

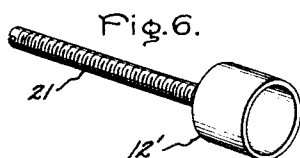
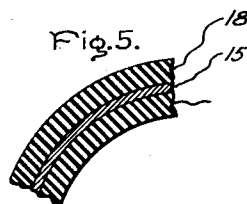
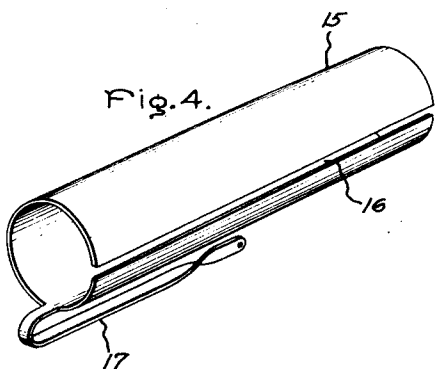
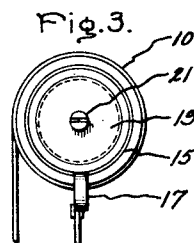
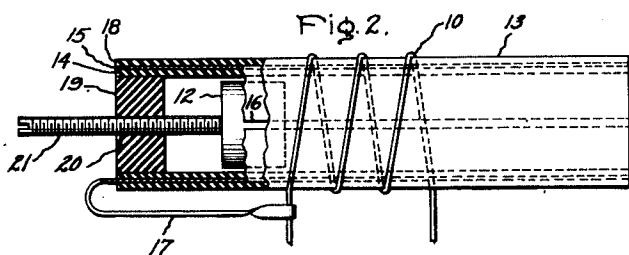
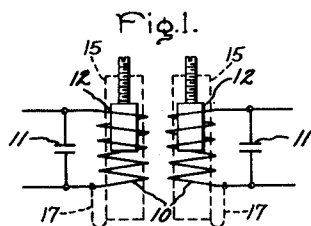
Aug. 5, 1941.

H. F. MAYER

2,251,631

INDUCTANCE DEVICE

Filed Dec. 29, 1939



Inventor:
Harry F. Mayer
by *Harry E. Dunham*
His Attorney.

UNITED STATES PATENT OFFICE

2,251,631

INDUCTANCE DEVICE

Harry F. Mayer, Schenectady, N. Y., assignor to
General Electric Company, a corporation of
New York

Application December 29, 1939, Serial No. 311,554

9 Claims. (Cl. 171—242)

My invention relates to an inductance device, the inductance of which may be varied or adjusted, and particularly to such a device adapted for use at very high radio frequencies.

Resonant circuits containing inductance and capacity elements, such as are commonly employed in high frequency circuits, may be tuned to different resonant frequencies by varying either the inductance or capacity thereof. In certain applications, particularly where very high frequencies are involved of the order of about 30 megacycles and upward, inductance tuning presents advantages over capacity tuning. Inductance tuning is particularly useful where the resonant frequency need be varied only over a relatively narrow range, for example in an intermediate frequency transformer.

Several different types of variable inductance elements have been employed in inductance tuned circuits. One known type of inductance device comprises a nonmagnetic, metallic member movable with respect to an inductance coil. As the member is moved into closer proximity to the coil, the effect is to increase the magnetic circuit reluctance, correspondingly decreasing the coil inductance. With an inductance device of this type it is possible to obtain a maximum variation in inductance of the order of two or three to one. However, the distributed capacity of the coil will ordinarily be increased as the metallic member is moved closer to the coil. This tends to offset the change in resonant frequency which would be obtained by the inductance change alone and may have a material effect at high frequencies. Hence it is highly desirable to reduce this capacity variation as far as possible.

It is an object of my invention to provide an improved adjustable or variable inductance device, particularly adapted for use at very high frequencies, of the type having a movable, non-magnetic, metallic member for changing the inductance thereof.

It is a further object of my invention to provide an improved inductance device of this type incorporating electrostatic shielding means for substantially eliminating variations in the distributed capacity of the device as the inductance is varied.

The features of my invention which I believe to be novel are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by

reference to the following description taken in connection with the accompanying drawing, in which Fig. 1 diagrammatically represents coupled resonant circuits employing variable inductance devices embodying my invention; Fig. 2 shows a side elevation, partly in section, of one form of inductance device embodying the invention; Fig. 3 shows an end elevation of the device of Fig. 2; Figs. 4 and 5 illustrate details of the construction of the device shown in Figs. 2 and 3; and Fig. 6 is a perspective view of a modified form of one element of Fig. 2.

In the drawing corresponding elements of the various figures have been designated by corresponding reference numerals.

Referring now to Fig. 1, two mutually coupled, parallel resonant circuits are diagrammatically illustrated, such as might comprise an intermediate frequency transformer for use in superheterodyne radio receivers. Each resonant circuit comprises an inductance coil 10, a capacitor 11 and a non-magnetic, metallic core 12 adapted to be moved relative to coil 10 to vary the inductance thereof. Ordinarily each circuit is tuned to the same resonant frequency. When such a circuit arrangement is operated at very high frequencies the external capacity 11, which resonates with the inductance of the coil 10, is very small. For example, it may comprise only the interelectrode capacity of thermionic devices, not shown, associated with the resonant circuit and the capacity of connecting leads. In such case the distributed capacity of the coil 10 may be comparable in magnitude to the external capacity. In the usual inductance device of this type the metallic core 12 presents a surface of considerable area adjacent the coil 10 and increases the distributed capacity of the coil as it is moved into closer proximity thereto. Since the resonant frequency varies inversely as a function of the product of inductance and capacity, a decrease in inductance caused by movement of the metallic core 12 may be largely offset by simultaneous increase in the distributed capacity, resulting in very little alteration of the resonant frequency. For example, for a certain experimental arrangement of this type operating in the neighborhood of 40 megacycles, movement of the metallic core produced a maximum inductance variation of approximately 40 per cent. However, the resonant frequency of the circuit was thereby varied only by about 5 per cent.

In accordance with my invention undesirable variations in the distributed capacity of the coil 10, as just described, are substantially eliminated

by electrostatically shielding the coil 10 from the movable core 12. As is diagrammatically indicated by the dotted cylinders in Fig. 1, an electrostatic shield 15 is interposed between each coil 10 and its associated core 12. The shield 15 preferably is maintained at a definite potential with respect to coil 10, as by a conductive connection 17 therebetween. For a better understanding of the features of my invention, including the function of the electrostatic shield 15, a preferred structural embodiment of my improved inductance device will now be described in detail.

Referring now to Figs. 2 to 5, inclusive, which illustrate one embodiment of an improved inductance device constructed according to the principles of the invention, there is illustrated an inductance coil 10 comprising a plurality of turns of wire. The coil is wound upon the surface of a cylindrical form 13. This form is of laminated construction and has an electrostatic shield incorporated therein. Fig. 5 is an enlarged, partial cross-section of the form 13 at right angles to the axis showing more clearly the laminated structure. The form consists of an inner cylinder 14 of suitable insulating material such as paper or fiber. Over this cylinder is placed a layer or shell of thin metal foil 15, preferably copper foil, which acts as an electrostatic shield. As is more clearly shown in Fig. 4, this cylindrical shell of foil does not close completely upon itself but has a gap 16 extending throughout its entire length. It is also provided with a strip or tab 17 which makes conductive connection to a point on the coil 10, as shown in Fig. 2. Preferably, this point is also grounded by any suitable means, not shown. Over the layer of foil 15 is placed another layer 18 of suitable insulating material to space the foil shield from the coil 10 and to insulate it therefrom in the event that the coil consists of a bare conductor wound directly upon the surface of the layer 18. The layers 14, 15 and 18 may be compressed or bonded together in any desired manner to form a unitary structure.

Supported within one end of the form 13 is a cylindrical disk 19 of insulating material having a threaded hole 20 therethrough coaxial with coil 10 and form 13. A threaded shaft 21 supported by the disk 19 provides means for mounting a non-magnetic, cylindrical, metallic core 12, such as one of copper or brass, coaxially with the coil 10 and also provides means for moving the core 12 axially with respect to the coil 10.

The electrostatic shield 15 provides an equipotential surface of substantially constant capacity with respect to the core 12 irrespective of the position of the latter. Since the shield is circumferentially incomplete, being open along one side at 16, it does not present closed current paths linked with the magnetic flux surrounding the coil 10 and hence has a negligible effect on the magnetic field. The core 12 does present low resistance, closed current paths linked with this magnetic flux and, hence, as the core 12 is moved into closer proximity to the coil 10 the interaction between the flux surrounding the coil 10 and the flux produced by circulating currents induced in the core 12 effectively reduces the inductance of the coil 10. Conversely, as the core 12 is moved away from the coil 10, the inductance is increased. However, at all times the distributed capacity of the coil remains substantially constant. For example, in an experimental device similar to that mentioned previously and operating under similar conditions, but incorpo-

rating the electrostatic shield, a maximum inductance variation of approximately 40 per cent was obtained as before. However, with this improved construction the resonant frequency of the circuit was thereby varied approximately 20 per cent, about four times the variation obtainable without the shield.

Since circulating current induced in the metallic core 12 will be concentrated largely at the surface by virtue of the well-known "skin effect" at high frequencies, the core may optionally comprise a hollow cylindrical shell 12', as illustrated in Fig. 6 with equally satisfactory results.

It is obvious that many modifications may be made without departing from the fundamental principles of my invention. The movable member and electrostatic shield may take various forms and may be arranged in various spatial relationships so long as each effects its intended function. While I have found it preferable to make a conductive connection between shield and coil to maintain the former at a definite potential with respect to the latter, there may be occasions where it is desirable to ground the shield independently or to omit the connection strip altogether, as will be apparent to those skilled in the art.

Several inductance devices constructed in accordance with my invention obviously may be coupled together in any conventional manner. For example, inductive coupling may be employed, as shown in Fig. 1.

Other modifications will readily occur to those skilled in the art. Therefore while I have shown a particular embodiment of my invention, it will of course be understood that I do not wish to be limited thereto since many such modifications may be made, both in the circuit arrangement and instrumentalities employed, and I 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. An inductance device comprising a coil having self inductance, means to modify said inductance comprising a non-magnetic, metallic body providing a closed path of low electrical resistance in proximity to said coil, means for moving said body relative to said coil to vary said inductance, and electrostatic shielding means interposed between said coil and said body to maintain the distributed capacity of said coil substantially constant at all positions of said body.

2. An inductance device comprising a coil having self inductance, means to modify said inductance comprising a non-magnetic, metallic body providing a closed path of low electrical resistance in proximity to said coil, means for moving said body relative to said coil to vary said inductance, means comprising an electrostatic shield interposed between said coil and said body to maintain the distributed capacity of said coil substantially constant at all positions of said body, and means for maintaining said shield at a definite potential with respect to said coil.

3. An inductance device comprising a coil having self inductance, means to modify said inductance comprising a non-magnetic, metallic body providing a closed path of low electrical resistance in proximity to said coil, means for moving said body relative to said coil to vary said inductance, means comprising an electrostatic shield interposed between said coil and said body

to maintain the distributed capacity of said coil substantially constant at all positions of said body, and a conductive connection between said coil and said shield.

4. A high frequency inductance device comprising a coil having self inductance, means to modify said inductance comprising a non-magnetic, metallic core movable within said coil, and providing a closed path of low electrical resistance, means to move said core to vary said inductance, means comprising an electrostatic shield interposed between said coil and said core to maintain the distributed capacity of said coil substantially constant at all positions of said body, and a conductive connection between said coil and said shield.

5. A variable inductance device comprising, in combination, a coil adapted to be energized from a high frequency source, a non-magnetic, metallic body providing a closed path of low electrical resistance in inductive relation to said coil, means for moving said body relative to said coil to vary the electromagnetic coupling therebetween, and electrostatic shielding means of non-magnetic, metallic material interposed between said coil and said body and arranged so as to have substantially no effect upon said electromagnetic coupling between said coil and said body while substantially preventing electrostatic coupling therebetween, thereby to maintain the distributed capacity of said coil substantially constant at all positions of said body.

6. A high frequency inductance device comprising, in combination, a coiled conductor having self inductance, means to modify said inductance comprising a non-magnetic, metallic core movable within said coil and providing a closed path of low electrical resistance, means to move said core relative to said conductor to vary said inductance, and electrostatic shielding means surrounding said core and interposed between said core and said conductor to maintain the distributed capacity of said coil substantially constant at all positions of said body, said shielding means comprising a non-magnetic, metallic circumferentially incomplete shell, and a conductive connection between said shell and said conductor.

7. A high frequency inductance device comprising a conductor in the form of a substantially cylindrical coil having self inductance, a substantially cylindrical, non-magnetic, metallic core of low electrical resistance coaxial with said

coil and adapted to modify said inductance in accordance with its proximity to said coil, means for moving said core along the axis of said coil to vary said inductance, means comprising an electrostatic shield coaxial with and interposed between said coil and said core to maintain the distributed capacity of said coil substantially constant at all positions of said body, said shield comprising a substantially cylindrical, non-magnetic, metallic shell having an insulated gap therein extending throughout its length to render said shell circumferentially incomplete, and a conductive connection between said shield and said coil.

8. A variable inductance device comprising, in combination, a coil adapted to be energized from a high frequency source, means providing closed paths of low electrical resistance in inductive relation to said coil comprising a non-magnetic, metallic core, means for moving said core relative to said coil to vary the electromagnetic coupling therebetween, and electrostatic shielding means interposed between said core and said coil to maintain the distributed capacity of said coil substantially constant at all positions of said body, said shielding means comprising a thin shell of non-magnetic, metallic material surrounding said core, said shell being circumferentially incomplete so as to have substantially no effect upon said electromagnetic coupling between said coil and said core while substantially preventing electrostatic coupling therebetween.

9. A variable inductance device comprising, in combination, a coil adapted to be energized from a high frequency source, means providing closed paths of low electrical resistance in inductive relation to said coil comprising a non-magnetic, metallic core, means for moving said core relative to said coil to vary the electromagnetic coupling therebetween, electrostatic shielding means interposed between said core and said coil to maintain the distributed capacity of said coil substantially constant at all positions of said body, said shielding means comprising a thin shell of non-magnetic, metallic material surrounding said core, said shell being circumferentially incomplete so as to have substantially no effect upon said electromagnetic coupling between said coil and said core while substantially preventing electrostatic coupling therebetween, and means for maintaining said shielding means at a definite potential with respect to said coil.

HARRY F. MAYER.