March 2, 1943. L. F. CURTIS 2,312,687

ADJUSTABLE COUPLING SYSTEM

Filed Aug. 23, 1941

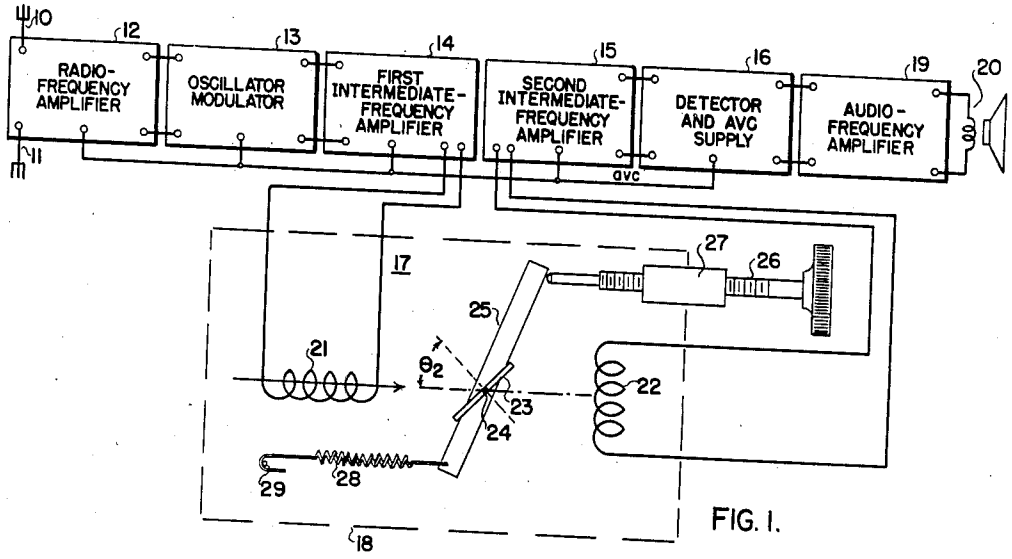


FIG. 1.

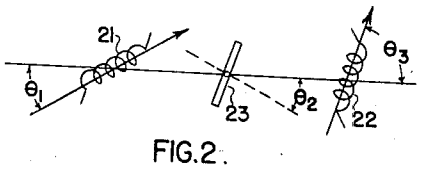


FIG. 2.

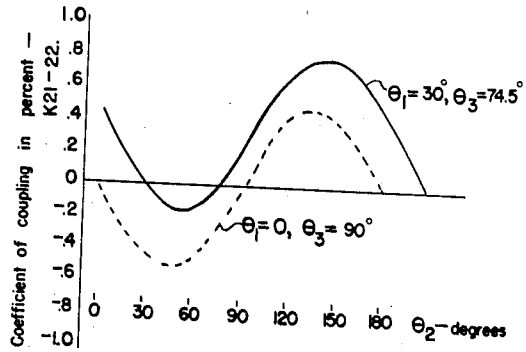


FIG. 3.

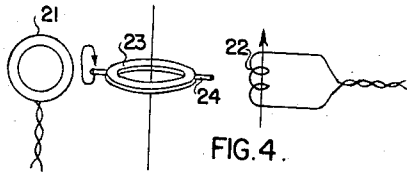


FIG. 4.

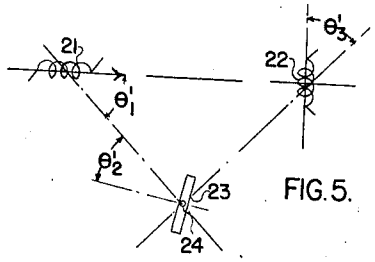


FIG. 5.

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## ADJUSTABLE COUPLING SYSTEM

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Application August 23, 1941, Serial No. 408,032

12 Claims. (Cl. 178—44)

This invention relates to adjustable coupling systems and more particularly to such systems of a type in which it is desired to adjust a very small inductive coupling between two inductors or in which it is desired to adjust the inductive coupling between two inductors to zero.

It is sometimes desirable in electrical systems to adjust a very small inductive coupling between two inductors. Band-pass selectors used, for example, in radio receivers generally comprise two inductors which are loosely inductively coupled and it is frequently desirable to adjust the magnitude of such coupling thereby to adjust the band width of the selector. Also, an electrical circuit may comprise two rather closely-spaced inductors between which it is desired that there be no inductive coupling. Various arrangements have been proposed by which such inductors may be so spaced that no coupling exists between them. One such arrangement is disclosed in Letters Patent No. 1,577,421, granted March 16, 1926, to Louis A. Hazeltine. However, in constructing an arrangement of the type under consideration, it is frequently found to be difficult so to position the inductors that no inductive coupling exists therebetween when one of the inductors is excited. It is accordingly desirable to provide a means for adjusting, with either polarity, a very small coupling between such inductors, thereby to reduce the total effective coupling between such inductors to zero.

It is an object of the present invention to provide an improved adjustable coupling system for adjusting a very small inductive coupling between two inductors.

It is another object of the present invention to provide an adjustable coupling system for adjusting to zero the residual inductive coupling between two inductors so disposed that only an inductive coupling of very small value exists between the inductors.

In accordance with the invention, an adjustable coupling system comprises a first inductor, an input circuit connected to the first inductor, and a second inductor so disposed in the magnetic field of the first inductor that the second inductor is substantially inductively uncoupled with the first shoulder. The system also comprises an output circuit connected to the second inductor and a movable conductive inductive-coupling means substantially nonselective over the frequency range of the system so disposed with reference to the inductors that, in a given position in its path of motion, it is substantially uncoupled with at least one of the inductors and, in another given position in its path of motion, it is substantially coupled with both of the inductors. Means are provided for moving the above-mentioned coupling means in the said path of motion to adjust the coupling between the inductors.

In accordance with a preferred embodiment of the invention, the conductive inductive-coupling means is so disposed that, in positions in its path of motion on opposite sides of the above-mentioned given position, it substantially couples the inductors with a polarity dependent upon the direction in the path from such given position. Also in this preferred embodiment of the invention, the means for moving the adjustable coupling means comprises means for moving the coupling means through the above-mentioned given position to adjust, with either polarity, the coupling between the inductors.

For a better understanding of the invention, together with other and further advantages thereof, reference is had to the following description, taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

Fig. 1 of the drawing is a circuit diagram, partly schematic, of a complete superheterodyne receiver including an adjustable coupling system in accordance with the invention in the intermediate-frequency channel thereof for the purpose of adjusting the selectivity of the receiver; Figs. 2, 4 and 5 illustrate modifications of the portion of the system of Fig. 1 constituting the present invention; while Fig. 3 comprises graphs utilized to explain the operation of the portion of the circuit of Fig. 1 comprising the present invention.

Referring now more particularly to Fig. 1 of the drawing, there is shown a circuit diagram, partially schematic, of a complete modulated-carrier signal receiver of the superheterodyne type embodying the invention. The receiver comprises, in cascade, an antenna-ground circuit 10, 11, a radio-frequency amplifier 12 of one or more stages, a frequency-changer or oscillator-modulator 13, intermediate-frequency amplifiers 14 and 15, each of one or more stages, coupled by means of a coupling system 17, a detector and automatic amplification control or A. V. C. supply 16, an audio-frequency amplifier 19 of one or more stages, and a sound reproducer 20. Automatic amplification control is secured in a well-known manner by applying a unidirectional bias voltage derived from the A. V. C. supply 16 to the control electrodes of one or more of the tubes

in radio-frequency amplifier 12, oscillator-modulator 13 and intermediate-frequency amplifiers 14 and 15.

Neglecting for the moment the system 17 embodying the present invention, the circuit described constitutes, in general, a conventional superheterodyne receiver including automatic volume control. The operation of such a receiver being well understood in the art, a detailed description thereof is deemed unnecessary herein. In brief, however, signals intercepted by antenna-ground circuit 10, 11 are selected and amplified in radio-frequency amplifier 12 and translated to oscillator-modulator 13, wherein they are converted to an intermediate-frequency signal. The intermediate-frequency signal is selectively amplified in intermediate-frequency amplifier 14 and translated through the coupling system 17 of the invention, to be described in detail hereinafter, and second intermediate-frequency amplifier 15 to detector 16, wherein the audio-frequency signals and the A. V. C. biasing potentials are derived. The audio-frequency signals are, in turn, amplified in audio-frequency amplifier 19 and supplied to sound reproducer 20 for reproduction. The automatic amplification control bias derived from unit 16 is effective to control the amplification of one or more of the units 12, 13, 14 and 15 to maintain the signal input to detector 16 within a relatively narrow range for a wide range of received signal intensities.

Referring now more particularly to the portion of the circuit comprising the present invention, an adjustable coupling system 17 is provided for coupling the output circuit of first intermediate-frequency amplifier 14 to the input circuit of second intermediate-frequency amplifier 15. This adjustable coupling system is preferably enclosed in a conductive shield 18 and comprises a first inductor 21 included in an input circuit connected to the output circuit of intermediate-frequency amplifier 14 and a second inductor 22 so disposed in the magnetic field of the first inductor 21 that the second inductor 22 is substantially inductively uncoupled with the first inductor 21, as with their axes normal to each other, as illustrated. Expressed somewhat differently, the second inductor is disposed in the magnetic field of the first inductor so that the axes of the inductors are in a common plane and have such an angle with respect to the line of centers of the inductors that the second inductor is substantially inductively uncoupled with the first inductor. The inductor 22 is included in the output circuit of the coupling system and is coupled directly to the input circuit of second intermediate-frequency amplifier 15.

A movable conductive inductive-coupling means is so disposed with reference to inductors 21 and 22 that, in a given position in its path of motion, it is substantially uncoupled with at least one of the inductors 21, 22 and substantially coupled to the other of said inductors and, in another given position in its path of motion, it is substantially coupled with both of the inductors 21, 22. This movable inductive-coupling means comprises a disc 23 of highly-conductive material and is substantially nonselective over the frequency range of the system and is adapted to be rotated about an axis 24 normal to the plane including the axes of inductors 21, 22, the last-named axes being normal to each other. The axis of the movable inductive-coupling means 23 is preferably in the line of centers of the inductors 21, 22. In order to move the disc 23 about the axis 24, there is provided an arm 25 of insulating material to which the disc 23 is rigidly fixed, the arm 25 being mounted to rotate about the axis 24. The means for moving the disc 23 in its path of motion to adjust the coupling between the inductors 21, 22 also includes a thumb screw 26, threaded in a stationary member 27 and adapted to bear against one end of arm 25, as well as a biasing means, such as a spring 28, connected between the other end of arm 25 and a stationary pin 29.

The movable inductive-coupling means 23, therefore, is so disposed with reference to the inductors 21, 22 that in a given position in its path of motion it is substantially uncoupled with at least one of the inductors 21, 22, and in other positions in its path of motion on opposite sides of the given position it substantially couples the inductors with a polarity dependent upon the direction of its position in its path of motion from the given position. The thumb screw 26, the cooperating stationary member 27, and the biasing spring 28 are included in a means for moving the coupling means 23 in its path and through the given position to adjust to either polarity the coupling between the inductors 21, 22.

Likewise, it may be stated that the movable inductive-coupling means 23 is so disposed with reference to the inductors 21, 22 that in a first given position in its path of motion it is substantially uncoupled with one of the inductors and substantially coupled with the other of the inductors, in a second given position in its path of motion it is substantially uncoupled with the other of the inductors and substantially coupled with one of the inductors, and in other positions in its path of motion on opposite sides of one of the given positions it substantially couples the inductors with a polarity dependent upon the direction in the path from one of the given positions. The thumb screw 26 is included in a means for moving the coupling means 23 in its path through one of the given positions to adjust to either polarity the coupling between the inductors 21, 22.

Expressed in a somewhat different manner, the movable inductive-coupling means 23 is so disposed with reference to the inductors 21, 22 that in a first given position in its path of motion it is substantially uncoupled with one of the inductors and substantially coupled with the other of the inductors, in a second given position in its path of motion it is substantially uncoupled with the other of the inductors and substantially coupled with the said one of the inductors, and in other positions in its path of motion including positions between the given positions it is substantially coupled with both of the inductors.

In considering the operation of the arrangement of Fig. 1, it will be seen that, in the absence of disc 23, there is substantially no coupling between the inductor 21 and the inductor 22. The reason that inductor 22 is uncoupled to inductor 21 is that the turns of inductor 22 are substantially parallel to the lines of force in the field of inductor 21. Furthermore, it will be seen that, in the presence of the coupling adjusting means 23 between inductors 21 and 22, for any position of disc 23 other than that parallel to or including the axis of one of the inductors, the disc is loosely coupled to both the inductors 21 and 22 and hence serves indirectly to couple them to each other. Further, adjustment of the screw 26 is effective to vary the position

of disc 23 thereby to vary the amount of such coupling between inductors 21 and 22.

It will be understood that inductors 21 and 22 may comprise the inductors of a double-tuned band-pass selector so that adjustment of the coupling between these inductors is effective to vary the selectivity of the receiver in a manner well understood in the art. In such a band-pass selector, it is, of course, only desirable to adjust the coupling between two rather low values of the same polarity. However, it will be understood that the inductors 21 and 22 can be connected in parallel with the coupled main inductors of a conventional double-tuned band-pass selector and that the band width of such a selector can be adjusted by varying both the magnitude and polarity of the coupling between inductors 21 and 22 to aid or oppose the coupling between the main inductors.

In order to explain the operation of the adjustable coupling system of the invention under these conditions, it will be assumed the angle $\theta_2$ designates the angle between the axis of disc 23 and the axis of inductor 21, as indicated. It will be seen that, in a given position in the path of motion of disc 23, namely, when $\theta_2$ is 90°, the disc 23 is substantially uncoupled with inductor 21 and has maximum coupling to inductor 22. It will also be seen that, in a second given position, namely, when $\theta_2$ is zero degrees, the disc 23 is substantially uncoupled to inductor 22 and has the maximum coupling with inductor 21. Adjustment of the disc 23 through either of these given positions is effective to adjust the coupling between inductors 21 and 22 so that the polarity of coupling is dependent upon the direction in the path of motion of disc 23 from the given position selected in which the coupling is zero.

The following equations are approximately valid for the coupling system of Fig. 1:

$$k_{21-23} = -K_{21-23} \cos \theta_2 \quad (1)$$

$$k_{23-22} = K_{23-22} \sin \theta_2 \quad (2)$$

$$k_{21-22} = -K_{21-23} K_{23-22} \sin \theta_2 \cos \theta_2 = -\frac{K_{21-23} K_{23-22}}{2} \sin 2\theta_2 \quad (3)$$

where

$k_{21-23}$=the coefficient of coupling between inductor 21 and disc 23;

$k_{23-22}$=the coefficient of coupling between disc 23 and inductor 22;

$k_{21-22}$=the coefficient of coupling between inductor 21 and inductor 22;

$K_{21-23}$=the maximum coefficient of coupling between inductor 21 and disc 23; and

$K_{23-22}$=the maximum coefficient of coupling between disc 23 and inductor 22.

From Equation 3 it is seen that for negative values $\theta_2$ or for values of $\theta_2$ greater than 90° the polarity of coupling or the sign of the coefficient of coupling reverses. The equations are based on the assumption that the separation of the inductors is large relative to the dimensions of the inductors. However, arrangements in accordance with the invention have been constructed in which the separation of the inductors was quite small and have been found to be practicable.

Inasmuch as very small values of coefficient of coupling are being dealt with in the arrangement of Fig. 1, it is advisable to observe certain precautions in designing the shield 18 therefor as otherwise circulating currents in the shield modify the field between inductors 21 and 22. Each of the sides of the shield acts like a stationary reflecting surface. The upper and lower surfaces of the shield are spaced the same distance from the axis of inductor 21 and the center of inductor 22. Thus, the coupling effect of the bottom of shield 18 between coils 21 and 22 is effectively neutralized by the coupling effect of the top of shield 18 inasmuch as these surfaces are symmetrical with respect to the inductors 21 and 22. Inasmuch as each end of the shield is no more closely coupled to the inductor remote therefrom than the inductor adjacent thereto is coupled to the remote inductor, circulating currents in the ends of the shield have very little effect on the coupling between the inductors. It is also important that the material of which the shield be made should be of a material having a low specific resistance, such as copper or aluminum, if the coupling between inductors 21 and 22 is to be reduced to zero by an arrangement in accordance with the invention. Metals such as iron introduce a complex coupling such as a coupling equivalent to mutual resistance and inductance. Disc 23 may then be made to balance out the reactive components but it will not be effective to balance out the resistive component.

Other positions of inductors 21 and 22, with the axes of the inductors coplanar, also provide zero coupling therebetween in the absence of disc 23 and may, therefore, be used in arrangements in accordance with the present invention. Reference is made to Fig. 2 for an explanation of why this is true. Elements of Fig. 2 which correspond to those of Fig. 1 have identical reference numerals. The following equation is approximately valid for the arrangement of Fig. 2 under the condition of zero coupling between inductors 21 and 22 and in the absence of any coupling effect of disc 23 between inductors 21 and 22:

$$\text{Cos}^2 \theta_3 = \frac{1-\cos \theta^2_1}{1+3 \cos^2 \theta_1} = \frac{\sin^2 \theta_1}{1+3 \cos^2 \theta_1} \quad (4)$$

where

$\theta_1$ and $\theta_3$ represent the angles between the axes of inductors 21 and 22, respectively, and their line of centers.

The following equations represent the conditions for which the coupling between disc 23 and inductors 21 and 22, respectively, is zero:

$$\text{Cos}^2 \theta_2 = \frac{1-\cos \theta^2_1}{1+3 \cos^2 \theta_1} = \frac{\sin^2 \theta_1}{1+3 \cos^2 \theta_1} \quad (5)$$

$$\text{Cos}^2 \theta_2 = \frac{1-\cos^2 \theta_3}{1+3 \cos^2 \theta_3} = \frac{\sin^2 \theta_3}{1+3 \cos^2 \theta_3} \quad (6)$$

The following table gives several values of the angles $\theta_1$ and $\theta_3$ which are effective to provide zero coupling between inductors 21 and 22 in the absence of disc 23.

| $\theta_1$ | $\theta_3$ |
|---|---|
| *Degrees* | *Degrees* |
| 0 | [1] 90 |
| 15 | 82.4 |
| 30 | 74.5 |
| 54.8 | 54.8 |
| 40 | 67.2 |
| 90 | 0 |

[1] Used in arrangement of Fig. 1.

It will be noted that the inductor arrangement in which $\theta_1$ and $\theta_3$ both are 54.8 degrees corresponds substantially to that utilized in the above-mentioned Hazeltine patent.

The disc **23** may be considered as a short-circuited winding and the coefficient of coupling for any of the arrangements just described may be calculated for any value of $\theta_2$ from the equation:

$$k_{21-22}=K_{21-23}K_{23-22}\sin(\theta_2-\theta_1)\sin(\theta_2-\theta_3) \quad (7)$$

where $\theta_1$ and $\theta_3$ are determined from the table given above.

Thus, if $\theta_1$ equals 30 degrees and $\theta_3$ equals 74.5 degrees, the disc **23** has no coupling to inductor **22** when $\theta_2$ equals 30 degrees and has no coupling to inductor **21** when $\theta_2$ equals 74.5 degrees. The maximum coupling from the disc to inductor **21** and inductor **22**, respectively, occurs when disc **23** is displaced 90 degrees from these positions. For any angle of $\theta_2$ the over-all coefficient of coupling under these conditions is:

$$k_{21-22}=K_{21-23}K_{23-22}\sin(\theta_2-30°)\sin(\theta_2-74.5°) \quad (8)$$

Curves of over-all coefficient of coupling between inductors **21** and **22** against values of $\theta_2$ are given in Fig. 3 for positions of inductors **21** and **22** corresponding to $\theta_1=30$ degrees and $\theta_3=74.5$ degrees, as well as for $\theta_1=0$ degrees and $\theta_3=90$ degrees.

Many other arrangements of elements **21**, **22** and **23** may be provided which meet the requirements of the present invention. One of these arrangements, for example, is illustrated in Fig. 4. Elements which correspond to those of Fig. 1 have identical reference numerals. In the arrangement of Fig. 4 inductor **21** has an axis perpendicular to the plane of the paper, inductor **22** has an axis in the plane of the paper normal to the line of centers, while disc **23** has an axis of rotation in the plane of the paper and perpendicular to the axes of inductors **21** and **22**. It will be understood that, as used in this specification, the term "disc" is intended to include either a circular disc, as in the arrangement of Fig. 1, or an annular disc, as in the arrangement of Fig. 4. The operation of the system of Fig. 4 is in all respects similar to that of Fig. 1 and the equations representing the several coefficients of coupling can be derived in an analogous manner.

Another arrangement of elements **21**, **22** and **23** which may be used in an embodiment of the invention is illustrated in Fig. 5. Elements which correspond to those of Fig. 1 have identical reference numerals, the angles being designated as illustrated in the figure. In the arrangement of Fig. 5 the coupling between inductors **21** and **22** is zero in the absence of disc **23** and, in the presence of disc **23**, there exist a plurality of disc positions, dependent upon the angles $\theta'_1$ and $\theta'_3$, at which the coupling of one of the inductors to the disc **23** is zero. In general, the arrangement of Fig. 5 provides greater coupling of one polarity than of the other polarity.

While in the arrangements of the invention described above, the inductors **21** and **22** are stationary and the disc **23** is rotated about an axis, it will be understood that, in certain modifications of the invention, the disc **23** can be maintained stationary and inductors **21** and **22** can be simultaneously moved relative thereto. In either event, it will be understood that the arrangement may be considered to comprise and is the full equivalent of a movable inductive coupling means so disposed with reference to one of the inductors that, in a given position of its path of motion, it is substantially uncoupled with at least one of the inductors and, in another given position in its path of motion, it is substantially coupled with both of the inductors.

While there have been described what are at present considered to be the preferred embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. An adjustable coupling system comprising, a first inductor, an input circuit connected to said first inductor, a second inductor so disposed in the magnetic field of said first inductor that said second inductor is substantially inductively uncoupled with said first inductor, an output circuit connected to said second inductor, a movable conductive inductive-coupling means substantially nonselective over the frequency range of said system so disposed with reference to said inductors that in a given position in its path of motion it is substantially uncoupled with at least one of said inductors and in another position in its path of motion it is substantially coupled with both of said inductors, and means for moving said coupling means in said path to adjust the coupling between said inductors.

2. An adjustable coupling system comprising, a first inductor, an input circuit connected to said first inductor, a second inductor so disposed in the magnetic field of said first inductor that said second inductor is substantially inductively uncoupled with said first inductor, an output circuit connected to said second inductor, a movable conductive inductive-coupling means substantially nonselective over the frequency range of said system so disposed with reference to said inductors that in a given position in its path of motion it is substantially uncoupled with at least one of said inductors and in other positions in its path of motion on opposite sides of said given position it substantially couples said inductors with a polarity dependent upon the direction in said path from said given position, and means for moving said coupling means in said path and through said given position to adjust to either polarity the coupling between said inductors.

3. An adjustable coupling system comprising, a first inductor, an input circuit connected to said first inductor, a second inductor so disposed in the magnetic field of said first inductor that said second inductor is substantially inductively uncoupled with said first inductor, an output circuit connected to said second inductor, a rotatably movable conductive inductive-coupling means substantially nonselective over the frequency range of said system so disposed with reference to said inductors that in a given position in its path of motion it is substantially uncoupled with at least one of said inductors and in another position in its path of motion it is substantially coupled with both of said inductors, and means for moving said coupling means in said path to adjust the coupling between said inductors.

4. An adjustable coupling system comprising, a first inductor, an input circuit connected to said first inductor, a second inductor so disposed in the magnetic field of said first inductor that said second inductor is substantially inductively uncoupled with said first inductor, an output cir-

cuit connected to said second inductor, a movable inductive-coupling means substantially nonselective over the frequency range of said system comprising a disc of conductive material so disposed with reference to said inductors that in a given position in its path of motion it is substantially uncoupled with at least one of said inductors and in another position in its path of motion it is substantially coupled with both of said inductors, and means for moving said coupling means in said path to adjust the coupling between said inductors.

5. An adjustable coupling system comprising, a first inductor, an input circuit connected to said first inductor, a second inductor so disposed in the magnetic field of said first inductor that said second inductor is substantially inductively uncoupled with said first inductor, an output circuit connected to said second inductor, a movable conductive inductive-coupling means substantially nonselective over the frequency range of said system so disposed with reference to said inductors that in a given position in its path of motion it is substantially uncoupled with one of said inductors and substantially coupled to the other of said inductors and in another position in its path of motion it is substantially coupled with both of said inductors, and means for moving said coupling means in said path to adjust the coupling between said inductors.

6. An adjustable coupling system comprising, a first inductor, an input circuit connected to said first inductor, a second inductor so disposed in the magnetic field of said first inductor that said second inductor is substantially inductively uncoupled with said first inductor, an output circuit connected to said second inductor, a movable conductive inductive-coupling means substantially nonselective over the frequency range of said system so disposed with reference to said inductors that in a first given position in its path of motion it is substantially uncoupled with one of said inductors and substantially coupled with the other of said inductors, in a second given position in its path of motion it is substantially uncoupled with said other of said inductors and substantially coupled with said one of said inductors, and in other positions in its path of motion including positions between said given positions it is substantially coupled with both of said inductors, and means for moving said coupling means in said path to adjust the coupling between said inductors.

7. An adjustable coupling system comprising, a first inductor, a second inductor so disposed in the magnetic field of said first inductor that said second inductor is substantially inductively uncoupled with said first inductor, an output circuit connected to said second inductor, a movable conductive inductive-coupling means substantially nonselective over the frequency range of said system so disposed with reference to said inductors that in a first given position in its path of motion it is substantially uncoupled with one of said inductors and substantially coupled with the other of said inductors, in a second given position in its path of motion it is substantially uncoupled with said other of said inductors and substantially coupled with said one of said inductors, and in other positions in its path of motion on opposite sides of one of said given positions it substantially couples said inductors with a polarity dependent upon the direction in said path from said one of said given positions, and means for moving said coupling means in said path through said one of said given positions to adjust to either polarity the coupling between said inductors.

8. An adjustable coupling system comprising, a first inductor, an input circuit coupled to said first inductor, a second inductor disposed in the magnetic field of said first inductor with the axis of said first inductor normal to the axis of said second inductor whereby said second inductor is substantially inductively uncoupled with said first inductor, an output circuit connected to said second inductor, a movable conductive inductive-coupling means substantially nonselective over the frequency range of said system so disposed with reference to said inductors that in a given position in its path of motion it is substantially uncoupled with at least one of said inductors and in another position in its path of motion it is substantially coupled with both of said inductors, and means for moving said coupling means in said path to adjust the coupling between said inductors.

9. An adjustable coupling system comprising, a first inductor, an input circuit coupled to said first inductor, a second inductor disposed in the magnetic field of said first inductor with the axis of said first inductor normal to the axis of said second inductor whereby said second inductor is substantially inductively uncoupled with said first inductor, an output circuit connected to said second inductor, a conductive inductive-coupling means substantially nonselective over the frequency range of said system, said means being rotatable about an axis normal to the plane including the axes of said inductors and so disposed with reference to said inductors that in a given position in its path of motion it is substantially uncoupled with at least one of said inductors and in another position in its path of motion it is substantially coupled with both of said inductors, and means for moving said coupling means in said path to adjust the coupling between said inductors.

10. An inductive-coupling system comprising, a first inductor, an input circuit coupled to said first inductor, a second inductor so disposed in the magnetic field of said first inductor that the axes of said inductors are in a common plane and have such an angle with respect to the line of centers of said inductors that said second inductor is substantially inductively uncoupled with said first inductor, an output circuit connected to said second inductor, a movable conductive inductive-coupling means substantially nonselective over the frequency range of said system, said means being rotatable about an axis normal to said plane and intersecting said line of centers and so disposed that in a given position in its path of motion it is substantially uncoupled with at least one of said inductors and in another position in its path of motion it is substantially coupled with both of said inductors, and means for moving said coupling means in said path to adjust the coupling between said inductors.

11. An adjustable coupling system comprising, a first inductor, an input circuit coupled to said first inductor, a second inductor so disposed in the magnetic field of said first inductor that said second inductor is substantially inductively uncoupled with said first inductor, an output circuit connected to said second inductor, a movable conductive inductive-coupling means substantially nonselective over the frequency range of said system so disposed with reference to said inductors that in a given position in its path of motion it

is substantially uncoupled with at least one of said inductors and in another position in its path of motion it is substantially coupled with both of said inductors, said inductors and said inductive-coupling means having axes two of which are normal to each other and in a common plane and the other of which is normal to said plane, and means for moving said coupling means in said path to adjust the coupling between said inductors.

12. An adjustable coupling system comprising, a first inductor, an input circuit connected to said first inductor, a second inductor so disposed in the magnetic field of said first inductor that the axes of said inductors are in mutually normal planes and said second inductor is substantially inductively uncoupled with said first inductor, an output circuit connected to said second inductor, a movable conductive inductive-coupling means substantially nonselective over the frequency range of said system so disposed with reference to said inductors that its axis is in the line of centers of said inductors and that in a given position in its path of motion it is substantially uncoupled with at least one of said inductors and in another position in its path of motion it is substantially coupled with both of said inductors, and means for moving said coupling means in said path to adjust the coupling between said inductors.

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