July 13, 1965 HIDEO KANEKO 3,194,654

MANGANESE ALUMINUM ALLOY MAGNETS

Filed Oct. 24, 1963 2 Sheets-Sheet 1

Fig. 1.

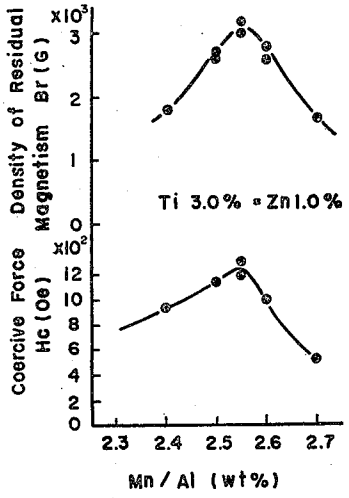


Fig. 2.

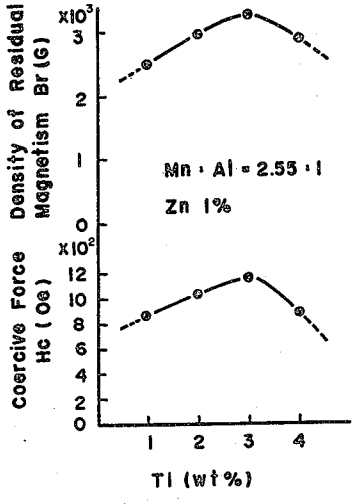


Fig. 3.

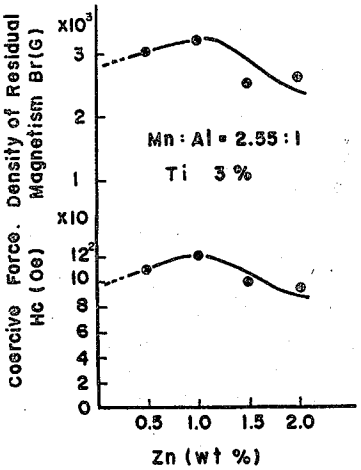
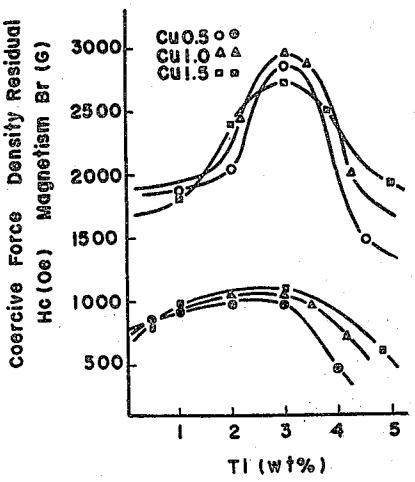


Fig. 4.



MANGANESE ALUMINUM ALLOY MAGNETS

Filed Oct. 24, 1963 2 Sheets-Sheet 2

Fig. 5.

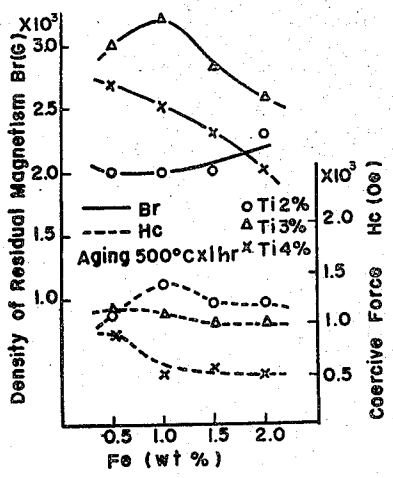


Fig. 6.

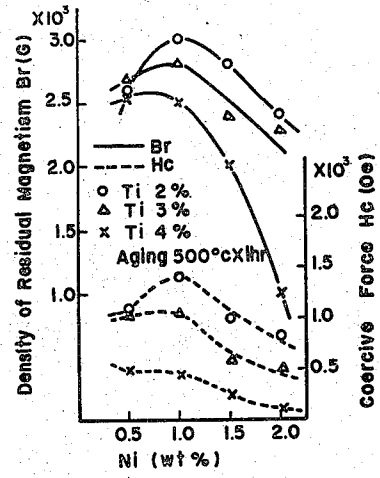


Fig. 7.

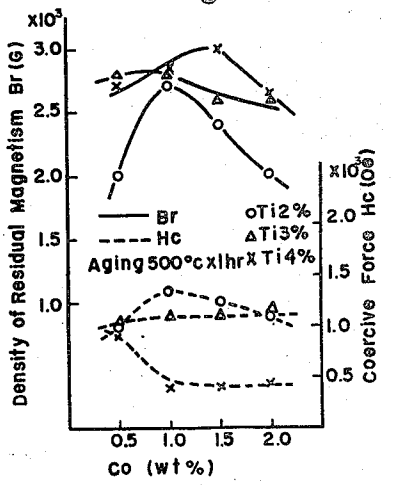
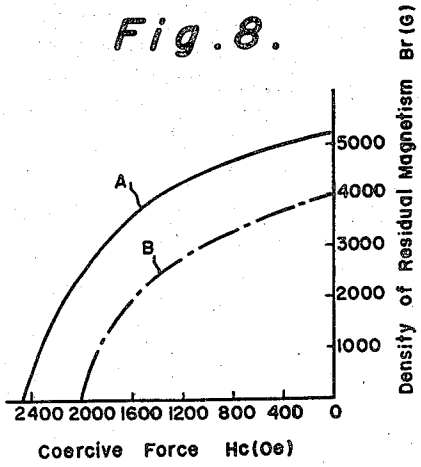


Fig. 8.



United States Patent Office 3,194,654 Patented July 13, 1965

3,194,654

MANGANESE ALUMINUM ALLOY MAGNETS

Hideo Kaneko, 558 Wakabayashi, Setagaya-ku, Tokyo, Japan

Filed Oct. 24, 1963, Ser. No. 318,595
Claims priority, application Japan, Dec. 27, 1962, 37/57,867
6 Claims. (Cl. 75—134)

The present invention relates to improvements in alloy magnets consisting of magnetic materials such as Mn, Al as the essential ingredients added with a suitable quantity of the other elements such as Ti and Zn and then subjected to a necessary treatment.

The principal object of the invention is to provide permanent magnets having most desirable powerful residual magnetism and high coercive force as well as large magnetic energy with less oxidation and high Curie point and minimum temperature effect and moreover, easily manufactured and worked by means of melting metallurgy at a lower cost.

Mn-Bi and Ba ferrites which have heretofore been used as magnetic materials have high coercive force but both of them should be manufactured by powder metallurgy so that it is very difficult to manufacture and it has disadvantage that the actual production and working are limited so that it has disadvantage that it becomes invariably expensive and also liable to be oxidized, and the Ba ferrites have disadvantage that Curie point is low and the magnetic properties vary substantially as the temperature changes. Moreover, the aluminum ferrite, so-called Alnico (an alloy of Al-Ni-Co) has excellent residual magnetism but its coercive force is exceedingly small, it is very expensive and a known Mn-Al ferrite material shows low residual magnetism and coercive force if not subject to a proper treatment.

The invention is to obviate the above disadvantages and to provide permanent magnets having various advantages as above explained.

For a better understanding of the invention reference is taken to the accompanying drawings, in which

FIGS. 1 to 7 are characteristic curves of the embodiment of the permanent magnets of the invention illustrating how the characteristics change according to the selection of mixture ratio and kinds of composition; and

FIG. 8 shows demagnetizing curves of the magnets embodying the invention.

The inventor has made numerous experiments, and the explanation will be made by taking the typical data among them. FIG. 1 illustrates the change of residual magnetism and coercive force when the weight ratio of the main ingredients of Mn and Al is changed in case of the first addition element Ti is 1 to 5%, preferably 3% and the second addition element Zn is 0.1 to 2.0%, preferably 1%, wherein the aging and heat treatments were done at a temperature of about 500° C. for about 1 hour. From these results it will be seen that both of the residual magnetism and coercive force become maximum at the weight ratio of Mn:Al is about 2.55. As further shown by FIG. 1, the weight ratio of manganese to aluminum can be in the range of from 2.4:1 to 2.7:1. When the weight ratio of manganese to aluminum is about 2.55:1, the alloys will contain 66.8% to 71.04% by weight manganese. Furthermore when the weight ratio of manganese to aluminum is in the range of from 2.4:1 to 2.7:1, the composition will contain between 65.65% and 72.17% by weight manganese. The remainder of the composition will be aluminum and between 1 and 5% titanium and 0.1% and 2% zinc. Since the total amount of manganese and aluminum in the alloy ranges between 93% and 98.9%

depending upon the amount of titanium and zinc present, the weight percent of manganese is between 66.8% and 71.04% when the manganese to aluminum weight ratio is 2.55:1. FIG. 2 shows curves when the aging and heat treatments similar to those of FIG. 1 were effected, wherein the weight ratio of Mn and Al was taken at 2.55 and 1% of Zn was added thereto as the second addition element and when the quantity of the first addition element Ti was changed the relation between the added quantity and the magnetic property is shown, from which it will be apparent that both of the residual magnetism and coercive force become high when Ti is 1 to 5%, especially they become maximum when Ti is about 3%. FIG. 3 illustrates the change of characteristics according to the change in quantity of the second addition element Zn when the first addition element Ti is settled at 3% and subjected to the similar aging treatment, from which it will be apparent that the residual magnetism and coercive force become high at 0.1 to 2% of Zn, especially they become maximum at about 1% of Zn. The ferrite materials consisting of the alloys of this invention, that is, Mn-Al+Ti (3%)+Zn (1%) of a suitable mixture ratio can considerably improve their magnetic properties by applying swaging treatment at room temperature before the aging treatment, then subjecting to a required aging as above described and an example of the demagnetization of the alloy magnets thus obtained is shown by the curve A in FIG. 8, from which it will be seen that the excellent magnetic properties can be given to such an extent that the residual magnetism arrives at 5200G and the coercive force to 2400 oe. and the magnetic energy more than 6×10^6, and the curve B in FIG. 8 illustrates the results of typical Ba ferrite which has been treated adequately.

According to the invention, it has been found that by adding to a known Mn-Al alloy about 1 to 5%, preferably 3%, of Ti as the first addition element and by subjecting to a conventional aging and heat treatments the magnetic properties can be greatly improved and moreover by adding 0.1 to 2%, preferably about 1%, of Zn as the second addition element the magnetic properties can be further improved and by subjecting to proper treatments to the above alloys permanent magnets having excellent properties as above explained can be obtained.

It has further been found that during the course of arriving at the invention, the addition of a suitable quantity of any one or more element of Cu, Fe, Ni and Co as the second addition element to the Mn-Al alloys containing certain extent of Ti provides the most favourable magnetic properties by subjecting the alloy to a conventional aging and heat treatment. When the second addition element is selected from the group consisting of copper, iron, nickel and cobalt, between 0.1% and 2% of these elements should be employed.

FIG. 4 illustrates the magnetic properties of the metallic compound of Mn-Al added with the first addition element of Ti, and the second addition element of Cu and subjected to a definite aging and heat treatments according to the invention, from which it will be apparent that in each case of 0.5, 1.0, and 1.5% of Cu the properties are improved by the addition of Ti within a range of 1 to 5%, more particularly when Ti is about 3% both of the residual magnetism and coercive force become maximum.

FIG. 5 illustrates the magnetic properties of said alloy of Mn-Al added with the first addition element Ti and the second addition element Fe and subjected to the necessary aging and heat treatment, from which it will be apparent that the magnetic properties are improved within the range of 0.1 to 2%, more particularly by the

addition of about 1% of Fe both of the residual magnetism and coercive force can be made maximum.

FIG. 6 illustrates the magnetic properties of said Mn-Al alloy added with the first addition element Ti and the second addition element Ni and subjected to the necessary treatment such as aging and heat treatments, from which it will be seen that by the addition of Ni of 0.1 to 2% the magnetic properties are improved, and at about 1% of Ni the residual magnetism and coercive force become maximum.

FIG. 7 illustrates the magnetic properties of said Mn-Al alloy when added with Ti as the first addition element and Co as the second addition element and subjected to the necessary aging and heat treatments, from which it will be seen that by the addition of 0.1 to 2% of Co the improvement of magnetic properties occur and at about 1% of Co the residual magnetism and coercive force become maximum.

What I claim is:

1. A magnetic material consisting essentially of 65.65% to 72.17% manganese, 1% to 5% titanium, 0.1% to 2% of an element selected from the group consisting of zinc, copper, iron, and nickel, and the remainder of aluminum.

2. A magnetic material consisting essentially of 65.65% to 72.17% manganese, 1% to 5% titanium, 0.1% to 2% zinc, and the remainder of aluminum.

3. A magnetic material consisting essentially of 65.65% to 72.17% manganese, 1% to 5% titanium, 0.1% to 2% copper, and the remainder of aluminum.

4. A magnetic material consisting essentially of 65.65% to 72.17% manganese, 1% to 5% titanium, 0.1% to 2% iron, and the remainder of aluminum.

5. A magnetic material consisting essentially of 65.65% to 72.17% manganese, 1% to 5% titanium, 0.1% to 2% nickel, and the remainder of aluminum.

6. A magnetic material consisting essentially of 66.8% to 71.04% manganese, 1% to 5% titanium, 0.1% to 2% zinc, and the remainder of aluminum.

References Cited by the Examiner

UNITED STATES PATENTS

2,245,477	6/41	Jonas	148—31.57
2,303,105	11/42	Anderson et al.	75—134
2,797,995	7/57	Morgan	75—134
3,116,181	12/63	Hokkeling et al.	148—101

FOREIGN PATENTS

964,444	5/57	Germany.

OTHER REFERENCES

Disclosure by Hames et al. in Nature, Dec. 18, 1948, vol. 162, page 968.

Morgan: Article in Journal of Metals, September 1954, pp. 983–988.

DAVID L. RECK, *Primary Examiner.*