

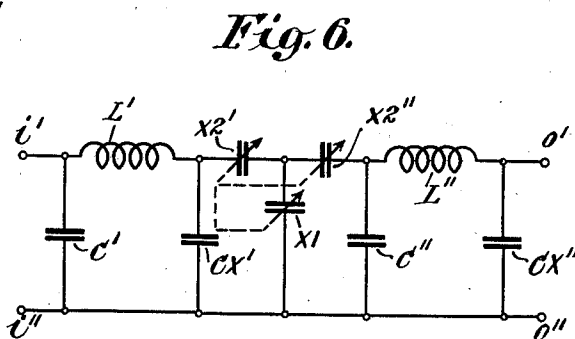
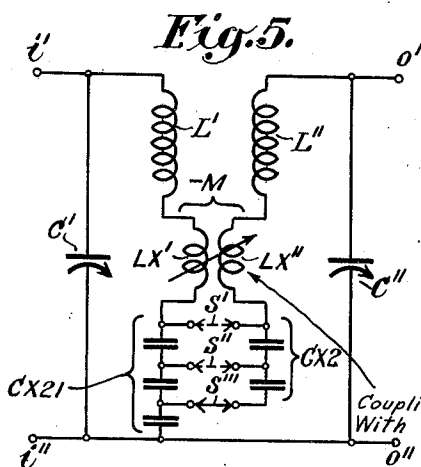
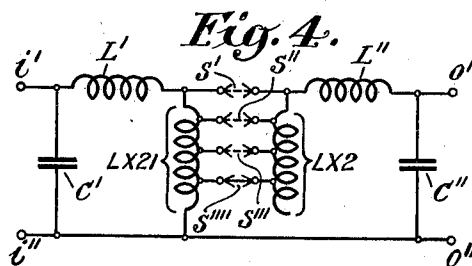
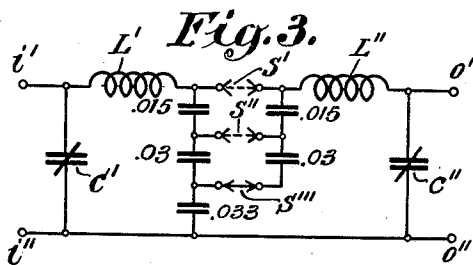
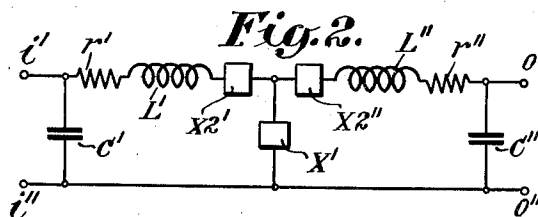
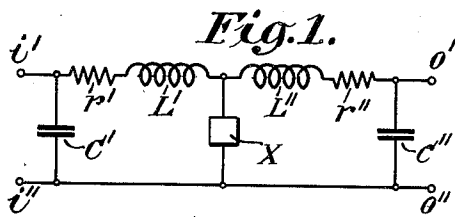
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J. D. BRAILSFORD

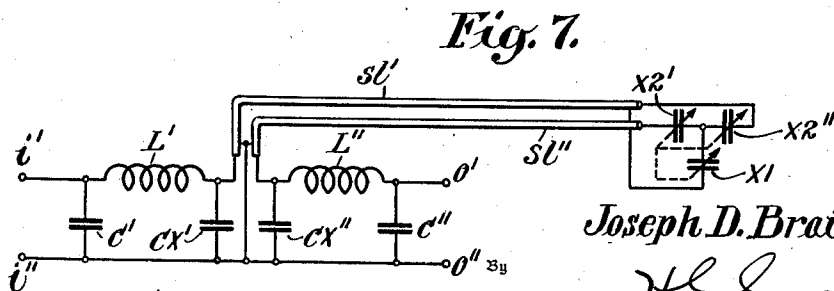
2,282,113

BAND PASS FILTER

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Coupling Adjustable In Steps And Simultaneously With The Control Of Switches S' , S'' And S'''



Inventor
Joseph D. Brailsford,

H. S. Swover

Attorney

UNITED STATES PATENT OFFICE

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BAND-PASS FILTER

Joseph Douglas Brailsford, London, England, assignor to Radio Corporation of America, a corporation of Delaware

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3 Claims. (Cl. 178-44)

This invention relates to band pass filters suitable for use in radio receivers and other like purposes. The main object of the present invention is to provide improved and simple band pass filters which are variable as to acceptance band width and which retain substantially symmetrical characteristics during said variation.

The novel features characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its construction and mode of operation together with the objects and disadvantages thereof, will best be understood by reference to the following description taken in connection with the accompanying drawing in which Fig. 1 represents a known band-pass filter network for the purpose of explanation; Fig. 2 is a modification of the filter network of Fig. 1 embodying the present invention, Figs. 3 to 5 are practical embodiments of the invention shown in Fig. 2, and Figs. 6 and 7 are further modifications of the invention.

In order that the invention may be the better understood consider first a simple known band pass network of the four terminal type illustrated in Figure 1 and consisting of two sections coupled by a coupling impedance. This network comprises in one series arm between one input terminal i' and one output terminal o' , a resistance r' , an inductance L' , a second similar inductance L'' and a second similar resistance r'' . The resistances r' , r'' , include that of each of, and may be constituted by, the resistances of the inductance coils L' , L'' . A condenser C' is connected across the input terminals and a second similar condenser C'' is connected across the output terminals. The other input terminal i'' is directly connected to the other output terminal o'' and the coupling impedance X is connected between this direct connection and the junction point of the two series inductances L' , L'' . This well known band pass transformer arrangement will produce the familiar "double hump" characteristic with "humps" or peaks disposed on either side of the mid-frequency. The frequency separation of these "humps" is determined by the reactance of the coupling impedance and if this is small with relation to each of the two resistances r' , r'' , in the series arm, the "humps" will be coincident. The coupling impedance may be a mutual inductance provided by magnetic coupling between the two inductances L' , L'' , in the series arm. In this case the expansion of the width of the acceptance band resulting from an

increase of the coupling impedance will occur symmetrically about the mid-band frequency. If, however, the coupling impedance is an inductance the lower frequency "hump" will move on expansion of the band whereas if the said impedance is a condenser, the higher frequency "hump" will move. Now, in practice, the design of the coupling impedance may be dictated by conditions quite different from those imposed from a consideration of the requirements for variation of band width alone. For example in the case of a tuned band pass filter for a radio-frequency stage of a radio receiver, it is a usual requirement that the width of the acceptance band of the filter shall not vary merely as a result of variation of tuning. The satisfaction of this requirement involves that the coupling impedance must have a definite law of variation of reactance with variation of frequency. In practice a reasonably close approximation to this required law can be obtained by employing as the coupling impedance a negative mutual inductance in effective series with a condenser—the well known "mixed coupling" type of arrangement. Such an arrangement will maintain a substantially constant width of acceptance band over a reasonable range of frequency—such, for example, as the medium-wave broadcast tuning range—but any attempt to change the width of the acceptance band for the purpose of varying selectivity involves changing both the negative mutual inductance and the capacity in series therewith. Though this does not, in itself, involve any very great difficulty any change in the series capacity will produce an asymmetrical variation of the width of the acceptance band. Thus the requirements for obtaining constant band width with variation of tuning conflict with those for obtaining variable selectivity with symmetrical expansion of the width of the band.

There are other cases where it is desired to be able to expand the band symmetrically and yet change a physical reactance in the coupling impedance, one such case being that of an intermediate frequency transformer (superheterodyne receiver) in which symmetrical expansion is required to be obtained by the varying of condensers only.

The present invention seeks to satisfy these requirements.

According to this invention a band pass filter comprises at least two tuned coupled circuits, a variable coupling impedance in the shunt arm and two further variable impedances, one in each

half of the series arm, all said variable impedances being arranged for simultaneous variation in such manner that the width of the acceptance band is variable in a symmetrical fashion.

In applying the present invention to the known band pass filter hereinbefore described, the said filter is modified, as illustrated in Figure 2 by including in the series arm and between the two similar inductances L' , L'' , two additional reactances X_2' , X_2'' , which are similar to one another, the junction point of said additional reactances being one of the points to which the coupling reactance X_1 is connected. The two additional reactances and the coupling reactance are gang-controlled for variation together in such manner that, for each tuned circuit of the filter, the sum

$$-j\frac{1}{\omega C} + r + j\omega L + jX_2 + jX_1$$

remains constant with such variation. In the foregoing expression C is the value of each of the two shunt condensers (C' or C'') in the filter; L is the value of each of the two series inductances (L' or L''); r is the value of the resistance (r' or r'') in each half of the series arm of the filter; X_2 is the value of each of the additional reactances (X_2' or X_2'') in the series arm; and X_1 is the value of the coupling reactance. In other words simultaneous variation is made in such manner that the sum $X_2 + X_1$ is constant as X_1 is varied.

In one practical embodiment of the invention, illustrated in Figure 3, a four terminal network in accordance with this invention comprises in the series arm between one input terminal i' and one output terminal o' and in the order stated, an inductance L' of 600 microhenries with a Q value of 150 at 460 kilocycles per second; a switch S' ; and a further similar inductance L'' . Connected between the two terminals of this switch is a circuit comprising, in the order stated, a condenser of .015 microfarad; a second switch S'' ; and a second condenser of .015 microfarad. Connected across the terminals of the second switch is a further circuit comprising, in the order stated, a condenser of .03 microfarad; a third switch S''' ; and a second condenser of .03 microfarad. A further condenser of .033 microfarad is connected between one terminal of the third switch and the remaining wire of the network. Condensers C' and C'' of .0002 microfarad are connected across the input terminals i' and i'' and the output terminals o' and o'' respectively. It will be seen that with this arrangement by selectively manipulating, as by opening and closing, the switches, so that only one of the switches is closed at any given time, simultaneous variation in the required manner of the series capacities in the series arm of the network and the capacity in the coupling or shunt arm, can be obtained. This arrangement may, therefore, be regarded as a tapped condenser arrangement.

The invention may also be carried into effect by an analogous tapped inductance arrangement as illustrated in Figure 4. In the tapped inductance arrangement, there is provided in the series arm of the network a first inductance L' ; a switch S' ; and a second inductance L'' . A shunt inductance LX_2 is connected from one terminal of the switch to the other wire of the network. Another inductance LX_1 is connected at one end to the other terminal of the switch and a series of corresponding tapping points on the last mentioned two inductances are so ar-

ranged that they can be selectively connected together by switches S'' , S''' , S'''' .

In yet another arrangement, illustrated in Figure 5, provision is made for simultaneous variation of mutual inductance $-M$ and capacity in the required manner. In this arrangement a first main inductance L' in series with an auxiliary inductance LX' and a desired plurality of condensers CX_2 is connected across the input terminals, this whole series circuit being in parallel with a tuning condenser C' . A second similar tuning condenser C'' is connected between the output terminals and a series circuit comprising a series main inductance L'' , a second auxiliary inductance LX'' and a plurality of condensers CX_2 is connected to the "live" output terminal. The two auxiliary inductances are mutually coupled in the negative sense and means, such as a cam drive (not shown), are provided for varying this mutual inductance in a plurality of steps, say three. A corresponding plurality of switches S' , S'' , S''' are provided for selectively making connection between corresponding points along the series condensers in the two halves of the network so that the mutual inductance and the effective capacity are variable simultaneously in the required manner. Since the mutual coupling is negative, this arrangement is of the "mixed coupling" type.

In the embodiments so far described variation is carried out in steps as distinct from continuously. In general this is not a disadvantage. If, however, continuous variation is required, this can be achieved by means of a condenser or condensers with vanes shaped to satisfy the requirements hereinbefore set forth. In general, the values required for condensers in "bottom end coupling" are too large to be suitable for continuous variation. This difficulty can, however, be overcome by employing, what may be termed a "tapping down" arrangement.

A band pass filter of the above mentioned kind, and as illustrated in Figure 6, comprises in one series arm, and in the order stated, an inductance L' , two similar variable condensers X_2' and X_2'' , and a second similar inductance L'' . A third variable condenser X_1 is connected between the junction points of the two variable condensers X_2' and X_2'' and the remaining wire of the network. Fixed condensers (four in all, namely C' , CX' and C'' , CX'') are connected between each of the inductance terminals and the said remaining wire of the network. The three variable condensers have vanes shaped to produce the required laws of variation and are gang controlled.

As indicated in Figure 7 of the accompanying drawing, the above arrangement is suitable for remote control, for the three variable condensers X_2' , X_2'' and X_1 —which are connected, inter se, in a T network—may be remotely situated with respect to the rest of the filter and connected thereto by means of two screened leads sl' , sl'' , which may be of considerable length, the inner conductors of the leads being connected between opposite ends of the "cross-piece" of the T and the respective inductances L' , L'' , and the screens being connected between the foot of the "up-right" of the T and the conductor connecting the input terminal i'' to the output terminal o'' .

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:

1. A variable band pass filter network comprising a pair of resonant circuits, the first includ-

ing a pair of reactances of opposite sign and a plurality of additional series-connected reactances all connected in a closed circuit, the second circuit including a similar pair of reactances of opposite sign and a plurality of additional series-connected reactances, switch means between corresponding tapping points between the sets of additional reactances so constructed and arranged that depending upon the selective closure of a particular switch means the resonant circuits are reactively coupled to different degrees without altering the natural resonant frequency of each circuit, means providing magnetic coupling between the pair of resonant circuits, and means for simultaneously varying in steps said reactive and magnetic couplings.

2. A variable band pass filter network as defined in claim 1 wherein the additional series-connected reactances are constituted by condensers, certain or all of which of the first circuit, depending upon which of the switch means is closed, serve as a common coupling means between the pair of circuits.

3. A variable band pass filter network comprising a pair of resonant circuits, the first including a pair of reactances of opposite sign

and a set of $n+1$ series-connected condensers connected in shunt across said pair of reactances, the second circuit including a similar pair of reactances of opposite sign and a set of n series-connected condensers, tapping points provided at the common terminals of the condenser sets and at the outer terminals of the end condensers of both sets except the outer terminal of the extra condenser of the first set which has a common connection to corresponding reactances of the resonant circuits, switch means between corresponding tapping points so constructed and arranged that only one switch means is closed at any given time to selectively include in each of said resonant circuits a corresponding number of series-connected condensers and simultaneously to connect into both circuits as a common coupling reactance the remaining condensers of the first circuit, said resonant circuits each including one of a pair of inductances mutually coupled in the negative sense, and means for varying in steps the mutual inductance of said inductances, the number of steps being equal to the number of condenser switch means.

JOSEPH DOUGLAS BRAILS福德.