April 25, 1950 E. G. HILLS ET AL 2,505,115

DIPOLE ANTENNA SYSTEM

Filed Sept. 11, 1944

FIG. 1

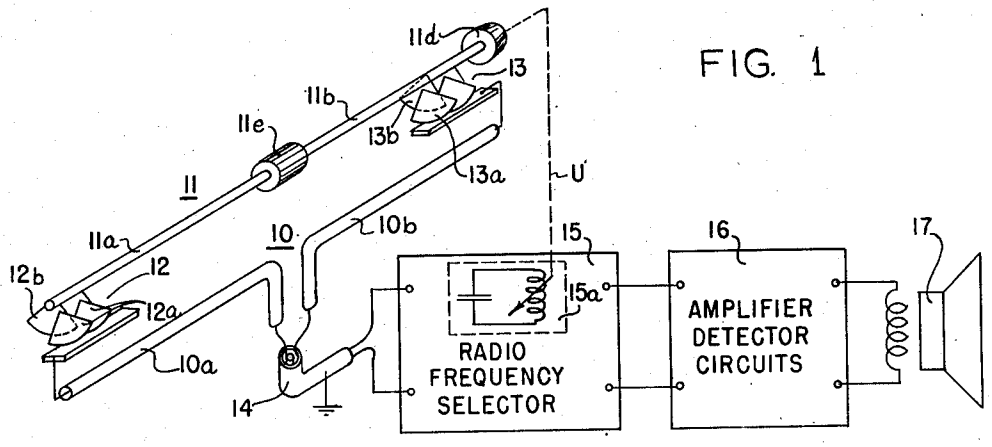


FIG. 2

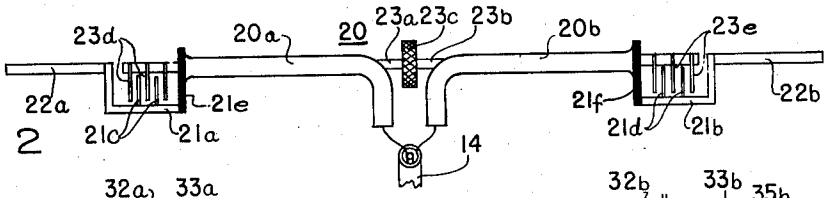


FIG. 3

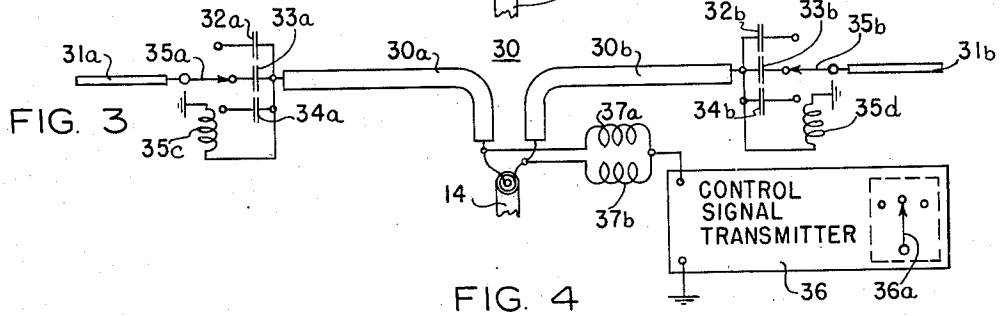
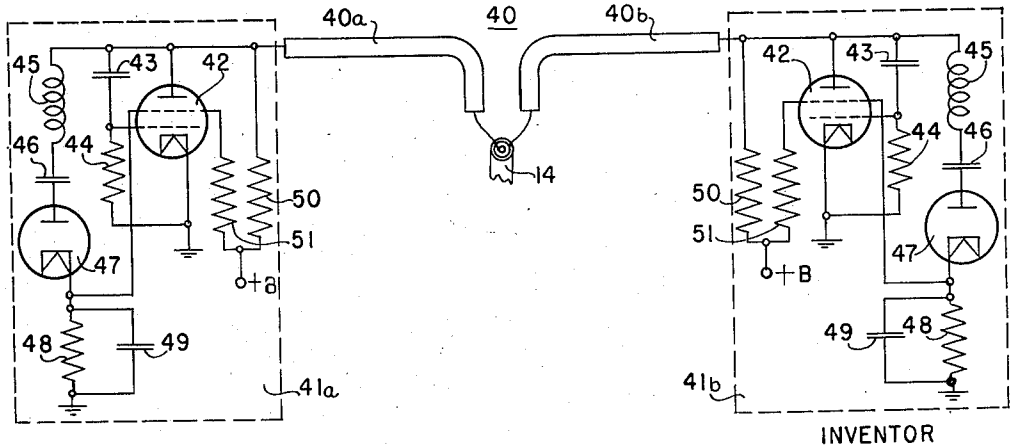


FIG. 4



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Patented Apr. 25, 1950 2,505,115

UNITED STATES PATENT OFFICE

2,505,115

DIPOLE ANTENNA SYSTEM

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Application September 11, 1944, Serial No. 553,486

11 Claims. (Cl. 250—33)

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This invention relates to dipole antenna systems and, while it is of general application, it is particularly suitable for embodiment in such systems of the type adapted to translate any of a plurality of wave signals of different frequencies within a wide frequency band and incorporating an antenna of fixed physical dimensions suitable for mounting in the cabinet of a wave-signal receiver with which it is designed to operate.

It is customary to utilize a dipole antenna in connection with a wave-signal transmitter or a receiver operating in the high-frequency or ultra-high-frequency range because of its superior response characteristics. However it is well known that the response and terminal impedance of a dipole antenna of any given physical dimensions are rather critical with respect to frequency and vary rapidly with departure of the operating frequency in either sense from the frequency for which the antenna was designed. On the other hand, it is often desirable or necessary to adjust a high-frequency or ultra-high-frequency wave-signal apparatus utilizing a dipole antenna for operation at any selected frequency within a wide frequency band.

In order to solve this problem, it has heretofore been proposed to utilize dipole antennas comprising extensible antenna arms which may be adjusted to the appropriate length in accordance with the frequency of the signal being translated. While such an arrangement is satisfactory for certain applications, it is difficult to adapt to a dipole antenna housed in a wave-signal receiver cabinet, which imposes a limit on the physical dimensions of the antenna. Also there are certain applications for which the mechanical adjustment of the physical length of the antenna may be difficult to incorporate in the antenna system.

It is an object of the invention therefore to provide a new and improved dipole antenna system of fixed physical length, the effective electrical length of which may be adjusted for operation at any selected one of a plurality of frequencies within a wide frequency band.

It is another object of the invention to provide a new and improved dipole antenna system of the type described which is particularly suitable for mounting in the cabinet of a wave-signal receiver with which it is designed to operate.

In accordance with the invention, a dipole antenna system adapted to translate any of a plurality of wave signals of different frequencies within a wide frequency band comprises a dipole

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antenna structure including a pair of opposed arms of fixed physical length, and means disposed at the remote ends of such arms for effectively modifying its electrical length to adjust the frequency of optimum response.

Further in accordance with the invention, the means for effectively modifying the electrical length of the antenna comprises a pair of elongated conductive elements individually associated with the arms of the dipole antenna in fixed relation thereto and means for adjustably coupling each of the elongated elements with associated dipole arms. In a preferred embodiment of the invention, such two elongated elements are embodied in a two-section elongated conductive operating shaft of an adjustable condenser including an insulating section at its midpoint. The condenser also comprises stator plate means mounted at the outer ends of the opposed arms and rotor plate means mounted at the outer end of the shaft and individually cooperating with the stator plate means to adjust the frequency of optimum response of the system.

For a better understanding of the invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawings while its scope will be pointed out in the appended claims.

Referring now to the drawing, Fig. 1 is a schematic representation of a dipole antenna system embodying the invention as applied to a wave-signal receiver; Fig. 2 is a diagrammatic representation of an alternative form of the invention in which the adjustment is also mechanical as in Fig. 1; while Figs. 3 and 4 represent other forms of the invention to which the adjustment of the electrical length of the antenna is effected by entirely electrical means suitable for operation from a position remote from the antenna structure.

Referring now to Fig. 1 of the drawings, there is represented a dipole antenna system adapted to translate any of a plurality of wave signals of different frequencies within a wide frequency band and to supply them to a wave signal receiver. This system includes a dipole antenna 10 which may be of conventional construction including a pair of opposed arms 10*a* and 10*b* of fixed physical length. The system also includes means disposed at the remote ends of the arms for effectively modifying the electrical length of the antenna to adjust the frequency of optimum response of the system, as by variably loading the remote ends of the antenna. This

means comprises an elongated conductive member 11 comprising the conductive sections 11a and 11b individually disposed generally parallel and spaced from the arms 10a and 10b, respectively, their adjacent or inner ends being electrically separated by means of an insulating section 11e Adjustable capacitance means 12 and 13 are provided for individually adjustably coupling the outer ends of the elements 11a, 11b to their associated dipole arms 10a, 10b, respectively. In a preferred form, the two-section elongated conductive member 11, including the insulating section 11e at its midpoint, may comprise the operating shaft of an adjustable condenser including the capacitance means 12 and 13. The capacitance means 12 and 13 comprise stator plate means 12a and 13a mounted at the outer ends of the opposed arms 10a, 10b, respectively, and rotor plate means 12b, 13b mounted at the outer ends of the shaft sections 10a, 10b and individually cooperating with the stator plates 12a and 13a, respectively. The adjustable condenser 11, 12, 13 may be provided with adjusting means, such as a manually operable knob 11d.

Signals intercepted by the dipole antenna 10 are translated by a co-axial cable 14 to the input circuit of a wave-signal receiver comprising a radio-frequency selector 15, an amplifier and detector circuit unit 16, and a signal reproducer, such as a loud speaker 17. The selector 15 includes one or more tunable selective circuits represented schematically at 15a, the adjustable elements of which are connected for operation with the adjustable condenser 11, 12, 13 by means of a unicontrol apparatus indicated at U.

The operation of the dipole antenna system of Fig. 1 will be apparent from the foregoing description. Briefly, high-frequency or ultra-high-frequency signals intercepted and translated by the dipole antenna 10 are applied through the cable 14 to the input circuit of the radio frequency selector 15, wherein the desired signals are selected and undesired signals rejected. The signals selected and amplified in unit 15 are translated to the unit 16 wherein they are further ampified, selected and detected for application to the loud speaker 17 for reproduction. It will be understood that, if the receiver 15, 16 is of the superheterodyne type, the adjustable tunable circuit of the local oscillator will also be included in unit 15, as represented schematically by the tunable circuit 15a.

By the connection of the adjustable element of the tunable circuit 15a to the shaft 11 by means of unicontrol mechanism U, adjustment of the tuning of the receiver 15, 16 is effective simultaneously to adjust the setting of the condenser 11, 12, 13, which is effective to adjust the coupling between the outer ends of the antenna arms 10a, 10b and the conductive shaft sections 11a, 11b, respectively. These shaft sections when coupled, as described, effectively comprise with the arms 10a, 10b a folded-back dipole antenna, the effective electrical length of which is adjusable by the adjustment of the coupling between the outer ends of the antenna arms 10a, 10b and the elements 11a, 11b, respectively. By the proper design of the unicontrol mechanism U, which may include cam means or other variable ratio drive means, the adjustment of the condenser 11, 12, 13 may be related to the tuning of the receiver 15, 16 in such a way that the characteristics of the dipole antenna system are always adjusted for optimum response at the frequency to which the receiver is tuned. It will be understood that by optimum response is meant not only that the actual signal voltage picked up at the antenna is a maximum but also that its radiation impedance, as reflected at the input circuit of the receiver unit 15, approximately matches the input impedance of unit 15, it being well understood that approximate impedance matching at this point is required for effective translation of the received wave signal.

In the modified form of the invention illustrated in Fig. 2, the means for variably loading the outer ends of the dipole antenna arms comprise elongated conductive elements 22a and 22b individually extending from such opposed arms, together with adjustable capacitance means coupling each of such elongated elements to its associated dipole arm. For example, the dipole antenna comprises arms 20a, 20b which support at their outer ends U-shaped brackets 21a, 21b from which extend the elongated conductive elements 22a, 22b, respectively, the units 22a, 22b, preferably being co-axial with the antenna arms 20a, 20b. The brackets 21a, 21b include sections 21e, 21f, respectively, of insulation material to isolate the extensions 22a, 22b from the arms 20a, 20b, respectively. The arms 20a, 20b are hollow and enclose shafts 23a, 23b electrically separated at their inner ends by a section 23c of insulation material and provided at their outer ends with rotor plate means 23d, 23e, which cooperate with stator plate means 21c, 21d mounted in the brackets 21a and 21b, respectively, the stator and rotor plate means described comprising adjustable capacitance means for coupling the elongated conductive elements 22a, 22b to the outer ends of the antenna arms 20a, 20b, respectively. The insulation section 23c may be knurled as indicated and comprise a manually operable adjusting means for the antenna system.

The operation of the antenna system of Fig. 2 is substantially similar to that of Fig. 1 except that, as the elongated extensions 22a, 22b are adjustably coupled to the antenna arms 20a, 20b, respectively, the antenna system operates as an antenna of effectively increased physical length rather than as a folded-back dipole antenna, increased coupling of the elements 22a, 22b increasing the wave length and decreasing the frequency of optimum operation of the antenna system.

In Fig. 3, there is represented a modified form of the invention in which the means for loading or adjusting the effective electrical length of the dipole antenna 30 is effected electrically so that it is particularly suitable for remote control. Specifically, the dipole antenna comprises arms 30a, 30b adapted to be adjustably coupled to co-axial elongated conductive elements 31a and 31b, respectively, effectively comprising extensions of the antenna arms. The adjustable coupling is effected by adjustable capacitance means such as the pairs of condensers 32a, 32b; 33a, 33b; and 34a, 34b, adapted to be selectively connected as coupling elements between the antenna arms and their respective extensions by means of selector switches 35a and 35b, respectively, which are preferably of the step-by-step type. The selector switches are provided with windings, 35c and 35d, connected to be energized from a control-signal transmitter 36, provided with an adjustable contact element 36a, through a circuit including radio-frequency choke coils 37a and 37b, which are connected directly to the antenna arms 30a, 30b, respectively, so that they serve to conduct both the translated high-frequency signal waves

and the control signals, which are of a relatively low frequency or direct current.

The operation of the antenna system, per se, of Fig. 3 is electrically the same as that of Fig. 2 described above. The control signal transmitter 36 and the step-by-step relays 35*a*, 35*c* and 35*b*, 35*d* operate in a conventional manner to connect selected pairs of condensers 32*a*, 32*b*; 33*a*, 33*b*; or 34*a*, 34*b* between the antenna arms 30*a*, 30*b* and their respective extensions 31*a*, 31*b* to adjust the effective electrical length of the dipole antenna in accordance with the frequency of the signal being translated.

In the form of the invention represented in Fig. 4, the means for variably loading the ends of the antenna arms comprises reactance means individually coupled to the remote ends of the antenna arms, the reactance means having a negative reactance-frequency characteristic, whereby the electrical length of the antenna is effectively modified with respect to frequency to impart to the system the optimum response at any selected one of the different frequencies within the operating frequency band. By the term "negative reactance-frequency characteristic" as used herein and in the appended claims, is meant a reactance characteristic which is the opposite of that of the usual physical reactance elements: for example, an inductive reactance which decreases with frequency or a capacitive reactance which increases with frequency.

Specifically, in the arrangement of Fig. 4, the dipole antenna 40 comprises arms 40*a*, 40*b* which are variably loaded at their ends by means of variable reactance means 41*a* and 41*b*, respectively. The reactance means 41*a*, 41*b* are identical and their components are identified by the same reference numerals. Each of the reactance means 41*a*, 41*b* comprises a vacuum tube 42, preferably of the screen grid type, connected directly between the end of its respective antenna arm and ground. The control grid of the vacuum tube 42 is excited from a phase-splitting circuit comprising a condenser 43 in series with a resistor 44 also connected between the end of its respective antenna arm and ground, the control grid being connected across the resistor portion of such series circuit. Also connected between the end of the antenna arm and ground is a series circuit comprising an inductor 45 in series with a condenser 46, a diode rectifier 47 and a load resistor 48 shunted by a filter condenser 49. The inductor 45 and condenser 46 are proportioned to resonate at or near the lower end of the frequency range over which the antenna system is intended to operate. The signal developed across the load circuit 48, 49 is applied to the screen grid of the tube 42, as indicated. Operating potentials for the anode and screen of the tube 42 are supplied from a suitable source +B through resistors 50 and 51, respectively.

In the operation of the system of Fig. 4, the phase-splitting circuit 43, 44 develops a voltage across the resistor 44 which leads the applied signal voltage by approximately 90°, which causes the anode current of tube 42 to lead its anode voltage, that is, the voltage at the outer end of its respective antenna arm, also by approximately 90°; thus, the tube 42 acts as a capacitive reactance, the magnitude of which is determined by its anode current which, in turn, is controlled primarily by its screen voltage. Since the circuit 45, 46 is resonant at the lower end of the operating frequency band, its series impedance is a minimum and it passes a maximum current at such frequency, developing a maximum rectified voltage across the load circuit 48, 49 of diode 47 which is applied to the screen grid of the tube 42. The tube 42, under such conditions, draws maximum current and is the equivalent of a capacitance of maximum value. As the operating frequency increases and the circuit 45, 46 departs from resonance, this circuit draws less current and the rectified voltage across the load 48, 49 proportionately decreases, thus decreasing the bias on the screen grid of the tube 42. That is, the tube 42 draws a maximum current, indicating a minimum capacitive reactance, at or near the low frequency end of the operating frequency range and such anode current decreases with increasing frequency, indicating an effective increase in capacitive reactance of the tube 42 with increase in frequency; that is, indicating a negative reactance-frequency characteristic.

It can be shown both mathematically and experimentally that a dipole antenna, when loaded at the outer ends of its arms by a negative reactance means of the type described, the constants of which are proportioned to cancel the positive reactance component of the radiation impedance-frequency characteristic of the unloaded dipole antenna, has a substantially uniform and optimum response over the operating frequency range.

From the foregoing it is apparent that each of the forms of the invention illustrated and described above comprises an antenna system in which the antenna structure is of fixed physical dimensions and therefore one which is suitable for embodiment in the cabinet of a wave-signal apparatus with which it is designed to operate. Furthermore, any of the difficulties attendant upon the construction of an antenna of physically adjustable length are eliminated.

While there have been described what are at present considered to be the preferred embodiments of the invention, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit or scope of the invention.

What is claimed as new is:

1. A dipole antenna system adapted to translate any of a plurality of wave signals of different frequencies within a wide frequency band comprising, a dipole antenna structure including a pair of opposed rectilinear arms of fixed physical length, a pair of variable capacitive reactance means disposed at the remote ends of said arms and individually coupled thereto for effectively modifying the electrical lengths of said arms to adjust the frequency of optimum response of the system, and means for simultaneously adjusting said variable capacitive reactance means for controlling the frequency of operation of said system.

2. A dipole antenna system adapted to translate any of a plurality of wave signals of different frequencies within a wide frequency band comprising, a dipole antenna structure including a pair of opposed arms of fixed physical length, a pair of elongated conductive elements individually associated with said arms in fixed relation thereto, said elements being insulated from said arms and from ground and capacitive reactance means for adjustably coupling each of said elongated elements to its associated dipole arm to adjust the frequency of optimum response of the system.

3. A dipole antenna system adjustable to receive wave-signals of any desired frequency within a wide band of frequencies comprising, a di-

pole antenna structure including a pair of opposed arms, a pair of opposed elongated conductive elements individually disposed generally parallel to and spaced from said arms and having their adjacent ends electrically separated, and capacitive reactance means for adjustably coupling the outer end of each of said elements to the outer end of its associated dipole arm to adjust the frequency of optimum response of the system.

4. A dipole antenna system adjustable to receive wave-signals of any desired frequency within a wide band of frequencies comprising, a dipole antenna structure including a pair of opposed arms, a two-section elongated conductive member disposed parallel to and spaced from said opposed arms and including an insulating section at its mid-point, and capacitive reactance means for adjustably coupling the outer ends of said member to the adjacent outer ends of said arms to adjust the frequency of optimum response of the system.

5. A dipole antenna system adjustable to receive wave-signals of any desired frequency within a wide band of frequencies comprising, a dipole antenna structure including a pair of opposed arms, a pair of opposed elongated conductive elements individually disposed generally parallel to and spaced from said arms and having their adjacent ends electrically separated, and an adjustable capacitance for adjustably coupling the outer end of each of said elements to the outer end of its associated dipole arm to adjust the frequency of optimum response of the system.

6. A dipole antenna system adjustable to receive wave-signals of any desired frequency within a wide band of frequencies comprising, a dipole antenna structure including a pair of opposed arms, and adjustable condenser means comprising a two-section elongated conductive operating shaft including an insulating section at its midpoint, said shaft being disposed parallel to and spaced from said opposed arms, said condenser means comprising stator plate means mounted at the outer ends of said opposed arms and rotor plate means mounted at the outer ends of said shaft and individually cooperating with said stator plate means to adjust the frequency of optimum response of the system.

7. A dipole antenna system adapted to translate any of a plurality of wave signals of different frequencies within a wide frequency band comprising, a dipole antenna structure including a pair of opposed arms of fixed physical length, a pair of elongated conductive elements individually extending from said opposed arms in fixed relation thereto, and adjustable capacitance means for adjustably coupling each of said elongated elements to its associated dipole arm to adjust the frequency of optimum response of the system.

8. A dipole antenna system adjustable to receive wave-signals of any desired frequency within a wide band of frequencies comprising, a dipole antenna structure including a pair of opposed arms, and reactance means individually coupled to the remote ends of said arms, said reactance means having a negative reactance-frequency characteristic, whereby the electrical length of the antenna is effectively modified with respect to frequency to impart to the system optimum response at any of said different frequencies.

9. A dipole antenna system adjustable to receive wave-signals of any desired frequency within a wide band of frequencies comprising, a dipole antenna structure including a pair of opposed arms, and a pair of reactance tubes individually coupled to the remote ends of said arms, each of said tubes including input and output electrodes and a regenerative coupling therebetween for imparting thereto a negative reactance-frequency characteristic, whereby the electrical length of the antenna is effectively modified with respect to frequency to impart to the system optimum response at any of said different frequences.

10. In a wave signal translating device which is tunable to a plurality of different frequencies, a dipole antenna system adapted to be contained in a housing with the translating device comprising, a dipole antenna structure including a pair of opposed rectilinear arms of fixed physical length, a pair of elongated conductive elements individually associated with said arms in fixed relation thereto, said elements being insulated from said arms and from ground, a pair of variable capacitive reactance means disposed at remote ends of said arms and individually coupled to said arms and said associated elements for effectively modifying the frequency response of said system, and means for simultaneously adjusting said variable reactance means so that the frequency response of said system corresponds to the frequency of said device.

11. In a wave signal translating device which is tunable to a plurality of different frequencies, a dipole antenna system adapted to be contained in a housing with the translating device comprising, a dipole antenna structure including a pair of opposed rectilinear arms of fixed physical length, a pair of variable capacitive reactance means disposed at remote ends of said arms and individually coupled thereto for effectively modifying the electrical length of said arms, and means for automatically adjusting said variable reactance means in accordance with the tuning of said translating device so that the effective length of said arms is optimum for the frequency of said device.

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