July 4, 1950 R. F. LEWIS 2,513,336

RADIO ANTENNA

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Fig. 1.

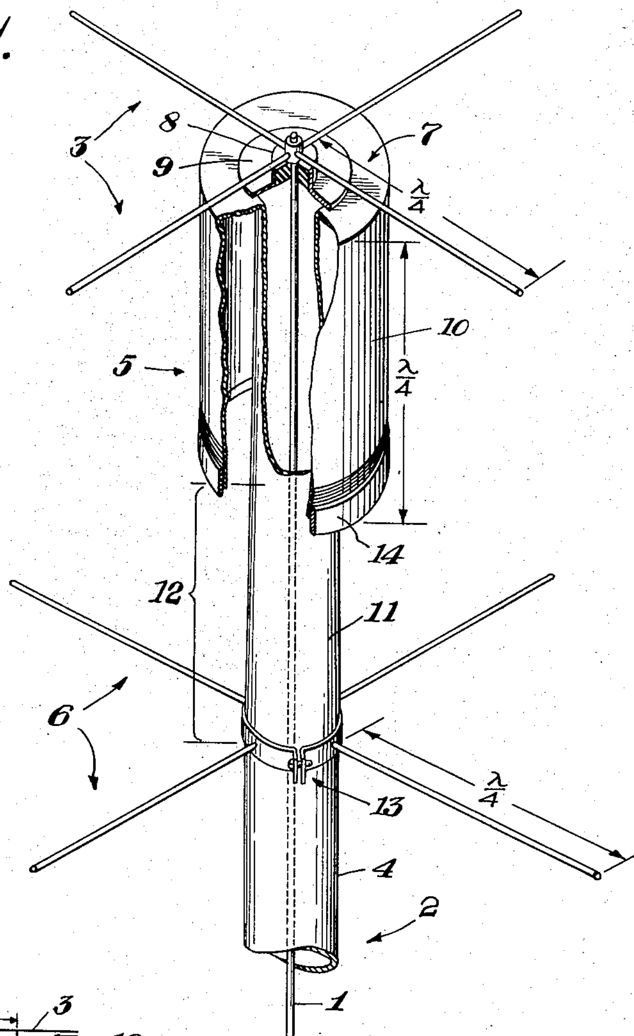

Fig. 2.

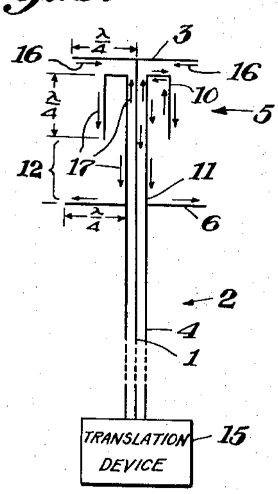

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Fig. 3.

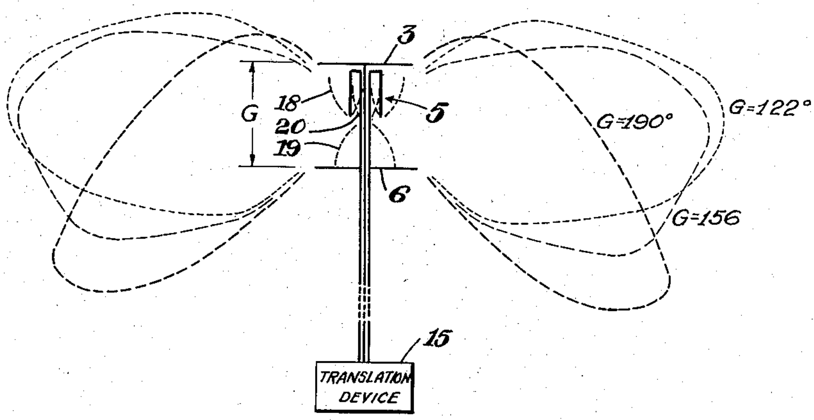


Fig. 5.

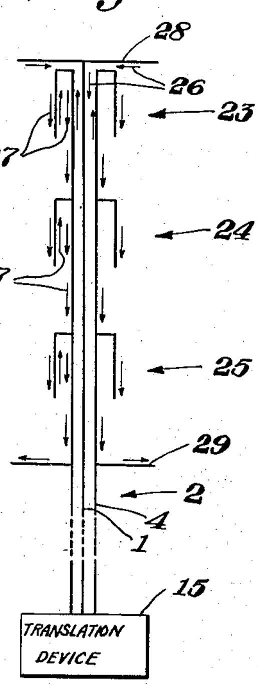
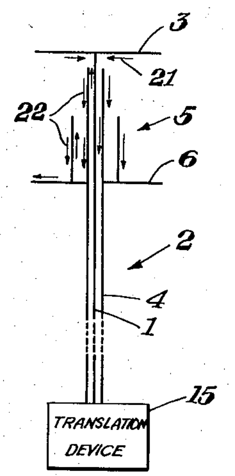


Fig. 4.



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RADIO ANTENNA

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8 Claims. (Cl. 250—33)

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The present invention relates to radio antennas and, more specifically, to high frequency directive antennas.

At frequencies which favor directive propagation of radio waves it is commonly essential, for reasons such as economy and reliability of operation, to minimize that radiation which may occur beyond certain limits and to concentrate the radiation along desired paths. In communicating between ground stations, for example, it becomes necessary to transmit maximum energy in a substantially horizontal direction and to reduce the non-useful power radiated upward. It is further desirable in certain instances that the radiation even be directed downward, to a degree which depends upon the limited distance over which it is intended that the signals may be received. By way of illustration, police communications systems may utilize such antennas to great advantage since the downwardly-directing signals transmitted to mobile units of the system will not be radiated effectively past a certain radial distance from any one antenna. By utilizing, such antennas at their central transmitting stations, communication systems in adjacent cities or districts may operate on the same or nearby frequencies without signals from such stations interfering with one another at receiving stations within certain areas.

An object of the present invention is to provide antennas which satisfy these requirements of efficient low angle radiation.

Another object is to provide an antenna of simple construction for propagation of radio waves over certain controllable distances.

A further object is to provide a broad band high frequency antenna which utilizes a portion of the supporting mast between two ground planes as a radiator to achieve low angle directivity.

The foregoing and other objects of this invention are achieved by antenna structures of the type illustrated as preferred embodiments in the accompanying drawings, wherein:

Figure 1 represents pictorially a double ground plane antenna, with portions of the structure broken away to expose the internal construction;

Figures 2 and 3 depict schematically a double ground plane antenna with instantaneous current distributions and the associated field patterns respectively;

Figure 4 shows an alternate arrangement of antenna components in schematic form; and

Figure 5 illustrates another modification of the present invention having a relatively large number of radiating sections.

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In accordance with the present invention, the antenna of Figure 1 is produced by: terminating the inner conductor 1 of a coaxial line 2, through which the radio waves it is desired to radiate are propagated, in a radio frequency (R. F.) ground plane arrangement 3; folding back the end of outer conductor 4 for a quarter wavelength to produce a skirt element 5 and accomplish phase reversal of the current distribution along the outside of the coaxial line below the skirt element; and, establishing a second R. F. ground plane 6 at a certain distance below the lower end of the skirt element. Upper R. F. ground plane 3 is separated from the conductive top 7 of the quarter wave skirt 5 by the stand-off insulator 8 and the insulating support and cover plate 9. The antenna radiating members comprise the outer surface 10 of the quarter wave skirt and the outer surface 11 of the coaxial conductor 4 which extends for a certain distance, say a quarter wavelength, between the lower R. F. ground plane 6 and the area surrounded by the skirt 5. When the arrangement is employed for propagating waves from a transmitter, the currents flowing along surfaces 10 and 11 will have the same polarity, and the standing waves set up along the outsides of the skirt and the exposed line 12 below it will have cophasal alternations. The oppositely phased alternations which take place within the quarter wave skirt 5 are prevented from contributing to the radiation from the system, and the arrangement functions generally as a pair of in-line and in-phase quarter wave dipole radiators.

Of fundamental importance is the fact that radiation from this antenna emanates principally from those external portions of the system which are included between the two ground planes. The sheath currents flowing along the outside of the supporting and feeding coaxial line 2 below the lower R. F. ground plane 6 are so minimized that they negligibly affect the antenna radiation patterns.

For convenience in interpreting the manner in which the desired field pattern configurations in the vertical plane are achieved, the present antenna may be considered to comprise two independently acting radiating sections whose fields combine to produce these desired configurations. The upper section, including the quarter wave skirt 5 and the upper R. F. ground plane 3, produces a substantially downwardly and radially directing field pattern. And the lower section, including the co-axial line member 12 and the lower R. F. ground plane 6, produces a substantially upward and radially directing field pattern which may be varied in intensity by moving the lower R. F. ground plane 6. Any suitable adjusting means, such as the clamping arrangement 13 permits this ground plane 6 to be moved to the optimum position for producing a specific field configuration. As this plane is lowered (but preferably not greatly in excess of 190 electrical degrees) with respect to the top R. F. ground plane 3, the effects of the lower radiating section on the combined field pattern configurations are such that the pattern becomes directed increasingly downward. Length of the phase inverting skirt 5 may be varied by adjusting the extension member 14 which may be threaded onto the skirt for the required distance. Field patterns are not appreciably affected by such skirt length adjustments, the primary advantage being that for various wavelengths the antenna input impedance may be controlled and the standing wave ratios of the double ground plane antenna improved. Conversely, adjustable positioning of the lower ground plane has comparatively little effect on the antenna impedance. Though the antenna structure has been illustrated with the transmission line as an integral part thereof, it should be recognized that the line may be a mechanically as well as electrically distinct unit, merely coupled to the antenna proper.

Instantaneous current distributions along the antenna surfaces are depicted in Figure 2 for the antenna of Figure 1 being fed from translation device 15. Radio frequency currents 16 illustrated flowing along the four radial arms of ground plane 3 to the central conductor 1 of coaxial line 2 produce fields which cancel at every point in space and hence render the plane 3 ineffective as a radiator. Currents 17, 180° out of phase with currents 16, flow from along the inside of outer co-axial line conductor 4 down the outer surface 10 of the quarter wave skirt 5, along the inner surfaces of the skirt, down the outer surface 11 of the coaxial line 2, and radially outward along the arms of ground plane 6 which, like ground plane 3, is ineffective as a radiator. Some R. F. current does flow along the outside of the coaxial line below the lower ground plane, but this current is so minimized by the action of the ground plane 6 as a R. F. ground and a choke to radio frequency currents that it is unimportant in a consideration of those currents which are primarily responsible for the propagation of directional radio energy.

In Figure 3 the standing wave patterns having similarly phased alternations 18 and 19 are shown for the upper and lower radiating sections respectively, those alternations 20 which are oppositely phased to 18 and 19 being suppressed in radiant action due to their enclosure within the quarter wave skirt 5 which functions as a half wave suppressor. Additionally, representative radiation patterns in the vertical plane are disclosed for certain electrical spacings G between the upper and lower ground planes. When G is 122 electrical degrees at the operating wavelength, i. e. when

$$G\text{ meters}=\frac{G\text{ electrical degrees}}{360\text{ electrical degrees}}\times\lambda\text{meters}$$

the directivity is principally horizontal, at 156 degrees the directivity is somewhat lowered, and at 190 degrees the directivity is markedly downward and radiation may be controlled to extend over a definite area. The field configurations in the horizontal plane are essentially circular in

all cases. Broadband characteristics of the double ground plane antenna are such that, for example, within a high frequency operating range of 152–162 megacycles the antenna may be fed into a 52 ohm coaxial transmission line with a standing wave ratio of two to one or less.

Results similar to those achieved by the antenna of Figure 1 may be obtained by the structure schematically represented in Figure 4. The tubular skirt member 5 in this embodiment is placed adjacent the lower ground plane 6 and connected conductively therewith. The instantaneous currents designated by numerals 21 and 22 indicate that the propagation from an antenna of this form is equivalent to propagation from the antenna of Figure 1.

In Figure 5 an additional embodiment of the double ground plane antenna is disclosed wherein a plurality of substantially quarter wavelength skirts 23, 24 and 25 are incorporated in accordance with the foregoing principles. Instantaneous currents 26 and 27 demonstrate the cophasal relationship of the currents on the outside of the coaxial structure between R. F. ground planes 28 and 29. This arrangement may of course be modified according to the teachings in Figure 4, that is, the tubular skirts may be positioned such that the lowermost skirt is in contact with the lower ground plane and the uppermost skirt is spaced substantially a quarter wavelength from the upper ground plane.

It should be realized that any convenient means for fastening the lower ground plane to the coaxial transmission line may be utilized, that the quarter wave skirt may be properly adjusted in length by any of numerous arrangements, and that R. F. ground planes in the form of solid conductive discs or having a number of radial members other than four may be employed. While it may be preferred to use a structurally rigid coaxial transmission line to feed the present antennas and simultaneously serve as a supporting structure, it is of course possible to employ flexible and even braided coaxial lines, and the skirt members may be constructed of a plurality of parts attached together. While intended mainly for the propagation of radio waves, the antennas disclosed herein may be utilized for receiving purposes as well; and, although illustrated as erected vertically these antenna systems may be positioned at any angle prescribed by specific requirements. Also, it is conceivable that the quarter wave skirt may be located at various positions along the co-axial line between the ground planes, depending upon the field configurations desired.

Hence, although the present antenna has been disclosed with reference to preferred embodiments it should not be considered limited thereto since there are obviously many changes which may be instituted by those skilled in the art without departing in spirit or scope from this invention.

I claim:

1. An antenna, comprising: a coaxial line, a ground plane member coupled with the central conductor of said line, a conductive sleeve substantially one quarter wavelength long surrounding a portion of said line and connected with the outer conductor of said line at that end of said line at which said ground plane member is coupled, and a second ground plane member adjustably coupled to said outer conductor at a distance slightly greater than a quarter-wave length from said sleeve for obtaining the

desired radiation pattern, said skirt and said outer conductor between said ground plane members functioning as a pair of in-phase quarterwave dipole radiators.

2. An antenna, comprising: a first tubular conductive section, a conductor internal to and concentric with said section, a second tubular section connected with one end of said first section and extending concentrically therewith over a certain distance, a first radio frequency ground plane member connected with said conductor adjacent said one end of said first section, a second radio frequency ground plane member adjustably connected to said first section at a distance slightly greater than a half-wave length from said one end for obtaining the desired radiation pattern, and a transmission line coupled to said first section and said conductor said first and second tubular sections between said ground plane members functioning as a pair of in-phase quarterwave dipole radiators.

3. A system for propagating or receiving radio frequency energy, comprising: a coaxial line, a quarterwave length tubular radiator colinear with said line over a certain distance thereof and connected to the outer conductor at one end of said line, one means acting as a ground plane at radio frequencies coupled to the inner conductor of said line at said one end, and a second means acting as a ground plane at radio frequencies coupled to said outer conductor at a distance greater than a half-wave length from said one end for obtaining the desired radiation pattern, said radiator and the part of said line between said ground plane acting means functioning as a pair of inphase quarterwave dipole radiators.

4. A system for propagating or receiving radio frequency energy, comprising: a radio frequency energy translating device, a coaxial transmission line coupled to said device, a quarterwave length tubular skirt extending colinearly with said line over a certain distance and conductively connected with the outer conductor of said line at the end thereof, one means acting as a ground plane at radio frequencies coupled to the inner conductor of said line at the end thereof, and a second means acting as a ground plane at radio frequencies coupled to said outer conductor at a distance greater than a half-wave length from said end thereof for obtaining the desired radiation pattern, said skirt and the part of said outer conductor between said ground planes functioning as a pair of in-phase quarterwave dipole radiators.

5. A system for propagating or receiving radio frequency energy, comprising: a radio frequency energy translating device, a coaxial transmission line coupled to said device, one means acting as a ground plane at radio frequencies coupled to the end of the internal conductor of said line, a second means acting as a ground plane at radio frequencies coupled to the outer conductor of said line at a distance greater than a half-wave length from the end thereof, for obtaining the desired radiation pattern, and a quarterwave length tubular member colinear with said line over a definite length of said line between said second means and said line end, said tubular member having one end connected to said outer conductor and being positioned there along such that said tubular member and the part of said outer conductor between said ground planes func-

tion as a pair of in-phase quarterwave dipole radiators.

6. A directional high frequency antenna, comprising: a pair of radio frequency ground planes spaced apart at a distance slightly greater than a half-wave length for obtaining the desired radiation pattern, a coaxial transmission line having its inner conductor terminated in one of said ground planes and having its outer conductor connected with the other of said planes and terminated in close proximity to said one plane, and a quarterwave length tubular skirt colinear for a certain distance and connected at one end with said outer conductor between said pair of ground planes, said skirt and the part of said outer conductor between said ground planes functioning as a pair of inphase quarterwave dipole radiators.

7. A broad band high frequency radio system, comprising: a radio frequency translation device, a transmission line coupled with said device, a concentric line coupled with said transmission line, one means acting as a ground plane at radio frequencies coupled to the inner conductor at the end of said concentric line, a second means acting as a ground plane at radio frequencies coupled to the outer conductor of said concentric line at a distance greater than a half-wave length from said one means, for obtaining the desired radiation pattern and a tubular skirt colinear with said coaxial line over a distance of a quarterwave length between said one and said second means and conductively connected at one end with said outer conductor, said skirt and the part of said outer conductor between said ground planes functioning as a pair of in-phase quarterwave dipole radiators.

8. A broad band high frequency radio system, comprising: a radio frequency translation device, a transmission line coupled with said device, a concentric line coupled with said transmission line, one radio frequency ground plane coupled to the inner conductor at the end of said concentric line, a second radio frequency ground plane coupled to the outer conductor of said concentric line at a distance substantially an integral number of half-wave lengths from said one ground plane, and a plurality of tubular skirts concentric with said line each of said tubular skirts being substantially a quarter wavelength long, wherein one skirt is conductively connected at one end with the end of said outer conductor which is not joined with said transmission line, wherein each of the other skirts is conductively connected to said outer conductor at the end nearer said one skirt, wherein substantially a quarter wavelength spacing exists between skirts, and wherein said second ground plane is spaced substantially a quarter wavelength from the tubular skirt most removed from said one skirt.

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