May 19, 1942. R. M. WILMOTTE 2,283,618

RADIO ANTENNA SYSTEM

Filed Dec. 18, 1941

Fig. 1.

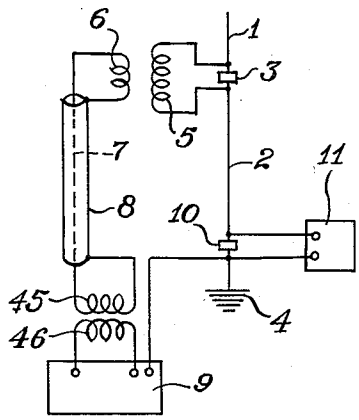


Fig. 2.

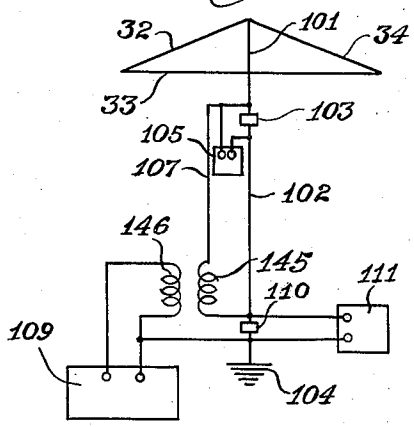


Fig. 3.

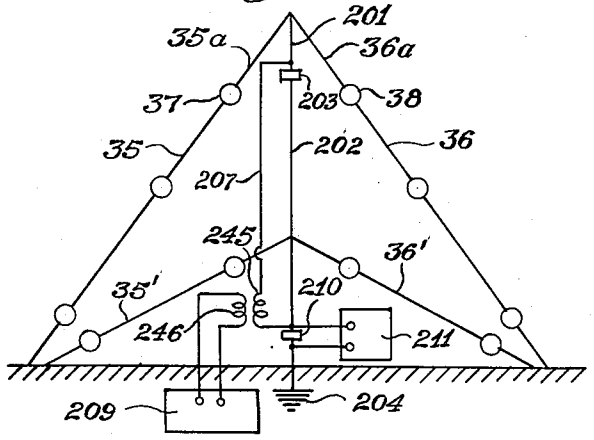


Fig. 4.

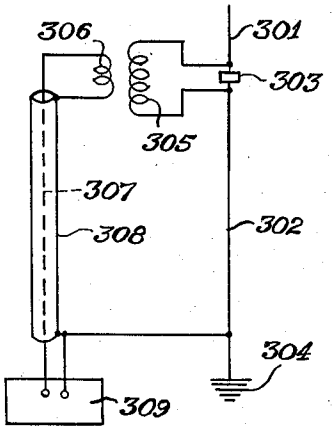


Fig. 5.

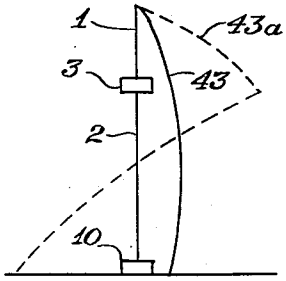


Fig. 6.

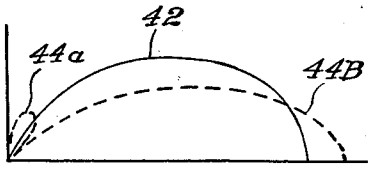
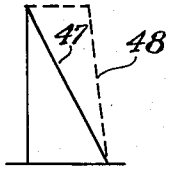


Fig. 7.



Inventor

Raymond M. Wilmotte

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2,283,618

RADIO ANTENNA SYSTEM

Raymond M. Wilmotte, Washington, D. C.

Application December 18, 1941, Serial No. 423,539

10 Claims. (Cl. 250—33)

This is a continuation-in-part of my co-pending application entitled Antenna, Serial No. 392,439, filed May 8, 1941.

This invention relates to radio antenna systems, and, more particularly, to arrangements for controlling the directional characteristics of a vertical radiator, especially in a vertical plane, and/or its radiation resistance.

One of the objects of this invention is to provide a vertical radiator fed at or near one end thereof, and having an impedance at or near the other end for obtaining other current distribution than is obtained with a simple vertical radiator. In the art to date, it is a common expedient to place an impedance at the top of a vertical radiator by mounting comparatively large structural elements at the head of a mast thus preventing the current value at the mast head from being zero. It is an object of the present invention to provide means in an antenna system for the controlling of the effective impedance at the end of an antenna from the ground.

Still another object of the invention is to provide an antenna which has a radiation resistance which may be controlled, and, in particular, in the case of short antennas the radiation resistance is made greater than is normally possible with simple vertical antennas.

A further object of the invention is to provide a transmission system for a radiator fed near the top or at some point intermediate along its length. In accordance with the teachings herein, it is proposed even to provide a vertical radiator having a vertical transmission line closely adjacent thereto and to prevent the transmission line from effectively short circuiting the radiator. These and other objects will appear from the following specification and diagrams in which:

Figure 1 diagrammatically illustrates one form of the invention;

Figure 2 shows a modification of the structure for feeding the radiator;

Figure 3 illustrates a third embodiment;

Figure 4 illustrates a fourth embodiment;

Figure 5 illustrates a typical current distribution in a radiator of the type illustrated in Figures 1 to 3;

Figure 6 shows a radiation pattern from an antenna according to the present invention; and

Figure 7 shows the current distribution in a radiator which is small compared with the wavelength.

Referring first to the Figure 1 embodiment, reference numeral 1 denotes the upper portion of a vertical radiator insulated from the lower, main portion 2 by an insulator 3. Preferably an insulator 10 isolates the lower portion of radiator 2 from the ground 4. In actual construction, radiator 2 may take the form of the mast, tower, or the like, supported by suitable guy wires, as illustrated in the Figure 3 embodiment.

The radiator is fed, for instance, by inductance 5 connected between portions 1 and 2 coupled to second inductance 6, which, in the form shown, is connected to one end of transmission line 7, 8 which, in turn is coupled at its lower end to transmitter 9 which constitutes the source of signal energy. The coupling to the transmitter is designed so as not to short circuit the insulator 10 and impedance 11. It is shown as consisting of a transformer made up of coils 45 and 46. The impedance 11 is connected between the lower end of radiator 2 and the ground, so that the current distribution and, in turn, the radiation pattern, may be adjusted.

In Figure 5 the full line 43 indicates the current distribution which normally would be obtained in the usual case of a simple vertical antenna of the same height excited at the base. Referring now to Figure 6, the full line 42 shows the radiation pattern of an antenna having a current distribution as indicated at 43 in Figure 5. It will be seen that a considerable portion of the radiated energy is dissipated upwardly and is lost for certain service purposes. However, when a current distribution, as shown at 43*a*, is attained in Figure 5, a radiation pattern 44*a*, 44*b* results. It will be seen that the pattern 44*a*, 44*b* provides greater signal in the horizontal direction plane as is frequently desirable. Since the radiation resistance of the antenna having the radiation characteristics shown by curve 42 is different from that shown by curve 44*a*, 44*b* in Figure 6, the invention may, therefore, be used to control the radiation resistance of an antenna. This further object of the invention is particularly valuable in the case of antennas that are short compared with the wavelength, such as are used with long radio waves. In this case, the current distribution for a simple vertical antenna fed at the base is approximately triangular as shown by the line 47 in Figure 7. When the radiator is effectively excited near the top in accordance with the invention, the current distribution is more nearly uniform as shown by line 48 in Figure 7. The shape of the radiation pattern will be very nearly the same in both cases, but the power radiated with the current distribution 48, will approximate four

times the power radiated with the current distribution 47. The radiation resistance will therefore be greater. Since the ohmic and other losses are frequently large in such installations, an increase in the radiation resistance will have the effect of increasing the efficiency of the radiator.

In all cases adequate load at the feed end of the radiator is required to feed the radiator efficiently.

In the embodiment shown in Figure 2, reference numeral 101 represents a top loading element, the top loading element including also conductors 32, 33 and 34. The conductors are insulated from the radiator 102 by insulator 103, radiator 102 preferably being insulated from ground 104 by insulator 110.

Conductors 101, 32, 33 and 34, which of themselves provide substantially no radiation, are fed by transmission line 107 lying closely adjacent to radiator 102 and connected at its lower end to the secondary coil 145 of the transformer, the other end of secondary coil 145 being connected to the lower end of radiator 102. The output of transmitter 109 is connected to primary coil 146, one side of the output being connected to ground 104. As in the embodiment first described, the variable impedance 111, which corresponds with impedance 11, is connected between the lower end of radiator 102 and ground 104. An impedance 105 is connected across insulator 103. For certain current distributions, impedance 105 may be zero, in which case the insulator 103 is not necessary, since it is short circuited. As in the embodiment shown in Figure 1, radiator 102 may assume any one of a number of conventional structural forms and it is further contemplated that suitable insulating supports be provided on radiator 102 for holding transmission line 107 closely adjacent thereto. When transmitter 109 is operated, it will be seen that transformer 145, 146 avoids short circuiting insulator 110.

Figure 3 shows a further embodiment wherein guy wires 35, 36 which may assist in the support of radiator 202, further constitute means for feeding the radiator at the top end thereof. It will be seen that conductor 201 is insulated by insulator 203 from the upper end of radiator 202 and that insulators 37, 38 are placed at intervals along the length of guy wires 35, 36 to separate the guy wires into a number of non-radiating sections. Sections 35 and 36 of the guy wires which are connected at their upper ends to conductor 201 and of themselves constitute conductors, are fed by transmission line 207, the lower end of line 207 being connected through transformer 245, 246 to transmitter 209. In this case instead of a regular transmission line, the radiator 202 acts as one of the conductors of the transmission line, and 207 as the other.

Thus, when transmission line 207, preferably supported closely adjacent to radiator 202, is energized, conductors 201, 35*a* and 36*a*, while being substantially non-radiating in their aggregate, effectively excite radiator 202 at its upper end. As in the previous embodiments, variable impedance 211 is connected between the lower end of radiator 202 and the ground for controlling the current distribution in radiator 202.

Lower guy wires 35', 36' with insulators suitably distributed therealong are provided in accordance with principals well known in the art.

Impedance 11 of Figure 1, 111 of Figure 2 and 211 of Figure 3 may be of any desired value and may be zero or infinity. If it is infinity, the impedance is not used. If it is zero the insulator at the base of the radiator is short circuited or removed. This latter arrangement is shown in Figure 4 in which numeral 302 designates the lower portion of the radiator, 301 the upper portion, 303 the insulator between them, 304 the ground to which the lower end of radiator 302 is connected, and numerals 305, 306 denote the transformer coupling the transmission line 307, 308 across insulator 303 to the transmitter 309.

It will be evident that the directivity may be controlled by changing the current distribution in the radiator by means, for instance, of impedance 11 of Figure 1, or the height of radiators 1 or 2. The change in directivity thus produced will have the effect of controlling the signal in the horizontal direction relative to the signal in other directions. It will also change the radiation resistance and the losses. It is possible, therefore, to excite an antenna so as to produce an optimum directivity condition. If a given amount of power is to be radiated, this condition will correspond to the maximum signal in the required direction for the particular method of excitation, which is equivalent to the condition of directivity. If, instead, the power input of the antenna is given, the optimum condition will then depend not only on the directivity, but also on the ohmic and other losses. In certain cases it will be found that this optimum condition is controlled principally by the optimum condition for directivity, while in others, the effect of the ohmic losses may have a dominant influence.

In order to obtain approximately maximum signal in the desired direction with a given antenna height, I have found that the type of excitation must be designed so that a condition is reached in which the ohmic and other losses play an important part. One object of my invention is, therefore, to use a design whereby the directivity may be increased so that the radiation resistance becomes comparable to the "loss" resistance and is so adjusted as to produce a maximum field in the required direction.

It will generally be found that if the optimum directivity is a dominant controlling factor in obtaining a maximum signal in the desired direction for a given power input to the antenna, then it becomes possible to improve the performance of the antenna by altering the excitation in accordance with my invention until the optimum condition is reached. Since these losses are difficult to evaluate and measure, it is important in many cases to be able to adjust the excitation until the measured field is a maximum. The invention is particularly suitable to permit such adjustments for it is only necessary to adjust impedance 11 in Figure 1.

The invention described above is not limited to the specific disclosure, but, on the contrary, embraces the full scope of equivalents and substitutions within the scope of the following claims.

What I claim is:

1. In a radio antenna system, an antenna element having two ends, an aperiodic electrical loading means adjacent to one end of said antenna element, means close to the antenna element for exciting said antenna at the said one end, and variable impedance means connected between the other end of said antenna element and its electrical ground for controlling the current distribution in said antenna element.

2. In a radio antenna system, an antenna element having two ends, an aperiodic electrical

loading element adjacent one end of said antenna element, a transmission line extending to adjacent said one end of said antenna element and adapted to be connected at its other end to a translating means, said transmission line lying close to the antenna element, coupling means connecting said transmission line to said one end of said antenna element for imparting signal energy to said one end of said antenna element, and variable impedance means connected between the other end of said antenna element and its electrical ground for controlling the current distribution in said antenna element.

3. In a radio antenna system, a first vertical transmission element, a second vertical transmission element adjacent thereto, an aperiodic electrical loading means adjacent the upper end of said elements, means coupling said loading means between the upper ends of said elements, a source of signal energy connected to the lower end of one of said elements, and variable impedance means connected between the other of said elements and the ground, said other element constituting a radiator.

4. In a radio antenna system, an antenna element, an aperiodic electrical loading element adjacent to the end of said antenna element remote from the electrical ground, means for insulating the electrical ground end of said antenna element from its electrical ground, a transmission line lying in closely adjacent spaced relationship with said antenna element, means at the electrical ground end of said transmission line for connecting the same to a translating means, coupling means at the remote end of the transmission line connected between the said end of the antenna element remote from the electrical ground and said aperiodic element for transferring signal energy between said remote end of said antenna element and said translating means, and variable impedance means connected between the electrical ground end of said antenna element and the electrical ground for controlling the current distribution in said antenna element.

5. In a radio antenna system, an antenna element having an electrical ground end and an end remote from the electrical ground, means for insulating the electrical ground end of said antenna element from its electrical ground, a transmission line lying in closely adjacent spaced relationship with said antenna element, a transformer having a secondary coil thereof connected between the electrical ground end of said transmission line and the electrical ground end of said antenna element, the primary coil of said transformer being connected at one end to the electrical ground and adapted at the other end to be connected to a translating means, aperiodic loading means at a remote end of said transmission line, said loading means constituting means for transferring signal energy between said remote end of said antenna element and said translating means, and variable impedance means connected between the said electrical ground end of said antenna element and its electrical ground for controlling current distribution in said antenna element.

6. In a radio antenna system, an antenna element having an electrical ground end and an end remote from the electrical ground, means for insulating the electrical ground end of said antenna element from its electrical ground, a transmission line lying in closely adjacent spaced relationship with said antenna element and adapted to be connected to one side of a translating means, means at the ground end of said transmission line for connecting the same to the other side of said translating means, conductor means supported at the end of said antenna element remote from the said electrical ground and connected to the end of said transmission line remote from the ground, said conductor means being aperiodic and constituting a top loading element for transferring signal energy between said remote end of said antenna means and said translating means, and variable impedance means connected between the said electrical ground end of said antenna element and its electrical ground.

7. The combination claimed in claim 6, said antenna element being elongated, said conductor means including a plurality of conductor elements extending outward from the longitudinal axis of said antenna element, and insulating means mounting said conductor means at the end of said antenna element.

8. In a radio antenna system, an antenna element, having an electrical ground end and an end remote from the electrical ground, means for insulating said electrical ground end of said antenna element from its electrical ground, a transmission line lying in closely adjacent spaced relationship with said antenna element and adapted to be connected at its electrical ground end to a translating means, conductor means supported at the end of said antenna element remote from said electrical ground, said conductor means being coupled to the end of said transmission line remote from the ground and constituting a top loading element for transferring signal energy between said remote end of said radiator and said translating means, variable impedance means, and means connecting said variable impedance means to said electrical ground end of said antenna element and to the electrical ground for controlling the current distribution in said antenna element.

9. In a radio antenna system, two radiators juxtaposed with respect to one another, said radiators having adjacent ends, coupling means between the adjacent ends, means for exciting both radiators through said coupling means, and variable impedance means connecting one of the non-adjacent ends of one of said radiators and its electrical ground, one of said radiators being aperiodic.

10. In a radio antenna system, two radiators having adjacent ends juxtaposed with respect to one another, means grounding the non-adjacent end of one of said radiators, coupling means between said adjacent ends, and transmission means extending closely adjacent to the grounded radiator and electrically coupled to said coupling means for exciting both radiators through said coupling means, one of said radiators being aperiodic.

RAYMOND M. WILMOTTE.