

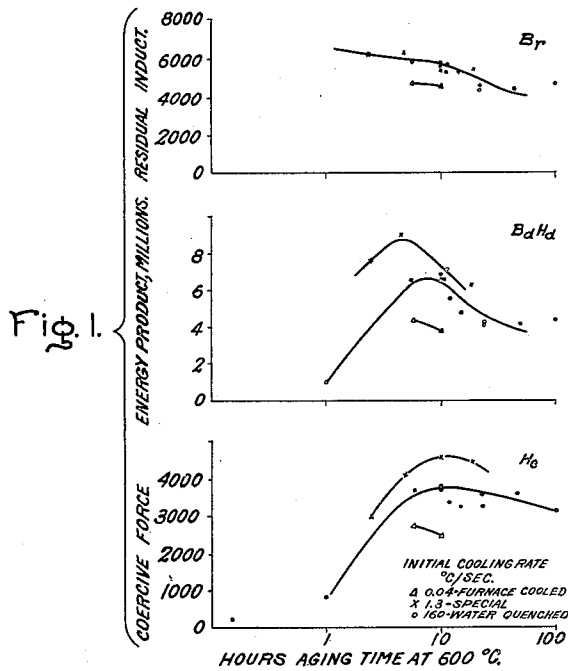
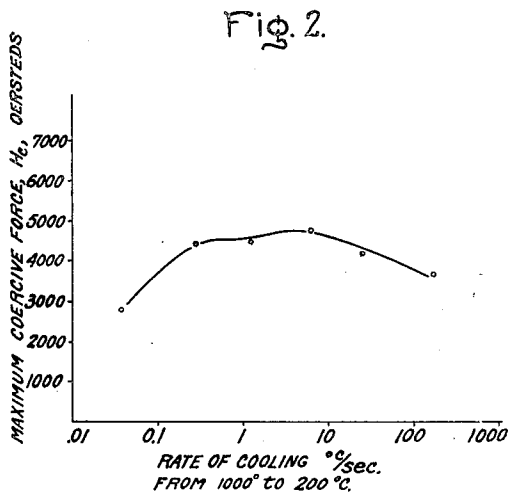
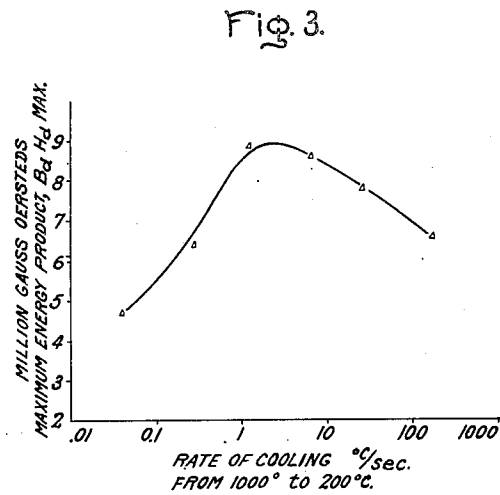
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PROCESS FOR HEAT-TREATING COBALT-PLATINUM MAGNETS

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Inventors:
Donald L. Martin,
Alfred H. Geisler,

by *Ames Coleman*
Their Attorney.

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PROCESS FOR HEAT-TREATING COBALT-PLATINUM MAGNETS

Donald Luther Martin and Alfred H. Geisler,
Schenectady, N. Y., assignors to General Electric Company, a corporation of New York

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The present invention relates to a cobalt-platinum magnet and is particularly concerned with the process of preparing a cobalt-platinum magnet having an exceptionally high energy value combined with a high coercive force.

It is well known that various cobalt-platinum alloys can be caused to exhibit permanent magnet properties. Prior investigations have shown that permanent magnets composed of alloys of cobalt and platinum can be prepared which possess a relatively high energy value of 3,800,000 gauss oersteds, combined with a high coercive force, H_c , in the neighborhood of about 2650 oersteds and an intrinsic coercive force, H_{ci} , of about 4000 oersteds. Heretofore, because of their high cost, no significant commercial interest has been shown in the cobalt-platinum magnet alloys due to the fact that the magnetic advantage previously exhibited by them over the known permanent magnet alloys was far outweighed by the exceptionally high cost of the platinum-containing alloys as compared with the commercially available high energy magnet alloys such as the magnetic alloys of iron, aluminum, cobalt and nickel known as Alnico.

While cost has probably been the determining factor in the commercial application of this material, it is obvious that given a material of sufficiently superior performance for a given application or applications, cost can become of secondary importance.

It is a primary object of the present invention to provide a cobalt-platinum permanent magnet possessing magnetic properties markedly superior to any realized heretofore, which properties are sufficiently good to warrant the commercial use of the magnet for certain applications in spite of the high cost thereof.

A further object of the invention is to provide a new and improved process for heat-treating a cobalt-platinum alloy whereby there is obtained a permanent magnet product possessing an energy value and a coercive force significantly higher than any heretofore obtained with the cobalt-platinum alloys or with any of the commercially available magnet alloys.

Additional objects of the present invention will become apparent with the following description thereof when taken in connection with the accompanying drawings in which Figs. 1 through 3 show the magnetic properties obtainable in accordance with the present invention.

Briefly described, the process of the present invention is based on the discovery that magnets possessing exceptionally high external energy and

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coercive force values can be obtained by subjecting a cobalt-platinum alloy containing from 17 to 23.5 weight-percent cobalt, balance platinum, to a disordering heat treatment at a temperature above 850° C., carefully controlling the rate of cooling of the alloy from the disordering heat-treatment temperature to a lower temperature not exceeding about 300° C., and thereafter subjecting the alloy to an ordering or annealing heat-treatment at a temperature of from 550 to 650° C.

The process of the present invention differs from the methods of processing the cobalt-platinum alloys as known heretofore primarily in the controlled rate of cooling from the disordering temperature and in the subsequent ordering or annealing treatment at a temperature between 550 and 650° C., preferably at about 600° C. As a result of the controlled cooling rate and the subsequent anneal, there has been obtained permanent magnets exhibiting maximum energy products $(B_a H_a)_{\max}$ over 8,500,000 gauss oersteds, coercive force values (H_c) of 4500 or more oersteds, and intrinsic coercive force values (H_{ci}) of 6000 or more oersteds.

In order to obtain these high values, it has been found necessary to employ alloys of cobalt and platinum in which the cobalt is present in amounts ranging from 17 to 23.5 percent by weight of the cobalt-platinum alloy. The alloys, prepared by any suitable method such as casting or sintering with or without hot or cold working, are subjected to a disordering treatment by heating to a temperature of at least 850° C. and preferably about 1000° C. for a period of time sufficient to obtain a complete or substantially complete disordering reaction within the alloy. Ordinarily, the alloy should be held at this temperature for from one to two hours. After the desired disordering reaction is obtained, the alloy is cooled to a low temperature below 300° C. at a rate of from 0.2 to 50° C. per second and is then aged or annealed at a temperature of from 550 to 650° C. for from 2 to 50 hours, the longer times being employed with the lower temperatures within this range. Finally the formed alloy is magnetized in a field of at least 10,000 and preferably 15,000 oersteds.

The rate at which the alloy is cooled from the disordering temperature has been found to be particularly critical when it is desired to obtain either a maximum external energy value or a high coercive force or both. This is best shown by reference to Fig. 1 of the drawing, setting forth the test results and curves based on these results for a number of different sam-

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ples of a cobalt-platinum alloy containing about 21.5% cobalt, cooled from the disordering temperature of 1000° C. down to a temperature of 200° C. at the rates indicated in the drawing. With reference to this figure, it will be noted that while there is no significant or substantial difference in the residual induction B_r , as between the water-quenched and specially-cooled samples, substantially higher energy values, $B_a H_a$, and coercive force values, H_c , were obtained by the specially-cooled samples over those which were cooled at either faster (water quenched) or slower (furnace cooled) rates. While the cooling rate for the specially-cooled samples in this series of experiments was 1.3° C./sec., substantial improvements in the magnetic properties can be obtained when the cooling rate is somewhat below or somewhat above this value, but within the range of from 0.5 to 50° C. per second, preferably from about 1 to 10° C. per second.

With further reference to Fig. 1, it will be seen that the external energy values and coercive force values are also dependent upon the time at which the products are held at the annealing or aging temperature, which in this case was 600° C. For example, it is to be noted that for maximum energy products, this time should range from approximately 2 to approximately 8 hours at 600° C., preferably about 5 hours, while if the primary requisite is a high coercive force, the preferred time of anneal at 600° C. may be anywhere from about 8 to 20 hours, with the highest values being obtained at about 9-14 hours.

The effect of the cooling rate on the magnetic values is best shown by reference to Figs. 2 and 3, where the maximum coercive force and energy product values obtained on magnets aged at 600° C. are plotted. Insofar as the coercive force is concerned, it will be seen in Fig. 2 that the cooling rate is critical. Air-cooled $\frac{1}{4}$ " diameter by $\frac{3}{8}$ " long samples which were cooled from 1000° C. to 200° C. at a rate of about 6.4° C./sec. exhibited coercive forces substantially higher than any of the remaining samples of the same dimensions which were cooled over this temperature range at either a faster or slower rate. The improved magnetic properties of the alloys prepared in accordance with the present invention are particularly evident from the results plotted in Fig. 3, showing the energy product values of the various samples cooled at different rates. From these results, it is seen that the products cooled at rates in the air cooling range, i. e., at a rate of from 1 to 10° C. per second, exhibit remarkably high external energy values, all of which are well over 8 million gauss oersteds.

All of the results plotted in the various figures of the accompanying drawing were obtained with cobalt-platinum alloys containing about 21.5% cobalt. Additional experiments have shown that the optimum composition for the alloys is within the range of 17 to 23.5 weight percent cobalt, corresponding approximately to 42 to 50 atomic percent cobalt. As the magnetic properties markedly decrease with a cobalt content above 50 atomic percent, it is desirable to maintain the cobalt content slightly below the 50-50 atomic ratio for optimum magnetic properties.

As a result of the present invention, there has been provided exceedingly strong permanent magnets which, in spite of their high cost, offer excellent possibilities for uses wherever a small

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but high energy magnet is required. For example, the magnets are particularly useful in certain types of instruments and meters where, due to space requirements, small but powerful magnets are required. Additional uses for the magnets of the present invention where cost is not a factor are those medical applications in which a small, powerful magnet is employed for removing ferromagnetic objects from the human body. Compared with the best-known commercially available, high energy magnet material, Alnico 5 (an anisotropic magnet composed of an alloy of 14% nickel, 24% cobalt, 3% copper, 8% aluminum, balance iron), a cobalt-platinum magnet $\frac{3}{8}$ " in length and $\frac{1}{4}$ " in diameter has a lifting power twenty-five times that of an Alnico 5 magnet of the same size. In smaller sizes these differences become even more marked, since the cobalt-platinum magnet with its high coercive force has greater resistance to self-demagnetization than the Alnico 5 magnet. Thus, it is seen that the magnets of the present invention are particularly useful and in fact relatively inexpensive wherever a small, powerful magnet is required.

A further and distinct advantage of the magnets of the present invention as compared with many commercially available magnet alloys is the fact that the cobalt-platinum alloys are ductile and machinable in the disordered condition and can be drawn into wires, formed into thin sheets, or otherwise shaped before being processed in accordance with the present invention. The ordering treatment hardens the alloy so that it is more difficult to deform and machine; however, even in the ordered condition the alloy is more readily machined than are the Alnico series of alloys.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. The method of treating a cobalt-platinum alloy containing from 17 to 23.5 weight percent cobalt, balance platinum, to obtain a high energy, high coercive force magnetic material, which method comprises subjecting said alloy to a disordering treatment by heating at a temperature of at least 850° C., cooling the alloy to a temperature not exceeding 300° C. at a rate of from 0.5 to 50° C. per second, and annealing the alloy at a temperature of 550 to 650° C. for from 2 to 50 hours.

2. The method of claim 1 in which the disordering treatment is carried out at a temperature of 1000° C.

3. The method of claim 3, in which the annealing temperature is about 600°, and the time of anneal is from 2 to 20 hours.

4. The method of treating a cobalt-platinum alloy containing about 21.5 weight percent cobalt, balance platinum, to obtain a high energy, high coercive force magnetic material which comprises subjecting said alloy to a disordering treatment by heating at a temperature of at least 850° C., cooling the alloy to a temperature not exceeding 300° C. at a rate of from $\frac{1}{2}$ to 50° C. per second, and aging the alloy at a temperature of from 550 to 650° C. for from 2 to 50 hours.

5. The method of claim 4, in which the disordering treatment is at a temperature of 1000° C.

6. The method of claim 5 in which the alloy is cooled from the disordering temperature to a temperature of 200° C. at a rate of from 1 to 10° per second.

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7. The method of claim 4, in which the disordering treatment is at a temperature of 1000°, the cooling rate is approximately 1.3 per second to a temperature of 200° C., and the alloy is aged at a temperature of 600° C. for about 9-14 hours to obtain a product which will exhibit a maximum coercive force.

8. The method of claim 4 in which the disordering treatment is at a temperature of 1000° C., the cooling rate about 1.3° C. per second to a temperature of 200° C., and alloy is aged a temperature of 600° C. for about 5 hours to obtain a product which after magnetization will exhibit a maximum energy product.

9. A high energy magnet consisting of an alloy of 17 to 23.5 percent by weight cobalt, balance

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platinum, which alloy has been subjected to a disordering heat treatment at a temperature of at least 850° C., cooled to a temperature of not over 300° C. at a rate of from 0.5 to 50° C. per second and annealed at a temperature of 550 to 650° C. for from 2 to 50 hours.

DONALD LUTHER MARTIN.
ALFRED H. GEISLER.

REFERENCES CITED

The following references are of record in the file of this patent:

"Zeitschrift fur Technische Physik," vol. 17, pages 33-36, 1936.