Oct. 18, 1932. J. K. JOHNSON 1,883,794

RADIO RECEIVING APPARATUS

Filed July 7, 1931

Fig. 1,

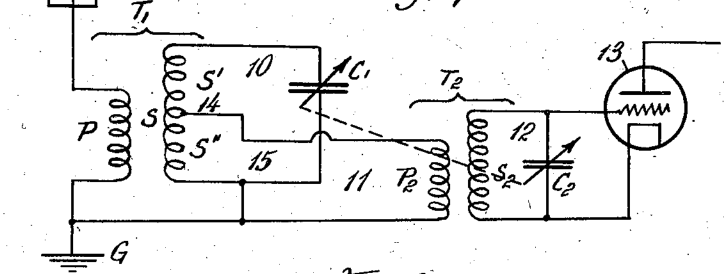


Fig. 2,

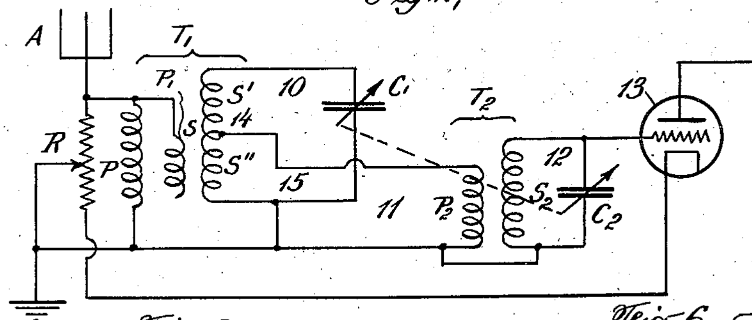


Fig. 3,

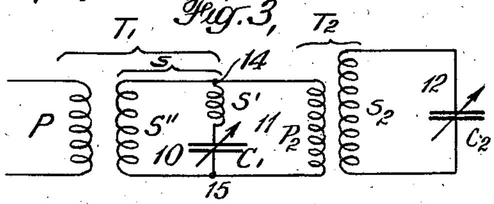


Fig. 6,

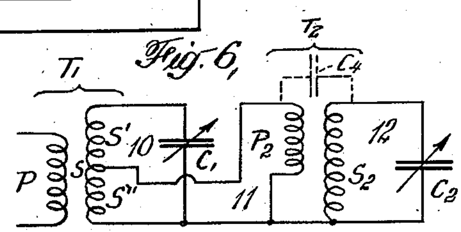


Fig. 4,

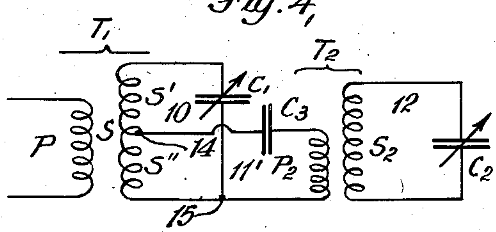


Fig. 7,

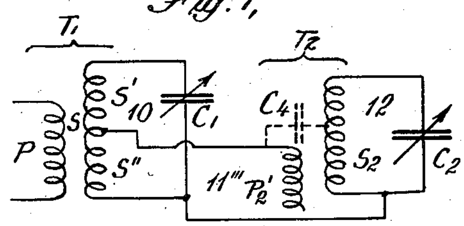
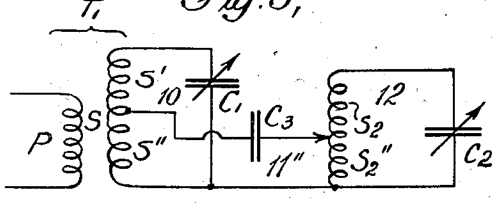


Fig. 5,



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UNITED STATES PATENT OFFICE

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RADIO RECEIVING APPARATUS

Application filed July 7, 1931. Serial No. 549,164.

The present invention relates to a radio frequency tuning system for use in connection with radio receiving apparatus of the superheterodyne type.

A problem common to all radio receiving apparatus is the selection of the desired signal and the rejection of undesired signals. A superheterodyne radio receiver is particularly sensitive to not only the desired signal but to a second frequency known as the "image" frequency which is that frequency displaced above the local oscillator frequency by the same amount that the desired frequency is displaced below the local oscillator frequency. If the radio frequency tuning circuits of a superheterodyne respond to the comparative close "image" frequency, and if a second transmitting station is within the range of the receiver and operates at a frequency at or near the "image" frequency, the local oscillator frequency currents will combine therewith and the intermediate frequency stages will pass the beat frequency thus produced, resulting in a signal which may be characterized as an unpleasant combination of the desired and undesired signals.

It is the object of the present invention to prevent the response of radio receivers to undesired signals and particularly the production of undesired "image" frequency signals in a superheterodyne receiver.

Various means have been proposed to eliminate the "image" frequency response occurring in superheterodynes. One such system utilizes a tapped secondary in the input transformer, the input to the first radio frequency amplifier tubes being taken across a portion of the secondary transformer. The portion of the secondary above the tap, in conjunction with the tuning condenser, constitutes a radio frequency by-pass circuit responsive to the undesired signal. Such a circuit is shown, for instance, in MacDonald Patent No. 1,680,424.

The above described system of "image" frequency rejection, however, has the disadvantage that the full voltage amplification of the preliminary tuned circuits can not be utilized.

It is a more specific object of the present invention to eliminate the response to "image" frequencies by the method outlined above and yet obtain the usual amount of amplification in the tuned input circuits.

These and further objects of this invention will become apparent from the following description when considered in connection with the drawing.

In accomplishing the objects of the invention, an input transformer is provided, and the secondary is tapped at a point such that the portion of said secondary above the tap, together with the tuning condenser, will constitute a radio frequency by-pass to signals of the "image" frequency and the terminals of the portion of the secondary below the tap will be at node potential relative to currents of the undesired or "image" frequency.

As the entire secondary circuit is tuned to the desired frequency, the by-pass circuit, which includes the tuning element, is likewise tuned to the undesired or "image" frequency. The misalignment between the actual "image" frequency and by-pass frequency is made as slight as possible and may be made zero for any point of the range desired. The voltage variations between the tap and the ground end of the secondary are used to supply a voltage to a second tuned circuit, which circuit is utilized to impress the signals upon the radio frequency amplifying devices, detectors, etc.

Having thus briefly described the invention, attention is invited to the accompanying drawing, in which:

Fig. 1 shows the imput radio frequency circuits of a radio receiver embodying this invention;

Fig. 2 shows the tuned radio frequency circuits, embodying this invention, used in connection with the input of a radio receiver as, for instance, a superheterodyne;

Fig. 3 is an elementary circuit diagram illustrating the principles of the present invention; and

Figs. 4, 5, 6 and 7 are elementary diagrams of modified circuits for carrying out the principles of the invention.

Fig. 1 shows the tuned input of a radio receiver. In this figure the antenna A is connected to the ground G through the primary P of the transformer T_1. The secondary S of the transformer is tapped at point 14, said tap being connected to the primary P_2 of the transformer T_2. In shunt with the secondary S is the tuning condenser C_1, said secondary S and condenser C_1 forming a tuned circuit 10 resonant to the frequency of the desired signals. Circuit 10 is made resonant to the desired frequency either by variation of the condenser C_1, made variable as shown, or by variation of the inductance of the secondary S. The secondary S_2 of the transformer T_2 is shunted by condenser C_2, forming the tuned circuit 12 which is tuned to the desired frequency in a manner similar to that in which circuit 10 is tuned.

Condensers C_1 and C_2 may be connected for uni-control operation, as indicated by the dotted line in Fig. 1, and the same control may be made to tune the remaining tuned circuits of the receiver.

Circuit 12 is connected to the input of thermionic device 13 which may be the radio frequency amplifier or detector of a radio receiver, as desired.

Attention is now invited to Fig. 2 in which similar parts are indicated by the same reference figures. This circuit is particularly adapted for use in a superheterodyne radio receiver. It differs from Fig. 1, just described, principally by the use of a volume-control variable resister R, a variable portion of which is shunted across the primary P of the transformer T_1. The cathode of the thermionic device 13 is also variably connected to ground through the resistor R for the purpose of varying the amplification of said device by varying its grid bias potential. Transformer T_1 includes also a second primary P_1 which may be wound on the secondary for the purpose of increasing the gain of said transformer by increasing the capacity coupling between the primary and secondary. This circuit is in other particulars essentially the same as that shown in Fig. 1.

In view of the fact that the primary P_2 of transformer T_2 is in shunt with a substantial portion of the tuning inductance S of transformer T_1 of Fig. 1 and T_1 of Fig. 2, it is desirable that its inductance be high in order to prevent its acting to short-circuit the portion of coil S below the tap, and thus interfere with the alignment of circuit 10 with the circuit 12.

As an example of what constants may be used for the various parts of the circuit constituting the invention, the following characteristics are given, although it is to be noted that others may be found satisfactory. However, by actual experience the following have been found satisfactory:

P—700 microhenries;
S—258 microhenries;
P_2—1920 microhenries;
S_2—252 microhenries;
Coupling between P and S—16½%;
Coupling between P_2 and S_2—8.8%;
R—10,000 ohms;
P_1—20 turns of #38 U. S. gauge double silk covered copper wire;
C_1 and C_2—0–350 micro-micro-farads.

The secondary S comprises 125 turns and the tap is taken 51 turns from the ground end. These characteristics are for a superheterodyne receiver using an intermediate frequency of 175 kilocycles in which the "image" frequency is 350 kilocycles above the desired frequency.

The condensers C_1 and C_2 may be connected together for uni-control operation. The circuit of Fig. 3 is the same as the circuit shown in Fig. 1 except that the inductances are differently arranged for the purpose of explaining the action of the circuit used in accomplishing the objects of this invention. As previously described, the secondary S of transformer T_1 is tapped at point 14. The two portions S' and S'' are so proportioned that, relative to the points 14 and 15, S' and C_1 will constitute a by-pass to currents of an undesired frequency. It can, therefore, be seen that the voltage gain characteristic curve of the portion S'' will show zero voltage at the "image" frequency, whereas the natural resonance of the circuit 10 may be such that a considerable voltage will be developed at a frequency the same amount on the other side of the signal frequency, thus producing a non-symmetrical curve relative to the voltages between points 14 and 15 at the different frequencies. The tap point 14 may be so chosen that the misalignment between the by-pass frequency as varied when the condenser C_1 is varied in tuning circuit 11 and the "image" frequency will be zero at any selected point in the range. Then the points 14 and 15 will remain at substantially less potential difference relative to currents of such undesired frequency throughout the tuning range of the receiver. The points 14 and 15 are connected to the primary P_2 of the transformer T_2, thus forming a link circuit 11. It is to be noted that the primary P_2 does not have impressed across it all of the voltage variations which are available across the secondary winding S, but only those existing across the substantially reduced portion S''. However, the primary P_2 is inductively related to the second tuned circuit

12 through the secondary S_2, the resonance characteristics of which permit the amplification to be made the maximum obtainable in the second of two coupled tuned circuits. In other words, substantially optimum coupling will be obtained regardless of the loss occasioned by the tapping of the secondary.

Fig. 4 shows a coupling circuit in which the link circuit 11′ includes a condenser C_3. The circuit 11′ may be made resonant to a frequency below the band it is desired to receive, in order to increase the response of the whole coupling circuit at low frequencies. For this purpose the inductance of P_2' must be made relatively high, and the coupling between P_2' and S_2 must be relatively loose.

Fig. 5 is a second modification of the circuit constituting the present invention. In this circuit the link circuit 11″ includes a portion S_2'' of the inductance S_2 in addition to the series condenser C_3. A circuit of this type gives a better response at high frequencies in which the current flowing in the link circuit is greater. However, it is important in this circuit that the capacity of C_3 be small to prevent short-circuiting of the portion S'' of secondary S.

Fig. 6 shows a third modification of the circuits embodying the invention. In this circuit the primary P_2 of the transformer T_2 is closely coupled to the high-potential end of the resonant circuit 12. The winding P_2 may be in such a direction relative to the winding of the secondary S_2 that the inherent capacity coupling C_4 between the primary P_2 and secondary S_2 will either oppose or aid the mutual inductive coupling between said primary and secondary. In the event that the capacitive coupling C_4 is in opposition to the inductive coupling, the response of the circuits is reduced at the higher frequencies.

Fig. 7 is still another modification of the circuits embodying this invention. In this circuit P_2' is connected to the tapped secondary S of transformer T_1 and the other end of the primary P_2' is left unconnected. In this circuit the link circuit 11‴ comprises the portion S'' of transformer T_1, the inherent capacity C_4 between the primary P_2', and secondary S_2 of transformer T_2 and the leads connecting S'' with P_2', and circuit 12 with circuit 10. This circuit gives better response characteristics to the entire coupling circuit at the higher frequencies.

The operation of circuits shown in Figs. 4, 5, 6 and 7 is similar to the operation of circuits shown in Figs. 1, 2 and 3 and may be summarized as follows: The tapped secondary S of the transformer T_1 permits a bypassing in each instance for the undesired frequency as, for instance, the "image" frequency in a superheterodyne. The voltage existing across the portion S'' of said secondary is applied by means of a link circuit to excite a second tuned circuit 12. Various means have been shown for coupling the circuits 10 and 12, but it is to be understood that they are each based upon the same principles, although the method of obtaining the desired mutual coupling may be varied in accordance with the circumstances, as shown for the purpose of illustration in the various figures.

When the circuits constituting this invention are being used in a superheterodyne receiver, the tap 14 is so chosen that the "image" frequency response of the tuning circuits will be reduced. However, when a tuned radio frequency receiver is used the tap may be so taken that any objectionable signal may be rejected.

I claim:

1. Signal selecting circuits for a radio receiver comprising a circuit tunable to the frequency of the current it is desired to receive, a second circuit tunable to the same frequency, and a link circuit connecting portions of the impedances of each of said circuits, the portion of the impedance of the first of said circuits being shunted by a circuit resonant to the current of a frequency it is not desired to receive and said link circuit being made resonant to current of a frequency lower than the band of frequencies to which said circuits are tunable.

2. A signal selecting device for a superheterodyne radio receiver which comprises a circuit tunable to a current of the frequency it is desired to receive, a second circuit likewise tunable to the current of the frequency it is desired to receive, and a link circuit connecting a portion of the impedance of said first mentioned circuit and inductively related to the second mentioned circuit, the portion of the impedance of said first mentioned circuit being so chosen that its terminals remain at substantially node potential relative to the "image" frequency of said receiver as the circuits are tuned, said circuits being so proportioned that the gain of said second circuit will compensate to some extent for the loss occasioned by the tapping of only a portion of the desired signal voltage across the first mentioned circuit.

3. A tuned radio frequency selective device for a radio receiver including a circuit tunable to the frequency of a current to be received, a second circuit also tunable to the frequency of the current to be received, and a link circuit connecting portions of the impedances of each of said circuits, the portion of the impedance of the first of said circuits being so selected that its terminals are at node potential relative to currents of an undesired frequency, and said link circuit having a resonance at a frequency outside the band of frequencies to be covered by said circuits whereby to emphasize the response to frequencies toward one side of the band.

4. Signal selecting circuits for a radio re-

ceiver which comprise a first circuit including an inductance and a capacity, a second circuit, means for tuning both of said circuits to the frequency of the current it is desired to receive, a link circuit connected between said circuits including a portion of the inductance of the first of said circuits and at least a portion of the impedance of said second-mentioned circuit, said link circuit being proportioned so that the impedance shunting the selected portion of said inductance remains substantially resonant to current of a particular undesired frequency as the circuits are tuned, said link circuit being resonant to a frequency below the band of frequencies to which it is desired to tune the said circuits whereby the gain of said circuits is increased at low frequencies.

5. A signal selecting device for a superheterodyne radio receiver which comprises a circuit tunable to a current of the frequency it is desired to receive, including an inductance and a capacity, a second circuit likewise tunable to the frequency of the current it is desired to receive, also including an inductance and a capacity, a link circuit connected to a portion of the inductance of the said first mentioned circuit and inductively related to said second mentioned circuit, a portion of the inductance of said first mentioned circuit being so chosen that its terminals are at node potential relative to the "image" frequency of said receiver, and a capacity of said link circuit so selected that said link circuit is resonant to a frequency outside the band of frequencies to which it is desired to tune said receiver.

6. A signal selecting device for a radio frequency receiver which comprises a circuit tunable to a current of the frequency it is desired to receive including an inductance and a capacity, a second circuit likewise tunable to the frequency of the current it is desired to receive also including an inductance and a capacity, and a link circuit connecting a portion of the inductance of said first mentioned circuit and including an inductance which is inductively related to the inductance of said second mentioned circuit, the portion of the inductance of said first mentioned circuit being so chosen that its terminals are at node potential relative to a specific frequency which it is not desired to receive.

7. A radio signal selecting circuit for a superheterodyne radio receiver which comprises two radio frequency circuits tunable to the frequency of the current to be received by said receiver, each circuit including inductive and capacitive reactances, a link circuit connected across a portion of the reactance of the first of said tuned circuits, so selected that the terminals of said link circuit are maintained at substantially node potential relative to currents of the "image" frequency as the circuits are tuned, said link circuit including an inductance inductively related to the high potential end of the inductive reactance of said second tuned circuit whereby the coupling between said tuned circuits includes the mutual inductance between the inductance of said link circuit and the inductive reactance of said second circuit and the inherent capacity between said inductances.

8. A signal-selecting device for a radio receiver which comprises a circuit tunable to a current of the frequency it is desired to receive, including an inductance and a capacity, a second circuit likewise tunable to the frequency of the current it is desired to receive also including an inductance and a capacity, and a link circuit connected to a portion of the inductance of said first mentioned circuit and including an inductance of relatively high impedance which is inductively related to the inductance of said second mentioned circuit, the portion of the inductance of said first mentioned circuit being so chosen that its terminals are at node potential relative to a specific frequency which it is not desired to receive, said circuits being so proportioned that substantially optimum coupling will be had between said first and said second mentioned circuits.

9. A signal selecting device for a superheterodyne radio receiver which comprises a circuit tunable to a current of the frequency it is desired to receive, including inductive and capacitive reactances, a second circuit likewise tunable to the frequency it is desired to receive also including inductive and capacitive reactances, and a link circuit connected to a portion of the reactances of said first mentioned circuit and including a relatively high inductance inductively related to the inductive reactance of the second mentioned circuit, the portion of the reactance of said first mentioned circuit being so chosen that its terminals are at node potential to the "image" frequency of said receiver, said circuits being so proportioned that the gain of said second mentioned circuit will permit optimum coupling regardless of the loss occasioned by tapping off only a portion of the desired signal voltage available in said first mentioned circuit.

10. A signal selecting device for a radio receiver which comprises a circuit tunable to a current of the frequency it is desired to receive including an inductance and a capacity, a second circuit likewise tunable to the frequency of the current it is desired to receive, and also including an inductance and a capacity, a link circuit connecting a portion of the inductance of said first mentioned circuit and including an inductance which is inductively related to the inductance of said second mentioned circuit, the portion of the

inductance of said first mentioned circuit being so chosen that its terminals are at node potential relative to a specific frequency which it is not desired to receive, and a capacity in said link circuit so selected that said link circuit is resonant to a frequency below the band of frequences to which it is desired to tune said receiver.

11. Radio signal selective circuits for superheterodyne radio receivers which comprise two radio frequency circuits tunable to the frequency of the current it is desired to receive, each including inductive and capacitive reactances, a link circuit connected across a portion of the reactance of one of said tuned circuits so selected that the terminals of said link circuit are at node potential relative to a current of the "image" frequency and including an inductance inductively related to the high potential end of the inductive reactance of the second of said tuned circuits whereby the coupling between said tuned circuits includes the mutual inductance between the inductance of said link circuit and the inductive reactance of said second mentioned circuit and the inherent capacity between said inductances, the winding of said inductances being so arranged that the mutual inductance coupling will oppose the capacitive coupling between the link circuit and the second of said circuits, thus providing a lesser response at the high frequency portion of the tuning range of said circuits.

12. A radio signal selecting device for a radio receiver which comprises two radio frequency circuits tunable to the frequency of the current to be received by said receiver, each including an inductance and a capacity, a link circuit connected across a portion of the inductance of the first of said tuned circuits so selected that the terminals of said link circuit are at node potential relative to the current of an undesired frequency, said link circuit including an inductance inductively related to the high potential end of the inductance of said second tuned circuit whereby the coupling between said tuned circuits includes the mutual inductance between the inductance of said link circuit and the inductance of said second mentioned circuit and the inherent capacity between said inductances.

13. A radio receiving apparatus of the superheterodyne type including signal selecting circuits comprising two circuits tunable to the frequency of the current it is desired to receive, each including inductances and capacities and a link circuit effectively connected across at least a portion of the inductance of each of said circuits and including a capacity, the portion of the inductance of the first of said tuned circuits being so chosen that the terminals of said link circuit are at node potential relative to a current of the "image" frequency of said receiver and the portion of the inductance of the second tuned circuit being so chosen that the voltage gain in said circuit will compensate for the loss due to the rejector action of the first circuit, and the capacity of said link circuit being so selected that said circuit will be resonant to a frequency outside the band of frequencies which it is desired to receive.

14. A radio signal selective device for radio receivers which comprises two radio frequency circuits tunable to the frequency of the current it is desired to receive, each including an inductance and a capacity, a link circuit connected across a portion of the inductance of one of said tuned circuits so selected that the terminals of said link circuit are at node potential relative to current of an undesired frequency and including an inductance inductively related to the high potential end of the inductance of the second of said tuned circuits whereby the coupling between said tuned circuits includes the mutual inductance between the inductance of said link circuit and the inductance of said second mentioned circuit and the inherent capacity between said inductances, the winding of said inductances being so arranged that the mutual inductance coupling will oppose the capacitive coupling between the link circuit and the second of said circuits, thus providing a lesser response at the high frequency portion of the tuning range of said circuits.

15. A radio frequency tuning system for a radio receiver of the superheterodyne type which comprises two circuits tunable to the frequency of the current it is desired to receive, each circuit comprising inductive and capacitive reactances, and a link circuit connected to said tuned circuits, including a portion of the inductance of each of said circuits, that portion of the inductance of the first of said circuits being so selected that the terminals of said link circuit will remain at substantally node potential relative to a current of the "image" frequency of said receiver as the circuits are tuned, and said link circuit including an open end winding inductively and capacitively related to the inductance of the second of said circuits whereby said link circuit comprises the capacitive coupling between said open end winding and the inductance of said second circuit and a portion of the inductances of each of said tuned circuits.

16. A radio frequency tuning system comprising two circuits tunable to the frequency of the current it is desired to receive, each comprising inductive and capacitive reactances, and a link circuit connecting said tuned circuits including a portion of the inductance of the first of said circuits so selected that the terminals of said link circuit are at node potential relative to a current of an undesired frequency, and an open end winding in-

ductively and capacitively related to the inductance of the second of said circuits, whereby said link circuit comprises the capacitive coupling between said open end winding and the inductance of said second circuit and a portion of the inductance of the first circuit.

In testimony whereof I affix my signature.

J. KELLY JOHNSON.