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MOLDED MAGNET AND MAGNETIC MATERIAL

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The present invention relates to moldable magnetic materials. More specifically, it is concerned with moldable friable magnetic alloys or compositions and particularly with Alnico magnetic compositions.

Various hard magnet alloys are well known. The Alnico magnet alloys, for example, essentially comprise aluminum, nickel and cobalt and an iron base, typical examples of such Alnico magnet alloys being designated commercially as Alnico V and Alnico XII having specific compositions of 8% aluminum, 14% nickel, 24% cobalt, 50.8% iron and 3.2% copper in the case of Alnico V and 6% aluminum, 18% nickel, 35% cobalt, 33% iron and 8% titanium in the case of Alnico XII. Like most permanent magnet alloys the Alnico magnet alloys are quite hard so that shaping by forging or pressing of the cast material is extremely difficult. For that reason many Alnico magnets are prepared by a sintering process. However, due to the shrinkage conditions inherent in any sintering process, this is not particularly satisfactory when it is desired to obtain a product of precision dimensions.

It has also been proposed to provide permanent magnets by molding a mixture of the finely-divided magnetic material and a resinous binding medium such as a phenolic resin. While such products have been acceptable for many applications, under some conditions of use as for example when the products are subjected to elevated temperatures, the plastic bonding material has been found to age with a resultant distortion of the molded product. As a result the resin bonded magnetic products have not been suitable for those applications in which the precision dimensions of the final part are to be maintained indefinitely and under somewhat elevated temperature conditions.

The present invention is based on the discovery that moldable Alnico magnet compositions which can be molded to precision dimensions and which will retain these dimensions indefinitely at ordinary operating temperatures can be obtained by employing as a binder for the magnetic particles a binding medium consisting of a low melting point metal or alloy having a melting point below 450° C.

The moldable compositions of the present invention are prepared by introducing a finely-divided magnetic alloy, such as Alnico, and a finely-divided low melting point alloy or metal into a flux composition comprising zinc chloride and while constantly agitating the mixture heating it to a temperature somewhat above the melting point of the low melting point metal or alloy. During this treatment the Alnico particles become coated with a layer or film of the low melting point metal or alloy. This layer or film consists not only of a superficial layer of the bonding metal, but also of intermetallic compounds formed between it and one or more constituent of the parent Alnico, probably the iron. Such intermetallic bonding leads to great bonding strength, as can be demonstrated by attempting to separate two large particles of the coated Alnico. In general, the Alnico crystals

fracture before the bonding yields. After washing the tinned or coated Alnico powder and drying the washed material, it can be placed in a mold, heated to a temperature slightly above or below the melting point of the low melting point metal or alloy, pressed and cooled under pressure to a temperature substantially below the melting point of the metal or alloy. The molded product will be found to have taken on the precise dimensions of the mold, which dimensions are retained at all temperatures below the melting point of the binder.

As compared with the known resin bonded Alnico products, the molded products of the present invention are generally stronger and have the additional advantage of being wholly metallic in character so that they can be readily bonded to other metallic parts by simple soldering operations. In addition, due to the manner in which the bonding metal is applied to the Alnico particles, there is obtained a uniform moldable mixture of the Alnico particles and the bonding medium providing uniform magnetic properties throughout the molded part. The moldable powder is non-deteriorating, e. g., chemically stable, so that it can be stored indefinitely after preparation and prior to molding. It addition, factory vibration and vibration due to handling or pouring does not alter its physical properties or composition. In this respect, the moldable material of the present invention markedly differs from known mixtures of finely-divided magnetic particles and finely-divided resin or metal binders. Such heterogeneous powder mixtures composed of heavy particles of magnetic alloy and lighter particles of binder separate during handling or storage, making quality control of the mixed or molded powders difficult. Such difficulties are not present in the products of the present invention in which a thin layer or coating of bonding alloy is effectively soldered to each magnetic particle. Each particle consists therefore not only of the nucleus of magnetic material, such as Alnico, and a low melting metallic coating, but also of intermetallic compounds of the low melting point coating metal and the Alnico, most probably the iron component thereof.

The preparation of the moldable Alnico composition can be carried out either by means of a molten zinc chloride or by means of a solution thereof.

When a solution of the zinc chloride is employed it is ordinarily necessary to carry out the heating step under pressure so that the solution can be maintained at a temperature above the melting point of the low melting point metal binder. For example, when employing a bonding material such as the low melting point solder composed of 50% bismuth, 20% lead and 30% tin melting at 158° C., the finely-divided Alnico having a particle size less than 100 mesh is mechanically mixed with the finely-divided low melting point metal binder and the mixture poured into a liquid flux consisting for example of a solution of two parts sulfuric acid, 2 parts hydrochloric acid, 25 parts zinc chloride in 100 parts water. The flux and mixture are then heated and tumbled in a pressure tank at 130 pounds per square inch pressure. The tumbling action at 170° C. agitates the particles of magnetic material and they become coated with the solder. Thereafter, the mixture is cooled, washed to remove excess flux, and dried. The resultant dried product can be molded at a temperature of about 180° C. and at a suitable pressure. The molded product is cooled to about 130° C. before being removed from the mold.

The use of superatmospheric pressure can be avoided by the employing of a flux consisting of molten zinc chloride. A mixture of the finely-divided Alnico, the finely-divided bonded metal and zinc chloride are heated together above the melting point of the zinc chloride and hence above the melting point of the low melting point alloy. After suitable agitation of the heated mix-

ture alloying and intermetallic bonding ensues between the Alnico and low melting alloy. The molten mass is then cooled slowly with constant agitation and yields finally a powdered material. The tinned Alnico is leached free of the zinc chloride and molded as described hereinbefore.

In general at least 15% by weight of the coated product should be composed of the coating metal. Preferably, the coated product should comprise from 70 to 75% by weight of Alnico and 25 to 30% by weight of the low melting point alloy. A composition comprising about 72% Alnico and 28% of the above-described lead-tin-bismuth alloy has been found to be particularly useful for the molding of precision parts.

Because of the uniform magnetic properties throughout any given molded piece as well as between the various pieces pressed from the same batch of material, the products of the present invention are particularly useful for magnetic suspension applications. One such application is described in Patent 2,311,382, Hansen, Jr., disclosing a magnetic suspension meter. Since the magnetic properties of the present products are much more uniform than could be obtained from cast magnetic materials or from materials prepared by processes which do not provide a uniformly distributed coating of the bonding metal over the Alnico particles, it is obvious that a substantial cost reduction can be realized in the manufacture of such magnetic suspensions both from the standpoint of obtaining magnetic elements of precision dimensions as well as from the standpoint of obtaining the proper magnetic adjustment of suspension comprising the magnetic elements.

It will also be understood that any low-melting point alloy including any of the solders melting below about 450° C. can be substituted for the particular binder described hereinbefore.

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

1. A moldable powdered Alnico composition capable of being molded to form a permanent magnet body having uniform magnetic properties throughout said body comprising finely divided particles of Alnico magnet alloy, each of said particles being an alloy comprising aluminum, nickel, cobalt, and iron to which is bonded by chemical intermetallic compounds a coating of a metal alloy having a melting point below 450° C., said Alnico magnet alloy comprising at least 70% and no more than 85% by weight of said moldable powdered composition.

2. A permanent magnet comprising a molded body of finely divided Alnico magnet alloy particles having uniform magnetic properties throughout said molded body, each of said particles being an alloy comprising aluminum, nickel, cobalt, and iron to which is bonded by chemical intermetallic compounds a coating of a metal alloy having a melting point below 450° C., said Alnico magnet alloy comprising at least 70% and no more than 85% by weight of said molded body.

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