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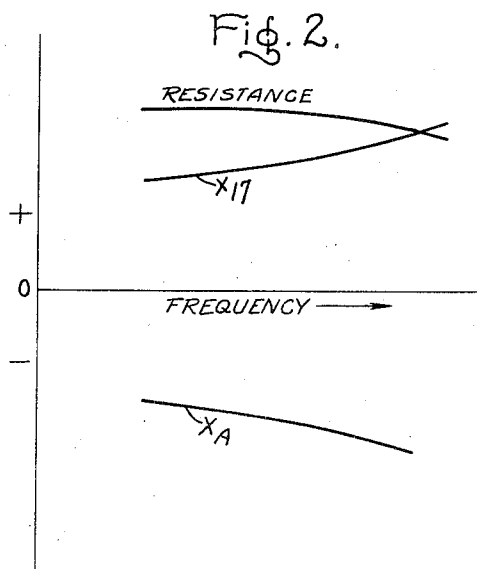
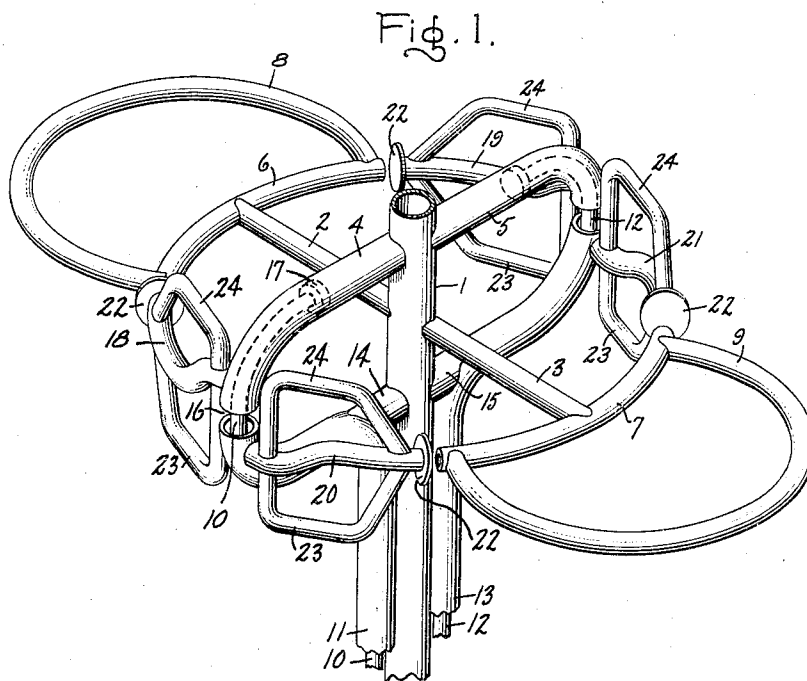
B. P. BROWN, JR

2,493,569

COMPOSITE LOOP ANTENNA SYSTEM

Filed May 13, 1946

2 Sheets-Sheet 1



Inventor:
Burton P. Brown, Jr.
by *Merton D. Mone*
His Attorney

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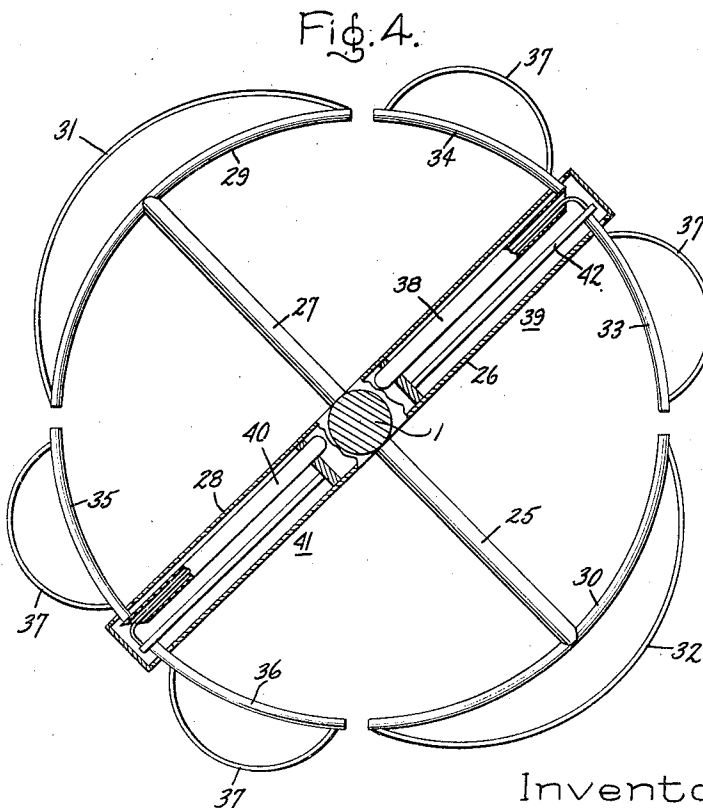
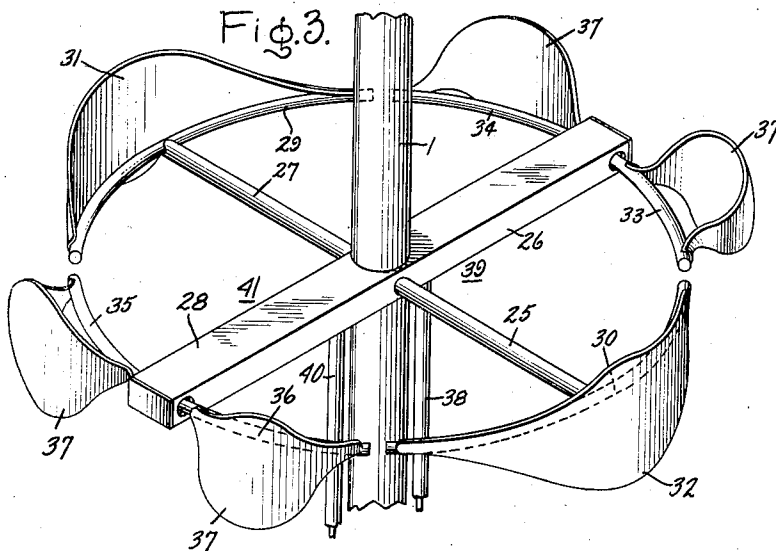
B. P. BROWN, JR

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Inventor:
Burton P. Brown, Jr.
by *Merton D. Morse*
His Attorney.

UNITED STATES PATENT OFFICE

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COMPOSITE LOOP ANTENNA SYSTEM

Burton P. Brown, Jr., Schenectady, N. Y., assignor
to General Electric Company, a corporation of
New York

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3 Claims. (Cl. 250—33)

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My invention relates to antennas for operation over a wide band of radio frequencies and it has for its object to provide a new and improved antenna system suitable for use in television and other purposes requiring wide band operation.

In an antenna system for broadcasting high frequency waves over a broad band of frequencies, it is desirable that the structure radiate horizontally polarized waves omnidirectionally in a horizontal plane which passes through the antenna. It is further desirable that the radiating structure present a constant purely resistive impedance to the transmission line which supplies the energy to be radiated and that this impedance be maintained constant and substantially purely resistive over a relatively wide range of frequencies. A substantially circular radiation pattern in the horizontal plane may be maintained by constructing the antenna in the form of a continuous circular loop which is open at one point for the purpose of being energized, the loop having a circumference of such length that it is considerably less than a half wavelength at the mid frequency of the band of frequencies to be radiated. Such a structure produces an approximately uniform ring of current from which results an omnidirectional radiation characteristic measured in the horizontal plane of the loop. However, when the impedance at the point of energization of such a structure is examined, it is found that it exhibits a narrow band width characteristic. Thus, the impedance does not remain constant and substantially purely resistive over a relatively wide range of frequencies. This limitation is brought about by the fact that the currents on opposite sides of the loop are in time phase opposition and the relatively short phase distance across the diameter of the loop produces a small resultant radiated field per unit current relative to the radiated field per unit current which may be produced if the segments of the loop are located in free space. Furthermore, this condition causes a relatively high amount of energy to be stored in the circuit so that the resultant structure exhibits impedance characteristics at the point of energization which have large variations in both resistance and reactance components as the exciting frequency is varied.

It is an object of my invention to provide an improved antenna structure in which the amount of energy stored in the radiating circuit is relatively low so that the resultant fields are more freely radiated.

It is still another object of my invention to

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provide a new and improved antenna system in which the impedance at the input terminals is substantially constant and purely resistive over a wide range of frequencies.

It is still a further object of my invention to provide a new and improved wide band antenna which presents a relatively low resistance to wind so that the forces on a supporting structure are relatively small.

One of the features of my invention is the use in a broadcast antenna system of a plurality of capacitively coupled radiating segments which are arranged in a loop and in which the lengths of the individual segments and the spacing between the segments are adjusted so that each segment carries substantially the same current both in amplitude and phase. Each of the individual segments is furthermore so constructed that it has a large current carrying surface. Another feature is the provision at the input terminals of the antenna structure of a reactance in series with the antenna impedance and adjusted so that the resultant impedance of the system remains substantially purely resistive over a wide band of frequencies.

The features of my invention which I believe to be novel are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing in which Fig. 1 is a perspective view of a wide band antenna suitably embodying my invention; Fig. 2 is a graph illustrating certain features of the system of Fig. 1; and Figs. 3 and 4 are, respectively, perspective and plan views of a modification of the antenna of Fig. 1.

Referring to Fig. 1, I have there illustrated a broad band antenna which comprises a vertical metallic supporting mast 1 having a first pair of transverse supporting arms 2, 3 rigidly attached thereto and a second pair of transverse arms 4, 5 arranged at right angles to the arms 2, 3. The arms 2, 3 may be solid metallic rods, while the arms 4, 5 may be metallic tubes. Supported at the outer ends of the arms 2, 3 are circular segments 6, 7. Circular metallic members 8, 9 are rigidly attached, respectively, to the segments 6, 7 and extend outwardly from the mast 1 in a horizontal plane.

A pair of transmission lines of the coaxial type and comprising, respectively, inner and outer conductors 10, 11 and 12, 13 are supported in a

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vertical direction and arranged on opposite sides of the mast 1. At their upper ends, these transmission lines are attached to the mast by means of supports 14, 15 which may be welded or brazed to both the mast 1 and the outer conductors 11, 13. Beyond this point of support, the transmission lines are bent through 90° and extend parallel to the arms 4, 5. At their ends remote from the mast, both the arms 4, 5 and the transmission lines are bent toward each other. The ends of the arm 4 and of the outer conductor 11 are spaced apart by a small gap 16. The inner conductor 10, however, extends across this gap and into the tubular arm 4. At a point within this arm, the distance of which depends upon considerations which are pointed out later, the inner conductor 10 is conductively connected by means of a plug 17 or any other suitable short-circuiting device to the inner surface of the arm 4. The arrangement of the arm 5 and the conductors 12, 13 is similar to that described in connection with the arm 4 and the conductors 10, 11. The conductor 12 is similarly short-circuited at a point within the tubular arm 5.

Supported from and conductively connected to the arms 4, 5 are short circular segments or loops 18, 19. Similarly supported from and conductively connected to the outer ends of the conductors 11, 13 are short circular segments 20, 21. Each of the segments 18—21 at its end remote from its point of support is provided with a metallic plate 22 which is spaced from the adjacent end of one of the segments 6, 7. The segments 18—21 are further provided with a pair of vertically extending loop-like members 23, 24 which form a radiating fin secured to the associated one of the segments 18—21.

In my composite antenna structure, the circular segments 6, 7, 18—21 are equally spaced from the mast 1 so that they are arranged as a loop, each of the segments being capacitively coupled to the others. Thus, for example, the segment 6 is capacitively coupled to the segments 18, 19 by means of the plates 22. When the capacitance between plate 22 and the segment 6 is adjusted correctly, each of the segments 6, 7, 18—21 carries substantially the same current both in amplitude and phase, which is the condition desired to provide an omnidirectional radiating characteristic. The loops 8, 9, attached to the segments 6, 7 and the members 23, 24, attached to the segments 18—21, all provide an increased current carrying surface for the radiating segments so that the resultant structure is provided with a broad band width characteristic.

It is found that, in the composite antenna structure comprising the circular segments and their complementary radiating surfaces, the input terminals of the antenna present a certain impedance which usually is not purely resistive but has a capacitive reactance component. Accordingly, the point of connection 17 of the inner conductor 10 within the arm 4 is arranged so that the portion of the conductor 10 within the arm 4 provides an inductive reactance in series with the antenna impedance, so that the resultant overall impedance presented to the input transmission line at the gap 16 is substantially purely resistive. A similar inductive reactance is provided at the upper end of the transmission line 12, 13. As a result, the composite antenna structure, together with the series inductive reactance, presents a substantially constant resistive

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impedance to the supply transmission lines over a relatively wide range of frequencies.

The manner in which the inductive reactance due to the short-circuited portion of the inner conductor 10 compensates the impedance to provide a broad band characteristic to the antenna is illustrated in Fig. 2 in which frequency is plotted as abscissa and impedance as ordinate. The upper curve denotes the resistance component of the composite antenna structure, while the curve marked X_A denotes a typical reactance curve of the antenna of Fig. 1. The curve X_A illustrates that the impedance of the composite antenna has a capacitive reactance component throughout the entire frequency band. The curve marked X_{17} illustrates the compensating reactance which is provided by the inductive reactance in series with the antenna impedance. This inductive reactance is serially added to the capacitive reactance X_A to provide compensation over substantially the entire range of frequencies to be radiated. As a result, the composite antenna structure presents a substantially constant resistive impedance to the input lines 10, 11, 12, 13.

In Figs. 3 and 4 I have shown a modification of the antenna arrangement of Fig. 1 in which the mast 1 is provided with four transverse arms 25—28 which are spaced apart by angles of 90°. The arms 25, 27 support, at their outer ends, circular segments 29, 30. Loop-like fins 31, 32, which extend outwardly respectively from the segments 29, 30, have their ends connected to the associated segment. The fins 31, 32 are likewise provided with a vertical extension to increase the current carrying surface of the associated radiators to provide a broad band width characteristic. Supported from the arms 26, 28 are circular segments 33—36. Each of these segments likewise is provided with a radiating fin 37 which both extends outwardly from the associated segment and likewise has a vertical extension. The antenna is supplied at two points with energy to be radiated. Thus, the segments 33, 34 are connected to the conductors of an input coaxial transmission line 38 through a line balance converter 39. Similarly, the segments 35, 36 are energized by connection to a coaxial transmission line 40 through a line balance converter 41. The line balance converters 39, 41 are conventional in structure and comprise an auxiliary conductor 42 to which the inner conductor of the coaxial line 38, for example, is connected. The segment 34 is directly connected to the outer conductor of the transmission line 38 and the segment 33 is connected to the auxiliary conductor 42.

In the structure of Figs. 3 and 4, a series capacitance for coupling adjacent of the circular segments is constituted by the adjacent ends of the segments. Depending upon the value desired, the capacitance may be adjusted to the correct value by controlling the spacing between the ends of adjacent segments or by the use of auxiliary plates or disks (not shown). I have found that, when the capacitances are adjusted correctly, each of the segments 29, 30, 33—36 carries substantially the same current both in amplitude and in phase. Where the input impedance of the structure is not purely resistive, but has a capacitive reactance component, such component may be compensated for by employing a series inductance in the line balance converters in a manner similar to that employed in the structure of Fig. 1.

An important advantage of my composite antenna structure is that it radiates horizontally

polarized waves omnidirectionally in a horizontal plane. In addition, by controlling the capacitance between adjacent segments and the value of a series inductive impedance, the composite antenna may be arranged to present a substantially constant resistive impedance to an input transmission line over a relatively wide range of frequencies.

Another important advantage of my composite antenna system is that currents to be radiated are applied thereto at two diametrically spaced points so that a truly circular radiation pattern is obtained. By this method of supplying the current to be radiated to the antenna, less variation in horizontal pattern is obtained as the frequency is varied over a broad range of frequencies.

Another important advantage of my composite antenna system is that it presents a low value of projected area for wind loading, the structure being relatively compact and providing no extensive surfaces. Furthermore, the spacing between the adjacent ends of the circular radiating elements, for example the plates 22 and the end of segment 6 of Fig. 1, is sufficiently great that even under adverse and inclement weather conditions ice does not build up on the antenna to a sufficient extent to injure the electrical characteristics of the antenna. Thus, in a typical antenna, the spacing between the plate 22 and the circular segment 6 is eight inches or greater even for operating at a low frequency. Such a spacing is sufficiently large that all troubles from build up of ice on the antenna are avoided.

Still another advantage of my composite antenna system is that all of the radiating elements are directly grounded to the supporting mast so that improved lightning protection of the radiating segments is provided.

While I have shown and described particular embodiments of my invention, it will of course be understood that various changes and modifications may be made without departing from my invention and I, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A broad band, high frequency, antenna system comprising an even number of radiators symmetrically arranged to form a discontinuous planar loop, each radiator comprising a linear conductor having its ends spaced from and capacitively coupled to the ends of adjacent conductors, a plurality of transmission lines connected respectively to center feed points of the linear conductors of even-numbered radiators around said loop, odd-numbered radiators being coupled to said lines through said capacitive couplings, each even-numbered radiator further comprising two auxiliary radiating surfaces conductively bridging the halves of the adjacent linear conductor on either side of the center feed point, each odd-numbered radiator further comprising an auxiliary radiating surface conductively bridging substantially the full length of the adjacent linear conductor, and means to adjust said transmission lines and capacitive couplings to cause substantially equal, in-phase currents to flow in each of said radiators when said antenna system is energized.

2. A broad band, high frequency, antenna system comprising an even number of radiators

symmetrically arranged to form a discontinuous planar loop, each radiator comprising an arcuate linear conductor having its ends spaced from and capacitively coupled to the ends of adjacent conductors, a plurality of transmission lines connected respectively to center feed points of the linear conductors of even-numbered radiators around said loop, odd-numbered radiators being coupled to said lines through said capacitive couplings, each even-numbered radiator further comprising two flat, arcuate, metal bands conductively bridging the halves of the adjacent linear conductor on either side of the center feed point, each odd-numbered radiator further comprising a flat, arcuate, metal band conductively bridging substantially the full length of the adjacent linear conductor, each of said bands having greater curvature than the conductor to which it is connected and lying outside said loop in the plane thereof with its widest cross-sectional dimension transverse of said plane, and means to adjust said transmission lines and capacitive couplings to cause substantially equal, in-phase currents to flow in each of said radiators when said antenna system is energized.

3. A broad band, high frequency, antenna system comprising a vertical conductive mast, an even number of horizontal antenna elements symmetrically positioned around said mast and each conductively supported thereby, each of said elements comprising a linear conductor in the form of a circular segment with its ends spaced from and capacitively coupled to the ends of adjacent conductors thereby to form a discontinuous, horizontal, circular loop surrounding said mast, even-numbered conductors around said loop having center feed points, a separate transmission line connected to each feed point, odd-numbered conductors being coupled to said lines through said capacitive couplings, each even-numbered antenna element further comprising means providing two auxiliary radiating sheets lying outside said loop and conductively bridging the respective halves of the adjacent conductor on either side of the center feed point, each odd-numbered antenna element further comprising means providing a single auxiliary radiating sheet lying outside said loop and conductively bridging substantially the full length of the adjacent conductor, said sheets having substantially greater current-carrying areas and greater curvatures than said conductors, and means to adjust said transmission lines and capacitive couplings to cause substantially equal, in-phase currents to flow in each of said radiators when said antenna system is energized.

BURTON P. BROWN, JR.

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