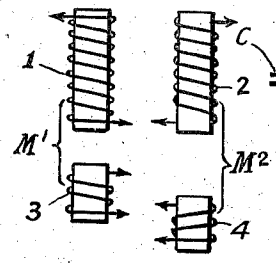
Jan. 17, 1939. F. BELOW 2,144,214

BAND PASS FILTER WITH VARIABLE BAND WIDTH

Filed July 1, 1936

Fig. 1

Fig. 5.



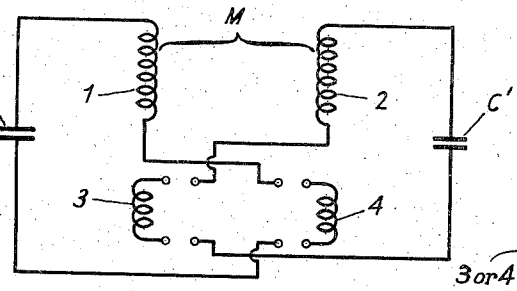


Fig. 4.

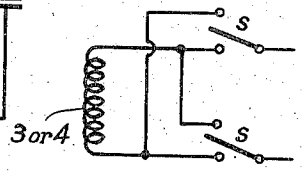
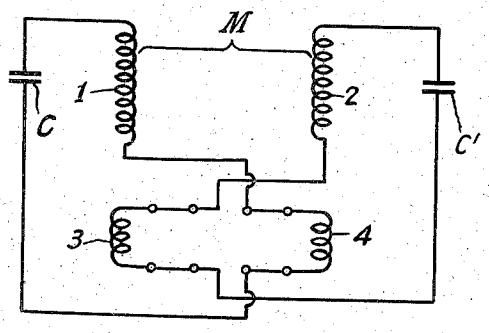


Fig. 1a

Fig. 1b



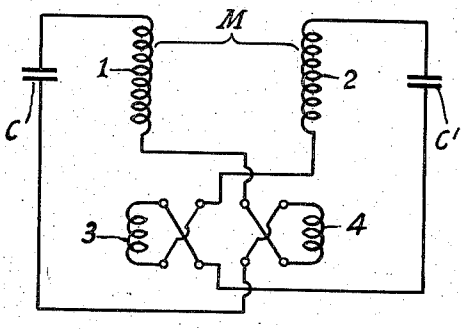
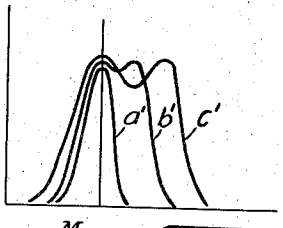
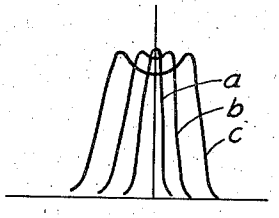


Fig. 2

Fig. 3





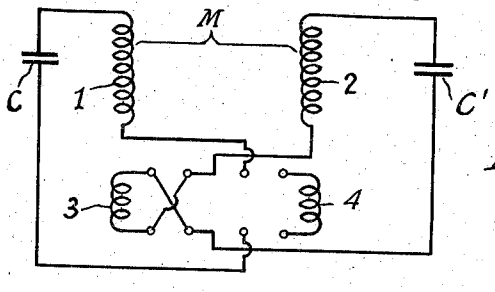


Fig. 1c.

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BAND PASS FILTER WITH VARIABLE BAND WIDTH

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8 Claims. (Cl. 178—44)

It has recently become common practice to provide wireless receiving sets with band filters of variable band width in order that it may be possible to adjust the selectivity of the set depending upon the conditions of reception. For example, in the reception from a distant transmitting station of low power and in the presence of high power local station, the selectivity of the set should be sharp in order to avoid interference from the local station, whereas for best quality reception from a local station of high power the set should be tuned broadly, that is, adjusted to transmit uniformly a wide band of frequencies. For varying the band width, only inductive coupling for the band filter is desirable, since only with such coupling the band width is capable of varying symmetrically about a middle line. With other forms of coupling the variation of the band width from a line of reference would be unilateral, that is, asymmetrical. Since, however, an illustrative embodiment according to the invention is disclosed in connection with a band-pass filter circuit for intermediate frequency amplifiers in receivers of the superheterodyne type, a symmetrical displacement towards both sides of the mid-frequency is necessary for obtaining the tuning of the preliminary selection means in the case of a variation of the band width.

In the drawing,

Fig. 1 discloses the circuit of a band-pass filter according to the invention.

Fig. 1*a* shows the manner of connecting the auxiliary coupling coils in the respective tuned circuits to provide an additive coupling effect between the coupled tuned circuits.

Fig. 1*b* shows an alternative manner of connecting the auxiliary coils for obtaining a subtractive coupling effect, one opposite to that obtained in Fig. 1*a*.

Fig. 1*c* shows still another manner of connecting the auxiliary coils, one to provide an additive coupling effect, and the other the subtractive coupling effect.

Fig. 2 shows the asymmetric displacement of resonance curves with increased coupling between coupled circuits of a band-pass filter according to the prior art.

Fig. 3 shows the symmetric resonance curves obtained with a filter circuit according to the invention with varying band width adjustments.

Fig. 4 shows a suitable form of switching means that may be employed, and

Fig. 5 shows only the coil portion of the filter, particularly the spatial relation between the auxiliary coils and the main coils.

It is known to bring about the variation of the band width by ensuring that the main coils of a pair of coupled circuits, such as 1 and 2 of Figure 1, are adapted to be shifted towards one another.

It is also well known to add two additional coils, such as 3 and 4, which by displacement or rotation permit of varying the additional coupling between them which also brings about a variation of the band width.

These arrangements have the disadvantage that additional capacitative couplings which are varied by the displacements of the coils bring about unilateral displacement of the resonance curve as shown in Figure 2 for curves *a'*, *b'* and *c'*, or again that the additional coils, if a large variation of the band width is required to take place, must be fairly large and consequently bring about heavy damping of the circuits. It is otherwise an essential disadvantage that in these arrangements the displacement of the coils entails the use of large devices which become complicated when a number of band filters are required to be varied at the same time.

According to the invention the said disadvantages are obviated by having the additional or auxiliary coil 3 (or 4) of one tuned circuit (see Fig. 1) inductively coupled to the main coil 1 (or 2) of the other tuned circuit with which the first tuned circuit is associated to form a band-pass filter circuit. With such circuit organization the additional coils can be made very small so that appreciable damping of the circuits is avoided. The band width need only be varied by change of poles (change of connections) of the coils 3 and 4 so that variation of the supplementary capacitative coupling is avoided and only variation of the supplementary inductive coupling is obtained. The arrangement must be such that the additional coil 3 pertaining to the circuit 2C' is coupled to the main coil 1 of the other circuit and the additional coil 4 associated with the circuit 1C is coupled to the main coil 2 of the first circuit. Since the two main coils 1 and 2 are also possessed of a mutual coupling it is possible to increase this coupling by the additional coils 3 and 4 or else to counteract it by change of poles.

This arrangement permits of obtaining four different band widths by change of connection. The additional or auxiliary coils 3 and 4 are arranged on the end side of the band filter in order to reduce as far as possible the effect of the harmful capacities. It is possible by suitable spatial arrangement of the coils 3 and 4

between the coils 1 and 2 as illustrated in Fig. 5, to control at will the working of the additional coupling in such manner that the additional coupling of the coil 4 to the coil 2 is different from that of the coil 3 to the coil 1. It is thus possible to have in addition to the three normal positions, namely, (1) when both coils are additive (Fig. 1*a*), (2) when both coils are subtractive (Fig. 1*b*), and (3) when one coil is additive and the other coil is subtractive (Fig. 1*c*), a fourth position which is obtained by the additive coupling between 4 and 2 being different from the additive coupling between 3 and 1. As shown in Fig. 5, the auxiliary coil 3 is spaced closer to coil 1 than the auxiliary coil 4 is spaced from the coil 2. The couplings M′ and M″ are therefore different. While the former is shown to be a closer coupling than the latter, the spacing of the coils may be altered as desired to provide an opposite effect, that is, so that the coupling M″ would be closer than the coupling M′. If the two couplings M′, M″ were equal to each other there would not be any difference in band width between the position when 3 is additive and 4 is subtractive and the position when 4 is additive and 3 is subtractive. An arrangement in which the coils 1 and 2 and the coils 4 and 2 and also 3 and 1 can be displaced towards each other permits in the manufacture of the band filter to adjust the band widths once at will to the desired values. Subsequently, these band widths can be varied at will only by change of connections of the coils 3 and 4. These connection-changing operations result in resonance curves as shown in Figure 3, the curve *a* of Figure 3 being formed when the coils 3 and 4 of Figure 1 are connected subtractively or deductingly (Fig. 1*b*). The curve *b* of Figure 3 is obtained when one of the auxiliary coils (3 or 4) of Figure 1 is connected additively and the other is connected subtractively (Fig. 1*c*) and the curve *c* of Figure 3 is formed when the two coils 3 and 4 of Figure 1 are connected additively (Fig. 1*a*). It is possible to split up the curve *b* of Figure 3 into two new curves by reason of the working of the couplings of coil 4 with respect to 2 and of 3 with respect to 1 of Figure 1 being not equal, as already mentioned.

If only two band widths are desired it is sufficient only to change the connections of one of the two additional coils. A suitable form of switching device is diagrammatically shown in Fig. 4. In the lower position of the switch blades *s* the auxiliary coil 3 (or 4) is included in its associated tuned circuit 2C′ (or 1C) to provide an increased coupling effect between the coupled circuits, and in the upper position of the switch blades the auxiliary coil 3 (or 4) is included in its associated tuned circuit to provide a decreased coupling effect therebetween.

By means of a switching device it is possible to make such an arrangement that the various band widths are successively obtained by a number of switching positions.

What I claim is:

1. A band-pass filter arrangement comprising a pair of substantially similar tuned circuits, each comprising a main coil, an auxiliary coil and a condenser, the main coils of the tuned circuits being in inductive coupling relation, and the auxiliary coil of either circuit being in inductive coupling relation with the main coil of the circuit which does not include said last mentioned auxiliary coil.

2. A band-pass filter arrangement comprising a pair of substantially similar tuned circuits, each comprising a main coil, an auxiliary coil and a condenser, the main coils of the tuned circuits being in inductive coupling relation, and each auxiliary coil being inductively coupled respectively to a main coil, said last mentioned coupled coils being included each in a different tuned circuit.

3. A band-pass filter arrangement according to claim 2, wherein the coupling between one of the auxiliary coils and its associated main coil is different than the coupling between the other auxiliary coil and its associated main coil.

4. A pair of tuned circuits each tuned to substantially the same resonant frequency and each including a main coil, an auxiliary coil and a condenser, all connected in series, the auxiliary coil of each circuit being inductively coupled to the main coil of the other circuit, and means for reversing the connections to one or both of said auxiliary coils whereby the coupling effect between the tuned circuits may be altered.

5. The combination with two coupled circuits, of reactive means for varying the coefficient of coupling between said circuits while maintaining their natural resonant frequency unchanged; said reactive means comprising a serially connected reactance in one of said circuits which is coupled to the other circuit, and means for causing said reactance to be connected in its circuit in an opposite sense.

6. The combination with two coupled circuits, of reactive means for varying the coefficient of coupling between said circuits while maintaining their natural resonant frequency unchanged; said reactive means comprising a serially connected reactance in each circuit, the reactance of one circuit being coupled to the other circuit, and means for causing one or both of said reactances to be connected in their respective circuits in an opposite sense.

7. The combination with a pair of circuits tuned to the same frequency and coupled to resonate as a whole at that frequency, of means for varying the coefficient of coupling between said circuits, said means comprising an impedance included in each of said circuits, the impedance of one circuit being in coupling relation with the other circuit, and means for causing one or both of said impedances to be connected in their respective circuits in an opposite sense.

8. A pair of tuned circuits each including an inductance, a capacity and an auxiliary coil, the inductances of said circuits being magnetically coupled, an additional coupling between said circuits provided by locating the auxiliary coil of one circuit in coupling relation with the inductance of the other circuit, and means for causing one or both of said auxiliary coils to be connected in their respective circuits in an opposite sense.

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