Oct. 27, 1953 A. J. RUNFT 2,657,310

ANTENNA COUPLING NETWORK

Filed Dec. 5, 1950 2 Sheets-Sheet 1

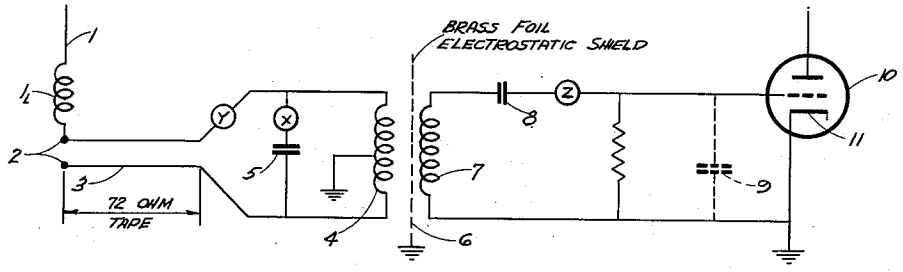


Fig. 1

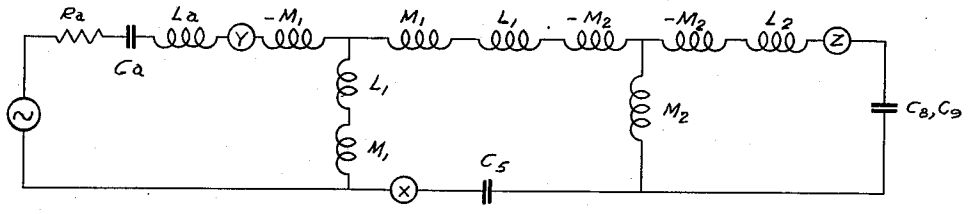


Fig. 2

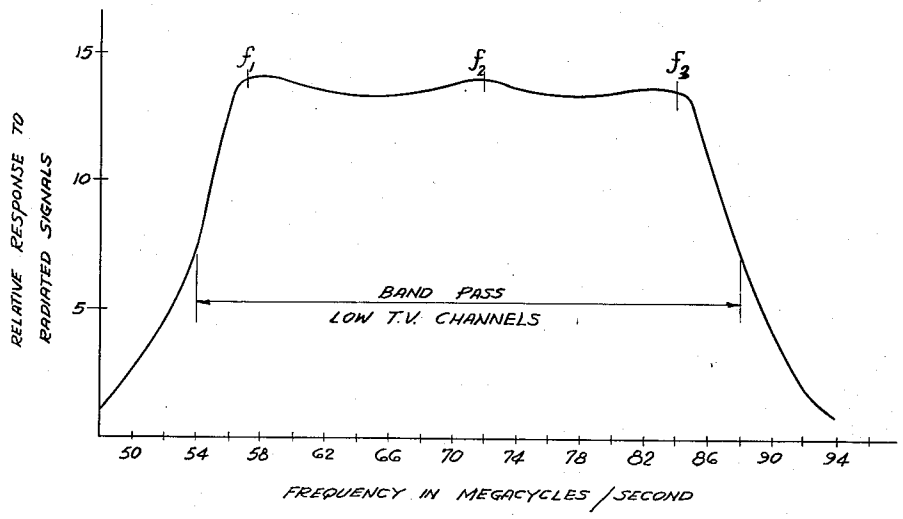


Fig. 3

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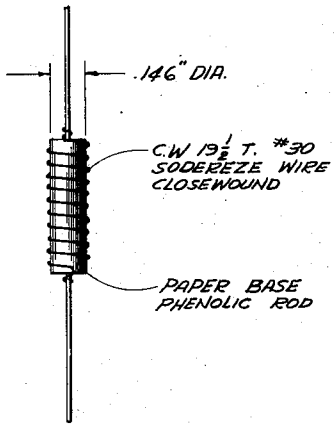


Fig. 4

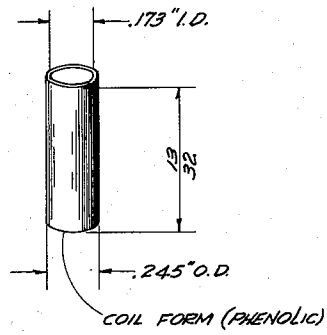


Fig. 5

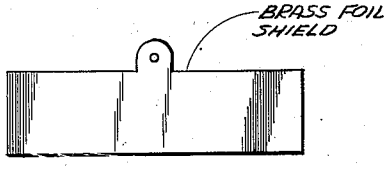


Fig. 7

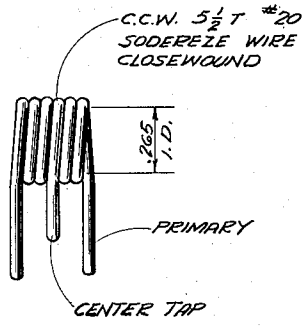


Fig. 6

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ANTENNA COUPLING NETWORK

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5 Claims. (Cl. 250—33)

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My invention relates broadly to passive networks and in particular, to a high frequency magnetically coupled triple-tuned receiver input system.

Double-tuned receiver input circuits have been used in the prior art. However, very little work seems to have been done in connection with increasing the selectivity and average gain of such circuits in combination with a rod type of built-in antenna. Especially is this true in the television art.

It is a primary object of my invention to provide an R. F. tuner input system which will have a substantially uniform response to radiated signals in a desired pass-band, said signals being received on either a single built-in rod type of antenna or on a balanced external type of antenna.

It is also an object of my invention to provide a new and improved circuit for coupling a single built-in rod antenna or a conventional balanced external antenna to the R. F. amplifier or converter tube in a television receiver.

It is a still further object of my invention to provide a new and improved means for coupling a built-in rod type of antenna to an input circuit in such a manner as to provide a high degree of skirt attenuation as well as a higher average gain than is provided by circuits of the prior art.

It is a still further object of my invention to provide a double-tuned over-coupled antenna transformer designed for 72 ohm balanced input and a high impedance single-ended output, which functions with a built-in rod type of antenna in such a manner as to form a triple-tuned input circuit.

For a better understanding of the present invention, together with other and further objects, advantages and capabilities thereof, reference is made to the following disclosure and appended claims, in connection with the accompanying drawings, in which:

Fig. 1 is a circuit diagram of my triple-tuned input circuit showing the points at which the circuit is opened for adjusting each tuned circuit;

Fig. 2 is an equivalent diagram of the circuit shown in Fig. 1.

Fig. 3 is a curve showing the response and band-pass characteristics of the circuit in Fig. 1 when used in conjunction with a rod type built-in antenna.

Figs. 4, 5, 6 and 7 show the components from which a specific coupling transformer was assembled.

Referring to Fig. 1, I have there shown a portion of a television receiver input circuit incor-

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porating a specific embodiment of my invention. A rod type antenna 1 is connected to one terminal of a balanced antenna input plug 2. The balanced antenna input plug 2 is connected through transmission line 3 to the primary 4 of an over-coupled input transformer in such a manner as to allow the use of either a balanced antenna, not shown, or a rod type antenna, such as antenna 1. Capacitor 5, which is connected across primary 4, is provided for tuning the primary circuit. An electrostatic shield 6 effectively eliminates capacitive coupling between primary winding 4 and secondary winding 7. The secondary winding 7 is tuned to band center by capacitor 8 in series with the input capacitance of tube 10, which might be either an R. F. amplifier or the converter. Also, secondary winding 7 is series tuned by capacitor 8 to the I. F. frequency, thereby producing a low impedance between the grid of tube 10 and ground at such frequency. This eliminates regenerative or degenerative effects brought about by I. F. feedback through the plate to grid capacitance of tube 10. The primary 4 has a center tap connected to ground while secondary 7 has one side connected to the grounded cathode 11 of tube 10, thereby providing a balanced to unbalanced input system. The shield 6 is also connected to ground.

It should now be obvious that the circuit which has so far been described, with the exception of antenna 1, is essentially a double-tuned magnetically overcoupled input circuit, having a typical double-humped gain characteristic. However, when antenna 1 is connected into the system, and the various circuits are tuned in a manner to be hereinafter explained, a triple-tuned magnetically overcoupled system obtains.

In Fig. 1 there are three circuits which are tuned to the approximate geometric mean of the selected band-pass frequency. The closed primary loop including capacitor 5 constitutes the first of these three tuned circuits. The secondary 7 along with capacitor 8 in series with the input capacitance 9 of tube 10 makes up the second of the three tuned circuits. The effective capacitive reactance to ground of antenna 1 and one lead of tranmission line 3 in combination with the inductance of one half of grounded primary 4 makes up the third and last of the three tuned circuits. It should be noted that transmission line 3 is not necessary if the antenna connections are made directly to primary winding 4.

The first two of the above mentioned tuned circuits form a double-tuned coupling circuit which must be capable of passing a given frequency band

when used with a balanced external type of antenna. The band width of the double-tuned transformer is primarily dictated by the band-pass requirements for connection to the balanced external type antenna and, as will now be shown, there is only one design coupling variable, K_1, which is available to determine the band-pass characteristics of the circuit when it is used with a built-in rod antenna 1.

Any two circuits which are coupled by a common impedance must have a coefficient of coupling K equal to the ratio of the common impedance to the square root of the product of the total impedances of the same type as the common impedance, which are present in the coupled circuits. In other words, if Z_m is the common impedance between two coupled circuits and Z_1 and Z_2 represent the total impedances of the same type in the coupled circuits, then

$$(1) \qquad K=\frac{Z_m}{\sqrt{Z_1 Z_2}}$$

Using Equation 1, the coupling coefficient K_1 of the circuit of Fig. 1 can now be developed from the equivalent circuit diagram Fig. 3, where R_a represents the resistance of rod type antenna 1; C_a represents the series capacitance of antenna 1; L_a represents the series inductance of antenna 1; L_1 represents the inductance of one half of primary winding 4; M_1 represents the mutual inductance between the two halves of the primary winding 4; M_2 represents the mutual inductance between the primary 4 and the secondary 7 and and L_2 represents the inductance of secondary 7. Substituting the values of Fig. 3 in Equation 1, it can be seen that,

$$(2) \quad K_1=\frac{L_1+M_1}{\sqrt{(L_1+L_a)\ (2L_1+2M_1)}}=\sqrt{\frac{L_1+M_1}{2(L_1+L_a)}}$$

In other words, increasing the turns on primary 4, that is increasing L_1, with the resultant increase in M_1 along with decreasing the antenna rod length, that is, decreasing L_a, tends to increase the coupling coefficient K_1, thereby increasing the responsive band width of the system when it is used with a rod type of antenna.

It may not always be convenient to adjust the length of antenna 1 in order to realize the correct antenna inductance L_a. Therefore I have included an inductance coil 1_L, in the circuit diagram of Fig. 1 which can be used to add inductance in the antenna circuit, if it be necessary to keep antenna 1 so short, because of cabinet design, that the antenna itself does not furnish sufficient inductance.

In Figs. 4, 5, 6 and 7 I have shown the coil data used in a specific embodiment of Fig. 1. The complete transformer was assembled by first placing secondary coil, Fig. 4, inside of the coil form Fig. 5. The brass foil shield, Fig. 7, was first covered with a thin sheet of insulating material so that it could not act as a shorted turn, magnetically speaking, and then it was wrapped around the outside of the coil form. Then the primary coil, Fig. 6, was placed over the brass shield.

The design of the transformer can be checked by testing the resonant frequency of each tuned circuit separately. Though variable capacitances are not used in the circuit and though it is not practical, because of the long lead length required, to use a variable capacitance for testing purposes in each tuned circuit, various capacitances may be connected into place until the correct capacitance is found that will cause the tuned circuit under test to resonate at the proper frequency. The resonant frequency of the tuned circuits in Fig. 1 may be each checked separately in the following manner:

1. The primary and secondary circuits are opened at terminals X and Z. The circuit which comprises antenna rod 1, one lead of transmission line 3 and one half of primary 4 is then tuned as a loaded quarter-wave configuration by adjusting the length of antenna rod 1 to the geometric mean of the given band frequency. Tuning may be done by observing the dip in a megacycle meter coupled to the grounded (high current) end of the rod or to the lead-in transmission line tape.

2. Next, terminal X is reconnected and terminals Y and Z are opened. The primary resonance of capacitor 5 and winding 4 is then adjusted at the geometric mean of the given frequency band.

3. Then, terminal Z is reconnected and terminals X and Y are opened. The circuit comprising secondary 7 along with capacitor 8 in series with input capacitance 9 is then adjusted to resonate at the geometric mean of the given frequency band.

After the circuits of Fig. 1 are tuned and properly connected for operation with a rod type antenna, a triple-tuned, overcoupled band pass response to radiated signals obtains and three resonant frequency peaks distributed across the band pass are indicated when the circuit is tested with a megacycle meter. In a specific embodiment of the circuit of Fig. 1, using a transformer made up from the components shown in Figs. 4, 5, 6 and 7, the units were tuned to the geometric mean of a frequency band extending from 54 megacycles to 88 megacycles. As can be seen in Fig. 3 the three peaks occur at approximately 57, 72, and 84 megacycles to give a resultant characteristic having greater average gain in the pass band and greater skirt attenuation than would be possible with a conventional double-tuned circuit.

Thus it will be seen that I have provided a circuit combination comprising a double-tuned electrostatically shielded magnetically overcoupled input circuit having a primary winding which is center tapped to ground (4, 5, 6, 7, 8, 9 and 10), a non-reflecting transmission line 3 connected to said input circuit, one side of said transmission line 3 and one half of said primary winding 4 having such a reactance as to form a resonant configuration tuned to the geometric mean of a given frequency band when connected to a rod type antenna 1.

While I do not desire to be limited to any specific circuit parameters such parameters varying in accordance with individual designs, the following circuit values have been found entirely satisfactory in the illustrated embodiment of the invention:

1—Approximately 37'' of #14 tinned copper buss (shorter if used with series inductance as loading coil) (controls value of L_a).
3—3½ inches of 72-ohm balanced transmission line.
4—Coil as shown in Fig. 6 (plain copper wire may be used in lieu of "sodereze" as shown on drawing).
5—33 micromicrofarads.
7—Coil as shown in Fig. 4 (plain copper wire may be used in lieu of "sodereze" as shown on drawing).
8—33 micromicrofarads.

9—Input capacity of one 12AT7 section plus wiring (approximately 5 micromicrofarads).
10—One triode section of a 12AT7 tube operated as a converter.

While there has been shown and described what at present is considered the preferred embodiment of the present invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention as defined by the appended claims.

Having thus described my invention I claim:

1. In a receiver the combination comprising a double-tuned electrostatically shielded magnetically over-coupled input circuit having a primary winding which is center-tapped to ground and tuned to the geometric mean frequency of a given frequency pass-band and a secondary winding tuned to said geometric mean frequency, a non-reflecting transmission line connected to said input circuit, one side of said transmission line and one half of said primary winding having reactance parameters which form a resonant configuration tuned to the geometric mean of said frequency band when connected to a rod type antenna having inherent reactance to ground.

2. In a receiver for receiving signals over a given frequency band, the combination comprising a center-tapped primary and a secondary winding connected to form an overcoupled double-tuned input system having two tuned circuits each being tuned to the geometric mean frequency of a given frequency band, a transmission line connected between said input system and a balanced antenna input plug, one-half of said center-tapped primary and one side of said transmission line being tuned with a rod type antenna to the geometrical mean of said given frequency band, whereby the input system when attached to said rod antenna forms a triple-tuned circuit.

3. In a receiver for receiving signals over a given frequency band, the combination comprising a capacitor tuned primary winding and a secondary winding being connected and adjusted to form an overcoupled double-tuned input circuit wherein the primary and secondary windings are each tuned to the geometric mean frequency of a given frequency band, said primary winding being center-tapped to ground, a transmission line connecting said input circuit to a balanced antenna input plug and a rod type antenna connected to one terminal of said plug, one-half of said center-tapped primary and one side of said transmission line being tuned with said rod type antenna to the geometrical mean of said given frequency band, whereby the input circut when attached to said rod antenna forms a triple-tuned circuit.

4. In a receiver for receiving signals over a given frequency pass-band the combination comprising a first circuit tuned to the geometric mean frequency of said given frequency pass-band consisting of a capacitor tuned primary winding having a grounded center-tap, a second circuit tuned to the geometric mean frequency of said given frequency pass-band which is magnetically overcoupled to and electrostatically shielded from said primary winding consisting of a capacitor tuned secondary winding, and a third circuit tuned to the geometric mean frequency of said pass-band frequency comprising a rod-type antenna, one side of a transmission line, one-half of said primary winding and the inherent antenna reactance to ground.

5. In a receiver for receiving signals over a given frequency pass-band the combination comprising a first circuit tuned to the goemetric mean frequency of a given frequency pass-band consisting of a capacitor tuned primary winding having a grounded center-tap, a second tuned circuit tuned to the geometric mean frequency of said given frequency pass-band which is magnetically over-coupled to and electrostatically shielded from said primary winding consisting of a capacitor tuned secondary winding, and a third circuit tuned to the geometric mean frequency of said pass-band frequency comprising a rod-type antenna, one-half of said primary winding and the inherent antenna reactance to ground.

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