Patented Feb. 13, 1934 1,947,274

UNITED STATES PATENT OFFICE

1,947,274

PERMANENT MAGNET AND METHOD OF MAKING IT

William E. Ruder, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

No Drawing. Application February 1, 1933 Serial No. 654,764

6 Claims. (Cl. 175—21)

The present invention relates to magnetic material and more particularly to cast alloy permanent magnets and to a method of making them.

It is one of the objects of the present invention to provide a permanent magnet, composed of relatively cheap materials, which may be fabricated easily and cheaply and which has desirable magnetic qualities.

The novel features which are characteristic of my invention are set forth with particularity in the appended claims. My invention however will best be understood from reference to the following specification.

My improved magnet material generally consists of a mixture of iron, nickel and aluminum in which the iron may comprise from about 60% to 70% of the composition, the aluminum from about 6% to about 15% and the nickel from about 20% to about 30%. The ingredients of the alloy in desired proportions are melted in any suitable furnace and then poured into castings. To obtain the most satisfactory magnetic qualities in the alloy the casting preferably should be cooled from the liquid to the molten condition very quickly. This may be accomplished by casting the metal in a chill mold. If desired, however, a sand mold may be employed. Under the latter circumstances it will be found desirable to sprinkle water on the mold immediately after the casting has been poured and to pull the casting out of the mold as soon as it has solidified sufficiently to permit such action. If desired, the cover of the sand mold may be removed and the casting exposed to a strong air blast.

Since difference in size and necessary variations in casting conditions for various shapes makes it difficult to get uniform results on all magnets of the same composition, it will generally be found desirable to give the alloy a heat treatment after the casting operation to obtain uniform results. This may comprise heating the casting at a normalizing temperature in the neighborhood of 1000 to 1500° C. This is merely a corrective heat treatment and is usually applied until the entire casting is heated to the normalizing temperature. After this treatment the casting is rapidly cooled preferably in moving air or oil. When the casting has been cooled to the desired extent, i. e. about room temperature usually or to the temperature of retreatment, it is given a further heat treatment which comprises heating the casting to a temperature between about 600° C. and 700° C. The time at which the casting is held in this temperature range may vary according to the temperature employed. For example, when the casting is heated to a temperature of 600° C. the heating period may be about five hours, while for a temperature of 650° C. the same results may be obtained in about half an hour. The product obtained after heating the casting in the 600 to 700° C. temperature range etches entirely different from the product obtained after heating the casting at about 1000° C. The explanation of this is that heating in the 600 to 700° C. range affects precipitation of an age hardening compound in the casting. This hardening compound is composed of particles of sub-microscopic size.

I have obtained the most satisfactory results with alloys consisting of 10 to 12% aluminum, about 20% nickel and the remainder iron. Age hardened alloys of this composition have a coercive force varying from about 330 to 350 gilberts per centimeter, a residual varying from about 7100 to 8500 gauss, and a maximum energy or $BH_{max.}$ varying from about one to one and one-half million. For the same maximum energy the relation of the coercive and residual may be varied with variations of the heat treatment and composition. For example, a composition containing 25% nickel gives a lower residual, other things being equal, and a higher coercive force than a composition containing 20% nickel, while prolonging the time or increasing the temperature of the treatment, increases the residual and reduces the coercive force.

If the cross section of the casting is very small, for example ¼" x ½", it will be found that its magnetic qualities in the cast condition are about as good as the magnetic properties of larger castings which have been age hardened according to my improved process. However, although castings of very small cross sections have desirable magnetic qualities in the as cast condition, it will nevertheless be found desirable to age harden all castings. This will be apparent when it is considered that castings having a cross section of ½" x ¾" are improved by the aging process. In general, the magnetic qualities of castings of relatively small cross section are better than the magnetic qualities of castings of relatively large cross section. This is apparently due to the rapidity with which the small castings solidify from the liquid state.

While I prefer to employ only iron, nickel and aluminum as the ingredients of my improved alloy the presence of minor impurities does not materially affect the magnetic properties of the alloy. If desired, a few per cent of chromium, for example about 3 to 5%, may be present in

the alloy. However, the presence of chromium is not desirable since it does not improve the magnetic properties of the alloy and does increase its cost.

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

1. An age hardened magnet consisting substantially of about 6% to 15% aluminum, about 20% to 30% nickel with the remainder iron.

2. An age hardened magnet consisting substantially of 10% to 12% aluminum, 20% to 25% nickel with the remainder iron.

3. An age hardened permanent magnet consisting of about 10% aluminum, about 20% nickel and about 70% iron.

4. The method of making a permanent magnet cast alloy consisting substantially of about 6% to 15% aluminum, about 20% to 30% nickel, and the remainder iron, which comprises melting the ingredients of the alloy, casting the alloy, quickly cooling the alloy from the liquid to the solid state and aging the alloy at a temperature varying from about 600 to 700° C.

5. The method of making a permanent magnet cast alloy consisting substantially of about 6% to 15% aluminum, about 20% to 30% nickel, and the remainder iron which comprises melting the ingredients, casting the alloy, quickly cooling the alloy from the liquid to the solid state, heating the casting at a temperature between 1000° C. and 1500° C. and cooling and then heating the casting at a temperature below 1000° C. but high enough to cause precipitation hardness thereof.

6. The method of making a permanent magnet cast alloy consisting of about 6% to 15% aluminum, about 20% to 30% nickel and the remainder iron which comprises melting the ingredients of the alloy, casting the alloy, quickly cooling the alloy from the liquid to the solid state and aging the casting at a temperature below 1000° C. but high enough to cause precipitation hardness of the alloy.

WILLIAM E. RUDER.