

Feb. 14, 1939.

V. D. LANDON

ANTENNA SYSTEM

2,147,168

Filed Sept. 29, 1934

2 Sheets-Sheet 1

Fig. 1.

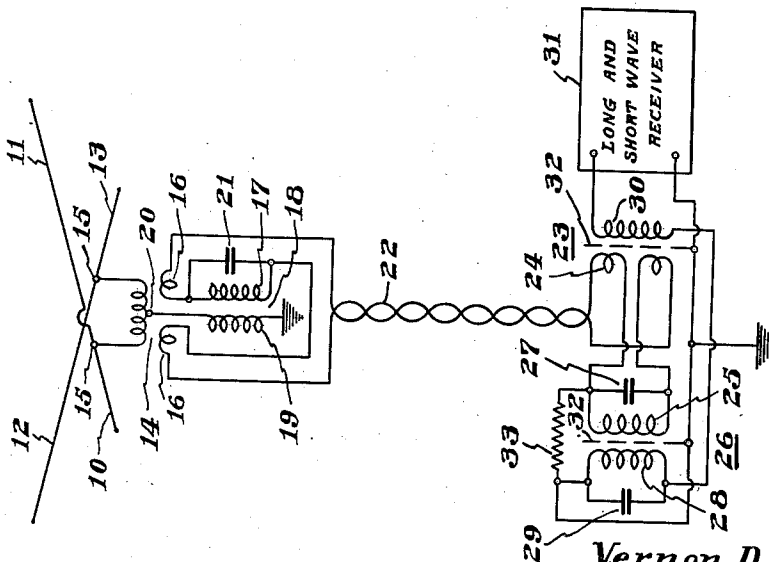


Fig. 2.

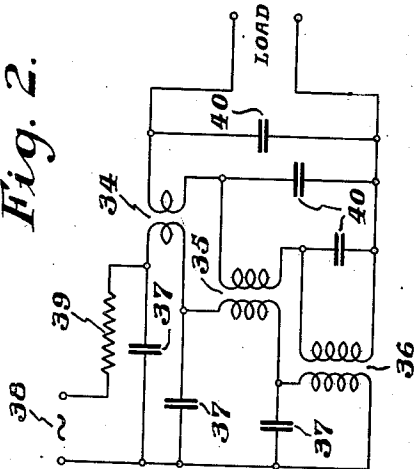
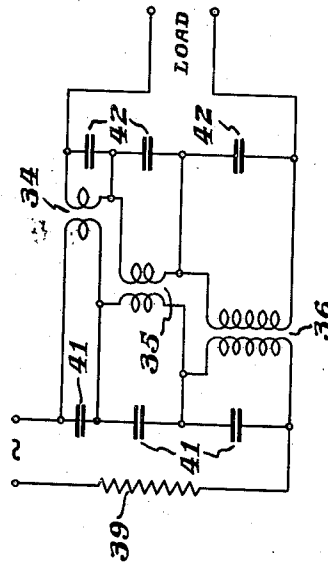


Fig. 3.



INVENTOR,

Vernon D. Landon

BY

W Goldborough

ATTORNEY

Feb. 14, 1939.

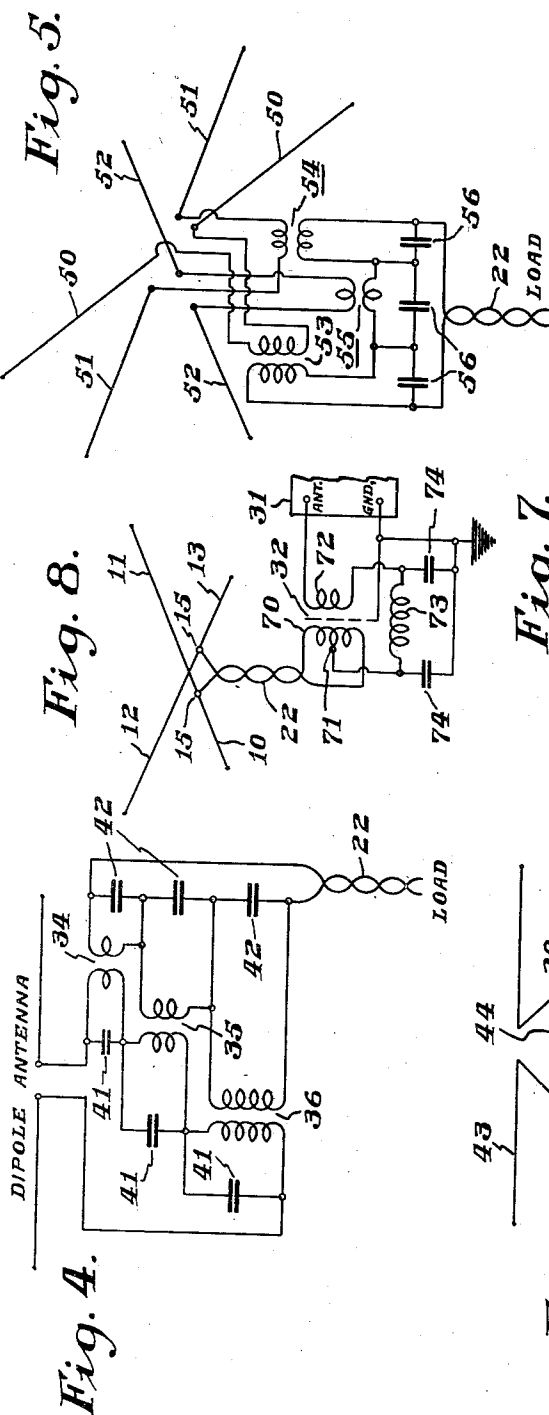
V. D. LANDON

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ANTENNA SYSTEM

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2 Sheets-Sheet 2



INVENTOR
Vernon D. Landon

BY *OR Goldborough*
ATTORNEY

UNITED STATES PATENT OFFICE

2,147,168

ANTENNA SYSTEM

Vernon D. Landon, Collingswood, N. J., assignor,
by mesne assignments, to Radio Corporation of
America, New York, N. Y., a corporation of Del-
aware

Application September 29, 1934, Serial No. 746,081

13 Claims. (Cl. 250—33)

This invention relates to antenna systems and particularly to apparatus for minimizing the effects of static and other interference upon a radio receiver either when used for the reception of long waves or for short waves.

In a copending application, Serial No. 722,842, filed April 28, 1934, by Landon and Reid, as joint inventors, there were disclosed various devices in which there is generally provided a twisted pair of conductors for the lead-in connection between an antenna system and a radio receiver. In that application, the use of a shielded transformer adjacent the receiver was also shown.

In the instant application I show certain developments of apparatus for further minimizing the effects of interfering waves and for more efficiently transferring waves of the desired frequency between the energy collecting devices and the radio receiver.

It is an object of my invention to provide an antenna system which is highly efficient for reception of radio waves of frequencies extending over a very considerable band.

Another object of my invention is to provide an antenna system in which one twisted pair of conductors may serve efficiently as the lead-in connection between the antenna and the receiver regardless of the frequency to which it is desired that the receiver shall be tuned.

Another object of my invention is to provide an antenna system in combination with suitable filters disposed in part adjacent the energy collecting device and in part adjacent a radio receiver whereby radio waves of any desired frequency may efficiently be transferred with minimum "pickup" of interfering waves and static.

Further objects and advantages of my invention will be apparent upon reading the following detailed description in connection with the accompanying drawings, in which:

Fig. 1 shows diagrammatically one embodiment having a pair of dipoles at one end and transformer devices at the two ends of a twisted pair of conductors;

Figs. 2 and 3 show different embodiments of filter systems for efficient transfer of waves of widely variant frequencies;

Fig. 4 shows an antenna system including a plurality of series-connected transformers;

Fig. 5 shows another embodiment of my invention in which a plurality of dipoles may be employed;

Fig. 6 is a diagram of an embodiment of my invention in which the transformers of the filter system are symmetrically arranged; and

Figs. 7 and 8 are diagrams of still further modifications.

Referring to Fig. 1, I show an energy collecting device of the type which I have disclosed in detail in U. S. Patent 2,110,159, comprising two dipoles the arms of which are designated 10, 11, 12 and 13 respectively. The arms 10 and 13 are of equal length. The arms 11 and 12 are also of equal length but this length is different from that of the arms 10 and 13 in order that different resonant points may be had at somewhat widely separated portions of the frequency spectrum to be covered. A filter system comprising a plurality of transformers is provided. The primary of a transformer 14 is connected across points 15 on the two dipoles. The transformer 14 preferably has a divided secondary 16 in order to provide the greatest possible symmetry in its electrical characteristics. The two portions of this secondary are interconnected through the secondary winding 17 of an additional transformer 18. The primary winding 19 of transformer 18 is connected between ground and a mid-tap 20 on the primary winding of transformer 14. The secondary winding 17, preferably, is made resonant to a desired frequency by means of the shunt-capacitor 21. The outer terminals of the secondary windings 16 are connected, respectively, to different conductors 22 of a twisted pair constituting the lead-in to a receiver. At the receiver end of this lead-in I preferably employ further filtering means comprising a plurality of transformers. In the embodiment shown in Fig. 1, there is one transformer 23 having a split primary 24 between the two portions of which are disposed a primary winding 25 of an additional transformer 26. A capacitor 27 serves to tune the circuit, including the winding 25, to a desired frequency.

The transformer 26 has a secondary winding 28 across which may be placed a capacitor 29 for providing resonance at a desired frequency. In series with the secondary winding 28 is the secondary winding 30 of transformer 23. A radio receiver or other load 31 may be connected between the secondary winding 30 and ground.

Suitable shielding 32 is preferably employed between the primary and secondary of each of the transformers 23 and 26. This shielding is, of course, grounded in order that stray currents which would otherwise be transferred by capacitive coupling between the primary and secondary may be drained to ground. The primary and secondary of the transformer 26 may, if desired, be interconnected by means of a resistor 33 to

avoid sparking due to static charges on the antenna system.

In the operation of the system shown in Fig. 1, noise pick-up is effectively avoided by providing as symmetrical an arrangement of the component parts as is possible. If the system is to be employed both for high frequency reception and for reception of waves in the usual broadcast band, then one or another of the transformers adjacent the energy collecting dipoles will become operative according to the tuning of the receiver.

At frequencies near quarter wave resonance of the short arms or near quarter wave resonance of the long arms or at an intervening frequencies near the half wave resonance of a long arm and a short arm in series, energy is delivered to the primary of transformer 14 with opposing phase at the two primary terminals. Thus current flows in the primary but little or no current flows in coil 19 at these frequencies. Magnetic coupling of the primary to the secondary in transformer 14 allows currents to be induced in the two transmission line wires, the currents in the two wires having opposite directions.

At lower frequencies the coils of transformer 14 provide negligible impedance. The four arms 10, 11, 12 and 13 pick up energy of substantially the same phase at the low frequencies. This energy causes a current to flow in coil 19. Coupling of coil 19 to coil 17 causes current to flow in the two transmission line wires 22. Again the current in the two wires is in opposite directions.

On the other hand, any noise picked up on the transmission line itself produces a current of the same direction in the two wires of the transmission line 22. Transformers 23 and 26 operate in such a manner as to pass on to the receiver any currents of opposing phase while rejecting currents of the same phase. Thus "pick up" on the transmission line 22 is eliminated.

Transformers 23 and 26 operate as follows: Currents of like phase (due to noise "pick up") in the transmission wires 22 have no effect upon the primaries 24 and 25 except to vary the potential equally at opposite terminals thereof. The static shields 32 prevent this voltage from being transferred by capacity coupling to the secondaries 28 and 30. Currents representing the desired signal have opposite polarity when applied to the respective terminals of either the primary 24 or the primary 25. If the signal is of high frequency, its currents are by-passed around the coil 25 by the capacitor 27. The energy is then transferred by magnetic coupling from primary 24 to secondary 30. The primary 24 is preferably split and symmetrically disposed as shown. If the distributed capacity to ground from the two halves of primary 24 were not equal, then in-phase currents on the two sides of the line would cause a slight primary current and interference would be transmitted. This condition is, of course, avoided by maintaining symmetry of the coils.

At low frequencies the impedance of coil 24 is low and the impedance of capacitor 27 is high. The energy transfer is then accomplished largely by the transformer 26 and is impressed across the terminals of the receiver 31 to which the secondary 28 is connected.

In order to demonstrate the improved performance of an antenna system when constructed in accordance with the showing of Fig. 1, an illustrative embodiment was made and its

efficiency tested under the following conditions:

The transformer coils were wound on a form so as to have an inside diameter of approximately $\frac{1}{8}$ ". The maximum width of each coil (whether primary or secondary) was $\frac{1}{8}$ ". The coils were then removed from the form. The primary of transformer 14 was sandwiched between the two portions of its secondary, these three coils being closely adjacent one another. The coils of other transformers were similarly made and assembled, except that in respect to transformers 23 and 26 the primary and secondary was in each case separated by a shielding fabric having metallic strands as illustrated in the aforementioned copending application, Serial No. 722,842. The number of turns in each unit and the inductance value in microhenries (μh) is given in the following table:

Transformer	Primary		Secondary	
	Turns	μh	Turns	μh
14.....	10	5	10	5
18.....	100	350	40	70
23.....	10	5	10	5
24.....	40	70	75	200

The embodiment just described provided high efficiency particularly over the two frequency bands for which it was designed, namely, from 540 to 1,500 kilocycles and from 6,000 to 18,000 kilocycles. Reception at frequencies from 1,500 to 6,000 kilocycles was also fair, although it was not to be expected that it would be as favorable as in the extreme bands.

Referring to Fig. 2, I show how a plurality of transformers may be employed in a single network operative over a very wide band of frequencies. Each of the transformers 34, 35 and 36 respectively, is so designed as to pass a band in which the upper frequency may be three or four times that of the lower frequency, while the coupling may be in the neighborhood of 50%. The primaries as well as the secondaries of the transformers 34, 35, 36 may be series-connected. Capacitors 37 are suitably connected in shunt with the primary windings so as to by-pass frequencies to which the transformer windings would offer too great an impedance. Any suitable source of alternating currents 38 may be provided for impress across the primaries of the transformers 34, 35 and 36. In this last mentioned circuit, the generator resistance is represented at 39.

Any suitable load may be connected to the outer terminals of the series-connected secondaries of the transformers 34, 35 and 36. These secondaries may likewise be shunted by means of capacitors 40.

If these transformers 34, 35 and 36 are designed individually for each of several adjacent frequency bands and then connected together as shown, it will be found that there are no dead spots at the points of overlap of the frequencies of the respective bands. High frequency energy is transferred chiefly by the high frequency transformer 34, being by-passed around the other windings by the shunt condensers 37. Lower frequency energy is transferred chiefly by the transformer 35, and so forth. A certain intervening frequency exists at which transformers 34 and 35 are equally effective in transferring energy to the secondary circuit. At this frequency there is a double phase reversal in the

transformer 35 due to the presence of the shunt condensers and the leakage reactance. Thus, over the range of frequency when the two transformers are about equally effective, the energy transfer is additive. Precautions are therefore taken to connect up the terminals of these transformers in aiding relation to one another. The curve of efficiency over the entire range of frequencies can, in fact, be made substantially flat, if desired.

The network shown in Fig. 3 is very similar to that of Fig. 2. Like parts have been given like reference numerals. The principal difference between the two figures is that in Fig. 2 the capacitors 37 and 40 are parallel-connected, whereas in Fig. 3 the capacitors 41, which are connected across the primaries, are series connected and so are the capacitors 42 which are connected across the secondaries. The condenser values chosen for best performance of the network shown in Fig. 3 may not be quite the same as those chosen for the capacitors shown in Fig. 2. Optimum efficiency may easily be obtained, however, with very little experiment. In order that my invention, as exemplified either in Fig. 2 or Fig. 3 may operate to best advantage, it is necessary that the mutual inductances of all transformers shall have the same phase or sign.

Fig. 4 shows how the filter system of Fig. 3 may be employed in connection with a dipole antenna and a load. Like reference numerals again represent like parts in the two figures. The foregoing description, therefore, explains Fig. 4.

Referring to Fig. 5, a further modification of my invention is shown in which there is a plurality of dipoles 50, 51 and 52. The two arms of the dipole 50 are interconnected through the primary winding of a transformer 53. Similar connections are made through the primary of the transformer 54 with respect to the dipole 51 and also through the primary of the transformer 55 with respect to the dipole 52. The secondaries of the three transformers 53, 54 and 55 are series-connected across the leads of the twisted pair of conductors. Capacitors 56 are also provided for obtaining suitable resonant points in the overlapping frequency bands within which each of the transformers 53, 54 and 55 will operate respectively.

Although the device shown in Fig. 5 contemplates the use of but one pair of lead-in conductors 22, it will be seen that the load may be receptive of energy as picked up on any of the different dipoles. Furthermore, if the load is to be divided between a plurality of receivers, it is equally possible to transmit simultaneously a plurality of different carrier waves, each of which will be picked up on the dipole best adapted to receive the same and transmitted to the receiver, or receivers, which are suitably tuned in.

The antenna system shown in Fig. 6 comprises a dipole antenna 43, the two arms of which are inter-connected through the primary winding 44 of a transformer 45. The primary winding 44 has a mid-tap 20 to which may be series-connected a plurality of primary windings of transformers 46 and 47. The circuit including these primary windings is grounded.

In order to provide electrical symmetry in this network, the secondary windings 48 of the transformer 45 are electrically separated by a circuit including secondaries of the transformers 46 and 47. The primaries and secondaries of the transformers 46 and 47 may be made resonant at desired points as by means of the capacitors 49.

Since each of the transformers 45, 46 and 47, with its respective capacitor, if any, is made resonant at an appropriate frequency, it may be seen that the structure of Fig. 6 is adapted to accept waves of widely differing frequencies. For high frequency reception the antenna 43 will operate in such manner that the two arms of the dipole are in phase opposition, whereas for low frequency reception the two arms operate in parallel and in phase.

A simpler modification of my invention is shown in Fig. 7 in which three dipoles 57, 58 and 59 are employed, each dipole being so designed as to respond effectively to frequencies within an appropriate frequency band. In this embodiment, however, but one transformer 60 needs be provided. The primary winding 61 interconnects opposing arms of the antenna 57. The secondary 62 is connected across the terminals of the twisted pair of lead-in conductors 22. The connecting points 63 may also serve to transfer to the conductors 22 energy picked up on either the long arms or the short arms of the dipoles 58 and 59. The operation of the system as shown in Fig. 7 will be apparent in view of the foregoing description.

In certain of the claims, I use the term "conjugate relationship", by which I define the independent actions of the antenna in relation to the transformer primaries, wherein the antenna acts as a capacity antenna for long waves and as a dipole for short waves.

The modification illustrated in Fig. 8 utilizes a double dipole system like that of Fig. 1. The transformers adjacent the center of symmetry of the dipole system are omitted and the lead-in conductors are connected directly to the dipoles at the points 15. Near the receiver, I may employ a short-wave transformer having a primary 70, a secondary 72 and a grounded electrostatic shield 32 interposed therebetween. The secondary 72 is connected in series with a low-pass filter comprising the inductance 73 and two capacitors 74 arranged as shown. This filter and the secondary 72 are series-connected between a mid-tap 71 of the primary 70 and the antenna post of the radio receiver 31. A ground connection is made from the electrodes of capacitors 74 which are opposite their connections to the two ends, respectively, of the inductance 73. This modification is the subject of a divisional application Serial No. 108,507, filed October 31, 1936 (RCV D-4317).

An embodiment of the system shown in Fig. 8 which was made and tested had substantially the following electrical characteristics: The inductance 73 was about 125 microhenries, and the capacitors 74 were about 125 micro-microfarads. Such a filter readily passed the frequencies of the usual broadcast band while considerably attenuating frequencies of the so-called short-wave bands. These latter frequencies are, however, effectively transferred by induction between the primary 70 and the secondary 72 to the receiver 31, because of the voltage difference across the primary 70. Interfering "pick-up" energy collected on the lead-in wires 22 does not produce a voltage difference across the primary and is drained to ground by the static shield 32. The filter system operates efficiently to by-pass signals of the broadcast band around the transformer especially because it is connected to the mid-tap 71 where there is a maximum voltage change at low frequencies.

While I have shown a number of embodiments of my invention, it will be apparent that there

are certain features common to them all. It will also be understood by those skilled in the art that further modifications may be made without departing from the spirit and scope of my invention. I intend, therefore, that no limitations shall be imposed except such as are necessitated by the prior art and by the scope of the appended claims.

I claim as my invention:

1. An antenna system comprising an energy collecting dipole the arms of which are interconnected through the primary winding of a transformer, at least one other transformer the primary of which is connected between a mid-tap on the first said transformer and ground, a pair of conductors connected with the secondaries of said transformers and constituting a transmission line independent of said connection to ground.

2. In an antenna system for a multi-band radio receiver, a plurality of interconnecting transformers having different frequency characteristics, means for connecting a plurality of primaries of said transformers in conjugate relation, means for connecting a plurality of the secondaries in series, and means including a plurality of capacitors suitably connected for by-passing high-frequency energy around low-frequency transformer windings.

3. A system according to claim 2 further characterized in that the inductance values of the transformer windings and the capacitance values of the capacitors are so proportioned as to provide a substantially flat efficiency curve over a frequency range greater than can be covered by any one of the transformers alone.

4. An antenna system comprising energy collecting means having a pair of symmetrically disposed sections, a pair of lead-in conductors terminating at one end adjacent the center of symmetry of said sections, means including a transformer having a primary winding interconnecting said sections and at least one secondary winding connected across the terminals of said lead-in conductors, said means being adapted to transfer oppositely phased high-frequency energy as developed on two of said sections respectively, and further transformer means having primary connections to said energy collecting means and secondary connections to said lead-in conductors for transferring low-frequency energy of like phase from each of said sections to said lead-in conductors.

5. An antenna system having a plurality of dipoles the arms of which differ in their frequency-response characteristics, a pair of lead-in conductors, means including a plurality of transformers having their primaries connected in conjugate relation and their secondaries in aiding relation to one another and having different impedance characteristics with respect to different frequencies for transferring signaling energy from said dipoles to said conductors in an oppositely phased sense, irrespective of the frequency of said energy, a leakage resistor for draining to ground interfering "pick-up" energy having like phase on the two lead-in conductors, and means including a second plurality of transformers having their primaries series-connected across said lead-in conductors and having their secondaries series-connected between a radio receiver and ground for transferring said signaling energy from said lead-in conductors to said receiver.

6. An antenna system for a short and long wave receiver comprising a pair of symmetrically disposed sections for collecting signal energy, a balanced transmission line for transferring signal energy from said sections to said receiver, a first and second transformer for transferring short and long wave signal energies respectively from said sections to said line, the primary of said first transformer being connected in series between said sections, the primary of said second transformer being connected from the substantial center of symmetry of the first primary to ground independently of said line, and the secondaries of said transformers being connected to said line, whereby said line is balanced for said short and long wave energy and against disturbing energy to which said line may be exposed.

7. The invention as set forth in claim 6 characterized in that said secondaries are connected in series.

8. The invention as set forth in claim 6 is further characterized in that said secondaries are connected in series and a capacitor connected in shunt with the secondary of said second transformer for by-passing short wave signal energy.

9. The invention as set forth in claim 6 is further characterized in that said second transformer has a substantial step down turn ratio from the antenna sections, which function as a capacity antenna for long waves.

10. In an antenna system for a short and long wave receiver comprising at least one pair of symmetrically disposed sections for collecting signal energy, a balanced two wire transmission line for transferring signal energy from said sections to said receiver, a pair of transformers responsive to short and long waves respectively interconnecting said sections and said line in matched relation, the primaries of said transformers being connected in conjugate relation to said sections and ground, whereby said sections function out of phase for short wave signals and in phase for long wave signals, and a ground connection for one of said primaries adjacent the antenna end of said transmission line and independently of said line.

11. The invention as set forth in claim 10 characterized in that said antenna sections each comprises a long and a short dipole arm.

12. The invention as set forth in claim 10 characterized in that each of said sections comprises a long and a short dipole arm extending substantially in opposite directions.

13. In an antenna system for a short and long wave radio receiver, a multiple dipole structure for collecting signal energy, a balanced transmission line interconnecting said dipole structure and said receiver, a plurality of impedance matching transformers responsive to different wave bands, adjacent said dipole structure and connected between said structure and said line, the primaries of said transformers being relatively so connected that said dipole structure acts as a half wave antenna for short waves and as a capacity antenna for long waves, additional impedance matching transformers adjacent said receiver for connecting said line thereto, certain of the windings of said transformers being arranged to prevent magnetic coupling therebetween, and means for preventing capacity coupling between said line and said receiver.

VERNON D. LANDON.