June 7, 1949. W. W. HANSEN 2,472,106

BROAD BAND ANTENNA

Filed Sept. 20, 1943

Fig. 1.

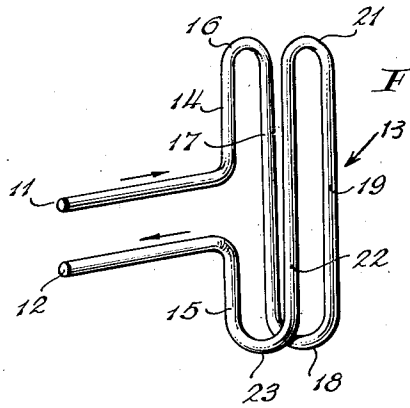


Fig. 2.

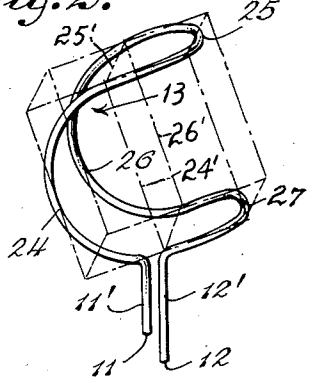


Fig. 3.

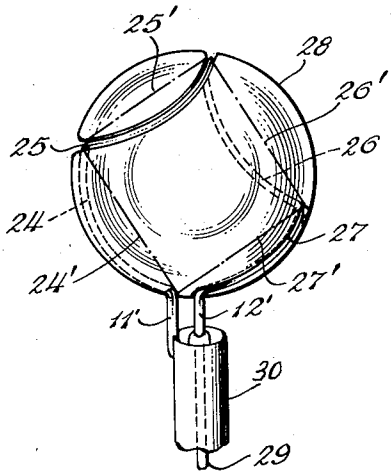


Fig. 4.

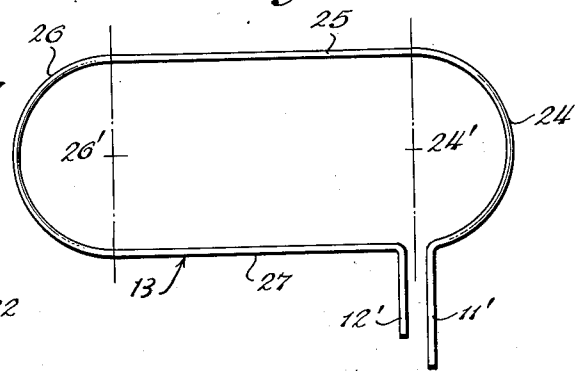


Fig. 5.

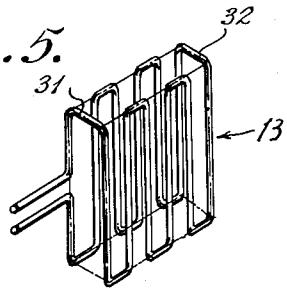
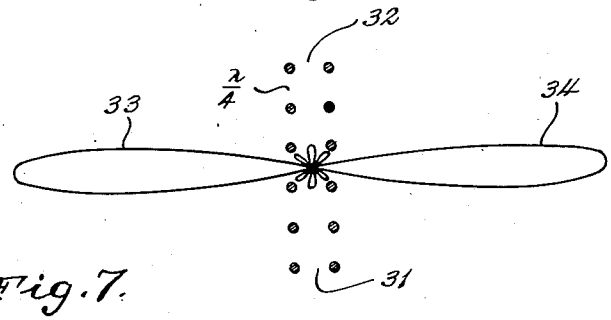


Fig. 6.



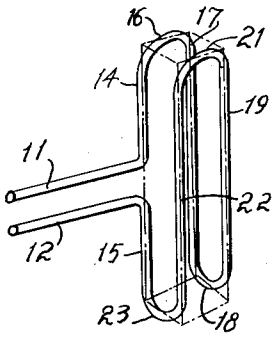


Fig. 7.

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Patented June 7, 1949 2,472,106

UNITED STATES PATENT OFFICE

2,472,106

BROAD BAND ANTENNA

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Application September 20, 1943, Serial No. 503,066

2 Claims. (Cl. 250—33)

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My invention relates to antennae or radiators for radio communication and signaling systems, and concerns particularly radiators suitable for use in high frequency radio systems such as may be used in connection with object detection.

An object of my invention is to provide an antenna having a pattern like a dipole, but having a broader frequency band. For example, an object is to provide an antenna having a radiation resistance at least sixteen times that of the conventional dipole and having a value of Q (or quality factor) one-fourth that of a dipole in order to broaden the frequency band.

A further object of my invention is to provide an antenna which may be buried in a dielectric sphere.

A further object of my invention is to provide a double-ended antenna which is useful in pulse systems and in which sparking is prevented.

Still another object of my invention is to provide an antenna array having a broad band but with a pattern similar to an end fire or a broad side array of dipoles.

Other and further objects and advantages will become apparent as the description proceeds.

In carrying out my invention in its preferred form, I utilize a rod or wire of suitable conducting material which is electrically continuous from one input terminal to the other and which may be bent to lie along a plurality of planes, at least four in number, including a pair of parallel planes, which are substantially perpendicular to a second pair of parallel planes.

A better understanding of the invention will be afforded by the following detailed description considered in connection with the accompanying drawings, in which:

Fig. 1 is a perspective view of one embodiment of my invention comprising a substantially rectangular form of antenna;

Fig. 2 is a perspective view of a modification in the arrangement of Fig. 1 in which the antenna conductor is bent in the form of circular segments or smooth curves instead of rectangles or straight-sided figures;

Fig. 3 is a schematic diagram illustrating the arrangement of the antenna on the surface of a sphere utilizing wire consisting of circular segments;

Fig. 4 is a view of a surface development of the antenna of Fig. 3;

Fig. 5 is a perspective view of a modification of the arrangement of Fig. 1 for producing the effect of a plurality of dipoles in broadside array;

Fig. 6 is a cross-sectional view of the arrangement of Fig. 5 and a diagram of the radiation pattern; and

Fig. 7 is a perspective view of the antenna shown in Fig. 1.

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Like reference characters are utilized throughout the drawings to designate like parts.

In the embodiment of Fig. 1 an antenna is formed by bending a unitary length of wire 13 along the lateral edges of a square base prism (shown by dotted lines in Fig. 7) with input connections at the center of one of the edges of the prism. Preferably the corners are rounded to avoid discontinuity effects. Input terminals from a suitable transmission line (not shown) are represented by the ends 11 and 12 of the length of wire 13 forming the antenna. The portions of the wire at the terminals 11 and 12 are bent at right angles in opposite directions to form two segments 14 and 15, which define one lateral edge of a square prism. The upper end of the wire segment 14 is bent to be tangent to one of the top edges 16 of the square prism or to actually form the edge of the prism and this portion of the wire is bent again to form a second lateral edge 17 of the square base prism adjacent a segment of wire 18 forming one of the lower edges of the square base prism or tangent thereto. A further continuation of the wire 19 forms a third lateral edge of the square prism. Parallel to the segment of wire 16 is a continuation 21 of the portion 19. The portion 21 forms or is tangent to the second top edge of the square prism and together with the portion 16 defines the top of such a prism. The antenna is completed by a portion 22, forming the fourth lateral edge of the square prism and a portion 23 forming or tangent to a second bottom edge of the square prism.

It will be observed that the portions of the wire 14, 15, 16, and 17 lie in one plane and the portions 19, 21 and 22 lie in a second plane parallel to the first; and that likewise portions 17, 18 and 19 lie in a plane which is perpendicular to the first two planes and parallel to a second plane defined by the portions 14, 15, 22 and 23 of the antenna. Thus, it will be observed that this embodiment of the invention consists of a length of conductor bent into four planes, two of which are parallel to each other and perpendicular to the latter two, which are parallel to each other.

The portions of the wire are thus bent to include straight portions that define two parallel planes, but if preferred these portions may be curved or semicircular in form, as illustrated in

Fig. 2. With this arrangement, any three consecutive portions of the wire 13 form a U-shaped plane figure.

In order to obtain the desired radiation characteristics, each of the lengths of the longitudinal portions 17, 19, 22 and 14+15 together with one-half their respective end portions 16, 18, 21 and 23 are of the order of a half-wave length of the wave which is intended to be propagated or detected by the antenna (e. g. length 19+½ end 18+½ end 21 is approximately equal to a half wave length). The spacings of these portions of the antenna, or the lengths of the portions 18, 23, 16 and 21, are so chosen as to leave the currents flowing in the portions 17, 19, 22, 14 and 15 substantially in phase if dipole radiation characteristics are desired. The cross-connections 16, 21, 18, 23 are relatively short and the longitudinal portions are substantially one-half an electrical wave length, making due allowance for the effect of the cross connections. Standing current waves in all of the longitudinal portions of the wire will produce field components which add in phase.

With these portions of the wire equal a half wave length, it will be apparent that the U-shaped portion formed by segments 14, 16 and half of segment 17 may be considered equivalent to a half wave length. Also half of segment 17, all of 18 and half of 19 form a U-shaped member that may be a half wave length. It will further be apparent that these U-shaped members define planes (Fig. 7) that are perpendicular, and two similar U-shaped portions define additional sides of the prisms to complete the antenna.

As already suggested, the end portions 16, 21, 18, 23 may be curved or straight, as desired. Furthermore, the entire radiating portion of the antenna, excluding the lead-in portions 11' and 12' from the terminals 11 and 12, may be curved as illustrated in Fig. 2. The use of circular segments of wire facilitates the adaptation of the antenna to a spherical outline. For example, as illustrated in Fig. 3, if the wire 13 is bent into four successive semicircles 24, 25, 26, 27, and these semicircles are arranged with their diameters along the sides of a square and lie in planes forming a cube having its sides perpendicular to the square (as shown by dotted lines in Fig. 2), the semicircles will then lie in small circles of a sphere 28, thus lying in the spherical surface. The fact that the antenna of Fig. 3 is composed of semicircles is illustrated by the development shown in Fig. 4, where the semicircles 24 and 26 are laid out in true form on the development plane and the semi-circles 25 and 27 have been straightened out by flattening the curve defined by the semicircles 25 and 27 of Fig. 3 into the development plane, i. e., the plane of the paper. It will be seen from Fig. 4 that the diameters 24' and 26' of the semicircles 24 and 26 are contiguous to the semicircles 25 and 27. Thus the diameters 24' and 26' form a square with the diameters 25' and 27' as shown in Fig. 3. Each of the semicircles is effectively one-half electrical wave in length for the desired radiation characteristics.

Fig. 3 illustrates also the manner of connecting the antenna to a coaxial transmission line comprising an outer cylinder 30 and a coaxial inner conductor 29. The terminal 12', for example, may be connected to the internal conductor 29 and the terminal 11' may be connected to the sheath or cylinder 30.

If desired, the antenna of Fig. 3 may merely

be formed on a sphere such as shown at 28, or it may actually be mounted in semicircular grooves on the surface of a sphere 28 composed of suitable dielectric material, such as either polystyrene or polymerized methyl methacrylate (Lucite). The whole may then be encased by a further coating of a similar dielectric material to form a spherical radiator.

The antenna illustrated is especially useful for pulse systems such as those used in object detectors and target locators, for example. The possibility of imbedding the antenna in dielectric material makes it possible to prevent sparking.

It will be understood that when the antenna is to be imbedded in the dielectric substance all of its physical dimensions should be reduced in the ratio of $1:\sqrt{E}$, where E is the electric inductive capacity of the substance compared with air.

Both the rectangular and curved forms of antenna illustrated in Figs. 1 to 3 will be observed to have four folds, represented in Fig. 1 by 18, 16, 21, 23, and in Fig. 3 by the semicircles 24, 25, 26, 27.

The radiation resistance and consequently the radiant power for constant current is increased in the ratio of the square of the number of folds, whereas the energy stored increases only with the number of folds. The Q (or quality factor) of elements of a radio system is expressed by the ratio of the stored energy to the dissipated energy in the element and accordingly the Q of the antenna is inversely proportional to the number of folds. Thus, in the four-fold arrangement of Figs. 1 to 3, the Q is made one-fourth that of the dipole and the frequency band of the antenna is correspondingly broader than that of a dipole.

If the radiation pattern of a broadside array of dipoles is desired, it may be obtained by arranging the folds in such a manner that there is a greater number of folds in one pair of planes than in another pair of perpendicular planes. For example, as illustrated in Fig. 5, an antenna with twelve folds may be constructed with a single length of conductor bent along the four side surfaces of an oblong base prism (shown by dotted lines in Fig. 5). In this case, two of the folds 31 and 32 and adjacent portions of wire define two parallel end planes and the remaining folds with their adjacent portions of wire define two other parallel planes which serve as side planes and are perpendicular to the end planes. The cross-sectional view of Fig. 6 represents the relationship between the successive conductors and shows the radiation pattern 33, 34 which may be obtained with the longitudinal spacing between conductors equal to $\lambda/4$. The lateral spacing between conductors, that is, the length of each of the folds 31, 32, is preferably of the order of $\lambda/4$ or less to minimize radiation effects from the folds 31 and 32.

I have herein shown and particularly described certain embodiments of my invention and certain methods of operation embraced therein for the purpose of explaining its principle of operation and showing its application, but it will be obvious to those skilled in the art that many modifications and variations are possible, and I aim, therefore, to cover all such modifications and variations as fall within the scope of my invention which is defined in the appended claims.

What is claimed is:

1. A radio antenna comprising a single unbroken length of wire forming a substantially U-shaped structure, said structure comprising a plurality of substantially semi-circular portions

lying in spaced parallel planes and discretely faced to each other, and other semi-circular portions connecting the free ends of said first-mentioned semi-circular portions and lying in spaced parallel planes, which planes are perpendicular to said first mentioned planes, and the ends of said length of wire having electromagnetic energy fed thereto.

2. A radio antenna comprising a single unbroken length of wire forming a substantially U-shaped structure, said structure comprising a plurality of substantially semi-circular portions lying in spaced parallel planes and discretely faced to each other, and other semi-circular portions connecting the free ends of said first mentioned semi-circular portions and lying in spaced parallel planes, which planes are perpendicular to said first mentioned planes, the ends of said length of wire having electromagnetic energy fed thereto, and dielectric means having a dielectric constant different from air substantially surrounding said antenna.

WILLIAM W. HANSEN.

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