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FERROMAGNETIC NON-FERROUS ALLOYS

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This invention relates to non-ferrous ferromagnetic alloys, that is to say magnetic alloys consisting essentially of two or more non-ferrous elements.

It is well known that ferromagnetic substances are those whose intensity of magnetization at saturation is similar to that of iron. Nickel and cobalt are such.

The particular magnetic properties of a given material determine its capacity to meet the exacting requirements in transformers, electric motors, communication equipment and electric instruments.

The Heusler type alloys, which owe their ferromagnetism to manganese, are known. They contain a relatively small proportion of manganese, not more than 27% by weight. They are body-centered-cubic in structure with the manganese atoms occupying alternate body-centered positions. That is to say the manganese atoms are never near neighbors, being always separated by other metallic atoms.

The object of the present invention is to provide manganese rich alloys which have magnetic properties such that they can replace existing magnetic materials which are based upon strategically important and scarce metals such as cobalt and nickel.

In the ferromagnetic phase the alloys of the present invention have a crystal structure with face-centered cubic symmetry, with manganese and substitutional metal occupying cube-corner and face-center positions, the interstitial body-center position being occupied preferably by carbon, although the latter may be partially replaced with another small atom, such as boron or nitrogen.

The alloys consist of not less than 60% by weight of manganese, 2.0 to 5.5% of carbon and the balance metal being at least one of a group of non-transitional metals, having an atomic diameter of not less than 2.66 Angstrom units and more than one electron in its valence shell in the elemental state, consisting of aluminum, indium, tin and zinc. The permissible proportion of these substitutional metals is respectively, aluminum 0.4 to 15.5% by weight, zinc 0.5 to 24.7%, indium 1.0 to 10.7% and tin 1.0 to 34.5%. That is to say the relative substitutional value of these metals compared to aluminum is zinc 1.59, indium 0.69 and tin 2.22.

The following examples illustrate ferromagnetic alloys of the invention:

Alloy Composition in Atomic proportions	Magnetic Moment relative to pure nickel
(1) $Mn_{80}Al_{10}C_{10}$	1.7
(2) $Mn_{75}In_{15}C_{10}$	0.8
(3) $Mn_{85}Sn_{10}C_{5}$	1.0
(4) $Mn_{80}Zn_{20}$	1.4

- (5) Manganese 84.7% by weight, aluminum 11.2% and carbon 4.1%
- (6) Manganese 76.8% by weight, tin 20.2% and carbon 3.0%
- (7) Manganese 80.8% by weight, aluminum 7.0%, zinc 7.0% and carbon 5.2%
- (8) Manganese 77.3% by weight, aluminum 6.7%, tin 12.3% and carbon 3.7%

It will be apparent that alloy compositions embodying the present invention may contain small proportions of ferromagnetic elements, such as nickel and cobalt, to replace part of the manganese.

It is of interest to observe that those alloys containing carbon, in excess of the amount specified for the stabilization of the ferromagnetic face-centered-cubic phase will contain other phases which decompose in the presence of air and water. It should also be observed that in Examples 2 and 3 the substitutional metal is in excess of the particular range specified but this does not alter the character of the ferromagnetic phase which does contain the substitutional metal within the ranges specified. By heat treatment the dispersion of the non-magnetic phases is controlled and the size of the ferromagnetic particles remaining, after aqueous oxidation, is also controlled and the alloy appears in the form of fine powder. This property of the alloys is highly beneficial for fabrication purposes.

The alloys of the invention may be prepared by melting together manganese and the substitutional metal, or metals if two or more are used, in the presence of carbon. Boron may be added in the same manner. Nitrogen may be added by melting or heating the mixture in a nitrogen atmosphere.

This application is a continuation in part of application S. N. 355,149, filed May 14, 1953, now abandoned.

I claim:

1. A ferromagnetic non-ferrous alloy in which the ferromagnetic phase has a crystal structure with face-centered-cubic symmetry with manganese and substitutional metal occupying cube-corner and face-center positions and carbon the body-center position and consisting essentially of not less than 60% by weight of manganese, 2.0 to 5.5% carbon and the balance metal being at least one of a group of non-transitional metals, having an atomic diameter of not less than 2.66 Angstrom units and more than one electron in its valence shell in the elemental state.

2. The alloy defined in claim 1 wherein the substitutional metal is aluminum in the proportion of 0.4 to 15.5% by weight of the alloy.

3. The alloy defined in claim 1 wherein the substitutional metal is zinc in the proportion of 0.5 to 24.7% by weight of the alloy.

4. The alloy defined in claim 1 wherein the substitutional metal is indium in the proportion of 1.0 to 10.7% by weight of the alloy.

5. The alloy defined in claim 1 wherein the substitutional metal is tin in the proportion of 1.0 to 34.5% by weight of the alloy.

6. The alloy defined in claim 1 containing the equivalent of 0.4 to 15.5% by weight of aluminum wherein the aluminum is in part replaced with other of said non-transitional metals on the basis of the equivalence ratio aluminum 1:zinc 1.59:indium 0.69:tin 2.22 to constitute the said balance metal.

7. The alloy defined in claim 1 containing the equivalent of 0.5 to 24.7% by weight of zinc wherein the zinc is in part replaced with other of said non-transitional metals on the basis of the equivalence ratio aluminum 1:zinc 1.59:indium 0.69:tin 2.22 to constitute the said balance metal.

8. The alloy defined in claim 1 containing the equivalent of 1.0 to 10.7% by weight of indium wherein the indium is in part replaced with other of said non-transitional metals on the basis of the equivalence ratio aluminum 1:zinc 1.59:indium 0.69:tin 2.22 to constitute the said balance metal.

9. The alloy defined in claim 1 containing the equivalent of 1.0 to 34.5% by weight of tin wherein the tin is

in part replaced with other of said non-transitional metals on the basis of the equivalence ratio aluminum 1:zinc 1.59:indium 0.69:tin 2.22 to constitute the said balance metal.

10. The alloy defined in claim 1 wherein the carbon is partially replaced with boron or nitrogen.

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