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MAGNET MATERIAL

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The present invention relates to magnet materials.

One object is to produce a strong permanent magnet, characterized by a high coercive force and a comparatively high remanence.

It is another object of the invention to provide a manufacturing method resulting in a product which is free from segregation.

A further object of the invention is to provide a manufacturing method which in combination with a special heat treatment will give consistently high values of coercive force and remanence.

It is still a further object of the invention to provide a material of very fine grain structure having high mechanical strength and resistance against shock.

Other objects of the invention will be apparent from the following description taken in connection with the appended claims.

The present invention comprises the combination of elements, methods of manufacture and the product thereof, brought out and exemplified in the disclosure hereinafter set forth, the scope of the invention being indicated in the appended claims.

Recently, a number of patents have appeared, describing the manufacture of a permanent magnet, containing nickel, aluminum and iron, with or without other alloying ingredients, such as for instance cobalt and copper from powders. In my experiments with metal powders containing nickel, aluminum, copper and iron, certain disadvantages were found in using such a straight powder mixture. The major disadvantages were that the resulting coercive force and remanence were not as high as could be obtained with cast material.

My experiments were extended, therefore, to a new type of permanent magnet which has been disclosed by a number of foreign patents, such as English Patent #428,288 and French Patent #764,375. The composition of such alloys consists of 3-50% nickel, 1-50% titanium, containing as additional ingredients, less than 20% of other alloying elements, such as silver, silicon, copper, molybdenum, tungsten, chromium, aluminum, arsenic, vanadium and manganese.

Since it is necessary to have a fairly high titanium content, in order to obtain satisfactory magnetic qualities, enormous difficulties were encountered to make castings of this material. As a matter of fact, these types of alloys have not been used commercially, because they are very brittle indeed and they can not be cast into sand or other molds. It further has been found that

in melting, various ingredients segregate very badly and that even from one and the same melt, differences in magnetic properties are obtained which are far beyond the tolerances acceptable for such products.

I have discovered a means for manufacturing a material of this description by starting out with the powders of the elements used or with alloy powders containing two or more of the elements in the right proportions, or with a powder produced from the completed alloy.

The latter type of powder can be manufactured, for instance, by pouring a melt into water and producing shot of small size which can be broken up into fine powder by crushing or ball milling. During melting the bath should be agitated by either mechanical or electrical means so that a homogeneous melt is secured at any time and particularly during the time of pouring.

Experimental evidence was obtained, showing excellent magnetic properties resulted by starting out with a powder mixture of an alloy powder containing 16 parts of nickel, 11 parts of titanium and 28 parts of cobalt. By mixing this powder with pure iron powder, pressing same, sintering and subsequently heat treating, a material of high coercive force and of high remanence, was produced.

In sintering it was found that it is advisable to go to a temperature just below the melting point of the mixture which is being used for magnetic purposes. This temperature will vary according to the composition which is being selected. It will be for most purposes, in the neighborhood of 1100 to 1400° C.

The sintering process can be carried out in a highly reducing atmosphere or in vacuum. It is very desirable to have nascent hydrogen present which can be accomplished by use of decomposing hydrides, such as calcium hydride. It has also been found very advantageous in certain cases to use a flux containing large portions of fluorides, such as cryolite. Such a flux will dissolve any oxides or similar compounds which are being formed during the sintering process, and therefore will produce a metallic, sintered product, very homogeneous and free from non-metallic matter. Since such non-metallic matter is non-magnetic, its presence will decrease the magnetic properties.

Since the expense of the alloy consisting of a high percentage of titanium is high, experiments were made to take such a powder and mix it in the approximate ratio of 1:1 with a powder consisting of nickel-aluminum-iron, with or without

additional alloying ingredients, such as, for instance, cobalt or copper. In using such mixtures, it is necessary, however, that coercive forces of the two materials used do not vary too greatly. By using the proper heat treatment, variations in the permanent magnetic properties of the two materials can be decreased.

I have found that by starting out with two mixtures of completed alloys, pressing to highest densities is possible, so that higher magnetic properties will result. Or, in other words, smaller size magnets can be used for applications where previously a greater volume of the permanent magnetic material is required to produce a certain flux density.

The heat treatment of the sintered permanent magnets will depend on the composition. Usually I found that quenching from 1000 to 1300° C. is necessary. The quenching medium can be either water or oil, or it is also possible to quench in a metal bath, such as lead or tin. These metal baths are usually kept at a temperature which is close to the subsequent aging temperature. These aging temperatures range from 500 to 750° C.

If the lower temperatures are used, usually longer aging periods are required than when higher temperatures are employed. The type of precipitate obtained during such aging determines the resulting coercive force and remanence. With proper heat treatment for the different compositions, it is possible to obtain a coercive force ranging from 350 to 900 oersteds and remanence values varying from 3000 to 8000 gauss. This shows that permanent magnetic values can be obtained which are far in excess of values previously obtained with pressed and sintered magnets, consisting of the nickel, aluminum, iron type.

While the present invention as to its objects and advantages, has been described herein as carried out in specific embodiments thereof, it is not desired to be limited thereby, but it is intended to cover the invention broadly within the spirit and scope of the appended claims.

What is claimed is:

1. The process of producing a fine grained, strong permanent magnet, containing a considerable percentage of an alloy consisting basically of nickel, titanium, cobalt and iron comprising the steps of mixing the powders of said materials with a decomposing hydride, pressing same into suitable forms, and sintering them at a temperature where the hydride present will decompose and release nascent hydrogen, said sintering being carried out in a non-oxidizing atmosphere, and then heat treating the sintered product to produce a high coercive force and high remanence.

2. The process of producing a fine grained, strong permanent magnet, containing a considerable percentage of an alloy consisting basically of nickel, titanium, cobalt and iron comprising the steps of mixing the powders of said materials with a decomposing hydride and a flux, pressing same into suitable forms, and sintering them at a temperature where the hydride present will decompose and release nascent hydrogen, said sintering being carried out in a non-oxidizing atmosphere, and then heat treating the sintered product to produce a high coercive force and high remanence.

3. The process of producing a fine grained, strong permanent magnet, containing a considerable percentage of an alloy consisting basically of nickel, titanium, cobalt and iron comprising the steps of mixing the powders of said materials with a decomposing hydride, pressing same into suitable forms, and sintering them at a temperature where the hydride present will decompose and release nascent hydrogen, said sintering being carried out in a non-oxidizing atmosphere, and then heat treating the sintered product by heating to a temperature in the order of 1000° C. to 1300° C. and quenching from that temperature and subsequently aging at a temperature in the order of 500° C. to 750° C. to produce a high coercive force and high remanence.

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