Jan. 12, 1932.

J. HERMAN

1,840,360

SELECTIVE CIRCUIT ARRANGEMENT

Filed Feb. 5, 1929

3 Sheets-Sheet 1

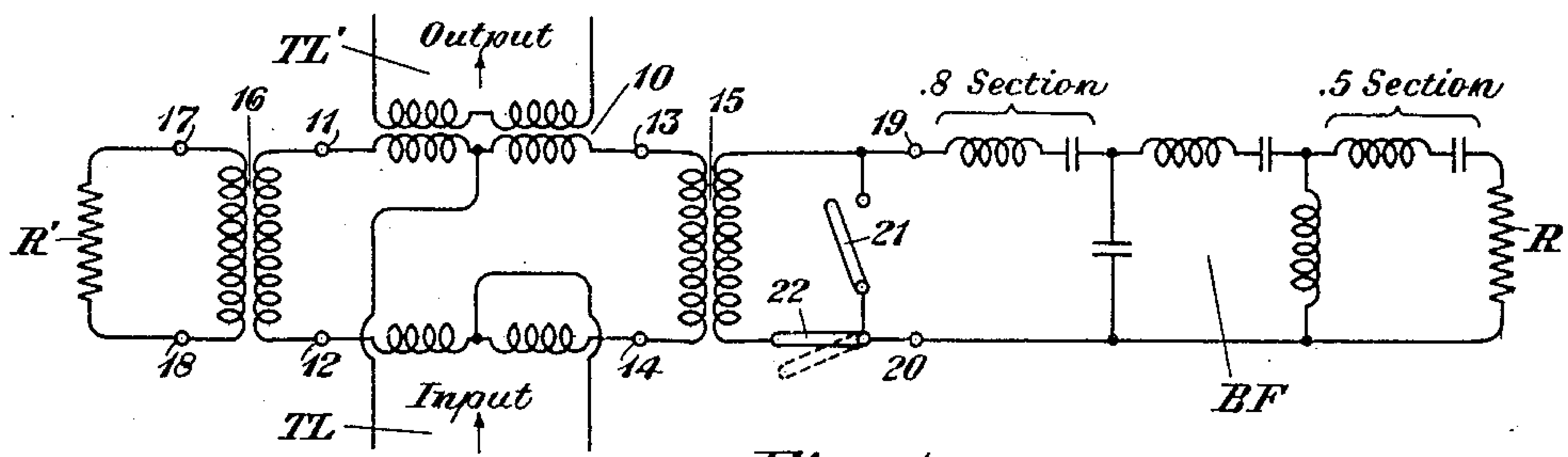

Fig. 1

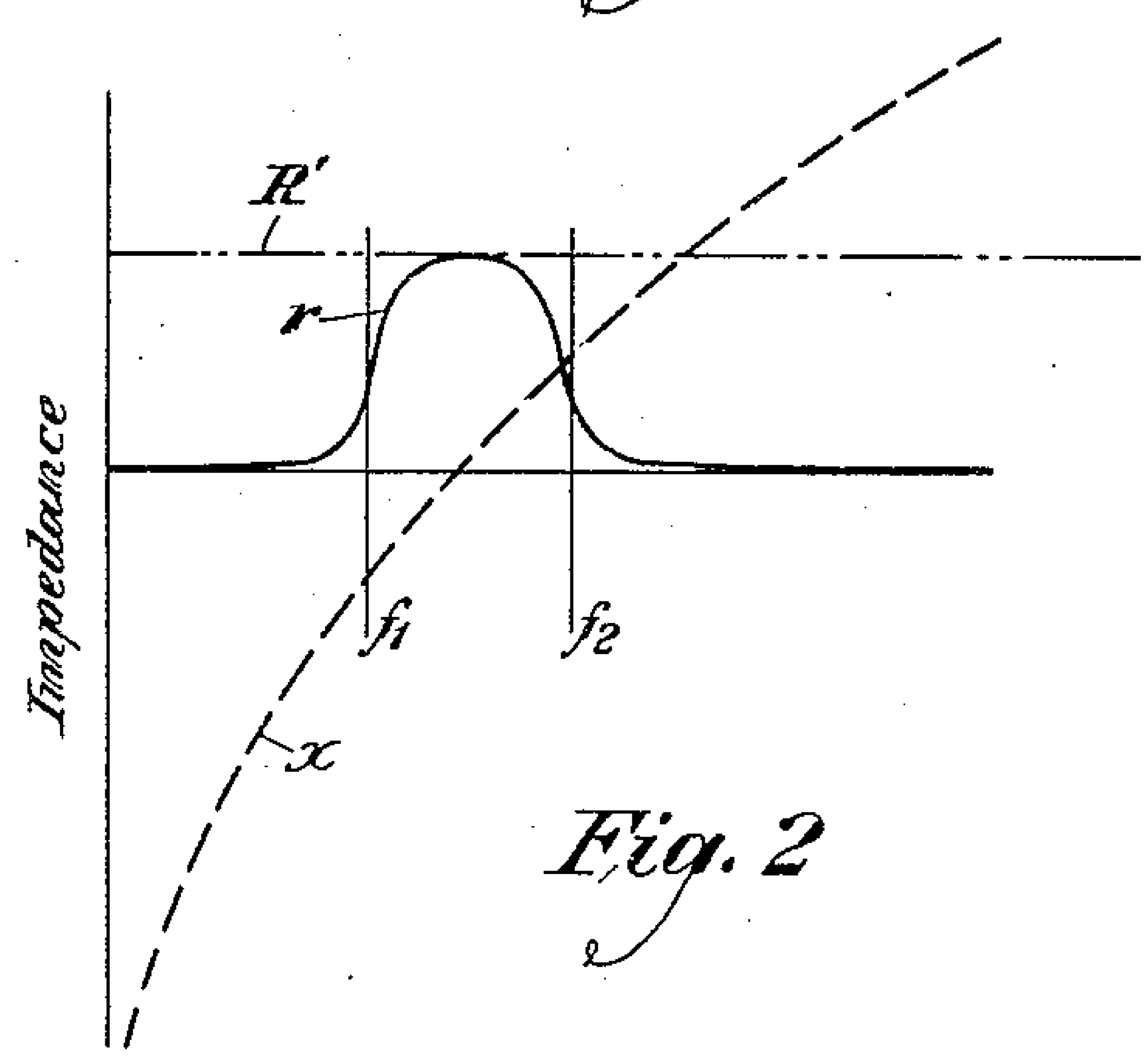

Fig. 2

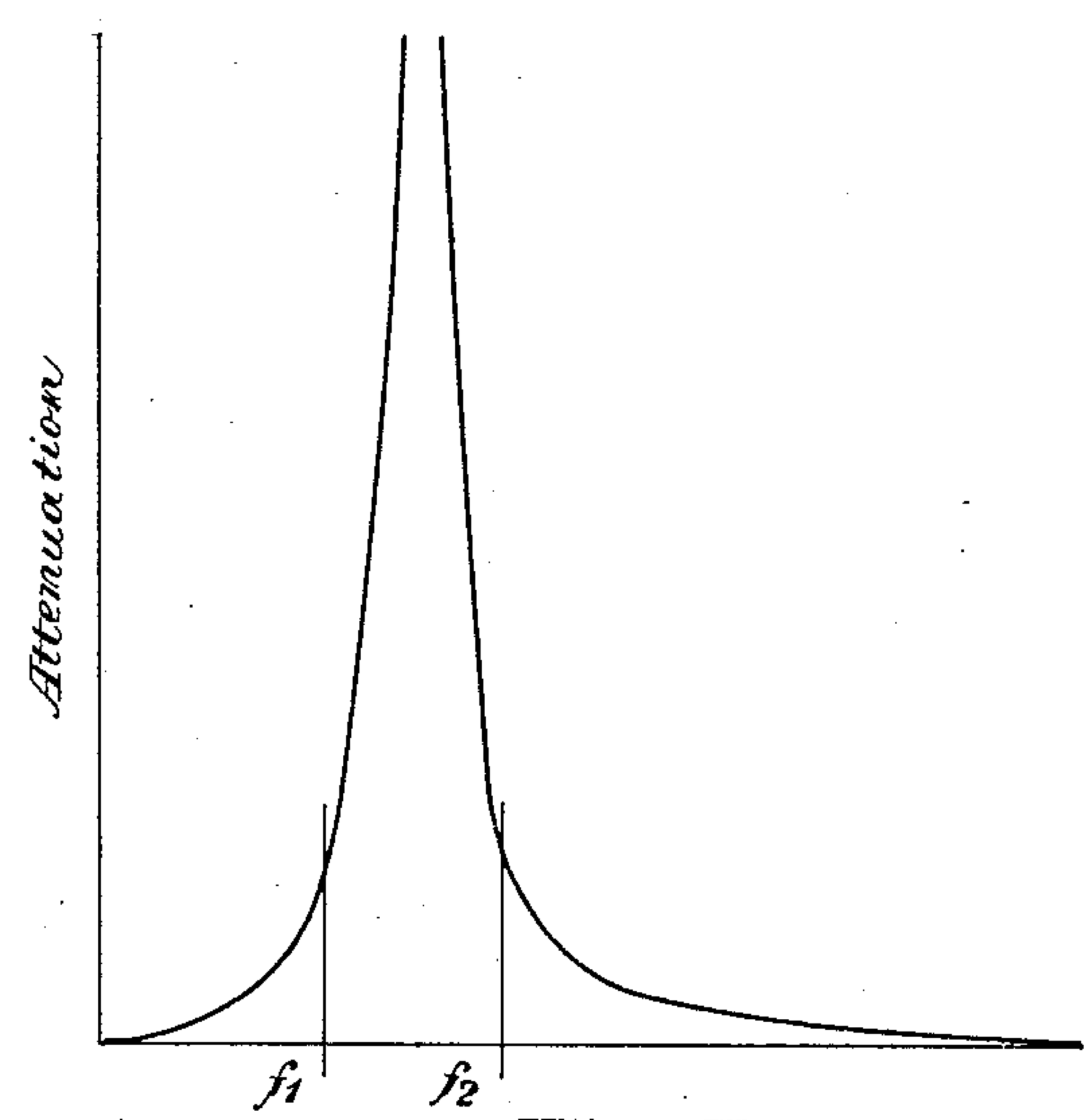

Fig. 3

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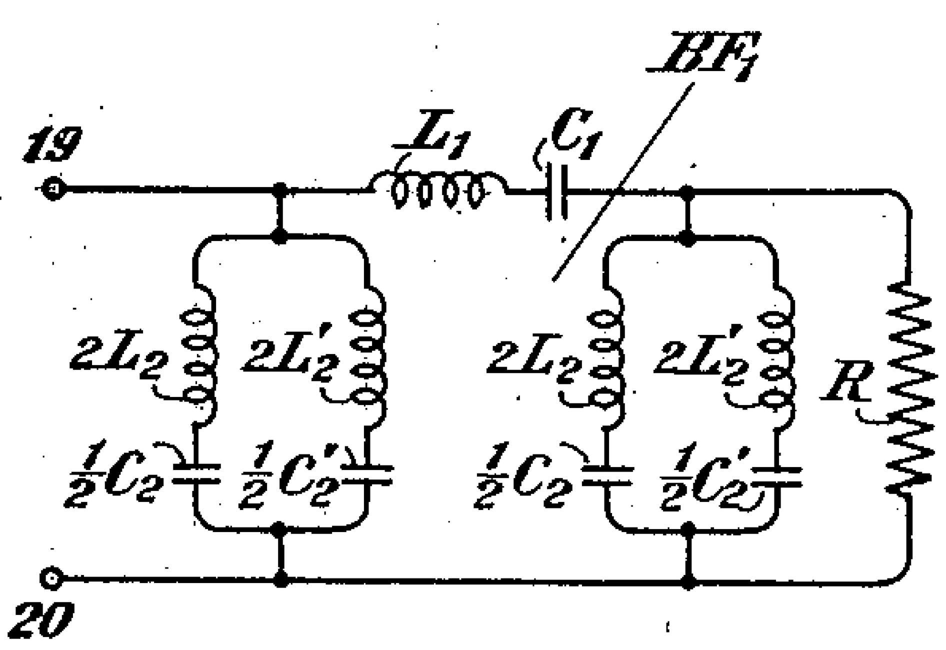


Fig. 4, Midshunt Section, Type IV_1, where $m = .6$

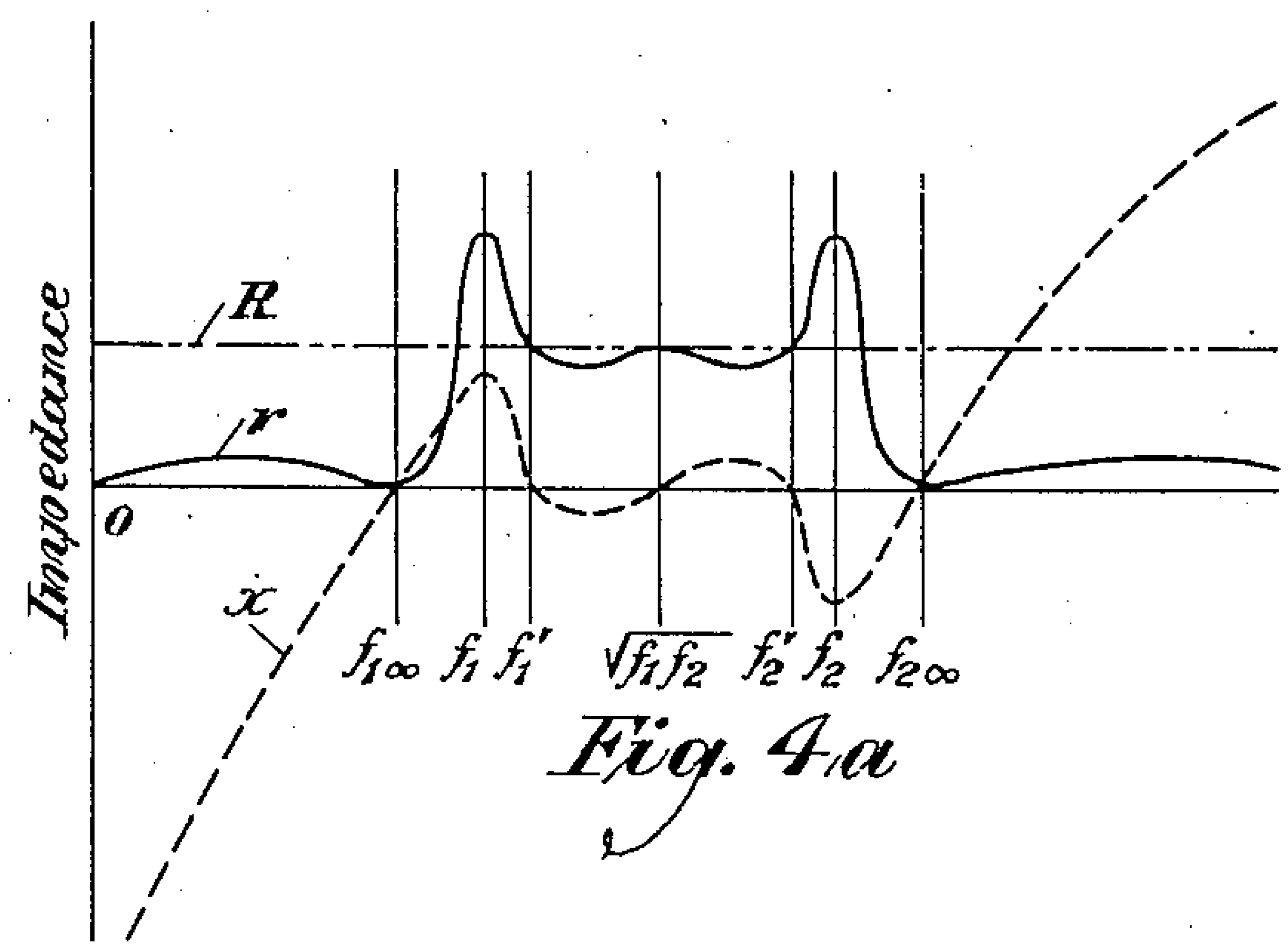


Fig. 4a

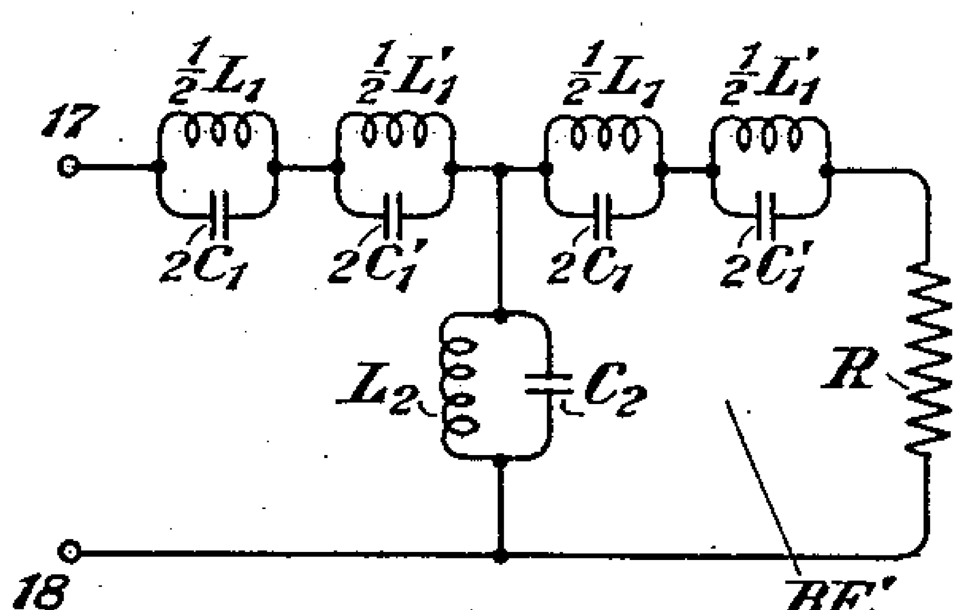


Fig. 5, Midseries Section, Type IV_2, where $m = .6$

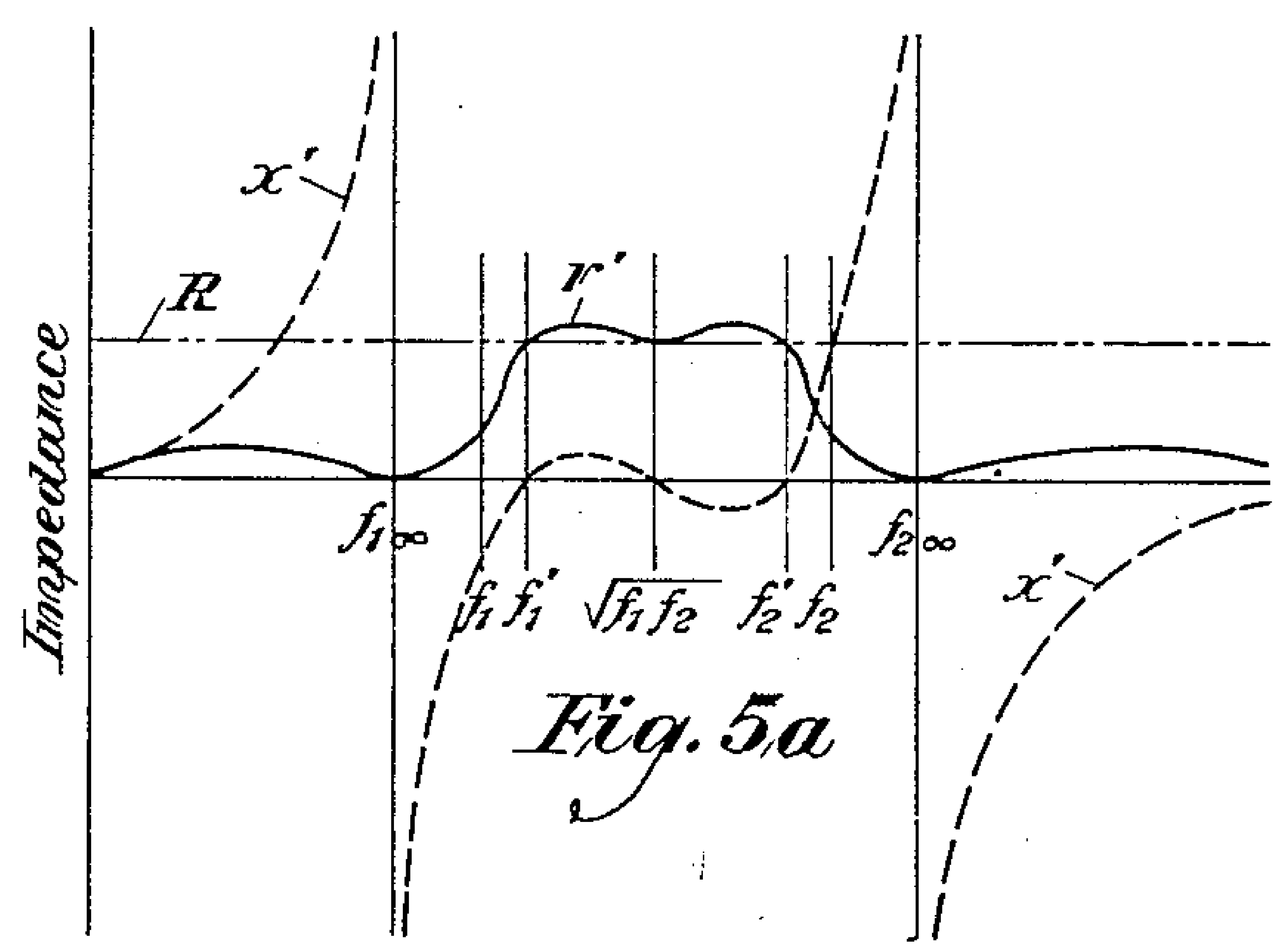
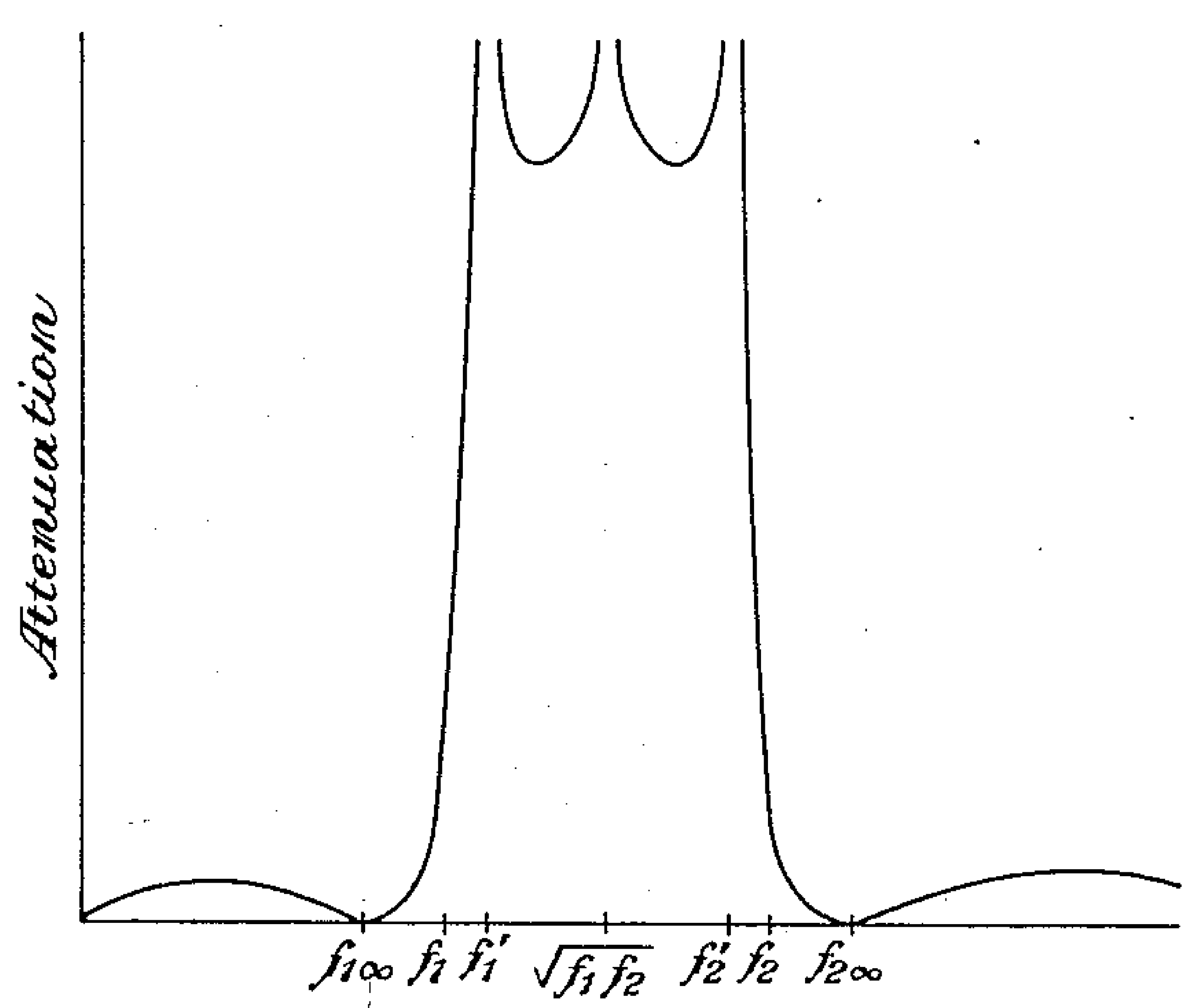


Fig. 5a

Fig. 6



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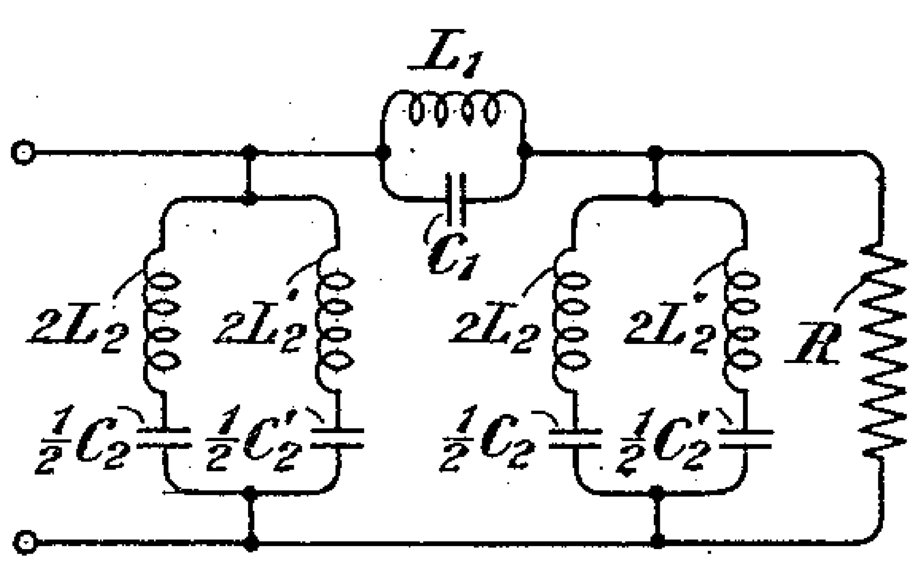


Fig. 7, Midshunt Section, Type III_1, where m = .6

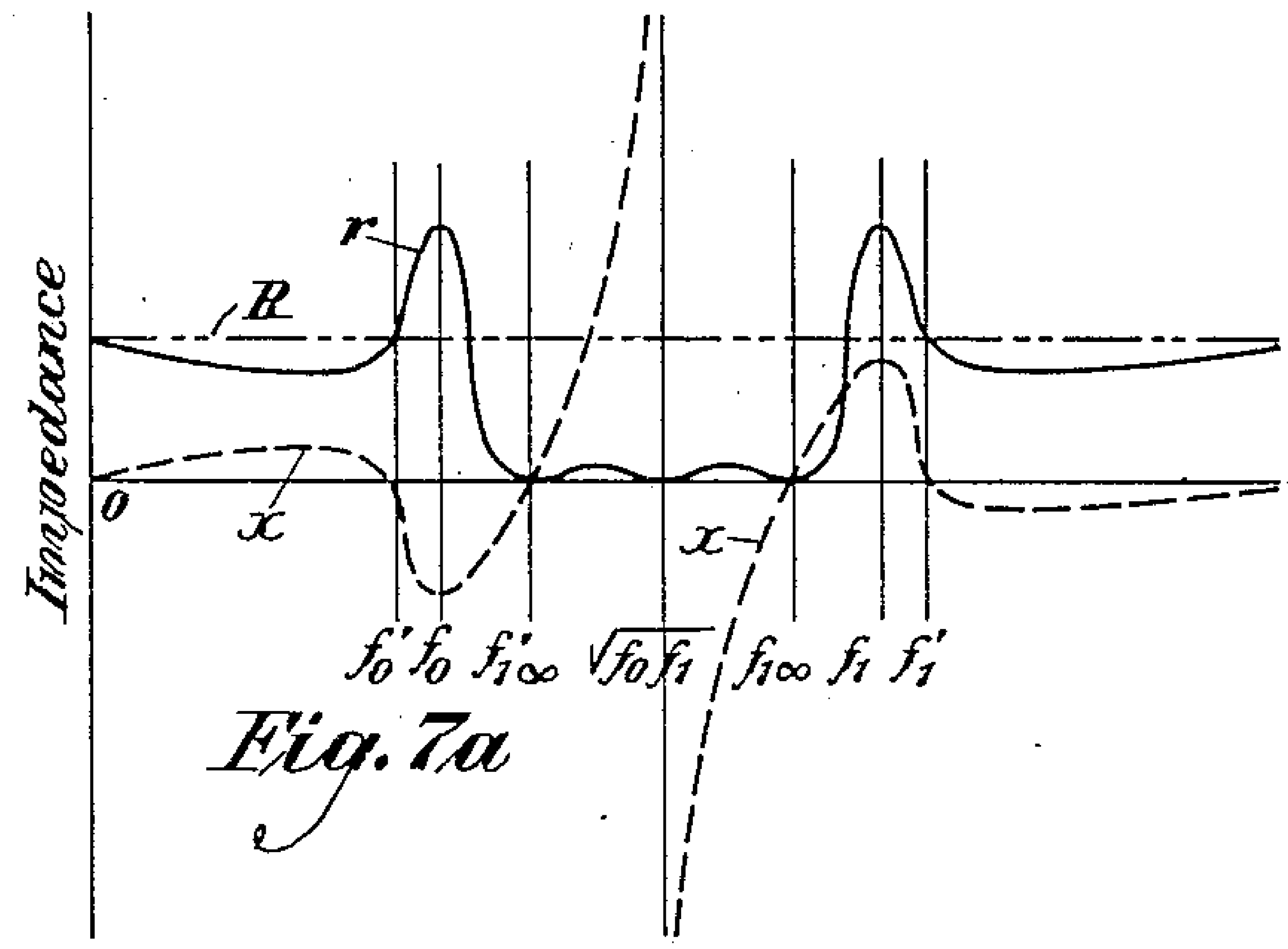


Fig. 7a

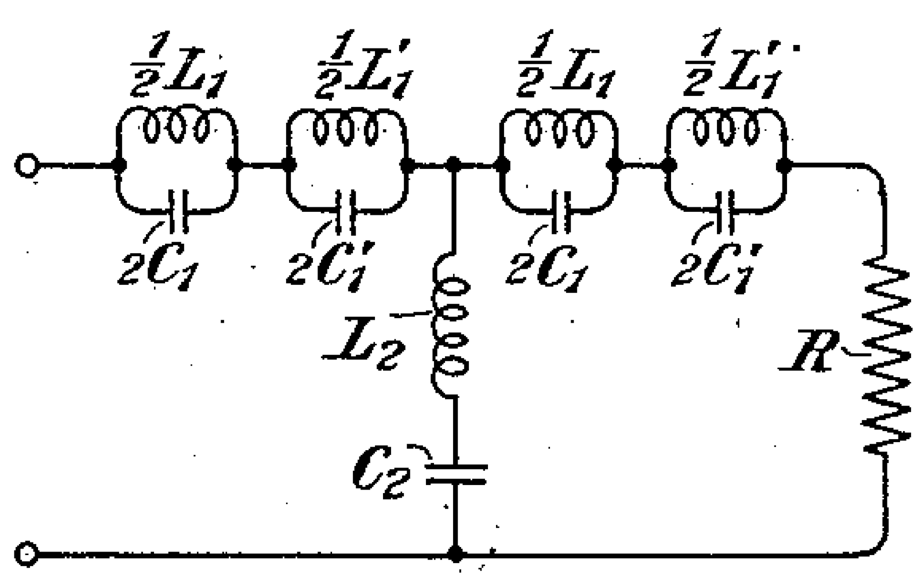


Fig. 8, Midseries Section, Type III_2, where m = .6

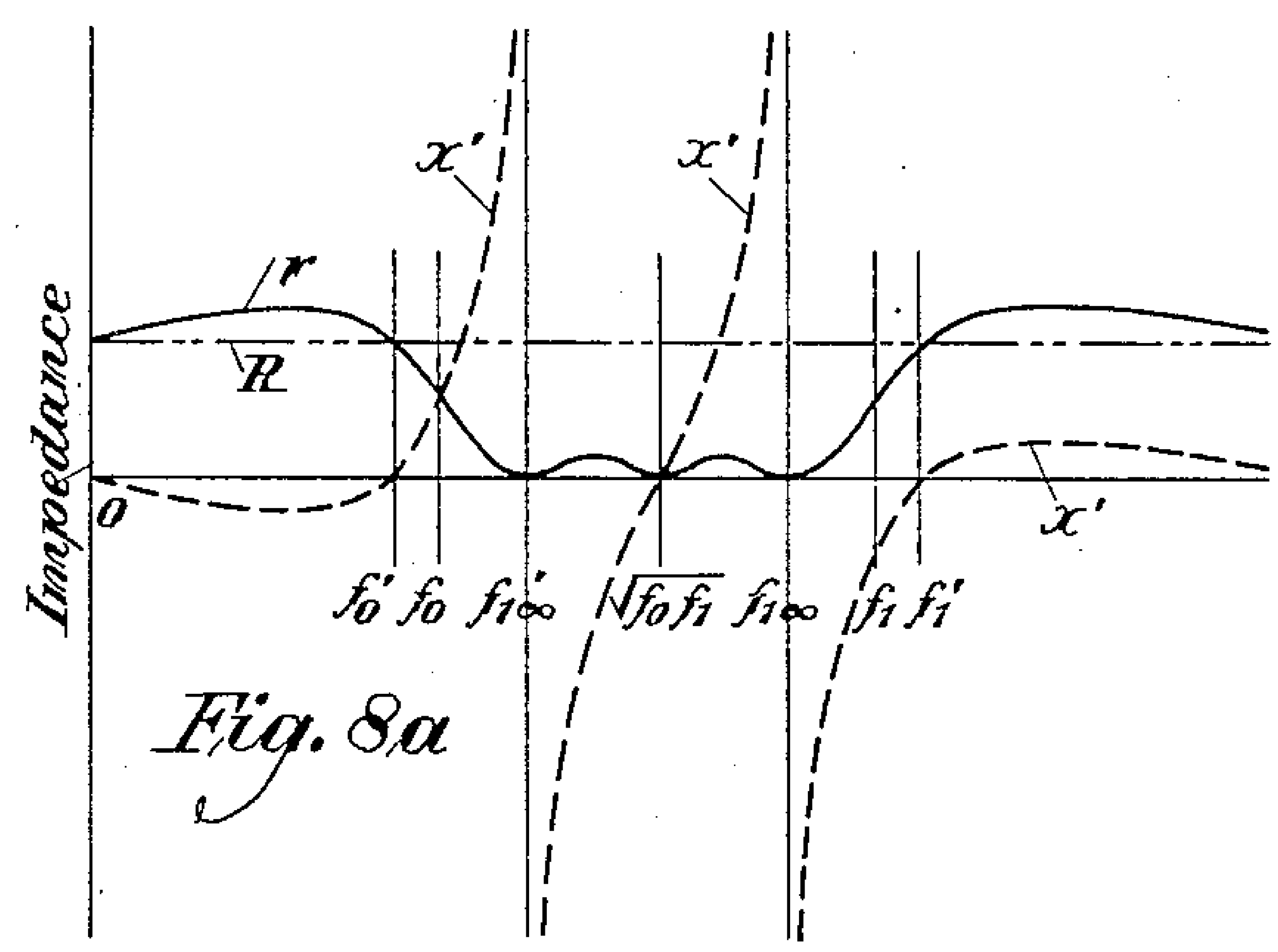
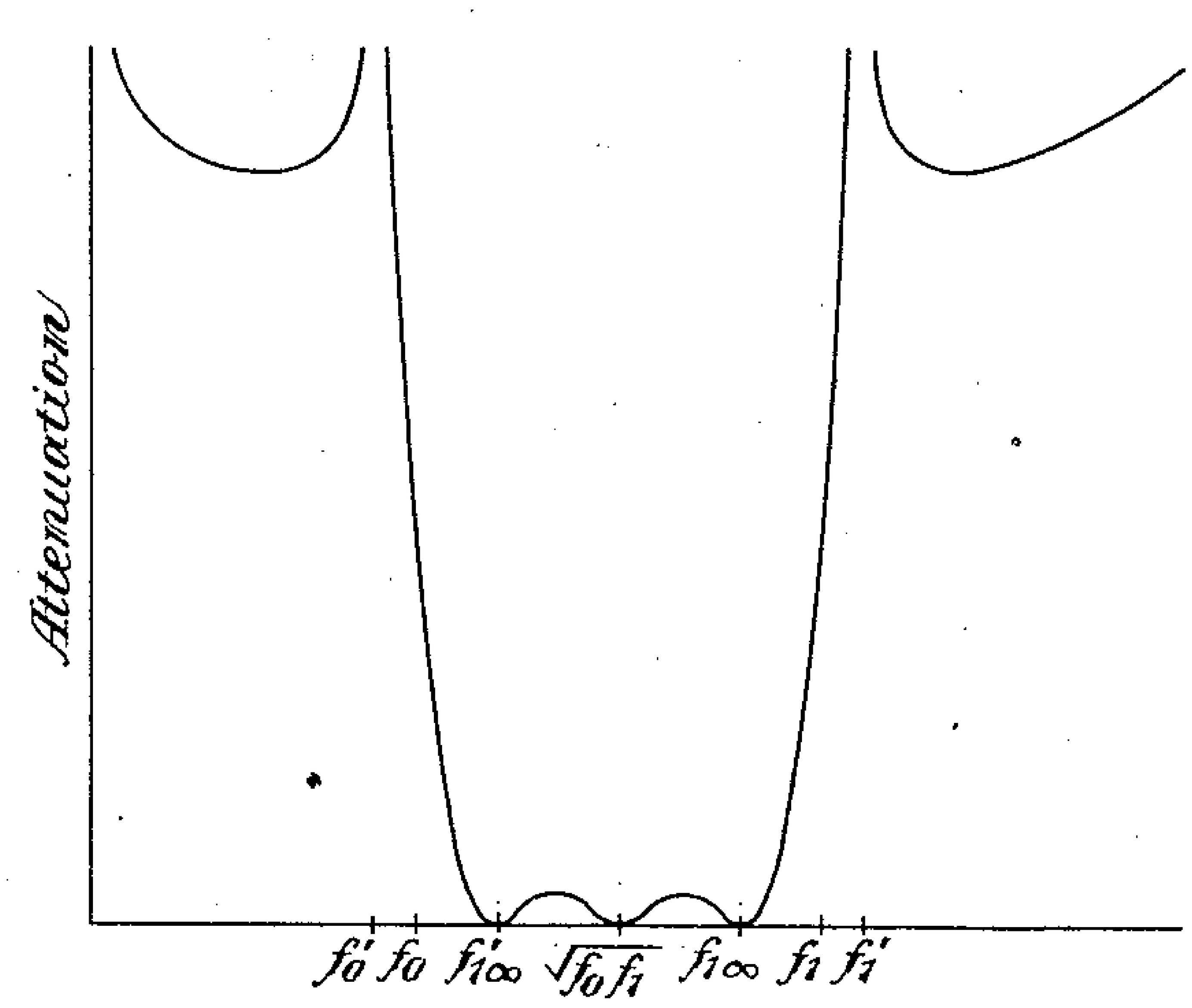


Fig. 8a

Fig. 9



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UNITED STATES PATENT OFFICE

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SELECTIVE CIRCUIT ARRANGEMENT

Application filed February 5, 1929. Serial No. 337,314.

This invention relates to selective circuits, and more particularly to selective circuit arrangements for suppressing a band of frequencies while passing frequencies outside the band, or for freely transmitting a band of frequencies while suppressing frequencies outside the band.

As is well known, filters of the Campbell type, which are made up of sections comprising series and shunt impedance elements, operate to discriminate between the band or bands of frequencies passed and the band or bands of frequencies suppressed by reason of the attenuation properties of the filter. These attenuation properties are such that within the band or bands of free transmission, the filter has little or no attenuation, but tends to suppress frequencies lying outside the band or bands of free transmission. The degree of selection depends upon the attenuation to which the frequencies outside of the free transmission range are subjected. The attenuation in the suppression range in turn depends upon the number of sections of the filter, the attenuation being greater as the number of sections increases.

In using a filter in the manner above described its selective functions do not depend upon the impedance looking into the filter, and the impedance is only of importance from the standpoint of connecting the filter in a circuit in such a way that reflection losses will not occur due to improper matching of the impedances of the filter of the circuit in which it is connected. In accordance with the present invention, however, a band selecting action is obtained by taking advantage of the fact that the impedance of the filter is different within its range of free transmission from the impedance without the range. This is accomplished by interconnecting two sections of the circuit in which the selective action is to take place through a hybrid coil or other balanced circuit arrangement with the filter connected on one side of the hybrid coil or other balancing arrangement and a suitable network or element connected on the other side to balance the impedance of the filter in the range over which suppression is to occur in the transmission circuit. With such an arrangement, if the impedance of the filter in a given range is balanced by a network whose impedance is the same, or substantially the same, over that range, while the impedances of the filter and balancing circuit are different for frequencies without the range, the two sections of the transmission circuit will be substantially conjugate over the range of frequencies for which a balance is obtained but will not be conjugate for frequencies outside the range. Consequently, a selective action will take place, which is due to the impedance characteristics of the filter and its balancing network.

With an arrangement such as above described, it will generally be true that where a band pass type of filter is employed, a suppression of the frequencies corresponding to this band will occur in the transmission circuit through the hybrid coil or balancing arrangement, while conversely, if a band suppression type of filter is employed, the band pass range of the transmission will substantially coincide with the band suppression range of the filter. In general, the sharpness of the selection and the relative amount of discrimination as between frequencies passed and frequencies suppressed will not require a large number of filter sections, since the discrimination depends upon the impedance balance between the filter and its balancing circuit at various frequencies.

The invention may be obviously embodied in a wide variety of forms. For example, in some cases, a filter on one side of the hybrid coil may be balanced by a network consisting of pure resistance on the other side and a sufficient degree of balance and suppression obtained. In other instances, a filter of one type will be connected on one side of the hybrid coil and it may be balanced by means of a filter of another type on the other side of the hybrid coil, the two filters being of such character that their impedances will be substantially the same within a certain range where suppression is to occur, but will be quite different in the range where free transmission is to take place.

The arrangement of the present invention has the advantage that if the filter circuit be opened or short-circuited, the selective effect of the filter is eliminated from the transmission circuit without opening the transmission circuit itself. Furthermore, the filter may be effectively removed from the transmission circuit in this manner by the use of a single contact. The circuit arrangement also enables a filter network, which normally functions as a band pass filter, to function as a band suppression filter, and vice versa.

The invention will now be more fully understood from the following description, when read in connection with the accompanying drawings, in which Figure 1 is a circuit diagram of one embodiment of the invention; Figs. 2 and 3 are curves illustrating the operation of the circuit of Fig. 1; Figs. 4 and 5 are diagrams of filter circuits which may be employed in connection with the circuit arrangement of Fig. 1; Figs. 4*a* and 5*a* are impedance curves for the filters of Figs. 4 and 5, respectively; Fig. 6 is a curve showing the attenuation characteristics of the selective circuit when filters of the type of Figs. 4 and 5 are employed; Figs. 7 and 8 are circuit diagrams of still further types of filter circuits which may be employed in connection with the circuit of Fig. 1; Figs. 7*a* and 8*a* are impedance curves for the filters of Figs. 7 and 8, respectively, and Fig. 9 is a curve showing the attenuation characteristics of the selective circuit when employing filters of the types of Figs. 7 and 8.

Referring to Fig. 1, TL and TL′ designate sections of a transmission circuit which are interconnected for transmission through a hybrid coil 10, the circuit TL being connected to the midpoints of the hybrid coil so that when a balance is obtained between terminals 11—12 and 13—14 of the hybrid coil at any frequency, the circuit TL will be conjugate with respect to the circuit TL′, thereby substantially preventing transmission between the two sections of the circuit at such frequencies as the condition of balance obtains.

Terminals 13 and 14 are associated through a transformer 15 with a filter BF. The filter BF is a known type of filter comprising two dissimilar sections, the series element of each section comprising an inductance and capacity in series resonant relation, and the shunt element in the one case comprising an inductance, and, in the other case, a capacity. The right-hand section, which is of the type having a shunt inductance, terminates in mid series, that is, the series resonant element comprising the inductance and capacity has one-half the value of the full series element of a normal section. The left-hand section, which includes the shunt capacity element, terminates in an eight-tenth series section, and the distant end of the filter is closed through a resistance R.

The opposite terminals 11 and 12 of the hybrid coil are connected through a transformer 16 with a balancing network which, in the case of the filter disclosed, may be a simple resistance R′ equal in value to the terminating resistance R of the filter. By means of a switch 21, a short-circuit may be established across the input terminals 19 and 20 of the filter BF to effectively remove the filter from the circuit and unbalance the hybrid coil 12 so that transmission may take place from TL to TL′ freely. The same result may be obtained by opening the circuit of the filter BF through switch 22. In either case, the effective elimination of the band filter BF from the circuit takes place without opening or closing any contacts in the transmission circuit from TL to TL′, and the operation of a single contact only is necessary to remove the filter.

As is well known, a filter of the type BF may be designed so that a band of frequencies between its cut-off limits f_1 and f_2 may be transmitted from end to end through the filter without substantial attenuation, while frequencies outside of the cut-off limits will be attenuated in passing through the filter. The selective action resulting from transmission end to end through the filter depends upon its attenuation properties. Its use in the circuit of Fig. 1, however, depends upon the impedance characteristics of the filter as seen from the terminals 19—20.

The impedance characteristics of the filter are illustrated by the curves of Fig. 2, in which r is a curve showing the variation of the resistance component of the impedance with frequency, and the curve x shows the variation of the reactance component of the impedance with frequency. As will be noted, the resistance r is substantially negligible in the range outside the pass band of the filter which extends from frequency f_1 to frequency f_2. Within the range of the pass band, however, the resistance component is equal to the terminal resistance R near the middle of the band and gradually decreases towards zero as the limiting frequencies f_1 and f_2 are approached, due to the dissipation effect of the filter. The reactance, as shown by the curve x, is zero near the middle of the band and gradually becomes more and more negative as the frequency approaches zero, and more and more positive in value as the frequency approaches infinity. The curve R′ of Fig. 2 represents the constant resistance component of the impedance of the balancing element R′ of Fig. 1. Where the balancing element is a pure resistance, as illustrated in Fig. 1, it will, of course, have no reactance component.

It will be obvious from a consideration of the curves of Fig. 2 that near the middle of the band where the reactance component x is zero and the resistance component r is equal to the resistance R′, the condition for perfect balance will obtain and substantially infinite attenuation occurs at this frequency, as is indicated by the curve of Fig. 3. As the frequency approaches the limiting frequencies f_1 and f_2, however, the unbalance between the resistance components on each side of the hybrid coil increases and the unbalance is further increased by the reactance component of the filter BF, with the result that the attenuation, as shown by the curve of Fig. 3, drops very rapidly, so that it approches a minimum at the limiting frequencies f_1 and f_2. At zero frequency and at infinite frequency, a condition of complete unbalance occurs because at these frequencies the resistance component r of the filter is zero as compared with the finite resistance R′ of the balancing circuit. At the same time, the reactance of the filter element is infinite at zero frequency and at infinite frequency. The result is that for transmission from TL to TL′ there is practically complete suppression of the band of frequencies near the middle of the pass band of the filter which lies between the frequencies f_1 and f_2. The suppression band resulting from the use of the filter in this manner is, in this instance, narrower than the pass band of free transmission of the filter when used normally, due to the fact that the resistance curve r is rounded off near the limiting frequencies of the band, and a substantial amount of reactance is also present near the edges of the band, resulting in a considerable degree of unbalance before the limiting frequencies f_1 and f_2 are reached.

A somewhat better and more sharply defined suppression band characteristic may be obtained by substituting for the filter BF in Fig. 1 a band filter section of the type BF_1 of Fig. 4 and by substituting for the balancing resistance R′ a band filter section of the type illustrated at BF_1' of Fig. 5. In this case, the terminals 19 and 20 of the filter BF_1 will be connected to terminals 19 and 20 of Fig. 1, while the terminals 17 and 18 of the filter BF_1' will be connected to the terminals 17 and 18 of Fig. 1. It will, of course, be obvious that the two filters BF_1 and BF_1' may be interchanged in Fig. 1 without changing the result. The filter BF_1 comprises a single section of the IV_1 type illustrated on page 41 of an article entitled "Theory and design of uniform and composite electric wave-filters" by Otto J. Zobel, published in the Bell System Technical Journal for January 1923, beginning at page 1 of Volume II, No. 1. This filter is of the band pass type, and, as herein used, terminates in mid-shunt section.

In order to understand what is meant by the expression "mid shunt termination," it should be noted that the inductance and capacities of the series and shunt elements of filter BF_1 are given the same designations as in the aforementioned article by Zobel. If we compare the filter section of Fig. 4 with the filter section shown at IV_1 on page 41 of the Zobel article, it will be seen that the series element in Fig. 4 has the same values as the series element in the Zobel filter. Now each shunt resonant element in the Zobel filter, such as, for example, L_2—C_2, may be considered as being made up of two parallel elements having twice the impedance of the single shunt resonant element, or, in other words, of two shunt resonant elements each having inductance $2L_2$ and capacity

$$1\Big/\frac{C_2}{2}$$

So also, the other shunt resonant element comprising inductance L_2' and capacity C_2' may be considered as being made up of two parallel shunt resonant circuits each having inductance $2L_2'$ and capacity

$$1\Big/\frac{C_2'}{2}$$

If, now, one-half of each of the shunt resonant circuits of the Zobel filter section as thus constituted is eliminated, the filter section is terminated in a mid shunt section. If, further, the eliminated half shunt impedances are connected on the opposite side of the series element, we have the arrangement shown in Fig. 4 of this application, with the filter section terminated at both ends in mid shunt. In other words, the filter BF′ of Fig. 4 is a complete filter section equivalent in all respects to the filter IV_1 of the Zobel article, differing only in the fact that the shunt impedance element of the filter is divided into two portions and arranged one at either side of the series element. A pure resistance R will be connected across the distant end of the filter section BF_1 as shown.

The variation of the resistance and reactance components of the impedance of the filter section BF_1, as seen from the terminals 19—20, are shown in Fig. 4*a*. In this figure, the curve r is the variation of the resistance component of the filter with frequency, while the curve x is the variation of the reactance component with frequency. The straight-line curve R represents the constant value of the terminating resistance R of the filter for all frequencies.

The filter section at Fig. 5 is of the type IV_2 shown on page 41 of the Zobel article above mentioned. The filter section of Fig. 5 is terminated in mid series. In other words, if the series element of the filter section on page 41 of the Zobel article be divided into two halves, arranged in series with each other and one on either side of the shunt element, we will have a complete filter section terminated at each end in mid series, as illustrated in Fig. 5. If now, the filter section of Fig. 5 be terminated by a resistance R at its far end, the impedance looking into the terminals 17—18 will be as illustrated in Fig. 5*a*. In this figure, the curve r' represents the variation of the resistance component of the impedance with frequency, and the dotted line curve x' the variation of the reactance component with frequency, the straight-line curve R, as before, representing the constant value of the terminating resistance R of Fig. 5.

Let us now compare the impedance of the filter section of Fig. 4, as shown in Fig. 4*a*, with the impedance of the filter section of Fig. 5 as shown in Fig. 5*a*. The frequencies f_1 and f_2 may be taken as the limiting frequencies of the bands of free transmission, while the frequencies $f_{1\infty}$ and $f_{2\infty}$ are the frequencies on either side of the band of free transmission at which the attenuation is infinite. If we examine the resistance component of the impedance of the filter of Fig. 4, it will be seen that it closely approximates the value of the terminating impedance R within the band represented by the limiting frequencies f_1 and f_2, and is approximately zero outside the band of free transmission. The resistance is actually zero at frequencies O, $f_{1\infty}$, $f_{2\infty}$, and at infinite frequency. Near the middle of the band at frequency

$$\sqrt{f_1 f_2}$$

the resistance component is just equal to the terminating resistance R, rising suddenly at the limiting frequencies f_1 and f_2 to a value somewhat greater than R. At frequencies f_1' and f_2' within the band and near the limiting frequencies, the resistance component of the impedance is just equal to the value of the terminating resistance, and between these two frequencies its value does not depart greatly from that of the terminating resistance.

The reactance component x, on the other hand, is zero at frequencies f_1', f_2' and

$$\sqrt{f_1 f_2}$$

and does not depart greatly from zero between frequencies f_1' and f_2'. It is also zero at frequency $f_{1\infty}$ and $f_{2\infty}$, but approaches an infinite value as the frequency decreases below $f_{1\infty}$ while approaching a positive infinite value as the frequency increases above $f_{2\infty}$.

If we now examine the components of the impedance of the filter section of Fig. 5 as shown in Fig. 5*a*, we find that at frequencies f_1',

$$\sqrt{f_1 f_2}$$

and f_2', the resistance component is just equal to the value of the terminating resistance R of the filter, and that it does not depart greatly from the value of R in this range. The resistance component drops off to zero at frequencies $f_{1\infty}$ and $f_{2\infty}$, and it is also zero at zero frequency and at infinite frequency. The reactance, on the other hand, is zero at zero frequency gradually rises to an infinite positive value at $f_{1\infty}$, and gradually decreases from an infinite negative value to zero as frequency f_1' is approached. At frequencies f_1',

$$\sqrt{f_1 f_2}$$

and f_2', the reactance is zero, rising to a positive infinitive value at frequency $f_{2\infty}$, again approaching zero from an infinite negative value as the frequency increases from f to infinity.

If now, the filter sections of Fig. 4 and Fig. 5 be connected on opposite sides of the hybrid coil, as previously described, the attenuation for transmission from TL to TL′ of Fig. 1 may be determined by comparing the impedance curves of Fig. 4*a* and Fig. 5*a*. Thus it will be seen that at frequencies f_1',

$$\sqrt{f_1 f_2}$$

and f_2', the resistance components of both filter sections are equal to the value of the terminating resistance R and the reactance components in both cases are zero, so that at these frequencies a perfect balance is obtained and infinite attenuation results in transmission from TL to TL′. At zero frequency, the resistance components are both equal and have zero value, but a complete condition of unbalance exists by reason of the fact that the reactance component is, in the case of the filter of Fig. 5, zero, while it is infinitely negative in the case of the filter of Fig. 4. At zero frequency, therefore, a condition of no attenuation would exist for transmission from TL to TL′. The same holds true for frequencies $f_{1\infty}$ and $f_{2\infty}$, for at these frequencies, while the resistance components are equal to each other since they are both zero, the reactance component of the filter section of Fig. 4 is zero, while that of the filter section of Fig. 5 is infinite, so that a complete unbalance exists. So also, at infinite frequency, a condition of complete unbalance exists notwithstanding the fact that both resistance components have zero value, the unbalance being due to the fact that the reactance component in the one case is zero, and in the other case is infinite.

The complete curve showing the variation of attenuation with frequency for transmission from TL to TL′, using the filter sections of Fig. 4 and Fig. 5, is illustrated in Fig. 6. It will be seen from this curve that the band pass filters of Figs. 4 and 5, when connected in a balanced circuit, give a band suppression characteristic having very sharp cut-off as the cut-off frequencies f_1 and f_2 are approached, the attenuation being very small in the region on either side of the suppressed band, and being infinite at three points within the suppressed band while being very large at all other points within the band between the frequencies f_1' and f_2'.

If desired, a band suppression effect may be obtained by balancing a network of the type shown in Fig. 4 or Fig. 5 by means of the pure resistance such as R′ of Fig. 1 having a value equal to the terminating resistance R of the network. For example, consider the network of Fig. 5 and its impedance characteristics as shown in Fig. 5a. The balancing resistance R′ would then have an impedance such as indicated by the straight-line curve R of Fig. 5a. Comparing this impedance with the impedance curves r' and x', it is evident that there would be an exact balance at frequencies f_1', $\sqrt{f_1 f_2}$ and f_2'. It is also evident that in the range from zero to f_1' and from f_2' to infinity, the reactance would be unbalanced. Likewise, the resistance components would be unbalanced in the ranges outside of the cut-off frequencies of the filter. The result is that for transmission from TL to TL′ the attenuation frequency curve would be of substantially the same shape as that indicated by Fig. 6.

A band pass characteristic for the circuit TL—TL′ may be obtained by connecting band suppression filters of the types shown in Fig. 7 and Fig. 8, one on either side of the hybrid coil. The filter section of Fig. 7 is of the type III_1 shown on page 40 of the Zobel article above referred to, the filter section in this case being terminated on each side in the mid shunt section with a resistance R connected across its distant termination. Likewise the filter section of Fig. 8 is of the type III_2 on page 40 of the aforesaid Zobel article, this filter section being terminated at each side in mid series with a resistance R connected across its distant termination.

The impedance components of the two filter sections are shown in Figs. 7a and 8a, respectively. Comparing the curves of these two figures, it will be seen that at frequencies $f_1'{}_\infty$, $\sqrt{f_0 f_1}$ and $f_{1\infty}$, all of which lie within the suppression band common to the two filters, the resistance components are both equal to each other and equal to zero, but the reactance components at each of these frequencies is zero in the one case and infinity in the other, so that a condition of complete unbalance exists, and the attenuation from circuit TL to circuit TL′ is zero. At frequencies f_0' and f_1', lying just outside the limiting frequencies f_0 and f_1 of the suppression band of the two filters, the resistance components in both cases are equal to the value of the terminating resistance R, and the reactance components in both cases are zero, so that perfect balance results and the attenuation from circuit TL to circuit TL′ is infinite. The same condition occurs at zero frequency and at infinite frequency.

The complete attenuation frequency characteristic is indicated by the curve of Fig. 9. From this curve, it will be seen that within the suppression band of the two filters (which lies between frequencies f_0 and f_1) a condition of substantially zero attenuation exists for transmission from circuit TL to circuit TL′, while in the frequency ranges on either side of the limiting frequencies f_0 and f_1 a suppression range occurs, each suppression range being bounded by points where the suppression is infinite with a range of very large attenuation between the points of infinite attenuation. It becomes apparent, therefore, that band suppression filters, when connected in a balanced circuit as above outlined, act to produce a band pass effect so far as transmission from circuit TL to circuit TL′ is concerned.

As in the case of Figs. 4 and 5, filters of the type of those shown in Figs. 7 and 8 may be balanced by a pure resistance R′ having a value equal to the terminating impedance R of the filter. For example, the filter of Fig. 8, when balanced by a pure resistance, would give accurate balance at frequencies O and f_0' and a fair degree of balance at intervening frequencies. Accurate balance would also occur at frequency f_1' and at infinite frequency with a fair degree of balance in the intervening range. In the suppression range of a filter, the reactance component, as indicated in Fig. 8a, would not be balanced, while the resistance component of the filter would either be very small or actually zero as compared with the finite resistance R of the balancing element. The result is that the attenuation frequency curve for transmission from TL to TL′, or vice versa, would be similar in form to that shown in Fig. 9.

It will be obvious that when the filters of Figs. 4 and 5 are connected on opposite sides of the hybrid coil, and also when the filters of Figs. 7 and 8 are connected on opposite sides of the hybrid coil, a condition of complete unbalance may be brought about at all frequencies by short-circuiting the input terminals of the one filter and open-circuiting the other filter, so that free transmission takes place at all frequencies from TL to TL′. Likewise, a condition of perfect balance at all frequencies may be brought about by short-circuiting the input terminals of both filters or by open-circuiting both filters, in which case transmission from TL to TL′ will be prevented at all frequencies.

It will also be obvious that various other types of filters and corresponding balancing networks may be employed in connection with the hybrid coil arrangement to produce other types of band suppression and band transmission effects, and that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated without departing from the spirit of the invention, as defined in the following claims.

What is claimed is:

1. In a selective system a balancing element having four connecting points so arranged that when two of said points are balanced no transmission takes place between the other two, a transmission circuit having two sections associated with said last two points, a network associated with one of the balancing points of said balancing element, said network having substantially uniform impedance in one range of frequencies and a materially different impedance outside said range, and an impedance device associated with the other balancing point of said balancing element in balancing relation to said network, said impedance device having substantially the same impedance as said network in said first mentioned range of frequencies and a different impedance outside said range, whereby said balancing element is balanced to prevent transmission of said first mentioned range of frequencies over said transmission circuit, but is unbalanced to permit transmission of frequencies outside said range.

2. In a selective system a balancing element having four connecting points so arranged that when two of said points are balanced no transmission takes place between the other two, a transmission circuit having two sections associated with said last two points, a network associated with one of the balancing points of said balancing element, said network having substantially uniform impedance in one range of frequencies and a materially different impedance outside said range, and an impedance device associated with the other balancing point of said balancing element in balancing relation to said network, said impedance device having a substantially uniform impedance at all frequencies which is equal to the impedance of said network in said first mentioned range of frequencies, whereby said balancing element is balanced to prevent transmission of said first range of frequencies over said transmission circuit, but is unbalanced to permit transmission of frequencies outside said range.

3. In a selective system a balancing element having four connecting points so arranged that when two of said points are balanced no transmission takes place between the other two, a transmission circuit having two sections associated with said last two points, a network associated with one of the balancing points of said balancing element, said network having two frequency ranges in one of which its impedance is materially different from that of the other, an impedance device associated with the other balancing point of said balancing element in balancing relation to said network, the impedance of said device being substantially the same as that of said network over one frequency range but materially different in the other range, whereby said balancing element is balanced to prevent transmission of one range of frequencies over said transmission circuit and is unbalanced to permit transmission in the other range.

4. In a selective system a balancing element having four connecting points so arranged that when two of said points are balanced no transmission takes place between the other two, a transmission circuit having two sections associated with said last two points, a band filter associated with one of the balancing points of said balancing element and having an attenuating range and a range of free transmission, said filter having substantially uniform impedance in one range and a materially different impedance in the other range, and an impedance device associated with the other balancing point of said balancing element in balancing relation to said filter, said impedance device having substantially the same impedance as said filter in a range corresponding to one of the ranges of said filter and a different impedance outside said range, whereby said balancing element is balanced to prevent transmission of one of said frequency ranges over said transmission circuit, but is unbalanced to permit transmission of frequencies outside said range.

5. In a selective system a balancing element having four connecting points so arranged that when two of said points are balanced no transmission takes place between the other two, a transmission circuit having two sections associated with said last two points, a band filter associated with one of the balancing points of said balancing element and having an attenuating range and a range of free transmission, said filter having substantially uniform impedance in one range and a materially different impedance in the other range, and an impedance device associated with the other balancing point of said balancing element in balancing relation to said filter, said impedance device having a substantially uniform impedance at all frequencies which is equal to the impedance of said filter in one of its frequency ranges, whereby said balancing element is balanced to prevent transmission of one range of frequencies over said transmission circuit but is unbalanced to permit transmission of frequencies outside of said range.

6. In a selective system a balancing element having four connecting points so arranged that when two of said points are balanced no transmission takes place between

the other two, a transmission circuit having two sections associated with said last two points, a band filter associated with one of the balancing points of said balancing element and having an attenuating range and a range of free transmission, the impedance of said filter being materially different in the two ranges, an impedance device associated with the other balancing point of said balancing element in balancing relation to said filter, the impedance of said device being substantially the same as that of said filter over one frequency range but materially different in the other range, whereby said balancing element is balanced to prevent transmission of one range of frequencies over said transmission circuit but is unbalanced to permit transmission in the other range.

7. In a selective system, a hybrid coil having balancing points, a transmission circuit comprising two sections, one of which is associated with a winding of said coil and arranged to transmit through the coil to the other section which is associated with the midpoint of another winding of said coil, a network associated with one balancing point of said hybrid coil, said network having substantially uniform impedance in one range of frequencies and a materially different impedance outside said range, and an impedance device associated with another balancing point of said hybrid coil, said impedance device having substantially the same impedance as said network in said first mentioned range of frequencies and a different impedance outside said range, whereby said hybrid coil circuit is balanced to prevent transmission of said first mentioned range of frequencies from one of said transmission sections to the other, but is unbalanced to permit such transmission of frequencies outside said range.

8. In a selective system, a hybrid coil having balancing points, a transmission circuit comprising two sections, one of which is associated with the winding of said coil and arranged to transmit through the coil to the other section which is associated with the midpoint of another winding of said coil, a network associated with one balancing point of said hybrid coil, said network having substantially uniform impedance in one range of frequencies and a materially different impedance outside said range, and an impedance device associated with another balancing point of said hybrid coil, said impedance device having a substantially uniform impedance at all frequencies which is equal to the impedance of said network in said first mentioned range of frequencies, whereby said hybrid coil is balanced to prevent tranmission of said first range of frequencies from one of said transmission sections to the other, but is unbalanced to prevent transmission of such frequencies outside said range.

9. In a selective system, a hybrid coil having balancing points, a transmission circuit comprising two sections, one of which is associated with the winding of said coil and arranged to transmit through the coil to the other section which is associated with the midpoint of another winding of said coil, a network associated with one balancing point of said hybrid coil, said network having two frequency ranges in one of which its impedance is materially different from that of the other, an impedance device associated with another balancing point of said hybrid coil, the impedance of said device being substantially the same as that of said network over one frequency range but materially different in the other frequency range, whereby said hybrid coil is balanced to prevent transmission of one range of frequencies from one of said transmission sections through the hybrid coil to the other, but is unbalanced to permit such transmission in the other range.

10. In a selective system, a hybrid coil having balancing points, a transmission circuit comprising two sections, one of which is associated with the winding of said coil and arranged to transmit through the coil to the other section which is associated with the midpoint of another winding of said coil, a band filter associated with one balancing point of said hybrid coil and having an attenuating range and a range of free transmission, said filter having substantially uniform impedance in one of said ranges of frequencies and a materially different impedance in the other range, and an impedance device associated with another balancing point of said hybrid coil, said impedance device having substantially the same impedance as said filter in a range corresponding to one of the ranges of said filter and a different impedance in the other range, whereby said hybrid coil is balanced to prevent transmission of frequencies in one of said ranges from one of said transmission sections through the hybrid coil to the other, but is unbalanced to permit such transmission of frequencies in the other range.

11. In a selective system, a hybrid coil having balancing points, a transmission circuit comprising two sections, one of which is associated with the winding of said coil and arranged to transmit through the coil to the other section which is associated with the midpoint of another winding of said coil, a band filter associated with one balancing point of said hybrid coil and having an attenuating range and a range of free transmission, said filter having substantially uniform impedance in one of said ranges of frequencies and a materially different impedance in the other range, and an impedance device associated with another balancing point of said hybrid coil, said impedance device having substantially uniform imped-

ance at all frequencies which is equal to the impedance of said filter in one of its frequency ranges, whereby said hybrid coil is balanced to prevent transmission of one of said frequency ranges from one of said transmission sections through the hybrid coil to the other, but is unbalanced to permit such transmission of the other range of frequencies.

12. In a selective system, a hybrid coil having balancing points, a transmission circuit comprising two sections, one of which is associated with the winding of said coils and arranged to transmit through the coil to the other section which is associated with the midpoint of another winding of said coil, a band filter associated with one balancing point of said hybrid coil and having an attenuating range and a range of free transmission, said filter having an impedance in one of said ranges which is materially different from its impedance in the other range, an impedance device associated with another balancing point of said hybrid coil, the impedance of said device being substantially the same as that of said filter over a frequency range corresponding to one of the ranges of said filter, whereby said hybrid coil is balanced to prevent transmission of one range of frequencies from one of said transmission sections through the hybrid coil to the other, but is unbalanced to permit such transmission in the other range.

13. A selective system, a hybrid coil having two balancing points, a transmission circuit comprising two sections, one of which is associated with the winding of said coil and arranged to transmit through the coil to the other section which is associated with the midpoint of another winding of said coil, impedance elements associated with the balancing points of said hybrid coil and having such impedance relative to each other as to produce a substantial balance over one band of frequencies while being unbalanced for frequencies outside the band.

14. In a selective system, a hybrid coil having balancing points, a transmission circuit comprising two sections, one of which is associated with the winding of said coil and arranged to transmit through the coil to the other section which is associated with the midpoint of another winding of said coil, a network inductively connected to one balancing point of said hybrid coil, and an impedance device inductively connected to another balancing point of said hybrid coil, said network and said impedance device having such relative impedances as to produce a balance at frequencies within a band while being unbalanced for a range of frequencies lying outside the band.

15. In a selective system, a hybrid coil having balancing points, a transmission circuit comprising two sections, one of which is associated with the winding of said coil and arranged to transmit through the coil to the other section which is associated with the midpoint of another winding of said coil, a network inductively connected to one balancing point of said hybrid coil, an impedance device inductively connected to another balancing point of said hybrid coil, said network and said impedance device having such relative impedances as to produce a balance at frequencies within a band while being unbalanced for a range of frequencies lying outside the band, and means to effectively remove the impedance of said network from the circuit without interrupting transmission from one of said transmission sections through the hybrid coil to the other.

In testimony whereof, I have signed my name to this specification this 4th day of February, 1929.

JOSEPH HERMAN.