

Nov. 12, 1957

S. DUINKER ET AL

2,813,256

INDUCTANCE CONTROLLABLE BY PREMAGNETISATION

Filed Aug. 31, 1954

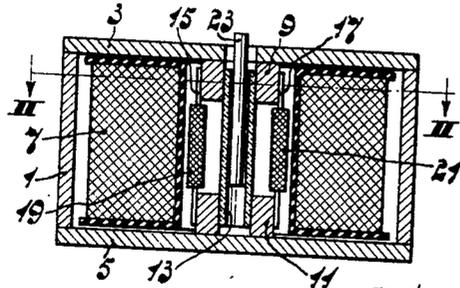


Fig. 1

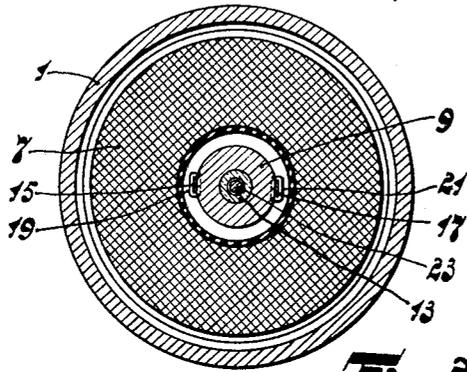


Fig. 2

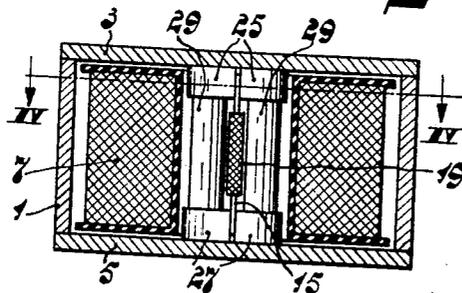


Fig. 3

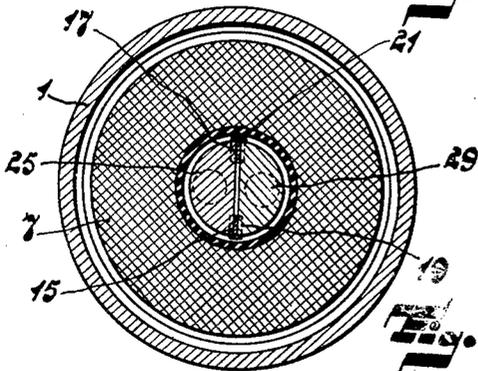


Fig. 4

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## INDUCTANCE CONTROLLABLE BY PREMAGNETISATION

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Application August 31, 1954, Serial No. 453,376

Claims priority, application Netherlands  
September 1, 1953

6 Claims. (Cl. 336—83)

This invention relates to controllable inductances comprising a coil arranged between the poles of an electromagnet and having a closed ferromagnetic core whose permeability may be varied by varying the strength of a premagnetising (polarising) field brought about by the electromagnet. Such devices may be used in, for example, controllable oscillatory circuits, magnetic amplifiers, trigger circuits (flip-flops), etc. The coil is usually connected, in series with a fixed impedance, to an alternating-current source, the current traversing the impedance being controlled by the current in the electromagnet.

In order that the electrical energy required for producing the premagnetising field may be maintained within reasonable limits, the core must have as small dimensions as possible, more particularly at high frequencies of the current traversing the coil.

The very small dimensions of the coil that are desirable at high frequencies (for example, from 1 to 10 mcs./s.) render the manufacture and the assembly of core and winding very difficult. The object of the invention is to provide a construction by which the said difficulties are obviated as much as possible.

According to the invention, the core comprises two yoke parts of sintered ferromagnetic material which are secured to a support of magnetically-indifferent, i. e. non-magnetic, material and each of which exhibits at least one flat ground surface, which ground surfaces are in line with one another, the core furthermore comprising at least two core rods of sintered ferromagnetic material surrounded by windings, which rods at their extremities likewise exhibit ground surfaces which engage the first-mentioned ground surfaces and which constitute a magnetic connection between the yoke parts.

In order that the invention may be readily carried into effect, it will now be described with reference to the accompanying drawing, given by way of example, in which

Figs. 1 and 2 show one embodiment in axial section and in cross-section, respectively, and

Figs. 3 and 4 show a second embodiment in the same way.

The device shown in Figs. 1 and 2 comprises an electromagnet having a core which is substantially pot-shaped and which comprises a ring 1 and two matching covers 3 and 5 of electrically-poorly-conductive, sintered, ferromagnetic material, for example, cubic ferrite. A field winding or coil 7 is housed in the box or pot formed by the said parts. The central part of the core comprises two annular parts 5 and 11, likewise of sintered ferromagnetic material, the extremities of which are secured to a tubular supporting member 13, coaxial with the ring 1, of magnetically-indifferent material, for example glass.

The rings 9 and 11 comprise flat ground surfaces on each side of the tube 13, which surfaces are located pairwise in line with one another, that is to say in the same plane. The said rings also constitute the yoke pieces of a closed ferromagnetic core which furthermore comprises

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two small flat rods 15 and 17 of poorly-conductive, sintered, ferromagnetic material, of which at least the extremities likewise exhibit ground surfaces which engage the said ground surface of the rings 9 and 11 and form a magnetic coupling between them.

The rods 15 and 17 are surrounded by windings 19 and 21 which may be connected in series and which constitute an inductance, the value of which may be controlled by premagnetisation (polarisation) of the core rods 15 and 17, which premagnetisation may be obtained by means of the winding 7 of the coil and the core 1, 3, 5, 9, 11 co-operating therewith. The premagnetising field brought about by a current traversing the winding 7 spatially has the same direction in the core rods 15 and 17, whereas the field produced by windings 19 and 21 is spatially oppositely directed in the core rods 15 and 17, so that the two coil systems comprising the winding 7 on the one hand and the windings 19 and 21 on the other are not coupled together. If the coil 19, 21 is traversed by, for example, high-frequency current, the voltage set up across the said coil may be varied by variations in the current flowing through the coil 7.

In order to restrict the required control energy which is to be supplied to the winding 7, it is of essential importance that the core rods 15 and 17 should be of a very small cross-section, for example,  $0.3 \times 1$  mm. This may readily be realised with the construction described, since the rods 15 and 17 are manufactured as individual parts and may be ground in a simple manner on a flat grindstone and after the windings 19 and 21 have been provided, be secured to the assembly comprising the supporting member 13 and the rings 9 and 11, for example by gluing. The assembly thus obtained is comparatively rigid despite the brittleness of the very thin cores 15 and 17 and can be handled very well during the manufacture owing to the rigidity of the assembly 9, 11, 13, in which the tube 13 constitutes a strong support. The said assembly is preliminarily manufactured by gluing the yoke pieces 9 and 11 to the tube 13, it being possible for the length of the assembly to be matched as accurately as possible to the spacing between the upper and lower sides of the covers 3 and 5 by providing an elastically expanding member, for example a compression spring, between the rings 9 and 11 before the glue solidifies and leaving the assembly within the pot 1, 3, 5 till the glue solidifies. The assembly 9, 11, 13 is subsequently removed from the pot and the ground surfaces are provided with the aid of a flat grindstone (see Fig. 2), whereafter the core rods 15, 17 and their windings 19, 21 are secured thereto by gluing with a suitable adhesive. As may be seen from Fig. 1, the length of the rods 15 and 17 is not critical, provided it is somewhat shorter than the inner height of the pot 1, 3, 5. The contact surface between the rods 15, 17 and the rings 9, 11 is comparatively large, so that the air gaps which exist between the rods and the rings bring about only a small increase in the magnetic reluctance of the closed magnetic circuit formed by the rods and the rings.

The engaging surfaces of the ring 1, the covers 3, 5 and the rings 9, 11 are also preferably ground, so that the air-gaps between these parts also constitutes only small obstacles for the premagnetising field of the coil 7. If desired, the core rods 15 and 17 may be secured to the assembly 9, 11, 13 under mechanical tensile stress or compression stress, for example by utilising for the carrier 13 a material of which the coefficient of expansion greatly differs from that of the rods 15 and 17 and by drying the glue at a comparatively high temperature. As is well-known, the mechanical stress may bring about a variation in the course of the magnetisation curve, so that a more advantageous course may be obtained for determined purposes.

If, in addition to the variable premagnetisation, a permanent premagnetisation is desired, a rod-like permanent magnet 23, for example of ceramic permanent magnetic material, may be arranged in the tube 13, which material must have a low permeability to prevent the magnet 23 from constituting a magnetic short-circuit of the core rods 15 and 17.

Figs. 3 and 4 show a second embodiment in which, instead of utilising the rings 9 and 11, use is made of two half ferromagnetic yoke pieces 25 and 27 in the form of segments of a circle, of which the adjacent straight sides are flat and enclose between them the core rods which in this case have to have flat, parallel sides. The yoke pieces 25 and 27 are supported by, for example, porcelain columns 29. A sufficiently accurate fit inside the pot 1, 3, 5 may be obtained by gluing together in a temple the assembly comprising the parts 15, 17, 27, 29, which have preliminarily been provided with the required ground surfaces.

What is claimed is:

1. A controllable inductance comprising a substantially closed body of sintered ferromagnetic material and having opposing wall portions, a closed magnetic circuit mounted within said closed body and comprising a first pair of spaced members of sintered ferromagnetic material each secured to an opposite wall portion of said closed body and a second pair of spaced rod-like bodies of sintered ferromagnetic material secured to and between said first pair of spaced members, said first pair of spaced members having aligned flat surfaces lying in a common plane, the ends of said second pair of spaced bodies also having flat surfaces and engaging said flat surfaces of said first pair of spaced members, a non-magnetic support member secured to and maintaining said first pair of spaced member in position, a pair of separate windings each encircling one of said rod-like members for carrying alternating current and exhibiting a given amount of inductance, and a coil within the closed body and surrounding the closed magnetic circuit for producing, when traversed by current, a controllable premagnetization of the rod-like members in the same direction to thereby vary, as desired, the inductance of the windings.

2. A controllable inductance as set forth in claim 1 wherein the non-magnetic support member is substantially

cylindrical in form and is mounted coaxially relative to the closed body.

3. A controllable inductance as set forth in claim 2 wherein the first pair of spaced members are each annular and each with an aperture, the support member is tubular and is secured within the apertures of said first pair of spaced members, and the sides of the first pair of spaced members remote from their respective aperture have the flat surfaces.

4. A controllable inductance as set forth in claim 3 wherein a rod-shaped permanent magnet of low permeability is mounted within the tubular support member.

5. A controllable inductance as set forth in claim 1 wherein the first pair of spaced members each comprises a pair of spaced semi-circular members having flat facing surfaces, and the rod-like bodies are mounted between and abutting the flat facing surfaces.

6. An inductive device comprising a closed magnetic circuit including a pair of spaced ferromagnetic members, a support of non-magnetic material secured to and maintaining said members in spaced relationship, said spaced members having aligned flat surfaces lying in a common plane, at least two, spaced, thin, fragile, sintered ferromagnetic, rod-like members having flat surfaces on their ends, adhesive means securing the rod-like members at their flat surfaces to said flat surfaces of the spaced members, a winding encircling one only of said rod-like members, and means including a coil surrounding said closed magnetic circuit for producing a controllable magnetic field in the same direction through the rod-like members to thereby control the inductance exhibited by said device when current traverses the winding.

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