Sept. 6, 1927. 1,641,925

J. C. GABRIEL

INDUCTIVE COUPLING DEVICE

Original Filed Dec. 29, 1923

Fig. 1

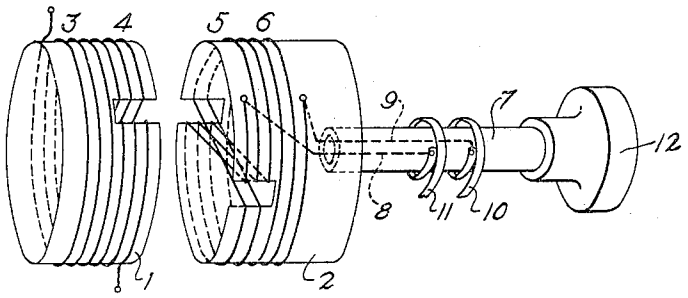


Fig. 2

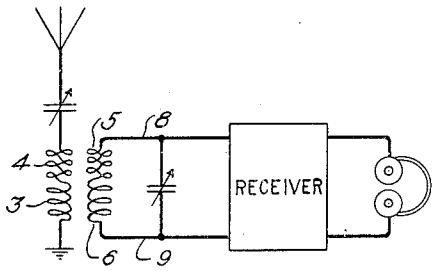
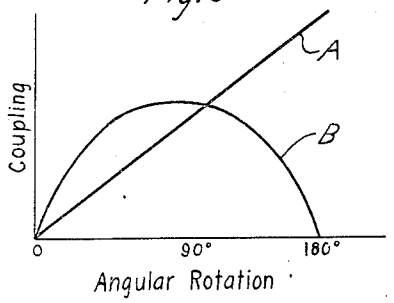


Fig. 3



Inventor:
John C. Gabriel
by J. L. Roberts Atty

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UNITED STATES PATENT OFFICE.

JOHN C. GABRIEL, OF NEW YORK, N. Y., ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

INDUCTIVE COUPLING DEVICE.

Original application filed December 29, 1923, Serial No. 683,299. Divided and this application filed December 29, 1925. Serial No. 78,149.

This invention relates to a coupling device and more particularly to an arrangement whereby the coupling between two circuits may be varied.

This application is a division of the application Serial No. 683,299 for high frequency transmission, filed December 29, 1923, to J. C. Gabriel.

In connection with certain apparatus, for example, that used in radio systems, it is desirable to be able to accurately adjust the degree of coupling between associated circuits.

In general it has heretofore been proposed to secure this result by providing adjustable coupling devices or vario couplers comprising solenoidal coils, one of which is rotatable relatively to the other.

In this type of vario coupler the adjustment for the entire range of coupling variation is affected by a 90° rotation of the rotatable coil. For equal angular adjustments of the coil the rate of change of coupling is non-uniform throughout the range of adjustment and increases sharply near the positions of minimum and maximum coupling.

This rapid and irregular variation of the coupling constitutes a marked disadvantage, since it increases the difficulty of effecting an accurate adjustment of the coupling, especially at or near the minimum limit.

An object of this invention is to permit the coupling between electrical circuits to be varied uniformly from maximum to minimum.

Another object is to vary the coupling by equal amounts for equal angular adjustments of the movable elements of the coupling device throughout the range of operation.

A feature of the invention relates to the provision of a vario coupling having windings such that the variation of coupling is substantially a linear function of the angle of rotation of the movable element over 180 degrees.

The novel features and combinations which are believed to be characteristic of this invention will be defined in the subjoined claims.

The invention both as to its construction and operation may be understood by reading the following description in connection with the accompanying drawings, in which Fig. 1 shows the construction of a coupling unit or vario coupler in accordance with this invention; Fig. 2 shows diagrammatically a circuit including the coupler; and Fig. 3 illustrates curves which serve to explain the operation of this invention.

In Fig. 1 there is shown a variable inductance or vario coupler comprising two coils, 1 and 2. Each of these coils comprises a cylindrical supporting form, having a slotted portion at one end upon which the conducting wire is wound to constitute a solenoidal winding and a figure 8 winding. By "figure 8" type is meant the general type illustrated in the U. S. patent to Curtis 1,367,734, February 8, 1921.

Coils 1 and 2 are so arranged that the slotted portions of the supporting forms, upon which the figure 8 turns are wound, face one another and are directly opposed. As herein shown coil 1 is stationary while coil 2 is mounted on the shaft 7 carrying the knob or dial 12 by which it may be rotated. The movable coil is connected to an external circuit or apparatus by leads 8 and 9 brought out through the shaft 7. If desired these leads may be connected to flexible conductors 10 and 11.

In Fig. 2 a coupler, such as has been described above, is shown included in a radio receiving system. The stationary coil is included in the antenna circuit and the movable coil is included in the tuned receiving circuit associated with the antenna.

Fig. 3 is a graphic representation of the coupling variation obtainable with a vario coupler having solenoid windings and that which may be obtained by using the vario coupler described above. The coupling characteristic of vario couplers having solenoid coils is represented by curve B, while the characteristic of the coupler hereinbefore described is represented by the curve A.

As appears from these curves, the range of adjustment from maximum to minimum coupling of a solenoid wound vario coupler is limited to 90° rotation of the movable coil while with a coupler comprising solenoid and figure 8 windings the variations of coupling from maximum to minimum is effected by rotating the movable coil through 180 de-

grees. Moreover, as shown in curve B, the rate of change of coupling is variable at all points throughout the range of adjustment of the movable coil and this variation is especially marked at or near the maximum or minimum values. In accordance with curve A, the rate of change of coupling is uniform between maximum and minimum values.

As stated above, each coil comprises both solenoidal and figure 8 windings. The number of turns in the solenoidal winding for each coil in relation to the number of turns of the figure 8 winding is proportioned in such a manner that the mutual inductance of the two solenoidal windings is substantially equal to that of the two figure 8 windings. When the coils consist of a few turns the number of each type will be approximately equal, the exact proportion being determined experimentally.

As coil 2 is rotated the mutual inductance between the solenoidal windings of the two coils will remain constant. The mutual inductance between the figure 8 windings, however, will be continuously variable and, beyond a certain point, the electromotive force thereby induced in coil 2 will oppose that induced by the cooperation of the solenoidal windings. When the coils are in such a position that the figure 8 windings of each coil are directly opposed, the direction of the E. M. F. induced in the figure 8 windings of coil 2 will be the same as the direction of the E. M. F. induced therein by the solenoidal windings of coil 1. Maximum coupling will occur in this position, since the E. M. F. induced in the figure 8 windings is added to the E. M. F. produced by the solenoidal winding. With the rotation of coil 2 the value of the current in the figure 8 winding decreases, until it reaches zero when the angle of rotation is 90°. As coil 2 is rotated further, that half of the figure 8 winding which was initially opposed to the upper half of the figure 8 winding of coil 1 is now approaching the lower half of the figure 8 winding of coil 1. Since, due to the figure 8 construction of the windings, the direction of flow of current in the lower half of coil 1 is opposite to the direction of flow in the upper half, the E. M. F. induced in the figure 8 winding of coil 2 will be changed in direction and will consequently oppose the E. M. F. induced in the solenoidal winding of coil 2. As the angle of rotation of coil 2 is increased from 90° to 180°, the opposing E. M. F. induced in the figure 8 winding increases until minimum coupling is reached, at which time the E. M. F. induced in the solenoidal winding is entirely offset by the E. M. F. induced in the figure 8 winding. In other words, at maximum coupling the effect of the mutual inductance of the figure 8 windings is equal and added to the mutual inductance of the solenoidal windings, while at minimum coupling the effect of the mutual inductance of the figure 8 windings is equal and opposed to the mutual inductance of the solenoidal windings.

Between maximum and minimum the coupling value varies by an amount which is proportional to the degree of angular rotation of the coil 2, thereby giving a change of coupling value which is linear over the entire adjustment range.

In view of the preceding description it will be seen that this invention provides an arrangement in which rotation of the movable element through an angle of 180° is necessary to vary the coupling over the complete range, and in which the rate of change of coupling is the same for equal angular adjustments of the movable element at all points in its operation, whereby very fine coupling adjustments may be readily and accurately made. While applicant for the purpose of disclosing the invention has described a coupler comprising two coils, modifications such as the use of additional coils will readily suggest themselves, and it is to be understood that this invention is limited only by the attached claims.

What is claimed is:

1. A coupling arrangement comprising coaxially arranged stationary and movable coils having windings composed of a solenoid section and a figure 8 shaped section, and means for rotating said movable coil through 180° to produce a coupling variable in the same sense and substantially linearly from maximum to minimum.

2. A variable inductive device, comprising coils having windings composed of a solenoid section and a figure 8 shaped section.

3. A coupling device comprising a plurality of coils electromagnetically related, each coil being composed of a solenoidal winding and a figure 8 winding, and means for rotating one of said coils.

4. A coupling device comprising two coils coaxially mounted and rotatable relatively to one another, each of said coils including a solenoid winding and a figure 8 winding.

5. A coupling device including electromagnetically related coils, means for relatively rotating said coils, each of said coils comprising a cylindrical supporting form having an unslotted portion and a slotted portion, and a winding consisting of solenoidal turns and figure 8 turns wound respectively upon said unslotted portion and said slotted portion.

6. A coupling arrangement comprising a plurality of coils electromagnetically related, each of said coils comprising a substantially cylindrical form, a portion of which is slotted to permit figure 8 turns to be wound upon it, a winding consisting of solenoidal

turns in series with said figure 8 turns wound upon said form, and means for rotating one of said coils through 180° to vary the coupling from minimum to maximum.

7. A coupling arrangement consisting of two inductively related coils, each of which is composed partly of solenoidal windings and partly of figure 8 windings, said windings being arranged to establish a constant mutual inductance between the coils, the rotation of one of said coils controlling the electromotive force induced in the secondary coil by inducing a second electromotive force which over one part of the range of adjustment of the rotary coil tends to increase, and over another part of the range of adjustment of the rotary coil tends to decrease said first mentioned electromotive force at a substantially uniform rate, whereby there is produced a coupling variation which is substantially linear over the entire range of adjustment.

8. In a variable coupling arrangement, means for varying the coupling between two circuits with a greater degree of uniformity than can be obtained by varying the relative position between two solenoids, comprising coupling coils each made up of a combination of a solenoid section and a figure 8 section of coil.

9. In a radio system, means for tuning the receiver for incoming waves comprising a coupling coil made up of a combination of a solenoid section and a figure 8 shaped section.

In witness whereof, I hereunto subscribe my name this 28th day of December A. D., 1925.

JOHN C. GABRIEL.