Patented Apr. 6, 1937

2,076,250

UNITED STATES PATENT OFFICE

2,076,250

METHOD OF MAKING FERRO-MAGNETIC ALLOYS

Walter E. Remmers and Kenneth L. Scott, Western Springs, Ill., assignors to Western Electric Company, Incorporated, New York, N. Y., a corporation of New York

No Drawing. Application October 31, 1934, Serial No. 750,749

5 Claims. (Cl. 148—2)

This invention relates to ferro-magnetic alloys and methods of making such alloys, and more particularly to methods of making cobalt steel alloys.

Cobalt steel alloys are used extensively for permanent magnets. These alloys are quite expensive and, therefore, improvements in the magnetic properties thereof, permitting the reduction in size of the magnets, results in a considerable reduction in the cost of the magnets.

An object of the invention is to provide methods for making ferro-magnetic materials having good magnetic properties, such as high coercive force and high residual induction.

In accordance with one embodiment of the invention, a deoxidizing agent, such as calcium, sodium, titanium, hydrogen, or a calcium-silicon alloy is added to the molten cobalt steel to improve the magnetic properties of the product.

The type of ferro-magnetic materials to which this invention particularly relates is cobalt magnet steel which usually contains cobalt from 5% to 40%, carbon from .4% to 1.25%, manganese from .1% to 2.5%, silicon .05% to 1.5%, chromium from 1.5% to 10.0%, tungsten 1.5% to 10.0%, and the balance iron. These percentages refer to the more commonly used cobalt steels for permanent magnets; however, the invention is applicable to permanent magnet cobalt steel including other ingredients and proportions.

In the manufacture of cobalt steel in accordance with this invention, a furnace, such as an arc furnace, may be charged with the proper proportions of scrap steel, cobalt and a high carbon iron, such as washed metal, and the charge melted. Ferro-chromium, ferro-manganese, ferro-silicon and ferro-tungsten are then added to the charge in proportions determined by the character of the scrap steel and the composition of the final product desired. This charge is melted under a suitable slag covering. When the charge and the alloy additions are molten, a suitable deoxidizing ingredient is added to the molten charge. It appears that when a charge such as described above is molten, oxygen is dissolved by certain portions of the charge forming on solidification inert materials, poorly magnetic materials and generally deteriorating the steel by solutions of oxides therein and by preventing the proper alloying of the desired constituents. The effect of this not only reduces the amount of magnetic material in a given volume but also decreases the interfacial contact areas of the alloy particles, tending to reduce the coercive force of the final product. In order, therefore, to remove the dissolved oxygen from the molten metal, the molten bath is treated with a suitable deoxidizing ingredient, such as calcium, silicon, titanium, hydrogen, or a calcium-silicon alloy. Calcium may be added in an amount of approximately .05% of the weight of the alloy and after combining with the oxygen dissolved in the bath passes into the slag. Sodium may be used in an amount of .05% and acts similarly to calcium. When titanium is used, an amount of .06% has been found to be advantageous. When a calcium-silicon alloy is used, an amount of .15% may be added. Hydrogen is preferably bubbled through the molten bath. The hydrogen may be passed into the bath through an iron pipe and since this pipe will tend to melt away, allowance for the amount of iron thus added may be made in compounding the alloy. While the amounts of these ingredients to be added as specified above are not critical, care should be taken to add them in such amounts that there will not be a substantial residue of these ingredients in the final product, since some of them particularly might have a deleterious effect upon the magnetic properties of the steel. Since the removal of the dissolved oxygen or oxides increases the amount of material in the magnetic state in the alloy, the maximum and residual induction of the alloy will be increased. Also some of the oxides left in the alloy are thrown into the grain boundaries of the alloy and consequently the removal of oxygen increases the interfacial contact area between the magnetic particles to increase the coercive force of the alloy.

The molten steel after having been thus treated is usually cast into ingots which are rolled into bars for magnets or the magnets may be cast directly. After the bars are formed or the magnets are cast, they are heated to a temperature which may range from 1500° F. to 1800° F., from which the material is quenched, preferably in oil. Due to the wide temperature range in which this steel may be heat treated, it is less critical and results in a more uniform product.

While the theory above presented is believed to be correct, it is to be understood that the invention is not limited to any particular theory regarding the metallurgical changes which are responsible for the increased magnetic properties.

It will be understood that the embodiment of the invention herein described is merely illustrative and that many changes and modifica-

tions may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A method of making cobalt steel, which comprises compounding a molten charge having from 5% to 40% cobalt, .4% to 1.25% carbon, .05% to 1.5% silicon, .1% to 2.5% manganese, 1.5% to 10.0% chromium, 1.5% to 10.0% tungsten and the balance substantially iron, adding a deoxidizing agent to the charge, casting the molten alloy into ingots, rolling the ingots into bars, and quenching the bars from a temperature above 1500° F.

2. A method of making permanent magnet cobalt steel which comprises compounding a molten charge having from 5% to 40% cobalt, .4% to 1.25% carbon, .05% to 1.5% silicon, .1% to 2.5% manganese, 1.5% to 10% chromium, 1.5% to 10% tungsten and the balance substantially iron, adding thereto a deoxidizing agent selected from the group of calcium, sodium, titanium, hydrogen and calcium silicon, casting the alloy into ingots, rolling the ingots into bars, and quenching the bars from a temperature between 1500° F. and 1800° F.

3. A method of making permanent magnet cobalt steel which comprises compounding a molten charge having from 5% to 40% cobalt, .4% to 1.25% carbon, .05% to 1.5% silicon, .1% to 2.5% manganese, 1.5% to 10% chromium, 1.5% to 10% tungsten and the balance substantially iron, adding thereto a deoxidizing agent selected from the group of calcium, sodium, titanium, hydrogen and calcium silicon, casting the alloy into magnet shapes, and quenching the magnet shapes from a temperature between 1500° F. and 1800° F.

4. A method of making cobalt steel, which comprises compounding a molten charge having from 5% to 40% cobalt, .4% to 1.25% carbon, .05% to 1.5% silicon, .1% to 2.5% manganese, 1.5% to 10.0% chromium, 1.5% to 10.0% tungsten and the balance substantially iron, adding a deoxidizing agent to the charge, and quenching the steel from a temperature range of 1500° F. to 1800° F. to improve the magnetic properties thereof.

5. A method of making permanent magnet cobalt steel which comprises compounding a molten charge having from 5% to 40% cobalt, .4% to 1.25% carbon, .05% to 1.5% silicon, .1% to 2.5% manganese, 1.5% to 10% chromium, 1.5% to 10% tungsten and the balance substantially iron, adding thereto a deoxidizing agent selected from the group of calcium, sodium, titanium, hydrogen and calcium silicon, casting molten steel and quenching the steel from a temperature range of 1500° F. to 1800° F. to improve its magnetic properties.

WALTER E. REMMERS.
KENNETH L. SCOTT.