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HIGH FREQUENCY COUPLING DEVICE

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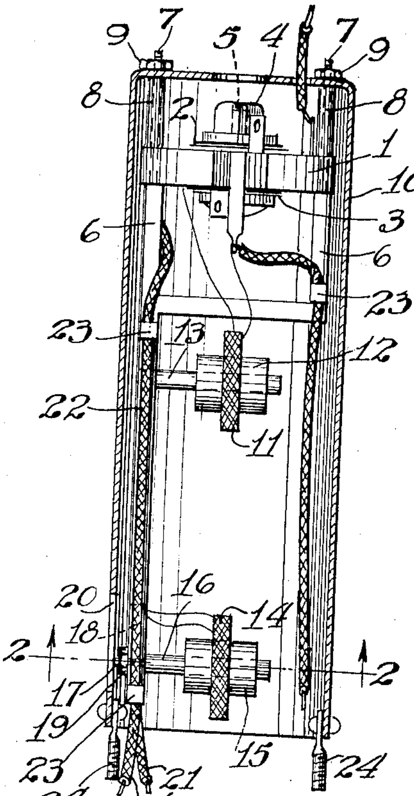

Fig. 1.

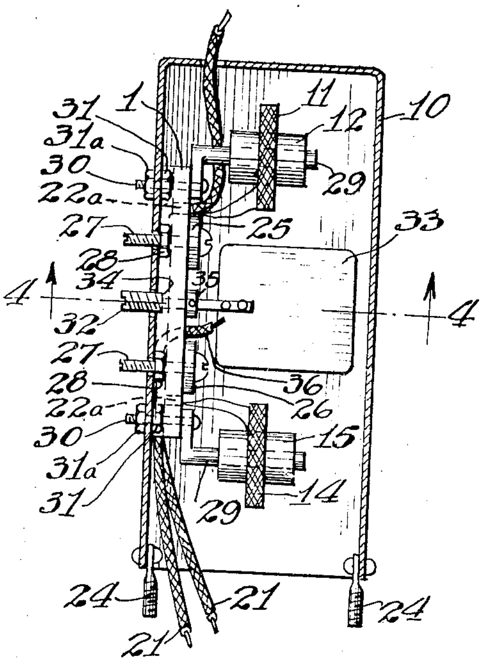

Fig. 3.

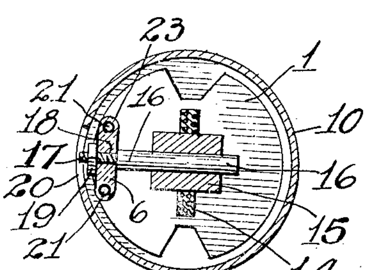

Fig 2.

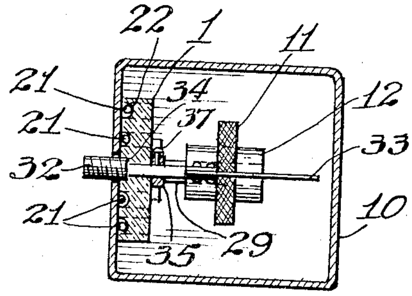

Fig. 4.

INVENTORS,
CHARLES C. NEIGHBORS
WILFRED H. JAMES.
BY
Thomas G. Steward
ATTORNEY.

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HIGH-FREQUENCY COUPLING DEVICE

Charles C. Neighbors and Wilfred H. James, Chicago, Ill., assignors to Johnson Laboratories, Inc., Chicago, Ill., a corporation of Illinois

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8 Claims. (Cl. 178—44)

This invention relates broadly to improvements in high-frequency amplifying systems, and more particularly to systems designed to be operated at a fixed frequency, such for example as those in the intermediate-frequency amplifiers of superheterodyne radio receivers. Such systems, in general, include, in addition to the amplifying thermionic relay, a resonant system consisting of two inductors and their tuning capacitors, the inductors being arranged either in magnetic relation or else capacitively coupled to each other. The capacitors are normally of a type having very low losses, and include means for a small adjustment of the capacitance. The efficiency of the complete design depends to a very large extent upon the inductors.

An object of this invention is to provide novel types of coupling means for use in such amplifying systems, which, because of their design, will materially increase the efficiency of the system. Additionally, it is the object of this invention to provide designs for the resonant circuits of such amplifying systems which will be more compact, and which can be easily adjusted to the desired coupling.

Further objects of the invention are attained by the employment of cylindrical and preferably hollow magnetic cores for the inductors in order that, when they are adjusted relatively to each other, values of coupling ranging from negligible to somewhat greater than optimum may be readily secured. The hollow cores also provide a more economical form than solid cores, and incidentally afford means for their ideal mounting.

A still further object of the invention is attained by so mounting the inductors that their axes are at right angles to the longest dimension of the shield can which is used in conjunction with such devices. This shield is usually necessary to prevent interaction between adjacent components of the equipment and the inductors of the device, and incidentally provides convenient mounting means and mechanical protection for the device. It has been found that the above-described positioning of the inductors gives an advantageous reduction in losses when the device is housed in a compact shield.

Additional objects of the invention are attained by provision for convenient adjustment of the degree of coupling between the inductors from without the shield, and for establishing the spacing of the leads to the inductors in order to prevent undesired variations in the stray capacitances of the device, as for instance might occur were one of the leads to shift relatively to the shield.

Circuits of the class here contemplated normally occur in pairs, one resonant circuit being connected to the output terminals of a first thermionic relay, and another circuit being connected to the input terminals of a second thermionic relay. In order to develop a maximum voltage in the second resonant circuit due to current in the first, the inductors are normally coupled inductively. The inductor in the circuit connected to the output terminals of the first thermionic relay is usually called the primary, and the inductor in the circuit connected to the input terminals of the second thermionic relay is usually called the secondary. In some instances, however, these designations may be reversed, and either of the thermionic relays may in certain types of apparatus be arranged so that it does not operate strictly as an amplifier. These variations, however, are not material with respect to the application and scope of the present invention.

In present-day designs, coupling devices of the class here under consideration normally do not employ magnetic cores. Across the first inductor, and also across the second inductor, there is connected a capacitor whose capacitance is adjustable over a limited range. By suitably designing the primary and secondary inductors and by adjustment of the associated capacitors, each of the circuits may be tuned to be resonant at the desired frequency. In order to develop a maximum voltage across the second inductor due to the current in the first inductor, it is essential that the inductive coupling between the two inductors shall be closely of the optimum value. In present designs, it is customary to establish the degree of coupling in the design of the device, so that when the inductors are assembled, the proper coupling will exist.

Because of the losses which normally exist in air-core inductors of the type now commonly used, it is not essential to provide means for adjusting the coupling between the primary and secondary inductors after the unit is assembled. It is usually sufficient to determine experimentally what physical relation between the two inductors will give approximately the correct coupling and then to mechanically design the device so as to produce this relation.

In the designs herein described, the losses in the inductors themselves are greatly decreased, and it therefore becomes desirable to provide means for accurately adjusting each unit to the desired coupling between primary and secondary. The present invention, therefore, includes designs for inductors having greatly increased efficiency, and arrangements whereby two such inductors may be inductively related in a coupling device with means for producing an accurate adjustment of the inductive coupling. The inductive coupling may be arranged to either add to or oppose the inherent capacitive coupling.

The increased efficiency of the inductors themselves is secured by introducing a magnetic core. These cores are preferably of a type made by compressing individually insulated magnetic particles of very small size. The size of the particles which will be most advantageous for use in any particular design will depend largely upon the frequency for which the system is being designed. In general, the higher the frequency, the smaller the particles will be. The insulation of the individual particles must be sufficiently complete to produce a very high electrical resistivity in the compressed comminuted core, which will then have very low electrical losses.

In cores of this preferred type, it is readily possible to secure effective permeability of the order of from 2 to 4. This greatly decreases the size of the winding itself, because less turns are required for any desired value of inductance. This materially decreases the resistance of the winding. Since the losses in air-core inductors of present designs are the chief source of inefficiency in high-frequency coupling devices, a reduction in the size of the winding will produce a corresponding decrease in the losses of the system, provided that the losses introduced by the introduction of the magnetic core are sufficiently small. Cores of the type which we have described possess this property of extremely low losses, so that our iron-core inductors are very much more efficient than the equivalent air-core inductors.

Because of the higher efficiency of the iron-core inductors, it is possible to obtain greater secondary voltage with less coupling than is permissible with air-core inductors. This results in an increase in the electrical efficiency of the device. In a high-frequency amplifier, for example, it is possible to get substantially twice the amplification while maintaining the selectivity the same as it would be with air-core inductors, or, if desired, it is possible to obtain approximately twice the selectivity while maintaining the same amplification. Similarly, a fifty per cent. increase in both amplification and selectivity can be secured.

This invention will be better understood by reference to the accompanying drawing, which is illustrative of practicable mechanical embodiments of the invention. It will be understood that numerous mechanical arrangements other than those shown may be employed to provide means for mechanical adjustments to vary the inductive coupling between the primary and secondary inductors, all within the scope of the present invention.

Referring to the drawing, Figure 1 is an elevation, partly in section, of a high-frequency coupling device employing magnetic cores;

Figure 2 is an elevation, in section, taken at line 2—2 of Figure 1;

Figure 3 is an elevation, partly in section, of a modified form of high-frequency coupling device, and

Figure 4 is an elevation, in section, taken at line 4—4 of Figure 3.

Referring to Figures 1 and 2, the device here illustrated includes an insulating base 1, preferably of a ceramic material. Secured to the base 1 are capacitors 2 and 3, which are so designed that their capacitances are adjustable over a limited range. The capacitance of capacitor 2 is altered by means of nut 4, and the capacitance of capacitor 3 is adjusted by means of screw 5, located inside of nut 4.

Frame 6 is preferably cast or molded in one piece of an insulating material such as bakelite, to avoid the cost of assembling operations which would be necessary if it included, as it might, a plurality of elements. Threaded inserts 7 are molded into the feet of frame 6, and, in conjunction with sleeves 8 and nuts 9, secure the frame 6 to the base 1. Inserts 7 also pass through holes in the top of shield 10, thereby serving to maintain the base 1 in a definite position relative to shield 10. A hole in the top of shield 10 gives access to adjustments 4 and 5 of capacitors 2 and 3.

Coil 11, which is preferably of the universal-wound type, is cemented or otherwise suitably secured to its cylindrical magnetic core 12, which in turn is mounted on frame 6 by means of insulating rod 13. As shown, the axis of the inductor 11—12 is perpendicular to the longitudinal axis of shield 10. Coil 14, of the same construction and usually of the same size as coil 11, is likewise mounted on its core 15, which in turn is secured to the insulating rod 16. A threaded insert 17 is molded into the end of rod 16, and passes through a slot 18 in frame 6. The nut 19 serves to secure inductor 14—15 in a desired position relative to inductor 11—12, and access is had to nut 19 through a suitable opening 20 in shield 10.

The slot 18 in the frame 6 is of length sufficient to provide the necessary range of coupling variation required by the design.

The leads 21 to the device are secured in slots 22 in frame 6 by means of tape bands 23 or in any other suitable manner. The whole device is mounted upon the chassis of the equipment with which it is to be used by means of threaded studs 24 suitably secured to the shield 10.

In quantity production of devices of the type shown in Figure 1, it will usually be preferable to design the insulating frame 6 with the slot 18 to permit coupling adjustment. After a considerable number of units have been manufactured, the exact position for the movable inductor to give the proper degree of coupling for the particular design will be known, and a jig may be made so that the inductors may be accurately positioned in the slot without resort to any electrical method of observing the performance of each device.

Inductor 14—15, therefore, may be fixed in a predetermined desired position relative to inductor 11—12, instead of being adjustable, without departing from the scope of the present invention. This makes possible a slight reduction in the cost of manufacture of the device without sacrificing any important feature of the invention.

The device shown in Figures 3 and 4 employs a different method of mounting the inductors and also has an alternative arrangement for varying the coupling between them. An insulating base 1, preferably of a ceramic material, has mounted on it adjustable capacitors 25 and 26, which are adjustable by screws 27 operating in countersunk nuts 28. Insulating brackets 29 supporting inductors 11—12 and 14—15 are secured to base 1 by means of bolts 30 and nuts 31. Bolts 30 together with nuts 31a also secure base 1 to the shield can 10, which in this embodiment is of rectangular cross section.

The leads 21 to the device pass through grooves 22 in base 1, and connecting holes 22a convey the leads through the base to the terminals of the capacitors. Base 1 also supports shaft 32, which has a slot for a screwdriver at its outer end, and to the inner end of which is attached metallic vane 33, preferably made of copper or aluminum.

Axial motion of shaft 32 is prevented by shoulder 34 and collar 35. A flexible lead 36 provides an electrical connection from the vane 33, to the shield, and therefore to ground, and a stop-pin 37 prevents the shaft 32 from rotating sufficiently to sever lead 36.

Shield can 10 is provided with holes to receive screws 27 and shaft 32, and with suitably attached threaded pieces 24 for securing the whole device to the chassis of the equipment with which it is to be used. Thus adjustment of the capacitances of capacitors 25 and 26, and of the position of vane 33, is readily made from without the shield even after assembly of the device on the chassis of the equipment.

The inductive coupling between the inductors may be varied over a substantial range by rotating the metallic vane 33. The presence of an ungrounded vane will appreciably increase the capacitive coupling between the inductors. If the vane is grounded by means of lead 36, the capacitive coupling between the inductors will be considerably decreased.

In either embodiment of the invention herein shown, the inductive coupling adds to or opposes the capacitive coupling which is present in accordance with the relative winding directions of the two inductors. Which arrangement is used depends largely upon how the device is to be employed, and is not material to the scope of the present invention.

It will be noted that the methods used in the present invention for adjusting the coupling between the inductors of the device are such that the adjustment may be readily changed when desired.

Various methods for making the vane 33 remain fixed in a desired position may be employed, as for instance a spring washer under collar 35. In other cases, rotation of the vane is a convenient method for obtaining variation in the degree of selectivity of the coupling device, as for instance to permit wide-band or highly selective performance from the same device at the option of the operator. By mechanically ganging the vanes of several units, a substantial range in selectivity may be readily obtained.

Having thus described our invention, what we claim is:

1. A high-frequency coupling device including two resonant circuits each having an inductor, said inductors each having a winding and a comminuted magnetic core, a conductive shield surrounding said inductors, said inductors being positioned with their axes parallel and at right angles to the axis of said shield to reduce the coupling between said inductors, and being so spaced from each other as to secure substantially optimum coupling between said circuits.

2. A high-frequency coupling device including two resonant circuits each having an inductor, said inductors each having a winding and a comminuted magnetic core, a conductive shield surrounding said inductors, said inductors being positioned with their axes parallel and at right angles to the axis of said shield to reduce the coupling between said inductors, and an insulating frame for supporting said inductors from said shield and for so spacing them from each other as to secure substantially optimum coupling between said circuits.

3. A high-frequency coupling device including two resonant circuits each having an inductor, said inductors each having a winding and a comminuted magnetic core, a conductive shield surrounding said inductors and having a closed end, said inductors being positioned with their axes parallel and at right angles to the axis of said shield to reduce the coupling between said inductors, and an insulating frame for supporting said inductors from said shield and for so spacing them from each other as to secure substantially optimum coupling between said circuits, said frame being mounted upon the closed end of said shield.

4. A high-frequency coupling device including at least two resonant circuits each having an inductor, tubular magnetic cores for each of said inductors, a tubular shield surrounding said inductors and having one closed end, and an insulating frame for supporting said inductors with their axes parallel and intersecting the axis of said shield at right angles and arranged to be mounted on one side of said shield whereby desired coupling between said inductors is achieved.

5. A high-frequency coupling device including at least two resonant circuits each having an inductor, magnetic cores for each of said inductors, a conductive shield surrounding said inductors, an insulating frame for supporting said inductors in spaced relation and with their axes parallel, and a conductive rotatable vane positioned between said inductors for varying the inductive coupling therebetween, whereby desired coupling between said inductors is achieved.

6. A high-frequency coupling device including two resonant circuits each having an inductor, said inductors each having a winding and a comminuted magnetic core, a conductive shield surrounding said inductors, said inductors being positioned with their axes parallel and at right angles to the axis of said shield to reduce the coupling between said inductors, and means whereby the coupling between said inductors may be adjusted to secure substantially optimum coupling between said circuits.

7. A high-frequency coupling device including at least two resonant circuits each having an inductor, means for supporting said inductors with their axes parallel but in spaced relation, a conductive shield surrounding said inductors, a conductive rotatable vane positioned between said inductors for varying the inductive coupling therebetween and means for adjusting the position of said vane from without said shield, whereby desired coupling between said inductors is achieved.

8. A high-frequency coupling device including two resonant circuits each having an inductor, said inductors each having a winding and a comminuted magnetic core, a conductive shield surrounding said inductors, said inductors being positioned with their axes parallel and at right angles to the axis of said shield to reduce the coupling between said inductors, and means for adjusting one of said inductors along the axis of said shield whereby the coupling between said inductors may be adjusted to secure substantially optimum coupling between said circuits.

CHARLES C. NEIGHBORS.
WILFRED H. JAMES.