Dec. 3, 1946. D. W. PETERSON 2,411,976

BROAD BAND RADIATOR

Filed Aug. 31, 1944

Fig. 4.

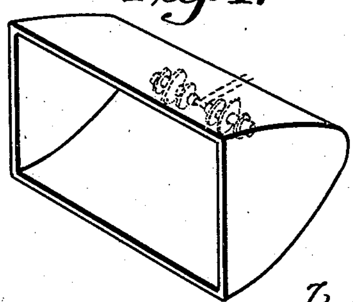


Fig. 1

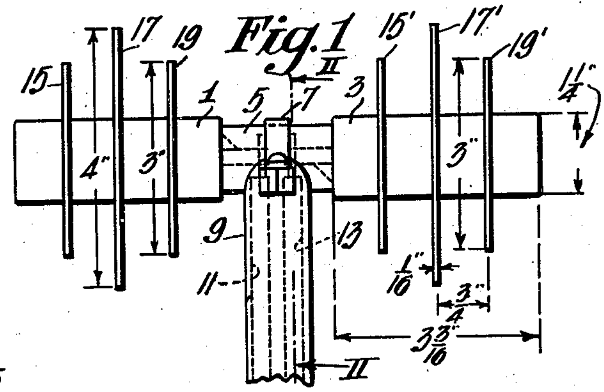


Fig. 2.

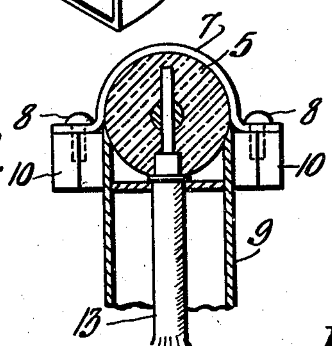


Fig. 3.

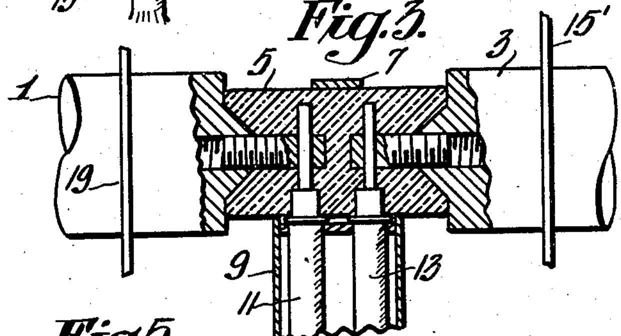
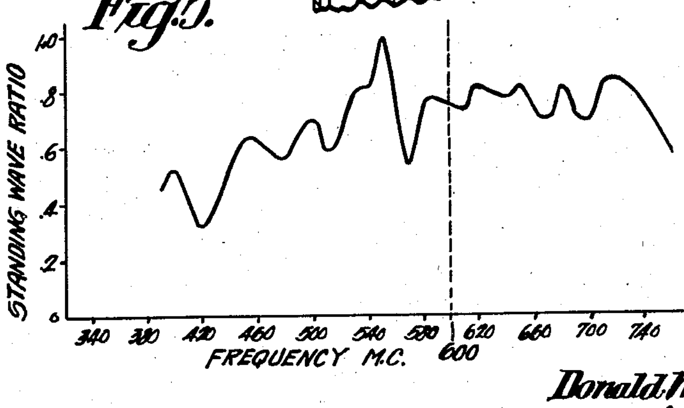


Fig. 5.



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BROAD BAND RADIATOR

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Application August 31, 1944, Serial No. 552,095

8 Claims. (Cl. 250—11)

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This invention relates to antennas, and more particularly to improvements in broad-band radiators for directive arrays.

It is known to those skilled in the art that a radiator may be made to exhibit a relatively constant impedance throughout a wide band of frequencies by designing it with a diameter which is large relative to its length, i. e. the diameter is a substantial fraction of the length, or in some cases may even be greater than the length. Various shapes of radiators such as cylinders, spheres, and cones, all follow similar laws in this regard. It is found that the impedances of such devices are ordinarily low throughout the operating band. This is sometimes a disadvantage, because some form of impedance transformer may be required to use the radiator with commercially available transmission lines having characteristic impedances of the order of 50 to 75 ohms. The frequency characteristics of the impedance transformer are superimposed upon that of the radiator itself, usually tending to narrow the effective operating band width. Moreover, the necessity for providing numerous transformers in a complex array is burdensome from the standpoint of construction, as well as that of design.

Accordingly, it is the principal object of the instant invention to provide an improved type of radiator structure which may be designed to offer a relatively constant high impedance throughout a broad band of frequencies.

Another object is to provide a device of the described type which may be adjusted readily by cut-and-try procedure to match an existing feed system.

A further object is to provide a device of the described type which is of simple, rugged construction.

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, in which:

Figure 1 is an elevation of a dipole radiator constructed in accordance with the invention,

Figure 2 is a section along the plane II—II of Figure 1,

Figure 3 is a view, partly in section of the central portion of the device of Figure 1,

Figure 4 is a schematic perspective diagram illustrating a directive antenna including a radiator like that of Figure 1, and

Figure 5 is a graph illustrating the variation of impedance with frequency of a system like that of Figure 4, in terms of the standing wave ratio on a line connected thereto.

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It is a comparatively simple matter to design an antenna to provide substantially any desired impedance at a single frequency, by choosing a radiator of the proper length and tuning it to resonance at that frequency with a separate reactive element. Thus it is common practice to design dipoles with radiators less than one-quarter wavelength at the desired frequency of operation, so that the impedance at that frequency includes capacitive reactance. The dipole is then shunted with sufficient inductance to resonate. The impedance of the combination is higher at resonance than a similar dipole using self-resonant quarter wave elements by an amount depending upon the reactance required to tune it to resonance, and the self resistance. The higher the impedance obtained in this manner, the sharper the resonance will be. In other words, high impedance is secured at the expense of band width.

The present invention contemplates raising the impedance of a radiator in a somewhat different manner so as to avoid sharpening the resonance. The radiator elements comprise cylinders substantially shorter than one-quarter wavelength, as before. However, the reactance required for tuning the radiators is distributed along the cylinders, with the reactance elements forming part of the radiating structure. By this means, the impedance may be maintained at a relatively constant high value throughout a wide band of frequencies.

Referring to Figure 1, a dipole radiator constructed in accordance with the present invention includes a pair of cylindrical rods 1 and 3 supported in collinear end-to-end relationship upon an insulating member 5. The member 5 is secured by means of a clamp 7 to a tubular support 9.

Referring to Figure 2, the clamp 7 is secured by means of screws 8 to a pair of lugs 10, which are brazed or welded to the support 9 to form an integral part thereof. A pair of coaxial transmission lines 11 and 13 extend through the support 9, with their outer conductors connected to the support 9 and the inner conductors connected respectively to the cylindrical members 1 and 3. See Figure 3. The inner conductors of the lines 11 and 13 are connected at their other ends to any desired radio translation device, such as a transmitter or receiver, not shown.

Each of the rods 1 and 3 is provided with a plurality of circular fins of conductive material, lying in spaced planes parallel to each other and perpendicular to the axis of the rods. In the structure shown in Figure 1, three such fins 15, 17 and 19 are provided on the rod 1, and similar fins 15′, 17′ and 19′ are provided on the rod 3. The above-described fins are secured to the respective rods by soldering or brazing to provide effective electrical connection thereto.

The dimensions indicated in Figure 1 are those which have been found to be suitable for a radio antenna to operate throughout a band centered at approximately 600 megacycles per second. The length of each radiator element is approximately $\frac{1}{6}$ wavelength. The diameters of the fins 15, 19 and 15′, 19′ are approximately $\frac{1}{7}$ wavelength, and the diameters of the fins 17 and 17′ are approximately $\frac{1}{5}$ wavelength. The fins are relatively close together, being separated by about $\frac{1}{32}$ wavelength. The cylindrical members 1 and 3 are approximately $\frac{1}{16}$ wavelength in diameter. The above dimensions are all referred to the wavelength at the center of band.

Although the theory of operation of the above-described device is not understood at present with sufficient accuracy to enable the exact prediction of the various dimensions required to provide given performance characteristics, it is clear that the transverse discs add reactances to the elements 1 and 3 to provide a broad resonance at some frequency corresponding to a wavelength greater than four times the length of each of the elements. The diameters and spacings of the discs in the system of Figure 4 were selected so as to provide a roughly spherical outline. In practice, the discs may be slid over the cylinders 1 and 3 to various positions before they are permanently secured, allowing measurements to be taken for determining optimum positions of the discs.

The radiator of Figure 1 was designed to operate in a parabolic reflector of the type illustrated in Figure 4. The particular reflector used has a focal length of 6 inches (approximately .3 wavelength at the center of the band), and a width across the mouth opening of 7½ feet. The variations of impedance with frequency of the structure of Figure 4 are indicated by the curve of Figure 5 which shows the standing wave ratio as a function of frequency upon a transmission line connected to one of the radiator elements of Figure 4. The measurements upon which the curve of Figure 5 is based were carried out only to a frequency of 760 megacycles. Definite indications were obtained, however, that the standing wave ratio remains within the limits illustrated in Figure 5 up to a frequency of at least 800 megacycles.

The invention has been described as an improved radiator structure, including cylindrical radiator elements provided with transverse fins spaced longitudinally thereof. By properly proportioning the diameter and length of the cylindrical members, and the diameters and spacings of the fins, the structure may be designed to provide a substantially constant and relatively high impedance over a broad band of frequencies.

I claim as my invention:

1. A broad band antenna system including a conductive reflector in the form of a cylindrical parabola, and at least one radiator element comprising a tubular conductor coaxial with the focal axis of said reflector, and a plurality of circular fins disposed on said conductor coaxially therewith in spaced planes normal to the axis of said conductor, the diameters and the spac-

ing of said fins being such that they form an approximately spherical outline.

2. A radiator element for radio antenna systems including a cylindrical rod of conductive material and a plurality of flat circular plates of conductive material connected to said rod and disposed concentrically therewith in planes spaced longitudinally thereof and normal thereto, the spacing and the diameters of said plates being such that they form an approximately spherical outline centered approximately midway between the ends of said rod.

3. A radiator for radio antenna systems comprising a tubular supporting member, a body of insulating material secured to one end thereof, a pair of tubular conductive members secured to said insulating body in collinear relationship, with their common axis at right angles to that of said supporting member, and a plurality of circular fins connected to each of said collinear members, disposed in spaced parallel planes perpendicular to said common axis, the diameters and the spacings of said fins on each of said conductive members being such as to form an approximately spherical outline.

4. A radiator for radio antenna systems comprising a tubular supporting member, a body of insulating material secured to one end thereof, a pair of tubular conductive members secured to said insulating body in collinear relationship, with their common axis at right angles to that of said supporting member, a plurality of circular fins connected to each of said collinear members, disposed in spaced parallel planes perpendicular to said common axis, and a pair of coaxial transmission lines extending through said tubular supporting member, with their inner conductors connected respectively to said collinear members and their outer conductors connected together and to said supporting member, the diameters and the spacing of said fins on each of said collinear members being such as to form an approximately spherical outline centered substantially midway of the respective collinear member.

5. A broad band antenna system including a conductive reflector in the form of a cylindrical parabola having a focal length of approximately 0.3λ, where λ is the wavelength at the mean frequency of the band throughout which the system is to operate, and at least one radiator element comprising a tubular conductor coaxial with the focal line of said reflector and having a diameter of approximately $\frac{1}{16}\lambda$, and a length of approximately $\frac{1}{6}\lambda$, and three circular fins disposed on said conductor coaxially therewith in planes spaced at intervals of approximately $\frac{1}{32}\lambda$ and normal to the axis of said conductor, the central one of said fins having a diameter of approximately $\frac{1}{5}\lambda$ and the other two of said fins having equal diameters of $\frac{1}{7}\lambda$.

6. A broad band antenna system including a conductive reflector in the form of a cylindrical parabola, and at least one radiator comprising a tubular supporting member secured at one end to the apex of said reflector and supporting at its other end a body of insulating material, a pair of tubular conductive members secured to said insulating body, with their axes in a common line perpendicular to said supporting member, and a plurality of circular fins connected to each of said conductive members, disposed in spaced parallel planes perpendicular to said common line, and forming two roughly cylindrical

outlines centered respectively at the midpoints of said tubular members.

7. A broad band antenna system including a conductive reflector in the form of a cylindrical parabola, and at least one radiator comprising a tubular supporting member secured at one end to the apex of said reflector and supporting at its other end a body of insulating material, a pair of tubular conductive members secured to said insulating body, with their axes in a common line perpendicular to said supporting member, a plurality of circular fins connected to each of said conductive members, disposed in spaced parallel planes perpendicular to said common line, and forming approximately spherical outlines centered respectively midway of said conductive members, and a pair of coaxial transmission lines extending through said tubular supporting member, with their inner conductors connected respectively to said conductive members and their outer conductors connected together and to said supporting member.

8. An antenna system including a conductive reflector in the form of a cylindrical parabola of focal length 0.3λ, where λ is the wavelength at the mean frequency of the band throughout which the system is to operate, and at least one radiator comprising a tubular supporting member of length 0.3λ secured at one end to the apex of said reflector and supporting at its other end a body of insulating material, a pair of tubular conductive members of lengths $\frac{1}{6}\lambda$ and diameters $\frac{1}{16}\lambda$ secured to said insulating body, with their axes in a common line perpendicular to said supporting member, and three circular fins disposed on each of said two conductive members coaxially therewith in planes spaced at intervals of $\frac{1}{32}\lambda$ and normal to said common line, the central ones of said fins have diameters of $\frac{1}{5}\lambda$ and the other of said fins having diameters of $\frac{1}{7}\lambda$.

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