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PERMANENT MAGNET ALLOY

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2 Claims. (Cl. 75—153)

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The invention relates to alloys for permanent magnets and is a continuation-in-part of the copending application Serial No. 237,957, filed October 31, 1938.

As stated in the application Serial No. 111,252, filed November 17, 1936, now Patent No. 2,170,047, permanent magnets of a coercive force above 100 oersted and a remanence above 1000 gauss and distinguished by high tensile strength and good working properties, can be obtained with copper base alloys with nickel and cobalt, containing iron, if any, as a mere auxiliary ingredient of relatively low percentage. The limits for the main constituents of these alloys is 5 to 70% cobalt, 10 to 50% nickel and 20 to 85% copper. Iron may be present in amounts below 30%, preferably below 10%. Other auxiliary metals such as manganese or metals of the chromium group may also be admixed in minor quantities, preferably not exceeding a total of about 5%.

According to the present invention, permanent magnet alloys of the above-mentioned type are improved by adding thereto silver in an amount not over 10%. According to the further invention, if the alloy, besides copper and metals of the iron group, contains other metallic ingredients such as manganese, aluminum or chromium, the total amount of silver plus such other metals should not exceed about 10%. For instance, if the alloy contains copper and metals of the iron group within the above-stated percentile limits and also an addition of manganese and silver, the total amount of silver plus manganese should not be higher than about 10% to obtain optimum results. The invention permits increasing the magnetic qualities of the alloys, in particular as manifested by the magnetic power contents or the product of coercive force and remanence. The invention is also favorable in uses where an increased coercive force is desired without undue lowering of the remanence or vice versa. It is well known that an increase in coercive force or remanence can be obtained in most permanent magnet alloys by merely modifying the heat treatment. However, an increase in coercive force thus obtained incurs a considerable reduction in remanence, and vice versa, thus impairing the magnetic power of the magnet as compared with the optimum power content. In contrast thereto, the silver-containing alloys according to the invention permit increasing the coercive force or remanence without impairment to the magnetic power, and even, as mentioned, permit increasing the power content, and in many cases afford an

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increase in both the coercive force and remanence.

The numerical values of coercive force and remanence are, of course, not only dependent on the presence and percentage of the silver addition, but also on the composition of the copper base alloy and on the heat treatment. However, the presence of silver has the effect of increasing the potential power factor as compared with an otherwise similar composition not containing silver. In particular, it is favorable to replace part of the nickel content of the base alloy by silver within the limits above specified.

The invention is preferably carried out with alloys containing 15 to 65% cobalt, 15 to 35% nickel and 20 to 65% copper, with or without auxiliary additions. Especially favorable results are obtained with alloys consisting substantially of 25 to 45% cobalt, 20 to 35% nickel, 1 to 6%, preferably 3 to 5% silver, remainder copper with or without auxiliaries as above mentioned and usually containing customary impurities.

The effect of the silver ingredient will be apparent from the following comparative examples of alloys, all produced and treated under similar conditions.

An alloy composed of 30% cobalt, 30% nickel and 40% copper after being heat-treated as described below and upon magnetization exhibits a coercive force of H_c=520 oersted and a remanence of B_r=3600 gauss, the magnetic power as represented by the product $H_c \times B_r$ being about 1,860,000. Another alloy composed of 30% cobalt, 26% nickel, 4% silver, and 40% copper, after being heat-treated, has a coercive force of H_c=720, a remanence of B_r=2700, the product being 1,940,000. It will be seen that merely by replacing in the first alloy 4% of its nickel content by an equal percentage of silver, an increase in coercive force together with an increase in remanence and hence a considerably increased power content are obtained. The exceptional effect of silver as compared with an addition of such other metals, as mentioned in Patent No. 2,170,047, will be seen from the comparison with a third alloy. An alloy of 30% cobalt, 25% nickel, 5% manganese, and 40% copper, upon heat treatment has a coercive force of H_c=540 and a remanence of B_r=3500, the product $H_c \times B_r$ being 1,880,000. It will be seen that in this alloy the gain in coercive force is accompanied by a drop in remanence so that the power content is low as compared with the silver-containing alloy.

The three alloys were melted in a high-frequency induction furnace and cast in ingot molds.

They were then annealed for ten hours at a temperature of 1100° centigrade, quenched in oil and finally heated at a temperature of 650° centigrade between four and sixteen hours.

Similar results are obtained with other percentile compositions of alloys containing cobalt, nickel and silver with a remainder substantially all of copper, provided these essential components stay within the above-stated limits. The expression "substantially all copper" is intended to include alloys whose remainder contains negligible impurities or additions of auxiliary nature, in particular those above mentioned, provided their nature and quantity is such as not to interfere with the desired magnetic qualities nor with the tensile strength, ductility and workability characteristic for these copper-base alloys. For instance, an alloy according to the invention containing the approximate amounts of 30% cobalt, 24% nickel, 2% manganese, 4% silver and 40% copper, is also characterized by a high coercive force and an increase in magnetic power, in particular after an annealing, quenching and tempering treatment as above described. Other compositions in accordance with the invention contain, for instance, 40% cobalt, 30% copper, about 25% nickel, the remaining 5% being silver alone, or 1 to 4% silver together with auxiliaries such as manganese, aluminum, chromium and vanadium. A silver addition of up to 10% is also applicable to advantage in alloys containing about 60% or more copper together with approximately equal amounts of two or all three ferromagnetic metals of the iron group; for example, an alloy of 20% cobalt, 20% nickel, about 5% silver, remainder substantially all copper, may be mentioned.

We claim:

1. A permanent magnet alloy consisting of a silver content exceeding 5% and ranging up to 10%, a copper content of at least 55%, the remainder consisting substantially all of ferromagnetic metals.

2. A permanent magnet alloy consisting of a silver content exceeding 5% and ranging up to 10%, a copper content of at least 55%, the remainder consisting substantially of equal amounts of ferromagnetic metals.

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