

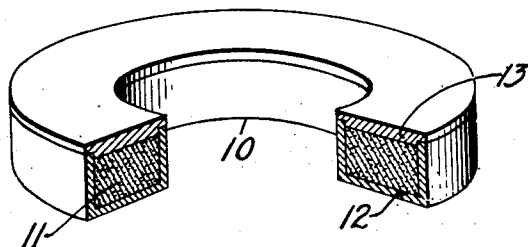
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G. A. KELSALL

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MAGNET CORE

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Inventor:
George A. Kelsall
by E. V. Briggs Attorney

UNITED STATES PATENT OFFICE

GEORGE A. KELSALL, OF BELLEVILLE, NEW JERSEY, ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

MAGNET CORE

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This invention relates to magnet cores and particularly to cores for transformers, inductance coils and the like for use in circuits carrying high frequency currents such as are employed in carrier and radio telephony.

An object of the invention is to increase the efficiency, at high frequencies, of electrical apparatus employing magnetic cores.

A specific object is to provide a core which has a low ratio of core loss to permeability at high frequencies.

Heretofore, magnetic cores of the so-called "dust" type have been made by applying sufficient pressure to finely divided magnetic material, the particles of which are preferably insulated from each other, to form a self-sustaining body with a specific gravity approximately equal to that of the undivided magnetic material. Apparatus employing such a core functions satisfactorily in circuits transmitting current within the audible frequency range, but, when considerably higher frequencies are employed, as for instance, those required in radio transmission circuits, core losses become sufficiently high to render the operation of the apparatus unsatisfactory. The air core, on the other hand, while it has no core loss, has such a low permeability that a comparatively large winding is required to obtain the desired inductance, thus not only increasing the size of the coil but also rendering the device inefficient by greatly increasing the so-called "copper losses".

The present invention contemplates the use of finely divided particles of a magnetic material which in undivided form has a high permeability at low values of magnetizing force and a low hysteresis. These particles are loosely packed in a suitable container to form a core having a specific gravity lower than that of the material in undivided or highly compressed form. Such a core has a permeability considerably higher than that of air and its core loss at high frequencies is considerably lower than that of a core composed of a solid or highly compressed magnetic material.

One embodiment of the invention is shown

in the accompanying drawing in which the single figure is a perspective view of a section of a loading coil core made in accordance with the present invention, a portion of the core being broken away to better illustrate its construction. It will be understood, however, that this is merely illustrative and that the invention is not limited to the production of this form of core but is adapted for the making of cores of many forms.

The toroidal core shown in the drawing comprises a suitable container 10 which is loosely filled with finely divided magnetic material 11. It has been found that an alloy composed of 78½% nickel and 21½% iron is a suitable magnetic material and that, when this material is employed, the core may have a specific gravity considerably less than that of solid iron and is preferably approximately 6. The container 10 may be of any shape and of any suitable material such as bakelite or fabric impregnated with a stiffening compound which is preferably moisture-proof. In the form shown the container comprises a member 12 of U-shaped cross section and a tight fitting cover 13.

While various magnetic materials may be employed in forming the core in accordance with this invention, improved results have been obtained by employing finely divided uncompressed particles of an alloy of approximately 78½% nickel and 21½% iron.

The core losses for such a core, at frequencies above the audible range are lower than for a similar core employing iron particles, and the effective permeability of the core employing the nickel-iron alloy is very much higher. Highly compressed cores of this material have heretofore been employed in apparatus for carrying current of the speech frequency range. As is well known, however, eddy current losses increase with the size of the particles employed, as the square of the frequency and as the square of the effective permeability of the magnetic core. In order to avoid excessively high eddy current losses, it has been found desirable to employ very fine particles of the alloy and to increase the distance between the particles. The effect

of increasing this distance is of course to reduce the effective permeability of the core but it has been found that when the nickel-iron alloy is employed, this distance can be increased sufficiently to bring about a large reduction in eddy current loss at high frequencies and at the same time maintain the effective permeability of the core at a high value. Since the eddy current loss varies inversely with the resistivity of the material, it is in some cases advantageous to add a substance for increasing the resistivity, for instance a small amount of chromium may be added to the nickel-iron alloy for this purpose. The combined effect of employing, in a core, a high permeability magnetic material in finely divided, uncompressed form is to reduce the core losses and at the same time to maintain the effective permeability of the core sufficiently high to permit its use in apparatus requiring considerable inductance and designed for use in circuits carrying high frequency currents.

In carrying out the invention the magnetic material is prepared in accordance with a method more fully described in the U. S. patent to C. P. Beath and H. M. E. Heinicke, No. 1,669,649, issued May 15, 1928. The method consists in melting $78\frac{1}{2}$ parts of nickel and $21\frac{1}{2}$ parts of iron in an oxidizing atmosphere and pouring the resultant alloy into a mold. When thus prepared the resulting alloy will be exceedingly brittle and is therefore adapted to be reduced to a finely divided or dust form. After the brittle ingots are obtained they are successively passed through progressively reducing hot rolls which form the alloy into flat slabs approximately $\frac{1}{4}$ " thick. By the hot rolling process the size of the crystalline structure is materially reduced and since the disintegration of the material takes place mainly at the crystal boundaries, small crystals are highly desirable in order to have a satisfactory yield of dust. The rolled slabs are broken into small pieces and are then crushed in a jaw crusher, hammer-mill, or any other suitable type of apparatus in which a further reduction occurs. The material after being passed through the jaw crusher is subsequently rolled in a ball mill until it is reduced to fine dust. This dust is sieved through a 120 mesh sieve and any residue is remelted and the foregoing operation is again repeated to reduce the material to a finely divided form. The finely divided particles of the nickel-iron alloy are then annealed in a closed container at a temperature of approximately 750° C. to 980° C. It is then necessary to again reduce the annealed alloy, which is now in the form of a cake, to a finely divided form, which may be done by crushing and sieving in the manner above described.

The alloy particles may then be sorted

by sifting through a fine mesh sieve and then coated with an insulating material. A suitable method of forming an insulating coating on the particles is described in the U. S. patent to A. F. Bandur No. 1,669,648, issued May 15, 1928. It consists in heating the particles in air for a short period of time at a high temperature, a temperature of approximately 500° C. having been found satisfactory for this purpose.

What is claimed is:

A magnetic core for use in circuits transmitting currents of super-audible frequencies, having the characteristics of low core loss coupled with high permeability at such frequencies, said core consisting of finely divided particles of a nickel-iron alloy annealed to remove strains and assembled loosely in core form in substantially the magnetic condition in which the material is left by the annealing treatment.

In witness whereof, I hereunto subscribe my name this 29th day of November A. D., 1926.

GEORGE A. KELSALL.