

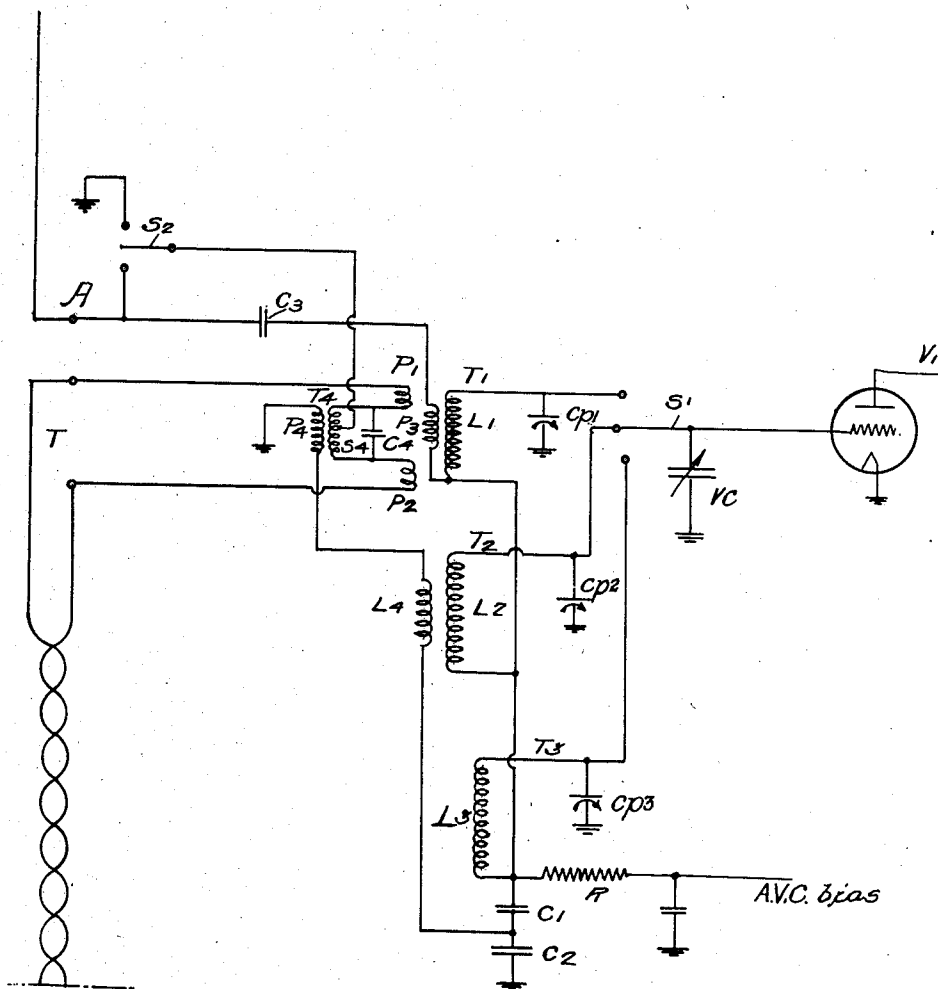
May 23, 1939.

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2,159,546

ANTENNA COUPLING DEVICE FOR RADIO RECEIVERS

Filed Dec. 5, 1936



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UNITED STATES PATENT OFFICE

2,159,546

ANTENNA COUPLING DEVICE FOR RADIO RECEIVERS

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Application December 5, 1936, Serial No. 114,486

11 Claims. (Cl. 250—20)

This invention relates to antenna coupling devices for radio receivers and has for its principal object the provision of novel means for coupling any one of several different types of antennae to a multiband receiver which is adapted to receive signals in a plurality of different wave-

An important feature of the invention, resides in the simplicity of the switching means for adapting the radio receiver to receive signals in different wave-bands. The invention is characterized particularly by the elimination of switching means in the input circuit of the device for adapting the receiver to receive signals in the different wave-bands. More particularly, the invention makes possible the use of a simple switching means adapted to modify the several secondary circuits to adapt the receiver for multiband reception, there being no other switching means required for this purpose.

Another important feature of the invention resides in its adaptability to transfer signals from any one of three different types of antennae, viz., a conventional single-wire antenna, an antenna of the type employing a balanced transmission line, and the so-called "doublet antenna" which has different operating characteristics at different frequencies as hereinafter mentioned. By means of the invention, it is possible to adapt the radio receiver for use with any one of these different types antennae by means of a single circuit modification as hereinafter described.

A further feature of the invention resides in the use of the self-impedance of the transmission line of the doublet antenna as a part of the coupling impedance of the circuit when this antenna is operating at relatively low frequencies.

Other objects and features of the invention will be apparent from the following description and the accompanying drawing in which the single figure is a diagrammatic illustration of one form of the invention.

Any antenna for a radio receiver is subject to two principal criteria which are, first, the ability of the antenna to pick up radiated signals and, second, the ability of the antenna lead-in to reject or refrain from picking up undesired noise signals. With this in mind, the several different antennae may be considered.

As is well known, the conventional capacity antenna may comprise one or more strands of wire suspended horizontally above the ground as high as possible with a single lead-in wire extending from the antenna to the radio receiver. The potential of the antenna as a whole varies

with respect to ground in accordance with the radiated signals picked up by the antenna, and these signals are transferred by the lead-in conductor so that at the receiver end of the lead-in, there is established between the lead-in and ground a potential difference which is proportional to the signal picked up by the antenna and its associated lead-in. Such an antenna system is quite efficient in the reception of signals in the low frequency bands, for example signals ranging in frequency from about 150 k. c. to about 1700 k. c. This type of antenna is not very efficient in the reception of signals in the short-wave band, however, for example signals having frequencies above 2 megacycles. Moreover, such an antenna system has no noise-reducing properties.

The more modern so-called "all-wave antenna" comprises a multi-section balanced antenna and a balanced transmission line coupled to the antenna by means of a coupling device which serves to match the impedance of the antenna to that of the transmission line when the antenna is operating to receive short-wave signals and serves also to convert potential variations of the antenna with respect to ground into a circulating current in the transmission line which supplies the signal to the receiving set. Such an antenna system is highly efficient in the reception of both long and short wave signals and it also has the advantage that the balanced transmission line is substantially free of noise pick-up. The potential difference between the two terminals of the transmission line at the receiving set varies in accordance with the received signal but the line is balanced to ground so that one of these terminals will always be positive with respect to ground by the same amount that the other terminal is negative with respect to ground.

The simple doublet antenna may comprise two horizontal lengths of wire, each of which may, for example, be 30 feet long, the mid point of which is connected to a transmission line through a suitable impedance-matching element or device. Such an antenna operates as a doublet antenna for short-wave signals and, during such operation, circulating currents are induced in the transmission line. In the reception of long-wave signals, however, the device operates as a capacity antenna and, during such reception, there is no potential difference between the terminals of the transmission line at the receiving set but the potential of both terminals varies with respect to ground.

Each of these various types of antennae are

conventional and are available at the present time in different specific forms. The circuit provided by the present invention is adapted to transfer signals from any one of these different types of antennae or signal collectors to a suitable selective circuit and amplifying stage of a radio receiver.

Referring now to the drawing, there is provided a coupling device comprising three tuned circuits T_1 , T_2 and T_3 which are adapted to transfer signals in different wave-bands and whose respective inductances L_1 , L_2 and L_3 are adapted to be tuned to a desired signal frequency in the short-wave, broadcast and long-wave signal bands, respectively, by means of the tuning condenser VC. There is also provided a transformer T_4 whose primary winding P_4 is connected to ground and to the winding L_4 and whose secondary S_4 is connected between the primary windings P_1 and P_2 which are inductively associated with the inductance L_1 . The windings P_1 and P_2 are connected to terminals T, as clearly illustrated. The mid point of the secondary winding S_4 is connected to a two-position switch S_2 having selectable contacts connected respectively to ground and to terminal A. The terminal A is also connected through condenser C_3 to the winding P_3 inductively associated with the inductance L_1 and also connected thereto.

In order to adapt the receiving set to receive signals in any one of the several frequency bands, there is provided a wave-band switch S_1 which serves to connect the input element of the amplifier stage V_1 to any one of the tuned circuits T_1 , T_2 and T_3 . The variable condenser VC may be permanently connected to the input element if desired. One end of each of the inductances L_1 , L_2 and L_3 may be connected together and to ground through two coupling condensers C_1 and C_2 . The winding L_4 may be connected to a point between the two condensers as illustrated. The condensers C_{p1} , C_{p2} and C_{p3} are padding condensers associated respectively with the three tuned circuits.

A suitable bias for the amplifier stage V_1 , such as an automatic volume control bias, may be applied to the input element of the vacuum tube stage by means of an isolating resistor R connected to the common point of the inductances L_1 , L_2 and L_3 .

When it is desired to use the receiving set with a conventional capacity antenna having a single lead-in conductor, the lead-in may be connected to the terminal A and the switch S_2 should then be thrown to its lowermost position so as to connect to the terminal A. When it is desired to use the receiving set with either of the other two types of antennae above mentioned, the transmission line in each case may be connected to the terminals T. When an antenna employing a balanced transmission line is used, the switch S_2 should be thrown to its upper position so as to connect to ground. When the simple doublet antenna is used, however, the switch S_2 should be thrown to its lower position.

The device is adapted to operate with the different types of antennae as follows: Let it be assumed first that the device is being used with an antenna having a balanced transmission line. As stated above, the transmission line will be connected to the terminals T and the switch S_2 will be thrown to its upper position so as to ground the mid-point of the secondary winding S_4 . The circulating currents in the transmission line will flow through the primary windings

P_1 and P_2 and will induce signals in L_1 , which signals will be supplied to the input element of the amplifying stage V_1 . For the reception of signals in the short-wave band, the switch S_1 will be thrown to its uppermost position. For such signals, the coupling condensers C_1 and C_2 will be of negligible impedance and, therefore, the secondary L_1 will be effectively connected to ground. Likewise, the condenser C_3 will present negligibly small impedance to short-wave signals. The grounding of the mid-point of the secondary winding S_4 will provide a suitable phantom ground for the circuit and will serve to prevent the building up of any simultaneous potential difference between both sides of the transmission line and ground.

For the reception of signals in the broadcast band, the switch S_1 will be thrown to its intermediate position. For such signals, the impedances of P_1 and P_2 will be small as compared with that of the tuned circuit comprising the secondary S_4 and its associated condenser C_4 . Consequently, substantially all of the signal will build up across this tuned or resonant circuit and will be transferred to the primary winding P_4 , which, in turn, will transfer the signal to the tuned circuit T_2 by means of the coupling winding L_4 and also by means of the capacitive coupling C_2 .

For the reception of signals in the long-wave band, the switch S_1 will be thrown to its lowermost position. Such signals will be transferred to the tuned circuit T_3 solely by means of the coupling condenser C_2 .

It will be seen, therefore, that for short-wave signals, the signal transfer will be inductive; for signals in the broadcast band, the signal transfer will be both inductive and capacitive and by suitably proportioning the relative degrees of inductive and capacitive coupling, substantially uniform sensitivity may be obtained over this band; and for long-wave signals, pure capacitive coupling is used to effect the signal transfer, which makes for maximum sensitivity at the low end of the frequency spectrum where it is most needed and which also minimizes the transfer of higher frequency image signals. The tuned circuit comprising the secondary S_4 and its associated condenser C_4 may be adjusted so as to be broadly resonant over the broadcast and long-wave bands.

Let it be assumed now that the device is to be used with a capacitive antenna. As stated above, the antenna lead-in will be connected to the terminal A and the switch S_2 will be thrown to its lower position so as to connect the antenna directly to the center tap of the secondary S_4 and to the primary P_3 through the coupling condenser C_3 . For the reception of signals in the different wave-bands, the switch S_1 will be manipulated as indicated above. For signals in the short-wave band, the impedances of C_1 , C_2 and C_3 will be small and the signal will be transferred to the secondary L_1 by means of the primary P_3 . In this case, the input circuit will comprise the elements C_3 , P_3 , C_1 and C_2 to ground.

For signals in the broadcast band, the impedance of the primary P_3 will be small and the signal will be transferred to the tuned circuit T_2 by means of the capacitive coupling of condenser C_1 and also by means of the coupling comprising the condenser C_2 in shunt with the windings L_4 and P_4 . It will be noted that in this instance, the self-impedance of the loop comprising the elements P_4 , L_4 and C_2 forms a common mutual

impedance between the two circuits. Furthermore, there will be some signal transfer due to the mutual impedance between the primary L_4 and the secondary L_2 . By suitable design of the several units, very uniform sensitivity may be obtained over the broadcast band.

For long-wave signals, the signal transfer will take place by virtue of the coupling between the input circuit and the tuned circuit T_3 , which coupling comprises the condenser C_1 and the condenser C_2 in shunt relation with windings L_4 and P_4 . Since the impedances of L_4 and P_4 will be small compared to the impedances of C_1 and C_2 for the low frequencies, the signal transfer will be largely of capacitive nature, thus providing the desired increase in sensitivity over the low frequency band.

Let it be assumed now that the device is to be used with a conventional doublet antenna. As stated above, the transmission line of the antenna will be connected to the terminals T and the switch S_2 will be thrown to its lower position so as to connect the center tap of the secondary S_4 to the primary P_3 through the coupling condenser C_3 . For short-wave signals, the antenna will set up circulating currents between terminals T , which currents will be transferred to the tuned circuit T_1 through the coupling condenser C_3 . Some signals will be induced by the winding P_3 back to the secondary S_4 , causing the potentials of terminals T to vary simultaneously with respect to ground, but no signal transfer will take place due to this action except at the low frequency end of the short-wave band.

For signals in the broadcast band, the antenna will operate substantially as a capacitive antenna; that is to say, the potential of both of the terminals T will fluctuate simultaneously with respect to ground and will thus build up a signal across C_1 and C_2 by virtue of the path from the terminals T through P_1 and P_2 , both of which have a negligibly small impedance, through the secondary S_4 , switch S_2 , condenser C_3 , primary P_3 and condensers C_1 and C_2 to ground. Additionally, the elements L_4 and P_4 in shunt with condenser C_2 will operate to modify the nature of the coupling impedance. In this particular instance, however, it will be noted that the secondary S_4 is connected to a transmission line whose characteristic impedance has the nature of a resistance. This impedance will be reflected into the primary P_4 and will thus change the nature of the coupling impedance of the loop P_4 , L_4 , C_2 . By suitable design, the circuit may be adapted to operate efficiently with either a capacitive antenna or with a doublet antenna operating as a capacitive antenna.

For signals in the long-wave band, the signal transfer action is substantially the same as that for signals in the broadcast band. Here again, the coupling impedance comprising the condenser C_1 and the condenser C_2 in shunt relation with L_4 and P_4 will be modified by the reflected impedance of the transmission line.

Experiment has shown that the device provided by the invention not only obtains the desired sensitivity characteristic for each of the several wave-bands with each of the several types of antennae but also eliminates detuning of the secondary circuit due to the nature of the antenna. This freedom from detuning is obtained, first, by virtue of the coupling condenser C_3 in series with the antenna which serves to minimize the effects of variations in antenna capacity and, second, by the use of the input impedance of the

doublet transmission line as part of the coupling impedance for signals in the broadcast and long-wave bands which permits design of the circuit to operate properly either with a capacitive antenna or a doublet antenna operating as a capacitive antenna.

Furthermore, it will be noted that the invention provides a coupling device which serves to transfer signals with maximum efficiency for each of the several wave bands and for each of the different types of antennae and that this efficient operation is obtained using circuits employing a minimum number of switches and other parts. The device may, therefore, be manufactured economically. The ability of the device to operate over the broadcast and long-wave bands, either with a capacitive antenna or a balanced-line antenna without change in the circuit is due to the use of the characteristic impedance of the doublet transmission line as part of the coupling impedance between the circuits.

Moreover, this impedance is used to advantage to obtain the desired modification of the circuit so as to permit its use with a single-wire lead-in or the doublet lead-in.

In a typical case, the design and structure of the essential elements of the device may be as follows: All of the windings may be wound on $\frac{1}{16}$ inch forms. The winding L_1 may comprise 17 turns of #22 enameled wire with 21 turns to the inch. The windings P_1 and P_2 may each comprise 6 turns of #30 enameled wire wound on the same form with winding L_1 on opposite sides thereof and spaced $\frac{1}{8}$ inch from winding L_1 . The winding P_3 may be interwound with the winding L_1 and may comprise 4 turns of #30 enameled wire.

The winding L_2 may comprise 82 turns of universal winding employing 7-41 Litzendraht wire. Winding L_4 may comprise 4 turns of the same wire wound on the same form with winding L_2 and spaced $\frac{1}{8}$ inch therefrom.

Winding L_3 may comprise 365 turns of universal winding employing 3-40 Litzendraht wire.

Winding S_4 may comprise 60 turns of #38 single silk enameled wire center-tapped as illustrated. Winding P_4 may comprise 170 turns of the same wire.

The condensers C_1 , C_2 and C_3 may each have a capacitance of .01 micro-farad. As stated above, the condensers C_{p1} , C_{p2} and C_{p3} are padding condensers.

The transmission line when used may comprise a standard line composed of a twisted pair of conductors. The characteristic impedance of the line may be 100 ohms.

Although a single embodiment of the invention has been illustrated and described for the purpose of disclosure, it will be understood that the invention is not thus limited but is capable of various modifications such as will occur to persons skilled in the art. It will be understood also that the values given above are not to be considered as limiting the invention but are merely illustrative of a practical embodiment of the invention.

We claim:

1. In an input system for a radio receiver, the combination of a circuit tunable to a desired signal, said tunable circuit having a grounded point, terminals for connecting an antenna to said system by means of a transmission line, a coil connected to said terminals, a first coupling circuit for connecting a tap on said coil to an ungrounded point in the tunable circuit, a second coil coupled to said first-mentioned coil, and a second

coupling circuit for coupling said second coil to said tunable circuit.

2. In an input system for a radio receiver, a transmission line for connecting said system to an antenna, a coil connected across one end of said transmission line, a tunable circuit having a grounded point, a first coupling circuit for connecting a point on said coil to an ungrounded point in said tunable circuit, and a circuit including a second coil coupled to said first-mentioned coil and to said tunable circuit for reflecting the characteristic impedance of the transmission line into the tunable circuit.

3. In an input circuit for a radio receiver, the combination of a circuit tunable to the frequency of the signal which it is desired to receive, a coupling impedance in said circuit, connections for connecting a transmission line from an antenna to said circuit, a coil connected to said connections, an impedance connected to a tap on said coil and to said coupling impedance, and a circuit inductively coupled to said coil and coupled to said tunable circuit.

4. In an input circuit for a radio receiver, the combination of a circuit tunable to the frequency of the signal which it is desired to receive, a coupling impedance in said circuit, connections for connecting a transmission line from an antenna to said circuit, a coil connected to said connections, an impedance connected to said coil and said coupling impedance, and a circuit inductively coupled to said coil and inductively and capacitively coupled to said tunable circuit.

5. In an input system for a radio receiver, a circuit tunable to a desired signal, a pair of antenna terminals, an input circuit connected to said terminals and inductively coupled to said tunable circuit, a tapped coil included in said input circuit, a coupling circuit connected to said tunable circuit, and switching means for connecting the tap of said coil either to said coupling circuit or to ground.

6. In an input system for a radio receiver, a circuit tunable to a desired signal, a pair of antenna terminals, an input circuit connected to said terminals and inductively coupled to said tunable circuit, a tapped coil included in said input circuit, a coupling circuit connected to said tunable circuit, an antenna terminal connected to said coupling circuit, and switching means for connecting the tap of said coil either to said coupling circuit or to ground.

7. In an input system for a radio receiver, a circuit tunable to a desired signal, a pair of antenna terminals, an input circuit connected to said terminals and inductively coupled to said tunable circuit, a tapped coil included in said input circuit, a coupling circuit connected to said tunable circuit, switching means for connecting

the tap of said coil either to said coupling circuit or to ground, to thereby adapt the system for use with different types of antennae, a second coil inductively associated with said first coil, and a second coupling circuit for connecting said second coil to said tunable circuit.

8. In an input system for a multi-band radio receiver, a variable tuning condenser and a plurality of coils selectively connectable therewith to form a tunable circuit, a pair of antenna terminals, an input circuit connected to said terminals and inductively coupled to one of said coils, a tapped coil included in said input circuit, a coupling circuit connected to one of said first-mentioned coils, an antenna terminal connected to said coupling circuit, switching means for connecting the tap of said tapped coil either to said coupling circuit or to ground, another coil inductively associated with said tapped coil, and a second coupling circuit connecting said other coil to said tunable circuit and inductively coupled to another of said first-mentioned coils.

9. In an input system for a radio receiver, a transmission line for connecting said system to an antenna, a coil connected across one end of said transmission line, a tunable circuit coupled to said line, means for connecting a tap on said coil to ground, and a circuit including a second coil coupled to said first-mentioned coil and to said tunable circuit for reflecting the characteristic impedance of the transmission line into the tunable circuit.

10. In an input system for a radio receiver, a circuit tunable to a desired signal, a pair of antenna terminals, an input circuit connected to said terminals and inductively coupled to said tunable circuit, a tapped coil included in said input circuit, a coupling circuit connected to said tunable circuit and to the tap of said coil, an antenna terminal connected to said coupling circuit, another coil inductively associated with said tapped coil, and a second coupling circuit connecting said other coil to said tunable circuit.

11. In an input system for a multi-band radio receiver, a variable tuning condenser and a plurality of coils selectively connectable therewith to form a tunable circuit, a pair of antenna terminals, an input circuit connected to said terminals and inductively coupled to one of said coils, a tapped coil included in said input circuit, a coupling circuit connected to one of said first-mentioned coils and to the tap of said tapped coil, another coil inductively associated with said tapped coil, and a second coupling circuit connecting said other coil to said tunable circuit and inductively coupled to another of said first-mentioned coils.

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