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Benz

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[54] **SINTERED COBALT-RARE EARTH INTERMETALLIC PRODUCT**

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Related U.S. Application Data

[60] Continuation of Ser. No. 209,372, Dec. 17, 1971, abandoned, which is a division of Ser. No. 33,348, April 30, 1970, Pat. No. 3,655,463.

[52] **U.S. Cl.** **148/31.57;** 148/103; 148/105

[51] **Int. Cl.**[2] **H01F 1/02**

[58] **Field of Search** 148/31.57, 101, 103, 105; 75/84, 200, 152

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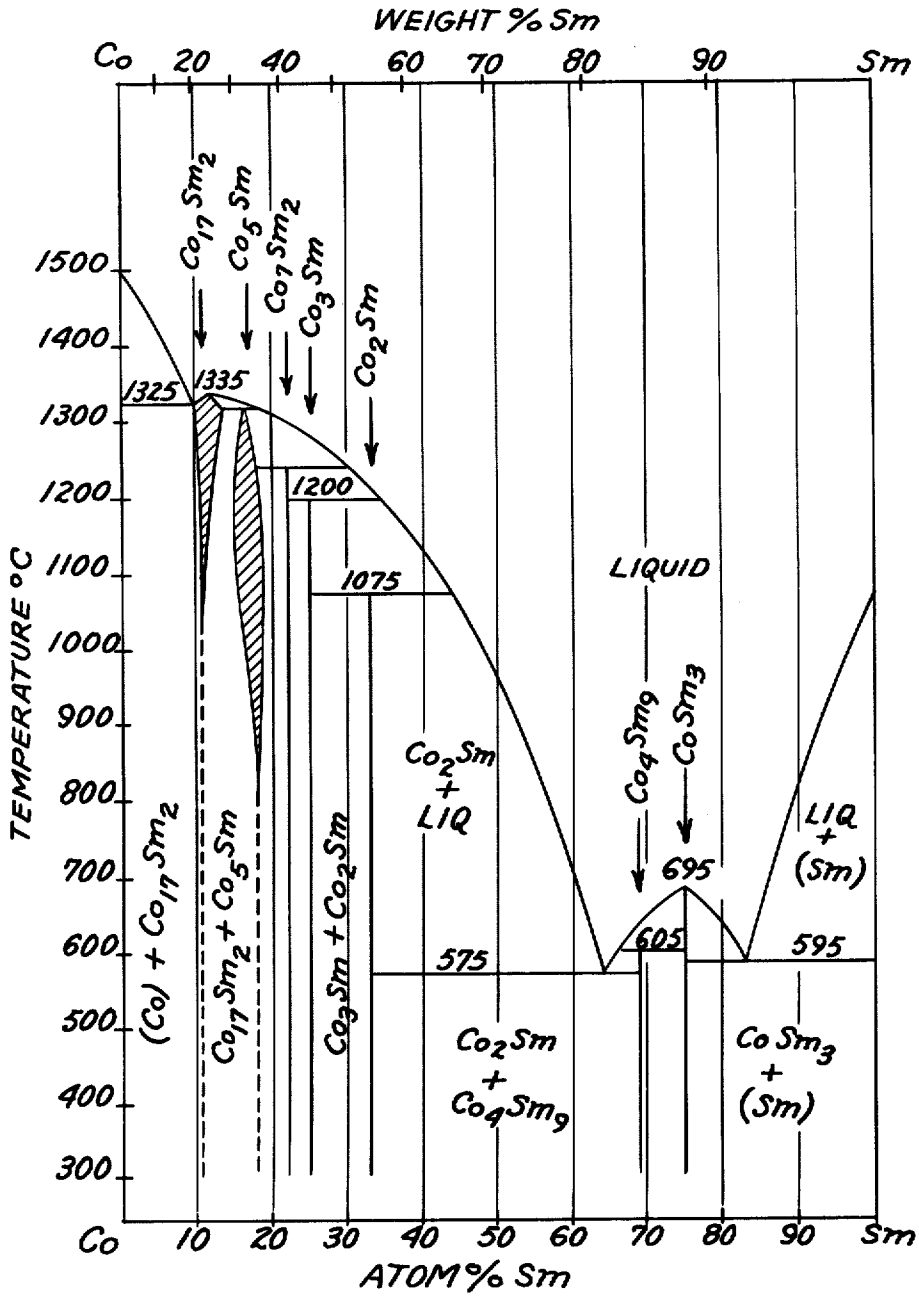
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[57] **ABSTRACT**

A sintered product having substantially stable permanent magnet properties in air at room temperature consisting essentially of compacted particulate cobalt-rare earth alloy consisting essentially of a Co_5R intermetallic phase and a CoR intermetallic phase which is richer in rare earth metal content than the Co_5R phase, where R is a rare earth metal. The Co_5R intermetallic phase is present in an amount of at least 65% by weight of the sintered product and the CoR intermetallic phase which is richer in rare earth metal content than the Co_5R phase is present in a positive amount having a value ranging up to about 35% by weight of the product. The sintered product has a density of at least 87% and has pores which are substantially non-interconnecting and wherein the component grains have an average size less than 30 microns.

1 Claim, 2 Drawing Figures

Fig. 1.


WEIGHT % Sm
Co
20
40
60
70
80
90
Sm
$Co_{17}Sm_2$
Co_5Sm
Co_7Sm_2
Co_3Sm
Co_2Sm
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
1325
1335
1200
1075
LIQUID
Co_4Sm_9
$CoSm_3$
695
605
595
575
Co_2Sm + LIQ
LIQ + (Sm)
Co_2Sm + Co_4Sm_9
$CoSm_3$ + (Sm)
(Co) + $Co_{17}Sm_2$
$Co_{17}Sm_2$ + Co_5Sm
Co_3Sm + Co_2Sm
TEMPERATURE °C
Co
10
20
30
40
50
60
70
80
90
Sm
ATOM % Sm

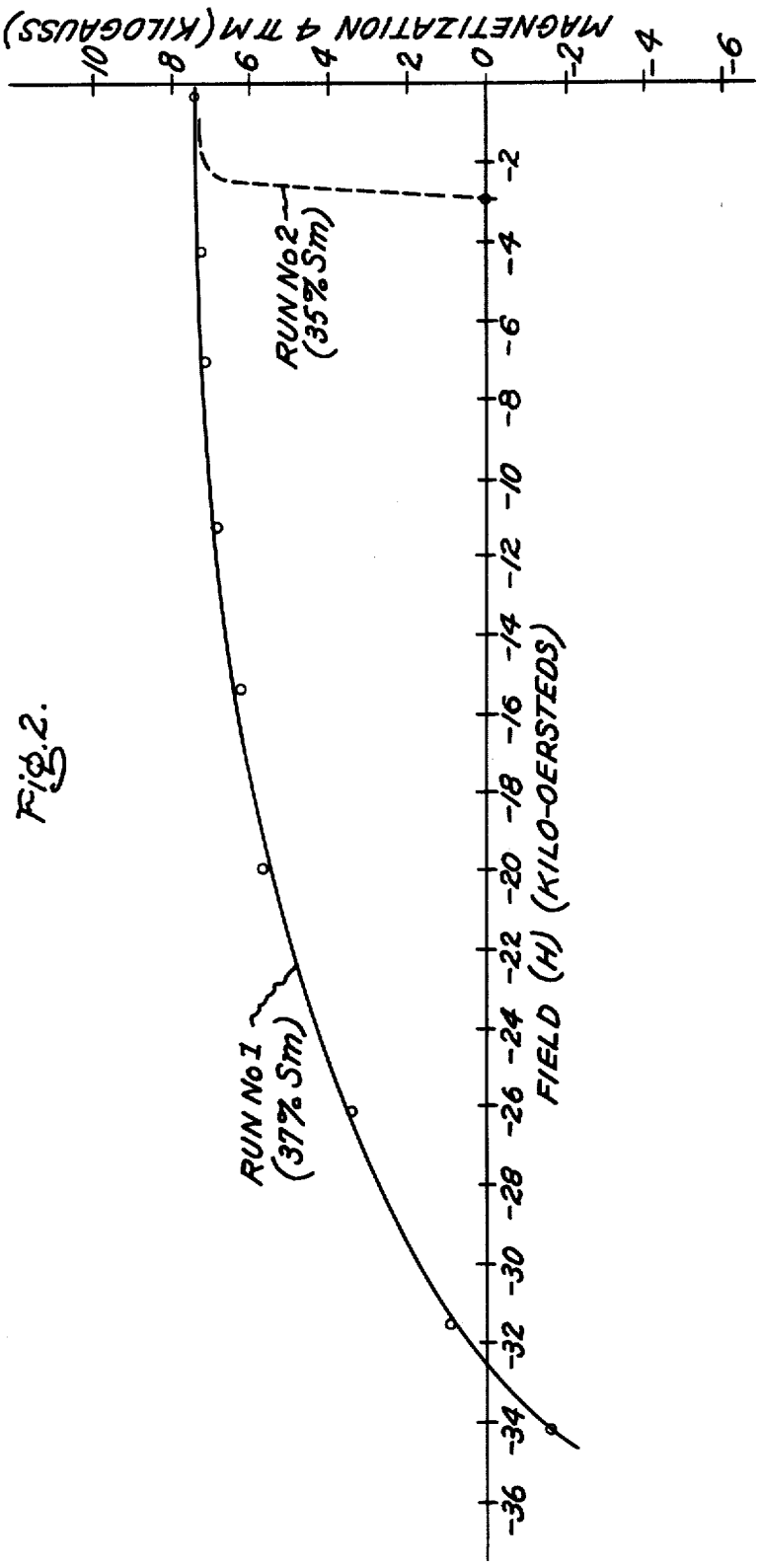

MAGNETIZATION 4 πM (KILOGAUSS)
10
8
6
4
2
0
-2
-4
-6
RUN No 2
(35% Sm)
RUN No 1
(37% Sm)
FIELD (H) (KILO-OERSTEDS)
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
-26
-28
-30
-32
-34
-36

Fig. 2.

SINTERED COBALT-RARE EARTH INTERMETALLIC PRODUCT

This is a continuation, of application Ser. No. 209,372, filed Dec. 17, 1971 now abandoned which is a division of application Ser. No. 33,348, filed Apr. 30, 1970, now U.S. Pat. No. 3,655,463.

The present invention relates generally to the art of permanent magnets and is more particularly concerned with novel sintered cobalt-rare earth intermetallic products having unique characteristics and with a sintering method for producing such products.

Permanent magnets, i.e., "hard" magnetic materials such as the cobalt-rare earth intermetallic compounds, are of technological importance because they can maintain a high, constant magnetic flux in the absence of an exciting magnetic field or electrical current to bring about such a field.

Cobalt-rare earth intermetallic compounds exist in a variety of phases, but the Co_5R intermetallic single phase compounds (in each occurrence R designates a rare earth metal) have exhibited the best magnetic properties. The permanent magnet properties of bulk Co_5R, as well as cobalt-rare earth intermetallic magnetic materials generally, can be enhanced by reducing the bulk bodies of powders, but in such finely-divided form these materials are unstable in air and their magnetic properties deteriorate after a short period of time.

It is an object of the present invention to provide cobalt-rare earth intermetallic magnets which have superior magnetic properties and are stable in air.

Those skilled in the art will gain a further and better understanding of the present invention from the detailed description set forth below, considered in conjunction with the figures accompanying and forming a part of the specification, in which:

FIG. 1 is the cobalt-samarium phase diagram. It is assumed herein, that the phase diagram at 300°C, which is the lowest temperature shown in the figure, is substantially the same at room temperatures.

FIG. 2 is a chart bearing curves which illustrate the effect of samarium content on the magnetic properties of permanent magnets including one produced in accordance with the present invention.

Briefly stated, the process of the present invention comprises the steps of forming a particulate mixture of a base cobalt-rare earth alloy and an additive cobalt-rare earth alloy, compacting the mixture to produce a green body, and sintering the green body to produce an ultimate sintered body containing a major amount of Co_5R and up to 35 percent of other cobalt-rare earth phases richer in rare earth content than Co_5R.

The base alloy is one which is sintering temperature exists as a solid Co_5R in intermetallic single phase where R is a rare earth metal. The additive cobalt-rare earth alloy is richer in rare earth metal than the base alloy and at sintering temperature it is a solid. The base and additive alloys, in particulate form, are each used in an amount to form a mixture which has a cobalt and rare earth metal content substantially corresponding to that of the final desired sintered product.

The mixture is pressed into compacts, preferably in an aligning magnetic field, and sintered to the desired sintered product phase composition and desired density. At sintering temperature, the final sintered product has a composition lying outside the Co_5R single phase region on the rare earth-rich side. Specifically, at sintering temperature, as well as at room temperature,

the final sintered product contains a major amount of the Co_5R solid intermetallic phase and up to about 35 percent by weight of the product of a second CoR intermetallic phase which is richer in rare earth content than Co_5R phase.

The base cobalt-rare earth alloy used in the present process is one which at sintering temperature exists as a Co_5R single intermetallic phase. Since the Co_5R single phase may vary in composition, the base alloy may vary in composition which can be determined from the phase diagram for the particular cobalt-rare earth system, or empirically. For example, FIG. 1 shows that for the cobalt-samarium system, the base alloy at room temperature may vary in samarium content from about 32 to 36 percent by weight since this particular composition is single phase at sintering temperatures ranging from about 950° to 1200°C. Preferably, for simplicity, the base alloy at room temperature is a Co_5R intermetallic phase.

The additive cobalt-rare earth alloy is one which is richer in rare earth metal content than the base alloy, and at sintering temperature it is a solid. It may vary in composition which can be determined from the phase diagram for the particular cobalt-rare earth system or which can be determined empirically. For example, FIG. 1 shows that for the cobalt-samarium system, there is a solid phase containing samarium in an amount greater than about 36

percent by weight at a temperature ranging from 950° to 1200°C, which is a suitable sintering temperature range for Co-Sm in the present process. Specifically, from a temperature of 950° to 1075°C, the solid additive alloy for the cobalt-samarium system ranges in samarium content from about 36 to about 55 percent by weight of the additive, and at temperatures ranging from 950° to 1200°C, the solid additive alloy may range in samarium content from about 36 percent to about 45 percent by weight of the additive. Any additive alloy within these ranges would be a satisfactory additive alloy in the present process. If desired an additive alloy can be determined empirically by a number of methods, such as by means of a composition scan at the sintering temperature, i.e., heating samples of various additive alloy compositions to the desired sintering temperature to determine which is solid at sintering temperatures.

Although suitable additive CoR alloys fall within a general composition range, the preferred ones are comparatively low in rare earth metal content so that undesirable characteristics of the pure rare earth metal in the additive alloy are minimized. Specifically, for example, pure samarium is both pyrophoric and very ductile and consequently difficult to crush and to blend with the base alloy since it has a tendency to separate out and fall to the bottom of the container. However, an additive CoSm alloy of the present invention is substantially non-reactive at room temperature in air, it can be crushed by conventional techniques, and being slightly magnetic, it clings to the base alloy resulting in a substantially thorough stable mixture. The higher the cobalt content of the additive alloy, the stronger are its magnetic properties and the more stable is the particulate mixture it forms with the base alloy.

The rare earth metals useful in forming the present cobalt-rare earth alloys and intermetallic compounds are the 15 elements of the lanthanide series having atomic numbers 57 to 71 inclusive. The element yttrium (atomic number 39) is commonly included in this

group of metals and, in this specification, is considered a rare earth metal. A plurality of rare earth metals can also be used to form the present desired cobalt-rare earth alloys or intermetallic compounds which, for example may be ternary, quartenary or which may contain an even greater number of rare earth metals as desired.

Representative of the cobalt-rare earth alloys useful as base and additive alloys in the present invention are cobalt-cerium, cobalt-praseodymium, cobalt-neodymium, cobalt-promethium, cobalt-samarium, cobalt-europium, cobalt-gadolinium, cobalt-terbium, cobalt-dysprosium, cobalt-holmium, cobalt-erbium, cobalt-thulium, cobalt-ytterbium, cobalt-lutecium, cobalt-yttrium, cobalt-lanthanum and cobalt-misch metal. Cerium misch metal is the most common alloy of the rare earth metals which contains the metals in the approximate ratio in which they occur in their most common naturally occurring ores. Examples of specific ternary alloys include cobalt-samarium-cerium misch metal, cobalt-cerium-praseodymium, cobalt-yttrium-praseodymium, and cobalt-praseodymium-misch metal.

In carrying out the present process, the base and additive cobalt-rare earth alloys can be formed by a number of methods. For example, each can be prepared by arcmelting the cobalt and rare earth metal together in the proper amounts under a substantially inert atmosphere such as argon and allowing the melt to solidify. Preferably, the melt is cast into an ingot.

The solid base and additive alloys can be converted to particulate form in a conventional manner. Such conversion can be carried out in air at room temperature since the alloys are substantially non-reactive. For example, each alloy can be crushed by mortar and pestle and then pulverized to a finer form by jet milling.

The particle size of the base and additive cobalt-rare earth alloys used in forming the mixture of the present process may vary. Each can be in as finely divided a form as desired. For most applications, average particle size will range from about 1 micron or less to about 10 microns. Larger sized particles can be used, but as the particle size is increased, the maximum coercive force obtainable is lower because the coercive force generally varies inversely with particle size. In addition, the smaller the particle size, the lower is the sintering temperature which may be used.

In forming the mixture in the present process, the base and additive alloys are each used in an amount so that the resulting mixture has a cobalt and rare earth metal content substantially corresponding to that of the final desired sintered product phase composition. In addition, however, in forming the mixture, the alloy additive should be used in an amount sufficient to promote sintering. This amount depends largely on the specific composition of the alloy additive and can be determined empirically, but generally, the additive alloy should be used in an amount of at least 0.5 percent by weight of the base-additive alloy mixture. Specifically, the larger the rare earth metal component of the additive alloy, the less is the amount of the additive alloy which need be used.

In the present invention, at sintering temperature, the final sintered product should have a phase composition lying outside the Co_5R single phase on the rare earth-rich side. Magnetization of such a product results in a permanent magnet with superior magnetic properties. On the other hand, if a final sintered product at sintering or room temperatures consists only of a single co_5R intermetallic phase, or if it contains a second cobalt-rare earth intermetallic phase of lesser rare earth content than the co_5R phase, a permanent magnet of only inferior magnetic properties can be produced no matter how the magnetization step is carried out.

Specifically, in the present invention at sintering temperature, as well as at room temperatures, the final sintered product contains a major amount of the Co_5R solid intermetallic phase, generally at least about 65 present by weight of the product, and up to about 35 percent by weight of the product of a second solid CoR intermetallic phase which is richer in rare earth metal content than the Co_5R phase. Traces of other cobalt-rare earth intermetallic phases, in most instances less than one percent by weight of the product, may also be present. Sintered products having the highest energy products are those having the smallest content of the second CoR phase. The preferred final sintered product, therefore, is comprised predominantly of the Co_5R intermetallic phase, i.e., about 95 percent by weight or higher but less than 100 percent, with only a detectable content of the second CoR phase, i.e., 5 percent or lower by weight of the product. If desired, for a particular cobalt-rare earth metal system of the present invention, a composition scan, i.e., a series of runs at the same sintering temperature with proportionately varying mixtures of base and additive alloys, may be made to determine the specific sintered product composition which produces the best magnetic properties. Determination of the second CoR phase can be made by a number of techniques, such as for example, x-ray diffraction as well as standard metallographic analysis. As the content of the Co_5R intermetallic single phase is decreased in the present sintered product, the magnetic properties obtainable decrease correspondingly. Furthermore, when the content of the Co_5R intermetallic phase is below about 65 percent by weight of the present sintered product, its permanent magnet properties are sharply reduced.

In carrying out the process of this invention, the base alloy is admixed with the additive alloy in any suitable manner to produce a substantially thorough particulate mixture. The particulate mixture can then be compressed into a green body of the desired size and density by any of a number of techniques such as hydrostatic pressing or methods employing steel dies. Preferably, the mixture is compressed in the presence of an aligning magnetizing field to magnetically align the particles along their easy axis, or if desired, the mixture may be compressed after magnetically aligning the particles. The greater the magnetic alignment of the particles, the better are the resulting magnetic properties. Preferably also, compression is carried out to produce a green body with as high a density as possible, since the higher its density, the greater the sintering rate. Green bodies having a density of about forty percent of theoretical or higher are preferred.

The green body is sintered to produce a sintered body of desired density. Preferably, the green body is sintered to produce a sintered body wherein the pores are substantially non-interconnecting. Such non-interconnectivity stabilizes the permanent magnet properties of the product because the interior of the sintered product or magnet is protected against exposure to the ambient atmosphere.

The sintering temperature used in the present process depends largely on the particular cobalt-rare earth

mixture to be sintered, and to a lesser degree, on particle size. The minimum sintering temperature must be sufficiently high for sintering to occur in a particular cobalt-rare earth system, i.e., it must be high enough to coalesce the component particles. Preferably, sintering is carried out so that the pores in the sintered product are substantially non-interconnecting. The particles do not melt but undergo solid state diffusion, i.e., the motion of the atoms is sufficient at sintering temperatures so that diffusion occurs and the particles coalesce to the desired density. A sintered body having a density or packing of at least about 87 percent of theoretical is generally one wherein the pores are substantially non-interconnecting. Such non-interconnectivity is determinable by standard metallographic techniques, as for example, by means of transmission electron micrographs of a cross-section of the sintered product. The maximum sintering temperature is preferably one at which significant growth of the component particles or grains does not occur, since too large an increase in grain size deteriorates magnetic properties such as coercive force. The green body is sintered in a substantially inert atmosphere such as argon, and upon completion of the sintering, it is preferably cooled to room temperatures in a substantially inert atmosphere.

The particular sintering temperature range can be determined empirically, as for example, carrying out a series of runs at successively higher sintering temperatures and then determining the magnetic properties of the sintered products. For the cobalt-samarium alloy mixture of the present invention, a sintering temperature ranging from about 950°C up to about 1200°C is suitable with a sintering temperature of 1100°C being particularly satisfactory.

The density of the sintered product may vary. The particular density depends largely on the particular permanent magnet properties desired. Preferably, to obtain a product with substantially stable permanent magnet properties, the density of the sintered product should be one wherein the pores are substantially non-interconnecting and this occurs usually at a density or packing of about 87 percent. Generally, for a number of applications, the density may range from about 80 percent to 100 percent. For example, for low temperature applications, a sintered body having a density ranging down to about 80 percent may be satisfactory. The preferred density of the sintered product is one which is the highest obtainable without producing a growth in grain size which would deteriorate magnetic properties significantly, since the higher the density the better are the magnetic properties. For cobalt-samarium sintered products of the present invention, a density of at least about 87 percent of theoretical, i.e., of full density, and as high as about 96 percent of theoretical is preferred to produce permanent magnets with suitable magnetic properties which are substantially stable.

Standard metallographic examination, as for example, under a light microscope or an x-ray microprobe, of a polished cross-section of the sintered product of the present invention shows that its grains differ significantly in appearance from the original particles used in forming the green body. Specifically, the original particles have an angular rough surface structure. In contrast, substantially all of the grains of the present sintered product are rounded and have a smooth surface. The pores of the sintered product are preferably substantially non-interconnecting. Generally, for the sintered product to have good magnetic properties, the component grains of the bulk product should preferably not have an average size larger than about 30 microns.

The sintered product of the present invention is useful as a permanent magnet. Its permanent magnet properties can be significantly enhanced, however by subjecting it to a magnetizing field. The resulting permanent magnet is substantially stable in air and has a wide variety of uses. For example, the permanent magnets of the present invention are useful in telephones, electric clocks, radios, television, and phonographs. They are also useful in portable applicances, such as electric toothbrushes and electric knives, and to operate automobile accessories. In industrial equipment, the present permanent magnets can be used in such diverse applications as meters and instruments, magnetic separators, computers and microwave devices.

If desired, the sintered bulk product of the present invention can be crushed to a desired particle size preferably a powder, which is particularly suitable for alignment and matrix bonding to give a stable permanent magnet. The matrix material may vary widely and may be plastic, rubber or metal such as, for example, lead, tin, zinc, copper or aluminum. The powder-containing matrix can be cast, pressed or extruded to form the desired permanent magnet.

All parts and percentages used herein are by weight unless otherwise noted.

The invention is further illustrated by the following examples in which, unless otherwise noted, the conditions and procedure were as follows:

The aligning magnetizing field was used to magnetically align along th easy axis.

The sintering furnace was a ceramic tube.

All sintering was carried out in an inert atmosphere of purified argon and upon completion of the sintering, the sintered product was cooled in the same purified argon atmosphere.

Particle size was determined by a standard metallographic method.

The density of the green body as well as the sintered product is given as packing. Packing is the relative density of the material, i.e., it is a percent of theoretical. Packing was determined by a standard method using the following equation:

$$\frac{\frac{\text{Weight}}{\text{Volume}}}{8.5\ \text{g/cc.}} \times 100 = \%\ \text{Packing}$$

where 8.5g/cc. is the density of Co_5Sm.

The intrinsic coercive force H_{ci} or ${}_mH_c$ is the field strength at which the magnetization (B-H) or $4\pi M$ is zero.

Normal coercive force H_c is the field strength at which the induction B becomes zero.

The maximum energy product $(BH)_{max}$ represents the maximum product of the magnetic field H and the induction B determined on the demagnetization curve.

cl EXAMPLE 1

In this example the magnetic properties of sintered products formed from three different cobalt-samarium mixtures were determined.

A base alloy melt and an additive alloy melt of cobalt-samarium were made under purified argon by arc-

melting and cast into ingots. The base alloy was formed from 33.3 weight % samarium and 66.7 weight % cobalt. The additive alloy was formed from 38.6 weight % samarium and 61.4 weight % of cobalt. Each ingot was initially crushed by means of mortar and pestle and then reduced by fluid energy "jet" milling to a powder ranging in size from approximately one to about 10 microns in diameter and having an average particle size of about 6 microns in diameter.

Portions of the particulate base and additive alloys were admixed by tumbling to prepare two mixtures. Specifically, for Run No. 1, 4.23 grams of the base alloy were admixed with 9.77 grams of the additive alloy to form a mixture composed of 63% by weight cobalt and 37% by weight samarium. For Run No. 2, 9.51 grams of the base alloy were admixed with 4.49 grams of the additive alloy to form a mixture composed of 65% by weight cobalt and 35% by weight samarium. Since the additive alloy as well as the base alloy were substantially non-reactive in air and magnetic, both mixtures were stable. Standard wet chemical analysis of a portion of the mixture of Run No. 1 showed a content of $37 \pm 0.3\%$ samarium and the same analysis of Run No. 2 showed a content of $35 \pm 0.3\%$ samarium.

A bar was formed from each mixture. Specifically, a portion of each mixture was weighed, placed in a rubber tube and magnetically aligned therein by means of an aligning magnetizing field of 60 kilo-oersteds provided by a superconducting coil. After magnetic alignment, the tube was evacuated to freeze the alignment and then it was pressed hydrostatically under a pressure of 200 K psi to form a green body in the shape of a bar.

For Run No. 3, 13.95 grams of the base alloy powder were admixed with 0.41 grams of an alloy powder formed from 77% by weight cobalt and 23% by weight samarium to form a mixture of 67% by weight cobalt and 33% by weight samarium. The alloy powder was the same size and was prepared in the same manner as the base alloy powder. A portion of this mixture was formed into a green body in the same manner as in Runs No. 1 and 2 except that an aligning magnetizing field of 100 kilo-gersteds was used.

Each green body was then sintered and its properties determined after sintering. After magnetization at room temperatures in a field of 100 kilo-oersteds, the magnetic properties of each sintered product were determined. Table I tabulates the specific procedure used for each run.

TABLE I

Run No.	Composition Co Wt.%	Composition Sm Wt.%	Compaction Pressures (K psi)	Green Body Wt. (gms)	Green Body Size(inches) Diam.	Green Body Size(inches) Length	Green Body Packing (%)	Sintering Method Time Hrs.	Sintering Method Temp. (°C)	Sintered Product Wt. (gms)	Sintered Product Size(inches) Diam.	Sintered Product Size(inches) Length	Sintered Product Packing (%)	Magnetic Properties of Sintered Product After Magnetization: Max. Energy Prod. $(BH)_{max}$ (10^6 gauss × oersteds)	Magnetic Properties of Sintered Product After Magnetization: Intrinsic Coercive Force $_mH_c$ (k oersteds)
1	63	37	200	10.06	.299	1.266	80	1/2	1100	10.05	.290	1.212	89	13.3	−32.5
2	65	35	200	10.17	.300	1.275	80	1/2	1100	10.16	.296	1.256	83.4	11	−2.8
3	67	33	200	Did not measure			81 (estimate)	1/2	1100	6.73	.265	1.055	83	6	−1.7

Run No. 1 of Table I illustrates the present invention and shows the significantly better magnetic properties produced by the present process. Specifically, Run Nos. 1 and 2 of Table I show that sintering of the green body produces a sintered product which weighs the same as the green body indicating no loss in the cobalt and samarium components. A comparison of the composition of Run No. 1 with those of Run Nos. 2 and 3 shows the criticality of sintering a cobalt-samarium mixture having a composition falling outside that covered by the single Co_5Sm intermetallic phase on the rare earth richer side.

The sintered bars of Run Nos. 1 and 2 were demagnetized using the specific magnetizing fields shown in FIG. 2 and their magnetization $4\pi M$ in such field was determined.

In FIG. 2, the abscissa of the graph is the magnetic field (H) in kilo-oersteds and the ordinate is magnetization $4\pi M$ in kilo-gauss. From the demagnetization curves of FIG. 2, it can be seen that the product of Run No. 1 containing 37% by weight samarium has the best magnetic properties. This is particularly illustrated by its high intrinsic coercive force. As can be seen from the phase diagram of FIG. 1, this product at the sintering temperature of 1100°C as well as at room temperature is comprised of a major amount of the Co_5Sm single intermetallic phase, i.e., about 95% by weight of the product, and a minor amount of the Co_7Sm_2 phase, i.e., about 5% by weight of the product.

FIG. 2 shows poor magnetic properties for the sintered product of Run No. 2 composed of 65% cobalt and 35% by weight samarium which according to FIG. 1 is the composition for a single Co_5Sm intermetallic phase.

The sintered product of each run of Table I was examined by standard metallographic analysis. Examination of a polished cross-section of each product was made under an x-ray microprobe and a light microscope and micrographs were made. In Run No. 1, the pores of the sintered product were substantially non-interconnecting which is the characteristic that maintains its permanent magnet properties stable. The Run No. 1 sintered product was composed of two phases, a major amount of one phase and a minor amount of a second phase with traces of a few other phases. Substantially all of the grains of this sintered product were rounded and had a smooth surface with the average grain size being about 7 microns. Standard wet chemical analysis of the product of Run No. 1 showed it to contain 37% by weight samarium. In Run Nos. 2 and 3, each sintered product was composed of only a single intermetallic phase and each had some interconnection of the pores. Standard wet chemical analysis of the product Run No. 3 showed it to contain 33% by weight samarium.

EXAMPLE 2

After five months in air at room temperature the intrinsic coercive force of the sintered product of Run No. 1 of Example 1 was determined and found to be unchanged. This illustrates the highly stable properties of the permanent magnets of the present invention.

All of the following cited copending patent applications are, by reference, made part of the disclosure of the present application.

In copending U.S. Pat. application Ser. No. 33,347, now U.S. Pat. No. 3,655,464 entitled "Liquid Sintered Cobalt-Rare Earth Intermetallic Product" filed of even date herewith in the name of Mark G. Benz and assigned to the assignee hereof, there is disclosed a process for preparing novel sintered cobalt-rare earth intermetallic products by forming a particulate mixture of a base cobalt-rare earth alloy, which at sintering temperature exists as a solid Co_5R intermetallic single phase, and an additive cobalt-rare earth alloy, which at sintering temperature is at least partly liquid, compacting the mixture to produce a green body and sintering the green body to produce a sintered product containing a major amount of Co_5R phase and up to about 35% by weight of the product of a second solid CoR intermetallic phase which is richer in rare earth metal content than the Co_5R phase.

In U.S. Pat. No. 3,684,593 which is a Continuation-in-part of copending U.S. Pat. application Ser. No. 33,315, now abandoned, entitled "Heat-Aged Sintered Cobalt-Rare Earth Intermetallic Product and Process", filed of even date herewith in the names of Mark G. Benz and Donald L. Martin and assigned to the assignee hereof, there is disclosed a process for preparing heat-aged novel sintered cobalt-rare earth intermetallic products by providing a sintered cobalt-rare earth intermetallic product composed of Co_5R intermetallic phase or a major amount of Co_5R intermetallic phase, and heat-aging said product to precipitate out of the Co_5R phase a CoR phase richer in rare earth metal content than the Co_5R phase in an amount sufficient to increase either its intrinsic coercive force H_{ci} and/or normal coercive force H_c by at least 10 percent.

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

1. A sintered product having significantly enhanced permanent magnet properties which are substantially stable in air at room temperature consisting essentially of compacted particulate cobalt-rare earth alloy consisting essentially of a Co_5R intermetallic phase and a CoR intermetallic phase which is richer in rare earth metal content than said Co_5R phase, said Co_5R intermetallic phase being present in an amount of at least 65% by weight of said sintered product and said CoR intermetallic phase which is richer in rare earth content than said Co_5R phase being present in a positive amount having a value ranging up to 35% by weight of said product, where R is a rare earth metal or metals, said sintered product having a density of at least 87 percent of theoretical and having pores which are substantially non-interconnecting and the component grains have an average size less than 30 microns, said sintered product being produced by admixing particles of a base cobalt-rare earth metal alloy and an additive cobalt-rare earth metal alloy, said particles having an average size ranging up to about 10 microns, said base alloy existing at sintering temperature as a solid Co_5R intermetallic phase and said additive alloy being a solid at sintering temperature and being richer in rare earth metal content than said base alloy, said base alloy and said additive alloy each being used to form a mixture which has a cobalt and rare earth metal content substantially corresponding to that of the final sintered product with said additive alloy being present in an amount of at least 0.5 percent by weight of said mixture, pressing said mixture into a green body, and sintering said green body in a substantially inert atmosphere to produce said sintered product.

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