Feb. 21, 1956 C. E. WILLIAMS 2,735,989

VARIABLE INDUCTANCE

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Fig. 1.

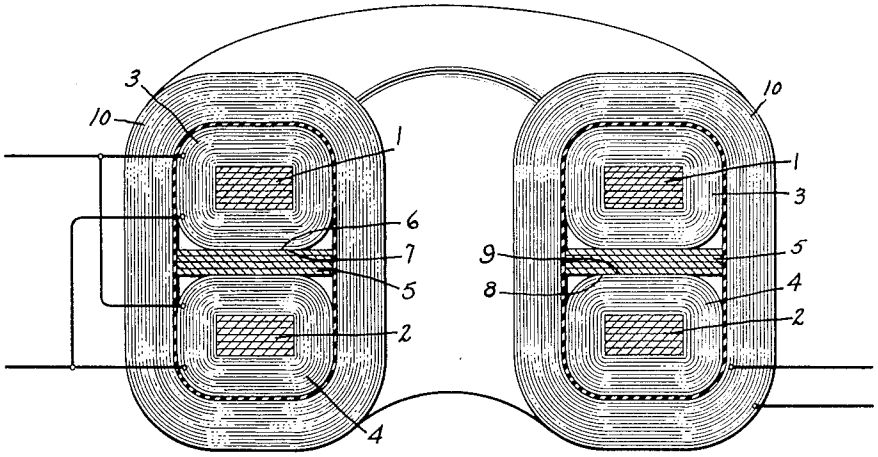
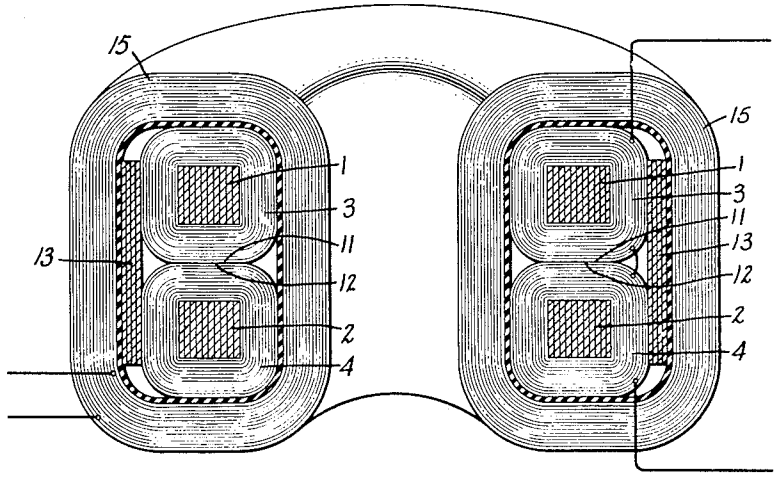


Fig. 2.



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VARIABLE INDUCTANCE

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5 Claims. (Cl. 336—155)

This invention relates to variable inductances of the type comprising a magnetic core on which is wound a main winding whose inductance is to be varied and an auxiliary winding through which can be passed a variable direct current for varying the magnetic saturation of the core and thus varying the effective inductance of the main winding. Such variable inductances are usually known as direct current saturable core reactors or transductors and are used, for example, as variable impedances in electric discharge lamp operating circuits for increasing or decreasing the current flowing through the lamps.

The arrangement of the main and auxiliary windings of a transductor is necessarily such that the windings are linked magnetically, and the transductor thus acts as a transformer so that the alternating voltage across the main winding in operation tends to induce an alternating voltage across the auxiliary winding; the windings are, however, usually arranged so that there is substantially no resultant induction of alternating current of fundamental frequency in the auxiliary winding, this usually being effected by forming one or both of the windings in two parts mounted in different parts of the core, and connecting and directing these parts so as to produce either a cancellation of magnetic flux components of fundamental frequency in the part of the core associated with the auxiliary windings or opposition of voltages of fundamental frequency induced in different parts of the auxiliary winding.

This arrangement of the windings does not, however, prevent the induction into the auxiliary winding of voltages of even harmonic frequency, with resultant flow of currents of similar frequency in the auxiliary winding which is often disadvantageous, especially in discharge lamp operating circuits.

An object of the present invention is to provide an improved form of such transductor where, in operation, the flow of current of even harmonic frequency in the auxiliary winding is substantially reduced.

According to the invention, in a variable inductance (transductor) of the type specified wherein the main winding and the auxiliary winding are arranged so that there is substantially no resultant induction of alternating current of fundamental frequency in the auxiliary winding in operation, there is provided a further magnetic core associated with the auxiliary winding but not associated with any part of the main winding, whereby the effective impedance of the auxiliary winding with respect to alternating currents of even harmonic frequency induced therein in operation is substantially increased. The induced voltage of even harmonic frequency causes a current to flow in the auxiliary winding, and the magnitude of this current is effectively reduced by the increased impedance of this winding.

Preferably, the said further magnetic core is made from magnetic material, which, in operation, saturates slowly and then only in a very strong magnetic field. To assist the slow saturation of the core, the core may be provided with an air-gap or a gap of non-ferromagnetic material. For example, the said further magnetic core may be formed from a magnetic powder which has an effective air-gap due to the powder being embedded in a non-ferromagnetic material.

The invention will be better understood from the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

In the drawing, Fig. 1 shows a cross-sectional perspective view of a double toroidal transductor in accordance with the invention, and Fig. 2 shows a cross-sectional perspective view of another form of double toroidal transductor also in accordance with the invention.

In the embodiment of the invention shown in Fig. 1, the double toroidal transductor comprises two annular magnetic cores **1**, **2** each of rectangular cross-section and formed from a stack of laminations. Each core **1**, **2** has insulatingly wound thereon a coil of wire **3**, **4** respectively for forming a section of the main winding of the transductor for the passage of alternating current in operation, the coils being wound in opposite directions.

These cores **1**, **2**, and coils **3**, **4** wound thereon, together with a third annular magnetic core **5**, of rectangular cross-section, formed from a stack of laminations are assembled together with their longitudinal axes substantially collinear, the third core being placed between the two coils **3**, **4** so that the adjacent surfaces **6**, **7** respectively of the coil **3**, and core **5** and the adjacent surfaces **8**, **9** of the coil **4** and core **5** are in intimate but insulating contact.

The assembly formed by the two coils **3**, **4** and the third core **5** is then provided with a further toroidal winding **10**, using the said assembly as a core, for forming the auxiliary winding for the passage of direct current, in operation.

In operation of this embodiment of the invention, the two sections **3**, **4** of the alternating current winding are so connected and directed that substantially no alternating current of fundamental and odd harmonic frequency is induced into the direct current winding **10**. This may be done by connecting them, with reverse polarity effect, in parallel as in Fig. 1 or in series as in Fig. 2. Since, due to the presence of the stack of annular laminations **5**, the impedance of the direct current winding is greatly increased, the magnitude of alternating currents of even harmonic frequency induced into this winding is reduced to a much lower level than would have been the case if the said laminations **5** had not been included.

The embodiment of the invention shown in Fig. 2 is structurally similar to that shown in Fig. 1 save that in this embodiment the location of said third core is changed and the two cores **1**, **2** together with their winding **3**, **4** respectively, are assembled together with the adjacent surfaces **11**, **12** of the coils **3**, **4** respectively in intimate insulating contact, the longitudinal axes of the two coils being substantially collinear.

In this embodiment, the assembly formed by the two coils **3**, **4** is provided around its outer circumferential surface with a third core in the form of a winding **13** of magnetic material, for example, several layers of metal tape wound around the circumferential surface **14** of the coil assembly. The assembly thus formed is then provided with a further toroidal winding **15** for forming the auxiliary winding for the passage of direct current in operation.

In the embodiments shown in Figs. 1 and 2, the stacks of core laminations on which the sections of the main winding were wound were formed from a grain oriented

high purity 50% nickel-iron alloy and were each dimensioned as follows:

	Inches
Internal diameter	3.35
External diameter	4.41
Thickness	0.394

Each section of the main winding comprised 3440 turns of 23 S. W. G. enamelled copper wire. The third core 5 referred to with reference to Fig. 1 comprises a stack of magnetic steel laminations dimensioned as follows:

	Inches
Internal diameter	2.6
External diameter	4.7
Thickness	0.11

In the case of the embodiment described with reference to Fig. 2, the said winding of magnetic material comprised 4 layers of strip formed from "Stalloy," the strip having the following dimensions:

	Inches
Width	2.37
Thickness	0.014
Total length	62.5

In both of these embodiments to the auxiliary winding comprised 2680 turns of 22 S. W. G. enamelled copper wire.

While I have shown particular embodiments of my invention, it will be understood, of course, that I do not wish to be limited thereto since many modifications may be made and I, therefore, contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

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

1. In combination, a two-coil winding, saturable magnetic core means for said winding, another winding linking said core means, the coils of said two coil winding being interconnected for reverse polarity, and an additional magnetic core means linking only said other winding.

2. A transductor comprising, in combination, a two-coil winding, a separate closed saturable magnetic core for each coil of said winding, another winding linking both of said cores, said coils being interconnected for reverse polarity, and a third magnetic core linking only said other winding.

3. A transductor comprising, in combination, a pair of similar coaxially separated magnetic ring cores each provided with a surrounding toroidal conductive winding, a third magnetic ring core coaxial with said pair of ring cores and outside each of the windings thereon, said windings being interconnected for reverse polarity, and a third toroidally shaped conductive winding enclosing said pair of ring cores with their windings and said third core.

4. A transductor comprising, in combination, a pair of similar coaxially separated magnetic ring cores each provided with a surrounding toroidal conductive winding, a third magnetic ring core coaxial with said pair of ring cores and between the windings thereon, and a third toroidally shaped conductive winding enclosing said pair of ring cores with their windings and said third core.

5. A transductor comprising, in combination, a pair of similar coaxially separated magnetic ring cores each provided with a surrounding toroidal conductive winding, a third magnetic ring core coaxial with said pair of ring cores and surrounding the windings thereon, and a third toroidally shaped conductive winding enclosing said pair of ring cores with their windings and said third core.

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