

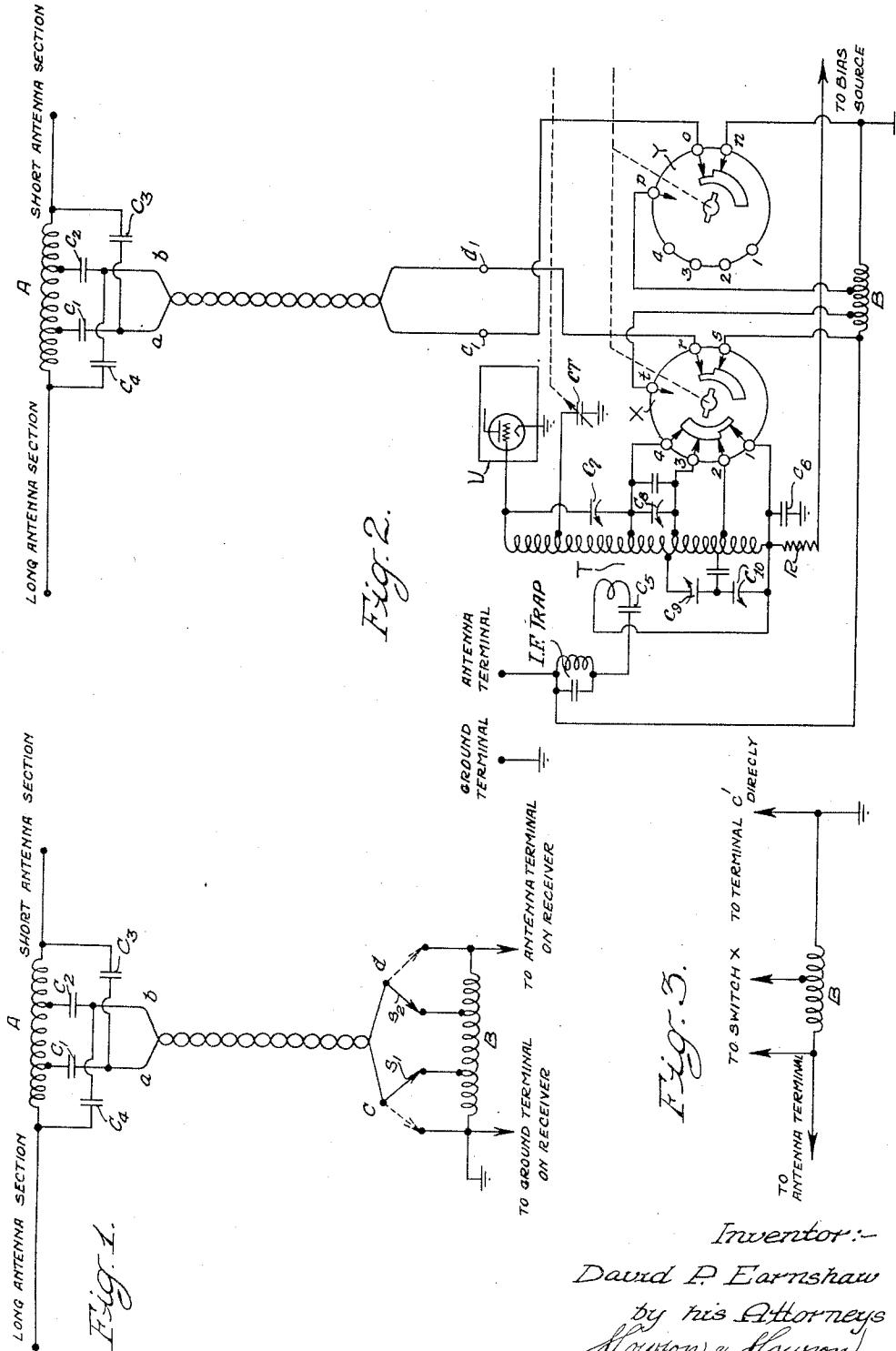
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ANTENNA SYSTEM FOR MULTIBAND RADIO RECEIVERS

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ANTENNA SYSTEM FOR MULTIBAND RADIO RECEIVERS

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This invention relates to antennae or energy collectors for radio-receiving systems and the like, and particularly to antennae for multi-band receiving systems. One object of the invention is to improve the quality of radio reception by increasing the efficiency of the antenna as a signal-collecting device and by reducing the effect on the receiving system of electrical disturbances in the vicinity of the antenna lead-in conductor. This object is accomplished as follows:—First, the device provided by the invention automatically changes the length of the antenna from an electrical point of view so that the proper length of antenna is provided for each frequency band without changing the antenna physically. Second, a lead-in line is provided between the antenna and the receiver for the transfer of signals to the receiver; which line is designed so as to effect minimum attenuation of signal strength, minimum pick-up of local interference, and maximum attenuation of such interference as is picked up by the lead-in line. Third, transfer impedances are provided between the antenna and the lead-in transmission line and between the said line and the receiver; which impedances are designed to increase the efficiency of the antenna and its lead-in line and to permit the use of a low impedance lead-in line.

Another object of the invention is to provide a specific adaptation of the antenna and its associated lead-in line to a conventional multi-band receiver.

Other objects and features will appear from the following description and the accompanying drawing. In the drawing:

Fig. 1 is a diagrammatic illustration of the antenna system;

Fig. 2 is a similar illustration of the adaptation of the antenna system to a multi-band receiver; and

Fig. 3 illustrates a modification.

In the specific embodiment of Fig. 1 which will serve to illustrate the antenna system, but which is not intended to limit the invention in any way, the antenna is divided into two parts, as illustrated, by one of the impedance devices above mentioned. One part of the antenna may be approximately 17 feet in length and the other part may be of any convenient length greater than the length of the first part. It has been determined, however, that the longer part of the antenna should preferably be about 40 feet and that there is no advantage in having the longer part of the antenna of greater length. These two parts of the antenna may be connected respectively to the

terminals or extremities of a small air core coil A.

The lead-in or transmission line may comprise two conductors which are closely twisted together, or otherwise transposed, and the extremities *a* and *b* of these conductors at the antenna end of the line may be connected respectively through small condensers *C*₁ and *C*₂ to points on coil A trisecting the coil or dividing it into three parts which may be about equal or preferably the central part may be somewhat smaller than the outer parts. Extremity *a* may be connected to the coil tap nearer the longer antenna section, while extremity *b* may be connected to the coil tap nearer the shorter antenna section. These same extremities of the lead-in line may also be connected respectively through smaller condensers *C*₃ and *C*₄ to the respective ends or terminals of the coil A, the extremity *a* being connected in this manner to the coil terminal at the shorter antenna section, while *b* is connected to the coil terminal at the longer antenna section.

Considering the transfer impedance between the lead-in transmission line and the antenna, it will be noted that there is provided an impedance unit comprising a plurality of condensers and coils and that each of the coils is closely coupled to the other coils. Due to the large number of loop circuits, each including an inductance and a capacitance, and due further to the high degree of coupling existing between these several circuits, the unit will be at least partially resonant at a large number of different frequencies and by proper design of the several electrical parameters, these different resonant frequencies may be made to cover the entire frequency range for which it is desired to use the antenna system. As has been mentioned, the number of individual resonant points has been augmented by the high degree of coupling, that is by over-coupling the several inductances, which effect may be brought about by winding the several sections on the same form, and the number of resonant frequencies may be further augmented by using this symmetrical device with a non-symmetrical antenna system. Thus, the different capacitances associated with each end of the unit due to the different lengths of the antenna sections connected thereto will increase the number of points at which the unit is at least partially resonant.

The condensers *C*₁ and *C*₂ may be larger than the condensers *C*₃ and *C*₄ and, consequently, will have a lower impedance. For example, the impedances of *C*₁ and *C*₂ may be one-tenth those of *C*₃ and *C*₄. Further, the impedance of the central section of the coil A to which *C*₁ and *C*₂ are

connected will be small as compared with the impedance of the entire coil. Thus, looking into the unit from the transmission line, it will appear as a relatively low impedance, whereas looking into the unit from either section of the antenna, it will appear as a relatively high impedance. The impedance matching between the high impedance antenna and the low impedance lead-in line is brought about in this fashion, the transfer unit, due to its large number of resonant frequencies, serving to match the impedance of the antenna to that of the transmission line over a wide frequency range.

The transfer impedance device connecting the lead-in or transmission line to the receiver may comprise a coil B similar to coil A but having more turns. The ends of this coil or points thereof near the ends may be connected to switch terminals, and the coil may be tapped at two points equidistant from its ends or the said points, and these latter points may also be connected to switch terminals. By suitable switch elements S_1 and S_2 , the ends or terminals c and d of the lead-in line at the receiver, corresponding respectively to extremities a and b , may be switched at will either to the outer contacts of coil B or to the intermediate contacts so as to include either substantially the entire coil B in the primary circuit or to include in such circuit only the portion of the coil between the innermost tapped points. The side of the coil B associated with the line terminal c may be grounded and suitable provision may be made for connecting that side of the coil to the usual ground terminal of the receiving set, while the other side of the coil may be connected to the usual antenna terminal of the receiver.

In using the device for the reception of the high frequency band, which may include the range from 1.5 to 23 megacycles, the switching elements S_1 and S_2 may be positioned to include the larger portion of coil B in its primary circuit. Conversely, when the device is used for reception in the low frequency band, which may include the range from 0.5 to 1.5 megacycles, the switch elements S_1 and S_2 may be positioned to include only the central portion of coil B or, in other words, the portion between the inner coil taps, in the primary circuit.

In the preferred form of the invention, as illustrated in Fig. 2, the switching in conjunction with the coil B is accomplished by the same switching devices which are customarily used to change the tuning elements of the receiver for reception of different frequency bands, the coil B supplying signal to the transformer T. As will be apparent, the signal obtained from the transmission line will appear across the inductance B and will be transferred to the tunable circuit comprising the secondary of the transformer T and the variable condenser CT, by means of the circuit including the I. F. trap, the condenser C_5 , the primary of the transformer T, and the condenser C_6 . The I. F. trap comprises a parallel tuned circuit tuned to the intermediate frequency of the receiver and serves to attenuate any signals of intermediate frequency which might be picked up by the antenna. The I. F. trap will have a very high impedance to signals of the intermediate frequency but will have a low impedance to signals of other frequencies, including the signals which it is desired to receive. The condensers C_5 and C_6 serve as blocking condensers and present a negligibly small impedance to signals of radio frequency. Thus,

signal energy from the coil B will be transferred to the primary winding of the transformer T, and thence to the secondary and to the input circuit of the valve V. The secondary of the transformer may be modified by short-circuiting various sections of it by means of the switch X and contacts 1, 2, 3 and 4. As will be apparent, in the position shown contacts 1, 2, 3 and 4 are all connected together and hence only that section of the secondary between the grid of the valve V and the tapped point of the secondary connected to switch point 4 is operable. In the next position of the switch, switch points 1, 2 and 3 would be connected together, whereas point 4 would be disconnected, and thus an additional portion of the secondary inductance would be included in the tunable circuit. Likewise, in a third position of the switch, contacts 1 and 2 would be connected together but 3 and 4 would be free, and in the fourth position of the switch all of the contacts would be free. The various condensers marked C_7 , C_8 , C_9 and C_{10} , are padding condensers and serve to orientate the tuning of the circuit with that of the oscillator of the receiver, which is not shown. Thus, as will be apparent, in the different switch positions which adapt the receiver to select signals in different frequency bands, the transmission line from the antenna is connected to different portions of the coil B, and in each case these portions are so selected that the most efficient transfer of signals in the desired frequency band to the input circuit of the valve V is obtained.

As illustrative of a manner in which the present invention may be practiced, the coil B may connect the antenna to ground so that the coil will by-pass disturbances of relatively low frequency compared with the signal frequency. In other words, the circuit to ground through the coil B offers low impedance to low frequency currents or surges and thus effectively prevents disturbances from entering the receiver proper. Thus, in addition to its function as a transfer impedance device during multi-band reception, the coil B may serve the purpose above noted when the ordinary antenna is used during single band reception. Moreover, the coil B presents high impedance to the relatively high frequency signal currents permitting them to enter the receiver.

It will be noted also that in the system of Fig. 2, the resistor R may be supplied with unidirectional current from a suitable biasing source to bias the stage V and thus control the amplification. For example, automatic volume control may be incorporated by connecting resistor R to a variable biasing source in accordance with conventional methods. It will be seen that the condensers C_5 and C_6 will each present infinite impedance to the unidirectional current, thus preventing the by-passing of such current to ground. Thus, the condenser C_5 , the transformer T, and the condenser C_6 are included in a series circuit between the antenna terminal and ground, and these elements in cooperation with coil B serve the above purposes.

Connections may be made from the coil B to switch points or contacts on the switching devices which are used to effect change of the tuning elements as above mentioned. The switching devices will, of course, be especially adapted for this purpose. It is merely necessary, however, to provide on those devices properly located selectable contacts which are engageable by a contact properly located on the movable part of

the switch. A pair of terminals c' and d' may be provided with conductors running from these terminals to the switching devices, the arrangement being such that these conductors may be switched to different points on coil B in the same manner that the lead-in line terminals c and d are switched in the device of Fig. 1. Two of the said switching devices may be used for this purpose, one for switching each of the said conductors. The conductor for terminal c' may be associated with the ground end of coil B.

In the device of Fig. 2, band selector switches X and Y are employed, which switches are preferably adapted for operation simultaneously with each other and with other devices by a conventional gang control arrangement, as indicated by the broken line representation. The switch X controls the conventional multi-band transformer T which supplies signals to the first vacuum tube stage V. The switch X has four positions designated 1, 2, 3 and 4. In the illustration, the switch is shown in position 4. Each of these positions may correspond to the following wave bands:

1. 0.5- 1.5 megacycles.
2. 1.5- 4.5 megacycles
3. 4.1-10.0 megacycles
4. 10.0-22.5 megacycles

Switch X is also provided with contacts t , r , and s while switch Y has corresponding contacts p , o and n , these contacts being connected as illustrated to terminals c' and d' and to coil B. Switch Y may also have four positions, corresponding to those of switch X, which may be utilized if desired to effect switching of the oscillator. This may be done by making the proper electrical connections and by providing a suitable movable contact in switch Y to effect the desired switching operation.

In positions 2, 3 and 4 of the switches X and Y, the contact o is connected to the contact n and the contact r is connected to the contact s . In position 1 of the switches, corresponding to the long wave band, the contact o is connected to contact p , while contact r is connected to contact t . These switching operations properly adapt the coil B for reception of high or low frequency bands when the antenna and lead-in line of Fig. 1 are used. The switching is accomplished simultaneously with the switching of the tuning elements of the receiver.

With such arrangement, the receiver may be used in conjunction with either an ordinary antenna or with the improved antenna of Fig. 1. If the ordinary antenna is used, it will, of course, be connected to the antenna terminal of the receiver and no connection will be made to the two terminals c' and d' . In such case, the switching elements provided in conjunction with coil B will have no effect, the said coil cooperating with elements C_5 , C_6 , T and R in the manner above described. If, however, it is desired to use the improved antenna system of Fig. 1, the lead-in line terminals c and d thereof may be connected to the terminals c' and d' of Fig. 2, terminal c of the antenna lead-in line being connected to terminal c' and terminal d of the antenna lead-in line being connected to terminal d' . In such case, the switching devices will function as described above when the receiver is operated for reception of different frequency bands. In either case, the ground terminal of the receiver should be connected to any convenient ground such as a water pipe, etc. in the usual way.

In the simplified modification of the device

shown in Fig. 3, one of the switching operations may be eliminated by permanently connecting the conductor from terminal c' to the grounded end of coil B and by switching the conductor from terminal d' between the other end of the coil and an intermediate point thereof. In such case, the tap connection of coil B may be located so that there is the same ratio of turns of the coil between high and low frequency operation as there is in the antenna system of Fig. 1 and in the system of Fig. 2. This modification reduces the cost of manufacture, inasmuch as it requires special adaptation of only one of the switching devices X and Y.

In operation of the system at high frequency, the short side only of the antenna appears to be effective. Experiment has indicated that an antenna length of 17 feet is best adapted for reception through the high frequency or short-wave band. The impedance device first described above serves to match the high impedance antenna to the relatively low impedance lead-in line. As explained above, the coil and condensers provide a plurality of resonant circuits having different natural periods so that the impedance device as a whole does not have a marked resonant frequency, thus making the gain as nearly uniform at all frequencies as possible and causing the response curve to be more even. At the receiver end of the lead-in line, the coil B acts as a return circuit for a reason which will appear later.

At low frequency, the longer side of the antenna is effective and the impedance device at the antenna again serves to match the impedances of the antenna and the lead-in line. At the receiver end of the lead-in line, the coil B matches the relatively low impedance transmission line to the antenna coil of the receiver which, in this case, is of relatively high impedance.

It will be seen that in the reception of both high and low frequency waves, there is obtained a gain in signal strength due to the more efficient transfer of energy from the antenna to the receiver by virtue of the impedance matching. In either case also, interference caused by electrical disturbances will be reduced as follows:—First, the use of two conductors closely twisted together serves to reduce the effect of disturbances by reducing the possible mutual inductive or capacitive coupling between the lead-in line and the source of disturbances. Second, a disturbance set up in a given direction in one conductor of the line will be induced also in the other conductor and will have the same direction and magnitude. Inasmuch as the two components of the disturbance will oppose each other in the lead-in circuit, they will largely counteract or neutralize each other at the coils constituting the terminals of the circuit. Third, the surge impedance of the low impedance lead-in line has been chosen so as to give a smooth response for signal energy but to reduce to a minimum the pick-up of disturbance energy.

In the specific example of the above-described device, the coil A may comprise 108 turns of #30 SCE wire wound in a honeycomb coil on a $\frac{1}{2}$ " bobbin and tapped at the 36th and 72nd turn. Coil B may comprise 207 turns of #32 SCE wire wound in similar fashion and tapped at the 92nd and 115th turn. Condensers C_1 and C_2 may each have a value of 1650 micro-microfarads, while condensers C_3 and C_4 may each have a value of 130 micro-microfarads. The transmission line may have a surge impedance of about 100 ohms at

1000 cycles. Such a line is of sufficiently low impedance to be effective and yet is not low enough to be expensive, it being noted that the cost varies approximately inversely with the impedance.

- 5 It will be understood, of course, that the invention is capable of modification and that the present disclosure is not intended to limit the invention.

I claim:

- 10 1. An antenna system for radio receivers, comprising an antenna terminal, a condenser, a first impedance connected to said condenser, a ground terminal, a second impedance connected to said ground terminal, said second impedance being
15 larger than said first impedance at low frequencies but less than said first impedance at high frequencies, said condenser and said impedances forming a series circuit between said terminals, a vacuum tube having input elements, means for
20 transferring high frequency signals appearing across said first impedance to said input elements and for conductively connecting said elements to the terminals of said second impedance, and a third impedance element of low impedance at low frequencies and of high impedance
25 at high frequencies connected to said antenna terminal and said ground terminal.

2. An antenna system for radio receivers, comprising an antenna terminal, a condenser, a first
30 impedance connected to said condenser, a ground terminal, a second impedance connected to said ground terminal, said second impedance being larger than said first impedance at low frequencies but less than said first impedance at high
35 frequencies, said condenser and said impedances forming a series circuit between said terminals, a vacuum tube having input elements, means for transferring high frequency signals appearing across said first impedance to said input elements
40 and for conductively connecting said elements to the terminals of said second impedance, and a third impedance element of low impedance at low frequencies and of high impedance at high frequencies connected to said antenna terminal
45 and said ground terminal, said third impedance being provided with terminals for connection to a transmission line.

3. In a multi-band radio receiving system, an antenna, a transmission line, coupling means between
50 said antenna and said transmission line for transferring signals in a plurality of frequency bands from said antenna to said transmission line, an amplifier including a space discharge device and a tunable input circuit for said device,
55 means for transferring signals from said transmission line to said input circuit, switching means for modifying said input circuit to select signals in any one of said plurality of frequency bands, and switching means operable simultaneously with said first switching means for modifying
60

fyng said signal-transfer means to transfer signals efficiently in the selected frequency band.

4. In a multi-band radio receiving system, an antenna, a low impedance transmission line, coupling means between said antenna and said
5 transmission line for transferring signals in a plurality of frequency bands from said antenna to said transmission line and for matching the impedances of said antenna and said transmission line, an amplifier including a space discharge device and a tunable input circuit for
10 said device, means for transferring signals from said transmission line to said input circuit and for matching the impedances of said transmission line and said input circuit, switching means
15 for modifying said input circuit to select signals in any one of said plurality of frequency bands, and switching means operable simultaneously with said first switching means for modifying
20 said signal-transfer means to transfer signals efficiently in the selected frequency band.

5. In a multi-band radio receiving system, an antenna, a two conductor transmission line, coupling means between said antenna and said
25 transmission line for transferring signals in a plurality of frequency bands from said antenna to said transmission line, an amplifier including a space discharge device and a tunable input circuit for said device, means for transferring signals from said transmission
30 line to said input circuit, switching means for modifying said input circuit to select signals in any one of said plurality of frequency bands, and switching means associated with each conductor of said transmission line and operable
35 simultaneously with said first switching means for modifying the connection of said line to said signal-transfer means to effect efficient transfer of signals in the selected frequency band.

6. In a multi-band radio receiving system, an antenna, a transmission line, coupling means between
40 said antenna and said transmission line for transferring signals in a plurality of frequency bands from said antenna to said transmission line, an amplifier including a space discharge device and a tunable input circuit for said device, means for transferring signals from said transmission
45 line to said input circuit, said signal transfer means comprising a coil having tapped points, switching means for modifying
50 said input circuit to select signals in any one of said plurality of frequency bands, and switching means operable simultaneously with said first switching means for connecting said transmission line to different tapped points of said coil
55 to effect efficient transfer of signals in the selected frequency band.

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