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ANTENNA

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Fig. 1.

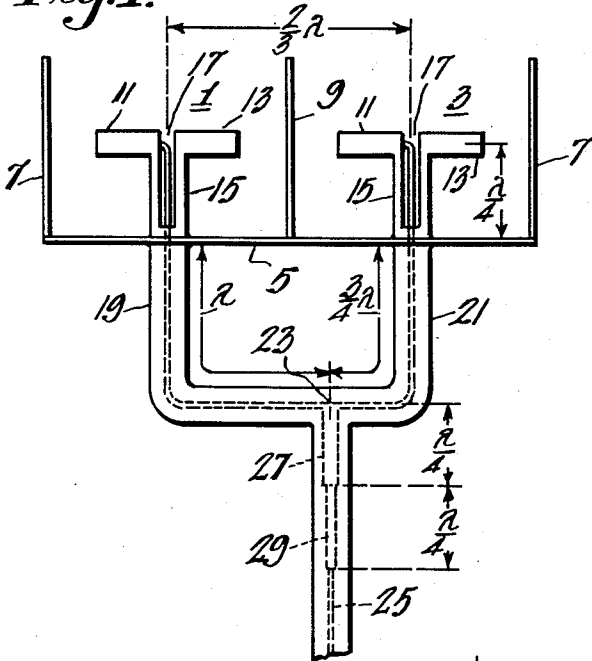


Fig. 2.

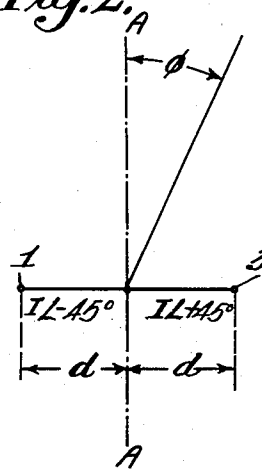


Fig. 3.

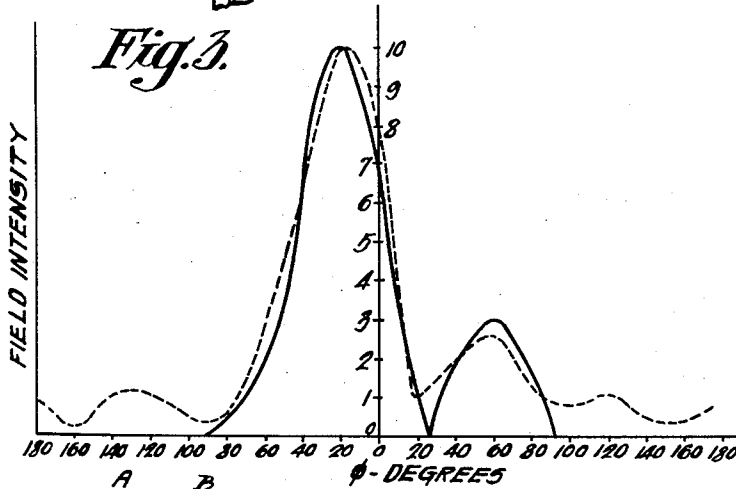
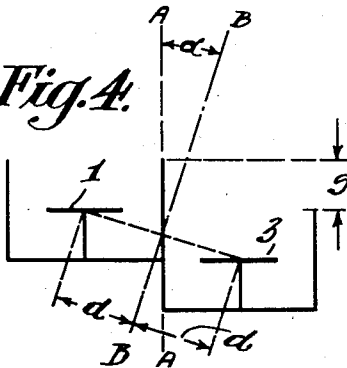


Fig. 4.



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4 Claims. (Cl. 250—33.65)

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This invention relates to antennas, and more particularly to broad-band directive antennas suitable for directional transmission of television signals and the like.

The principal object of the instant invention is to provide an improved method of and means for compensating the variations with frequency of the reactances of the radiator elements of a directive antenna.

Another object is to provide an improved directive antenna in which the reactance of one radiator or group of radiators is balanced by the similar reactance of another radiator or group of radiators, throughout a relatively wide band of frequencies.

A further object of the present invention is to provide an antenna system of the described type which is simple and rugged in structure, easily designed for specific performance requirements, and involves no critical adjustments.

The invention will be described with reference to the accompanying drawing, of which Figure 1 is a schematic plan view of an antenna system embodying the invention.

Figure 2 is a geometrical diagram used in deriving the directive pattern of the system of Figure 1.

Figure 3 is a graph showing the directive pattern of an antenna of the type illustrated in Figure 1, as calculated and as measured experimentally, and

Figure 4 is a schematic diagram of a modified form of the antenna of Figure 1.

Referring to Figure 1, a pair of dipole structures 1 and 3 are supported in front of a conductive screen or reflector 5. Side members 7, similar to the screen 5, are provided at the ends of the screen 5, and a partition 9, also of conductive material, is disposed between the radiators 1 and 3. The top and bottom of the screen structure may be left open, as in Figure 1. The screen 5 may be flat, as shown, or curved to a parabolic or other shape. It is important, however, that the radiators 1 and 3 be separated by the shield 9, to minimize coupling between them.

The radiators 1 and 3 may be of any known type. In the present example, each radiator comprises a so-called slotted dipole, including cylindrical radiator elements 11 and 13 secured to a tubular support 15, which is provided with a slot 17 extending approximately one-quarter wavelength down from the elements 11 and 13. The radiator 1 is fed by a coaxial line 19, which has its outer conductor connected to the support 15 and its inner conductor extending up within the slotted portion of the support 15 and connected

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to the junction of the radiator element 11 with the support 15. This arrangement constitutes a simple and effective way of feeding the dipole, which is symmetrical or balanced to ground, from the coaxial line 19, which is unsymmetrical to ground.

The radiator 3 is connected like the radiator 1 to a coaxial line 21. The lines 19 and 21 differ in length by one-quarter wavelength, the line 19 in this case being one wavelength long, while the line 21 is $\frac{3}{4}$ wavelength long. The lines 19 and 21 are connected together at a junction point 23, to which a main feed line 25 is also connected. The final portion of the main feed line 25 may include an impedance transformer of the cascaded quarter wave line type, such as that described and claimed in U. S. Patent 2,249,597. In the present illustration the transformer includes two sections 27 and 29. The section 27 is designed to have a characteristic impedance somewhat higher than the impedance presented at the junction point 23 by the lines 19 and 21 and the section 29 is designed to have a characteristic impedance somewhat lower than that of the line 25. This arrangement enables the use of identical structures for the lines 19, 21, and 25, while maintaining impedance match throughout a broad band of frequencies. The dipoles 1 and 3 are preferably designed to match the lines 19 and 21 at their resonant frequency.

In the operation of the above-described system, energy applied to the junction point 23 through the feed line 25 is divided equally between the radiators 1 and 3. At the resonant frequency, the radiators present purely resistive impedance to their respective lines 19 and 21, so that no standing waves appear in the system. At frequencies lower than the resonant frequency, the impedances presented by the dipoles include capacitive reactance. The reactance of the radiator 1 is transferred without change by the line 19 to the point 23, where it appears as a shunt capacitance. Since the line 21 is only $\frac{3}{4}$ wavelength long, however, the reactance of the radiator 3 is inverted, appearing at the point 23 as a shunt inductance. The inductive reactance presented by the line 21 is equal to the capacitive reactance presented by the line 19, so that the net effect at the point 23 is that of a parallel resonant circuit of such high impedance as to have a practically negligible shunting effect. Thus only the resistive components of the impedances of the radiators 1 and 3 remain at the point 23 and the impedance match to the feed line 25 is substantially the same as at resonance. Operation at fre-

quencies higher than the resonant frequency is similar to that described above with the exception that both radiators are inductive, so that the line 21 presents capacitive reactance at the junction 23 while the line 19 presents an equal inductive reactance. This reactance cancellation is effected throughout a very wide band of frequencies, enabling efficient power transfer over a frequency range of better than 2:1.

Since the radiators 1 and 3 are fed in quadrature, rather than in phase, the directive pattern will be somewhat unsymmetrical, with the axis of maximum radiation extending slightly to one side of the mechanical center line of structure. Referring to Figure 2, the radiators are represented by points 1 and 3, disposed equally distant on opposite sides of the axis A—A. In the present instance, it is assumed that the radiators are separated from each other by $\frac{2}{3}$ wavelength. The dipoles 1 and 3 are fed in quadrature. The theoretical horizontal pattern is proportional to

$$f(\phi) = \cos [(120^\circ \sin \phi) \pm 45^\circ] \sin (90^\circ \cos \phi) \cos \phi$$

where ϕ is the angle referred to the axis A—A. The first term is the directivity function of two point sources spaced 240° and fed in quadrature. The second term is the factor for the image produced by an infinite screen 90° behind the radiators. The third term is the directivity factor for a short dipole. This directive pattern is represented graphically in Figure 3 by the solid curve.

Experimental measurement of the directive pattern of an antenna similar to that of Figure 1 results in the dash curve of Figure 3. It is apparent that the direction of maximum radiation is at an angle of approximately 20° to the physical axis of the structure. Since the reflector tends to provide concentration of the radiation directly along the physical axis, the sharpness of the beam may be improved to a slight extent by displacing the radiators 1 and 3 with respect to each other in the direction of the axis, so as to align their pattern with that of the reflector. This arrangement is illustrated in Figure 4, where the radiator 1 is advanced by a distance S with respect to the radiator 3. The perpendicular bisector B—B of the line between the radiators is now at an angle α to the axis A—A, where

$$\alpha = \sin^{-1} \frac{S}{2d}$$

The distance S is made such that the angle α is approximately 20° .

Although the invention has been described with reference to a system including only two radiator elements, it will be apparent to those skilled in the art that any desired number of such pairs of radiator elements may be employed as subcombinations in a complex array. Furthermore, each of the radiator elements of the described system may be replaced by a plurality of radiator elements connected together. Briefly, the invention contemplates the use of pairs of radiators shielded from each other and energized from a common feed point through transmission lines which differ in length by $\frac{1}{4}$ wavelength. This arrangement results in cancellation of the reactances of the radiators at the common feed point.

I claim as my invention:

1. A directive antenna system including a pair of parallel radiator elements each provided with a plane reflector, a shield between said radiators whereby direct space coupling between said radiators is avoided, transmission lines coupled respectively to each of said antennas and to a common feed line, the lengths of said transmission lines differing by one quarter of the operating wavelength, one of said radiator elements and its associated reflector being spaced from the other along a line normal to the plane of said reflectors a distance such that the maximum response of said antenna system is along said line.

2. A directive antenna system including a number of parallel radiator elements each provided with a plane reflector, a shield between said radiators whereby direct space coupling between said radiators is avoided, transmission lines coupled respectively to each of said antennas and a common feed line, the lengths of said transmission lines differing by one quarter of the operating wavelength, half of said radiator elements and their associated reflectors being spaced from the remainder along a line normal to the plane of said reflectors a distance such that the maximum response of said antenna system is along said line.

3. A directive antenna system including a pair of parallel radiator elements each provided with a plane reflector, a shield between said radiators whereby direct space coupling between said radiators is avoided, said radiator elements being spaced apart a distance substantially equal to two thirds of the operating wavelength, transmission lines coupled respectively to each of said antennas and to a common feed line, the lengths of said transmission lines differing by one quarter of the operating wavelength, one of said radiator elements and its associated reflector being spaced from the other along a line normal to the plane of said reflectors a distance such that the maximum response of said antenna system is along said line.

4. A directive antenna system including a number of parallel radiator elements each provided with a plane reflector, a shield between said radiators whereby direct space coupling between said radiators is avoided, said radiator elements being spaced apart a distance substantially equal to two thirds of the operating wavelength, transmission lines coupled respectively to each of said antennas and to a common feed line, the lengths of said transmission lines differing by one quarter of the operating wavelength, half of said radiator elements and their associated reflectors being spaced from the remainder along a line normal to the plane of said reflectors a distance such that the maximum response of said antenna system is along said line.

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