to treatments of magnetic materials and particularly to treatments of magnetic materials containing iron, nickel and cobalt.

5 Magnetic iron-nickel-cobalt compositions suffer from the disadvantage that when they once have been subjected to the influence of large magnetizing forces, their magnetic properties are affected in a manner detrimental for certain uses. It is in particular two important properties of such compositions, to wit, the initial permeability and the constancy of permeability with increasing magnetic flux density which are changed by such exposure. The initial permeability is usually increased considerably and the constancy of permeability with flux density is usually decreased to an extent such that the permeability has become too variable for many purposes, particularly for use in signalling systems where uniformity of permeability is desired.

An object of the present invention is to so condition magnetic iron-nickel-cobalt compositions that their magnetic characteristics will recover from exposure to adverse magnetic influences with less impairment of their desirable properties.

A further object of the invention is to so treat magnetic iron-nickel-cobalt alloys which are applied around a signalling conductor in a continuous manner that their immunity to the detrimental effects of excessive magnetization is increased.

In accordance with this invention certain magnetic characteristics of magnetic materials are rendered insensitive to the effects of large or disturbing antecedent magnetizing forces by first strongly magnetizing the magnetic materials and then heating them for a considerable period of time at a temperature ranging somewhere between 400° C. and 600° C. The methods of this invention are applicable for improving the properties of magnetic materials both in the form of solid compositions and in the form of finely divided material having the form of dust. Compositions which are particularly benefited by these treatments are those of the type described in Elmen U. S. Patents

1,715,541 and 1,715,647, both granted June 4, 1928.

In connection with such treatments of magnetic materials it has been observed that after a specimen has been treated in the manner of this invention its permeability is substantially stabilized against magnetization in the direction in which it has last been highly magnetized, but its permeability is somewhat less constant for magnetization in the direction opposite to that in which it has last been highly magnetized.

The invention is applicable to iron-nickel-cobalt magnetic materials and other compositions having similar properties, but a description of specific treatments as applied to the particular materials of the type mentioned will now be made in referring to the accompanying drawings in which,

Figs. 1 and 1—A show suitable circuits for subjecting magnetic materials to magnetizing forces in accordance with this invention;

Figs. 2 and 4 show curves depicting the variation of the initial permeability after application and removal of varying magnetizing forces; and

Figs. 3 and 5 show curves depicting the variation of the permeability coefficient after application and removal of different magnetizing forces, of test samples of magnetic materials. In Figs. 3 and 5 the ordinates represent the permeability coefficients

$$\lambda = \frac{1}{\mu_0} \frac{d\mu_0}{dB}$$

and the abscissæ the magnetizing forces. Unless otherwise specified the magnetization forces applied were all in the same direction.

Fig. 1 shows a ring-shaped test sample which is to be subjected to magnetizing forces in accordance with this invention. For this purpose it is surrounded by a winding 11 of an insulated conductor which is connected to a suitable source of current, such as battery 12, for instance. By employing sufficient turns and a suitable battery, the current can be adjusted to any suitable value, by means of adjustable resistance 13, to produce any desired magnetizing force. Ammeter 14 is provided

for the purpose of indicating the amperage, from which the value of the corresponding magnetizing force may be calculated.

The samples employed for furnishing the data used for plotting the curves of Figs. 2 to 5, inclusive, had the form of rings, as shown in Fig. 1. They consisted of a powdered magnetic composition containing about 45% nickel, 25% cobalt, 27% iron and 3% molybdenum. The finely divided particles of this composition were insulated with chromic acid-talc-sodium-silicate insulation.

A sample of this composition, after having been given the usual heat treatment consisting of annealing at 500° C. for 80 minutes, was found to have an initial permeability of 58.4 (see point "a" of curve A, Fig. 2) and a permeability coefficient λ of 1.0×10^{-4} (see point "b" of curve B, Fig. 3). The sample was then magnetized as described in connection with Fig. 1 by applying and removing various increasing magnetizing forces varying from zero gauss to about 50 gauss. After each magnetization the initial permeability and the permeability coefficient at low magnetizing forces were measured and curves A (Fig. 2) and B (Fig. 3) were plotted from the readings. As curve A shows, the initial permeability increased from 58.4 to about 66, or about 16%, after a magnetization of 50 gauss. Likewise, as curve B shows, the permeability coefficient increased from 1.0×10^{-4} to about 3.5×10^{-4} after a magnetization of 50 gauss, that is an increase of 250%. This illustrates the extent of the change in the properties of the material by its exposure to such high magnetizing forces. The winding was then removed from the sample and the sample heated or "baked" at about 425° C. for 36 hours. The material was then again measured for initial permeability and permeability coefficient. The initial permeability was found to be back at its original value of 58.4 (point "a" curve C of Fig. 2) and the permeability coefficient was found to be 1.3×10^{-4} (point "d" curve D of Fig. 3), which was almost at its original value of 1.0×10^{-4} . Magnetizing forces were then applied and removed increasing step by step to a value of 50 gauss, and the permeability and the permeability coefficient measured after each step and curves C and D plotted. The sample was then given another baking treatment at 425° C. lasting 48 hours. This treatment succeeded in reducing the permeability to 48.8 (point "e" curve E of Fig. 2) and the permeability coefficient to 0.5×10^{-4} (point "m" of curve M of Fig. 3). After magnetizing treatments similar to the previous ones up to 50 gauss the permeability increased only 2.4% and the permeability coefficient remained constant. Further applications and removals of high magnetizing forces did not alter the stability of the initial permeability and permeability coefficient.

Figs. 4 and 5 show graphs plotted in further tests when using two similar samples of magnetic dust material of the same composition as those to which Figs. 2 and 3 relate. In these tests, the sample represented by curves H and I was not magnetized before the baking. The other sample had an initial permeability of 48.5 (point "f" of curve F) which was increased to about 54 after the application and removal of a magnetizing force of 50 gauss, while its permeability coefficient rose from a value of 2.1×10^{-4} (point "g" of Fig. 5) to 4.8×10^{-4} , an increase of 130% (curve G). Both samples were then heat treated at 425° C. for 48 hours. After this treatment the initial permeability of the non-magnetized sample was 47.3 (point "h" of curve H) and its permeability coefficient 0.8×10^{-4} (point "i" of curve I), while the initial permeability of the premagnetized sample was 42.3 and its permeability coefficient 0.5×10^{-4} . Both samples were then subjected to the effect of gradually increasing detrimental magnetizing forces varying up to 50 gauss. Upon measuring the properties of the samples, it was found that the initial permeability of the premagnetized sample had increased only 1.9% from its original value of 42.3 (point "j" of curve J), and that its permeability coefficient (0.5×10^{-4}) had remained unaltered after the application and removal of 50 gauss; see point "k" and curve K of Fig. 5. In contrast to this, the comparison sample was found to be very unstable, its initial permeability rose from 47.5 to nearly 54 (curve H, Fig. 4), and the permeability coefficient increased from 0.8×10^{-4} to 4.5×10^{-4} (curve I, Fig. 5), which is about 460%.

In addition to the heat treatments on samples consisting of powdered material, tests were made on solid tape rings which showed that the treatment is equally applicable to solid materials.

In accordance with this modification of the invention, a sample ring of spirally wound tape material of composition 7% Mo, 45% Ni, 25% Co, 23% Fe was given the usual annealing treatment consisting in heating it at about 900° C. for about 1 hour. It was then strongly magnetized, and subsequently heated 48 hours at 440° C.

The initial permeability of the material was 566 and the permeability coefficient was 0.10×10^{-4} . The ring was then magnetized in the manner shown in Fig. 1 increasing to 50 gauss. Its initial permeability was then measured and found to be 570 an increase of less than 1%, while the permeability coefficient was not at all adversely affected.

In another test of this type the magnetizing field to which the loading material was subjected was carried up to about 200 gauss, without causing substantial injury to the initial permeability or to the permeability coefficient. In a further test on another ring

specimen, the initial permeability was found to remain constant to within 1% of the value measured immediately after baking, after being subjected to a magnetizing field of about 100 gauss. The direction of the magnetizing field was then reversed and a progressively increasing magnetizing field of opposing direction applied to the loading material. The initial permeability was measured after each magnetizing field had been applied and removed. It was found that the initial permeability had increased only about 2% after the field of 2 gauss had been applied and removed, but that between magnetizing forces of 3.3 gauss and 4.1 gauss there was an increase in the initial permeability amounting to about 13% of the original permeability. A value within 2% of the original initial permeability was again reached after a magnetizing force of 17 gauss had been applied and removed. The initial permeability remained practically constant for further increasing magnetizations. The loading material was then subjected to increasing magnetizing forces applied in the same direction as the previous magnetization; in this case, no increase in the initial permeability such as had been noticed in the immediately preceding test was found.

In accordance with another modification of the invention tape of composition similar to the above was applied helically to a copper conductor and thus annealed for 6 minutes at approximately 950° C. It was then magnetized strongly by passing current through the conductor using the circuit shown in Fig. 1—A. After subsequent heat treatment for 48 hours at about 450° C. the conductor was cooled and measured to determine the initial permeability and permeability coefficient of the loading material. A magnetic field of 50 gauss was then applied and removed by passing the proper current through the conductor, after which measurements showed that the initial permeability had increased only 1% and the permeability coefficient was not at all affected.

The present invention has been described in connection with the application of a direct current magnetizing force as a means for conditioning the materials before the annealing treatment but use may also be made of alternating current magnetization with similar results.

What is claimed is:

1. Method of conditioning a magnetic material which comprises first subjecting the material to the effect of an intense magnetic field and then heating it to an elevated temperature.

2. A method of rendering magnetic characteristics of magnetic materials insensitive to the effect of magnetization which comprises magnetizing the materials and then heating them to an elevated temperature for at least 8 hours.

3. A method of treating a magnetic material containing iron, nickel and cobalt as essential elements thereof, which comprises magnetizing the material and heating it to a temperature between about 400° C. and 600° C.

4. A method of conditioning a body containing a magnetic composition comprising iron, nickel and cobalt, which method includes strongly magnetizing said body and then heating it to a temperature of at least 400° C.

5. Method as defined in claim 1, further characterized in this that the material is in a finely subdivided condition.

6. Method as defined in claim 1, further characterized in this that the material during treatment is applied in a continuous manner around a conductive element.

In witness whereof, I hereunto subscribe my name this 19th day of January, 1931.

VICTOR E. LEGG.