

UNITED STATES PATENT OFFICE

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MAGNETIC MATERIAL

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This invention relates to electromagnetic materials for use in weak electromagnetic fields such as are present in the cores of loading coils, and magnetic wire or tape spirally applied to conductors to increase the inductance thereof, and methods of producing such materials.

An object of the invention is to increase the constancy of permeability of magnetic materials.

With the development of long-distance signalling-technique, magnetic materials came into demand for windings, transmitters, "Krarup" helically applied loading, etc. which possess excellent magnetic properties, particularly in weak fields. More particularly has importance been placed upon the attainment of high initial permeability. The known processes for the production of magnetic wires, bands, plates or the like, without exception are designed to attain a high initial permeability of the final products. This end can be attained also with alloys of iron and nickel. With a 78/22% nickel-iron alloy, an initial permeability of 10,000 can, for instance, be obtained. It is disadvantageous, that with these alloys, the hysteresis and the current-dependency of the magnetic values, so closely connected with it, in connection with weak fields, also increase to an extraordinary degree: (Compare Jordan, "Magnetische Konstanten" E. N. T., vol. 1, No. 1). Nickel-iron alloys usually show a poor degree of magnetic stability, i. e. their properties change considerably, with weak fields, during or after they are subjected to intense fields. A further disadvantage of the wires or similar materials made from highly permeable alloys, is their sensitiveness with regard to mechanical strain and internal strain due to uneven thermal conditions.

According to the present invention, the ferromagnetic material is selected and worked in such a way, that the permeability and stability of the winding cores, "Krarup"-windings, etc., produced from the material, are equal in value to the stability and permeability of a core with air-gaps, even in cores with a closed magnetic circuit.

For instance, molten alloys are first rendered as homogeneous as possible by melting in high-frequency furnaces, and afterwards worked mechanically in such a way, that, in the first place, as great as possible elongation of the single crystals is attained. This is effected most advantageously, with material cast in the form of bars, by annealing and subsequent working down in a train of rolls, as finely graded as possible, to a small sheet-metal-, tape- or wire-thickness. During this working, the material is subjected to one or several intermediate annealings, which should be as few as possible, in order to again recrystallize, the crystallite, which in the meantime had been considerably elongated by working. Towards the end of this operation, which is subject to variations with regard to the elongation, the details of the train of rolls or the annealing such as would occur to anyone skilled in the art, the material is worked in a cold state and brought into its final state of sheet metal, tape, or wire by a series of elongations by working without intermediate annealing. The material is allowed to remain in this final state, and is subjected to no final thermic treatment whatever at higher temperatures.

The following example of carrying out the process is given:

As initial material, 50-50 iron-nickel alloy is employed, in bar-form. This is first homogenized by annealing at 800 to 900° for about an hour, whereupon it is elongated, to such an extent that a cross-sectional reduction of 10% results. It is then annealed for an hour at 900°, then again elongated while cold, and so on. The elongation and intermediate annealing are repeated in the same way three times. After the third annealing, the material is elongated in a cold state, until the cross-sectional reduction amounts to about 60-70%.

The wires, tapes or plates, produced by a process according to the invention, generally possess an initial permeability which is less than that of ordinary iron. However, they possess favorable values of hysteresis and of magnetic stability. If for instance, a 50-50 iron-nickel alloy is employed having an

initial permeability of about 52, the hysteresis loss will be equivalent to an effective increase in resistance of the circuit of 80 ohms per ampere turn per cm. at a given frequency, the stability being 1.5%. In comparison with this, steel, the low hysteresis of which is known, possesses, with an initial permeability of 70, a hysteresis loss equivalent to an increase in resistance of 100 ohms per ampere turn per cm. for the same frequency, the stability being 45%.

With a process according to the invention, a number of other alloys of ferro-magnetic substances can be treated, also with the addition of silicon, manganese, copper or similar substances, influencing the magnetic and mechanical properties. The magnetic values of the wires, tapes, sheet-metal or similar materials, produced according to this process, correspond substantially with those of the above-mentioned example.

The magnetic materials produced according to the invention, are particularly suited for the production of cores for Pupin-windings with sheet-metal, tape or wire-cores, as also as wires for over-spinning copper-conductors in Krarup-cable, because it is now possible to construct devices of this kind with closed magnetic circuits without air-gaps and in spite of this to attain high stability and permeability. Owing to the small hysteresis losses of the magnetic material, cables of this kind are particularly suitable for broadcasting transmissions. Also the substances made in accordance with the process of the invention can be pulverized and used in dust cores, which are notable for small variations of permeability with current and for their insensitiveness to the magnetic influence of intense fields.

For the magnetic loading employed in long-distance transmission, particularly for the transmission of speech, it is of importance that they retain their properties under all working conditions. In connection with windings and Krarup-conductors, this is predominantly the inductivity. Although it is particularly well known, that, by the employment of magnetic materials of high permeability, a considerable saving of material can be attained by reducing the dimensions of cores, for such windings, the relatively low permeabilities of dust cores have been considered sufficient. Cores of compressed pulverized iron were employed, solely because such cores possess more stability, than all known materials in solid form, i. e., in the form of sheet-metal, tape or wire cores. The expression "Stability" has on occasion been employed in order to characterize generally the capacity for being influenced, of the permeability for magnetizing forces corresponding to speech currents, through the temporary influence of more intense fields, such as are produced, in working, possibly

by the effect of measuring, signalling or disturbing currents. In connection with Pupin-windings, it is prescribed, for instance, that the inductivity and thus the permeability shall not vary to the extent of 2%, when influenced by any field-strengths whatever up to about 50 ampere turns per cm. It has consequently become usual, to designate briefly as "Stability", the highest alteration per cent, which can be caused by field-intensities within this limit. Of course in accordance with this method of designation, the stability is greater, the less this number is, which more accurately stated, measures the "Instability". By "stable" in this specification, we mean relatively little influenced by intense temporary fields.

The changes in the permeability, owing to such influences, constitute a special property of magnetic materials. For solid materials the lowest values of variation in inductance, hitherto known, therefore the greatest stabilities, always hitherto amounted to at least 30%. The exclusive employment of cores made of aggregations of powdered materials in Pupin-windings, serves as proof of the fact, that with the state of the art as it is today, the attainment of the required stability with solid material is looked upon as impossible, although numerous materials are known, which possess other desirable magnetic properties, such as very high permeability, which should therefore enable the production of especially small windings.

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

1. The method of treating magnetic material to increase its magnetic stability which comprises successively annealing and forcibly elongating the material and, finally, after the final annealing, further forcibly elongating the material for application as a magnetic body.

2. The method of treating magnetic nickel-iron alloy magnetic materials, including those having other substances, such as manganese, silicon and copper added, to increase the stability of their magnetic properties which comprises alternately annealing and working the material and finally cold working it to elongate it as the final step of the treatment.

In witness whereof, we have hereunto set our hands this 26th day of June, 1930.

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