Oct. 12, 1937. W. J. POLYDOROFF 2,095,420

VARIABLE INDUCTANCES FOR TUNED HIGH FREQUENCY CIRCUITS

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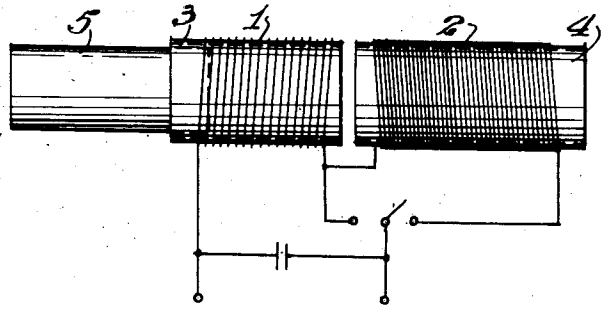


Fig. 1.

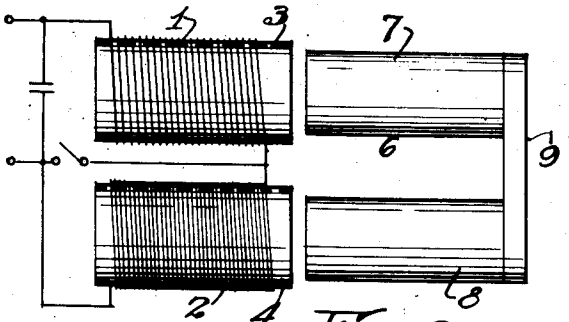


Fig. 2.

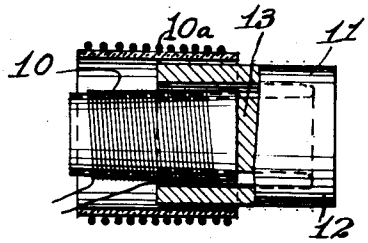


Fig. 3.

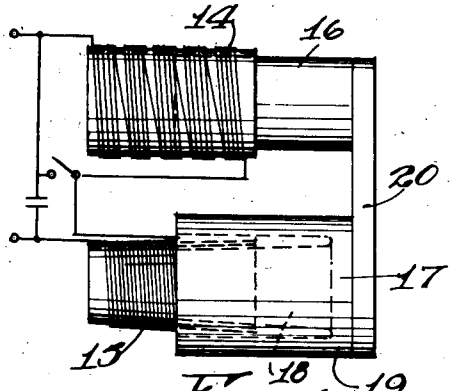


Fig. 4.

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VARIABLE INDUCTANCES FOR TUNED HIGH-FREQUENCY CIRCUITS

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2 Claims. (Cl. 171—242)

This invention relates to variable inductances, and more particularly to variable inductances suitable for use in high-frequency resonant circuits, arranged to be adjusted to any frequency within a relatively wide band. Variable inductances of this type may be employed, for example, in broadcast receivers.

The variable inductances of the present invention are of the type having compressed comminuted magnetic cores arranged to be movable relatively to the coils with which they are associated, the relative motion of the coil and core producing changes in inductance which permit tuning the resonant circuit of which the inductance may form a part, with or without the usual capacitance variation.

Variable inductance devices suitable for tuning resonant circuits over a range having a ratio of maximum to minimum frequency of the order of 3 are disclosed in my French Patent No. 737,154. The present specification is addressed to cases in which it is desired to tune one or more resonant circuits through a plurality of frequency ranges which may be widely separated from one another (e. g. the "medium" and "long" wavelength ranges usually provided for in modern broadcast receivers) and additionally to cases in which it is desired to tune over a range of frequencies greater in extent than can be covered by a simple variable inductance device such as those described in my French patent above referred to.

It is one object of the present invention, therefore, to provide variable inductance devices capable of being varied through two distinct ranges of inductance values. The maximum value of one range may be the same as the minimum value of the other, or they may be different. Another object of the invention is to operatively link at least two windings by a unitary common core structure in such a manner that the mutual inductance between two windings is considerably varied in addition to the usual inductance variation.

The invention will be best understood by reference to the accompanying drawing in which Fig. 1 shows a variable inductance device employing two coaxial coils differing in self-inductance value and a magnetic core member movable relatively to the coils; Fig. 2 shows an arrangement in which two coils are placed side by side with their axes parallel, and the relatively movable core member consists of two cylindrical portions, preferably joined by a magnetic yoke; Fig. 3 shows an arrangement in which the two coils are concentric, one coil being cylindrical and the other tapered in form, the core member being shaped to adapt it to the coils; and Fig. 4 shows an arrangement in which a cylindrical coil and a tapered coil are arranged side by side, the core consisting of separate members adapted to cooperate with the coils.

Magnetic core materials and cores suitable for use in the construction of the variable inductances of the present invention are disclosed in my U. S. Patents Nos. 1,940,228 and 1,982,689. In general, the cores consist of very finely divided magnetic material, such as pure iron, the particles being of such size as to reduce the losses in the resultant cores to a suitable minimum. The particles are individually insulated with a suitable insulator and are then molded into compressed bodies of suitable shape by the employment of an appropriate plastic binding material, sufficient pressure being used in the molding to give the resultant cores the desired value of apparent permeability.

Circuit arrangements in which variable inductance devices of the types herein contemplated may be advantageously employed are described in my French Patents Nos. 737,154 and 771,898.

According to the present invention, two separate coils or windings are associated with a single magnetic core unit, which is movable relatively to the coils. The movement may be so arranged that the core influences both coils simultaneously or it may be arranged in such a manner that the core influences either winding at will. In either arrangement the inductances of the two windings are controlled by the relative movement of the single core unit.

In the embodiments shown in Figs. 1 and 2, the two coils or windings 1, 2 are wound on two cylindrical forms 3, 4 of the same dimensions, although one coil may be of greater diameter than the other if required. In the arrangement shown in Fig. 1 the two coils 1, 2 are mounted coaxially on any suitable support. The core member 5 is cylindrical in shape and is arranged to be moved progressively through the coils. It will be understood that the two coils may be so connected relatively to each other that they will be either additive or subtractive in inductance value. As will be seen from the drawing, however, in order to secure the advantages of the invention, the windings are so wound and connected that current flow in one of the windings is in opposite angular sense to current flow in the other winding. As disclosed in my French Patent No. 771,898, the coils may be connected to appropriate switching means, which may be automatically operated by the core as it moves relatively to the coils, the switching means being arranged to connect either coil into the resonant circuit, with or without short-circuiting of the coil not in use.

Additionally, the switching means may be arranged to connect the two coils in series or in parallel and to change the direction of the wind-

ings from an additive to a subtractive relation or vice versa. By proper choice of the switching arrangement employed and by appropriate design of the coils themselves, variation throughout two or more different frequency ranges, each having a ratio of maximum to minimum frequency of the order of 3 to 1, may be readily accomplished.

In the embodiment illustrated in Fig. 2 the two coils 1, 2 are mounted side by side with their axes parallel. The core member 6 differs from that illustrated in Fig. 1 in that it consists of two cylindrical members 7, 8 and a yoke member 9. The coils 1, 2 are securely supported by any suitable means and the core unit is arranged to be moved in such a manner that the core member 7 may be moved into and out of coil 1 while the core member 8 moves into and out of coil 2.

Similarly to the arrangement shown in Fig. 1, the coils of Fig. 2 may be connected to appropriate switching means to accomplish changes in inductances to produce variation throughout two or more different frequency bands.

In Fig. 3 the coil 10*a* is wound on a cylindrical form, whereas the coil 10 is wound on a tapered form, the coils 10*a*, 10 being coaxially mounted on a suitable support, such as a plate. The core member 11 consists of two portions 12 and 13, the portion 12 being of tubular form and of such dimensions as to influence the inductance of coil 10*a* directly, whereas the portion 13 is conical in shape and is arranged to influence the inductance of the coil 10 directly. The two portions 12 and 13 of the core unit 11 may be separately molded and mechanically joined in such a manner that they are intimately associated magnetically at one end, or the entire core member 11 may be molded in one piece. The arrangement of this Figure is particularly useful when the larger diameter winding 10*a* is used for short-wave tuning.

In the embodiment shown in Fig. 4, the coil 14 is cylindrical whereas the coil 15 is conical in shape, the two coils being mounted side by side with their axes parallel on any suitable support. The core member 16 is cylindrical in shape and is arranged to directly influence the inductance of the coil 14. The core member 17 consists of two portions 18, 19, the member 18 being conical in shape and adapted to be moved into the coil 15, the member 19 being tubular in shape and arranged to move outside the coil 15 in such a manner as to substantially surround the coil 15 when fully advanced. The members 18 and 19 may be joined by a separate magnetic yoke 20 or the yoke 20 may be molded as part of the internal core member 18 or a part of the external core member 19. Alternatively, the entire core 17 consisting of the portions 18, 19, 20 may be molded in one piece. In Figs. 2 and 4 the smaller inductance coil alone operates over the high-frequency range, the other part of the core providing a low-reluctance path for the return flux, thus increasing the range. When the higher inductance coil is switched into series relation with the first coil, both cores also act to increase the inductance variation.

In the arrangement of Figs. 2 and 4, the two coils (1, 2 in Fig. 2 and 14, 15 in Fig. 4) are so connected that the fluxes in the two coils will be in opposite directions at any instant. Thus practically all the flux from one end of one coil enters the adjacent end of the other coil, the arrangement being what is commonly known as a "binocular" pair. It will be noted that the arrangement is such that current flow in one of the windings is in opposite angular sense to current flow in the other winding. With the coils so wound and connected there is a very material increase in the coupling between the two coils if the core unit is advanced into them, because the core forms a substantially complete iron path for the flux. In this manner, a considerably greater variation in the inductance of the device with the two coils connected in series and additively related, may be secured.

It will be observed that the coils have been shown as single-layer solenoidal windings, since this produces minimum high-frequency resistance in the winding itself; but, where high inductance values are required, multiple-layer windings, preferably bank-wound, may be employed.

It is preferable to use a conductor consisting of several insulated strands, commonly known as Litz wire, for the windings, although, of course, a solid conductor may be used if desired. In practical embodiments of the invention it will frequently be found convenient to make one of the coils single-layer solenoidal with spaced turns for the higher frequency range, and the other coil a multiple-layer winding for the lower frequency range.

For securing the relative movement between the coils and the core unit, any suitable mechanical drive may be employed. Forms of mechanical movement which have been found to be suitable are described in my French Patent No. 737,154.

It will be understood that any of the arrangements herein described may be employed in the construction of a band-pass filter or other tuning system in which two oscillatory circuits are tuned simultaneously through two different ranges of frequency and in which some inductive coupling between the two oscillatory circuits is permissible or desirable. It will also be understood that plural inductance devices of types herein disclosed may be arranged to tune a plurality of circuits through two or more frequency ranges. In such embodiments the mechanical drive will move all the cores simultaneously, relatively to the coils, and adjustments such as those described in my French Patent No. 771,898 will be provided in order to secure and maintain synchronism or alignment of the several circuits.

Having thus described my invention, what I claim is:

1. A variable inductance device for multi-range tuning, including a comminuted magnetic core structure, two windings of different self-inductance value and whose effective inductance is varied by said core structure, and switching means to alter the connections of said windings, said core structure constituting a common magnetic path for said windings to increase the total effective inductance variation, and said windings being arranged coaxially end to end and magnetically in opposed relation.

2. A variable inductance device for multi-range tuning, including a comminuted magnetic core structure, two windings of different self-inductance value and whose effective inductance is varied by said core structure, said windings being arranged coaxially end to end and magnetically in opposed relation, and switching means to alter the connections of said windings, said core structure constituting a common magnetic path for said windings to increase the total effective inductance variation and being arranged to move into one of said windings and out of the other of said windings simultaneously.

WLADIMIR J. POLYDOROFF.