March 11, 1947. G. H. BROWN 2,417,290

ANTENNA SYSTEM

Filed Feb. 23, 1943

Fig. 1.

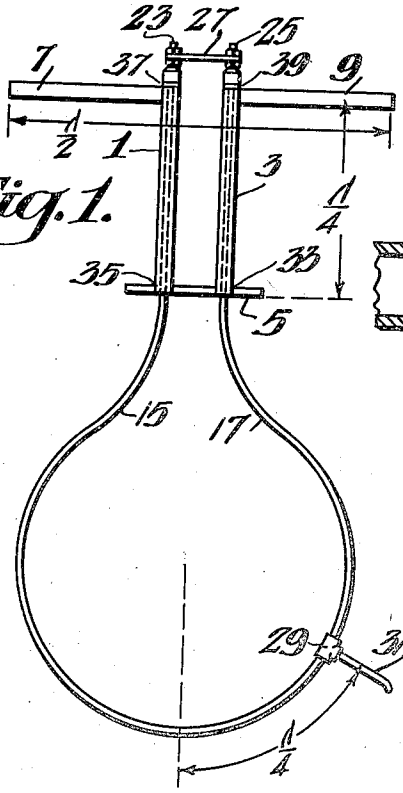


Fig. 2.

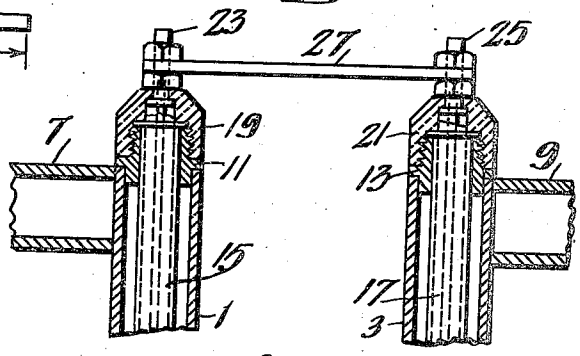


Fig. 4.

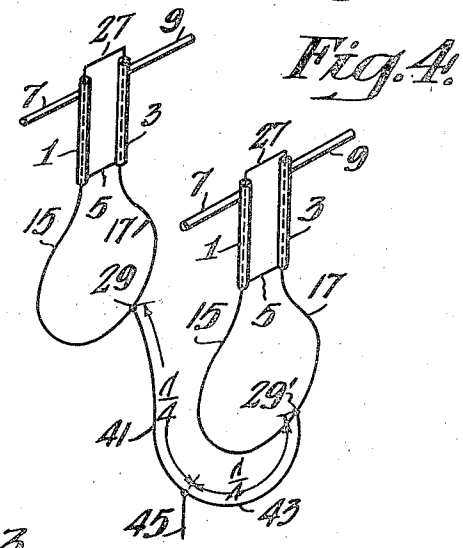
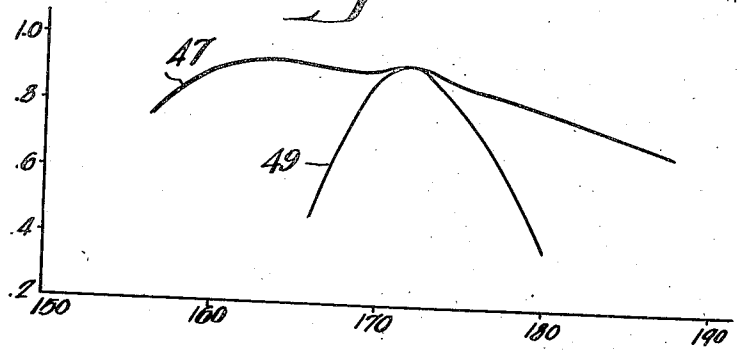


Fig. 3.



Inventor
George H. Brown

By C. D. Fuska

Attorney

Patented Mar. 11, 1947

2,417,290

UNITED STATES PATENT OFFICE

2,417,290

ANTENNA SYSTEM

George H. Brown, Princeton, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application February 23, 1943, Serial No. 476,820

5 Claims. (Cl. 250—33)

1

This invention relates to antennas, and more particularly to structures for radiating energy with high efficiency over a broad band of ultra high frequencies.

It is the principal object of this invention to provide an improved dipole antenna structure having a broad resonance characteristic.

Another object is to provide an improved dipole antenna which is mechanically strong, of light weight, and simple in construction.

A further object is to provide an improved dipole antenna which may be coupled to a standard concentric transmission line without requiring transformers or complex networks.

These and other objects will become apparent to those skilled in the art upon consideration of the following description with reference to the accompanying drawing, of which Fig. 1 is an elevational view of a dipole constructed according to the present invention, Fig. 2 is an enlarged sectional view of a portion of Fig. 1, illustrating the connections to the radiator elements, Fig. 3 is a graph showing how the impedance of the dipole of Fig. 1 varies with frequency, as compared with the variations in impedance of a dipole of conventional construction, and Fig. 4 shows an array comprising two dipoles of the type shown in Fig. 1.

Referring to Fig. 1, a pair of parallel tubular supporting members 1 and 3 are fastened by welding, for example, to a base plate 5. Tubular radiator elements 7 and 9 are similarly secured to the supports 1 and 3 at the upper ends, as shown more clearly in Fig. 2. The members 1, 3 and elements 7, 9 may be made of thin-walled steel tubing or the like. Metal bushings 11 and 13 are inserted at the upper ends of the supports 1 and 3. Coaxial lines 15 and 17 extend through the supports 1 and 3 respectively and the bushings 11 and 13. The outer conductors of the lines are connected to the bushings. Insulating caps 19 and 21 are provided for the bushings 11 and 13, and conductors 23 and 25 respectively are supported by and extend through the caps. The inner conductors of the lines 15 and 17 are connected to the conductors 23 and 25. The conductors 23, 25 are connected together through a shorting bar 27.

The dimensions of the various parts in terms of the wavelength, λ, at the center of the band over which the system is to operate, are indicated in Fig. 1. The supports 1 and 3 and the radiator elements 7 and 9 are each substantially one quarter wavelength long. The line 15, from the terminal 23 to the junction point 29, is electrically

2

one half wavelength longer than the line 17. The physical difference in length between the lines 15 and 17 will be somewhat less if the velocity of propagation of energy through the lines is less than that in space. A line 31 is connected to the junction 29 and leads to a source of energy or radio device, not shown. The base plate 5 may be grounded, as by connection to a metallic supporting framework or to a reflector, and the outer conductors of the lines 15, 17 and 31 are also grounded at any convenient points.

The operation of the above described structure is substantially as follows:

Radio frequency voltage is applied between the inner and outer conductors of the lines 15 and 17 through the line 31. At the instant the inner conductor of the line 17 is positive at the point 33 at the base 5, the inner conductor of the line 15 is negative at the point 35, because the length of the line 15 between the points 29 and 35 is 180 electrical degrees longer than that of the line 17 between the points 29 and 33. Since the ends of the inner conductors of the lines 15 and 17 are connected together by the shorting bar 27, current flows up through the inner conductor of the line 17, across the bar 27, and down through the inner conductor of the line 15. The above conditions are reversed with each R.-F. cycle. The currents flowing in the inner conductors of the lines 15 and 17 induce opposite currents in the respective outer conductors. Thus the instantaneous flow of current on the outer conductor of the line 15 is upward when that on the line 17 is downward. The supports 1 and 3 constitute a parallel line, short circuited by the base 5, and thus present a high impedance between the points 37 and 39, at the ends of the outer conductors of the lines 15 and 17. The voltage between these points is applied to the dipole 7, 9.

The dipole is equivalent to a series resonant circuit comprising capacitance, inductance, and resistance. Near the resonant frequency, the effective resistance between the inner ends of the radiator elements is 36 ohms. The parallel line formed by the supports 1 and 3 is equivalent to a parallel resonant circuit. With the dimensions indicated, the resonant frequency of the dipole is slightly lower than that of the parallel line, so that at a frequency at which the dipole exhibits, for example, 20 ohms inductive reactance, the line has sufficient capacitive reactance to resonate the dipole. At this frequency the line and the dipole together act like a parallel resonant circuit connected between the points 37 and 39 with the re-

sistance in the inductive arm, and present a purely resistive load of

$$Z_r=\frac{R^2+X^2}{R}$$

which in this case is about 50 ohms, and is substantially equal to the surge impedance of the coaxial lines 15 and 17. At other frequencies, the reactance of the dipole is still opposite in sign to that of the parallel line, since as the frequency is increased the series resonant circuit becomes more inductive and the parallel resonant circuit becomes more capacitive, and vice versa. Thus the combined impedance of the radiator and the support is a relatively constant resistance over a wide frequency band, providing uniformly high efficiency of radiation.

If the lines 15 and 17 match the dipole impedance, as described above, the impedance looking toward the antenna from the junction point 29 is one-half the line impedance, or in the example given above, 25 ohms. To prevent reflection at this point, the impedance looking into the line 31 must also be 25 ohms. If a single dipole is to be used, a 25 ohm line may be employed, or impedance matching means may be provided on the line 31.

Referring to Fig. 4, a pair of dipoles like that shown in Fig. 1 may be connected together through quarter wave lines 41 and 43 to a main line 45. With this arrangement all of the lines may have the same characteristic impedance and no further impedance matching means is required. If the impedance looking towards the antennas from the junction points 29 and 29' is 25 ohms, the impedance looking into each of the quarter wave lines 41 and 43 from this junction with the line 45 is:

$$Z_{in}=\frac{Z_0^2}{Z_{out}}, \text{ or } \frac{(50)^2}{25}=100 \text{ ohms}$$

The impedance of the two lines in parallel is then 50 ohms, which matches the line 45.

Referring to Fig. 3, the curve 47 represents the standing wave ratio in a line feeding the antenna system of Fig. 4, as a function of frequency. This ratio is a measure of the impedance match between the antenna and the line. Thus, if the ratio is 1, the impedances are perfectly matched, and substantially all of the energy fed into the line is applied to the antenna. Fig. 3 shows that this ratio remains above 70 precent over the range of 156 megacycles to 188 megacycles, for an antenna designed for a frequency band centered at 172 megacycles. The curve 49 shows the standing wave ratio measured in the same manner as a conventional dipole centered at the same frequency. The band width at 70 percent is approximately one-third of that of the system of Fig. 4.

Thus the invention has been described as an improved antenna system. Half wave dipoles are coupled by concentric lines differing in length by 180 electrical degrees to provide an unsymmetrical input circuit suitable for coupling to concentric lines. Contrary to conventional practice, the radiator elements are connected to the outer line conductors and the inner line conductors are connected to each other at the center of the dipole. The outer conductors are connected together one quarter wavelength from the ends of the lines, and function as a short circuited quarter wave parallel line shunted across the dipole. Currents flowing through the inner conductors induce currents in the outer conductors, providing coupling to the dipole. The quarter wave line provides loading for the dipole to broaden the resonance and maintain substantially constant and resistive impedance over a wide frequency band.

I claim as my invention:

1. A dipole antenna comprising a pair of parallel tubular supporting members, radiator elements secured in end-to-end relationship at the ends of said supporting members, and coaxial transmission lines extending through said supports with their outer conductors connected to said supports and their inner conductors connected together near the adjacent ends of said radiator elements.

2. A dipole antenna comprising two radiator elements disposed colinearly in end-to-end relationship, two concentric lines with the ends of their outer conductors connected respectively to said radiator elements and the ends of their inner conductors connected together, and a connection between the outer conductors of said lines at a point substantially one quarter wavelength from said ends.

3. A dipole antenna comprising a pair of parallel tubular supporting members substantially one quarter wavelength long, radiator elements each substantially one quarter wavelength long connected in end-to-end relationship at the upper ends of said supporting members, a plate of conductive material connected at the lower ends of said supporting members, and coaxial transmission lines extending through said supports with their outer conductors connected to said supports and the ends of their inner conductors connected together, said transmission lines differing in length by substantially 180 electrical degrees.

4. An antenna array comprising at least one pair of dipoles, each of said dipoles including tubular supporting members, coaxial transmission lines extending through said supporting members with ends of their outer conductors connected to said supports and the ends of their inner conductors connected together, said lines differing in length by substantially one half wavelength and being connected together to a branch line of substantially one quarter wavelength, the two branch lines for each pair of dipoles being connected together to a common main line.

5. The invention as set forth in claim 4 wherein said tubular supporting members are substantially one quarter wavelength long and are connected together at their ends remote from the radiator elements of said dipoles.

GEORGE H. BROWN.