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[54] **FLEXIBLE COBALT-RARE EARTH PERMANENT MAGNET PRODUCT AND METHOD FOR MAKING SAID PRODUCT**

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[63] Continuation-in-part of Ser. No. 410,621, Oct. 29, 1973, abandoned.

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[58] **Field of Search** 148/103, 102, 108, 31.57; 117/234; 264/DIG. 58, 104; 335/297; 427/126, 127, 132

[56] **References Cited**

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[57] **ABSTRACT**

A flexible cobalt-rare earth alloy permanent magnet product comprised of a non-magnetic flexible substrate having bonded to a single side thereof a number of sintered cobalt-rare earth alloy magnetic members substantially in juxtaposition wherein each member has its easy axis of magnetization aligned in a certain direction. For example, each bonded member has its easy axis aligned perpendicular to the plane of the substrate and is magnetized along its easy axis resulting in the magnetic flux being concentrated at the bonded surface as well as the outside surface opposite the bonded surface. The bonded members have a size which allows each one foot length of the resulting product to be flexed through its thin dimension through an arc of at least 45° without rupture.

8 Claims, 2 Drawing Figures

Fig. 1.

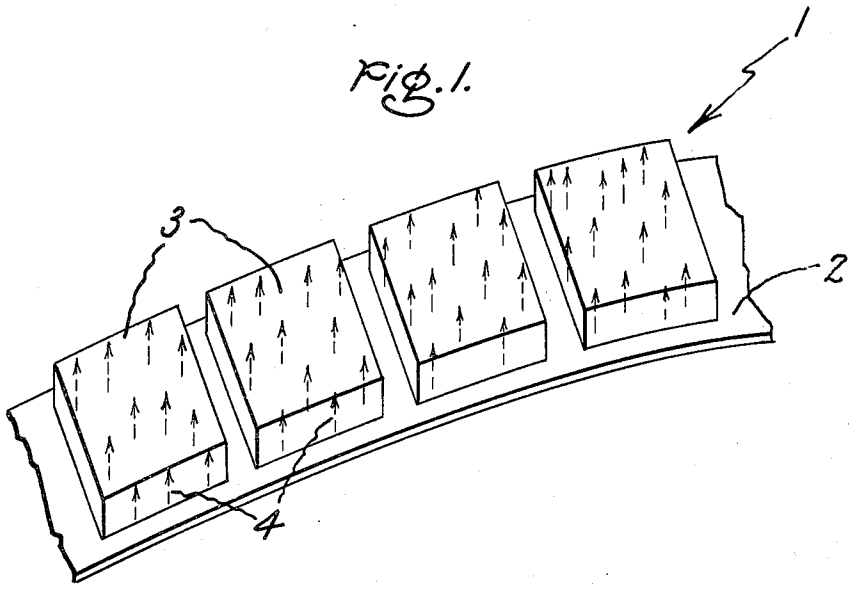
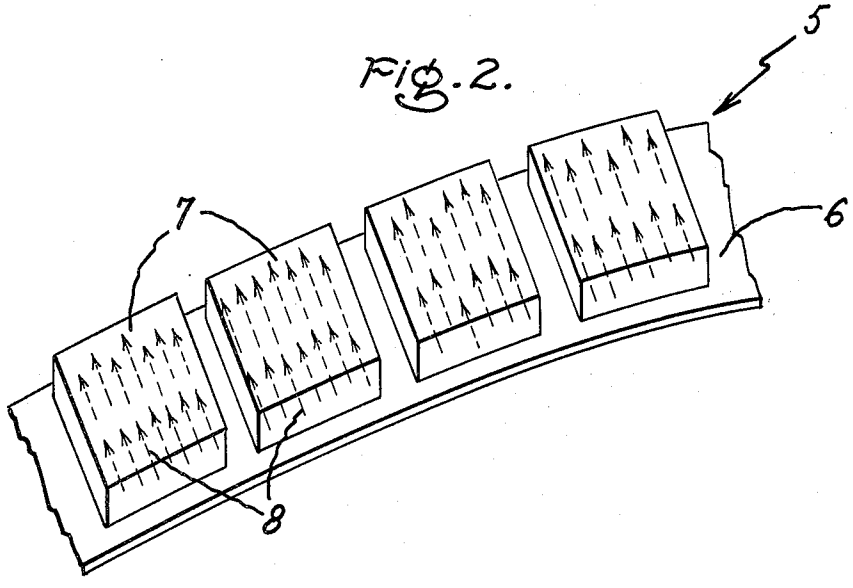


Fig. 2.



FLEXIBLE COBALT-RARE EARTH PERMANENT MAGNET PRODUCT AND METHOD FOR MAKING SAID PRODUCT

This is a continuation-in-part of copending application Ser. No. 410,621 filed Oct. 29, 1973 in the name of Mark G. Benz and now abandoned.

The present invention relates generally to the art of making permanent magnets and is more particularly concerned with flexible cobalt-rare earth permanent magnet products.

Within the past few years a new class of materials for making permanent magnets has been developed based on cobalt and rare-earth elements. The improvement over prior art materials is so great that the cobalt-rare-earth magnets stand in a class by themselves. In terms of their resistance to demagnetizaton the new materials are from 20 to 50 times superior to conventional magnets of the Alnico type, and their magnetic energy is from 2 to 6 times greater. Since the more powerful the magnet for a given size is the smaller it can be for a given job, the cobalt-rare-earth magnets have applications for which prior art materials cannot even be considered.

Permanent magnets, i.e., "hard" magnetic materials such as the cobalt-rare earth alloys, 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.

The present invention is directed to producing a novel flexible cobalt-rare earth permanent magnet product, particularly a product in the form of a tape or strip. Specifically, the present product is comprised of a plurality of sintered cobalt-rare earth alloy thin magnetic members bonded substantially in juxtaposition to the same side of a flexible non-magnetic substrate with the easy axis of magnetization of each bonded member aligned in a certain direction.

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 illustrates one embodiment of the present flexible permanent magnet product showing a number of magnetic members substantially in juxtaposition with the easy axis of magnetization of each bonded magnetic member aligned perpendicular to the plane of the substrate and magnetized along the easy axis resulting in the magnetic flux being concentrated at the bonded surface as well as the outside surface opposite the bonded surface of each member.

FIG. 2 illustrates another embodiment of the present invention which shows the easy axis of magnetization of each bonded magnetic member aligned in a direction parallel to the plane of the substrate and perpendicular to the transverse surfaces of each member so that, when magnetized, the magnetic flux is concentrated at the transverse surfaces.

Briefly stated, the process of the present invention comprises providing a layer of cobalt-rare earth alloy particles having permanent magnet properties, applying a magnetic field to the layer of particles to align them along their easy axis of magnetization in a direction perpendicular to the longitudinal surfaces of the layer, compacting the particles in their aligned position

to form a number of thin members, sintering each member to produce a sintered member having a density of at least 87% of theoretical, bonding one side of each sintered member to the same side of a non-magnetic flexible substrate, said member being bonded so that its aligned easy axis of magnetization is perpendicular to the substrate, said members being bonded substantially in juxtaposition, and said bonded members having a size which allows each one foot length of the resulting product to be flexed longitudinally through an arc of at least 45° without rupture. A magnetizing field is applied parallel to the easy axis of magnetization of each sintered member either before or after bonding, as desired, resulting in the magnetic flux of each magnetized bonded member being concentrated at the bonded surface and the outside surface opposite the bonded surface. This embodiment is illustrated by FIG. 1 which shows the flexible permanent magnet product **1** comprised of flexible non-magnetic substrate **2** having bonded to one side thereof magnetic members **3** with their easy axis of magnetization **4** perpendicular to the plane of substrate **2**. This particular embodiment is particularly useful in applications requiring magnets in the form of a ring or arc to provide a radial type of flux or magnetic energy.

In an alternate embodiment of the present invention the procedure is substantially the same except a magnetic field is applied to a layer of the alloy particles to align them along their easy axis of magnetization in a direction perpendicular to the transverse surfaces of the layer, and the sintered member formed therefrom is bonded to the substrate so that its aligned easy axis is parallel to the plane of the surface of the substrate and directed across the width thereof. When this product is magnetized, i.e., after a magnetizing field is applied parallel to the easy axis of magnetization, the magnetic flux of each bonded member is concentrated at its transverse surfaces, i.e. at opposing edges of transverse surfaces of the resulting product. This embodiment is illustrated by FIG. 2 where flexible permanent magnet product **5** is comprised of flexible non-magnetic substrate **6** which has bonded to one side thereof magnetic members **7** having their easy axis of magnetization **8** aligned parallel to the plane of substrate **6** and directed across the width of the substrate to concentrate magnetic energy or flux at opposing transverse sections of bonded members **7**.

Alternatively, the present process can be carried out by forming a layer of the cobalt-rare earth alloy particles applying a magnetic field to the layer to align the particles along their easy axis of magnetization in a direction perpendicular to the longitudinal surfaces of the layer or perpendicular to the transverse surfaces of the layer, compacting the particles in their magnetically aligned position to form an elongated thin green member, sintering the member, bonding a longitudinal surface of the elongated sintered member to the substrate, scribing spaced parallel lines across the width of the outside longitudinal surface of the bonded elongated member, and cracking the bonded member along the scribed lines to produce a plurality of bonded members having a size which allows each one foot length of the resulting product to be flexed longitudinally through an arc of 45° without rupture. In yet another embodiment, additional spaced parallel lines are scribed along the length of the elongated sintered member to form a grid, i.e. screen configuration, and the elongated bonded member is cracked along the grid

lines to produce a plurality of bonded members having a size which allows each one foot length of the resulting product to be flexed longitudinally through an arc of 45° without rupture and also which allows each 2 inch width of the product to be bent laterally in at least a single direction through an arc of 45° without rupture, i.e., the product is flexible longitudinally and laterally.

The present flexible cobalt-rare earth permanent magnet product has a number of applications. It provides a practical and economical method of providing magnets of complex geometries, or high flux or both. Specifically, to produce a sintered magnet of large size and of particular geometry is time-consuming and costly. The present product, however, can be cut to the desired size and geometry, as well as be flexed to the desired geometry, and when desired, a number of layers of the present product be used in juxtaposition, for example, to provide the particular magnetic energy or flux required. For example, a plurality of layers of the present product in juxtaposition could readily be used in a variety of motors. Also, the present product is useful in magnetrons where it can be flexed to direct the magnetization factor inward.

Cobalt-rare earth intermetallic compounds or alloys exist in a variety of phases, but the Co_5R single phase alloys (in each occurrence R designates a rare earth metal) have exhibited the best magnetic properties, and generally, the present sintered products contain the Co_5R phase in at least a significant amount.

In forming the alloy in the present process, the cobalt and rare earth metal are each used in amounts substantially corresponding to those desired in the final sintered product. The alloy can be formed by a number of methods. For example, it can be prepared by arc-melting 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.

The alloy can be converted to particulate form in a conventional manner. For example, the alloy can be crushed by mortar and pestle and then pulverized to a finer form by jet milling.

The particle size of the cobalt-rare earth alloy of the present process may vary. It 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 carrying out the present process, a layer of the cobalt-rare earth alloy particles is formed and an aligning magnetizing field is applied preferably at room temperature, to the layer of particles to align them substantially along their preferred axis of magnetization which is the "C" or easy axis of magnetization. Specifically, during this alignment, the aligning magnetizing field is used to orient the particles in a direction which is either perpendicular to the longitudinal surfaces of the layer or perpendicular to the transverse surfaces of the layer depending upon the particular surfaces of the sintered magnetic member formed therefrom at which the concentration of magnetic flux or energy is desired. At least a portion of the layer is then compressed with the particles in their aligned position to form a thin green member of desired size, i.e., one which when sintered to a density of at least 87% produces a sintered member of desired size. Preferably, compression is carried out while the particles are still subject to the aligning magnetizing field which generally ranges from about 10 kiloersteds to about 100 kiloersteds, to produce satisfactory alignment.

The particulate alloy can be compressed into a green thin member of the desired size and density by a number of conventional techniques such as hydrostatic pressing or methods employing steel dies. Green members having a density of about 40 percent or higher of theoretical are preferred.

The green member of compacted magnetically aligned particles is sintered in a substantially inert atmosphere to produce a sintered member wherein the pores are substantially non-interconnecting, which generally is a sintered member having a density of at least about 87 percent of theoretical. Such non-interconnectivity stabilizes the permanent magnet properties of the product because the interior of the sintered member is protected against exposure to the ambient atmosphere.

Sintering temperature depends largely on the particular cobalt-rare earth alloy to be sintered. For most cobalt-rare earth alloys, a sintering temperature ranging from about 950° to about 1200°C is suitable. For example, for cobalt-samarium alloys a sintering temperature of 1100°C is particularly satisfactory.

The density of the sintered product may vary. The particular density depends largely on the particular permanent magnet properties desired. In the present invention, the density of the sintered member ranges from about 87 percent to 100 percent of theoretical.

Specifically, the sintered cobalt-rare earth alloy member of the present process may be prepared by a number of techniques. Those techniques which are particularly useful in the present invention are disclosed in U.S. Pat. Nos. 3,655,464; 3,655,463; and 3,695,945, all filed in the name of Mark G. Benz, and assigned to the assignee hereof, and all of which by reference are made part of the disclosure of the present application.

Each of the aforementioned patents discloses a process for preparing novel sintered cobalt-rare earth intermetallic products which can be magnetized to form permanent magnets having stable improved magnetic properties.

Briefly stated, in U.S. Pat. No. 3,655,464, a body of a compacted particulate mixture of a base CoR alloy and an additive CoR alloy, where R is a rare earth metal or metals is sintered to produce a product having a composition lying outside the Co_5R single phase on the rare earth richer side. Specifically, the base alloy is one which at sintering temperature exists as a solid Co_5R intermetallic single 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. The additive cobalt-rare earth alloy is richer in rare earth metal than the base alloy and at sintering temperature it is at least partly in liquid form and thus increases the sintering rate. The additive alloy may vary in composition and can be determined from the phase diagram for the particular cobalt-rare earth system or it can be determined empirically. 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 since sintering causes little or no loss of these components.

The additive alloy should be used in an amount sufficient to promote sintering, and generally, should be used in an amount of at least 0.5 percent by weight of the base-additive alloy mixture.

The procedure for forming sintered products disclosed in U.S. Pat. No. 3,655,463 is substantially the same as that disclosed in U.S. Pat. No. 3,655,464 except that an additive CoR alloy which is solid at sintering temperature and which is richer in rare earth metal than the base alloy is used.

The procedure for forming the sintered products disclosed in U.S. Pat. No. 3,695,945 is substantially the same as that disclosed in U.S. Pat. No. 3,655,464 except that a cobalt-rare earth metal alloy of proper composition is initially formed.

Preferably, in the present process, the sintered members contain a major amount of the Co_5R solid intermetallic phase, generally at least about 70 percent by weight of the sintered member, and a second solid CoR intermetallic phase which is richer in rare earth metal content than the Co_5R phase and which is present in an amount of up to about 30 percent by weight of the sintered member. Traces of other cobalt-rare earth intermetallic phases, in most instances less than 1 percent by weight of the product, may also be present.

In addition, in U.S. Pat. No. 3,684,593, which by reference is made part of the present application, 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 ranging in composition from a single solid Co_5R phase to that composed of Co_5R phase and a second phase of solid CoR in an amount of up to about 30 percent by weight of the product and richer in rare earth metal content than said Co_5R, and heat-aging said product at an aging temperature within 400°C below the temperature at which it was sintered to precipitate CoR phase richer in rare earth metal content than said Co_5R in an amount sufficient to increase intrinsic and/or normal coercive force of said product by at least 10 percent, where R is a rare earth metal or metals. Heat-aging is carried out in an atmosphere such as argon in which the material is substantially inert. The precipitated CoR phase is generally present in an amount ranging from about 1 to 15 percent by weight of the product. These heat-aged sintered products are particularly useful in the present invention.

The rare earth metals useful in preparing the cobalt-rare earth alloys and intermetallic compounds used in forming the sintered members 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 compound which, for example may be ternary, quartenary or which may contain an even greater number of rare earth metals is desired.

Representative of the cobalt-rare earth alloys useful in forming the sintered products 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-mischmetal. Mischmetal 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-mischmetal, cobalt-cerium-praseodymium, cobalt-yttrium-praseodymium, and cobalt-praseodymium-mischmetal.

In carrying out the present process, one side of the sintered member is bonded to one side of the substrate. Bonding can be carried out by a number of conventional techniques. Where a bonding medium is used, it must be non-magnetic and have no significant deteriorating effect on the substrate or the sintered member. Typical bonding media include epoxy resin glues and metallic solders. In some instances, particularly when a plastic substrate is used, a portion of the substrate can be softened and one side of the sintered member can be embedded in the softened portion which upon hardening result in a satisfactory bond with the sintered member.

The substrate used herein is generally in the form of a tape or strip and its particular dimensions depend on the particular application of the product. For most applications, as a protective measure, due to the brittleness of the sintered member, the substrate is usually at least as wide as the sintered member. The substrate must be non-magnetic and flexible. By flexible it is meant that each one foot length of the substrate can be flexed or bent in its thin dimension, i.e. longitudinally, through an arc of at least 45° without rupturing. Representative of the substrate materials useful in the present invention are non-magnetic metals such as aluminum and steel, plastics and rubbers.

The bonded magnetic members must have a size which allows each one foot length of the resulting flexible cobalt-rare earth permanent magnet product to be flexed or bent longitudinally in at least a single direction through an arc of 45° without rupture. By the term flexing or bending the product without rupture, it is meant herein without rupture of the substrate as well as the sintered members bonded thereto. The particular size and shape of the bonded sintered members can vary depending on the particular properties desired. For most applications requiring magnetic flexible strips or tapes, the bonded sintered members which are square or rectangular in size have a final size wherein the width ranges from about 1/32 inch to 6 inches, a thickness ranging from about 0.01 inch to 0.5 inch and a length ranging from about 1/32 inch to 2 inches.

The sintered member is bonded to the substrate in a manner which depends on where the concentration of magnetic flux or energy is desired. The sintered members are bonded preferably in contact with each other so as to attain a maximum number bonded per unit volume of the product. The distance between bonded members is critical only to the extent that it diminishes the magnetic flux or energy available per unit volume of the resulting product. For best results, the bonded members should be separated only to the extent necessary to attain the flexibility or bendability required of the final product for a particular use. A magnetizing field is applied to the sintered member parallel to its aligned easy axis of magnetization, before or after it is bonded to the substrate as desired, to produce a permanent magnet. The magnetizing field is preferably applied to the sintered member at room temperature, and its specific strength depends largely on the degree of magnetic alignment of the number and the particular magnetic properties desired. Generally, the magnetiz-

ing field ranges from about 10 kiloersteds to 100 kiloersteds.

The invention is further illustrated by the following examples.

EXAMPLE 1

Particles of a 66.7 wt. percent cobalt-33.3 wt. percent samarium base alloy were admixed with particles of an additive 40 wt. percent cobalt-60 wt. percent samarium alloy to form a thorough mixture composed of 62 wt. percent cobalt and 33 wt. percent samarium.

An elongated layer of the mixture of particles was formed and a magnetizing field of about 15 kiloersteds was applied to the layer to align the particles along their easy axis of magnetization in a direction perpendicular to the longitudinal surfaces of the layer. The layer of aligned particles was then compressed and sintered at a temperature of 1100°C for about 1 hour in an atmosphere of argon. The resulting elongated sintered member had a density of about 87 percent of theoretical and was about 1/16 inch thick, ½ inch wide and 2 inches long. This member was comprised substantially of a Co_5Sm phase and contained a minor amount of Co_7Sm_2 phase.

One side of the elongated sintered member was bonded to the adhesive side of a flexible plastic adhesive tape which had the same width as the sintered member. A grid, i.e. a screen configuration, wherein the parallel lines thereof were spaced about 1/16 inch apart, was scribed on the outside longitudinal surface of the bonded sintered member along the length thereof.

A rolling motion was used to crack the bonded sintered member on the grid lines. A magnetizing field of 60 kiloersteds was applied at room temperature to the bonded sintered members along their easy axis of magnetization in a direction perpendicular to the plane of the substrate tape to produce a permanent magnet.

A one inch length of the resulting permanent magnet tape could be flexed longitudinally through an arc of 90° without rupture and without dislodging the adhered sintered members.

EXAMPLE 2

A number of elongated cobalt-samarium sintered members were prepared in the same manner as set forth in Example 1.

Spaced parallel lines were scribed across the width of each sintered member which was then cut along the lines to produce a plurality of rectangular sintered members with each member being about 1/16 inch in thickness, 3/16 inch in length and ¼ inch in width.

The resulting sintered members were adhered in juxtaposition to the adhesive side of a pressure sensitive adhesive fiberglass tape with their easy axis magnetization perpendicular of the plane of the substrate tape. A 1 inch length of the resulting tape could be flexed longitudinally through an arc of 90° without rupture.

A magnetizing field of 60 kiloersteds was applied at room temperature to the bonded sintered members along their easy axis of magnetization to produce a permanent magnet.

This permanent magnet tape was wrapped around a conventional Alnico magnet and the resulting assembly installed in a klystron. The radial orientation produced by the wrapped tape of the present invention improved the magnetic field in the gap significantly.

What is claimed is:

1. A process for producing a bendable cobalt-rare earth permanent magnet product in the form of a tape or strip consisting essentially of a plurality of brittle sintered magnetic members bonded in juxtaposition to a flexible non-magnetic substrate wherein each said bonded member has its easy axis of magnetization aligned perpendicular to the plane of the substrate, each said sintered member containing the Co_5R solid intermetallic phase in an amount of at least about 70 percent by weight of the sintered member, where R is a rare earth metal or metals, which comprises providing a layer consisting essentially of cobalt-rare earth alloy particles having a cobalt and rare earth metal content corresponding to that of said sintered member, applying a magnetic field to said layer of particles to align them along their easy axis of magnetization in a direction perpendicular to the longitudinal surfaces of the layer, compacting the particles in their magnetically aligned position to form a number of thin green members, each green member being a body of compacted particles, sintering each said green member to produce a sintered member of compacted particles having a density of at least 87 percent of theoretical, each said sintered member having a thickness ranging from 0.01 inch to 0.5 inch, bonding one side of each sintered member to the same side of said substrate, said substrate being in the form of a tape or strip at least as wide as the sintered member, each one foot length of said substrate being flexible longitudinally through an arc of at least 45° without rupturing, said sintered member being bonded so that its aligned easy axis of magnetization is perpendicular to the plane of the substrate, said sintered members being bonded in juxtaposition, and said bonded sintered members having a size which allows each one foot length of the resulting product to be bent in at least a single direction longitudinally through an arc of at least 45° without rupture.

2. A process according to claim 1 wherein a magnetizing field is applied to said sintered member parallel to its easy axis of magnetization before or after said bonding.

3. A process for producing a bendable cobalt-rare earth permanent magnet product in the form of a tape or strip consisting essentially of a plurality of brittle sintered magnetic members bonded in juxtaposition to a flexible non-magnetic substrate wherein each said bonded member has its easy axis of magnetization aligned parallel to the plane of the substrate across the width thereof, each said sintered member containing the Co_5R solid intermetallic phase in an amount of at least 70 percent by weight of the sintered member, where R is a rare earth metal or metals, which comprises providing a layer consisting essentially of cobalt-rare earth alloy particles, applying a magnetic field to said layer of particles to align them along their easy axis of magnetization in a direction perpendicular to the transverse surfaces of the layer, compacting the particles in their magnetically aligned position to form a number of thin green members, each green member being a body of compacted particles, sintering each green member to produce a sintered member of compacted particles having a density of at least 87 percent of theoretical, each said sintered member having a thickness ranging from 0.01 inch to 0.5 inch, bonding one side of each sintered member to the same side of said substrate, said substrate being in the form of a tape or strip at least as wide as the sintered member, each one foot length of said substrate being flexible longitu-

dinally through an arc of at least 45° without rupturing, said sintered member being bonded so that its aligned easy axis of magnetization is parallel to the plane of the substrate, said sintered members being bonded in juxtaposition, and said bonded sintered members having a size which allows each one foot length of the resulting product to be bent in at least a single direction longitudinally through an arc of at least 45° without rupture.

4. A process according to claim wherein a magnetizing field is applied to said sintered member parallel to its easy axis of magnetization before or after said bonding.

5. A process for producing a bendable cobalt-rare earth permanent magnet product consisting essentially of a plurality of brittle sintered magnetic members bonded to a flexible non-magnetic substrate wherein said bonded members have their easy axis of magnetization aligned perpendicular to the plane of the substrate or parallel to the plane of the substrate across the width thereof, each said sintered member containing the Co_5R solid intermetallic phase in an amount of at least 70 percent by weight of the sintered member, where R is a rare earth metal or metals, which comprises providing a layer consisting essentially of cobalt-rare earth alloy particles having a cobalt and rare earth metal content corresponding to that of said sintered member, applying a magnetic field to said layer of particles to align them along their easy axis of magnetization in a direction perpendicular to the longitudinal surfaces of the layer or perpendicular to the transverse surfaces of the layer, compacting the particles in their magnetically aligned position to form an elongated thin green member, sintering said elongated member to produce an elongated sintered member of compacted particles having a density of at least 87 percent of theoretical and a thickness ranging from 0.01 inch to 0.5 inch, bonding a longitudinal surface of said elongated sintered member to said substrate, said substrate being in the form of a tape or strip at least as wide as the sintered member, each one foot length of said substrate being flexible longitudinally through an arc of at least 45° without rupturing, scribing spaced parallel lines across the width of the outside longitudinal surface of said elongated member, cracking said bonded member along said scribed lines to produce a plurality of sintered bonded members of compacted particles, said plurality of sintered bonded members having a size which allows each one foot length of the resulting product to be bent longitudinally in at least a single direction through an arc of at least 45° without rupture.

6. A process for producing a flexible cobalt-rare earth permanent magnet product according to claim **5** wherein spaced parallel lines are also scribed along the length of the elongated sintered member to form a grid and wherein said bonded member is cracked along the grid lines to produce a plurality of bonded members with said plurality of bonded members having a size which also allows each 2 inch width of the product to be bent laterally in at least a single direction through an arc of at least 45° without rupture.

7. A bendable cobalt-rare earth alloy permanent magnet product in the form of a tape or strip consisting essentially of a non-magnetic flexible substrate having bonded to a single side thereof a number of brittle sintered cobalt-rare earth alloy magnetic members in juxtaposition, wherein each member consists essentially of cobalt-rare earth alloy and contains the Co_5R soild intermetallic phase in an amount of at least 70 percent by weight of the sintered member, where R is a rare earth metal or metals, and wherein each said member has its easy axis of magnetization aligned perpendicular to the plane of the substrate, said substrate being in the form of a tape or strip at least as wide as the sintered member, each one foot length of said substrate being flexible longitudinally through an arc of at least 45° without rupturing, each said sintered member being a body of compacted particles having a density of at least 87 percent of theoretical, a thickness ranging from 0.01 inch to 0.5 inch, and having a size which allows each one foot length of said product to be bent longitudinally in at least a single direction through an arc of at least 45° without rupture.

8. A bendable cobalt-rare earth alloy permanent magnet product in the form of a tape or strip consisting essentially of a non-magnetic flexible substrate having bonded to a single side thereof a number of brittle sintered cobalt-rare earth alloy magnetic members in juxtaposition, wherein each member consists essentially of cobalt-rare earth alloy and contains Co_5R solid intermetallic phase in an amount of at least 70 percent by weight of the sintered member, where R is a rare earth metal or metals, wherein each said member has its easy axis of magnetization aligned parallel to the plane of the substrate across the width thereof, said substrate being in the form of a tape or strip at least as wide as the sintered member, each one foot length of said substrate being flexible longitudinally through an arc of at least 45° without rupturing, each said sintered member being a body of compacted particles having a density of at least 87 percent of theoretical and having a size which allows each one foot length of said product to be bent longitudinally in at least a single direction through an arc of at least 45° without rupture.

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