

UNITED STATES PATENT OFFICE.

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METHOD OF TREATING MAGNETIZABLE MATERIALS.

No Drawing.

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This invention relates to an improved method for increasing the magnetic permeability of magnetizable material in general, and more particularly to a method of improving the characteristics of nickel iron alloys which are used as a loading material for electrical signaling conductors.

as a loading material preferably about 78% nickel and the balance iron (impurities not being considered) and is of such a nature that it has a very high permeability at low magnetizing forces. The properties and uses of this material are described more in detail in Patent 1,586,884 to G. W. Elman, issued June 1, 1926.

It is characteristic of certain magnetizable materials, particularly of the nickel iron alloy known as "permalloy", which will be described hereinafter, that when they are stressed they lose a very great deal of their permeability.

In order to understand more in detail the manner of employing the method referred to above, and at the same time to enable those skilled in the art to apply the same or analogous details of the method to other materials, the method as applied to permalloy, will be explained.

The principal object of this invention is to provide a method for so treating a nickel iron alloy that if after it has been treated, it be subjected to stress or strain below its elastic limit, its magnetic permeability will not be deleteriously affected.

Another object of the invention is to provide an improved method for increasing the magnetic permeability of magnetic materials.

Other objects and features of the invention will appear from the consideration of the following description and will be particularly pointed out in the appended claims.

This invention consists in a novel heat treatment to be applied to magnetic material which has been applied to a copper conductor to form inductive loading therefor wherein the loading material is subjected to a very high temperature, the rate of cooling being controlled so that below a predetermined temperature, for a nickel iron alloy such as permalloy about 550° C. the cooling is very rapid. The quick heating is accomplished by locally flash heating the material, and the cooling is controlled by any suitable means.

Owing to the difficulties which arise in a commercial process, when the method as stated above is employed, a double heat treatment is preferably used instead of controlling the temperature. In this case the material is heated to a high temperature by flashing, cooled at a normal rate, reheated in an auxiliary furnace to a somewhat lower temperature which will be explained more in detail hereinafter, and then cooled quickly. The method can be advantageously employed for treating nickel-iron alloys, and particularly the nickel-iron alloy which has been termed "permalloy." This material is an alloy of nickel and iron, and when used

One of the uses of permalloy is as a continuous inductive loading material for electrical conductors as described in Patent 1,586,874 to O. E. Buckley, issued June 1, 1926. Permalloy used in this manner is made into a thin narrow tape and spiralled onto the conductor. It is given a final heat treatment for the purpose of building up a high permeability therein after it has been applied to the conductor, the heat treatment before application being insufficient because the mechanical manipulation incident to applying the tape to the conductor causes a stressing of the permalloy and a consequent loss of permeability.

Permalloy in the form of tape and applied to a conductor can be treated by the process constituting this invention. In its preferred form the process comprises four steps, and these steps may be as follows:

Specifically, the first step is to locally flash heat the tape at a high temperature and for a comparatively short length of time. This might be supposed to present difficulties on account of the difference in the melting points of permalloy and the copper conductor, the melting points for the two metals being about 1470° C. and 1060° C. respectively. It is found, however, that flash heating of the permalloy tape at a temperature above 1200° C. will induce the proper conditions in the tape if continued for a space of time less than two seconds, and it has been observed that if the permalloy is heated in this manner, it will not conduct sufficient heat to the conductor to cause the copper to melt. A very desired temperature in this step is found to be 1275° C.

In order to obtain the characteristic in the treated tape which causes the permea-

bility to increase instead of decreasing when stressed within its elastic limits a temperature at least as high as 900° C. should be employed. This property which causes the permeability to increase instead of decreasing may be termed the stress characteristic and will be explained more in detail hereinafter.

The second step of the preferred embodiment of the invention consists in cooling the material treated, specific reference being had to permalloy tape. Certain materials including nickel-iron alloys show a change on heating, termed an allotropic change and inversely an allotropic change is observed in these same materials on cooling. However, if certain impurities such as carbon be present in the material, these changes will be retarded if the material is cooled too quickly. It is desirable when treating materials according to the preferred embodiment of the present invention to cool them as quickly as possible without retarding metallurgical and allotropic changes. Permalloy being a comparatively pure composition, whatever allotropic changes occur take place very rapidly and the tape therefore may be cooled in air after the first heat treatment. It should be allowed to assume a temperature as low as 300° C. before it is subjected to the next step of the process.

The third step of the preferred embodiment of the present invention applied to permalloy consists in heating the material to a predetermined temperature which is lower than the temperature employed in the preliminary heating. In general this second temperature should not be appreciably below 550° C. In some materials the best temperature may coincide with the Curie point. For instance the Curie point for permalloy is about 610° C. By heating this material to a temperature above the Curie point the greatest permeability to which the material is susceptible can be obtained in a shorter length of time than if a temperature below the Curie point is employed. Good results have been obtained by heating permalloy tape at temperatures between 600° C. and 800° C. A specific temperature which gives very desirable results is 690° C. continued for slightly less than two minutes.

The fourth step in the treatment of permalloy tape is cooling it after the second application of heat. As was indicated above, if material, particularly alloys of nickel and iron, having high magnetic permeability be subjected to stress or strain a great deal of their permeability is lost. Nonuniform expansion or contraction of such materials will set up mechanical strains in portions of the material. After the application of the second heat treatment, it is desirable to cool the permalloy as quickly as possible without causing non-uniform contraction and

consequent strain in the material. Good results have been obtained by cooling permalloy tape at a maximum cooling rate of 25° C. per second maintaining an average rate of about 15° C. per second. The temperature may be controlled by cutting out turns of a rheostat if electric heating is used or by other suitable means where other types of heating are employed.

By employing only the first and second steps of the process described above, comparatively good permeability may be obtained and the stress characteristic referred to above is also present to a certain extent. Where the maximum amount of permeability is not necessary the permalloy on the conductor may be treated according to the first and second steps of the process only. However, to establish the maximum characteristics, it is desirable that the process be carried on as described, the different requirements outlined in the consideration of each one of the four steps being observed.

Permalloy tape when treated according to the method constituting this invention shows a slight rise in permeability when tension is applied, and shows very little loss in permeability until its elastic limit is reached. When permalloy is treated according to this process it has a higher permeability than is obtainable by processes heretofore employed. For example, a comparison made in two representative pieces of permalloy tape, one treated according to a former process and the other treated by the process constituting the present invention is as follows:

The permeability of the unstressed stock was 3750 and 5500 respectively. A stress of 4000 pounds per square inch applied to each, caused a drop in permeability of the first-mentioned stock from 3750 to 1750 and a rise in permeability of the latter-mentioned stock from 5500 to 7200. An additional stress of 4000 pounds per square inch caused the first-mentioned stock to drop from 1750 to 1250 in permeability while the same stress applied to the second-mentioned stock caused its permeability to drop from 7200 back to 5500.

Permalloy in the form of tape applied to a conductor is under a stress continually, the force necessary for retaining the tape on the copper conductor varying from one to three pounds. The cross-sectional area of the tape usually employed is about .00075 inch, and a three pound load on a tape of this size is equivalent to a stress of about 4000 pounds per square inch. The advantages of employing a tape which will increase in permeability from 5500 to 7200 over a tape which will decrease from 3750 to 1750 when three pounds stress are applied thereto is obvious in the light of this fact. It is also to be observed that besides

the advantage of this stress characteristic, unstressed permalloy treated according to this improved process has a considerably higher permeability than unstressed permalloy treated according to other processes.

Although a specific description has been given with reference to the application of the method constituting this invention to permalloy in the form of tape, it is to be understood that the invention is not to be thereby limited, but is to be restricted only by the scope of the appended claims.

What is claimed is:

1. A method for improving the magnetic characteristics of magnetizable materials, which consists in locally flash heating said material to a high temperature, cooling the material, and controlling the rate of cooling to cause a rapid loss of heat in the material from a temperature not below 500° C.

2. A method for improving the magnetic characteristics of magnetizable materials in strand form, which consists in successively flash heating contiguous portions of the strand, cooling said strand, and controlling the rate of cooling thereof to cause a rapid loss of heat in the material composing said strand from a temperature not below 500° C.

3. A method for increasing the permeability of permalloy which has been applied to a copper conductor which consists in locally flash heating said tape at a temperature above 900° C. cooling the air, and then reheating to a temperature above the temperature at which maximum permeability occurs.

4. A method for increasing the permeability of permalloy tape which has been applied to a copper conductor, which consists in locally flash heating said tape at a temperature above 900° C. cooling in air, and then reheating said tape to a temperature not lower than 500° C.

5. A method for increasing the permeability of permalloy tape which has been applied to a copper conductor, which consists in locally flash heating said tape at a temperature above 900° C. cooling in air, reheating said tape at 690° C. and then cooling at the rate not greater than 25° C. per second maximum.

6. A method for increasing the permeability of permalloy tape which has been applied to a copper conductor, which consists in locally flash heating said tape at 1275° C. cooling in air, and then reheating said tape at 690° C.

7. A method for increasing the permeability of permalloy tape which has been applied to a copper conductor, which consists in locally flash heating said tape at 1275° C. cooling in air, reheating said tape at 690° C., and then cooling at the rate of about 15° C. per second.

8. A method for improving magnetic characteristics of materials, which consists in locally flash heating the material at a temperature above 900° C. cooling, and then reheating at 690° C.

9. A method for improving the magnetic characteristics of material, which consists in locally flash heating the material at a temperature above 900° C., cooling at least to 300° C. and then reheating at 690° C.

10. A method for improving the magnetic characteristics of material, which consists in locally flash heating the material at a temperature above 900° C. cooling at least to 300° C., reheating to 690° C. and then cooling at the rate of about 15° C. per second.

In witness whereof, I hereunto subscribe my name this 2nd day of December A. D., 1924.

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