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IMAGE FREQUENCY REJECTION SYSTEM

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Fig. 1

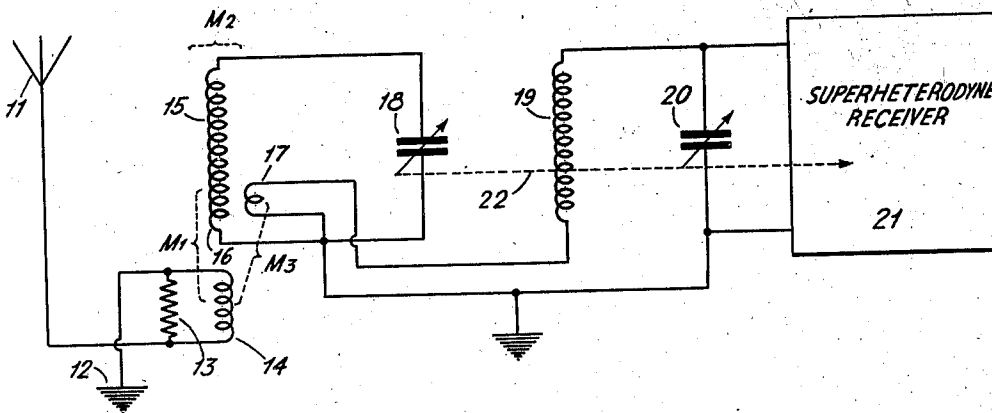
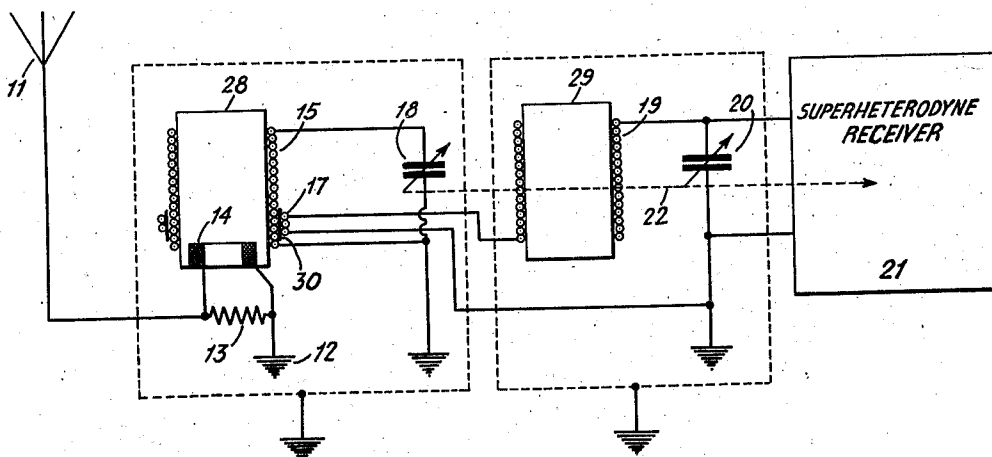


Fig. 2



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IMAGE FREQUENCY REJECTION SYSTEM

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ware

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14 Claims. (Cl. 250—20)

The present invention relates to the selection of a radio-frequency signal being transmitted on one carrier frequency and the simultaneous reduction of interference being transmitted on other frequencies not greatly different from the frequency of the desired signal.

This invention contemplates the provision of two coupling paths between the antenna circuit and the first tube of a radio receiver. The first coupling path comprises a highly selective coupling circuit and the second path comprises an aperiodic coupling. The couplings which are in phase opposition are so proportioned as to be equal for currents of a frequency differing by any desired amount from the desired signal frequency to which the selective coupling circuit is tuned.

The invention is particularly applicable to a superheterodyne type of receiver. It is well known that the superheterodyne receiver is sensitive to signals of two frequencies when set to receive any given frequency. The two frequencies differ from each other by twice the amount of the off-set or intermediate frequency to which the intermediate-frequency amplifier is permanently tuned.

It is a common practice to employ a signal selecting system to amplify the desired frequency of the two carrier frequencies to which the superheterodyne receiver responds, the desired frequency herein being called the signal frequency, and which signal selecting system attenuates the undesired carrier frequency or disturbance occurring at the other frequency, herein called the "image" frequency.

The relative attenuation of the "image" frequency can be increased by simultaneously tuning several selective circuits to the signal frequency. However, if the station transmitting at the "image" frequency comes in rather strong, it is difficult to differentiate between the signal and "image" frequencies.

It is the object of the present invention to overcome this disadvantage in a superheterodyne receiver and provide a circuit for suppressing currents of the "image" frequency.

This and further objects of this invention will become apparent from the following specification and claims taken in connection with the accompanying drawing.

In accomplishing the objects of this invention the undesired "image" frequency currents are attenuated by a special arrangement of two coupled tuned circuits constituting the preselector of a radio receiver in place of those which

are generally used to selectively couple the antenna to the first tube of said receiver. More specifically, the inductance coil of the first of the two tuned circuits is inductively coupled to an antenna circuit primary coil and is also inductively coupled to a coupling coil included in the second tuned circuit. An element of the invention in its preferred form resides in positioning this latter mentioned coil relative to the other two coils so that when the first tuned circuit is tuned to a certain signal frequency, an "image" frequency signal causes two equal and opposite voltages to be induced in the coupling coil at the "image" frequency, thus minimizing the resultant voltage at the "image" frequency. This results in a great attenuation of the "image" frequency currents over and above that due to the inherent selectivity of the first tuned circuit.

The first two tuned circuits may be individually shielded and the coupling coil may constitute a very few turns of wire coupled to the first tuned circuit. Alternatively the coupling coil may constitute the entire inductance of the second tuned circuit. By means of the circuits just described the "image" frequency currents may be greatly attenuated without any detriment to the sensitivity of the receiver to the desired signal.

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

Fig. 1 is a circuit diagram of a preselector circuit for providing "image" frequency suppression in accordance with this invention;

Fig. 2 shows the circuit of Fig. 1 illustrating the preferred structural details of the inductances employed.

Referring now to Fig. 1, there is shown an antenna or input circuit coupled to a superheterodyne receiver by a tuned preselector. The antenna circuit comprises antenna 11, ground connection 12, primary coil 14 and damping resistance 13. This antenna circuit is designed in accordance with U. S. Patent No. 1,852,710 to L. A. Hazelbline.

The first tuned circuit comprises secondary coil 15 and variable condenser 18 connected in a closed series circuit. The primary coil 14 is inductively coupled to the ground end 16 of tuned coil 15. The second tuned circuit comprises coil 19, variable condenser 20, and coupling coil 17, connected in a closed series circuit. The coupling coil 17 is coupled to tuned coil 15 in a manner which will be described in more detail below. The second tuned circuit is connected to the superheterodyne receiver 21. The

first and second tuned circuits may be tuned simultaneously by unicontrol means 22, which is preferably extended to also tune the receiver 21.

In Fig. 2, which shows the same circuit as Fig. 1, corresponding elements are designated by the same reference characters. The two figures are identical except that in Fig. 2 the two pre-selector coil assemblies are shown in cross-section, thereby showing a preferred arrangement of the coils. Secondary coil 15 is a single-layer helical coil wound on a cylindrical form 28. Coil 14 is a high inductance multi-layer coil mounted co-axially in one end of form 28. Coupling coil 17, consisting of a relatively few turns is wound over a portion of coil 15, and is separated therefrom by insulating material 30. In this figure, the two tuned circuits are shown as enclosed by individual shields indicated by dotted lines.

The mutual inductances between coils will be designated as follows:

M_1 between coils 14 and 15.

M_2 between coils 15 and 17.

M_3 between coils 14 and 17.

Referring to Fig. 1, the operation at the signal frequency may be explained as follows. The two tuned circuits are tuned to the signal of the desired frequency by means of condensers 18 and 20. The receiver 21 is also tuned to the signal. The signal currents are transferred by M_1 from antenna circuit to first tuned circuit, where they are built up by resonance to a much greater value. A voltage is induced in coil 17 through M_2 , and a second resonant current is built up in the second tuned circuit. The resulting voltage across condenser 20 is coupled to the receiver 21. The voltage induced in coil 17 directly through M_3 is negligible because the antenna current in coil 14 is so much smaller than the resonant current in coil 15, at the signal frequency.

Having tuned the system of Fig. 1 to the signal frequency, the superheterodyne receiver is also incidentally sensitive at the "image" frequency which is herein assumed to be higher than the signal frequency and which differs therefrom by twice the intermediate frequency. The behavior of the preselector toward "image" frequency signals may be explained as follows. The antenna current in coil 14 induces a voltage in coil 15 due to M_1 and in coil 17 due to M_3 . A current is thereby caused to flow in the first tuned circuit, which induces another voltage in coil 17 due to M_2 . The first tuned circuit is not resonant at the "image" frequency and therefore the image frequency current incidentally induced therein is comparable with the antenna current. By adjusting any one or more of the values M_1 , M_2 and M_3 , a combination is found which makes equal and opposite the two voltages which are induced in coil 17. As a result, the "image" frequency signal is not transferred to the second tuned circuit and to the receiver 21, but is substantially completely suppressed.

The condition for complete "image" suppression is given by the equation:

$$\frac{M_1 M_2}{M_3 L} = 1 - \frac{f_1^2}{f_2^2}$$

in which L is the inductance of coil 15, f_1 is the desired signal frequency, and f_2 is the undesired "image" frequency. In a great many broadcast receivers, f_1 lies within 550 to 1500 kilocycles, and the intermediate frequency lies within 125 to 550 kilocycles. In these cases, the right side of the equation lies between 0.26 and 0.89, and is there-

fore on the order of 0.5, being always less than unity and greater than zero.

The above equation indicates the desired condition that the product $M_1 M_2$ should be on the order of one-half the product $M_3 L$, and should always be less than $M_3 L$. This relation may be satisfied by a number of coil arrangements in space. Fig. 2 shows a preferred arrangement, and has been described in a general way, with reference to Fig. 1. The above equation is easily satisfied by the following conditions and experimental procedure. Coils 14 and 17 are both displaced in the same direction from the center of coil 15, and coil 14 is displaced farther than coil 17. In other words, the center of coil 17 is located between the centers of coils 14 and 15. The value of M_1 required for effective signal transfer is first obtained, by the correct distance between centers of coils 14 and 15. Leaving these coils fixed, coil 17 is moved along the surface of coil 15 until a position is found where the "image" frequency is balanced out. In this procedure, M_1 and L are unchanged, while M_2 and M_3 vary in opposite directions, there being only one position of coil 17 which satisfies the above equation and results in balancing out the "image" frequency. In an experiment using a 1000 kilocycles signal and 125 kilocycle intermediate frequency, the correct position of the coil 17 was found to be about one-eighth of the way along secondary coil 15, from the ground end 16.

In a given receiver, f_1 and f_2 vary over a wide range but their difference is constant, equal to twice the intermediate frequency. Therefore the ratio f_1^2/f_2^2 varies somewhat with tuning. Using the specific circuits of Figs. 1 and 2, the same positioning of coils 14, 15 and 17 will not exactly balance out the "image" frequency over the entire tuning range. In this case, the coils are positioned to exactly balance out the "image" at one point in the tuning range, whereby considerable "image" attenuation may be secured over the entire tuning range.

While the term "superheterodyne receiver" has been used to refer to the element 21, it is equally applicable to the entire system, including antenna, preselector, and receiver.

Whereas this invention, as described, is applicable to the preselector circuit of a superheterodyne radio receiver, it is to be understood that the principles involved are equally applicable to any selector network for use in connection with any type of receiver or to interstage coupling circuits for use generally with any radio responsive devices.

I claim:

1. In a superheterodyne radio receiver, means for attenuating image frequency currents, which comprise a single signal input circuit, a circuit tuned to the desired frequency and coupled to said input circuit for building up by resonance current of the signal frequency impressed on said input circuit and incidentally transferring current of the image frequency, and a coupling coil coupled to said tuned circuit and aperiodically coupled to said input circuit, said couplings being proportioned to induce in said coil equal and opposite voltages in response to image frequency currents in said input circuit.

2. In a superheterodyne radio receiver, means for attenuating image frequency currents, which comprise a single signal input circuit, a circuit tuned to the desired frequency and inductively coupled to said input circuit for building up by resonance current of the signal frequency im-

pressed on said input circuit and incidentally transferring current of the image frequency, and a coupling coil inductively coupled to said tuned circuit and aperiodically coupled to said input circuit, said couplings being proportioned to induce in said coil equal and opposite voltages in response to image frequency currents in said input circuit.

3. A selector network for selecting currents of frequency f_1 and attenuating currents of frequency f_2 , comprising a primary coil, a secondary coil tuned to f_1 and having inductance L , and a coupling coil; said coils having mutual inductance M_1 between primary and secondary, mutual inductance M_2 between secondary and coupling coil, and mutual inductance M_3 between primary and coupling coil; the voltages induced in the coupling coil by currents of f_2 in the primary and secondary coils being at least partially balanced out by positioning the coils to make M_1M_2 on the order of one-half of M_3L .

4. A selector network for selecting currents of frequency f_1 and rejecting currents of frequency f_2 , comprising a primary coil, a secondary coil tuned to f_1 and having inductance L , and a coupling coil; said coils having mutual inductance M_1 between primary and secondary, mutual inductance M_2 between secondary and coupling coil, mutual inductance M_3 between primary and coupling coil, and being positioned so that the equation

$$\frac{M_1M_2}{M_3L} = 1 - \frac{f_1^2}{f_2^2}$$

is satisfied, whereby the voltages induced in the coupling coil by currents at f_2 in the primary and secondary coils are balanced out in the coupling coil.

5. A selector network for selecting currents of a desired frequency and attenuating currents of an undesired frequency, comprising a single signal input circuit, a first circuit tuned to the desired frequency for building up by resonance current of the signal frequency impressed on said input circuit and incidentally transferring current of the undesired frequency, and a second circuit tuned to the desired frequency for further building up by resonance current of the signal frequency, said first tuned circuit being coupled to said input circuit and said second tuned circuit being coupled to said first tuned circuit and aperiodically coupled to said input circuit, said couplings being so proportioned that currents of the undesired frequency in the input circuit cause two opposing voltages of such undesired frequency to be induced in said second tuned circuit.

6. A selector network for selecting currents of a desired frequency and attenuating currents of an undesired frequency, comprising a single signal input circuit, a first tuned circuit tuned to the desired signal frequency for building up by resonance current of the desired frequency impressed on said input circuit and incidentally transferring current of the undesired frequency, and a second tuned circuit tuned to the signal frequency for further building up by resonance current of the desired frequency, said first tuned circuit being inductively coupled to each of the other circuits and said second tuned circuit being aperiodically coupled to said input circuit, said couplings being so proportioned that currents of the undesired frequency in the input circuit cause two equal and opposite voltages of such undesired frequency to be induced in the second tuned circuit.

7. A preselector circuit for transferring desired currents, but not image frequency currents, from an antenna to a superheterodyne receiver, comprising a primary coil connected to said antenna, a helical secondary coil tuned to the desired frequency and having one end coupled to the primary coil, and a coupling coil coupled to said receiver, said coupling coil having relatively few turns wound over the secondary coil in a position intermediate the ends thereof, said position being chosen to minimize the voltage induced in the coupling coil at the image frequency.

8. A preselector circuit for transferring desired currents, but not image frequency currents, from an antenna to a superheterodyne receiver, comprising a primary coil connected to said antenna, a helical secondary coil tuned to the desired frequency and having one end coupled to the primary coil, and a coupling coil coupled to said receiver, said coupling coil having relatively few turns wound over the secondary coil in a position about one-eighth the way along the secondary coil from said end.

9. In a superheterodyne radio receiver, means for attenuating image frequency currents, which comprise a single antenna circuit including an inductance; a first tunable circuit for building up by resonance current of the signal frequency impressed on said antenna circuit and incidentally transferring current of the image frequency, said circuit including a variable condenser and an inductance inductively coupled to said antenna inductance; a second tunable circuit including a variable condenser and an inductance coupled to said antenna inductance and aperiodically coupled to the inductance of said first tunable circuit; and a superheterodyne receiver coupled to said second tunable circuit, the mutual inductances of said circuits being so chosen that equal and opposite currents are transferred to the second tunable circuit from the first tunable circuit and the antenna circuit, respectively, at the image frequency.

10. In a superheterodyne radio receiving system, means for attenuating image frequency currents, which comprise a single antenna circuit including an inductance; a first tunable circuit for building up by resonance current of the desired frequency impressed on said antenna circuit and incidentally transferring current of the image frequency and comprising an inductance and a variable condenser, said last-mentioned inductance being inductively coupled to the inductance of said antenna circuit; a second tunable circuit comprising an inductance, a coupling coil inductively coupled to the inductance of said first tunable circuit and aperiodically coupled to the inductance of said antenna circuit, and a variable condenser; and a superheterodyne receiver connected in shunt across said last-mentioned variable condenser, the mutual inductances of said circuits being so chosen that equal and opposite currents are transferred to the second tunable circuit from the first tunable circuit and the antenna circuit, respectively, at the image frequency when both of said tunable circuits of said receiver are tuned to receive currents of a desired signal frequency.

11. In a superheterodyne radio receiving system, means for attenuating image frequency currents, which comprise a single antenna circuit including a high inductance; a first tunable circuit for building up by resonance current of the desired frequency impressed on said antenna cir-

5 cuit and incidentally transferring current of the
 image frequency and comprising an inductance
 and a variable condenser, said last-mentioned
 inductance being inductively coupled to the in-
 10 ductance of said antenna circuit, a second tunable
 circuit comprising an inductance, a coupling coil
 inductively coupled to the inductance of said
 first tunable circuit and aperiodically coupled to
 the inductance of said antenna circuit, and a
 15 variable condenser; and a superheterodyne re-
 ceiver connected in shunt across the last-men-
 tioned variable condenser, both of said variable
 condensers being connected for uni-control oper-
 ation together with the tuning elements of said
 20 receiver, the mutual inductances of said circuits
 being so chosen that equal and opposite currents
 are transferred to the second tunable circuit from
 the first tunable circuit and the antenna circuit,
 respectively, at the image frequency when both
 25 of said tunable circuits of the receiver are tuned
 to receive currents of a desired signal frequency.
 12. In a superheterodyne radio receiver, means
 for attenuating image frequency currents, which
 comprise a single antenna circuit, a first tunable
 30 circuit coupled to said antenna circuit for build-
 ing up by resonance current of the desired signal
 frequency impressed on said antenna circuit and
 incidentally transferring current of the image
 frequency, and a second tunable circuit aperiodi-
 cally coupled to said antenna circuit and coupled
 to said first tunable circuit, said couplings being
 so proportioned that when said tunable circuits

are tuned to receive a desired signal frequency,
 equal and opposite voltages at the image fre-
 quency are transferred from said antenna circuit
 and said first tunable circuit to said second tun-
 able circuit.

13. In a superheterodyne radio receiver, means
 for attenuating image-frequency currents com-
 prising a single signal input circuit, a coupling
 coil, a path between said circuit and said coil in-
 10 cluding means for building up by resonance cur-
 rent of a desired signal frequency impressed on
 said input circuit and effective incidentally to in-
 duce in said coil a voltage of the image frequency,
 and an aperiodic coupling path between said cir-
 15 cuit and said coil for inducing in said coil a volt-
 age of the image frequency equal and opposite
 to said first-mentioned image-frequency voltage.

14. In a superheterodyne radio receiver, means
 for attenuating image-frequency currents com-
 prising a single signal input circuit, a coupling
 coil, a path between said circuit and said coil in-
 20 cluding means for building up by resonance cur-
 rent of a desired signal frequency impressed in
 said input circuit and effective incidentally to
 induce in said coil a voltage of the image fre-
 25 quency, and a fixed aperiodic coupling path be-
 tween said circuit and said coil for inducing in
 said coil a voltage of the image frequency equal
 and opposite to said first-mentioned image-fre-
 30 quency voltage.

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