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METHOD OF MANUFACTURING ANISOTROPIC PERMANENT MAGNETS

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U.S. Cl. 148—103 1 Claim

ABSTRACT OF THE DISCLOSURE

A method of manufacturing an anisotropic permanent magnet wherein a ferrous alloy consisting of 28 to 45% of Co, 10 to 20% of Ni, 7 to 9% of Al, 7 to 10% of Ti, up to 6% of Cu, and the remainder principally iron is quenched only from a temperature between 900° and 1000° C. to below its Curie point and held at a temperature of 10° to 70° C. below the Curie point in a magnetic field.

The invention relates to a method of manufacturing anisotropic permanent magnets of an alloy on the basis of Co, Ni, Al, Ti and Fe, in which a magnet body is quenched to below the Curie temperature, and then exposed to a magnetic field for some time in a temperature range of 10° C. to 70° C. below the Curie temperature.

Such a method is known from U.S. patent sepcification 2,837,451. Above 1200° C. a magnet body is formed by the solidification of a homogeneous melt of the alloy concerned. The magnet body is formed as a homogeneous mixed-crystal having a cubic space-centered lattice, the so-called α-phase. If cooling is performed down from said α-phase without special precautions being taken, the α-phase will partly change into the γ-phase, which is cubic, plane-centered. This γ-phase is very harmful to the magnetic properties. The formation of this γ-phase may, however, be prevented by quenching the body from a temperature above 1200° C. to below about 900° C. Below this value of about 900° C. a temperature is found at which the α-phase changes partly into a different phase (α'-phase), which is also cubic, space-centered. The temperature at which said separation of the α-phase into the $(\alpha+\alpha')$-phase takes place, in general, substantially coincides with the Curie temperature of the alloy concerned.

In the temperature range from 10° C. to 70° C. below the Curie point the magnet body is exposed, as described in the said patent specification, to a magnetic field for 2 to 30 minutes, after which a known tempering process is carried out.

According to the invention the method described in the U.S. patent specification 2,837,452 can be considerably simplified for a given group of alloys belonging to the group of alloys described in said specification. It has even been found that this simplified method frequently provides an improvement in the magnetic properties.

The invention is based on the experimentally acquired recognition that no γ-phase is found in the alloys of the group mentioned in said patent specification, which have a sufficiently high Al-content and a sufficiently high Ti-content, when cooled from the state of the homogeneous melt down to the point of separation of the α-phase into $(\alpha+\alpha')$, even when cooled across said temperature range instead of being quenched. This involves in the first place that the quenching process in this temperature range can be omitted from the manufacturing process out of the melt of permanent magnets having a high Al-content and a high Ti-content. A more important consequence is, however, that such permanent magnets can now be manufactured directly from the solidified alloy without the need for previous homogenization above 1200° C.

It has been found, however, that with the alloys having a high Al-content and a high Ti-content said point of separation and the Curie point do no longer coincide approximately: the point of separation is higher (for example, 50° C. higher) than the Curie point. This means that, when the magnet body has been cooled down to the point of separation, the thermal treatment in the magnetic field known from said patent specification cannot be directly carried out. The magnet body must first be quenched to below the Curie point. However, because of the smaller temperature range (for example, 100° C.) and the lower temperature of quenching the quenching process can be carried out in a much simpler manner than the quenching process known from said patent specification. This advantage becomes particularly manifest when the bodies to be quenched are comparatively large; since the temperature range according to the invention can be covered more rapidly, the magnetic properties are, in general, better.

The method according to the invention is characterized in that the magnet body of an alloy having 28 to 45% of Co, 10 to 20% of Ni, 7 to 9% of Al, 7 to 10% of Ti, up to 6% of Cu and otherwise mainly Fe is quenched from a temperature lying between 900° C. and 1000° C.

The value of said temperature between 900° C. and 1000° C. depends upon the alloy selected, that is to say, mainly upon the Al- and Ti-contents.

According to the invention not only the process is much simpler and hence more economical than the process hitherto known, but also, as stated above, the magnetic properties appear to be considerably improved. The latter is due to the fact that quenching can be performed at a higher rate, which is particularly important in quenching comparatively large bodies.

From the following tables it will be apparent that the magnetic properties of the permanent magnets manufactured by the method according to the invention are better than those of the known permanent magnets manufactured by the known method.

In Table I two good specimens of magnets manufactured by the known method are compared with magnets manufactured by the method according to the invention. The four said magnets did not exhibit crystal orientation.

TABLE I

[Without crystal orientation]

	Composition in percent					Magnetic properties		
Number of the alloy	Co	Ni	Al	Cu	Ti	Br (g.)	H_0 (oe.)	$(BH)_{max.}$(g.oe.)
1	33	14	7	3	8.5	7,250	1,890	5.35×10^6
2	40	14.5	7	4.5	8	6,860	1,400	3.05×10^6
3	32	17.5	8	2.5	8	7,850	2,040	6.3×10^6
4	40	14	8	3	8	7,700	2,215	6.7×10^6

The magnets made from the alloys 1 and 2 are known from "Cobalt" No. 34, March 1967, page 16 (French edition) and from the U.S. patent specification 2,837,452 respectively. The magnets made from the alloys 3 and 4 are manufactured by the method according to the invention.

TABLE II

Number of the alloy	Composition in percent					Magnetic properties		
	Co	Ni	Al	Cu	Ti	Br (g.)	H_0 (oe.)	$(BH)_{max.}$ (g.oe.)
5	34	14.5	7	4.5	7	8,200	2,000	8.2×10^6
6	40.3	14.7	7	2.9	8.3	8,950	2,010	8.4×10^6
7	40	14	8	3.0	7.5	----------	1,980	9.1×10^6
8	38	15	8	3	8	9,500	2,015	11.2×10^6

The magnets made from the alloys 5, 6 and 7 are known from "Proceedings of the International Conference on Magnetism," Nottingham, September 1964, pages 767 ff., the French Pat. No. 1,493,293 and the French Pat. No. 1,482,702. The magnet of the alloy 8 is made by the method according to the invention.

What is claimed is:

1. A method of manufacturing anisotropic permanent magnets comprising the steps of forming a ferrous alloy consisting of about 28 to 45% of Co, 10 to 20% of Ni, 7 to 9% of Al, 7 to 10% of Ti, up to 6% of Cu and the balance principally iron, quenching said alloy only from a temperature between 900° to 1000° C. to below the Curie temperature, and then exposing the alloy to a magnetic field for a given period of time in a temperature range of 10° to 770° C. below the Curie temperature.

References Cited

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634,700	3/1950	Great Britain	148—102
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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,598,662 Dated August 10, 1971

Inventor(s) Krijn Jacobus De Vos et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 31, "2,837,451" should read -- 2,837,452 --.

Signed and sealed this 23rd day of May 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

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