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TREATMENT OF MAGNETIC ALLOYS AND PRODUCTS RESULTING THEREFROM

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This invention relates to a process of treating magnetic alloys and more particularly to a method of heat treating alloys of the nickel-iron type to increase the permeability thereof, and to the new products resulting therefrom.

An object of the present invention is to provide a method of heat treating magnetic alloys to increase the permeability thereof.

A further object of the invention is to provide a simple and practical method of heat treating magnetic alloys of the nickel-iron type which can be carried out satisfactorily on an industrial scale.

It is another object of the invention to provide a method of heat treating magnetic alloys particularly permalloy and the like so as to increase the permeability thereof several times greater than that of the commercial alloys on the market while only increasing the cost of production a practically negligible amount.

Other objects of the invention will become clear from the description of a specific procedure for carrying the invention into practice.

A magnetic alloy of the iron-nickel type such as permalloy is produced in the usual way. After production, the alloy is preferably fabricated into the form in which it is to be used. For example, the alloy may be rolled into sheets. Care should be exercised at this stage of the operation to clean the fabricated magnetic alloy and free the same from grease before annealing.

The magnetic alloy of the permalloy type is subjected to an initial super-annealing treatment in which a super-temperature is employed for a period of time sufficient to produce the new results of the present invention. In practice, it has been found that subjecting the magnetic alloys to a super-temperature of about 2000° F. to about 2200° F. is satisfactory when maintained for a period of time from about 4 hours to about 8 hours. Following this initial super-annealing treatment, the alloy is preferably slowly cooled. By "slow cooling" is meant cooling at a rate slower than 1000° F. per hour. It should be noted that the initial super-annealing and the slow cooling should be carried out in a hydrogen or equivalent atmosphere.

The cooled magnetic alloy is reheated in air to a temperature of about 1000° F. to about 1200° F. for a period of time of about 10 minutes to about 20 minutes. The reheated magnetic alloy is then rapidly cooled on a copper plate which initially has a temperature approximating that of the atmosphere. Instead of using a copper plate, a moist cloth can be used for rapidly cooling the heated magnetic material.

The magnetic alloys produced by the foregoing procedure have been found to possess far greater permeability than the same alloy when subjected to the old conventional heat treatment. On the average, it has been found that the permeability of the magnetic alloy subjected to the heat treatment of the present invention is at least two to three times greater than the permeability of the same magnetic alloy when subjected to the old conventional heat treatment. At the same time, the cost of producing the greater permeability in the magnetic alloy is very slight and is practically negligible when compared with the selling price of the alloy.

A specific example will now be described of carrying the invention into practice on an industrial scale. It is to be noted, however, that the example is merely for illustrative purposes and for a better understanding of the invention for those skilled in the art.

A magnetic alloy of the permalloy type composed of about 78½% nickel and about 21½% iron is cleaned and is free from grease. It is preferred to coat the sheets or the like of magnetic alloy with a refractory powder such as MgO or CaO to prevent the sheets from sticking together. It should be noted that care should be taken to have the refractory powder free from sulphur.

The prepared sheets of magnetic alloy are now subjected to an initial super-annealing treatment. In practice, it has been found satisfactory to heat those sheets in an atmosphere of hydrogen to a super-annealing temperature to about 2000° F. This super-annealing is preferably carried out in a resistance type of furnace. By maintaining the

sheets at the super-annealing temperature of 2000° F. for a period of about 4 hours, the new results of the present invention may be obtained.

The sheets heated to the super-annealing temperature are slowly cooled in the furnace preferably in a hydrogen atmosphere. After cooling, the sheets are reheated in air to a temperature of about 1160° F. for a period of about 15 minutes. The reheated sheets are then rapidly cooled on a copper plate which initially has a temperature approximating that of a room or space in which the cooling is carried out.

Magnetic alloys of the permalloy type when subjected to the foregoing procedure were found to give surprisingly high permeability. These permeabilities were in each case at least three times greater than the permeabilities of the same alloy when subjected to the old conventional heat treatment. The following table gives figures which clearly illustrate the new results produced by the present invention.

Table

Maximum permeabilities of nickel-iron alloy of permalloy type

Basic electric furnace melts

Melt No.	Old heat treatment	New heat treatment
Y-745	80,000	230,000
Y-815	40,000	200,000
Y-820	83,300	210,000
Y-849	94,000	325,000

Acid electric furnace melts

Melt No.	Old heat treatment	New heat treatment
Y-946	90,000	203,000
Y-947	85,000	230,000

Acid open hearth melts

Melt No.	Old heat treatment	New heat treatment
Y-944	120,000	205,000
Y-950	110,000	200,000

From the foregoing table, it will be appreciated that the permeabilities given for the magnetic alloys when subjected to the old conventional heat treatments approximate those of the commercial magnetic alloys of the permalloy type now on the market. The figures given for the magnetic alloys of the permalloy type show that the present invention produces permeabilities which are far in excess of those of old conventional alloys. In general, the present invention gives permeabilities from about two to above five times higher than those given by conventional heat treatments. The benefits to be enjoyed by the art from the present invention are evident to those skilled in the art. The electrical industry will be greatly benefitted by the present invention and the improved magnetic alloy with super-permeabilities can be used with especially good results in the production of transformers and other apparatus and electrical machinery in which magnetic alloys of the permalloy type are subjected to alternating magnetizing forces which have a tendency to cause electrical losses through hysteresis effects, non-uniform distribution of flux, etc., as those skilled in the art will readily understand.

While the above example illustrates the great value of the new heat treatment on nickel-iron alloys having nickel in the neighborhood of 78½%, it will be understood that other alloys of nickel-iron composition will be greatly enhanced in their permeability by employing the method of heat treatment herein.

For instance, alloys having nickel from 65% to 80% and the balance iron show increases in permeability in accordance with the following table:

Maximum permeability

Per cent nickel	Old heat treatment	New heat treatment
65	20,700	56,800
70	59,000	76,000
75	61,000	83,500
78	145,000	250,000
80	150,000	233,000

It will be noted from the above disclosure that a new product has been produced which has especially valuable magnetic characteristics. It will be further noted that the improved method for producing this novel product is simple and neither difficult nor lengthy in application, but it does permit production of a product having great value and permits this production with very little increase in cost, and practically no increase in cost when considering the value of the new product.

It will also be observed that the present invention provides a process wherein permeabilities can be obtained which are in excess of 120,000; 150,000; 200,000 and even 300,000. With nickel-iron alloys of the permalloy type, it will be observed from the first table that a magnetic product can be produced of a super-annealed nickel-iron alloy of the permalloy type having permeabilities of at least 200,000.

It will also be noted that the present invention provides a process which can be carried out on an industrial scale and which is capable of producing consistently and repeatedly magnetic alloys having a permeability in excess of industrial magnetic products which have heretofore been commercially available.

What is claimed is:

1. The process of heat treating magnetic alloys of the nickel-iron type, which com-

prises subjecting such alloys to an initial super-annealing treatment, slowly cooling the super-annealed alloys in a hydrogen atmosphere, reheating the cooled alloys to about 1160° F. in air, and rapidly cooling said reheated alloy on a copper plate.

2. The process of heat treating magnetic alloys of the nickel-iron type, which comprises subjecting an iron-nickel alloy containing about 78% nickel and about 22% iron to an initial super-annealing treatment for about 4 hours at a temperature of about 2000° F., slowly cooling the super-annealed alloy in an atmosphere of hydrogen, reheating the cooled alloy to a temperature of about 1160° F. for about 15 minutes and then rapidly cooling the thus reheated alloy on a copper plate having a temperature approximating that of the atmosphere, whereby the magnetic permeability of the alloy is increased several times greater than the permeability of magnetic alloys treated with conventional heat treatments.

3. An article of manufacture comprising an industrial magnetic product composed of a nickel-iron alloy having a permeability in excess of at least 200,000.

4. An article of manufacture comprising an industrial magnetic product composed of a nickel-iron alloy having a permeability in excess of at least 300,000.

5. An article of manufacture comprising an industrial magnetic product composed of an iron-nickel alloy which has been super-annealed in a hydrogen atmosphere to impart a permeability in excess of 150 000.

6. An article of manufacture comprising an industrial magnetic product composed of an iron-nickel alloy which has been super-annealed, slowly cooled in a hydrogen atmosphere, reheated in air to a high temperature and then rapidly cooled on a copper plate to impart a permeability to the product in excess of 150,000.

7. An article of manufacture comprising an industrial magnetic product composed of an iron-nickel alloy which has been super-annealed at a temperature of about 2000° F. for about 4 hours, slowly cooled in an atmosphere of hydrogen, reheated in air to a temperature of about 1160° F. for about 15 minutes and rapidly cooled on a copper plate to impart to the product a permeability in excess of about 150,000.

8. An article of manufacture comprising an industrial magnetic product composed of an iron-nickel alloy consisting of about 75% nickel to about 80% nickel and the balance iron, which has been super-annealed in a hydrogen atmosphere to impart a permeability in excess of 150,000.

9. An article of manufacture comprising an industrial magnetic product composed of an iron-nickel alloy consisting of about 75% nickel to about 80% nickel and the balance iron, which has been super-annealed to impart a permeability in excess of 200,000.

10. An article of manufacture comprising an industrial magnetic product composed of an iron-nickel alloy consisting of about 75% nickel to about 80% nickel and the balance iron, which has been super-annealed to impart a permeability in excess of 300,000.

11. In the art of heat treating magnetic alloys of the nickel-iron type, that improvement which comprises subjecting the nickel-iron alloy to an initial super-annealing treatment in a hydrogen atmosphere substantially free from moisture and oxygen, slowly cooling the super-annealed alloy in a hydrogen atmosphere substantially free from moisture and oxygen, reheating the cooled alloy to a temperature lower than said super-annealing temperature and rapidly cooling the thus reheated alloy, whereby the permeability of the alloy is greatly increased.

12. The process of heat treating magnetic alloys of the nickel-iron type, which comprises rolling a magnetic iron-nickel alloy to form a sheet, treating said sheets to clean the same and remove grease therefrom, coating the cleaned sheets with a refractory material of the group comprising magnesia and lime, said refractory material being free from sulfur, arranging the thus-coated sheets in a stack, subjecting the stack to an initial super-annealing treatment for about several hours at a temperature of about 2000° F., slowly cooling the super-annealed alloy in a reducing atmosphere of dried gases, re-heating the cooled alloy to a temperature of about 1160° F. for a relatively short time and then rapidly cooling the thus reheated alloy, whereby the magnetic permeability of the alloy is greatly increased.

13. The process of heat treating magnetic alloys of the nickel-iron type which comprises subjecting such alloys to an initial super-annealing treatment in a reducing atmosphere containing hydrogen substantially free from moisture, slowly cooling the super-annealed alloys in a reduced atmosphere containing hydrogen substantially free from moisture, reheating the thus cooled alloys to a lower temperature than the super-annealing temperature and rapidly cooling the thus reheated alloys whereby the permeability of the alloys is greatly increased.

In testimony whereof, I have hereunto set my hand.

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