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IMAGE SUPPRESSION CIRCUIT

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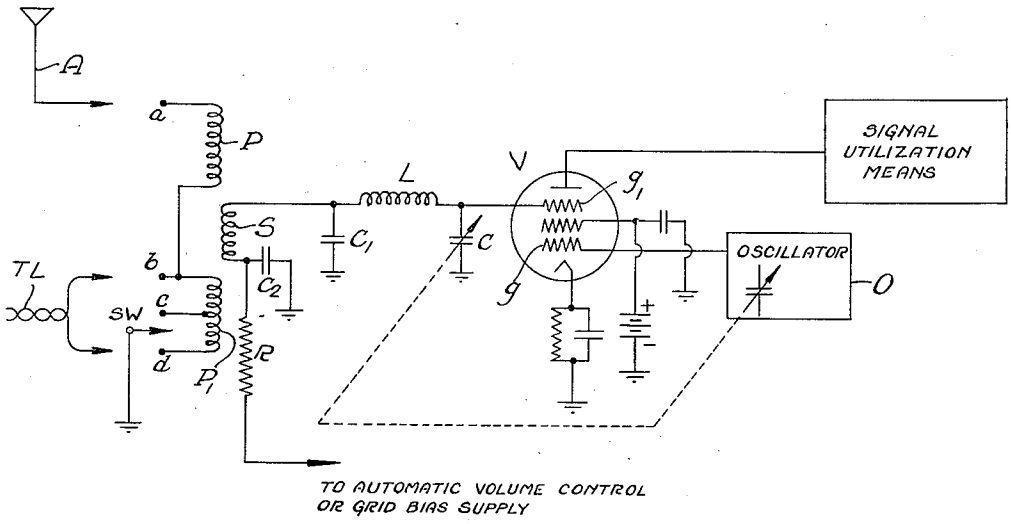


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## IMAGE SUPPRESSION CIRCUIT

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This invention relates to novel signal transfer means for radio receivers and like systems wherein it is desired to transfer signals of certain frequency and to reject signals of certain other frequencies. More particularly, the invention relates to a novel circuit for a superheterodyne radio receiver by means of which undesired signals, commonly known as "image signals", may be effectively suppressed while desired signals may be transmitted substantially unaffected.

One object of the invention, therefore, is to provide novel signal transfer means adapted to transfer desired signals and to reject undesired signals.

Another object of the invention is to provide a novel circuit which is adapted to receive signal energy either from a high impedance source, such as a conventional antenna, or from a low impedance source, such as a transmission line associated with certain well-known antennae.

A further object of the invention is to provide a novel capacitive coupling between an input circuit and a tuned circuit, by means of which image signals may be effectively attenuated.

The invention is particularly adapted for use in a superheterodyne radio receiver to suppress or reject the image signals commonly encountered in such a system, as above mentioned. For the purpose of disclosure, therefore, the invention will be described with particular reference to this adaptation, but it will be understood that the invention is not thus limited in scope.

In the accompanying drawing, the single figure is a diagrammatic illustration of a preferred form of the invention as applied to a superheterodyne radio receiver.

As is well known, in a superheterodyne receiver, the desired signal is combined with a signal from a local oscillator producing signals having frequencies equal to the sum and difference of the desired signal frequency and the oscillator frequency. The difference frequency signal, having the intermediate frequency, is selected and amplified. The oscillator frequency is thus the desired signal frequency plus the intermediate frequency. Likewise, undesired image signals, whose frequency is equal to the oscillator frequency plus the intermediate frequency, or twice the oscillator frequency minus the intermediate frequency, will, when combined with the oscillator signal, produce undesired signals of intermediate frequency. For example, if the desired signal frequency band is from 150 to 300 k. c., i. e., the long wave band, and the intermediate frequency is 450 k. c., the image signal frequency band will extend from 750 to 1200 k. c.

The present invention, when applied to a superheterodyne radio receiver, is adapted to suppress or reject the undesired image signals, such as those above mentioned. For the purpose of the present specification and appended claims, an "image" or undesired signal may be defined as a signal other than the one it is desired to receive which will heterodyne with the local oscillator signal or a harmonic thereof to produce a signal, at least one component of which is of the intermediate frequency, or thereabouts.

The circuit shown in the drawing is particularly adapted to select signals in the long wave band, that is signals having a frequency in the general region 150 to 300 kilocycles, and to attenuate undesired signals in the frequency region 750 to 1200 kilocycles. It will be noted that such suppression must be highly effective because the undesired signal region includes the more powerful commercial broadcast stations, while the range of desired signals include stations which, in general, transmit signals with less power than those in the frequency range of the undesired signals. The circuit of the present invention is adapted to suppress effectively undesired signals emanating from powerful transmitting stations without affecting desired signals from less powerful stations.

Referring now to the drawing, signals generated by the local oscillator, indicated by reference character O, may be applied to a control grid $g$ of vacuum tube V, whose output circuit may be connected to utilization means including a conventional intermediate frequency amplifier, detector, audio frequency amplifier, and loud speaker or equivalent device. The signal which it is desired to receive may be selected by the means described hereinafter and supplied to a control grid $g_1$ of the tube V. The mixing or heterodyne action may take place within the tube V. The means for selecting the desired signal and for attenuating the undesired signal comprises a tuned circuit L, C and $C_1$ which circuit may be tuned by means of the variable condenser C to the frequency of the signal which it is desired to receive. The variable condenser C may be controllable jointly with the variable condenser of the oscillator, as well understood. Preferably, the variable condenser C is connected in shunt with the control grid $g_1$ and to ground, as illustrated. The inductance L may be connected to the control grid $g_1$ and also to the condenser $C_1$,

which condenser may also be connected to ground.

Signals built up across the condenser $C_1$ will be applied through the inductance L to the control grid $g_1$. Signals may be supplied to the condenser $C_1$ by means of the secondary winding S of the input transformer, the other end of the secondary winding being connected to ground through a blocking condenser $C_2$, which condenser may have a very low impedance to signals of radio frequency. A biasing potential, for example, either a fixed bias or an automatic volume control bias, may be applied to the control grid $g_1$ through the isolating resistor R. The primary winding of the input transformer may be divided into sections P and $P_1$. Winding $P_1$ may be center tapped, as illustrated. Designating the terminals of the primary winding as *a*, *b*, *c*, and *d*, the impedance looking into $P_1$ between terminals *b* and *d* may be low, whereas looking into the transformer from terminals *a* and *d*, the impedance may be very high. A switch SW may be adapted to connect either of the terminals *c* and *d* to ground, depending upon whether the transformer is connected to a high impedance antenna A or to a low impedance transmission line TL.

When it is desired to supply signals to the receiver by means of the low impedance line, the line may be connected across terminals *b* and *d*, and the terminal *c* may be grounded by means of the switch SW. The input circuit is then balanced to ground, as will be obvious, and noise-signal pick-up of the transmission line will be minimized. When it is desired to supply signals to the receiver from the high impedance antenna A, the antenna may be connected to terminal *a*, and the terminal *d* may be connected to ground by means of the switch SW. Preferably the coupling between P and S and between $P_1$ and S should be as high as possible. Signals supplied to the receiver either from the antenna or from the transmission line will appear across the secondary S. In addition, the transformer will also introduce an effective inductive reactance in series with the signal source, due first to the effective impedance of the signal collector, which may be either inductive or capacitive, and second to the leakage reactance of the transformer itself. Thus, the transformer serves first to form an effective signal source properly matched to either a high impedance collector or a low impedance signal source which may in addition be balanced to ground, and second the transformer serves to introduce an effective inductive reactance in series with the signal source. The circuit S, $C_1$ may be tuned to be resonant either above or preferably below the frequency range of signals which it is desired to receive, but in any case this circuit should be resonant well below the frequency range of undesired signals. It is apparent that the impedance of an inductive reactance will increase with frequency while that of a capacitive reactance will decrease. Thus, the equivalent impedance of the secondary or equivalent signal source will increase with frequency while the impedance of the condenser $C_1$ which serves to transfer the desired signals to the circuit L, C, $C_1$ will decrease with increasing frequency. Thus, by proper design of the circuit, desired signals may be transferred to the second circuit L, C and $C_1$ substantially unattenuated, and by virtue of the tuned resonant characteristic of this circuit, the particular desired signal may be selected and applied in augmented magnitude to the control grid $g_1$ of the tube V. However, undesired signals, which may be present at the secondary S, will not build up to an appreciable extent in the second tuned circuit L, C and $C_1$ due to the fact that the impedance of the condenser $C_1$ will be small for signals of this frequency, whereas the equivalent series impedance of the input transformer will be high for signals in this frequency region. Thus, the amplitude of undesired signals transferred to the condenser $C_1$ will be substantially attenuated by this coupling condenser. The undesired signals will be further attenuated by means of the inductance L whose impedance to signals of this frequency will be very high as compared with either the impedance of condenser C or that of $C_1$. Hence, the selecting circuit serves to attenuate undesired signals, first, by short-circuiting them through the condenser $C_1$, and, second, by the operation of the inductance L to prevent the development of undesired signal voltage across the tuning condenser C.

In one practical embodiment of the invention a circuit having the following constants was found to be highly satisfactory. The inductance L comprised 400 turns of litzendraht wire (3 strands No. 40 B. & S.) wound on a one-half inch form and had an inductance of about 2500 microhenries. The condenser $C_1$ had a value of 0.02 mf. and the condenser C was a variable condenser having a maximum capacity of 385 mmf. The inductance S had a value of about 150 microhenries and comprised 100 turns of No. 38 B. & S. wire on a one-half inch form. The inductance $P_1$ was similar to S and was center tapped at the 50th turn. Inductance P comprised 600 turns of No. 38 wire. All three of the inductances P, $P_1$ and S were closely wound together using a winding of the universal type on a one-half inch diameter form. The coupling between S, P and $P_1$ was made as high as possible. This particular transformer was suited to match a 100 ohm transmission line connected between terminals *b* and *d*, whereas the inductance between terminals *a* and *d* was about 9 millihenries and thus was of sufficiently high impedance to work satisfactorily out of a conventional antenna. The resonant frequency of the circuit S—$C_1$ was about 100 k. c.

It will be seen from the illustration and above description that the novel circuit provided by the invention is adapted to effectively suppress undesired signals in a frequency range including powerful transmitting stations, while permitting the transfer of signals in another frequency range including less powerful transmitting stations. Moreover, the invention makes possible the use of either a high impedance signal source or a low impedance signal source in cooperative association with the novel circuit for suppressing undesired signals. Although the invention has been illustrated and described with reference to a particular preferred embodiment, it will be understood that various changes and modifications may be made without departing from the spirit and scope of the invention.

I claim:

1. In a radio receiving system, a source of desired wave signals and undesired wave signals, said undesired signals having a higher frequency than said desired signals, a space discharge device having an input circuit, means for transferring said desired signals from said source to said input circuit and for minimizing the transfer of undesired signals comprising means providing an effective inductive reactance in series with said source, purely capacitively reactive

means serially connected to said source and said inductively reactive means for forming a loop circuit resonant to a frequency below said undesired wave signal frequency, a resonant circuit including said purely capacitive means and energized only by the signal across said capacitive means, said last-named circuit being tunable to the frequency of said desired wave signal, and a connection between said input circuit and said tuned circuit.

2. In a radio receiving system, a source of desired wave signals and undesired wave signals, said undesired signals having a higher frequency than said desired signals, a space discharge device having an input circuit, means for transferring said desired signals from said source to said input circuit and for minimizing the transfer of undesired signals comprising means providing an effective inductive reactance in series with said source, purely capacitively reactive means serially connected to said source and said inductively reactive means for forming a loop circuit resonant to a frequency below said desired wave signal frequency, a resonant circuit including said purely capacitive means and energized only by the signal across said capacitive means, said last-named circuit being tunable to the frequency of said desired wave signal, and a connection between said input circuit and said tuned circuit.

3. In a radio receiving system, a source of desired wave signals and undesired wave signals, said undesired signals having a higher frequency than said desired signals, a space discharge device having an input circuit, means for transferring said desired signals from said source to said input circuit and for minimizing the transfer of undesired signals comprising means providing an effective inductive reactance in series with said source, purely capacitively reactive means serially connected to said source and said inductively reactive means for forming a loop circuit resonant to a frequency below said undesired wave signal frequency, a resonant circuit including an inductively reactive element and said purely capacitive means, said last-named circuit being energized only by the signal across said capacitive means and being tunable to the frequency of said desired wave signal, and connections for supplying a signal from said capacitively reactive element to said input circuit.

4. In a radio receiving system, a source of desired wave signals and undesired wave signals, said undesired signals having a higher frequency than said desired signals, a space discharge device having an input circuit, means for transferring said desired signals from said source to said input circuit and for minimizing the transfer of undesired signals comprising a transformer having a primary winding connected to said source and a secondary winding for forming an effective signal source having an effective inductive reactance in series therewith, purely capacitively reactive means serially connected to said effective source and said inductively reactive means for forming a loop circuit resonant to a frequency below said undesired wave signal frequency, a resonant circuit including said purely capacitive means and energized only by the signal across said capacitive means, said last-named circuit being tunable to the frequency of said desired wave signal, and a connection between said input circuit and said tuned circuit.

5. In a radio receiving system, a source of desired wave signals and undesired wave signals, said undesired signals having a higher frequency than said desired signals, a space discharge device having an input circuit, means for transferring said desired signals from said source to said input circuit and for minimizing the transfer of undesired signals comprising a transformer having a tapped primary winding, connections for alternatively connecting said source to different portions of said primary winding, and a secondary winding for forming an effective signal source having an effective inductive reactance in series therewith, purely capacitively reactive means serially connected to said effective source and said inductively reactive means for forming a loop circuit resonant to a frequency below said undesired wave signal frequency, a resonant circuit including said purely capacitive means and energized only by the signal across said capacitive means, said last-named circuit being tunable to the frequency of said desired wave signal, and a connection between said input circuit and said tuned circuit.

6. In a radio receiving system, a source of desired wave signals and undesired wave signals, said undesired signals having a higher frequency than said desired signals, a space discharge device having an input circuit, means for transferring said desired signals from said source to said input circuit and for minimizing the transfer of undesired signals comprising a transformer having a primary winding connected to said source and a secondary winding for forming an effective signal source having an effective inductive reactance in series therewith, purely capacitively reactive means serially connected to said effective source and said inductively reactive means for forming a loop circuit resonant to a frequency below said undesired wave signal frequency, a resonant circuit including an inductively reactive element and said purely capacitive means, said last-named circuit being energized only by the signal across said capacitive means and being tunable to the frequency of said desired wave signal, and connections for supplying a signal from said capacitively reactive element to said input circuit.

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