May 26, 1942. R. L. HARVEY 2,283,926

COUPLING METHOD AND APPARATUS

Filed May 31, 1938

FIG. 1.

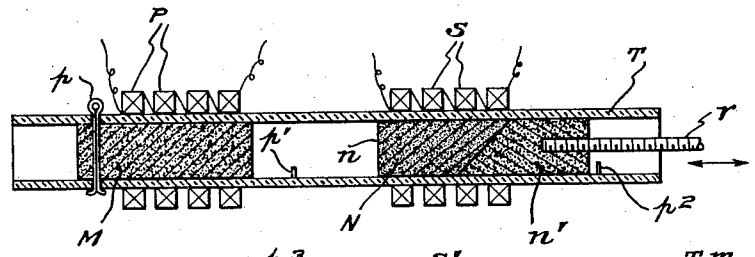


FIG. 2.

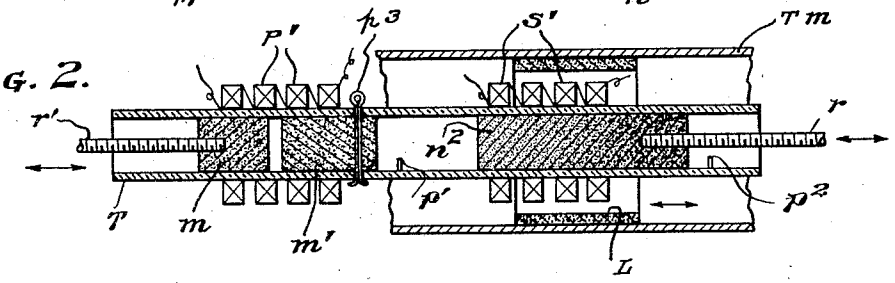


FIG. 3.

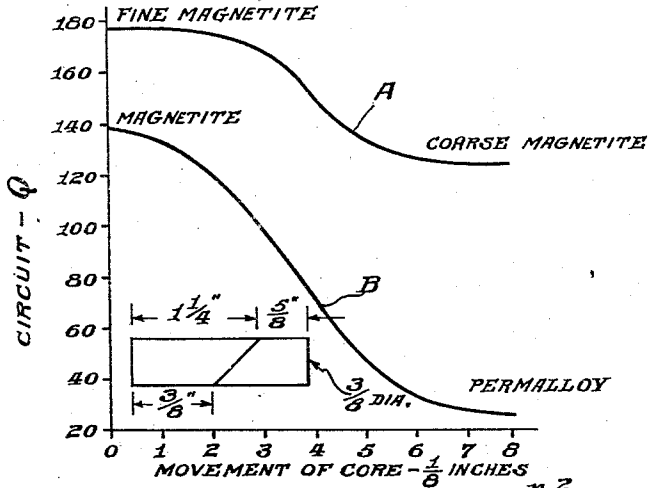
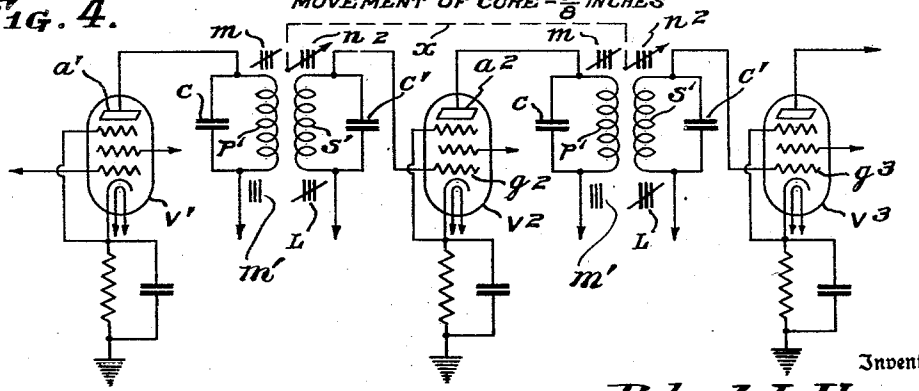


FIG. 4.



Inventor

Robert L. Harvey

By

Attorney

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UNITED STATES PATENT OFFICE

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COUPLING METHOD AND APPARATUS

Robert L. Harvey, Oaklyn, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application May 31, 1938, Serial No. 210,935

16 Claims. (Cl. 178—44)

This invention relates to coupling methods and apparatus for use in radio and other systems for the communication of intelligence and has special reference to the provision of improvements in the coupling of tuned circuits designed to be operated at a predetermined frequency. This application is in the nature of an improvement over my application Serial No. 56,993, filed December 31, 1935.

While the invention will be described as applied to coupling units designed for use in the intermediate frequency stages of a superheterodyne radio receiver, it will be understood that the disclosure in this respect is merely illustrative for purposes of explaining the inventive ncept.

An object of the present invention is to provide a magnetic core coupling device capable of being adjusted, at the will of the operator, to vary the selective response of the system of which the coupling device is a part.

Another object of the present invention is to provide a coupling device wherein the mutual coupling and damping may be changed at a relative rate designed to ensure a resonance curve the contour of which is substantially uniform irrespective of its width.

Still another object of the invention is to provide a coupling device including primary and secondary inductor elements capable of individual alignment and incorporating means for so varying the coefficient of coupling between said inductor elements as to change the width of the resonance band without changing the resonant frequency or the uniform contour of the resonance curve.

Other objects and advantages together with certain details of construction will be apparent and the invention itself will be best understood by reference to the following specification and to the accompanying drawing wherein:

Figure 1 is a sectional view of a coil and core assembly constructed in accordance with the principle of the invention,

Figure 2 is a sectional view of a coil and core assembly including means for presetting or "aligning" the primary and the secondary coils,

Figure 3 is a chart which will be referred to explaining the invention, and

Figure 4 is a diagram of a circuit which includes two transformers, similar to those of Fig. 2, with tandem or ganged control.

The high frequency coupling unit of Fig. 1 comprises primary and secondary coils P and S, respectively, which may comprise windings of any convenient type, mounted on a sleeve T of insulating material such as fiber tubing. Each of the transformer coils P and S is provided with a core M, N, respectively, constituted, at least in part, of a paramagnetic material.

One of the cores, in this case, core N, is of duomagnetic construction, that is to say, it is constituted of two magnetic materials which, in the instant case, form discrete core sections n and n' intimately bonded or otherwise joined one to the other. One core section, say section n, is constituted of a "low loss" material such as iron oxide or the ore magnetite, and the other core sections n' is constituted of a "high-loss" material such, for example, as coarse particles of magnetite, iron filings, comminuted ferrochrome steel, permalloy, or equivalent substance molded in a well known manner.

The core sections n and n' are so designed that their effective permeability is substantially equal or uniform. Equality in this respect may be simply achieved either (a) by varying the proportion of binder in the core material of which the core parts are formed, or (b) by varying the diameter of the cores.

Core M is maintained in fixed register with the primary coil P by means of a pin p. Core N, which is preferably longer than coil S, is provided with an adjusting arm or rod r and is slideable within the tube T. Its range of movement is limited, however, by pins p^1 and p^2 so that it is at all times presented to the interior of the secondary coil S while varying the coupling determining distance from core M. Since, as pointed out above, the permeability of each of the core sections n and n' is the same, movement of the core within the coil S in no wise alters the effective inductance of that coil or changes the frequency of the tuned circuits. The mutual inductance is increased when core N is made to approach core M. This would ordinarily give rise to a double-peak resonance curve, however, since the damping, or resistance introducing effect, is increased as more of the high loss section n' of the core enters the coil, the width of the resonance or pass band is increased without changing the contour of the resonance curve.

In the coupling device of Fig. 2, the core for the primary winding P^1 is of bipart construction. The inner part m' is immovably fixed within the insulating tube T by means of a pin p^3. The outer part or section m is provided with an adjusting rod r' and is slidably mounted in tube T, whereby the effective inductance of the coil P' may be adjustably preset or "aligned" to a de-

sired frequency in circuit with the capacitor (C, Fig. 4) or other tuned-circuit element.

A hollow cylinder L constituted of paramagnetic material and preferably designed to exhibit uniform permeability throughout its length surrounds the secondary winding S'. Cylinder L is slideably seated within a hollow cylinder T^m which may be constituted of metal and comprise an electrostatic shield for the entire unit. Cylinder L, when moved with respect to the coil S, alters the effective inductance thereof, so that, like coil P', it may be aligned to a given frequency in circuit with the capacitor (C', Fig. 4) with which it is associated.

The core N^2 for the secondary coil S', like core N of Fig. 1, is of duomagnetic construction. In this embodiment, however, the core, instead of being formed of discrete sections (n, n', Fig. 1) joined together, comprises a molded body wherein the high loss and the low loss sections merge into each other by gradations, as indicated by the shading of the core n^2 in the drawing.

Fig. 4 shows a pair of coupling devices of the type shown in Fig. 2 suitably connected in the intermediate frequency amplifying stages of a superheterodyne receiver. The primary windings P' of each unit has a fixed capacitor C, connected across its terminals, and one side of each resonant circuit thus formed is connected to the plate a^1, a^2, respectively, of thermionic amplifiers V^1, V^2. The secondary windings S' of each coupling unit has a fixed capacitor C^1, respectively connected across its terminals and one side of each resonant circuit thus formed is connected to the input electrodes g^2, g^3, respectively, of the amplifiers V^2, V^3.

As previously described, and as indicated by the conventional symbols in Fig. 4, the inductance, and hence the frequency of the resonant circuits CP' and C'S' may be adjusted or preset by relative movement of the inner core m and outer cylindrical core L (Fig. 2) with respect to the coils individual thereto.

The cores n^2 for varying the mutual coupling and damping of the separate units may be mechanically coupled as indicated at x in the drawing (Fig. 4) for operation in unison. When the cores n^2 are in that position whereat the low loss material is substantially entirely within the coils S' the coupling between these coils and their primary coils P', respectively, is small and the damping is also small. The exact damping characteristic for any given setting will, of course, depend upon the loss-permeability distribution of the cores.

Curve A of Fig. 3 shows how the damping changes with the position of a core, when the core is of the indicated dimensions and constituted of fine (section n) and coarse (section n') particles of the ore magnetite. Curve B of this figure shows how the damping changes with the position of a core of similar dimensions and constituted of magnetite (section n) and permalloy particles (section n') of similar size. Considered jointly, curves A and B show that by varying the type and particle size of the core materials, and hence the eddy current losses, any desired damping characteristic may be achieved so that the coefficient of coupling and the damping of at least one of the circuits may be varied at a relative rate calculated to ensure a resonance curve of substantially uniform or similar contour irrespective of its width.

Various modifications of the invention will suggest themselves to those skilled in the art. It is to be understood therefore that the foregoing is to be interpreted as illustrative and not in a limiting sense, except as required by the prior art and by the spirit of the appended claims.

What is claimed is:

1. The method of broadening the frequency band width of a plurality of tuned fixed frequency type magnetically coupled circuits by means of a body of magnetically permeable material, said method comprising maintaining the contour of the resonance response characteristic and the resonant frequency of said circuits substantially constant while increasing, at a relative rate calculated to insure constancy of said contour, the magnetic coupling and resistance introducing effect by movement of said body.

2. The method of broadening the frequency band width of tuned magnetically coupled circuits including an inductor, by means of a core of magnetically permeable material having relatively low loss and relatively high loss portions, said method comprising increasing the coupling and the damping of said circuits at a relative rate for maintaining the resonant frequency of said circuits substantially constant by movement of said low loss portion away from the field of said inductor and by movement of said high loss portion into the field thereof.

3. The method of increasing the frequency band width of two magnetically coupled tuned circuits each including an inductor, by means of a core of magnetically permeable material having uniform permeability but portions of different resistance introducing effects throughout its length, said method comprising simultaneously increasing the mutual coupling between said circuits and the damping of one of said circuits at a relative rate calculated to ensure a resonance curve of substantially uniform contour, by moving one end of said core away from one of said inductors and toward the other of said inductors.

4. In a transmission system, the combination with two fixed-frequency circuits, means including a plurality of magnetic cores determining the coupling of said circuits in energy transfer relation, one of said cores being of substantially uniform permeability but having portions throughout its length of differing resistance introducing effects varying the mutual coupling between said circuits and the damping of at least one of said circuits, and means for preventing a change in frequency of said tuned circuits when the coupling and damping are varied.

5. In a coupled circuit system for transmitting a band of signals of radio frequency including an inductor and an adjustable body of magnetically permeable material in the field of said inductor, said body having substantially uniform permeability throughout its length but varying in resistance introducing effects in different portions thereof, the method of widening said band and simultaneously introducing resistance into one of said circuits for ensuring a resonance curve of substantially uniform contour, which consists in moving said body in the field of said inductor in such manner that a portion thereof having relatively low resistance introducing effect is moved away from the field of said inductor while a portion of relatively high resistance introducing effect is moved closer into the field of said inductor.

6. In a radio frequency coupling system, the combination of two tuned circuits each including an inductor of a predetermined fixed value of inductance, said inductors being mounted in energy

transfer relation, of a movable magnetically permeable core of substantially uniform permeability but of differing resistance introducing effect throughout its length for simultaneously varying the mutual coupling between said circuits and the damping of at least one of said circuits while maintaining substantially uniform the contour of the resonance curve of said circuits and the frequency response thereof for different band widths.

7. The invention as set forth in claim 6 wherein said core is axially disposed within one of said inductors and extends beyond the opposite ends thereof.

8. A device for coupling two tuned circuits, said device comprising primary and secondary fixed inductors mounted in energy transfer relation, magnetic cores individual to said fixed inductors for adjusting the tuning thereof, a second set of cores for said inductors individual thereto, respectively, means for effecting relative movement between said second set of cores whereby to vary the mutual coupling of said inductors without substantially changing the self-inductance thereof, one of said sets being characterized by different resistance introducing effects throughout its length for concomitantly varying the damping in one of said circuits to ensure substantial uniformity of the contour of the resonance curve of said coupled circuits for different band widths.

9. In a radio frequency coupling system, a plurality of coupled circuits comprising a pair of magnetically coupled inductors, said inductors having turns positioned relatively remote magnetically and turns relatively closely coupled, respectively, a magnetically permeable core for at least one of said inductors, said core being adjustably disposed for operation substantially entirely in the field of the remotely positioned turns thereof, whereby the self-inductance of said one of said inductors may be independently adjusted to a desired value without substantially affecting the coefficient of coupling between said circuits, and means comprising a second core adjustably disposed for axial movement within one of said inductors for varying the pass band width of said system without substantially affecting the contour of the resonance characteristic of said system.

10. In a radio frequency coupling system, a plurality of coupled circuits comprising a pair of magnetically coupled inductors, said inductors having turns positioned relatively remote magnetically and turns relatively closely coupled, respectively, a magnetically permeable core for at least one of said inductors, said core being adjustably disposed for operation substantially entirely in the field of the remotely positioned turns thereof, whereby the self-inductance of said one of said inductors may be independently adjusted to a desired value without substantially affecting the coefficient of coupling between said circuits, and band width varying means comprising a second core adjustably disposed for axial movement with respect to one of said inductors and a core fixedly disposed in the field of the other of said inductors and disposed in spaced end-to-end relation with respect to said second core.

11. In a radio frequency coupling system, a plurality of coupled circuits comprising a pair of magnetically coupled inductors, said inductors having turns positioned relatively remote magnetically and turns relatively closely coupled, respectively, a magnetically permeable tuning core for at least one of said inductors, said core being adjustably disposed for operation substantially entirely in the field of the remotely positioned turns thereof, whereby the self-inductance of said one of said inductors may be independently adjusted to a desired value without substantially affecting the coefficient of coupling between said circuits, a relatively fixed core disposed in the field of said one of said inductors adjacent said relatively closely coupled turns thereof, a second tuning core and a selectivity controlling core disposed in different planes in the field individual to the other of said inductors in coaxial relation therewith, and structure supporting said selectivity controlling core for distance changing movement relative to said fixed core to vary the coupling between inductors.

12. In a radio frequency coupling system, a plurality of coupled circuits comprising a pair of magnetically coupled inductors, said inductors having turns positioned relatively remote magnetically and turns relatively closely coupled, respectively, a magnetically permeable core for at least one of said inductors, said core being adjustably disposed for operation substantially entirely in the field of the remotely positioned turns thereof, whereby the self-inductance of said one of said inductors may be independently adjusted to a desired value without substantially affecting the coefficient of coupling between said circuits, a relatively fixed core disposed in the field of said one of said inductors adjacent said relatively closely coupled turns thereof, and a second movable core disposed within the field individual to the other of said inductors adjustable axially with respect to said fixed core for varying the pass band substantially independently of said self-inductance adjustment, said second movable core being so proportioned and arranged with respect to said other of said inductors that said pass band is varied by the movement of said second core without substantially affecting the inductance of said other of said inductors.

13. In a radio frequency coupling system, a plurality of coupled circuits comprising a pair of magnetically coupled inductors, said inductors having turns positioned relatively remote magnetically and turns relatively closely coupled, respectively, a magnetically permeable core for at least one of said inductors, said core being adjustably disposed for operation substantially entirely in the field of the remotely positioned turns thereof, whereby the self-inductance of said one of said inductors may be independently adjusted to a desired value without substantially affecting the coefficient of coupling between said circuits, a relatively fixed core disposed in the field of said one of said inductors adjacent said relatively closely coupled turns thereof, a second movable core disposed within the other of said inductors adjustable axially with respect to said fixed core for varying the pass band substantially independently of said self-inductance adjustment, and a third core axially disposed about the other of said inductors for adjusting the self-inductance thereof.

14. In a radio frequency coupling system, a plurality of coupled circuits comprising a pair of magnetically coupled inductors, core tuning means comprising a magnetically permeable core adjustably disposed in the field of at least one of said inductors for varying the self-inductance thereof to a desired value without substantially changing the coupling, and separate core means of magnetically permeable material comprising a

second core adjustably disposed in axial relationship relative to said core tuning means and disposed continuously in the field individual to the other of said inductors for varying the coefficient of coupling between said inductors without substantially affecting the self-inductance of said other inductor.

15. In a radio frequency coupling system, a plurality of coupled inductors, means comprising a fixed magnetically permeable core and a closely adjacent core relatively adjustably disposed in the field of one of said inductors for varying the self-inductance thereof to a desired value without substantially changing the coupling, and selectivity control means of magnetically permeable material disposed continuously in the field individual to the other of said inductors comprising a third core adjustably disposed axially relative to said fixed core for varying the coefficient of coupling between said inductors without substantially affecting the self-inductance of said other inductor.

16. In a radio frequency coupling system, a plurality of coupled circuits comprising a pair of magnetically coupled inductors, a magnetically permeable core adjustably disposed in the field of at least one of said inductors for varying the self-inductance thereof to a desired value without substantially changing the coupling, and separate core means of magnetically permeable material comprising a second core adjustably disposed axially relatively to said inductors for varying the coefficient of coupling therebetween, said second core being longer than one of said inductors and axially disposed within the field thereof extending beyond the ends of said one of said inductors.

ROBERT L. HARVEY.