

Aug. 22. 1933.

W. T. LEWIS ET AL

1,923,155

RADIO RECEIVING SYSTEM

Filed May 5, 1930

3 Sheets-Sheet 1

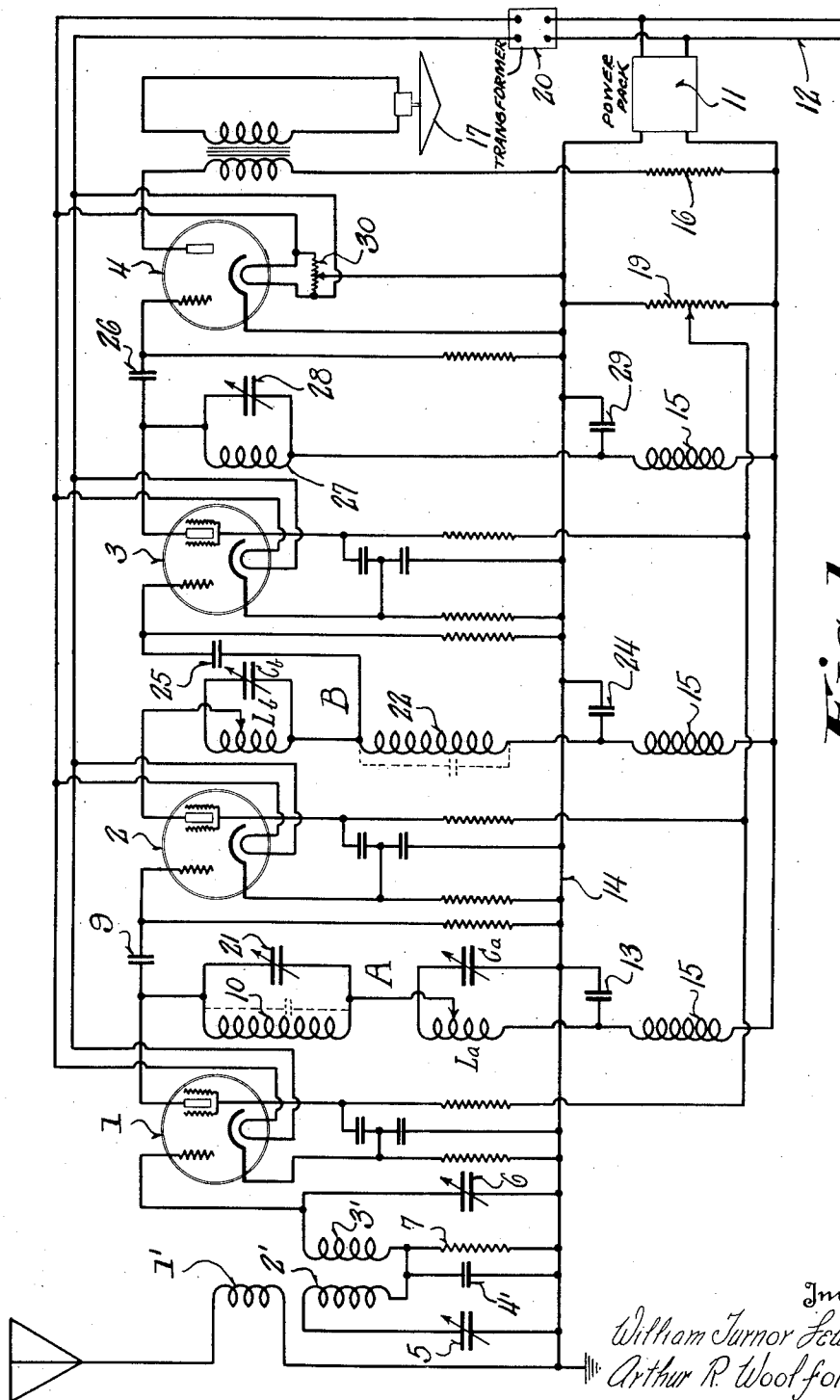


Fig. 1

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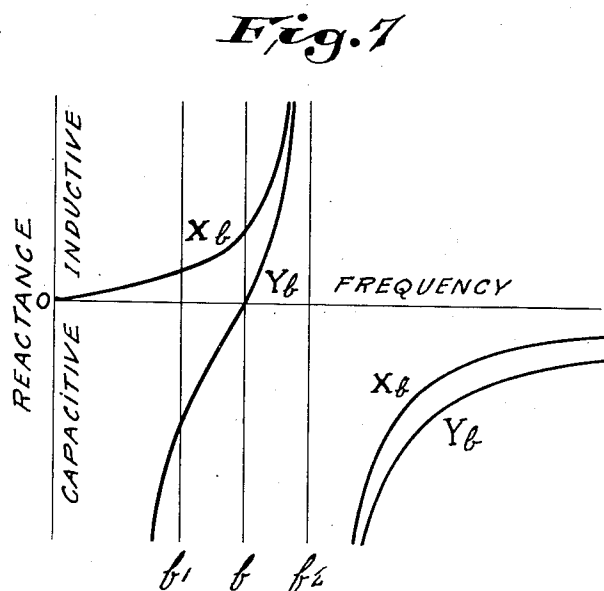
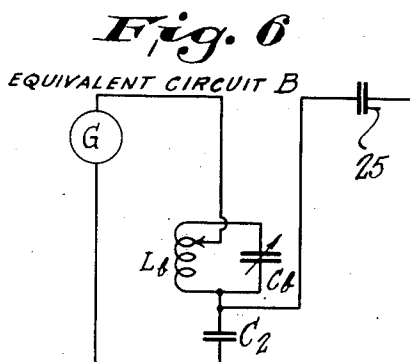
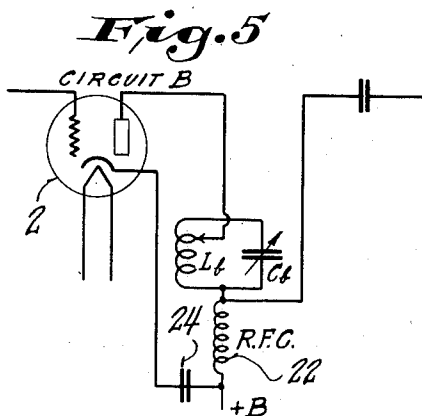
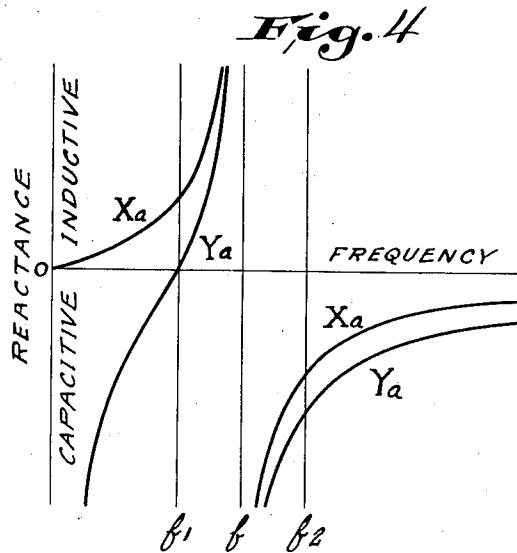
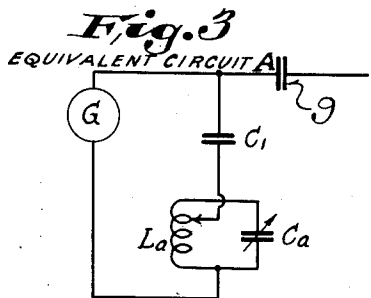
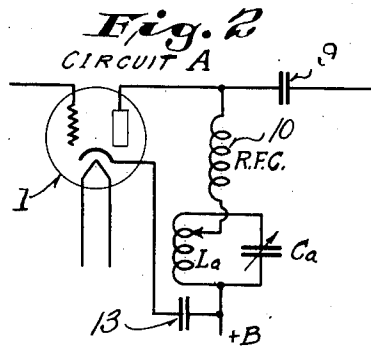
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3 Sheets-Sheet 2



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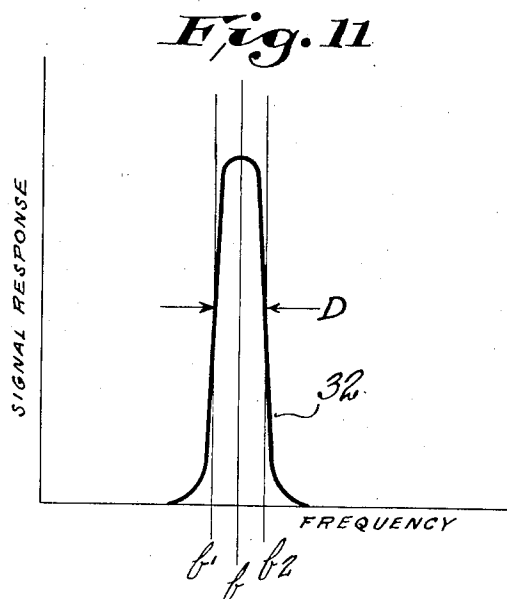
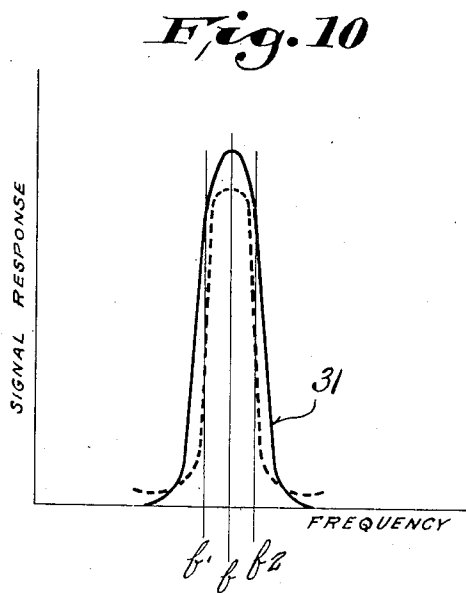
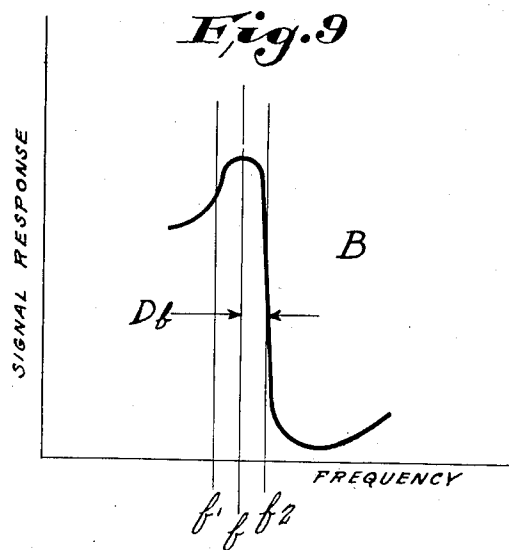
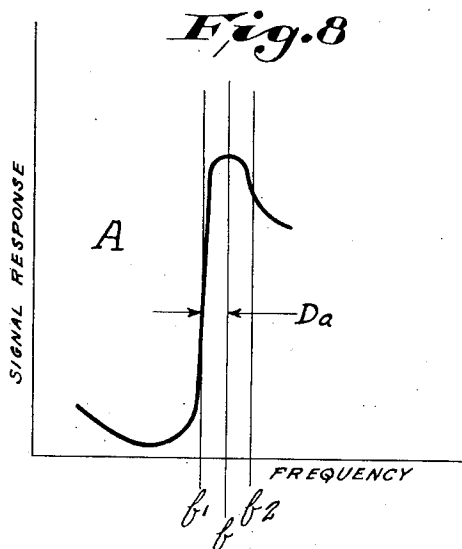
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3 Sheets-Sheet 3



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## UNITED STATES PATENT OFFICE

1,923,155

## RADIO RECEIVING SYSTEM

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8 Claims. (Cl. 178—44)

This invention relates to radio receiving systems.

In radio receiving systems it has been found that when the system is designed to be tuned very sharply, the quality of the music or voice reproduced by the system is defective. On the other hand, when the system is designed for broad tuning, the quality of the reproduction is improved, but other stations broadcasting or transmitting on frequencies near the selected frequency are brought in and disturb the reproduction.

This invention is designed to overcome the defects noted above, and objects of this invention are to provide a radio receiving system which will cut off or reject radio frequency energy close to that for which the system is tuned, but which will not injure the tone quality of the reproduced speech or music, and which is so made that a certain width of upper and lower side bands are passed through the system and in which the width of either or both the upper and lower side bands may be selected or determined and made of any value desired.

It is to be noted that even with the old style of broad tuning this tuning is in reality peak tuning, and that although certain side bands are brought in, that the strength of the radio frequency energy amplification of the side bands gradually diminishes as the frequencies depart from the selected frequency, so that the tone quality suffers even with broad peak tuning. When it is considered that the quality of the reproduced tone is dependent upon the frequencies closely adjacent that of the carrier wave frequency, the above described result is immediately appreciated.

Further objects of this invention are to provide a radio receiving system in which the amplification of the radio frequency energy in the side bands above and below the radio frequency energy of the selected frequency is substantially the same as that of the selected frequency, although means are provided for making these side bands as wide or narrow as desired, so that the signal response curve plotted with frequency as abscissas and signal response as the ordinates will have substantially vertical front and rear faces and only a slightly rounding or nearly flat top, although, as stated, means are provided for making the distance between these substantially vertical front and rear faces as wide or as narrow as desired.

Although the exact principles underlying this invention may not be fully understood, it is believed that a brief outline of the principles which appear to be effective in securing the above outlined objects will aid in a clear understanding of this invention. It is to be noted at this point that actual tests in a radio laboratory of the ra-

dio receiving system constructed in accordance with this invention bear out the results outlined below.

It is well known that when a coil is in circuit with a condenser either in series or in parallel, that when the circuit is just above the parallel resonant frequency, the circuit has a very great inductive reactance. When a second circuit is connected to this coil and condenser, the enormous inductive reactance of the circuit must be balanced by the capacitive reactance of a condenser, or other capacity producing device, if series resonance is to be secured in the second circuit for a frequency close to that for which the first circuit is resonant. The condenser, or other capacity producing device, in the second circuit must be extremely small, if this result is obtained, and, due to the capacity of the leads, etc., it is difficult to bring this value down to a practical point. However, this invention discloses a method by means of which a capacity producing device having a practical value, when associated with the capacity of the leads, etc., may be used. A portion only of the coil in the first resonant circuit is used, and consequently the inductive reactance of the portion at slightly above resonant frequencies is less than the inductive reactance of the entire coil. Therefore, it is a simple matter to form a second circuit, using a portion only of the coil, which is resonant at a frequency very close to that of the first circuit; in fact, as close as desired, and either above or below the frequency of the first circuit.

Now if the first circuit is employed to pass on radio frequency energy of one frequency, and the second circuit is employed to reject radio frequency energy of a frequency close to that of the first circuit, it is clear that the difference between the frequency passed on through the system and the frequency rejected, can be made greater or lesser as desired.

It has been found that the actual tests follow precisely this theory and that the sharpness of cut-off can be made any value desired.

Consider first circuit A, which is parallel resonant for the desired frequency,  $f$ , and circuit A', which is series resonant for a frequency  $f_1$ , slightly less than  $f$ . Consequently radio frequency energy of frequency  $f$  is passed along through the system and radio frequency energy of frequency  $f_1$  and lower frequencies particularly adjacent thereto is rejected, and the side band for lower frequencies can thus be made of any desired width.

Now if this system contained a somewhat similar pair of circuits B and B', the circuit B being series resonant for the desired frequency,  $f$ , and the circuit B' being parallel resonant for a frequency,  $f_2$ , slightly greater than  $f$ , it is clear that the circuit B could be used to pass

energy, of frequency  $f$ , through the system and the circuit B' could be used to reject energy of frequency  $f_2$  and higher frequencies, particularly adjacent thereto. Consequently, the width of the side band above the desired frequency, or the difference between  $f$  and  $f_2$  could be made as small as desired, and a very abrupt upper cut-off secured.

Therefore, by using these two pairs of circuits in the system, the total width of side bands, or differences between  $f_1$  and  $f_2$ , could be readily controlled and made as small as desired. In addition, if it is found desirable, the upper or the lower side band could be independently adjusted to any desired value.

In both pairs of circuits use is made of the fact that a circuit, including a coil, which is near resonance has an enormous inductive reactance, and only a portion of the coil in each case is used and is balanced by a condenser, or other device for producing condensive reactance, of practical size having a capacitive reactance suitable for balancing the inductive reactance of the selected portion of the coil with which it is associated. The balancing, or resonance of the circuit, occurs for one pair of circuits just below the selected or desired frequency, and for the other pair of circuits, just above the selected or desired frequency.

With this explanation, it is believed that the invention will be fully understood from the detailed description and from the accompanying drawings which show an embodiment of the invention. In the drawings:—

Figure 1 is a diagrammatic view showing the system.

Figure 2 is a fragmentary diagrammatic view showing the first rejector-selector portion of the system, such circuit being designated circuit A.

Figure 3 is a view showing the electrical equivalent of circuit A.

Figure 4 shows the reactance curves for the different portions of circuit A.

Figure 5 is a diagrammatic view showing the second rejector-selector portion of the system and designated circuit B.

Figure 6 is a diagrammatic view showing the electrical equipment of Figure B.

Figure 7 is a view showing the reactance curves for circuit B.

Figure 8 is a view showing the signal response—frequency curve for circuit A.

Figure 9 is a similar view showing the signal response—frequency curve for circuit B.

Figure 10 is a view showing the signal response—frequency curves for different portions of the system superimposed one upon the other.

Figure 11 is a view showing the signal response—frequency curve of the entire system.

Referring first to Figure 1, it will be seen that the radio receiving system has been illustrated as provided with three radio frequency amplifying tubes 1, 2 and 3, and a detector tube 4. It is to be distinctly understood that this showing is merely an illustration of the invention showing one embodiment thereof, and that any number of tubes may be employed, and that the detector tube may occupy a different position from that shown in the drawing. For example, it may replace the tube 3. In addition, more or less amplifying tubes may be employed, and obviously audio frequency amplifying tubes can be added and arranged in any suitable manner without departing from the spirit of the invention.

The tubes employed may be and preferably

are of the alternating current heater type cathode, although, obviously, other types of vacuum tubes could be employed. It is also preferable to employ screen grid tubes, which have been diagrammatically illustrated in Figure 1.

Means are provided for receiving the radio frequency energy and transmitting such energy to the grid of the first tube. Any suitable means may be employed. In the form shown, the antenna circuit includes the primary coil 1' coupled to the secondary coil 2'. The secondary coil 2' is electrically connected to a coil 3', the circuits including the coils 2' and 3' having a common portion provided with a fixed condenser 4'. Variable tuning condensers 5 and 6 are placed in the circuits of the coils 2' and 3' respectively, and preferably a high resistance grid leak 7 is connected as shown.

The tuning device chosen for illustration and connected to the first tube constitutes a band pass filter. However, it is to be understood that other tuning devices could be used, or that the tube 1 could be connected, without tuning, to the means for receiving radio frequency energy, and that any suitable means can be employed for receiving the radio frequency energy.

The plate of the tube 1 is connected through a blocking condenser 9 to the grid of the tube 2. It is also connected through a radio frequency choke coil 10 to the inductance coil  $L_a$  and to the source of plate supply such as the power pack 11, such power pack being supplied from the alternating current mains 12. Further, it is to be noted that the lower end of the coil  $L_a$  is connected through a relatively large fixed condenser 13 to the negative grounded bus bar 14, which is the main bus bar in the system. This bus bar, of course, may be the metal frame of the set, if the set is so formed as to lend itself to this construction. It is preferable, also, to connect the plate supply for each of the three amplifying tubes 1, 2 and 3 to the power pack through radio frequency chokes 15, as shown in Figure 1, and to connect the plate of the detector tube 4 through a suitable resistance 16 to provide the proper voltage, the plate of the detector tube being connected in any suitable manner, for instance, by means of a transformer to the dynamic or other type of speaker or translating device 17.

Further, it is to be noted that the auxiliary or screen grid of each of the tubes is provided with a suitable voltage by means of the potentiometer 19. The potentiometer 19 may be used as a volume control, if desired. The filaments of each of the several tubes may be supplied through a step down transformer 20. The coil  $L_a$  is connected in parallel to a variable tuning condenser  $C_a$ , the condenser 13 being in reality in this circuit. It is to be noted, however, that the lower end of the radio frequency choke 10 is connected intermediate the ends of the coil  $L_a$  for a purpose hereinafter to appear.

It is preferable to provide a small variable condenser 21 in parallel to the radio frequency choke coil 10, as shown in the drawings, so that, as the system is tuned for longer wave lengths the capacity furnished jointly by the choke coil 10 and the condenser 21 will slightly increase.

The plate of the tube 2 is connected intermediate the ends of a second inductance coil  $L_b$ , which is, in turn, connected in parallel with the tuning condenser  $C_b$ . The lower end of the

coil  $L_b$  is connected to the source of plate supply through the radio frequency choke coil 22. The lower end of the choke coil is connected to the source of plate supply through one of the choke coils 15, as indicated. A large, fixed by-passing condenser 24 is connected between the lower end of the choke coil 22 and the bus bar 14, and corresponds identically to the by-pass condenser 13 previously described.

The grid of the tube 3 is connected through a blocking condenser 25 to the lower end of the coil  $L_b$ .

The plate of the tube 3 is connected through a blocking condenser 26 to the grid of the detector tube 4, and is connected through a tuning device such as the coil 27 and the variable condenser 28, arranged in parallel, to the source of plate supply, preferably through one of the choke coils 15. A by-pass condenser 29 corresponding to the condensers 13 and 24 is placed between the bus bar 14 and the lower end of the coil 27.

The grid of the detector tube is connected through a suitable resistance to the cathode of such tube and to the bus bar 14 as shown. Preferably the center point of a resistance 30, bridged across the terminals of the heating filament for the tube 4, is connected to the bus bar 14.

It is to be distinctly understood that the several grids and cathodes and other elements of the tubes may be connected to the bus bar 14 by suitable fixed resistances to improve the characteristics of the receiving set, as shown in Figure 1, or in any similar manner, and may be provided with other by-pass condensers, as shown in Figure 1, or in a similar manner, without departing from the spirit of the invention. The specific connections through these means are not described in detail as they are clearly shown in the drawings, and primarily as they form no part of this invention.

From this brief outline of one form of circuit embodying the invention, it will be seen that a usual type of tuning device, such, for example, as the coil 27 and condenser 28, has been provided for one portion of the system, and that special forms of rejector-selector tuning circuits have been provided for other portions of the system, as will be developed in greater detail hereinafter.

The first rejector-selector circuit is indicated generally by the reference character A, and the second one by the reference character B in Figure 1. The circuit A is shown separate from the remainder of the system in Figure 2, and the circuit B is similarly shown in Figure 5.

It is preferable to have all of the variable condensers simultaneously tuned by a single tuning means, as has been diagrammatically indicated in Figure 1.

Referring to Figure 2, it will be seen that the choke coil 10 acts as a capacity for all radio frequencies in the broadcast range, or, in other words, for all radio frequencies above that for which the radio frequency choke coil is resonant. The same is true of the choke coil 22. In "equivalent circuit A" shown in Figure 3, the condenser effect of the choke coil 10 and that of the leads and by-pass condenser 13 have been indicated by means of a condenser  $C_1$ . Similarly, in Figure 6, the condenser effect of the choke coil 22, the leads, and the by-pass condenser 24 have been indicated by means of the condenser  $C_2$ . The purpose of giving these dia-

grammatic equivalent circuits is to simplify the analysis or action of these two rejector-selector circuits. In each of these equivalent circuit diagrams, the tubes may be considered as generators of radio frequency oscillations and have, accordingly, been indicated G in each equivalent circuit shown in Figures 3 and 6.

Consider Figure 3 and Figure 4. It is a well known fact that when a circuit including a coil and a condenser in parallel is approaching resonance, the reactance of the parallel circuit is enormous at a point very close to resonance, and that the reactance of the circuit is predominantly inductive when radio frequency energy of frequencies slightly less than resonance is supplied the circuit. At resonance the inductive reactance of the coil is precisely equal to the capacitive reactance of the condenser and for a parallel circuit the impedance of the circuit is theoretically infinite. Just before resonance is reached, the parallel circuit including the condenser and the inductance is, as a whole, highly inductively reactive. Just after resonance has been passed, the parallel circuit, including the coil and condenser, has a high capacitive reactance. This state of affairs is indicated by the curve  $X_a$  in Figure 4.

If a second circuit, for example that including the tube or generator of oscillations G and the choke coil which acts in the capacity of a condenser  $C_1$ , is connected to the parallel circuit consisting of inductance  $L_a$  and condenser  $C_a$ , it is apparent that the reactance curve will be indicated by that shown at  $Y_a$  in Figure 4. In view of the fact that the reactance curve  $Y_a$  should pass through its zero point for a frequency  $f_1$  closely adjacent the selected frequency  $f$ , it is clear that only a portion of the highly inductively reactive coil  $L_a$  should be used. This is what is actually done in this invention, and the connections are shown in Figures 1, 2 and 3. These connections may be variable, as indicated, or may be fixed, so as to determine the exact point at which the reactance  $Y_a$  of the entire circuit A, see Figure 3, will be zero. Obviously, at the point where the reactance of the entire circuit A is zero, the radio frequency energy corresponding to this frequency will be rejected or passed to the bus bar 14 in Figure 1. However, this point is represented as corresponding to a frequency  $f_1$  in Figure 4 and corresponds to the point at which the reactance curve  $Y_a$  crosses the zero line. This, obviously, is the cut-off frequency for the first rejector-selector circuit A. Immediately after this frequency  $f_1$  is passed and the selected frequency  $f$  is arrived at, parallel resonance obtains for the coil or inductance  $L_a$  and the condenser  $C_a$ , and consequently this parallel circuit has theoretically infinite impedance. Consequently, signals are passed through the blocking condenser 9 to the next tube. The reactance curves for the parallel circuit,  $L_a-C_a$ , are indicated at  $X_a$  in Figure 4.

Immediately after the frequency  $f$  has been passed, the parallel circuit,  $C_a-L_a$ , has a high capacitive reactance and consequently the entire rejector-selector circuit A has a high capacitive reactance, as indicated by the right hand branch of the curve  $Y_a$  in Figure 4.

It is clear that the signal response—frequency curve for the circuit A is as indicated in Figure 8, and such has been the actual curve obtained by tests in a radio testing laboratory.

Referring to Figure 8, it will be seen that at the

frequency  $f_1$  there is a complete cut-off and that at frequency  $f$  the signal response is a maximum. After the frequency  $f$  has been passed, the signal strength drops off slightly and thereafter remains at a somewhat high level, but less than that of the maximum point corresponding to the frequency  $f$ . Consequently the width of the lower side band indicated at  $D_a$  in Figure 8 can be accurately controlled by selecting the point of the coil  $L_a$ , see Figures 2 and 3, at which the lower end of the radio frequency choke coil 10 is connected.

The analysis for circuit B will now be given. In the equivalent circuit B it is apparent that the reactance curves  $X_b$  and  $Y_b$ , as shown in Figure 7, will be of the same form as the reactance curves  $X_a$  and  $Y_a$  shown in Figure 4 for circuit A. However, the coil  $L_b$  is so made that it has slightly less inductance than the coil  $L_a$  and consequently the point at which the curve  $Y_b$  crosses the zero line (frequency axis) will be shifted slightly to the right. The design of this circuit and the point at which the coil  $L_b$  is tapped intermediate its ends is so arranged that the reactance curve  $Y_b$  crosses the zero line at the selected frequency  $f$ . Also, parallel resonance for the circuit,  $C_b-L_b$ , occurs for the higher frequency  $f_2$  as shown in Figure 7.

In view of the fact that the grid of the succeeding tube is connected through the blocking condenser 25 at a point between the lower end of the coil  $L_b$  and the radio frequency choke coil 22, see Figure 5, it is apparent that when the entire circuit B is series resonant, that signals will be transmitted at maximum strength to the succeeding tube, for the potential difference between the ends of the coil  $L_b$  and the potential difference between the ends of condenser  $C_2$  will be a maximum at this instant. However, when the circuit,  $L_b-C_b$  is parallel resonant, signals are rejected or blocked, as this circuit then offers infinite impedance to the radio frequency energy. It is clear that the point at which the reactance curve  $Y_b$  crosses the zero line can be accurately determined by the point at which the coil  $L_b$  is tapped intermediate its ends. Consequently the width of the upper side band indicated at  $D_b$  in Figure 9 can be accurately predetermined or controlled.

The signal response—frequency curve shown in Figure 9 is like that shown in Figure 8, except that it is reversed, as is obvious from an examination of Figures 6 and 7. It is clear that as resonance is approached for the entire circuit B, that the signal response—frequency curve rises, and the circuit is so designed that it rises for the frequency  $f_1$ . Thereafter the maximum is reached for the frequency  $f$ , which corresponds to the frequency at which the curve  $Y_b$  crosses the zero line. However, when parallel resonance for the circuit  $L_b-C_b$ , which is shown by the reactance curve  $X_b$  in Figure 7, is reached, it is clear that a complete cut-off of the signal transmission to the next tube is effected. This corresponds to the frequency  $f_2$ , as shown in both Figures 7 and 9, and consequently there is an abrupt cut-off for this frequency and for all higher frequencies, the curve slightly rising, however, for frequencies considerably higher, as indicated in Figure 9. It is apparent that the width of the upper side band  $D_b$  can be accurately predetermined or controlled by the point at which the coil  $L_b$  is tapped intermediate its ends.

It is believed that with the following state-

ment the entire operation of these rejector-selector circuits A and B will be fully understood. The coils  $L_a$  and  $L_b$  in these two circuits have an enormous reactance at frequencies closely adjacent resonant frequency. However, the effect of the entire coil need not be used for the complete circuits A and B, but only a fraction of the entire effect need be used. This result is obtained by using only a portion of each of these coils in the entire circuits A and B by tapping the coils at points intermediate their ends. Consequently the width of either the upper or the lower side band can be independently controlled or predetermined and consequently the total width, as indicated at  $D$  in Figure 11, for the side bands can be controlled or predetermined and made as narrow or as broad as desired. As an example, where broadcast spacing is ten kilocycles, the spacing of the side bands at which cut-off occurs, that is to say the spacing between the frequencies  $f_1$  and  $f_2$ , should be approximately ten kilocycles or of some value a trifle less than this.

To prevent disturbance from the rising portions of the signal response—frequency curves shown in Figures 8 and 9, it is preferable to have some other form of tuning device in the system, such, for instance, as the conventional tuning devices shown in Figure 1, which may take the form either of the band pass filter or of the tuning device consisting of the coil 27 and condenser 28. The signal response—frequency curve for a conventional tuning device is indicated by the curve 31, as shown in Figure 10, and this curve is drawn in full lines and superimposed upon the signal response curves of the circuits A and B shown in dotted lines.

It is apparent that when the three curves are combined as shown in Figure 11, a fine signal response curve 32 is obtained which has abrupt cut-offs at the frequencies  $f_1$  and  $f_2$  and a substantially flat top.

This obviously is the ideal tuning curve for a radio receiving system for the reason that maximum amplification of all frequencies in the side bands between the cut-off frequencies and of the selected frequency is obtained, and consequently the tone quality is theoretically perfect.

This radio receiving system has been actually tested under working conditions in a well-equipped radio testing laboratory, and it has been found that the signal response curves follow identically those shown and described herewith.

It will be seen that the width of the upper and lower side bands and consequently the total width of the side bands can be made any suitable value desired by following the teachings of this invention.

It will be seen, further, that any suitable type of tube can be used or any suitable conventional type of tuning device can be employed, provided the rejector-selector circuits A and B, or their equivalents, are employed.

The system is so sharp in its cut-off on opposite sides of the selected frequency that it will receive and fully amplify distant stations which are broadcasting on waves closely adjacent those generated by local broadcasting stations, without bringing in the local broadcasting stations.

It is specifically intended that the expression "signal" or "signal response" be interpreted to mean any type of radio frequency energy

whether broadcast as music or speech or whether sent as code signals, or in any other manner such as television signal impulses. In other words, "signal" or "signal response" is to be interpreted in the broadest possible manner.

It is also apparent that the radio frequency choke coils 10 and 22 can be replaced by condensers, provided some means are employed for furnishing the tubes 1 and 2 with current at suitable voltage.

Other changes could be made in the precise disclosure of this invention without departing from the spirit thereof, and therefore, although this invention has been described in considerable detail, it is to be understood that such description is intended as illustrative rather than limiting, as the invention may be variously embodied and is to be interpreted as claimed.

We claim:

1. In a radio receiving system the combination of means for receiving radio energy; a radio frequency amplifying vacuum tube; means for transmitting energy of a selected wave length from said first mentioned means to said tube, said means including a resonant circuit having capacity and inductance and adapted to be tuned to said selected wave length; means resonating with a portion only of said inductance for rejecting energy of a wave length on one side of said selected wave length; a second vacuum tube; means including a resonant circuit having capacity and inductance and adapted to be tuned to a wave length differing from said selected wave length, said last mentioned means being interposed between said first and second mentioned tubes; and means resonating with a portion only of said last mentioned inductance for rejecting energy of a wave length on the other side of said selected wave length, whereby a sharp cut-off is obtained on each side of said selected wave length.

2. In a radio receiving system having two separate resonant coupled circuits adapted to be tuned to two selected wave lengths, each circuit having capacity and inductance, the combination of two distinct means separately respectively resonating with a portion only of said inductances for rejecting energy of wave lengths on opposite sides of one of said selected wave lengths.

3. In a radio receiving system having a plurality of operatively interconnected vacuum tubes and having at least two resonant circuits serving as connecting means between certain of said tubes and adapted to be tuned to different selected wave lengths, each circuit having capacity and inductance, the inductance being furnished by a coil in each resonant circuit, means connected intermediate the ends of one of said coils for rejecting energy of a wave length less than the selected wave lengths; and a second means connected intermediate the ends of the other of said coils for rejecting energy of a wave length greater than the selected wave length, whereby a sharp cut-off is secured on opposite sides of the selected wave length.

4. In a radio receiving system having a plurality of operatively interconnected vacuum tubes and having at least two resonant circuits serving as connecting means between certain of said tubes and adapted to be tuned to different selected wave lengths, each circuit having capacity and inductance, the inductance being furnished by a coil in each resonant circuit, means

connected intermediate the ends of one of said coils for rejecting energy of a wave length less than the selected wave length; and a second means connected intermediate the ends of the other of said coils for rejecting energy of a wave length greater than the selected wave length, the width of the side bands being controlled by the points at which said means are connected to the respective coils of the said resonant circuits.

5. A tuning system for a radio receiver including an amplifying tube, said tuning system comprising means for accepting and impressing upon said amplifying tube a signal of one frequency and suppressing a signal of a different frequency and preventing said last mentioned signal from passing to said amplifying tube, and means resonating with a portion only of said first mentioned means for determining the frequency separation between the accepted and suppressed frequencies.

6. A radio receiving system comprising means for receiving radio frequency energy, amplifying means supplied from said first mentioned means for amplifying the radio frequency energy, a tuning circuit provided with an impedance-producing device, a second tuning circuit provided with an impedance-producing device, both said tuning circuits forming a portion of said receiving system and being connected to said amplifying means and means connected to each of said tuning circuits for rejecting radio frequency energy above and below the selected frequency, said means resonating with a portion only of said impedance-producing devices.

7. A radio receiving system comprising means for receiving radio frequency energy, amplifying means supplied from said first mentioned means for amplifying the radio frequency energy, a tuning circuit provided with an impedance-producing device, a second tuning circuit provided with an impedance-producing device, a single means for simultaneously controlling said tuning circuits, both said tuning circuits forming a portion of said receiving system and being connected to said amplifying means and means connected to each of said tuning circuits for rejecting radio frequency energy above and below the selected frequency, said means resonating with a portion only of said impedance-producing devices.

8. In a radio receiving system, a grounded buss bar; a vacuum tube; a second vacuum tube; each vacuum tube having a cathode connected to said buss bar, a grid, and a plate; a circuit for passing energy from the plate of the first mentioned vacuum tube to the grid of the second mentioned vacuum tube; a third vacuum tube having a cathode connected to said buss bar, a grid, and a plate; a second circuit for passing energy from the plate of said second mentioned vacuum tube to the grid of said third mentioned vacuum tube; said first and second mentioned circuits each including a coil and a condenser connected in parallel and means resonating with a portion only of said coil; said first and second mentioned circuits being bridged respectively between the plate-grid circuit of said first and second mentioned vacuum tubes and said buss bar, and between the plate-grid circuit of said second and third mentioned vacuum tubes and said buss bar.

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