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COUPLING ARRANGEMENT

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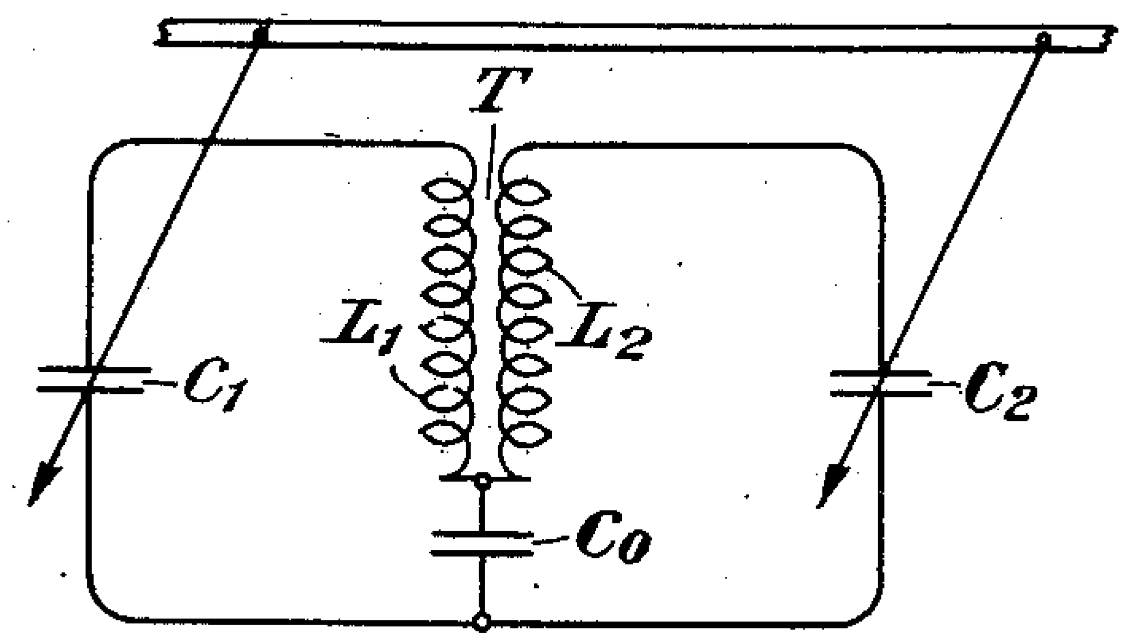

Fig. 1

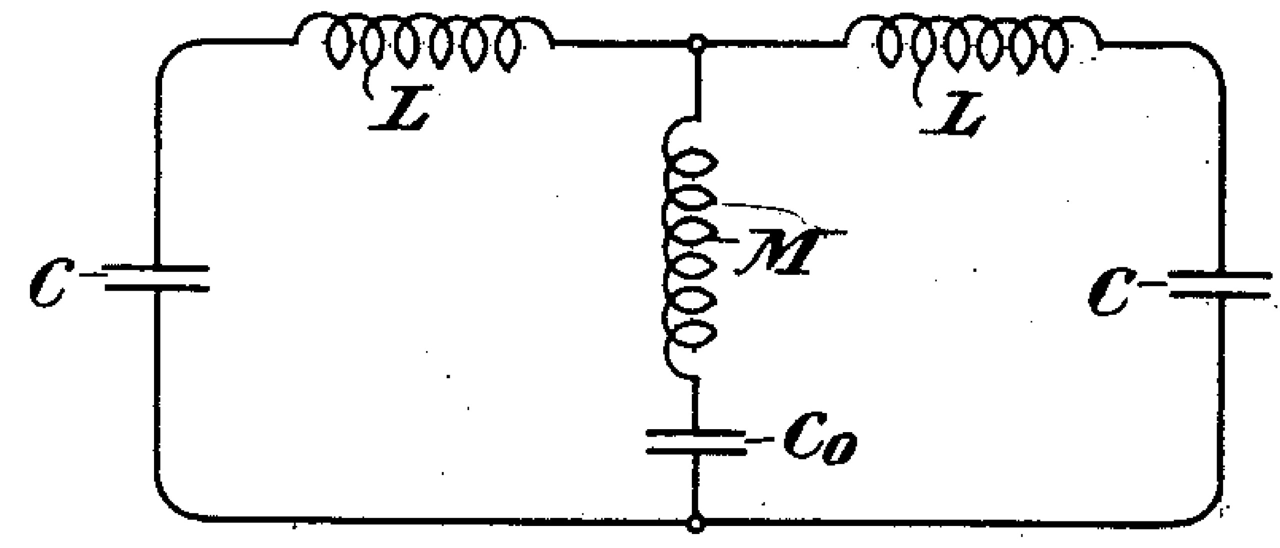

Fig. 2

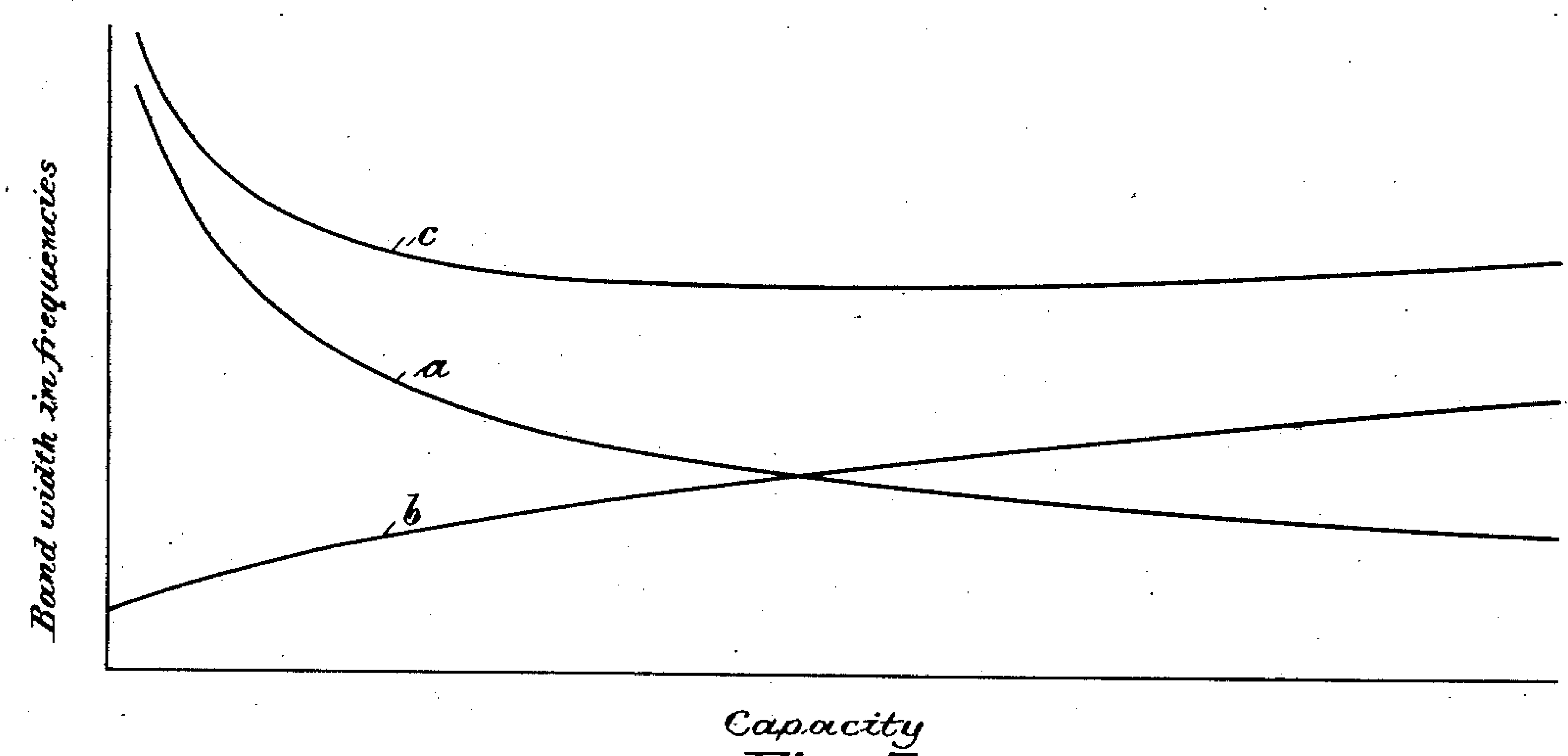

Fig. 3

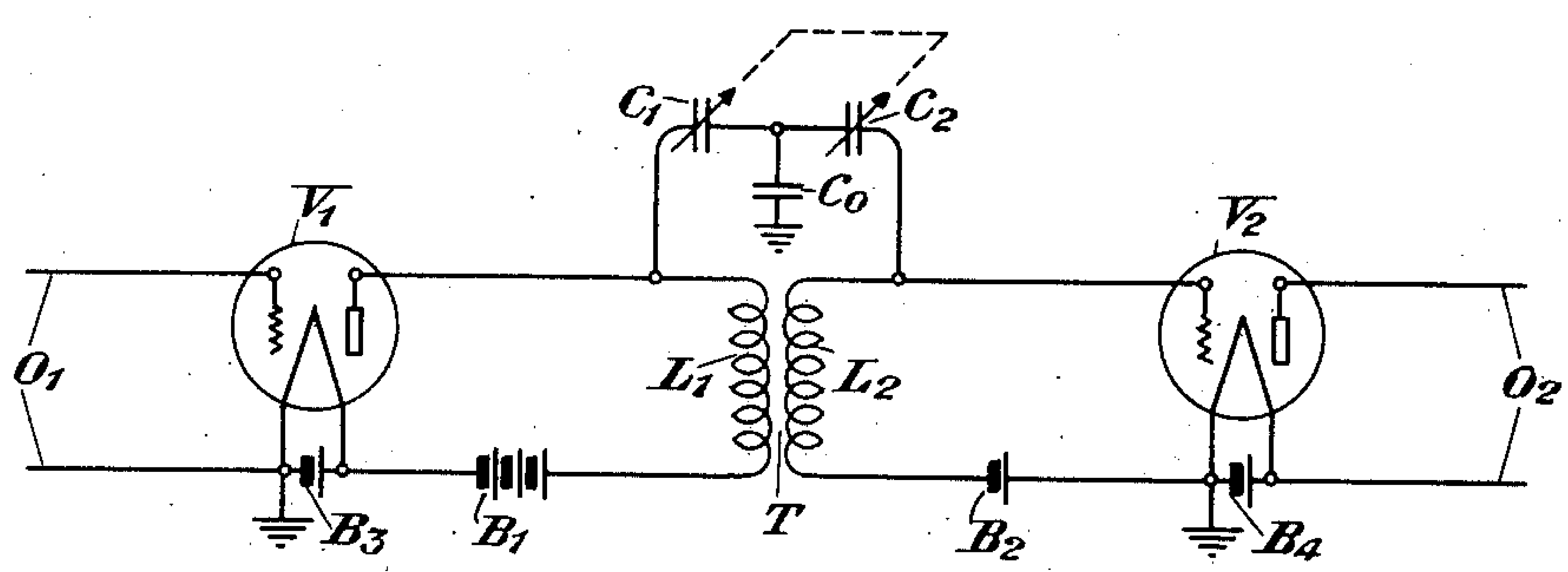

Fig. 4

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COUPLING ARRANGEMENT

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3 Claims. (Cl. 178—44)

This invention relates generally to signaling systems. More particularly, it relates to systems for the transmission of currents within bands of different frequency components which are of substantially equal widths. Still more particularly, this invention relates to arrangements for selectively receiving the currents within any one of a plurality of bands all occupying different positions in the frequency spectrum and having the same widths.

In a radio broadcast system, it is necessary to employ apparatus capable of selectively receiving any one of a plurality of programs all of which are represented by bands of frequencies of substantially equal widths. The selection of any one of the various programs may be obtained by varying one or more of the reactive elements of the receiving apparatus in a manner well understood in the art. It has been found that one setting of the reactive elements permits the reception of a band of frequencies of one width, and a different setting of these reactive elements permits the reception of another band of frequencies of a substantially different width. When the received band is too narrow, some of its component currents become suppressed and, therefore, the quality of the program is greatly distorted. On the other hand, if the width of the band received is too great, too many currents of adjacent programs become introduced into the receiving apparatus, and these similarly interfere with the efficient reproduction of the desired program matter. The need for apparatus capable of efficiently transmitting any one of a plurality of programs represented by bands of different frequencies occupying equal spaces in the spectrum, is very important and it is as important in carrier and other signaling systems as it is in radio broadcasting.

One of the objects of this invention is to provide an arrangement for selectively transmitting any one of a plurality of different bands of frequencies which have substantially the same widths.

Another of the objects of this invention is to provide an arrangement for shifting the limits of currents to be freely transmitted from one position in the frequency spectrum to another position in the spectrum so that these limits may remain of the same width.

Other and further objects of this invention will be apparent from the detailed description of the invention hereinafter following when read in connection with the accompanying drawing in which Figure 1 discloses an arrangement including the elements generally required in practicing the invention; Fig. 2 shows a circuit electrically equivalent to the one shown in Fig. 1; Fig. 3 shows curves illustrating the various features of the invention; and Fig. 4 shows a vacuum tube system for selectively transmitting the currents within any one of a plurality of different bands of frequencies which have substantially equal widths.

Fig. 1 of the drawing discloses the elements generally required in carrying out the principles of this invention. It includes a transformer T which has two windings L_1 and L_2 inductively related to each other. These windings are designed to exhibit the same inductances, and their mutual reactance may be made as large or as small as desirable, as is well understood in the art. Condensers C_1 and C_2 are both of the variable type and they are preferably equal in their exhibited capacities. These condensers may be simultaneously operated and varied to the same extent by mechanical coupling means which may take the form of a common shaft, as is well known in the radio art. Another condenser C_0 of a predetermined capacity may be connected between the lower terminals of the windings L_1 and L_2 of the transformer T and the lower terminals of the condensers C_1 and C_2, as shown.

The arrangement shown in Fig. 1 of the drawing involves two local circuits which are electrically coupled. One of these circuits includes the condenser C_1, the winding L_1 and the condenser C_0, and the other includes the condenser C_2, the winding L_2 and the condenser C_0. The mutual reactance between windings L_1 and L_2 is effectively in series with the reactance of the condenser C_0. In accordance with this invention, the mutual reactance of these windings is made of a negative order so that this reactance may be additive in effect with that of the condenser C_0. If these windings are found to exhibit a positive mutual reactance, this reactance may be made of a negative order merely by the reversal of one of the windings with respect to the other.

Fig. 2 of the drawing schematically represents a circuit electrically equivalent to the one shown in Fig. 1 after the condenser C_1 and C_2 are both set at a common and definite, predetermined capacitive value. The inductances L—L simulate the inductances of the windings L_1 and L_2 of the transformer T. The capacities C—C are equal to the capacities of condensers C_1 and C_2. The condenser C_0 represents the capacity of the condenser C_0 of Fig. 1, while the inductance M represents the mutual inductance of the windings L_1 and L_2, which is made to have a negative reactance so as to have an effect which is additive with respect to the reactance of condenser C_0.

When a voltage is impressed in series with either of the capacities C—C, then the total reactance of the circuit will be represented by the following expression:

$$\frac{\left(\omega L-\frac{1}{\omega C}\right)\left(-\omega M-\frac{1}{\omega C_0}\right)}{\omega L-\omega M-\frac{1}{\omega C}-\frac{1}{\omega C_0}}+\omega L-\frac{1}{\omega C} \qquad (1)$$

Setting this expression equal to zero in order to determine the frequencies of resonance and simplifying the resultant equation, then the following expression may be obtained:

$$\omega^4(L^2C^2C_0-2LC^2MC_0)-\omega^2(2LC^2+2LCC_0-2CMC_0)+2C+C_0=0 \qquad (2)$$

The value of ω^2 may be found from the following equation:

$$\omega^2=2LC^2+2LCC_0-2CMC_0\pm(2LC^2+2CMC_0) \qquad (3)$$

Two values of ω^2 will be obtained from Equation (3), and these will be determined by the following expressions:

$$\omega_1^2=\frac{1}{LC} \qquad (4)$$

and

$$\omega_2^2=\frac{C_0+2C}{C_0C(L-2M)} \qquad (5)$$

One of the resonant frequencies will be determined by the square root of the expression at the right hand side of the sign of equality in Equation (4). Another of the resonant frequencies will be similarly determined by the square root of the expression at the right hand side of the sign of equality in Equation (5).

In order that the band of frequencies transmitted by the arrangement involved in this invention may be highly constant in width over a range which may, for example, be associated with a carrier frequency or, for example, some frequency midway between the limits of some desired band, it will be necessary to make the ratio of the mutual inductance M to the inductance L the same as the ratio of the capacity of condenser C_0 to the particular value of the capacity C. It will be understood that the capacity C represents the capacity of either of the condensers C_1 or C_2 shown in Fig. 1 after these condensers have been set at some effective value, which for the determination of the above-mentioned equality, should be approximately their mid-capacities. It will be understood that the mid-capacity referred to herein represents half the sum of the maximum and minimum capacities obtainable upon adjustment of the rotatable elements of either of the condensers C_1 or C_2. Thus, it will be apparent that the inductive coupling coefficient must be made equal to the average capacitive coupling coefficient in the practice of this invention.

The curves *a*, *b* and *c* of Fig. 3 are plotted with the capacity of either of the condensers C_1 or C_2 of Fig. 1 as abscissæ, and the band widths obtained by variations in the capacities of condensers C_1 and C_2 as ordinates. The curve *a* will be obtained from an inductive coupling between the two local circuits, in which case the condenser C_0 will be omitted from consideration. The curve *b* will be obtained when the two local circuits are capacitively coupled, in which case there will be no mutual inductance between these circuits. The first of these curves shows that the band of frequencies transmitted decreases in width with an increase in capacity, and the second of these curves indicates that the band width increases with each increase in capacity. The curve *c* represents the sums of the ordinates of the curves *a* and *b*. Curve *c* clearly indicates that throughout the broad range of variation in the capacities of condensers C_1 and C_2, the width of the band transmitted will be substantially constant.

If it is desired to increase the width of the transmitted band, it will be necessary to increase the amount of inductive coupling as well as the amount of capacitive coupling while maintaining the ratio of the mutual inductance M to the inductance L the same as the ratio of the capacity of condenser C_0 to the mid-capacity of either of the condensers C_1 or C_2. Similarly, the width of the band transmitted may be decreased by decreasing the amounts of the inductive and capacitive couplings while maintaining the coupling coefficients in the same ratio. Thus, the width of the band may be increased by increasing the negative reactance of the mutual inductance and by decreasing the capacity of the condenser C_0. Similarly, the width of the band may be decreased by decreasing the negative reactance of the mutual inductance and by increasing the capacity of the condenser C_0. It will be found that the change in the width of the band transmitted by the arrangement described herein will be directly proportional to the changes in the inductive and capacitive couplings.

Fig. 4 shows a vacuum tube system for selectively transmitting any one of a plurality of bands of frequencies, which may have the same widths, from an input circuit O_1 to an output circuit O_2. The input and output circuits are connected to two vacuum tubes V_1 and V_2, respectively, which are coupled by an arrangement similar to the one shown in Fig. 1.

The plate electrode of the vacuum tube V_1 is connected to its filament electrode through the winding L_1 of the transformer T and a battery B_1. The grid electrode of the vacuum tube V_2 is connected to its filament electrode through the winding L_2 of the transformer T and a battery B_2. The filament electrodes of the tubes may be connected to batteries B_3 and B_4. It will be apparent that the lower terminal of the winding L_1 is grounded through batteries B_1 and B_3, and that the lower terminal of the winding L_2 is grounded through the battery B_2.

The upper terminals of the windings L_1 and L_2 of the transformer T are connected in series with equal condensers C_1 and C_2 which may be varied in their capacities to the same extent. The midpoint of these condensers, i. e. the conductor common to their adjacent electrodes, is connected to ground through a condenser C_0. The vacuum tube V_1 should preferably be one in which the impedance between its plate and filament electrodes is very high as compared with the impedance of the winding L_1.

The vacuum tube system shown in Fig. 4 of the drawing may be inductively coupled to an antenna circuit in any well known manner, in which case the vacuum tube system will be employed for freely transmitting any one of a plurality of bands of frequencies impressed upon the antenna circuit. It will also be understood that this vacuum tube system may be connected to a wired circuit upon which are impressed a plurality of bands of carrier frequencies so that any one of these bands may be selected and freely transmitted by the vacuum tube system. In either case adjustments of the condensers C_1 and

C_2 will permit the free transmission of any one of the bands impressed upon the input circuit O_1, and the width of the band transmitted will remain the same regardless of the band selected.

It will be understood that the coupling arrangement characteristic of this invention may be connected between an antenna circuit and a vacuum tube system in such a manner that a portion of the high frequency energy impressed upon the antenna circuit will be introduced into the coupling arrangement. The coupling arrangement will then transmit a band of high frequencies, the position in the spectrum of which may be adjusted in the manner already discussed hereinabove.

While this invention has been shown and described in certain particular arrangements for the purpose of illustration, it will be understood that the general principles of this invention may be applied to other and widely varied organizations without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. A coupling arrangement for freely transmitting any one of a plurality of bands of frequencies which occupy different positions in the frequency spectrum and which have the same widths. including two equal circuits each comprising a winding and a condenser, a circuit common to said equal circuits comprising a condenser, the mutual inductive reactance of said windings being negative and additive to the reactance of the condenser of the common circuit, and means for simultaneously varying the capacity of the condensers of said two equal circuits by equal amounts.

2. A coupling arrangement for freely transmitting any one of a plurality of bands of frequencies having the same definite and controllable width, including two equal circuits each comprising a winding and a variable condenser, the windings of said two equal circuits being mutually inductive, a circuit common to said equal circuits comprising a condenser which is effectively in series with the mutual inductance of said windings, the ratio of the capacity of the variable condenser of each of said equal circuits to the capacity of the condenser of the common circuit being equal to the ratio of the mutual inductive reactance of the windings of said equal circuits to the inductive reactance of each winding of said equal circuits at the mid-capacity of each of the variable condensers.

3. In a system for freely transmitting any one of a plurality of bands of frequencies each of which when transmitted has a width in cycles which is constant and controllable, the combination of two vacuum tubes each having plate, filament and grid electrodes, the filament electrodes of which are grounded, a transformer having equal primary and secondary windings, the primary winding being connected between the plate and filament electrodes of one vacuum tube and the secondary winding being connected between the grid and filament electrodes of the other vacuum tube, two equal and variable condensers connected in series with each other between the ungrounded terminals of the windings of said transformer, and a fixed condenser connected between the conductor common to said equal and variable condensers and ground, the ratio of the mutual inductance between the windings of the transformer to the inductance of either of said windings being substantially the same as the ratio of the capacity of the fixed condenser to the capacity of either of said variable condensers.

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