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HEAT TREATMENT OF CONDUCTORS

Filed Feb. 24, 1928

FIG. 1

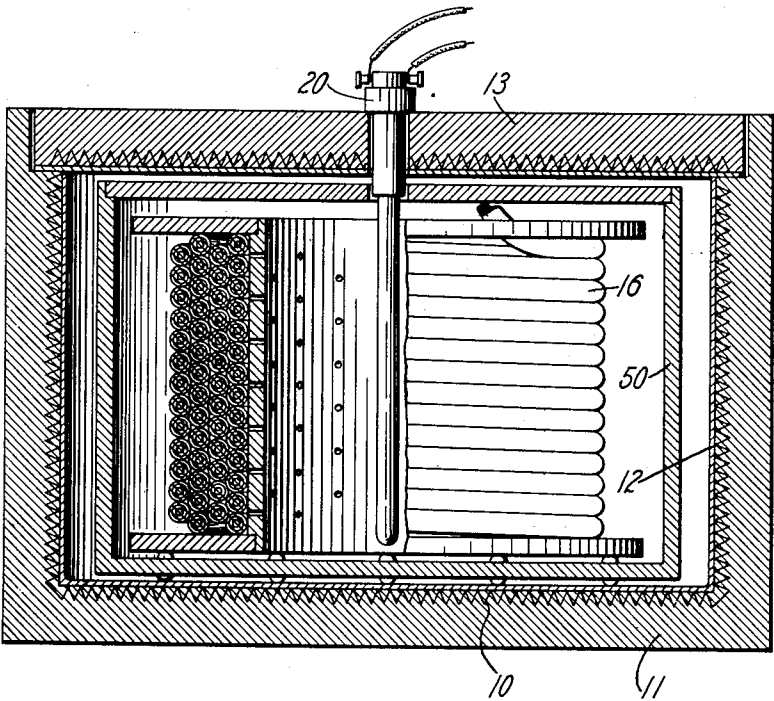
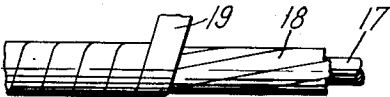


FIG. 2



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HEAT TREATMENT OF CONDUCTORS

Application filed February 24, 1928. Serial No. 256,657.

The present invention relates to heat treatments of magnetic alloys, particularly iron-nickel-cobalt alloys, and signaling conductors magnetically loaded therewith.

5 The present application is, as to part of the subject matter, a continuation of applications Serial Nos. 119,622, 119,623, filed June 30, 1926, and 220,387, filed Sept. 19, 1927, which have become U. S. Patents 1,715,541, 10 1,715,646 and 1,715,647, all issued June 4, 1929.

15 An object of the present invention is to develop satisfactory electrical and magnetic properties in conductors loaded with magnetic materials requiring lengthy or definitely controlled heat treatments or definitely controlled cooling rates.

20 A particular object is to so heat treat loaded conductors as to cause the loading material to have reduced hysteresis losses, high initial permeability, and high constancy of permeability.

25 A further object is to control more effectively than heretofore the factors affecting the useful properties of magnetic iron-nickel-cobalt alloys during heat treatment thereof.

30 A further object is to expedite the heat treatment of conductors loaded with magnetic loading materials requiring long heat treatments and slow rates of cooling and thereby reduce the expense of treatment of such conductors on a commercial scale.

35 A feature of the invention resides in methods of heat treating conductors loaded with magnetic material in which usual methods of continuous heat treatment are unsatisfactory because of difficulty in controlling with sufficient accuracy the temperatures, rates of cooling and atmospheres.

40 Loading materials of various kinds appear to be susceptible to stray magnetic fields during heat treatment and cooling to an extent and in a manner not thoroughly

understood and perhaps in a different manner in different cases.

Consequently a further object of the invention is to prevent the loading material of a continuously loaded conductor from becoming permanently magnetized during those periods of time when the loading is most susceptible to the influence of weak magnetic fields, such as the earth's magnetic field, namely during cooling after annealing.

45 In accordance with the invention the factors making for any set of concomitant properties in magnetic materials may be controlled much more effectively than heretofore by varying the heating time, the heating temperature, the change of temperature and the rate of change of temperature, so as to make the properties produced in the magnetic material more accurately correspond to those required in service.

50 An advantage of the present invention is that it satisfies an important requirement in manufacturing and heat treating magnetic alloys, namely the reproducibility of one particular heat treatment found to be most suitable for one particular composition of alloy. In the case of a long loaded submarine signaling conductor, for instance, it is essential to the satisfactory operation of the cable system to have the same inductance in the individual elementary sections of the cable. This is only possible if the loading over the entire length of the cable possesses the highest homogeneity of structure and material, together with the highest uniformity of magnetic properties attainable.

55 Magnetic alloys which have been found susceptible to be greatly benefited by the methods of the present invention may contain, by way of example; between 9% and 81% nickel, between 5% and 80% cobalt, and between 9% and 50% iron, with or without a fourth element, such as molybdenum or chromium, in amounts up to about 10% add-

ed for the purpose of increasing the resistivity.

The above mentioned objects of the present invention may be attained and other advantages realized in the manner to be described with reference to the accompanying drawings in which:—

Fig. 1 represents an electric furnace in which is placed an annealing pot containing magnetic material, specifically, a signaling conductor continuously loaded with a nickel-iron-cobalt alloy, to be treated in accordance with the invention, and

Fig. 2 is a view in elevation of the loaded conductor proper. The central copper conductor 17 is surrounded by a plurality of segmented copper strands 18 shaped to fit around the central wire. A tape of magnetic loading material 19, of approximately .002" thickness and .020" width is wrapped around strands 18.

The furnace illustrated in Fig. 1 is of the resistance type and adapted to have its temperature regulated accurately to any desired value. The furnace comprises heating elements 10 between a layer of fire clay 11 and a lining of refractory material 12. The lid 13 of the furnace is removable. Thermocouple pyrometer 20 is preferably connected to a recording indicator for the purpose of accurately supervising and controlling the temperature variations inside the annealing pot 50.

The operation of the method when used in connection with the apparatus described is as follows: The loaded conductor is carefully wound upon a reel of heat resisting material such as nichrome, for instance, having a sufficiently large radius to prevent the permeability being reduced by subsequent straightening of the conductor. The reel and conductor are then placed into the annealing pot and the whole bodily inserted into the furnace. Cover 13 of the furnace is put in position and luted with refractory material. The power is turned on and pot and contents slowly heated to about 900° C. The increase in temperature of the annealing chamber is carefully followed by means of pyrometer 20. The temperature of about 900° C. is maintained constant for about one hour, and then the pot and contents allowed to cool to room temperature; this ordinarily requires about 10 hours, so that an average cooling rate of about 1.5° C. per minute results and a cooling rate of about 1° C. per minute prevails for cooling from 400° C. to about room temperature. This treatment ordinarily is conducive to fair values of initial permeability and constancy of permeability.

In accordance with a modified method the loaded conductor may also be passed first through a furnace in a continuous process at such a rate as to be heated to about 800° to 900° C. After cooling the conductor is

then wound in coils of large radius and the coils heat treated at about 400° to 450° C. for a length of time sufficient to bring the initial permeability of the loading material to the required value. This is followed by slow cooling in the furnace.

In accordance with other modified methods, the conductor, after having been given the continuous process heat treatment mentioned in the first sentence of the previous paragraph, or the treatment described in the second previous paragraph, is heated in coiled form to about 400°–450° C. In the case of the first mentioned treatment (second previous paragraph), the cooling may be interrupted at about 400° C. and the conductor then reheated to between 400° C. and 600° C., and then cooled at a faster rate, such as cooling the annealing pot and contents in air.

The greatest possible constancy of permeability of magnetic loading materials is often greatly desired. With many magnetic compositions it has been found that the constancy of permeability is greatly increased by maintaining the compositions at about 400° to 450° C. for several hours—after they have been heated considerably higher and cooled down to about 450° C.—or by very slow cooling through the range of 450° C. to 400° C. more or less.

If intermediate value of permeability and constancy of permeability are desired, the length of time for which the conductor is maintained at a temperature of 400° to 500° C. may be varied to obtain these results.

For such treatments continuous heat treatment methods of conductors heretofore used are inapplicable on a commercial scale because of the excessive slowness of the process and for other reasons; they are difficult to practice with uniform and satisfactory results. Although it has heretofore been proposed to heat treat small or moderately large compact masses of magnetic material by pot annealing methods, the present invention involves the treatment of large reels of composite conductors. Because of the excessive strain sensitiveness of the magnetic materials the turn of smallest radius must be of a considerable radius. The entire reel must necessarily be introduced bodily into the furnace. By this radical departure from prior methods all complications of driving machinery are avoided and the product may be made with properties of great uniformity and desirability with facility and ease. Whereas prior methods required continuity of operation and constant skilled attendance, the present method may be carried on by having the furnaces unattended for long periods of time, all night, for example, if, in conjunction with the pyrometer, automatic time control mechanism is employed to regulate the temperature. An accurate check may be kept by automatic temperature recording apparatus.

The annealing temperature, annealing time, cooling rate and succession in the cooling rate may vary greatly with variations of the properties of magnetic materials desired in any particular instance. Certain desired properties may be accentuated and undesirable properties suppressed by particular treatments.

In particular cases it may be necessary or desirable to heat the loaded conductors to about or almost to 1100° C. for a short time at the beginning of the heat treating process. The heating above about 900° C. has little effect, in general, upon the particular types of magnetic materials containing iron, cobalt, and nickel which are discussed but it has a desirable effect in removing mechanical hardness.

One particular advantage of heat treating a continuously loaded conductor in the form of a spirally coiled member is that during those intervals of time in which the conductor is most susceptible to become magnetized and most likely to be detrimentally affected by the earth's magnetic field, namely, when it is being cooled after annealing, the effects of stray fields of the order of magnitude of the earth's magnetic field or of greater or lesser intensity are compensated by the demagnetizing effects of adjacent parts of the coils of magnetic material upon themselves, and also by the shielding actions of the reel, pot, and furnace structure.

What is claimed is:

1. The method of imparting to loaded conductors desired and uniform magnetic and electrical properties which comprises coiling the loaded conductor with a large radius upon a suitable heat resistant support, enclosing the entire support with the conductor in an annealing pot, placing the annealing pot in a furnace, and heating and cooling the conductor within the annealing pot.

2. The method of controlling the factors affecting the magnetic properties, during heat treatment, of a magnetic alloy having the form of an elongated member spirally wound round a signaling conductor, which comprises coiling said conductor upon a reel of large radius, inserting said reel into an annealing pot, placing said pot and contents in a furnace, heating said pot and contents to an annealing temperature, and cooling the pot and contents within the furnace to room temperature at an average rate of about 1° C. per minute, whereby there is imparted to the magnetic material a high degree of constancy of permeability.

3. The method of developing a high degree of constancy of permeability, high initial permeability and low hysteresis loss in a magnetic material wrapped about a signaling conductor, which method includes slowly heating said conductor in the form of a coil of large radius to about 900° C., maintaining

said temperature for at least one hour, and cooling said coil to room temperature at such a rate that the cooling through a range of temperature of at least 100° C. in the region of the critical temperature range takes place at an average rate not to exceed 1° C. per minute.

4. The process of improving the magnetic properties of a magnetic alloy containing nickel, iron and cobalt as essential constituents thereof and wrapped around a copper conductor, which process comprises coiling said conductor upon a refractory support of relatively large radius, placing said support and conductor into an annealing pot, inserting said pot and contents into a heat treating furnace, heating to a temperature short of fusion of said copper conductor for about one hour, and cooling said conductor at an average rate of about 1° C. per minute whereby the initial permeability, and the constancy of permeability are increased and the hysteresis loss at magnetizing forces employed in signaling is decreased.

5. The method of controlling the development of magnetic properties in a magnetic material containing iron, nickel and cobalt as essential elements thereof and wrapped around an extensive length of signaling conductor, which method includes heating said conductor upon a refractory support, surrounded by an annealing pot, to about 900° C. for at least one hour, and slowly cooling said pot and contents at an average rate of 1° C. per minute.

6. The method of improving the constancy of permeability, increasing the initial permeability, and reducing hysteresis losses in a magnetic material comprising nickel, cobalt and iron as essential elements thereof, said material being wrapped about a copper conductor, which method includes heating said conductor in the form of a relatively large coil to a temperature below the melting point of said copper, and cooling said conductor at such a rate as to impart the desired properties to said magnetic material.

7. The method of increasing the initial permeability, the constancy of permeability, and lessening the hysteresis losses, at magnetizing forces of the order of 0.2 gauss, of a magnetic composition comprising between 9% and 81% nickel, between 5% and 80% cobalt, and between 9% and 50% iron, said composition having the form of a member spirally coiled around a signaling conductor, which method includes heating said conductor in the form of a coil in an annealing pot to a temperature of about 900° C. for at least one hour, cooling said conductor at least to about 400° C. within said pot at a relatively slow rate, by way of example, a rate of about 1° C. per minute, reheating said conductor to between 400° and 600° C., and cooling it rapidly to room temperature.

8. Process for improving the magnetic and electrical properties of a conductor loaded with a magnetic material comprising nickel, iron and cobalt, which process comprises heat treating said conductor in a continuous process, cooling to room temperature, winding it upon a refractory support of relatively large radius, heating the conductor inside an annealing furnace to a lower high temperature and cooling it.

In witness whereof, I hereunto subscribe my name this 21st day of February, 1928.

GUSTAF W. ELMEN.

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