

106. COMPOSITIONS,
COATING OR PLASTIC
84-M

Cross Reference

Examiner

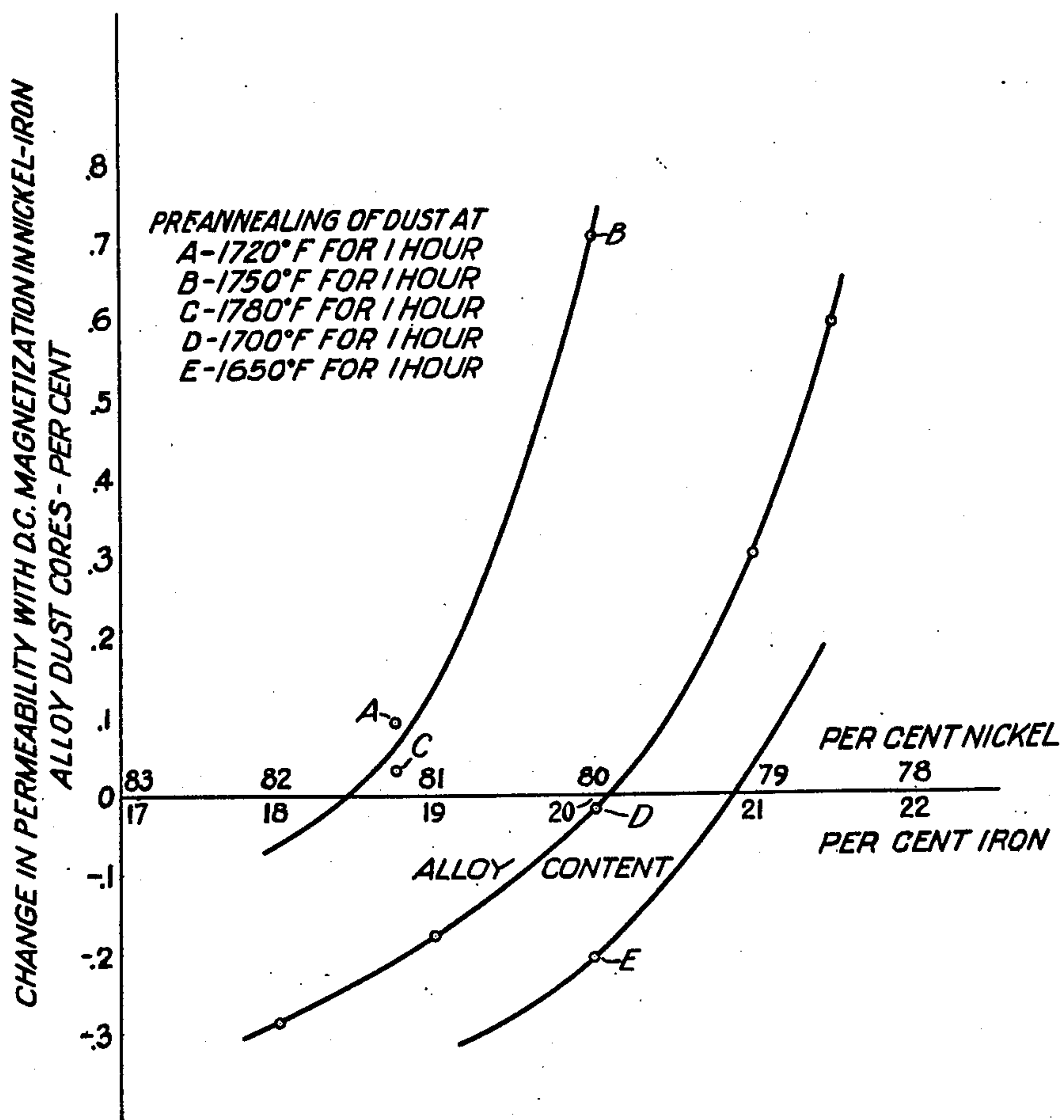
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F. J. GIVEN ET AL

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METHOD OF PRODUCING MAGNETIC BODIES

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F. J. GIVEN
INVENTORS: R. M. C. GREENIDGE
J. R. WEEKS, JR.
BY *H. A. Buzger*
ATTORNEY

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FREDERICK J. GIVEN, OF EAST ORANGE, RALPH M. C. GREENIDGE, OF ORANGE, AND JOHN B. WEEKS, JR., OF EAST ORANGE, NEW JERSEY, ASSIGNORS TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

METHOD OF PRODUCING MAGNETIC BODIES

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This invention relates to magnetic bodies and particularly to magnetic bodies made from comminuted magnetic material.

The invention has special application to magnetic bodies of the "dust" type formed by compressing finely divided magnetic material, particularly alloys including nickel and iron, and insulating material under high pressure to form a homogeneous structure, which bodies are commonly used as cores for loading coils in telephone circuits to improve the transmission characteristics thereof. This invention in its broader aspects is applicable as well to magnetic bodies made of loosely assembled particles of magnetic material either with insulating material therebetween or with no other insulation other than air spaces separating the magnetic particles.

An object of the invention is to secure constancy of operating characteristics in transmission apparatus, such as loading coils and the like employing magnetic material of the kind described above, especially in transmission circuits when subjected to extraneous electrical influences.

A related object is to reduce in magnetic bodies used in connection with transmission circuits variations in magnetic characteristics tending to introduce distortion in the currents transmitted thereover.

Another and more specific object is to control the magnetic stability of a magnetic body made from a magnetic material, such as an alloy of nickel and iron, in comminuted form, by a preliminary heat treatment of the particles of magnetic material.

The term "magnetic stability" is used in this specification and in the annexed claims in connection with a magnetic body to define the degree to which its permeability, or the inductance of a coil employing such a body as a core, is stable when subjected to extraneous magnetizing forces, particularly direct current magnetizing forces. Transmission apparatus in telephone circuits, such as loading coils, are often subjected in service to such magnetizing forces due to external influences, such as accidental contacts with power lines, the effects of lighting, the aurora borealis or other atmospheric disturbances.

Maximum stability corresponds to zero percentage change in the permeability of a core, or in the inductance of a coil around the core, with direct current magnetization. A large change in permeability with direct current magnetization corresponds to low magnetic stability. Positive magnetic stability refers to the case of an increase in permeability with direct current magnetization, and negative magnetic stability to a decrease in permeability with direct current magnetization.

The copending application of J. W. Andrews and R. Gillis, Serial No. 244,020, filed December 31, 1927, discloses that the magnetic stability with respect to direct current magnetizations of a magnetic core for a loading coil comprising finely divided particles of a magnetic alloy including nickel and iron may be controlled by proper selection of the relative proportions of the nickel and iron in the alloy. Hitherto, it has been known also that the constancy of magnetic properties, such as permeability and hysteresis losses, in loading coil cores comprising finely divided nickel-iron alloy as the magnetic material, over the usual range of alternating current flux densities to which they are subjected in telephone circuits, is improved by subjecting the alloy particles prior to their assembly into a core to a heat treatment at an elevated temperature in the neighborhood of 950° C. for a short time.

In accordance with the present invention, the magnetic stability of a magnetic body comprising finely divided magnetic material, such as a magnetic dust core for a loading coil, is controlled to a desired degree by giving the magnetic particles a proper pre-annealing heat treatment, the annealing temperature and the time of anneal being determined by the relative proportions of the constituents of the magnetic material. In a particular application of the invention to a magnetic dust core for a loading coil, in which the magnetic dust material was prepared in a particular way from an alloy including nickel and iron in the ratio of about 80 per cent nickel to 20 per cent iron, a very high degree of stability together with a high permeability and low core losses was obtained in

the final core by subjecting the magnetic particles prior to forming them into a core to an annealing heat treatment at a temperature of approximately 1700° F. (930° C.) for about one hour and then slowly cooling them. Both the temperature and time of anneal are important factors in this treatment. If a higher annealing temperature is used, to obtain a similar effect as regards magnetic stability, a shorter annealing time would be required and vice versa. If the ratio of nickel to iron in the magnetic dust is greater than the ratio specified above, either the temperature of the annealing heat treatment or its duration should be increased to obtain the optimum effect as regards magnetic stability.

The exact nature and advantages of the invention will be better understood from the following detailed description thereof when read in connection with the accompanying drawing, the single figure of which shows curves illustrating the invention.

Reference will first be made to the drawing which illustrates graphically the results of tests to determine the effect on the magnetic stability of magnetic cores of various pre-heat treatments of the particles used to make the cores. These particular cores were for loading coils and comprised compressed finely divided particles of an alloy including nickel and iron in different proportions, and insulating material between the particles.

In the graphical diagram referred to, the relative percentages of nickel and iron in the magnetic alloy in the test cores are plotted as abscissæ, and the ordinates are the per cent variation in permeability of the cores with direct current magnetization, and are an indication, therefore, of the magnetic stability of the core. Each point of the diagram indicated by the small circles represents a test of a different dust core in which the dust particles contain definite proportions of nickel and iron, and have been subjected prior to their insulation and compression into a core, to an annealing heat treatment at a particular temperature for a particular length of time as indicated by the table accompanying the figure. The finely divided particles of magnetic material in each core tested were prepared by the same general method, subjected to the preliminary annealing heat treatment under like conditions, and were insulated and formed into cores by the same methods. The processes used in preparing the test cores and the method of test will be described in detail below.

In the figure, the points A and C represent the percentage variations in permeability with D. C. magnetization of a magnetic core made from magnetic particles comprising an alloy of nickel and iron in the approximate relative proportions of 81.25 per cent nickel and 18.75 per cent iron, which particles

have been pre-annealed at a temperature of about 1720° F. and 1780° F., respectively, for one hour. The points B and E represents the percentage variation in permeability with D. C. magnetization of magnetic dust cores made from magnetic particles comprising an alloy of nickel and iron in the approximate relative proportions of 80 per cent nickel and 20 per cent iron, which particles have been preannealed at temperatures of about 1750° F. and 1650° F., respectively, for one hour. The points D represent the percentage variation in permeability with D. C. magnetization of magnetic cores made from magnetic particles comprising an alloy of nickel and iron in the approximate relative proportions of 82—18, 81—19, 80—20, 79—21, and 78.5—21.5 per cent, respectively, all of which have been pre-annealed at a temperature of about 1700° C. for one hour.

The points A, B and C approximately determine the shape of the magnetic stability curve corresponding to nickel-iron alloy dust cores in which the magnetic particles have been pre-annealed at a temperature of approximately 1750° F. for one hour. The points D determine the shape of the magnetic stability curve for nickel-iron alloy dust cores in which the magnetic particles have been pre-annealed at a temperature of approximately 1700° F. for one hour. It will be noted that the curves through the points D and B respectively, for considerable portions of their lengths are approximately parallel. From this it may be deduced that curve shown through the point E and approximately parallel to the curves B and D represents the magnetic stability curve for nickel-iron alloy dust cores in which the magnetic particles have been pre-annealed at a temperature of 1650° F. for one hour.

The curves of the figure show clearly that the magnetic stability of a magnetic dust core in which the dust particles comprise an alloy including nickel and iron may be controlled in a definite manner by the preliminary annealing treatment of the magnetic dust particles, and that the particular preliminary heat treatment required in a given case to obtain a desired degree of stability in the final core will vary in accordance with the proportions of the nickel and iron in the alloy constituting the magnetic particles. The curves show that the temperature, or the product of temperature and time of anneal, for the annealing heat treatment of the dust to provide maximum magnetic stability in a given dust core, increases as the ratio of nickel to iron in the alloy dust increases.

The curves show, moreover, that the percentage change in permeability in a magnetic alloy dust core with D. C. magnetization for given proportions of nickel and iron in the alloy will be positive if the magnetic par-

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5 ticles are subjected to a pre-annealing heat treatment at a given temperature for a given length of time, negative if subjected to a certain other and lower temperature for the same length of time, and zero if subjected to a certain intermediate temperature for the same length of time. For example, as indicated by the points B, D and E on the curves, the change in permeability with D. C. magnetization, for magnetic alloy dust cores in which the magnetic alloy in the dust particles comprises nickel and iron in proportions of approximately 80 per cent nickel and 20 per cent iron, the magnetic dust being prepared in a certain way, is approximately +0.7 per cent when the magnetic particles are pre-annealed at a temperature of 1750° F. for one hour, approximately -0.2 per cent when the magnetic particles are pre-annealed at a temperature of 1650° F. for one hour, and approximately 0.0 per cent when the magnetic particles are pre-annealed at a temperature of 1700° F. for one hour.

10 It is evident that if a series of curves are drawn substantially parallel to the curves shown in the figure, each spaced therefrom for a distance which would correspond to a different value of temperature for the pre-annealing heat treatment, they may be used to predict the optimum pre-annealing heat treatment from the standpoint of magnetic stability of the magnetic dust cores, for the nickel-iron alloy dust particles of different nickel-iron contents, if the dust cores are prepared by methods similar to those used for preparing the magnetic particles of the test cores.

15 The details of the methods used in preparing the magnetic dust test cores, the properties of which are represented by the curves of the figure, are as follows. Nickel and iron in proportions depending upon the desired percentage composition of the alloy, are first melted in small lots (approximately 3½ pounds each) in silica crucibles in a high frequency induction furnace, a small amount of iron sulphide being added to each melt to embrittle the resulting alloy sufficiently so that it may easily be reduced to finely divided form by mechanical methods. To produce a fine grained structure in the alloy material in which the individual crystals are approximately the size desired in 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 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.

70 The fine dust is then annealed by the following method. A small quantity (approximately 1500 grams) of each lot of dust of the different compositions is placed in an airtight pot and the pots inserted into an electric (batch type) furnace which has been preheated to the desired annealing temperature. The pots are allowed to remain in the heated furnace for one hour, after which the heat is turned off and the pots allowed to cool in the furnace over night. As indicated in the table accompanying the figure, the different lots of dust from which the test cores were made were annealed at temperatures of 1650° F., 1700° F., 1720° F., 1750° F., and 1780° F., respectively, for one hour.

75 In order to break up the lumps of annealed dust, they are placed in tumbling jars and tumbled until they are again reduced to finely divided forms. The dust is then sieved, all particles passing through a 120 mesh sieve being used for making cores.

80 The annealed dust particles are then insulated with a suitable insulating material. In the case of the test cores, the annealed particles were insulated with a chromic acid-water glass-talc composition, in the manner disclosed in detail in the U. S. patent to Andrews and Gillis No. 1,669,643, issued May 15, 1928. The insulated particles are then formed into core rings at a pressure of approximately 200,000 pounds per square inch in a hydraulic press. The rings are then annealed for about 20 minutes in an annealing furnace at a temperature of approximately 500° C. and then cooled. The rings are then boiled in water to remove any soluble substances of the insulating materials, and they are then dried at a temperature of approximately 100° C.

85 In the case of the test cores, the rings were stacked axially to form cores of three rings on each of which the usual toroidal loading core winding was wound, which cores were then subjected to the usual permeability and core loss tests, and to a test for magnetic stability.

90 The magnetic stability test comprised measuring by suitable means the change in inductance of the loading coils before and after subjecting them to a D. C. magnetic force of approximately 20 gilberts per centimeter. This force was applied in the case of the test cores by applying momentarily (for 3 to 5 seconds) direct current of suitable value to the windings of the coils.

95 It was found that the permeabilities of

the several test cores made by the method which has just been described differed appreciably, probably due to small differences in the methods used for preparing the different lots of dust. It was necessary, therefore, in order that the values obtained in the magnetic stability test, might be readily compared, to recompute these values on the basis of a permeability of 75. The results plotted in the figure of the drawing are the recomputed values.

Although in the case of each of the test cores, the duration of the dust annealing heat treatment to obtain the optimum effects as regards magnetic stability has been specified as one hour, this particular time only applies when the annealing temperature in each case is that specified, and in accordance with the principles of the invention substantially equivalent effects may be obtained in a given case by making the duration of the heat treatment any appreciable time more or less than one hour and lowering or raising the annealing temperature proportionately.

The invention has been illustrated and described as applied to the production of magnetic dust cores for loading coils from finely divided particles of a magnetic alloy comprising certain constituents, i. e., nickel and iron, prepared in a certain way. It is to be understood that the principles of the invention are applicable as well to any magnetic body employing finely divided magnetic material of an alloy comprising nickel and iron or nickel and iron together with another metal or other metals, such as copper, cobalt, molybdenum, etc.

The particular values for temperature and duration of the annealing heat treatments of the alloy particles specified above are given by way of example only as applicable to loading core coils made of magnetic dust prepared in a certain way. It is understood that the principles of the invention apply equally well to magnetic bodies in which the magnetic particles have been prepared by other methods, in which case, of course, the optimum annealing heat treatments of the magnetic particles may be somewhat different from those specified.

What is claimed is:

1. In the process of producing a magnetic body comprising finely divided particles of a magnetic alloy including nickel and iron in given proportions, formed into a substantially homogeneous mass, the method of improving the magnetic stability of the final body which consists in subjecting the magnetic particles prior to their assembly into final form to an annealing heat treatment at a temperature and for a length of time determined by the relative proportions of the nickel and iron in said alloy.

2. In the process of producing a magnetic body comprising finely divided particles of a

magnetic alloy including nickel and iron in given proportions, and insulating material between the magnetic particles, compressed to form a substantially homogeneous mass, the step of improving the magnetic stability of the final body which comprises heat treating the magnetic particles prior to their insulation and compression at a temperature and for a length of time determined by the relative proportions of the nickel and iron in said alloy.

3. In the process of producing a magnetic body comprising finely divided particles of a magnetic alloy including nickel and iron in given proportions, and insulating material between the magnetic particles, compressed to form a substantially homogeneous mass, the method of improving the magnetic stability of the final magnetic body which consists in heat treating the magnetic particles prior to their insulation and compression at a temperature and for a length of time determined by the relative proportions of the nickel and iron in said alloy, and then slowly cooling the heat treated particles.

4. The process of producing a magnet body the magnetic properties of which are substantially unaffected by the application thereto of direct current magnetic forces, from a finely divided magnetic alloy including nickel and iron in given proportions, and insulating material, which consists in annealing the finely divided magnetic particles at a temperature and for a length of time determined by the relative proportions of the nickel and iron in said alloy, slowly cooling the annealed particles, coating the annealed particles with said insulating material, and forming the coated particles into a substantially homogeneous mass.

5. The process of claim 4 and in which, when the nickel-iron content of said alloy in said particles is substantially 80 per cent nickel and 20 per cent iron and said particles have been subjected to ball-milling in reducing them to their finely divided condition, the annealing temperature for said particles is approximately 930 degrees centigrade, and the duration of the annealing treatment approximately one hour.

In witness whereof, we hereunto subscribe our names this 3rd, day of June, 1929.

FREDERICK J. GIVEN.

JOHN R. WEEKS, JR.

RALPH M. C. GREENIDGE.