United States Patent Office 2,816,053 Patented Dec. 10, 1957

2,816,053

POWDERED METAL MAGNET WITH LOW RESIDUAL CHARACTERISTICS

Godshalk Berge, Skokie, Ill., assignor to The Yale & Towne Manufacturing Company, Stamford, Conn., a corporation of Connecticut

No Drawing. Application April 8, 1954, Serial No. 421,957

5 Claims. (Cl. 148—100)

This invention relates to the manufacture of magnet cores of powdered metals, the magnet cores to have low residual magnetic characteristics. As a feature of my invention, I contribute not only a magnet core of low residual characteristics, but also a magnet that may be manufactured economically and from materials that are readily available. As an example, I am able to contribute a very effective magnet of the particular class without utilizing nickel, which in itself is a contribution of considerable value because of the scarcity of nickel and its cost. In the art it is customary at this time to manufacture magnets utilizing iron, nickel and molybdenum. In actual composition it is customary to use approximately forty-eight percent (48%) to fifty percent (50%) iron powder, forty-seven percent (47%) to forty-nine percent (49%) nickel and two and twenty-eight hundredth percent (2.28%) to two and forty-eight hundredth percent (2.48%) molybdenum. In addition, there are traces of carbon, silicon, sulphur, and phosphorous.

The core of my invention is formed by the sintering of powdered iron, powdered tin and powdered molybdenum. I have found that by mixing about eighty (80) to ninety-seven (97) parts of iron powder, two (2) to six (6) parts of tin powder and one (1) to five (5) parts of molybdenum powder, I produce substantially the correct basic mixture. These powders I prefer to mold at approximately forty (40) tons per square inch pressure to the desired form, after which the powdered part is sintered in an atmosphere of dry hydrogen or dry dissociated ammonia at approximately twenty-one hundred degrees Fahrenheit (2100° F.) to twenty-three hundred degrees Fahrenheit (2300° F.) for two and one-half (2½) hours to three and one-half (3½) hours. Preferably, the mixture contains approximately five-tenths percent (.5%) of lubricant, such as zinc stearate, it being the function of the lubricant to decrease the friction between the powder particles to allow the movement of the particles toward one another when they are subjected to pressure. The lubricant definitely allows me to obtain a greater density at lower pressure than otherwise would be possible. In addition, the lubricant decreases the friction between the powder particles and the surface of the die, thereby also increasing the life of the die. I have found that when the pressed or molded parts are sintered, the lubricant is removed by decomposition or volatilization usually below six hundred degrees Fahrenheit (600° F.).

The sintering in an atmosphere of dry hydrogen or some other reducing atmosphere such as dry dissociated ammonia is extremely important since the atmosphere I have chosen protects the molded part from oxidation. Because the powders usually have some surface oxidation, and this may run as high as six-tenths percent (.6%) oxidation, the dry hydrogen atmosphere reduces this oxidation at least at the surfaces of the particles, and the resulting pure metal particles tend to alloy at least at their

surfaces. This surface alloying is of very considerable importance.

Of course, where prealloying is important, I utilize iron oxide (Fe_2O_3 or Fe_3O_4), tin oxide (SnO_2) and molybdenum oxide (MoO_3). These oxides are mixed in accordance with the percentage composition of the alloy and are then preferably reduced with hydrogen to their metallic alloy state. The resultant metal is then milled down so as to pass a one hundred (100) mesh screen. This resulting mixture can then be subjected to forty (40) tons pressure per square inch to form the final part that is to be sintered.

It is possible for me also to utilize a mixture of iron powder, tin powder, and ferromolybdenum powder, also in conformance to the percentage composition required. I have found that the most effective composition is ninety-four percent (94%) iron, four percent (4%) tin, and two percent (2%) molybdenum.

Frequently the sintered part finally produced under the teachings of my invention is more porous than desired, and therefore, it may become necessary to subject the part to coining, preferably under approximately fifty (50) tons per square inch pressure. Of course, coining may also take place frequently where close physical dimensions are required. I have found that by coining parts made in accordance with my invention under fifty (50) tons per square inch, the density is increased to seven and eighty-four hundredths (7.84) grams per cubic centimeter, this being very close to a non-porous condition. The quality of the magnet cores produced by me under this process improves with the increase in density, but it is not practical to go beyond the figures I have just indicated, since the increase in quality to be gained is very slight in proportion to the die wear and die breakage that would result through the application of higher pressures.

I have found that it is very important to subject the magnet cores to annealing, and preferably this annealing takes place in the same atmosphere in which the parts are sintered. In the annealing process the cores are heated to approximately twenty-two hundred and fifty degrees Fahrenheit (2250° F.) in a time period varying from one-half (½) hour to one (1) hour. Thereafter the temperature is gradually decreased approximately four degrees Fahrenheit (4° F.) to eight degree Fahrenheit (8° F.) per minute down to approximately ten hundred and fifty degrees Fahrenheit (1050° F.). I have found that the heat treatment and this annealing is extremely important because crystal or molecular strain must be removed in order to contribute the desired results.

As a particular example of my invention, I should like to refer to the following. To any of the basic mixtures I have described containing ninety-four percent (94%) iron, two percent (2%) molybdenum, and four percent (4%) tin, there is added five-tenths percent (.5%) lubricant such as zinc stearate. The mixture is then molded to the desired shape at a pressure of forty (40) tons per square inch and is preferably placed in a preheating furnace for the purpose of eliminating the lubricant, this elimination of the lubricant taking place at approximately six hundred degrees Fahrenheit (600° F.) to eight hundred degrees Fahrenheit (800° F.). The parts are then sintered in a reducing atmosphere of dry hydrogen or dry dissociated ammonia at approximately twenty-two hundred degrees Fahrenheit (2200° F.) for three and one-half (3½) hours. Thereafter, the parts are coined at fifty (50) tons per square inch to increase the density and to make the parts more accurate in physical dimensions. The sintered parts are then given a final annealing treatment by heating to twenty-two hundred and fifty degrees Fahrenheit (2250° F.) for one (1) hour, the temperature being then decreased at the rate of six degrees Fahren-

heit (6° F.) per minute down to ten hundred and fifty degrees Fahrenheit (1050° F.) to ten hundred degrees Fahrenheit (1000° F.).

Magnet cores formed of the composition I have herein set forth have electrical characteristics far superior to those of the prior art. In addition, the cost of my new magnet cores is thirty-five percent (35%) to fifty percent (50%) below that of prior art magnets because of the fact that I have eliminated use of the nickel required in the prior art. Magnet cores made in accordance with the teachings of my invention have been tested for residual magnetism after as many as one million (1,000,000) cycles of operation and have been found far superior to those magnets of the prior art. I think that my contribution to the art will now be clearly understood.

I claim:

1. A magnet core of low residual characteristics consisting of a sintered mixture of ninety-four percent (94%) powdered iron, four percent (4%) powdered tin, and two percent (2%) powdered molybdenum.

2. The method of making a magnet core of low residual characteristics comprising sintering a mixture of ninety-four percent (94%) powdered iron, four percent (4%) powdered tin, and two percent (2%) powdered molybdenum and then annealing the resulting body by subjecting it substantially to twenty-two hundred and fifty degrees Fahrenheit (2250° F.) in one hour and then decreasing the temperature six degrees Fahrenheit (60° F.) per minute to ten hundred and fifty degrees Fahrenheit (1050° F.) to ten hundred degrees Fahrenheit (1000° F.).

3. A magnet core of low residual characteristics consisting of a sintered mixture of eighty-nine (89) to ninety-seven (97) parts of iron powder, two (2) to six (6) parts of tin powder, and one (1) to five (5) parts of molybdenum powder.

4. A magnet core of low residual magnetic characteristics comprising a sintered and annealed body consisting essentially of (A) two (2) to six (6) parts of powdered tin, (B) one (1) to five (5) parts of powdered molybdenum, and (C) the balance to make a total of one hundred (100) parts, consisting substantially entirely of powdered iron.

5. The method of producing a magnet core of low residual magnetic characteristics, comprising sintering a compressed mixture of (A) two (2) to six (6) parts of powdered tin, (B) one (1) to five (5) parts of powdered molybdenum, and (C) powdered iron in an amount to constitute substantially the entire balance making up a total of one hundred parts, said sintering being carried out in a reducing atmosphere and at temperatures of the order of approximately 2100° to 2300° F., and then annealing the sintered body by heating to a temperature of approximately 2250° F. for one-half to one hour and gradually decreasing the temperature to approximately 1050° F. at the rate of approximately 4° F. to 8° F. per minute.

References Cited in the file of this patent

UNITED STATES PATENTS

1,790,704	Harris	Feb. 3, 1931
2,339,137	Berge	Jan. 11, 1944
2,407,234	Guthrie et al.	Sept. 10, 1946