Sept. 20, 1938. E. PETERSON 2,130,508

INDUCTANCE DEVICE

Filed April 29, 1937

FIG. 1

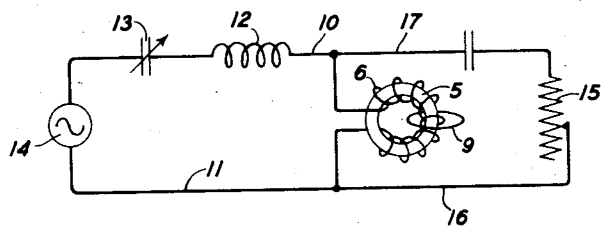


FIG. 2

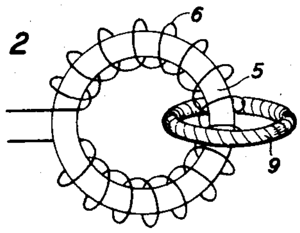


FIG. 3

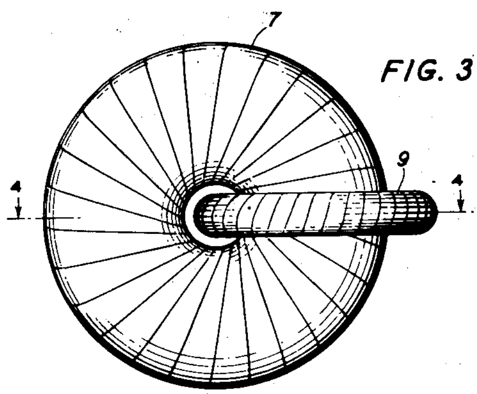
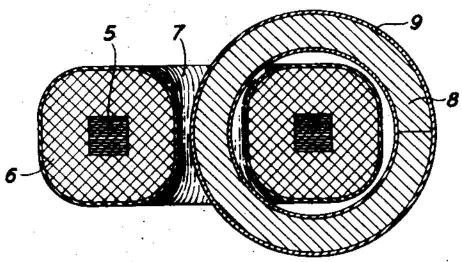


FIG. 4



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2,130,508

INDUCTANCE DEVICE

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5 Claims. (Cl. 172—281)

This invention relates to inductance devices particularly of the type employed as static frequency converters for changing electrical energy of one frequency into electrical energy of another frequency or other frequencies.

Heretofore it has frequently been found desirable in transmission systems requiring a large number of different frequencies for use, for example, as the carrier waves for the several channels of a multiplex carrier telephone system to simultaneously provide the different frequencies by distorting a sinusoidal current by the use of a single wave distorting device such as a saturating magnetic core coil. From the output of such a device the desired harmonic frequencies may be selected by suitable circuits or filters.

An object of this invention is to provide a non-linear coil capable of producing large magnetizing forces at relatively low values of applied current.

In accordance with this invention the magnetic material active in producing the non-linear relation between B, the induction, and H, the magnetizing force, necessary for the generation of frequencies different from the applied frequency, comprises a layer of magnetic material surrounding a conductor of small cross-section, preferably where the conductor acts as a single turn secondary of a transformer having a multi-turn primary and a core of any suitable construction. In a specific embodiment the frequency changer of this invention comprises a toroidal core of relatively small diameter having a primary winding of as large a number of turns as is practicable, and a single turn secondary where the secondary comprises a conductor of small diameter surrounded over at least a portion of its length with a layer of magnetic material. The magnetic material for the secondary conductor may be in the form of tape spirally wound around the secondary wire uniformly over its entire length or the tape may be applied in several layers around only a portion of the length of the secondary conductor.

With such a construction the primary may be operated in the region over wihch the non-linearity of the B—H relation in the primary toroidal core is not large, the principal non-linear effect being produced by the much greater magnetizing force applied to the magnetic tape by the large induced current in the single turn secondary. This enables the primary toroidal core to be built up with much thicker laminations than could be used if the main core were subjected to large magnetic fields creating correspondingly large eddy current losses,—a feature of substantial importance when a high frequency is desired in the output. The construction above described has a much higher ratio of magnetic force to applied current than would be possible of attainment with the more usual construction of a frequency changer comprising a single winding on a suitable core.

Referring to the drawing,

Fig. 1 is a frequency changer circuit utilizing a frequency changer construction in accordance with this invention;

Fig. 2 is a schematic showing of the frequency changer of this invention; and

Fig. 3 is a view in perspective of the frequency changer of this invention; and

Fig. 4 is a view partly in section taken along the line 4—4 of Fig. 3.

Referring more particularly to Figs. 2, 3 and 4, the static frequency converter of this invention comprises a laminated toroidal core **5** having a uniformly wound multi-layer primary winding **6** surrounded by a suitable insulating tape **7** wound in the usual manner. A conductor **8** is formed as a single turn secondary and the secondary conductor **8** is spirally wrapped with a thin tape **9** of magnetic material. Both the core **5** and tape **9** preferably comprise magnetic material of high initial permeability saturating at relatively low magnetizing forces such as molybdenum permalloy as disclosed in Elmen U. S. Patent 1,768,443, issued June 24, 1930.

In order to reduce the incidental leakage to a minimum there should be a substantial overlapping of the individual turns of the magnetic tape **9** around the shorted secondary **8**; and the shorted turn **8** with its tape **9** should be of such a diameter and configuration as to fit tightly around the primary winding **6** so as to include a minimum of air space between the primary winding and the secondary winding. It is also important to provide some suitable insulating material between conductor **8** and tape **9** since there would be excessive eddy current losses if the tape **9** were in good electrical contact with conductor **8**. It also follows that the overlapping portions of the tape should be insulated from each other. Alundum dust or quartz dust will serve as a satisfactory insulating material for this purpose.

Although the drawing shows only one secondary winding **8** comprising a single turn, it is to be understood that there may be several secondary windings, each of a single short-circuited turn or a single short-circuited secondary winding may be employed of a plurality of turns.

The above transformer construction is used as a static frequency changer in the circuit illustrated in Fig. 1 where the primary winding 6 by means of conductors 10, 11 is connected through a tuned circuit 12, 13 with the source 14 of the fundamental frequency. The current through primary winding 6 from source 14 produces a much greater current in the secondary winding 8 to operate the magnetic tape 9 over a region where the non-linearity of the B—H relation is large, thereby producing in a well-understood manner harmonics of the fundamental frequency, which harmonics may be supplied to a suitable load circuit 15 by output leads 16, 17 and selectively utilized in any desired manner, for example, as disclosed in L. R. Wrathall U. S. Patent No. 2,117,752, issued May 17, 1938.

In one specific example, the following dimensions were utilized. The mean diameter of toroidal core 5 was 2 centimeters with a cross-sectional area of 0.2 centimeter^2. The effective cross-sectional area of tape 9 was 5×10^{-3} centimeters^2. The primary winding 6 had 200 turns and the diameter of wire 8 was 0.2 centimeter. Utilizing these dimensions in the construction illustrated in the drawing, the magnetizing force applied to tape 9 is the same as would be applied to a toroidal core of a diameter of 0.2 centimeter with a magnetic cross-sectional area of 5×10^{-3} centimeters^2 surrounded by a single winding of 200 turns. That is, the transformer structure above described is an expedient for obtaining the equivalent of a reduction in the physical size of the core of the converter to a point which would be physically unattainable. This effective reduction in size of the core of the converter makes it possible to increase the ratio of the magnetizing force to the applied current so that a desired degree of non-linearity may be had at smaller current values. This method of obtaining large magnetizing forces per unit current enables the converter to function efficiently at much lower currents than are required with the more usual construction of a frequency converter utilizing a single winding on a toroidal core.

The embodiment of the invention above described is for illustrative purposes only since the scope of the invention is defined in the appended claims.

What is claimed is:

1. In a frequency changing system, an inductance device comprising a core having a closed magnetic path, a multi-turn primary winding surrounding said core, a short-circuited secondary winding of a small number of turns surrounding said core, and magnetic material closely surrounding said secondary winding.

2. In a frequency changing system, an inductance device comprising a core having a substantially closed magnetic path, a multi-turn primary winding surrounding said core, a conductor forming a short-circuited secondary winding surrounding said core and a shell of magnetic material closely surrounding said conductor for at least a part of the length of said conductor.

3. In a frequency changing system, an inductance device comprising a core having a substantially closed magnetic path, a multi-turn primary winding on said core, and a conductor forming a short-circuited secondary winding surrounding said core, said conductor comprising a core of non-magnetic conducting material and an outer shell of magnetic material.

4. In a frequency changing system, an inductance device comprising a toroidal shaped core comprising laminations of magnetic material, a multi-turn primary winding surrounding said core, a conductor forming a single short-circuited turn surrounding said core, and magnetic material closely surrounding a portion of the length of said conductor.

5. An inductance device comprising a core having a substantially closed magnetic path, a multi-turn primary winding surrounding said core, a conductor forming a short-circuited winding surrounding said core, and a tape of magnetic material spirally wrapped around a portion of the length of said conductor with a substantial overlapping of the turns of said tape, said tape being insulated from said conductor.

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