March 3, 1942. G. H. BROWN 2,275,342

HIGH FREQUENCY ANTENNA

Filed Nov. 24, 1939

FIG. 1.

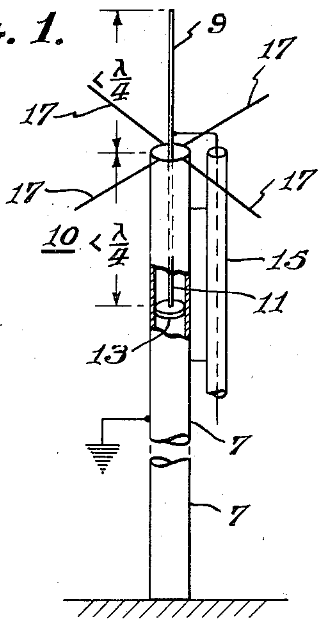


FIG. 2.

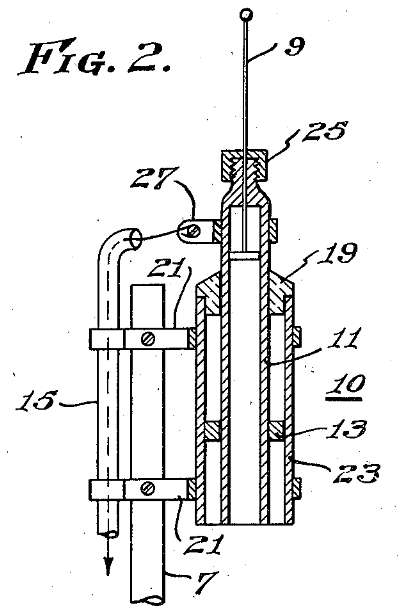


FIG. 4.

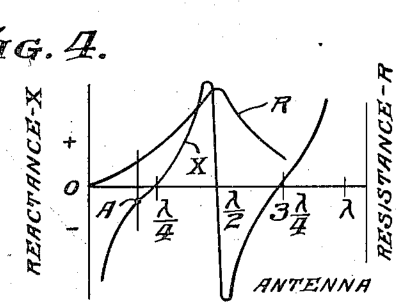


FIG. 5.

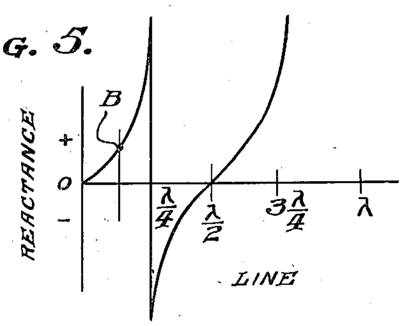


FIG. 6.

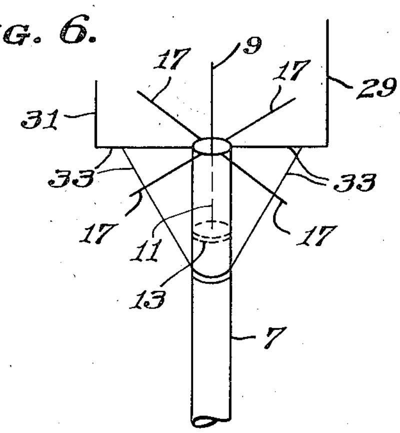
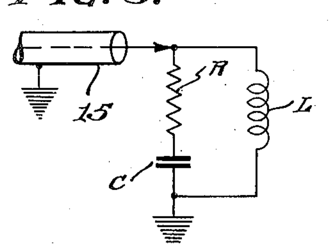


FIG. 3.



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2,275,342

HIGH FREQUENCY ANTENNA

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Application November 24, 1939, Serial No. 305,813

14 Claims. (Cl. 250—33)

This invention relates to high frequency antennas, and more particularly to an improved demountable antenna, the impedance of which is readily adjusted to match the impedance of a conventional transmission line.

This invention is an improvement over the high frequency demountable antenna described and claimed in U. S. Patent No. 2,234,333, issued March 11, 1941, to G. H. Brown et al., for "Demountable antennas."

The antenna described in the above-identified patent utilizes a quarter wave concentric line to support a quarter wave antenna. A matching transformer is used to couple a standard 70-ohm transmission line to the antenna which has a resistive impedance of approximately 21.5 ohms. I have found that an antenna of this type may be made more compact, lighter, and considerably more economical by eliminating the coupling transformer which has heretofore been deemed necessary. The modifications to the concentric line and the antenna, which are necessary as a result of the elimination of the coupling transformer, also produce a further reduction of size, as will appear subsequently.

Inasmuch as the 70-ohm transmission line has been standardized by the industry and is commercially available, and since many transmitter output circuits are designed to accommodate 70-ohm lines, it is believed to be inadvisable to eliminate the coupling transformer of the antenna described in said patent by changing the impedance of the line to match that of a quarter wave antenna. Nor can the antenna impedance be changed to match the line impedance merely by changing its length, for it would then become reactive and its impedance would vary sharply with frequency, thus producing reflections in the line at sideband frequencies.

It is the primary purpose of this invention, therefore, to provide means for adjusting the impedance of an antenna to equal that of a standard transmission line, and particularly to adjust the impedance of an antenna of the type described in the above-identified patent for the same purpose. Further objects of this invention are the provision of an improved demountable antenna, and the provision of a high frequency antenna adapted for use at a given frequency within a wide range of frequencies.

This invention will be better understood from the following description when considered in connection with the accompanying drawing; its scope is indicated by the appended claims. Referring to the drawing, Figure 1 is a perspective view of an embodiment of this invention; Figure 2 is a view, partly in section, of an embodiment of this invention; Figure 3 is a schematic diagram of an equivalent circuit; Figures 4 and 5 are curves illustrating the theory of operation of this invention; and Figure 6 is a view of an embodiment utilizing a reflector and a director to obtain a directional radiation pattern. Similar reference numerals refer to similar parts throughout the several drawings.

Referring to Fig. 1, a hollow metallic mast 7 supports the radiating element 9 and a non-radiating element 10. The radiating element is that portion 9 of the antenna extending above the top of the mast 7. The radiating element 9 is connected to and is supported by the non-radiating element which includes the upper portion of the mast 7 and the conductor 11 which extends centrally into the mast and terminates in a shorting block 13. The shorting block 13 makes an electrical connection between the mast 7 and the conductor 11. The antenna is fed by a concentric transmission line 15, having its outer conductor grounded to the mast 7 and its inner conductor connected to the bottom of the radiating element 9, that is, to the junction of the radiating and nonradiating elements. As in the antenna described in said patent, four horizontal conductors 17 extending radially from the top of the mast 7 may be used to provide an effective ground for the antenna. The arrangement illustrated in Fig. 1 is intended merely to illustrate the essentials of this invention and not to embody the requirements of an actual construction. Its adjustment and operation will now be explained.

The length of the antenna 9 is made slightly less than a quarter wavelength so that it has a capacitive reactance. The position of the shorting block 13 is then adjusted until the antenna is tuned to parallel resonance at the operating frequency. The shunt impedance may also be selected by a suitable choice of antenna length, as will now be explained.

The impedance of a quarter wave antenna which is mounted above four radial ground rods, as illustrated in Fig. 1, has a purely resistive impedance of approximately 21 ohms. Above and below a quarter wavelength, the antenna impedance becomes reactive, as shown in Fig. 4, to which reference is now made. Fig. 4 represents the reactance vs. length characteristic of a radiating conductor, for a given operating frequency. It will be noted that the curve crosses the zero axis at each multiple of a quarter wavelength. Just below a quarter wave, for example, the antenna reactance is negative, that is, capacitive, while, just above a quarter wave, the reactance is positive, that is, inductive. The curve is a cotangent curve modified by the finite value of antenna resistance which prevents the antenna impedance from reaching a very high value on either side of resonance at the half wave position. The curve R represents the effective antenna radiation resistance.

The reactance vs. length characteristic of a concentric line short-circuited at one end is illustrated in Fig. 5, to which reference is now made. This curve is approximately a tangent curve but, as before, the theoretical infinite reactance adjacent the quarter wave position is not reached due to its finite resistance. Since the resistance of a closed quarter wave line is much less than the radiation resistance of an antenna, however, the reactance becomes very much greater at the resonant point. In this case, it will be noted that the reactance is positive, that is, inductive just below the quarter wave point.

Now the impedance looking from the transmission line 15 into the antenna is equivalent to that of the circuit illustrated in Fig. 3 in which R is the antenna radiation resistance, C is the capacitive reactance of the antenna, assuming it to be less than a quarter wave long, and L is the parallel inductive reactance of the supporting concentric line, assuming it also to be less than a quarter wave long.

The shunt admittance of such a circuit may be obtained by adding the admittances of the two branch circuits, thus

$$Y_1=\frac{R}{R^2+\left(\frac{1}{\omega C}\right)^2}+j\frac{\frac{1}{\omega C}}{R^2+\left(\frac{1}{\omega C}\right)^2} \quad (1)$$

$$Y_2=\quad -j\frac{1}{\omega L} \quad (2)$$

where Y_1 is the admittance of the antenna branch including R and C, and Y_2 is the admittance of the concentric line, neglecting its resistance.

If the two reactive components are made equal, which is done in accordance with this invention by adjusting the relative lengths of the antenna and the concentric line, the input impedance Zin is seen to be the reciprocal of the first term of Equation 1. Thus

$$Zin=\frac{R^2+\left(\frac{1}{\omega C}\right)^2}{R} \quad (3)$$

From Equation 3 is may be seen that the capacitive reactance of the antenna affects its input impedance at resonance. By making the length of the antenna a little less than a quarter wave, or odd multiple thereof, it will have a capacitive reactance, and the actual value of capacitance may also be controlled. Assume, for example, that the length of the antenna is made such that its reactance is represented by the point A in Fig. 4. In order to tune the shunt circuit to parallel resonance, the concentric line must be made inductive, and it is therefore shortened until its reactance is represented by point B in Fig. 5. The input impedance at the base of the antenna will be a pure resistance and will have some value which is determined by the R and C of the antenna, as indicated in Equation 3. If it is found that this value of impedance is too low for the transmission line impedance, increasing the length of the antenna will decrease C and increase R which will increase the input impedance. The concentric line inductance is then corrected to return the system to resonance.

It will be found in practice that the measured length of the antenna and concentric line will vary somewhat from the calculated value. This is due to the capacitive effect of insulators and clamps which are necessary for structural reasons. For a given design, however, the fractional wavelength for the antenna and the concentric line corresponding to a given input impedance, remain constant over a wide range of operating frequencies. For example, to match an antenna of this type to a standard 70-ohm line, I have found that the antenna should be 0.243 λ and the concentric line resonator should be 0.119 λ. The difference in their lengths is due to the different effect of the insulator on the concentric line and the antenna, and the difference in the behavior of the characteristic curve near the quarter wave point. That is, Fig. 4 shows that immediately below the quarter wave point, the antenna reactance is small, but immediately below the quarter wave point, the concentric line inductance is very large. Consequently, the line must be shortened more than the antenna to provide an equal reactance. This, however, is an advantage, since it reduces the weight and size of the concentric section.

Fig. 2 illustrates a practical example of an antenna which may be adjusted for operation in any desired frequency band. For any given installation in which the operating frequency is fixed, however, it is recommended that the construction be simplified by building the concentric line resonator and the antenna to the required length. This may be determined for any frequency from the fractional wavelength figures given above. However, the adjustable arrangement shown is frequently desirable.

The antenna is clamped to a metal or wooden mast 7 by a pair of clamps 21 which are securely fastened to the outer conductor 23 of the concentric line resonator 10. The inner conductor 11 is also hollow, and includes means for slidably adjusting the length of the antenna radiator 9, which is clamped in position by a clamp screw arrangement 25. An insulator 19 is located at the top of the concentric line to hold the inner conductor in position. The shorting block 13 may be adjusted by inserting a suitable tool in the bottom of the line. The transmission line is connected to the base of the antenna by means of a clamp 27.

In case the concentric resonator 10 is built to the required length, it may conveniently be mounted within the supporting mast, since no adjustment need be made.

Referring now to Fig. 6, we have shown an arrangement for making a directional antenna. Like the arrangement shown in Fig. 1, the concentric resonator is within the upper section of the metal mast 7, and the grounding rods 17 are also provided. In addition, a vertical reflector 29 is suitably mounted on a bracket 33. It is spaced approximately

$$\frac{3\lambda}{8}$$

from the antenna. A vertical director 31 may also be employed. The director is on the opposite side of the antenna from the reflector, and similarly spaced from the antenna. The length of the reflector is greater than that of the antenna, while the director is preferably shorter than the antenna.

I have thus described a compact antenna which may be built to match the impedance of a given transmission line, which is at ground potential to lightning and static discharges, and which may be conveniently mounted in or on a metallic or wooden supporting mast.

I claim as my invention:

1. A high frequency antenna comprising a radiating element having one end electrically connected to the inner member of a reactive concen-

tric supporting element, means for connecting the junction of said antenna and said supporting element to a transmission line of predetermined characteristic impedance, the length of said radiating element and the reactance of said supporting element being so selected that the impedance of said antenna and supporting element at said point of connection is equal to said predetermined characteristic impedance.

2. A high frequency antenna comprising a radiating element having a capacitive reactance connected to a concentric supporting element having an inductive reactance, means for connecting the junction point of said elements to a transmission line having a predetermined characteristic impedance, the reactances of said elements being selected to match the impedance of said antenna at said junction point to the impedance of said line.

3. A high frequency antenna comprising a radiating element and a closed concentric line nonradiating element, means connecting one end of said radiating element to the open end of the inner conductor of said nonradiating element, means for connecting a transmission line to the junction point of said elements, the reactance and resistance of said elements being selected to match the impedance of said antenna to the impedance of said line, said non-radiating element having an electrical length less than a quarter of the operating wavelength, or any odd multiple thereof.

4. A device of the character described in claim 3 and in which said radiating element is an extension of the inner conductor of said concentric line having an electrical length less than a quarter of the operating wavelength, or an odd multiple thereof.

5. A high frequency antenna comprising a radiating element and a non-radiating element, said non-radiating element comprising a concentric line section having means for adjusting its electrical length, and said radiating element comprising an extension of the inner conductor of said concentric line, means for adjusting the electrical length of said radiating element, and means for connecting a transmission line to the junction of said elements.

6. A high frequency antenna comprising a radiating element joined to a non-radiating element, said non-radiating element serving to support and to tune said radiating element to resonance at the operating frequency, and means for connecting a transmission line to the point of junction of said elements.

7. A high frequency antenna comprising a concentric line section having inner and outer conductors, means slidably mounted on said inner conductor and engaging said outer conductor for adjusting the electrical length of said line, a radiating element connected to said inner conductor, means for adjusting the electrical length of said radiating element, and means for connecting a transmission line to the junction of said radiating element and said inner conductor.

8. In a high frequency antenna having a reactive radiating element and a reactive concentric line section connected to said radiating element for supporting and resonating said element, said elements, being connected at their junction to a transmission line, the method of adjusting the shunt impedance of said antenna to equal that of said line, which comprises adjusting the length of said radiating element and said concentric line section to resonate said element at the operating frequency, the reactances and resistance of said elements being selected to produce an antenna impedance equal to the impedance of said transmission line.

9. A high frequency antenna comprising a radiating element connected to a reactive concentric supporting element, means for connecting the junction of said antenna and said supporting element to a transmission line of predetermined characteristic impedance, the length of said radiating element and the reactance of said supporting element being so selected that the impedance of said antenna and supporting element at said point of connection is equal to said predetermined characteristic impedance, and a plurality of quarter wave conductors connected to the end of the outer conductor of said supporting element adjacent said radiating element.

10. A high frequency antenna comprising a radiating element having a capacitive reactance connected to a concentric supporting element having an inductive reactance, means for connecting the junction point of said elements to a transmission line having a predetermined characteristic impedance, the reactances of said elements being selected to match the impedance of said antenna at said junction point to the impedance of said line, and a plurality of quarter wave conductors connected to the end of the outer conductor of said supporting element adjacent said radiating element, and perpendicular to the axis of said supporting element.

11. A high frequency antenna comprising a radiating element connected to a reactive concentric supporting element, means for connecting the junction of said antenna and said supporting element to a transmission line of predetermined characteristic impedance, the length of said radiating element and the reactance of said supporting element being so selected that the impedance of said antenna and supporting element at said point of connection is equal to said predetermined characteristic impedance, a plurality of quarter wave conductors connected to the end of said supporting element adjacent said radiating element, and a reflecting conductor mounted on the end of one of said quarter wave conductors and parallel to said radiating element.

12. A high frequency antenna comprising a radiating element and a concentric conductor supporting element, said radiating element being a linear continuation of the inner conductor of said supporting element, a transmission line connected to the junction point of said members, and a plurality of quarter wave conductors connected to the outer conductor of said supporting member at the end adjacent said radiating member, and perpendicular to the axis of said members.

13. A device of the character described in claim 12 in which the electrical lengths of said supporting and radiating members are less than a quarter wave at the operating frequency and of equal and opposite reactance.

14. A device of the character described in claim 2 which includes means connected to the end of the outer conductor of said supporting element adjacent said radiating element for establishing an effective ground for said radiating element.

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