

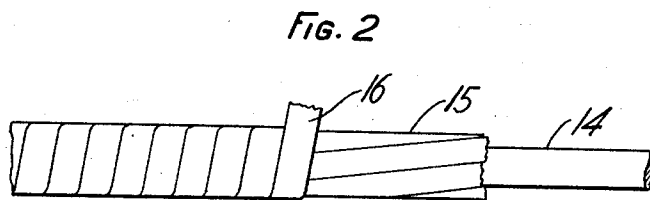
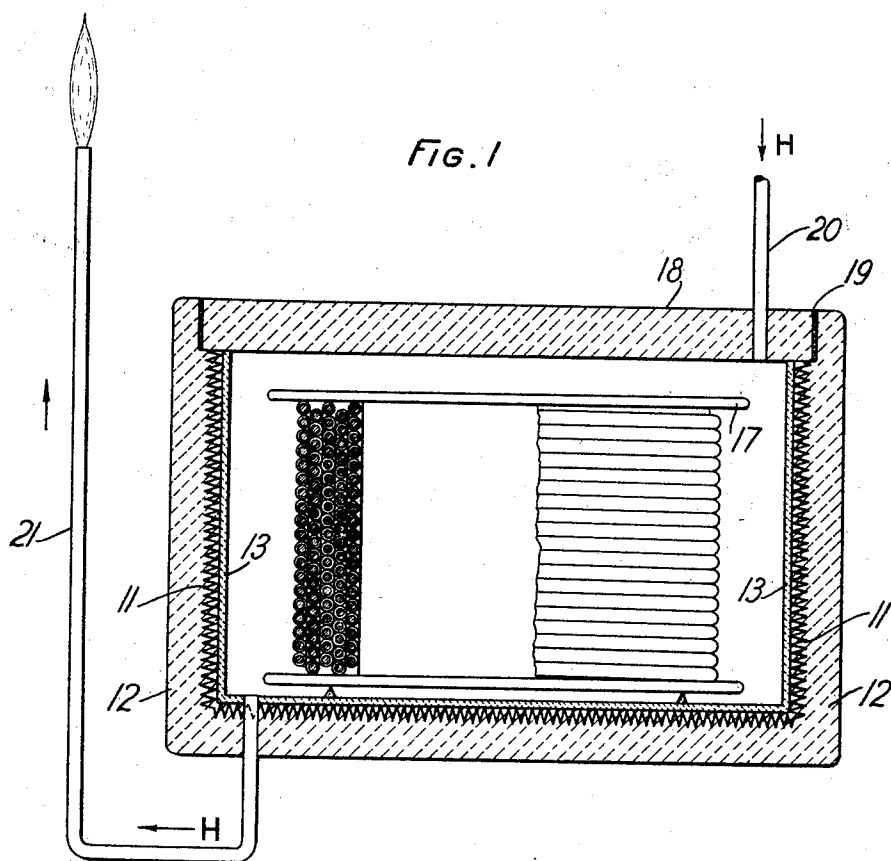
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MAGNETIC MATERIAL

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MAGNETIC MATERIAL

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The present invention relates to heat treatments for developing desired magnetic properties in magnetic materials, and particularly to the loading of conductors with magnetic materials having properties improved by heat treatments in hydrogenous atmospheres.

An object of the invention is to load electrical conductors with magnetic materials having improved properties. In general this improvement is effected by heat treatments in hydrogen.

Another object of the invention is to produce high initial permeability, high constancy of permeability, low coercive force and low hysteresis loss, in magnetic materials applied to inductively loaded conductors.

A further object of the invention is to improve the magnetic properties of loading material applied to a conductor. This object is effected by heat treating the loaded conductor in hydrogenous atmospheres.

A feature of the invention is the annealing of conductors loaded with magnetic material heat treated in hydrogen prior to the loading, in order to partly or entirely restore the original magnetic properties to the loading material.

This application is, as to part of the subject matter, a continuation of applicant's former application, Serial No. 325,883, filed December 13, 1928. Information given herein is to be interpreted in the light of the disclosure of that application.

In the said former application there are disclosed methods of securing desirable magnetic properties in magnetic materials such as iron and alloys of iron with other elements, such as nickel, cobalt, molybdenum, aluminum, etc. by heat treating the materials in hydrogenous atmospheres.

Magnetic materials treated in accordance with the invention of the former application may find a field of application as inductive loading material for signaling conductors, owing to the fact that their useful magnetic properties may be restored after the original heat treated material has been subjected to detrimental influences, simply by giving the material a heat treatment at about or in the neighborhood of the phase transformation

point (i. e., the point at which the material changes its crystal structure), if the material exhibits such a transformation at a temperature below the melting point of the loaded conductor, which is at about 1080° C. in the case of a copper conductor (iron has such a transformation point at about 880° C.). Either after or before having received the first heat treatment in hydrogen at a temperature near the melting point of the magnetic material, the material is formed by known methods into tape or wire of suitable dimensions, and then applied helically to the conductor to be loaded. Deleterious strains introduced into the tapes or wires of the magnetic loading material during the forming and/or winding operations are relieved by giving the loaded conductor the second heat treatment in hydrogen or not, as preferred.

In the continuous loading of signaling cables by tapes or wires of material of high initial permeability wrapped around the conductor to be loaded, the operations involved in the production and the wrapping of the loading tape around the conductor introduce considerable stresses and strains in the material. This causes a decrease of the initial permeability and a deterioration of the other magnetic properties. The initial permeability of iron, for instance, has been found to be reduced from about 3500 to a value as low as 250. In order to partly, at least, restore the high permeability, a special heat treatment has to be resorted to after the loading tape has been wound in place on the conductor. With some of the loading materials of the type known heretofore, this heat treatment gives the best results at temperatures between 1000° and 1100° C. Since, however, the melting point of copper is around 1080° C., this heating operation is not only difficult of execution and requires great precautions, but it often results in the softening of the copper conductor and causes the loading tape to adhere thereto, thus defeating the purpose of the heat treatment.

In accordance with one feature of the present invention this difficulty is avoided by:

(1) Heat treating the loading material in

hydrogen, before its application to the conductor, at any desired high temperature and corresponding hydrogen pressure;

(2) Applying the loading material to the copper conductor; and

(3) Heat treating the loading material in situ on the conductor at a lower temperature; it is not essential in many cases for the attainment of improved results from the first treatment in hydrogen that the second step of the heat treatment should be carried out in a hydrogenous atmosphere, a feature which is of considerable practical importance.

Magnetic materials comprising about 45% nickel, 25% cobalt and the balance iron, with or without molybdenum, are beneficially influenced by the treatments set forth in the parent application. These materials are particularly suitable as loading materials in view of the fact that they are not only susceptible of having the initial permeability increased if treated in accordance with the invention, but also since this increase in the initial permeability is not accompanied by a noteworthy decrease in the constancy of permeability.

A magnetic material of this type which comprised about 47% nickel, 25% cobalt, 7½% molybdenum, 0.3% manganese and the balance iron, having the form of tapes .125" (3.175 millimeters) wide and .006" (0.1524 millimeter) thick, heated in hydrogen at 1100° C. for one hour and cooled to room temperature in about 20 minutes, was found to have an initial permeability of about 3525 and a constancy of permeability such that the permeability changed only 6% for a magnetizing force varying from zero to .51 gauss.

In Fig. 1 of the accompanying drawing is shown a furnace suitable for carrying out the heat treatment of this invention in the case where the magnetic materials are used to continuously load a signaling conductor, the loaded conductor itself being shown in Fig. 2.

The furnace shown in Fig. 1 is of the electrical resistance type and comprises heating element 11 between a layer of fire brick or fire clay 12 and a lining of refractory material 13. The conductor 14 including the segmental surrounds 15 (see Fig. 2) and loading material 16 is wound upon a reel 17 of heat resisting material having a sufficiently large diameter to prevent the deterioration of the magnetic properties of the loading material when subjected to the strains involved in the unwinding and straightening of the conductor after the heat treatment. Cover 18 is luted to the furnace with fire clay 19 and is pierced by a pipe 20 connected to a source of hydrogen supply (not shown). An exhaust pipe 21, provided in the bottom of the furnace, conducts the hydrogen into the atmosphere where it is burned.

A sample conductor loaded with a tape

.002" (0.0508 millimeter) by .025" (0.635 millimeter) of magnetic material comprising 47% nickel, 25% cobalt, 7½% molybdenum, .03% manganese and the balance iron, was heated to a temperature of 950° C. for 6 minutes in hydrogen at atmospheric pressure. It was then cooled slowly by allowing it to cool within the furnace, and its magnetic properties were measured. It was found to have an initial permeability of 930 and a constancy of permeability such that the permeability increased only 3% for a magnetizing force varying from zero to .11 gauss.

Another sample conductor loaded with the same material and heated to the same temperature for the same length of time was found to have an initial permeability of 722; this permeability varied only 3% for a magnetizing force varying from 0 to 0.14 gauss.

Commercial iron, such as Armco iron, for instance, may be first heat treated in the form of wire or tape in hydrogen at a temperature between 1200° C. and the melting point of the iron, with a gas pressure in accordance with the following table:

A

Temperature	Pressure
1200-1300° C.	At least 1520 mm. of mercury
1300-1400° C.	At least 760 mm. of mercury

After cooling, the iron wire may be wound around the copper conductor and the loaded conductor may be heat treated, either in hydrogen or not, at a temperature between 800° C. and 900° C., until the desired magnetic properties are restored to the loading tape.

Cooling the wire at a rapid rate after the first hydrogen treatment appears to have substantially the same effect upon the magnetic properties as cold working it. Thus a wire which was heated in hydrogen at about 1500° C. for 30 minutes and rapidly cooled was found to have an initial permeability of 400 while the same wire slowly cooled had an initial permeability of 2000. However, by again heating the rapidly cooled wire in hydrogen at a temperature of only 880° C., an initial permeability of 9100 and a maximum permeability of 49000 was produced.

Iron is of low resistivity and is not a preferred magnetic loading material for this reason. The present invention is generally applicable to alloys of iron with other substances to produce compositions of increased resistivity, increased initial permeability and other desirable properties. Iron-molybdenum compositions, compositions containing iron oxides, iron-nickel alloys of the permalloy type, iron-silicon alloys, and iron-nickel-cobalt alloys are usually preferable

to iron although the scope of the invention is not limited to the treatment and use of the materials mentioned, but contemplates the loading of any conductor with any magnetic material whose properties are susceptible of being improved by heat treatment in a hydrogenous atmosphere such as hydrogen or mixtures of hydrogen and nitrogen, etc. Furthermore, the heat treatment of the magnetic material may be done either before or after its application to the conductor, or both before and after such application.

After these materials have been heated in hydrogen in accordance with the data listed in Table A, and cooled, they may be applied to load a conductor, and again heated on the conductor at a temperature corresponding to their phase transformation point, that is, to a temperature in the neighborhood of 900° C. The second heat treatment may take place in a hydrogenous or other atmosphere.

What is claimed is:

1. Method of loading an electrical conductor, which comprises heat treating a magnetic material, applying the material to the conductor and heat treating the material on the conductor, characterized in this, that at least one of the heat treatments takes place in a hydrogenous atmosphere.

2. Method of loading an electrical conductor, which comprises heat treating a magnetic material, applying the material to the conductor, and heat treating the material on the conductor, characterized in this, that only the first of said treatments takes place in a hydrogenous atmosphere.

3. Method in accordance with claim 1 characterized in this, that both heat treatments take place in a hydrogenous atmosphere.

4. Method as defined in claim 1 characterized in this, that at least one of the heat treatments is in accordance with the following table:

Temperature	Hydrogen pressure
1200-1300° C.	At least 1520 mm.
1300-1400° C.	At least 760 mm.

5. Method as defined in claim 1 characterized in this, that the second heat treatment is at a temperature in the neighborhood of the phase transformation point of the magnetic material, but below the melting point of the conductive material.

6. Method as defined in claim 1 characterized in this, that the second heat treatment is at a temperature sufficient to relieve strains introduced in the magnetic material by the cold working thereof.

7. Method of continuously loading a conductor incapable of standing high temperatures, for example, a copper conductor loaded with iron, characterized by first heating the iron in a hydrogenous atmosphere to a tem-

perature which the conductor is incapable of withstanding, for example, in the case of a copper conductor, above the melting point of copper, then applying the iron about the conductor and heating the iron after its application to a temperature sufficient to compensate for the loss of permeability in the iron due to mechanical strain, but insufficient to damage the conductor, for example, to a temperature lower than the melting point of copper.

In witness whereof, I hereunto subscribe my name this 8th day of May, 1930.

PAUL P. CIOFFI.