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MOLDED MAGNETIC POWDERED METAL

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ABSTRACT OF THE DISCLOSURE

A moldable magnetic material having improved magnetic qualities including good residual induction is prepared by combining alnico material and single domain, low melting metal bonded material.

The present invention relates to moldable magnetic materials. More particularly, it relates to such materials which are characterized by good mechanical properties and salutary magnetic properties, particularly residual induction or ability to retain magnetism and to structures of such materials.

Magnetic alloys are well known, such materials including alnico magnet alloys comprising primarily aluminum, nickel, cobalt and iron in various proportions. Such materials are widely described in the literature, including Patent 2,724,174 and elsewhere. Alnico materials which are anisotropic or have directional magnetic characteristics are typified by alnico 5 containing by weight 8% aluminum, 14% nickel, 24% cobalt, 50.8% iron and 3.2% copper. Certain other alloys such as alnico 7 are isotropic or nondirectional in their magnetic properties. Alnico 7 typically contains by weight 8.5% aluminum, 18.0% nickel, 24.0% cobalt, 41.25% iron, 5% titanium and 3.85% copper.

Also well known are compositions of elongated, single domain particles basically of iron or iron-cobalt, such materials being known hereinafter as "single domain material" and described, for example, in United States Patents 2,974,104; 2,999,777 and 2,999,778. These Lodex materials are highly directional in nature and are often bonded together with a lead or lead antimony alloy as described in the above related patents.

Alnico magnets, while they have a high coercive force and a reasonably high residual induction or ability to retain induced magnetism, are, because of their friable or brittle nature, particularly difficult to fabricate into desired shapes particularly where such shapes are intricate. Alnico magnets are often made by powder metallurgy methods and sintered in shapes which are then ground, if necessary, to final dimension. The difficulty in shaping alnico magnets has been suitably overcome by coating or tinning the crushed alnico with a low melting alloy as described in the above Patent 2,724,174, this teaching overcoming the shrinkage inherent in sintering such materials and also providing an article having shape stability as compared to such alloys which are bonded, for example, with resinous materials. The teachings of all of the above patents are incorporated herein by reference, insofar as they are applicable, to the present invention.

A primary disadvantage of structures prepared by crushing alnico type material and thereafter bonding as with a low melting alloy resides in the fact that even though such crushed particles may be only about 1 mil in average diameter, voids between the particles in the final material reduce the achievable residual induction to from about 50 to 60% of the theoretical value attainable. In addition, where the original alnico material has directional magnetic properties, it is difficult to achieve or regain such directionality by alignment while pressing in a magnetic field because of the irregularity of the finely divided particles.

Since the residual induction or the ability to retain magnetism is of utmost importance in applying such materials in equipment and apparatus, it is desirable that alnico containing materials which are readily shapeable and at the same time have good residual induction be provided, and it is a primary object of this invention to provide such materials.

Briefly, the invention relates to magnetic compositions characterized by good moldability and desirable mechanical properties as well as good retention of magnetism which are prepared by blending together crushed or finely divided alnico type materials and single domain material consisting essentially of iron or iron-cobalt material matrixed in a low melting metal, such materials being described in the above Patents 2,974,104; 2,999,777 and 2,999,778. The alnico material may be tinned or bonded as described in the above referred to Patent 2,724,174, or it may be devoid of the tinning or bonding material.

Those features of the invention which are believed to be novel are set forth with particularity in the claims appended hereto. The invention will, however, be better understood from a consideration of the following description.

By the practice of the present invention, the residual induction, flux carrying capacity, or ability to retain magnetism of a typical alnico material is improved by 50% or better by the blending therewith of appropriate amounts of single domain material, the latter serving to not only improve the magnetic characteristics of the final product but to provide a readily moldable and shapeable material.

Any of the well known alnico type magnetic materials may be used in connection with the present invention even though in the specific examples below, alnico 7 of the composition given above is used as exemplary of such materials. Likewise, any of the single domain materials described in the above pertinent patents may be used, a typical composition containing by weight 25% iron, 12% cobalt, 54% lead and 5% antimony with the balance essentially mercury.

In carrying out the present invention, the finely divided, bonded or unbonded, alnico and finely divided, single domain material are thoroughly mixed and molded under pressure to form a final magnetic structure of any desired shape. A particular advantage of the present invention is the reproducibility not only of any precise shape but also of the magnetic qualities of such shapes. Such uniformity of magnetic quality from lot to lot, typically ±2% as compared to ±15% with alnico alone, makes possible, for example, the use of very accurate preprinted instrument scales. This eliminates the need for costly, time-consuming point-to-point marking of such scales. A typical such instrument is described in United States Patent 2,311,382.

Shown in the table below are the magnetic characteristics of various powdered or finely divided mixtures of alnico material and single domain materials processed according to the present invention.

Shown in Table A below is a material prepared according to U.S. Patent 2,724,174 containing as a bonding material about 33%, based on the weight of the alnico, of low melting tinning or bonding material consisting of by weight about 60% tin and about 40% lead.

TABLE A.—100% BONDED ALNICO 7

Molding pressure, p.s.i.	Parallel and Perpendicular	
	B_r gauss	H_c oersteds
148,000	3,500	890
175,000	3,700	860
200,000	3,800	850

From the above table it will be seen that the optimum residual induction with this nondirectional alloy is attained at a molding pressure of 200,000 p.s.i. All samples herein were pressed in the shape of a cylinder having a diameter of 0.75" which was then ground to a one-half inch cube. Magnetic data in all cases was taken from demagnetization curves plotted by a hysteresigraph.

Shown in Table B below are the results obtained at various molding pressures with materials consisting of 100% single domain material as specifically described above and a 50–50 by weight mixture of untinned or unbonded alnico 7 and single domain material.

TABLE B.—100% SINGLE DOMAIN MATERIAL

Molding pressure	B_r gauss		H_c oersteds	
	Parallel	Perpendicular	Parallel	Perpendicular
100,000	3,800	5,700	650	840
122,000	3,800	5,600	650	840
148,000	3,900	5,700	640	880
175,000	3,800	6,100	640	880
200,000	3,700	5,200	640	870
	50/50 untinned alnico 7 and single domain material			
148,000	4,400	5,400	790	830
175,000	4,500	4,800	780	820
200,000	4,500	4,600	750	800

Shown in Table C below are magnetic characteristics obtained from tinned and untinned mixtures of alnico 7 and single domain material.

TABLE C.—TINNED ALNICO 7 AND SINGLE DOMAIN MATERIAL [1]

Composition, wt. percent alnico 7/single domain material	B_r gauss		H_c oersteds	
	Parallel	Perpendicular	Parallel	Perpendicular
90–10	3,700	3,700	840	800
80–20	3,800	3,800	850	820
50–50	3,600	4,500	720	820
	Untinned alnico 7 and single domain material [2]			
70–30	3,800	4,200	790	890
60–40	4,400	4,400	820	840
50–50	4,400	5,400	790	830
40–60	4,400	5,700	760	770

[1] Molding pressure 175,000 p.s.i.
[2] Molding pressure 148,000 p.s.i.

From the above tables, the efficacy of the present invention will readily be seen. This is particularly evident when one keeps in mind that in a direction perpendicular to the pressing direction, a powdered tinned alnico 7 magnet pressed at 200,000 p.s.i. has a residual induction of 3,800 gauss and a coercive force of 850 oersteds and that 100% single domain material pressed at 200,000 p.s.i. has corresponding values of 5,200 gauss and 870 oersteds. Referring to Table C, it will be seen that a 50–50 by weight mixture of tinned alnico 7 and single domain material molded at 175,000 p.s.i. has a perpendicular residual induction of 4,500 gauss and a coercive force of 820 oersteds. When untinned alnico 7 is used, a 50–50 by weight mixture of the untinned alnico 7 and single domain material molded at 148,000 p.s.i. has corresponding values of 5,400 gauss and 830 oersteds.

The easy forming capability of the present materials brought about by taking advantage of the low melting alloy bonding material for the single domain material and where used the corresponding material for the bonded alnico 7 combined with the very favorable magnetic characteristics mentioned above, particularly their ability to retain induced magnetism, makes them particularly desirable for structures used in meters and other instruments of the D'Arsonval and taut-band types where indicating structures are magnetically suspended to reduce friction and increase sensitivity. The unexpected reproducibility of the magnetic characteristics of the present materials makes possible indicating accuracies in preprinted instrument scales of down to ±½% of full scale or better whereas typical prior art materials have made possible corresponding accuracies of only about ±1% or higher. Other uses wherein such magnetic and readily molding characteristics are desirable will occur to those skilled in the art.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. A moldable magnetic composition comprising by weight (1) from 10 to 90 percent of a material selected from finely divided particles of alnico magnet alloy and (2) from about 90 to 10 percent of finely divided, low-melting, metal-bonded, single domain material selected from iron and iron-cobalt alloys.

2. A moldable magnetic composition as in claim **1** wherein said alnico magnet alloy is bonded with low melting metal.

3. A moldable magnetic composition as in claim **1** wherein said alnico magnet alloy is unbonded.

4. A moldable magnetic composition as in claim **1** wherein said metal-bonded, single domain material consists essentially of by weight 25% iron, 12% cobalt, 54% lead, and 5% antimony, with the balance essentially mercury.

5. A permanent magnet comprising a molded body prepared from the material of claim **1**.

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