

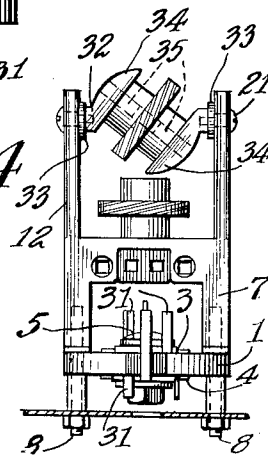
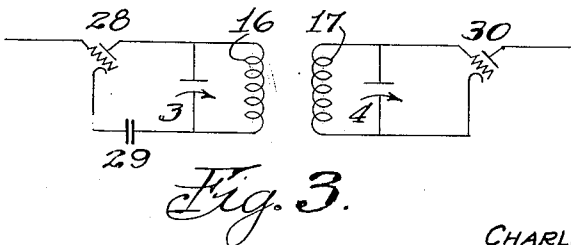
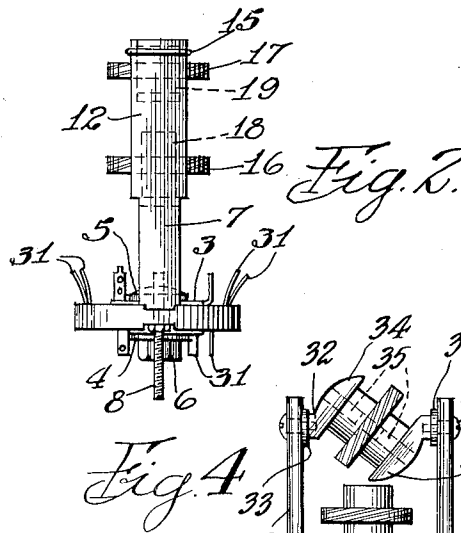
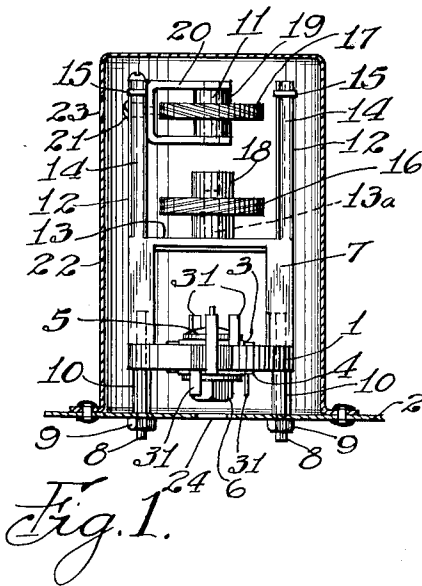
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2,082,589

ADJUSTABLE COUPLING FOR HIGH FREQUENCY COUPLING DEVICES

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ADJUSTABLE COUPLING FOR HIGH-FREQUENCY COUPLING DEVICES

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This invention relates to coupling devices for use in high-frequency signaling systems and more particularly to the types used in signal receiving apparatus in which the energy handled is small. High-frequency coupling devices of the type herein contemplated are commonly called transformers and may be divided into two general groups, namely, radio-frequency transformers and intermediate-frequency transformers, these being the designations commonly used in the radio art.

It will be understood that while in describing our invention we have in mind particularly its use in space signal receiving apparatus, it is nevertheless applicable to receiving apparatus for carrier and other high-frequency receiving systems.

Coupling devices of the types herein contemplated will have at least two windings, which may be designated as the primary and the secondary, either or both of which may be tuned by a suitable condenser. If the transformer is intended to be tuned to a particular frequency, the associated condensers will be adjustable over a limited range to produce resonance at that frequency. If the transformer is intended to be tuned over a considerable range of frequencies, it will be associated with a variable condenser having a suitable range of minimum to maximum capacitance.

It is desirable, in transformers of the class here contemplated, to have a convenient means for adjusting the coupling between the primary and the secondary. This coupling may be entirely inductive, entirely capacitive, or inductive and capacitive combined. In the transformers now generally employed, the coupling, of whatever type, is established in the design, and no means is provided for an adjustment of the coupling during manufacture or in use. One of the objects of our invention is to provide a transformer in which the coupling can be conveniently and accurately adjusted.

Another object of our invention is to provide an improved type of high-frequency coupling device having higher efficiency than is attainable in the types now commonly employed, or in any type heretofore disclosed. A still further object is to provide a coupling device in which the performance over a range of frequencies will be substantially improved over the types now commonly in use or heretofore described, and in which one of the principal difficulties encountered in these earlier types is, at least to a very considerable degree, overcome.

Additional objects and advantages of our invention include providing a coupling device inexpensive to manufacture, whose components can be produced on automatic machines and which in its completed form may include the necessary condensers as a part of the manufactured unit.

These and other objects of our invention will be best understood from the following description taken in connection with the drawing, in which—

Fig. 1 is a front elevation of a high-frequency coupling device;

Fig. 2 is a side elevation of the device shown in Fig. 1;

Fig. 3 is a wiring diagram showing how the device of Fig. 1, or a similar transformer, is to be connected to a circuit including a pair of thermionic relays; and

Fig. 4 is a modification of the device of Fig. 1.

Referring to Fig. 1, it will be noted that the coils 16, 17 are mounted upon open-type cores 18, 19. These cores are ferromagnetic and consist of finely divided individually insulated magnetic particles compressed with a binding material to make a core body. Cores of this type, suitable for use at high frequencies, are disclosed in United States Patents Nos. 1,940,228 and 1,982,689, and have recently been described in numerous publications in the United States and abroad. The inductor is preferably designed in accordance with United States Patent No. 1,978,568, for High-frequency inductance. The inductance consists essentially of a tubular cylindrical core of the type described, with a pancake universal winding at its center, the length of the winding being usually from three-eighths to two-thirds of the radial depth and the length of the core being from $2\frac{1}{2}$ to 5 times the length of the winding.

The advantages of these magnetic-core inductors may be briefly summarized by pointing out that they provide a much more efficient inductor than can be produced with an air core, that they are inexpensive to manufacture, that they require a minimum of space and that because of the improved control of the distribution of the magnetic field they make it possible to secure an entirely adequate control of coupling between the windings of a transformer by mechanically simple means.

It has long been known that in systems in which one or more circuits are made resonant to the impressed frequency, it is essential that the degree of coupling be accurately controlled if

the system is to have a maximum, or any desired, degree of discrimination against undesired frequencies. It is also well known that in systems of this type the circuits react upon each other so that adjustments to produce resonance in one circuit may destroy the condition of resonance in a second circuit coupled thereto. Particularly is this the case where both circuits are intended to be tuned to resonance at the same frequency, as is usually the case in the intermediate-frequency amplifiers of radio broadcast receivers.

In a transformer in which the coupling is fixed and is determined by the physical relation between the primary and the secondary established in the design, it is often a matter of considerable difficulty to adjust both the primary and the secondary to resonance, or to that degree of approach to resonance which will produce the desired over-all response characteristic for the system. On the other hand, if suitable arrangements for adjusting the coupling are provided, each circuit may be tuned to resonance with the coupling so loose that the reaction of each circuit on the other is negligibly small, and the coupling may then be increased to a desired value. When this procedure is followed, the system remains tuned to the desired frequency and the desired over-all response characteristic can readily be secured.

In transformers of the types now commonly employed, having air cores, the coupling is established in the design and, because of manufacturing variations, must be set somewhat below the value which would be best for each transformer. This is because, if the circuits are over-coupled, the over-all response characteristic will become excessively broad and the reaction between the circuits will have a tendency to tune each of them to a different frequency, and to thus produce a response characteristic having two distinct peaks, one on either side of the frequency to which the system would otherwise be tuned.

As is explained in greater detail in United States Patent No. 1,978,568 above referred to, the field distribution around magnetic-core inductors made in accordance with that patent is radically different from that secured with air-core coils, even though windings closely similar to those employed in the magnetic-core inductors be used. This new field distribution, secured through the use of the magnetic core, makes it possible to so associate two such inductors that the inductive coupling between them can be very accurately controlled by simple mechanical means.

Referring to Figs. 1 and 2, the device here illustrated consists of an insulating base 1, preferably of a ceramic material. The base 1 is designed to be conveniently secured to the chassis 2 upon which the other portions of the complete apparatus are mounted. Secured to the base 1 are condensers 3 and 4 which are so designed as to be adjustable, in their capacitance values, over a limited range. As illustrated in Fig. 1, the capacitance of condenser 3 is adjusted by means of a screw 5, the lower end of which is slotted, and the capacitance of the condenser 4 is adjusted by means of a nut 6.

Still referring to Figs. 1 and 2, the support or frame 7, preferably made of a molded insulating material such as for instance bakelite and produced in a single piece to avoid assembly costs, is secured to the base 1 by means of threaded studs 8 extending through spacing sleeves 10.

These studs serve to secure the whole assembly to the chassis 2 by means of nuts 9.

The frame 7 comprises parallel and fixed side bars 12 which, preferably, are united by a cross bar 13, and are provided with grooves 14 in which may rest certain leads to or from the coils and associated apparatus, held in place by any suitable cementitious substance or by any other suitable means, as for instance non-ferrous binding strips 15, which will adequately and securely hold them in place, in order to maintain their relative positions.

The cross bar 13 sustains the coil 16 and may be provided with a preferably integral fixed stud 13a, extending into and preferably cemented to the cylindrical core 18 of coil 16. One side bar 12 of the frame 7 supports a U-shaped yoke 20 by means of a slotted-head pivot 21. The yoke 20 supports the core 19 of the coil 17, the core 19 preferably being cemented to the yoke 20 and the insulating spindle 11. The coil 16 is secured to the core 18 by any suitable cement, and the coil 17 is likewise secured to the core 19.

Suitable lugs 31, secured in apertures in the base 1 and integral with the plates of the condensers 3 and 4, serve as terminals for receiving the leads from the coils 16 and 17 and suitable leads from other portions of the complete apparatus.

A metal shield 22 is provided and may be secured in place by any suitable means, as for instance by fitting snugly over the base 1 or by being flanged and riveted to the chassis 2. The shield 22 is provided with an aperture 23 so placed as to permit adjustment of the position of inductor 17—19 by means of a small screw-driver inserted in the slotted pivot 21. The shielding of the coupling device is completed by the metallic chassis 2, and an aperture 24 is provided to permit adjustment of the condensers 3 and 4 after installation on the chassis 2.

It should be noted that the assembly may be mounted with the studs 8 extending through the closed end of the shield 22, the latter being flanged and riveted or otherwise arranged for attachment to the chassis 2. This variation is a preferred form under certain conditions, since the whole device including its shield can be handled and mounted as a single unit, and condensers 3 and 4 may be adjusted from the top through a suitable hole in shield 22.

Referring to Fig. 3, a coil 16 shunted by a condenser 3 is shown in the plate circuit of a thermionic relay 28. A condenser 29 is employed as a by-pass for radio-frequency voltage across the B-voltage source. A coil 17 shunted by a condenser 4 is shown in the grid circuit of a thermionic device 30. It is to be understood that the coils 16 and 17 or the condensers 3 and 4 may be interchanged without departing from the scope of the invention.

Fig. 4 shows a modification of the mounting yoke, in which the movable inductor, in two positions 180° apart, has its axis at an angle less than 90° to the axis of the fixed inductor. At 90° from either of these positions, however, the axis of the movable inductor is at right angles to the axis of the fixed inductor. The members 32 are of insulating material and are trunnioned in the upstanding side members of the frame. Each has a shoulder 33 to give it a thrust bearing against the frame member. The inwardly extending portions 34 of the members 32 have their faces at an appropriate angle to the axis of rotation of the member, and may have either

a short stud 35 extending from this face, or may have a hole for the reception of an insulating rod, to support the core with its coil between them. This modification has the advantage of providing a very gradual adjustment of the coupling, and the mounting angle can be so chosen as to give any desired maximum degree of inductive coupling.

Having thus described our invention, what we claim is:

1. A high-frequency coupling device including a fixed inductor and a second inductor in spaced relation to said fixed inductor, each of said inductors comprising an open-type ferromagnetic core and a winding coaxial therewith; an adjustable condenser connected in shunt with each of said inductors to form a pair of resonant circuits tuned to a desired frequency; and means for rotating said second inductor about an axis at an angle to its magnetic axis to secure, at said resonant frequency, a desired degree of inductive coupling between said resonant circuits lying between zero and an upper limit determined by said angle, the magnetic axis of said fixed inductor extending through said second inductor and intersecting the axis of rotation of said second inductor.

2. A high-frequency coupling device including a fixed inductor and a second inductor in spaced relation to said fixed inductor, each of said inductors comprising an open-type ferromagnetic core and a winding coaxial therewith, said windings having more layers than turns per layer; an adjustable condenser connected in shunt with each of said inductors to form a pair of resonant circuits tuned to a desired frequency; and means for rotating said second inductor about an axis at an angle to its magnetic axis to secure, at said resonant frequency, a desired degree of inductive coupling between said resonant circuits lying between zero and an upper limit determined by said angle, the magnetic axis of said fixed inductor extending through said second inductor and intersecting the axis of rotation of said second inductor.

3. A high-frequency coupling device including

a fixed inductor and a second inductor in spaced relation to said fixed inductor, each of said inductors comprising an open-type ferromagnetic core and a winding coaxial therewith, said windings having more layers than turns per layer, means for rotating said second inductor about an axis oblique to its magnetic axis, said inductors having their axes mutually at right angles in one condition of adjustment and being adjustable to a position of substantially zero inductive coupling, and means for tuning at least one of said inductors over a desired range of frequencies.

4. A high-frequency coupling device including a fixed inductor and a second inductor in spaced relation to said fixed inductor, each of said inductors comprising an open-type ferromagnetic core and a winding coaxial therewith, said windings each having more layers than turns per layer, means for rotating said second inductor about an axis oblique to its magnetic axis, said obliqueness determining the maximum degree of inductive coupling between said inductors, said inductors having their axes mutually at right angles in one condition of adjustment, and means for tuning said inductors to exact resonance at a particular frequency, whereby said inductive coupling at said resonant frequency may be varied over a definitely limited range.

5. A high-frequency coupling device including a fixed inductor and a second inductor in spaced relation to said fixed inductor, each of said inductors comprising an open-type ferromagnetic core and a winding coaxial therewith, means for rotating said second inductor about an axis oblique to its magnetic axis, said obliqueness determining the maximum degree of inductive coupling between said inductors, said inductors being adjustable to a position of substantially zero inductive coupling, and means for tuning said inductors to exact resonance at a particular frequency, whereby said inductive coupling at said resonant frequency may be varied over a definitely limited range.

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