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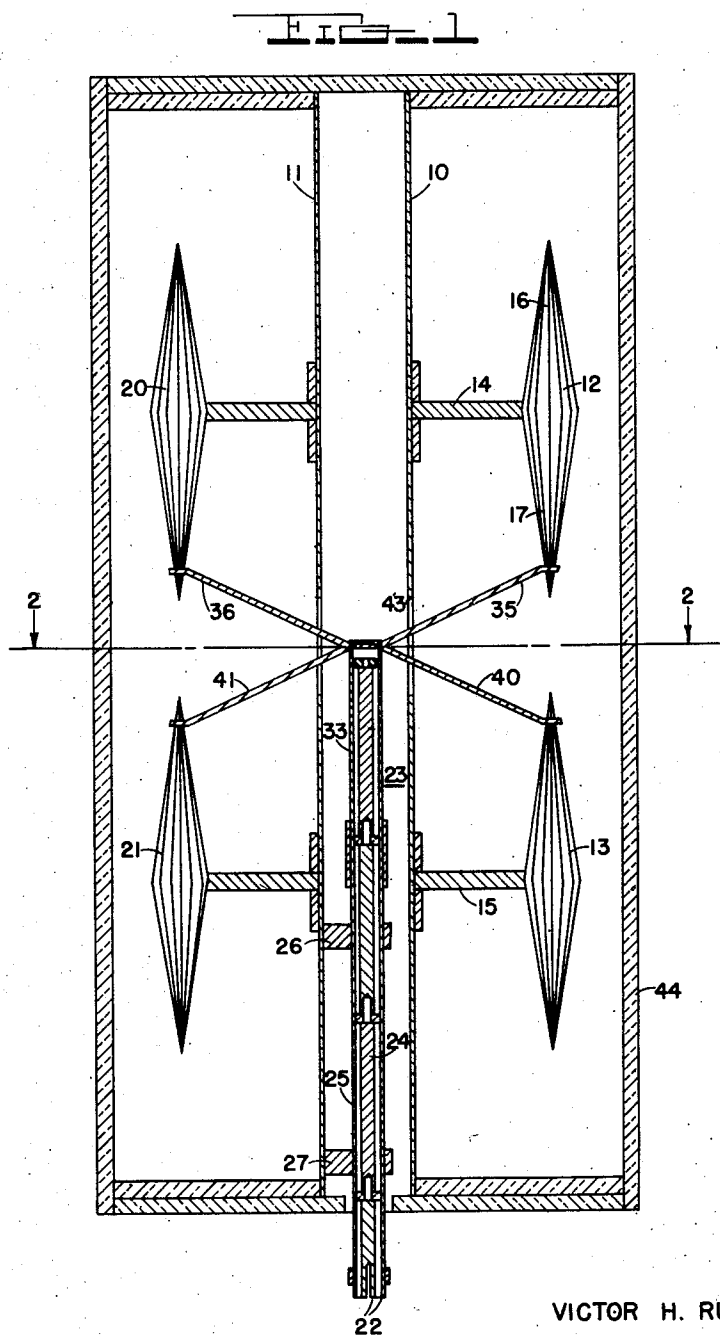
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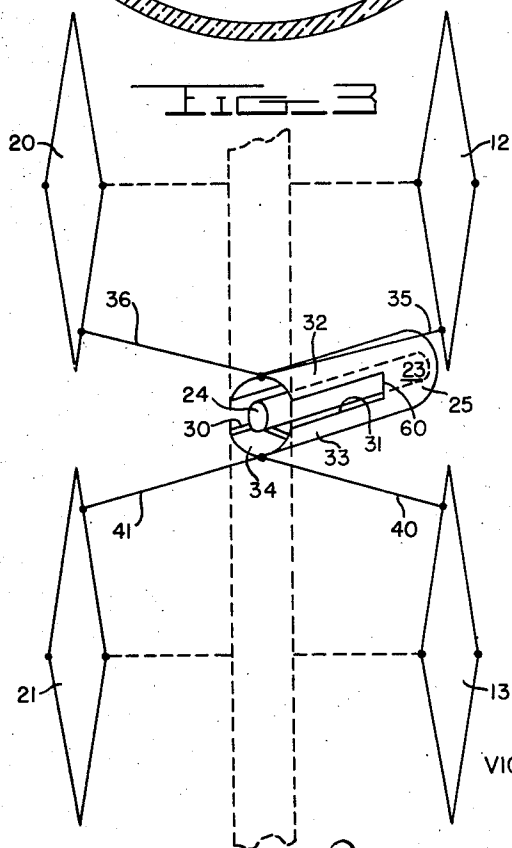
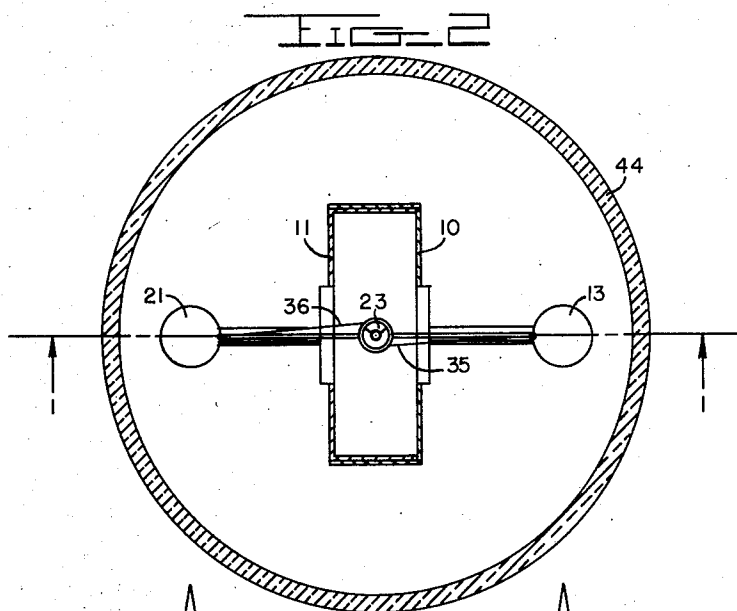
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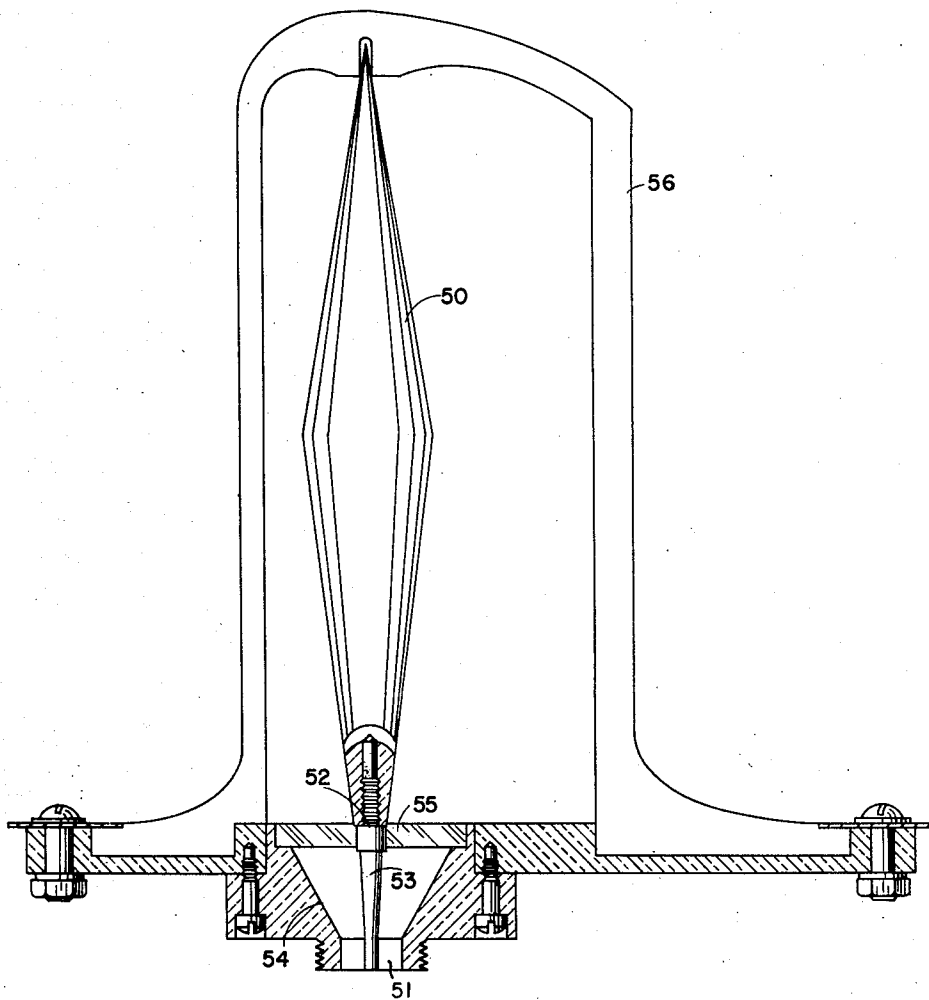
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FIG. 4



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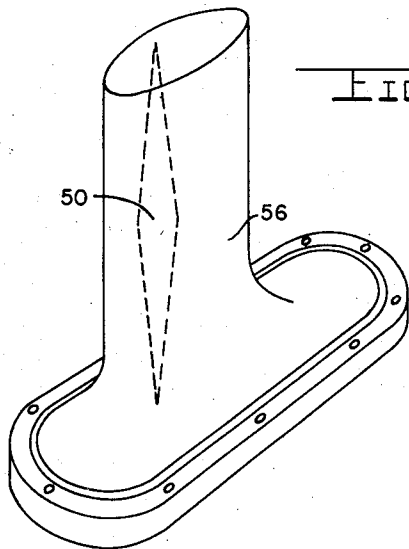
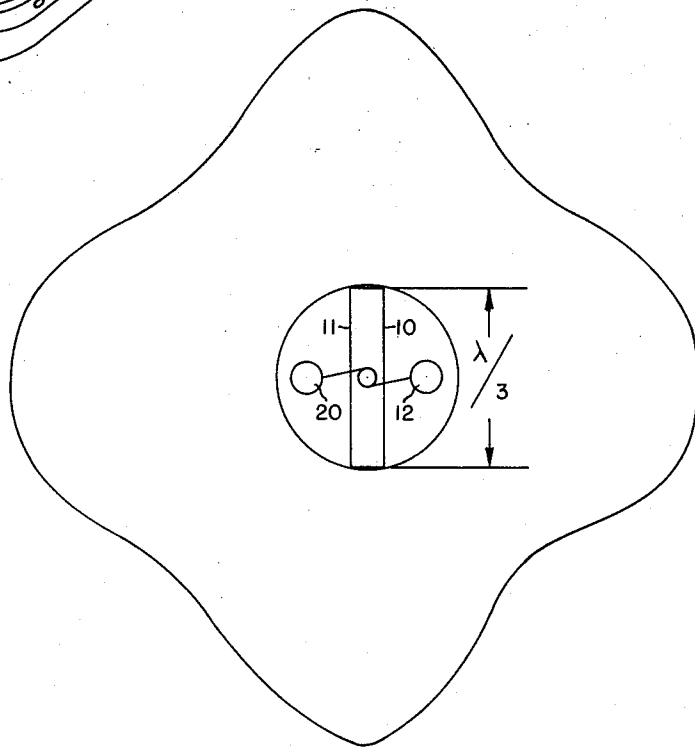


FIG. 5

FIG. 6



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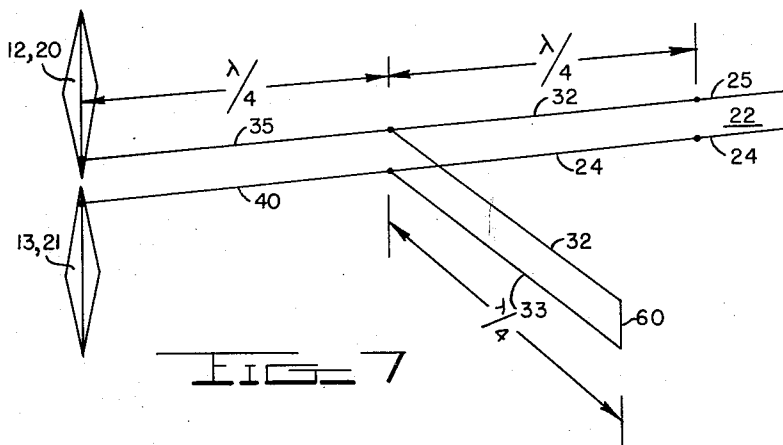


FIG. 7

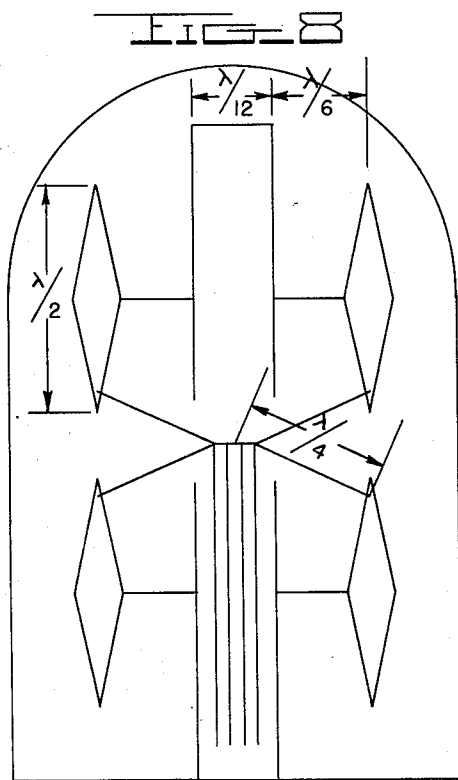


FIG. 8

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UNITED STATES PATENT OFFICE

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5 Claims. (Cl. 250—33.57)

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This invention relates to an antenna, and more particularly to an antenna having a broad band impedance-frequency response characteristic.

An object of this invention is to produce an antenna which will present an input impedance substantially constant over a wide band of frequencies.

Another object of this invention is to produce an antenna array which will have substantially omni-directional radiation properties in a given plane.

A further object of this invention is to devise improved means for translating energy between a concentric line feeding an antenna and the antenna radiators.

A still further object of this invention is to provide an antenna array feeder system having the property that the input impedance of the antenna radiator elements will match that of a concentric transmission line feeding the antenna, over a wide band of operating frequencies.

In accordance with these objects, and with further objects which will become apparent, this invention will now be described with reference to the accompanying drawings in which:

Fig. 1 illustrates a sectionalized elevation of an antenna array embodying this invention, taken along line 1—1 of Fig. 2;

Fig. 2 illustrates a sectionalized plan view of the antenna array of Fig. 1 taken along line 2—2 thereof;

Fig. 3 is a view, partially schematic, of the transforming means whereby energy is translated from an unbalanced, concentric transmission line to a balanced transmission line feeding the radiator elements;

Fig. 4 illustrates one of the radiating elements of Fig. 1 used alone;

Fig. 5 is a perspective view of the antenna and housing of Fig. 4;

Fig. 6 illustrates the horizontal radiation pattern produced by the antenna array of Figs. 1 and 2;

Fig. 7 is a schematic diagram illustrating the operation of the matching transformer shown in Fig. 3; and

Fig. 8 illustrates, somewhat schematically, the antenna array of Fig. 1, giving preferred dimensions for certain of the parts.

Referring now to the drawings, Fig. 1 illustrates an antenna array embodying this invention and comprising a reflector having conducting reflector plates 10 and 11. Wall 10

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supports a pair of double cone radiators 12 and 13, by means of rods 14 and 15 attached to the respective mid points of the radiators. Supported by reflecting plate 11 are radiators 20 and 21, corresponding, respectively, to radiators 12 and 13 supported by reflecting plate 10.

Each of the radiators is similar, for example, to radiator 12, which consists of a pair of cones 16 and 17 placed base to base, with their common axis along a vertical line. Radiators 12 and 13 are each approximately one-half wave length long at the mid point of their broad operating band of frequencies, thus constituting together a full wave dipole, each radiator of which has the special double-coned configuration described above.

Energy is translated between concentric feeder line 22 and the radiators 12, 13, 20 and 21 by means of a special matching transformer 23 shown more particularly in Fig. 3. Concentric line 22, consisting of inner conductor 24 and outer conductor 25, is separated from, and supported by, reflecting plates 10 and 11 by means of spacers 26 and 27, and is terminated in the matching transformer 23 which will now be described.

Referring to Fig. 3, matching transformer 23 will be seen to consist of inner conductor 24 and outer conductor 25, forming an extension of concentric line 22. In the end of outer conductor 25, are cut a pair of diametrically opposed slots 30 and 31, bifurcating outer conductor 25 into two branches, 32 and 33. At the end of branch 33 a conducting segment 34 is attached, forming an electrical connection between the end of branch 33 and inner conductor 24. From branch 32 of bifurcate outer conductor 25 extends one side of a balanced transmission line consisting of electrically paralleled conductors 35 and 36 connected to predetermined points on radiators 12 and 20, respectively. Similarly, the other side of the balanced transmission line, consisting of electrically paralleled conductors 40 and 41, is connected at one end to branch 33 of bifurcate conductor 25 and at the other end to radiators 13 and 21. In practice, slots 30 and 31 are made equal approximately to a quarter wave-length at the mid-point of the frequency band to be translated. Conductors 35, 36, 40, and 41 are each made equal approximately to a quarter wave length, for a purpose which will be described hereinbelow.

In operation, when the antenna of Fig. 1 is used, for example, as a transmitting antenna, energy will be transmitted upward along concen-

tric, unbalanced transmission line 22. In transformer 23, the unbalanced line 22 will be converted into a balanced line consisting of conductors 35, 36 and 40, 41. As shown, balanced line 35—40 extends through a hole 43 in reflector 10 to a point near the extremities of radiators 12 and 13, where conductor 35 is connected to radiator 12, and conductor 40 to radiator 13. These points of connection are chosen so that the input impedance to the radiating elements is slightly greater than that of the transmission line 35—40, as will be explained more fully below.

Radiator 12 being a half wave-length long, maximum current will exist in the center thereof, while maximum voltage will exist at each end. It will thus be seen that the lower tip of radiator 12 is a point of high impedance; by going upward along radiator 12, lower and lower impedance is encountered until a minimum impedance appears at the center, where support 14 joins radiator 12. On the other hand, it will be seen that increasing impedance is encountered with outward movement along balanced transmission line 35—40, by virtue of the outward divergence of these members. That is, spreading of the outer ends of conductors 35 and 40 increases the impedance of the feed line 35—40 while simultaneously bringing the terminating or connection points into regions of lower and lower impedance on radiators 12 and 13. At a certain point, the impedance of the line 35—40 will slightly exceed the impedance of radiators 12 and 13. Connection of the feeder line to the radiators at this point will contribute to broad banding of the impedance match between the concentric feeder line 22 and radiators 12 and 13.

It will be clear that the same considerations as have been stated for radiators 12 and 13 apply equally to radiators 20 and 21.

The entire antenna array is shown surrounded by a non-conductive, protective cylinder 44 which, in the preferred embodiment, is constructed of Plexiglas.

If desired, any of the radiating elements 12, 13, 20 or 21 may be used as an individual antenna in a manner illustrated in Fig. 4. In Fig. 4 the double-cone antenna 50 is end fed at a high impedance point, the transformation between the concentric feed line 51 and end 52 of radiator 50 being made through the use of a conical transforming member comprising inner conductor 53 and outer conductor 54. An insulating disc 55 serves to support the antenna in a streamlined housing 56, which may be made of Plexiglas or polystyrene. A perspective view of antenna 50 in the streamlined housing 56 is shown in Fig. 5.

Reference to Fig. 6 will demonstrate the substantially omnidirectional radiation pattern obtained from the antenna array of Fig. 1. To obtain this pattern dipoles 12—13 and 20—21 were placed as close together as feasible. The optimum width of reflectors 10 and 11 was found to be approximately one-third wave length ($\lambda/3$).

The operation of matching transformer 23 will best be understood by reference to Fig. 7, wherein the electrical elements comprising the transformer have been shown schematically. Conductors 35 and 40 constitute a balanced transmission line translating energy between radiators 12—13 and the ends of branches 32 and 33 of bifurcate outer conductor 25. Along branches 32 and 33, transmission line 35—40 looks into a quarter-wave line shortcircuited at end 60. Along inner conductor 24 and branch 32, line 35—40 looks into a quarter-wave line 32—24, to the end of

which is connected the unbalanced concentric line 24—25. It will thus be seen that by use of the slots 30 and 31, a quarter-wave transforming section has been created, which serves to transform balanced line 35—40 into unbalanced line 24—25.

If the matching transformer were not used, and if one of the balanced conductors were simply connected to inner conductor 24 while the other were connected to outer conductor 25, energy would flow out of the end of the concentric line 22 and down around the outside of outer conductor 25, so that any contact made to the outside of conductor 25 would disturb the energy flow and create serious mismatch in the system. For this reason it is necessary to use a matching means as described in connection with transformer 23.

Fig. 8 illustrates schematically the antenna array of Fig. 1 giving the magnitude of certain critical dimensions in terms of the wave length at the mid-point of the frequency band to be radiated or received. While it has been found that certain of these dimensions must be held within a reasonably close tolerance of approximately 25%, it will be apparent from the specification and appended claims that certain features of this invention are entirely free from critical dimensions. For example, the individual radiators, when used alone as illustrated in Fig. 4, should be equal to an odd number of half-wave lengths and should be alternately slender and thick at each quarter wave point as illustrated. On the other hand, the spacing between radiators and reflectors should be as close as possible without introducing undesirable cancellation of signal strength due to out-of-phase reflection at the reflector. The dimension given constitutes simply one reasonable value which gives satisfactory operation.

Broad band operation of the antenna array of Fig. 1 is dependent on a number of factors, one of which is the particular configuration of the individual radiators 12, 13, 20 and 21. Each of these radiators is so fashioned that a small conducting surface is presented in regions of high voltage, resulting in small capacitance; whereas a large surface for current flow is presented in regions of high current, resulting in low inductance. Inasmuch as current flow will be largely confined to the surface of the radiator, it is to be understood that the important dimension in the double cone radiator is—in addition to the half-wave length—the periphery of the cross section taken normal to the longitudinal axis at any given point.

Even with the special double-coned radiator configuration, the input impedance to the radiator will vary over the frequency band, going from inductive to capacitive reactance as the frequency increases. In order to compensate for this change in impedance, thereby further to enhance the broad band characteristic of the array, certain compensating features are introduced. The length of a feeder line from the end of transformer 23 to the connecting point on a radiator—e. g., the length of line 35—is made equal approximately to a quarter wave length at the mid point of the frequency band. The impedance of transmission line 35—40 at its outer end is made slightly greater than the input impedance to the radiators 12 and 13 at the points of juncture. The decreasing impedance of line 35—40 as one moves toward the reflector serves to enhance this compensation. Final compensation is provided by the shunt reactance of the matching

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transformer 23, i. e., transmission line 32—33 (see Fig. 7). The final compensation thus introduced is greatest when the slots 30 and 31 are narrow, while a lesser degree of compensation is introduced by widening the slots.

The features described above, comprising transformer 23, feeder lines 35—40 and 36—41, and double-coned radiators 12, 13, 20 and 21, produce a broad band frequency response for the array, by providing proper impedance transformation at the mid-point of the frequency band, as well as optimum compensation for radiator impedance variation over the width of the band to be translated.

The particular omnidirectional pattern illustrated in Fig. 6 is obtained by making the reflector plates 10 and 11 of horizontal width equal approximately to a third of a wave length as shown.

Although I have shown and described certain specific embodiments of the invention, I am fully aware of the many modifications possible thereof. This invention is not to be restricted except insofar as is necessitated by prior art and the spirit of the appended claims.

What is claimed is:

1. An antenna and feeder system comprising a reflector, a pair of elongated radiating elements each a half wave length long at the mid-frequency point of operation disposed along a common axis spaced less than a quarter-wave length at the mid-frequency point of operation from said reflector, and a pair of diverging conductors extending thru a hole in said reflector and connected respectively to said pair of elements at points thereon which display an impedance slightly less than the impedance of said diverging conductors at the points of their connection to said radiating elements, and a matching transformer having one side connected to said conductors, and the other side connected to a concentric transmission line.

2. An antenna array and feed system comprising a dipole including a pair of radiating elements each one-half wavelength long at the mid-frequency point of operation and each characterized by a cross sectional periphery varying from a small fractional part of a quarter wavelength at each end of the radiator to substantially a quarter wave length at the mid-frequency point of operation near the center thereof, and a pair of divergent conductors forming a balanced feeder line for said radiators connected to said radiators, respectively, at points thereon which display an impedance slightly less than the impedance of said divergent conductors at the point of connection thereof to said radiators, and a matching transformer having one side connected to said divergent conductors and the other side connected to a concentric transmission line.

3. A substantially omnidirectional antenna array comprising a pair of juxtaposed vertical, dipoles one wavelength long at the mid-frequency point of operation and spaced apart substantially one-half wave length at said frequency, and a reflector disposed between said dipoles with the

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plane thereof normal to the common vertical plane passing through said dipoles, said reflector having a horizontal width equal substantially to a third of a wave length of said frequency.

4. An omnidirectional antenna array and feeder system comprising a pair of parallel, closely adjacent reflecting plates, a concentric transmission line positioned between said plates, a matching transformer having one side connected to an end of said concentric line, two pairs of divergent conductors forming a pair of balanced transmission lines each connected to said matching transformer and extending through a respective reflecting plate, and a pair of dipoles each one full wavelength long at the said frequency point of operation respectively connected to said balanced lines at points on said dipoles matching the impedance of said balanced lines.

5. An antenna array and feed system comprising a full wave dipole, each half radiator of which is one-half wavelength long at the mid-frequency point of operation and each characterized by a cross sectional periphery varying from a small fractional part of a quarter wave length at said frequency at each end to substantially a quarter wave length at said frequency near the center thereof, and a pair of divergent conductors forming a balanced feeder line for said radiators connected at its wide end to said radiators at points thereon intermediate the adjacent ends of said radiators and the respective centers thereof and a matching transformer having one side connected to the small end of said divergent conductors and the other side to a concentric transmission line.

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