Sept. 27, 1966 P. E. MAYES ET AL 3,276,028

HIGH GAIN BACKFIRE ANTENNA ARRAY

Filed Feb. 18, 1964

FIG. 1.

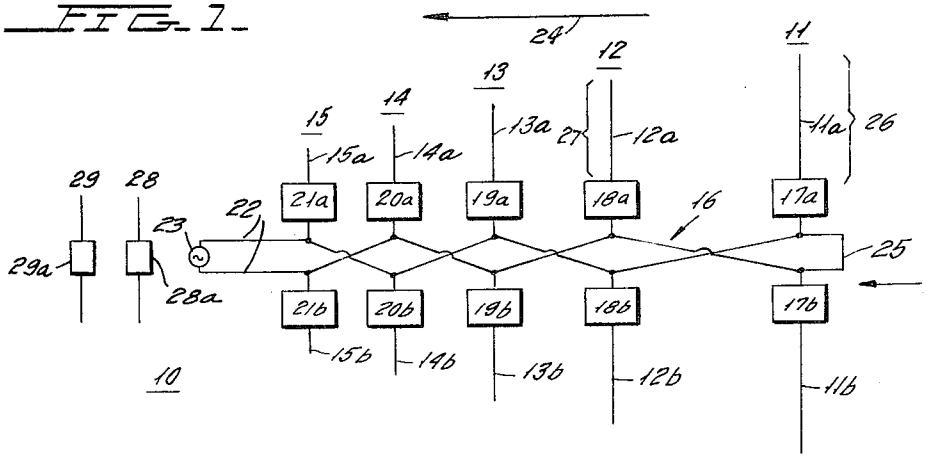


FIG. 2.

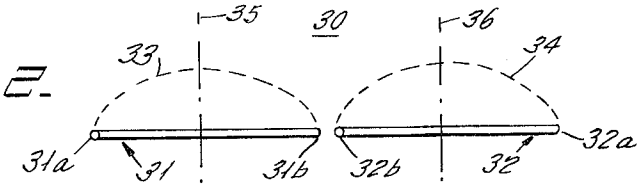


FIG. 3a.

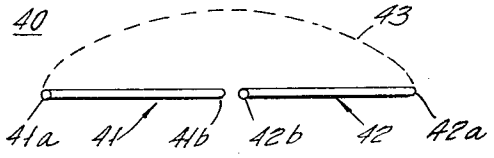


FIG. 3b.

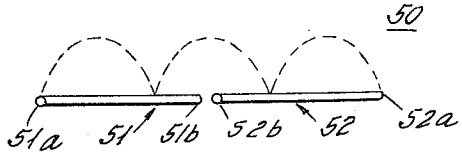


FIG. 4.

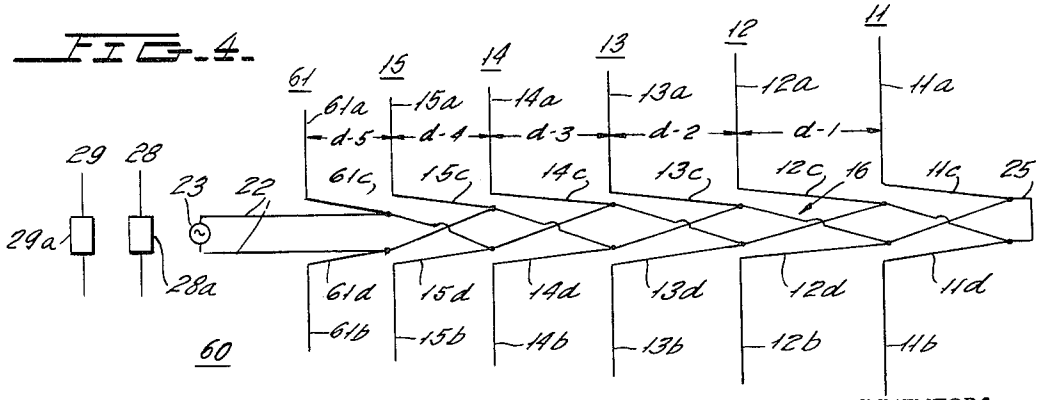
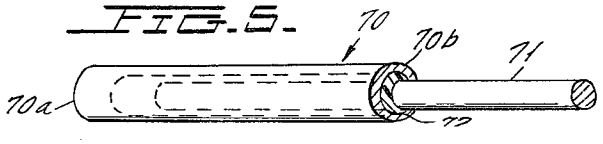


FIG. 5.



INVENTORS
PAUL E. MAYES
RONALD D. GRANT

BY
OSTROLENK, FABER, GERB & SOFFEN
ATTORNEYS

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HIGH GAIN BACKFIRE ANTENNA ARRAY

Paul E. Mayes and Ronald D. Grant, Champaign, Ill., assignors to JFD Electronics Corporation, Brooklyn, N.Y., a corporation of New York

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The instant invention relates to antennas and more particularly to an antenna configuration providing uniform electrical performance over a wide band of frequencies by means of varying the element lengths while maintaining desirable directional characteristics and reasonable values of input impedance. Extremely desirable directivity values are also obtainable in this arrangement without requiring an extremely large length for the antenna array.

The need for antennas exhibiting high directivity values is quite widespread. One typical application for antennas of such design is in an area which is located at a substantial distance from transmitters from which television or FM radio reception is desired. In cases where antennas are located in such fringe areas, it is highly desirable to provide high gain and high value directivity characteristics in order to insure adequate reception of the transmission from a remote location.

Antennas having high values of directivity normally contain a few elements (usually one or two) which are connected to the antenna feed line, as well as several other elements commonly known as parasites, which although forming a part of the antenna are insulated from the feed line. Antennas of this general type are commonly called Yagi arrays and are widely used for receiving FM and television broadcasts as well as in other VHF and UHF communication links. The principal disadvantage with these arrays is the narrow band of frequencies over which the electrical characteristics remain usable. Certain techniques have been devised for improving the bandwidth of Yagi arrays. These techniques have always been at the sacrifice of the gain of the antenna. The gain of an antenna is defined as its signal receiving capability when compared to a standard dipole antenna. Gain is normally expressed in units of decibels.

More recently a new class of antennas has been developed, which antennas are comprised of many driven elements which cooperate to provide high values of gain over bandwidths which are theoretically of unlimited scope. Such antennas are referred to as frequency independent antennas. One particular type of such frequency independent antenna is known as the log-periodic antenna. Antennas having log-periodic arrays of dipole elements have been employed to achieve half-power beamwidths in the plane of the electric field of the antenna, which can be varied from approximately 100° down to about 55°. This is set forth in detail in the article by D. E. Isbell, entitled "Log-Periodic Arrays," IRE Transactions Vol Ap–8, No. 3, May 1960. Narrower E-plane beams utilizing the log-periodic array are practically impossible due to the necessity of providing an excessive number of dipole elements, thus producing an inordinate array length.

In order to obtain narrower beamwidths, antennas have been designed having the V-shaped dipole elements operating near higher order resonances. Such antennas are described in the article by P. E. Mayes, entitled "Broadband Backward Wave Antennas," Microwave Journal, vol. 6, No. 1, January 1963. However, the use of such antenna arrays is impractical in the low band for VHF television and on the FM radio band since the required odd-integer multiple half-wavelength dimensions for the V-dipole elements needed to achieve such high values of directivity is prohibitive.

The instant invention permits the highest possible directivity values compatible with usable element lengths to be obtained. In other words, the antenna array of the instant invention permits directivity values substantially greater than those presently obtainable to be derived while at the same time providing such directivity values through the use of dipole elements of lengths substantially shorter than those required in present day antenna designs to obtain similar results.

The instant invention is comprised of an antenna having a plurality of pairs of substantially coplanar conducting elements which are fed from a two-wire balanced feeder in a manner similar to the log-periodic dipole and log-periodic resonant-V arrays. Each element of the pairs of coplanar elements, however, is connected to the feeder by means of a network of either lumped or distributed elements. These networks are comprised of impedance transforming elements which are selected in accordane with the dipole elements to which they are attached so as to provide suitable energy transfer between the dipole elements and the feeder line. This arrangement enables the overall antenna array to provide extremely high directivity values with an array length which is substantially shorter than that required in antennas of present da ydesign to obtain similar high directivity values.

The antenna array is of the endfire type. The dipole elements are designed preferably in the log-periodic fashion with the lengths of adjacent elements differing by a constant scale factor Tau_1 and the spacings or distances between adjacent element pairs differing by a constant scale factor Tau_2. In one preferred ararngement Tau_1 is approximately equal to Tau_2. With the antenna being used in conjunction with a receiver the elements of shortest length face in the direction of the transmitted signals. The receiver is connected to the feed line near the end of the antenna array at which the shorest length elements are located. In the case where the antenna is employed for transmission purposes the receiver is replaced by a suitable generating means. The array provides extremely high directivity values and high gain characteristics over an extremely large bandwidth or over extremely large groups of bandwidths. As one example, the antenna array of the instant invention may be employed for television reception having channels allocated to the frequency ranges of 54 mc.p.s. to 88 mc.p.s. and 174 mc.p.s. to 216 mc.p.s. The bandwidth characteristics obtainable are extremely flat, thereby providing extremely advantageous results in television applications.

The lumped or distributed elements employed in the network connecting dipole element pairs to a feeder line may be any suitable impedance transforming elements, such as for example, quarter-wavelength wires, coil type transformers, capacitors, or any other kind of impedance transforming networks.

It is therefore one object of the instant invention to provide a novel antenna array of extremely high directivity values through the use of a substantially short array of dipole elements.

Another object of the instant invention is to provide a novel antenna having extremely high directivity values and high gain characteristics over a substantially unlimited bandwidth.

Another object of the instant invention is to provide a novel antenna having high gain and directivity values over extremely large bandwidths through the use of dipole elements which are not of resonant length but which are connected to the antenna feeder line through impedance transforming networks.

Still another object of the instant invention is to provide a novel antenna having extremely high directivity and gain characteristics over several discrete wide fre-

quency bands by means of connecting dipole element pairs which are not of resonant length to a transposed feeder line through impedance transforming networks.

Still another object of the instant invention is to provide a novel antenna having extremely high directivity and gain characteristics over several discrete, wide frequency bands by connecting dipole elements which are not of resonant length but are arranged in substantially coplanar fashion to a transposed feeder line by means of impedance transforming networks.

These and other objects of the instant invention will become apparent when reading the accompanying description and drawings in which:

FIGURE 1 is a schematic diagram of an antenna array designed in accordance with the principles of the instant invention.

FIGURE 2 shows a typical full-wavelength dipole arrangement.

FIGURE 3*a* and 3*b* are views showing typical half-wave length and three-half wave length dipoles, respectively.

FIGURE 4 shows a specific embodiment for the antenna array of FIGURE 1.

FIGURE 5 is a perspective view showing one possible impedance transforming element which may be employed in the array of FIGURE 1.

FIGURE 1 shows an antenna array **10** designed in accordance with the principles of the instant invention and which is comprised of a plurality of dipole elements **11–15** wherein each dipole consists of an upper element **11***a*–**15***a* and a lower element **11***b*–**15***b*, respectively. Each of the dipoles **11–15** are connected to a transposed feeder line **16** such that each succeeding element **11***a*–**15***a* is connected to the alternate side of the feeder line **16** through the impedance transforming networks **17***a*–**21***a*, respectively, and in similar fashion the successive elements **11***b*–**15***b* are connected to alternate sides of feeder line **16** by means of impedance transforming elements **17***b*–**21***b*, respectively.

In the case where the antenna array **10** is employed for transmission purposes, a generator **23** is connected to the transposed feeder line **16** by means of a balanced line **22**. The direction of transmission is represented by the arrow **24**. In the case where the antenna array **10** of FIGURE 1 is to be employed for receiving signals, the generator **23** is replaced by suitable receiver means and is connected to the balanced line **22**.

The connection of the adjacent elements **11***a*–**15***a* and **11***b*–**15***b* to opposite conductors of the transposed two-wire line feeder **16** is utilized for the purpose of achieving radiation directed toward the feed point rather than away from it as for a conventional endfire array.

In order to achieve frequency independent operation over extremely broad bands of frequencies, the length and spacings of the elements **11***a*–**15***a* and **11***b*–**15***b* are determined substantially in accordance with log-periodic formulas. The spacings, such as the spacing between adjacent elements **11***b* and **12***b* and the spacing between the elements **13***b* and **12***b* differ by a substantially constant scale factor Tau_2 while the elements such as, for example, the elements **11***a* and **12***a* differ in their lengths **26** and **27** by a substantially constant scale factor Tau_1. In the preferred arrangement Tau_1 is equal or is approximately equal to Tau_2. In the case of relatively narrow bandwidths, departure from the log-periodic design is not only possible, but is desirable in some cases in order to compensate for truncation effects at the upper and lower band limits. In general, the element lengths vary progressively from one end of the array to the other in the manner shown in FIGURE 1. Connection to the generator in the transmitting case or to the receiver in the receiving case is always made near the end of the shorter elements. The spacing between adjacent elements may decrease from the end of the longer elements toward the end of the shorter elements. However, for narrow bands, the variation may be quite small so that little deterioration in performance is experienced by maintaining constant spacing between the elements **11–15**.

For some applications the performance over a relatively narrow band of frequencies near the upper end of a band may be enhanced by addition of one or more parasitic elements **27–28**, in FIGURE 1. The resonant frequency of these parasitic elements may be adjusted for best performance at one or more frequencies by design of suitable two-terminal networks located in the elements as **28***a*–**29***a*, in FIGURE 1. Performance at the extreme low frequency end of one or more frequency bands may be enhanced by terminating the two-wire feeder in a short circuit **25** at some distance behind the last element as shown in FIGURE 1.

The instant invention differs from the present day antennas in achieving radiation from elements which differ in length appreciably from those presently used. In the log-periodic dipole array the radiation occurs from the elements near the dipole which is one-half wavelength in total length for the frequency being transmitted or received. In the log-periodic resonant-V array the radiation occurs from the elements near the one which is an odd integer multiple of half-wavelengths in its total length relative to the frequency being transmitted or received.

The formation of the radiating regions on the log-periodic dipole and log-periodic resonant-V array antennas is dependent upon the impedance at the junction between the radiating elements and the two-wire feeder. The impedance of elements of other lengths can be transformed to the appropriate value by adding a network of lumped elements or a section of transmission line between the radiating elements or feeder, as shown by the networks **17***a*–**21***a* and **17***b*–**21***b* respectively.

As one example, consider the case of the full-wavelength dipole **30**, shown in FIGURE 2. When the dipole elements **31** and **32** are each one-half wavelength long the current is distributed along these elements approximately as shown by the dotted waveforms **33** and **34**, respectively. The current has a zero magnitude at the outer ends **31***a* and **32***a* of the full-wave dipole; has its maximum magnitude at the quarter-wavelength distance from the ends represented by the dashed lines **35** and **36**, respectively; and decreases to an appreciably small value at the input terminals **31***b* and **32***b* respectively of the dipole **30**. The impedance at the dipole terminals **31***b* and **32***b* is therefore quite high and little energy is transferred from the low impedance feeder, such as for example, the feeder **16** of FIGURE 1, to the full-wave dipole **30**.

In contrast to the full-wavelength dipole, such as for example, the dipole **30**, the half-wave and three-half wave dipoles **40** and **50**, respectively, are shown in FIGURES 3*a* and 3*b*. Considering FIGURE 3*a*, dipole **40** is comprised of elements **41** and **42**, the total length of which is a half-wavelength. At the outer ends **41***a* and **42***a* the current magnitude is zero, while at the inner ends **41***b* and **42***b* the current has its maximum magnitude. This is also true of the dipole **50** of FIGURE 3*b*, having elements **51** and **52**. Their outer ends **51***a* and **52***a* are at zero magnitude and with the dipole element **50** being three-half wavelengths long, the inner ends **51***b* and **52***b* are at substantially maximum current magnitude.

Dipoles of the type shown in FIGURES 3*a* and 3*b* have lower input impedance and energy is readily transferred to dipoles of these and other dipoles having lengths equal to an odd integer number of wavelengths. It is desirable to be able to use full-wave dipoles in cases where directivity greater than possible with half-wave dipoles is required and yet where a three-half wavelength dipole would be impractical to build because of its extremely large physical size.

In order to transform the high impedance of a full-wave dipole which necessarily has substantially zero current magnitude at its inner ends, to a value comparable

to that of the odd integer half-wavelength, a transformer or transforming network can be inserted between the full-wave dipole and the two-wire feeder. A simple transformer can be provided by utilizing the length of the two-wire line which is approximately one-quarter wavelength long. This method proved extremely successful in the embodiment of FIGURE 4.

In the antenna array **60**, shown in FIGURE 4, this array is somewhat similar to the arrangement of FIGURE 1 with like elements bearing like numeral designations. In the embodiment of FIGURE 4, the antenna **60** is comprised of six dipole elements **11–15** and **61**, each comprised of elements **11***a*–**15***a* and **61***a* and **11***b*–**15***b* and **61***b*. The major portions of the elements **11***a*–**15***a*, **11***b*–**15***b* and **61***a* and **61***b* are substantially perpendicular to the direction of the transposed feeder line **16**. Each element is provided with a short end portion **11***c*–**15***c*, **11***d*–**15***d* and **61***c* and **61***d*, respectively, with these portions being substantially parallel to the line of direction of feeder line **16** and connecting the respective portions **11***a*–**15***a*, **11***b*–**15***b*, **61***a* and **61***b* to the feeder line. Taken together each pair of end-portions **11***c*-**11***d*, **12***c*–**12***d*, et cetera, form a short section of two-wire balanced line which transforms the input impedance of each dipole to a different value at the point of connection to the transposed two-wire feeder **16**. The design dimensions of the antenna array **60**, shown in FIGURE 4, are given in the table below:

Tau—0.950		Beta—4		Sigma—0.074	
	Inches		*Inches*		*Inches*
11*a*	7.2	11*c*	1.80	*d*–1	2.02
12*a*	6.84	12*c*	1.71	*d*–2	1.92
13*a*	6.50	13*c*	1.63	*d*–3	1.82
14*a*	6.17	14*c*	1.54	*d*–4	1.73
15*a*	5.86	15*c*	1.47	*d*–5	1.69
61*a*	5.57	61*c*	1.39		

Interpreting the data shown in the above chart, the first column setting forth **11***a*–**61***a* gives the dimension for each of these elements. The second column setting forth **11***c*–**61***c* gives the dimensions for the parallel leg portions **11***c*–**61***c*. The third column setting forth the values *d*–1 – *d*–5 yields the spacing between the adjacent elements **11***a*–**61***a*. The constant scale factor Tau, when multiplied by the value of any element length, yields the length of the next shorter element. For example, the length of element **11***a* multiplied by Tau equals the length of **12***a*. In order to determine the length of each parallel portion of **11***c*–**61***c*, the length of each perpendicular portion **11***a*–**61***a* is divided by the constant Beta. For example, dividing the length of element **11***a* by Beta yields the length of element **11***c*.

In order to obtain the spacing betwen adjacent dipoles this is performed by multiplying the constant Sigma by the length of an element times four. For example, given the length of element **11***a*, multiplying this by four and further by Sigma, this yields the spacing distance *d*–1.

Advantageous backfire radiation patterns were observed utilizing the above embodiments over the band of frequencies comparable to the FM radio band from 88 mc.p.s. to 108 mc.p.s. The exemplary embodiment of FIGURE 4 was constructed as a scale model of the antenna operating on a 5:1 scale. Thus, if the perpendicular and parallel element lengths and the spacings between adjacent dipoles is multiplied by five, such an arrangement will provide operation over the FM radio band. The antennas constructed in accordance with the principles of the instant invention have been shown to provide improved performance with half-power beamwidths in the E-plane as small as 32° and front-to-back ratios greater than 18 decibels without the presence of side-lobes. This design permits extremely high values of directivity to be achieved compatible with practical transverse dimensions of the radiating elements on a broadband backfire array. In other words, the directivity characteristics of the antenna arrays **10** and **60** of FIGURES 1 and 4 respectively, have yielded extremely advantageous directivity characteristics without the need for use of extremely long dipole elements or inordinate array lengths. If greater directivity is desired, the element length of each dipole element can be controlled within desirable limits simply by adding impedance transforming elements between the dipoles and feeders.

Although the examples described above employ transmission line elements as transformers, other impedance transforming networks may be utilized. As one example, FIGURE 5 shows the capacitor arrangement **70** which may be employed at the base of each dipole element. Such an element transforms the resonant value of impedance which normally occurs near the half-wave dimension of the dipole. The new resonance would occur at a longer length of the dipole. The capacitor arrangement **70** can be built into the tubular elements as shown in FIGURE 5. A large diameter tube **70** is provided which is connected to the feeder line **16** (see FIGURES 1 or 4) at its left-hand end **70***a*. The dipole element **71** has a smaller outside diameter than the tube **70** and is inserted through the opening **70***b* therein. Dipole element **71** is insulated from tubular member **70** by means of a dielectric sleeve **72**. This arrangement provides adequate positioning and support of the dipole element **71**, as well as providing the capacitive coupling between the feeder line and the dipole element.

It can therefore be seen that the instant invention provides a novel antenna array which has extremely high directivity characteristics over an extremely broad band of operating frequencies, while at the same time keeping the length of the dipole elements as well as the overall length of the array well within reasonable limits so as to prevent the overall structure from becoming impractical for both construction and use. These features are obtained by employing lumped or distributive networks as connecting means between the feeder line and the dipole elements to provide the desired resonance characteristics for each of the dipole elements.

Although there has been described a preferred embodiment of this novel invention, many variations and modifications will now be apparent to those skilled in the art. Therefore, this invention is to be limited, not by the specific disclosure herein, but only by the appending claims.

What is claimed is:

1. An antenna array providing high directivity values over extremely broad bands of operating frequencies comprising a plurality of dipoles being arranged at spaced intervals; each of said dipoles being comprised of first and second elements substantially colinear to one another; all of said elements lying substantially in a single plane; a two-wire feeder line; adjacent elements of said dipoles being connected to alternate sides of said feeder line; the lengths of said dipoles being maximum at a first end of said feeder line and being progressively shorter toward the opposite end of said feeder line; a plurality of impedance-transforming networks each connecting an associated dipole element to said feeder line to provide maximum energy transfer between said feeder line and said element when the length of its associated dipole is substantially different from the odd-integer multiple of half-wave length corresponding to the frequency of operation.

2. An antenna array providing high directivity values over extremely broad bands of operating frequencies comprising a plurality of dipoles being arranged at spaced intervals; each of said dipoles being comprised of first and second elements substantially colinear to one another; all of said elements lying substantially in a single plane; a two-wire feeder line; adjacent elements of said dipoles being connected to alternate sides of said feeder line; the lengths of said dipoles being maximum at a first

end of said feeder line and being progressively shorter toward the opposite end of said feeder line; the lengths of the elements of each dipole differing from the lengths of the adjacent longer dipole elements by a substantially constant scale factor; a plurality of impedance-transforming networks each connecting an associated dipole element to said feeder line to provide maximum energy transfer between said feeder line and said element when the length of its associated dipole is substantially different from the odd-integer multiple of half-wavelength corresponding to the frequency of operation.

3. An antenna array providing high directivity values over extremely broad bands of operating frequencies comprising a plurality of dipoles being arranged at spaced intervals; each of said dipoles being comprised of first and second elements substantially colinear to one another; all of said elements lying substantially in a single plane; a two-wire feeder line; adjacent elements of said dipoles being connected to alternate sides of said feeder line; the lengths of said dipoles being maximum at a first end of said feeder line and being progressively shorter toward the opposite end of said feeder line; the lengths of the elements of each dipole differing from the lengths of the adjacent longer dipole elements by a substantially constant scale factor; the distance between adjacent dipoles being maximum at the first end of said feeder line and being progressively shorter toward the opposite end of said feeder line; a plurality of impedance-transforming networks each connecting an associated dipole element to said feeder line to provide maximum energy transfer between said feeder line and said element when the length of its associated dipole is substantially different from the odd-integer multiple of half-wave length corresponding to the frequency of operation.

4. An antenna array providing high directivity values over extremely broad bands of operating frequencies comprising a plurality of dipoles being arranged at spaced intervals; each of said dipoles being comprised of first and second elements substantially colinear to one another; all of said elements lying substantially in a single plane; a two-wire feeder line; adjacent elements of said dipoles being connected to alternate sides of said feeder line; the lengths of said dipoles being maximum at a first end of said feeder line and being progressively shorter toward the opposite end of said feeder line; the lengths of the elements of each dipole differing from the lengths of the adjacent longer dipole elements by a first substantially constant scale factor; the distances between adjacent dipoles being maximum at the first end of said feeder line and being progressively shorter toward the opposite end of said feeder line; the distance between adjacent dipoles differing from the distance between succeeding adjacent dipoles by a second substantially constant scale factor; a plurality of impedance-transforming networks each connecting an associated dipole element to said feeder line to provide maximum energy transfer between said feeder line and said element when the length of its associated dipole is substantially different from the odd-integer multiple of half-wave length corresponding to the frequency of operation.

5. An antenna array providing high directivity values over extremely broad bands of operating frequencies comprising a plurality of dipoles being arranged at spaced intervals; each of said dipoles being comprised of first and second elements substantially colinear to one another; all of said elements lying substantially in a single plane; a two-wire feeder line; adjacent elements of said dipoles being connected to alternate sides of said feeder line; the lengths of said dipoles being maximum at a first end of said feeder line and being progressively shorter toward the opposite end of said feeder line; the lengths of the elements of each dipole differing from the lengths of the adjacent longer dipole elements by a first substantially constant scale factor; the distances between adjacent dipoles being maximum at the first end of said feeder line and being progressively shorter toward the opposite end of said feeder line; the distance between adjacent dipoles differing from the distance between succeeding adjacent dipoles by a second substantially constant scale factor; a plurality of impedance-transforming networks each connecting an associated dipole element to said feeder line to provide maximum energy transfer between said feeder line and said element when the length of its associated dipole is substantially different from the odd-integer multiple of half-wave length corresponding to the frequency of operation; said first and second scale factors being substantially equal.

6. An antenna array providing high directivity values over extremely broad bands of operating frequencies comprising a plurality of dipoles being arranged at spaced intervals; each of said dipoles being comprised of first and second elements substantially colinear to one another; all of said elements lying substantially in a single plane; a two-wire feeder line; adjacent elements of said dipoles being connected to alternate sides of said feeder line; the lengths of said dipoles being maximum at a first end of said feeder line and being progressively shorter toward the opposite end of said feeder line; the lengths of the elements of each dipole differing from the lengths of the adjacent dipole elements by a first substantially constant scale factor; the distances between adjacent dipoles being maximum at the first end of said feeder line and being progressively shorter toward the opposite end of said feeder line; the distance between adjacent dipoles differing from the distance between succeeding adjacent dipoles by a second substantially constant scale factor; a plurality of impedance-transforming networks each connecting an associated dipole element to said feeder line to provide maximum energy transfer between said feeder line and said element when the length of its associated dipole is substantially different from the odd-integer multiple of half-wave length corresponding to the frequency of operation; said first and second scale factors being substantially equal.

7. An antenna array providing high directivity values over extremely broad bands of operating frequencies comprising a plurality of dipoles being arranged at spaced intervals; each of said dipoles being comprised of first and second elements substantially colinear to one another; all of said elements lying substantially in a single plane; a two-wire feeder line; adjacent elements of said dipoles being connected to alternate sides of said feeder line; the lengths of said dipoles being maximum at a first end of said feeder line and being progressively shorter toward the opposite end of said feeder line; a plurality of impedance-transforming networks each connecting an associated dipole element to said feeder line to provide maximum energy transfer between said feeder line and said element when the length of its associated dipole is substantially different from the odd-integer multiple of half-wave length corresponding to the frequency of operation, said networks comprising transformer means for substantially matching the impedance of each element to the impedance of said feeder line.

8. An antenna array providing high directivity values over-extremely broad bands of operating frequencies comprising a plurality of dipoles being arranged at spaced intervals; each of said dipoles being comprised of first and second elements substantially colinear to one another; all of said elements lying substantially in a single plane; a two-wire feeder line; adjacent elements of said dipoles being connected to alternate sides of said feeder line; the lengths of said dipoles being maximum at a first end of said feeder line and being progressively shorter toward the opposite end of said feeder line; a plurality of impedance-transforming networks each connecting an associate dipole element to said feeder line to provide maximum energy transfer between said feeder line and said elements; said networks having values to

cause said dipoles to operate at lengths corresponding substantially to integer multiples of the wave length.

9. An antenna array providing high directivity values over extremely broad bands of operating frequencies comprising a plurality of dipoles being arranged at spaced intervals; each of said dipoles being comprised of first and second elements substantially colinear to one another; all of said elements lying substantially in a single plane; a two-wire feeder line; adjacent elements of said dipoles being connected to alternate sides of said feeder line; the lengths of said dipoles being maximum at a first end of said feeder line and being progressively shorter toward the opposite end of said feeder line; a plurality of impedance-transforming networks each connecting an associated dipole element to said feeder line to provide maximum energy transfer between said feeder line and said elements; said networks comprising transformer means for substantially matching the impedance of each element to the impedance of said feeder line; said networks having values to cause said dipoles to operate at lengths corresponding substantially to integer multiples of the wave length.

10. An antenna array providing high directivity values over extremely broad bands of operating frequencies comprising a plurality of dipoles being arranged at spaced intervals; each of said dipoles being comprised of first and second elements substantially colinear to one another; all of said elements lying substantially in a single plane; a two-wire feeder line; adjacent elements of said dipoles being connected to alternate sides of said feeder line; the lengths of said dipoles being maximum at a first end of said feeder line and being progressively shorter toward the opposite end of said feeder line; a plurality of impedance-transforming networks each connecting an associated dipole element to said feeder line to provide maximum energy transfer between said feeder line and said elements; said networks comprising transformer means for substantially matching the impedance of each element to the impedance of said feeder line; said transformer means being a section of two-wire balanced transmission line.

11. An antenna array providing high directivity values over extremely broad bands of operating frequencies comprising:

a plurality of dipoles being arranged at spaced intervals;

each of said dipoles being comprised a first and second elements substantially colinear to one another;

each of said dipoles having a length of substantially integer multiples of the wave length corresponding to the frequency to be received by said each of said dipoles;

all of said elements lying substantially in a single plane;

a two-wire feeder line;

adjacent elements of said dipoles being connected to alternate sides of said feeder line;

the lengths of said dipoles being maximum at a first end of said feeder line and being progressively shorter toward the opposite end of said feeder line;

a plurality of impedance-transforming networks each connecting an associated dipole element to said feeder line to provide maximum energy transfer between said feeder line and said elements;

said networks comprising transformer means for substantially matching the impedance of each element to the impedance of said feeder line;

said transformer means being a section of two-wire balanced transmission line extending substantially parallel to said feeder line;

each of said two-wire balanced transmission lines having a length of substantially one-quarter multiples of the wavelength corresponding to the frequency to be received by its associated dipole element.

12. An antenna array providing high directivity values over extremely broad bands of operating frequencies comprising:

a two-wire feeder line;

a plurality of dipoles being arranged transverse to said feeder line at spaced intervals along the length thereof;

each of said dipoles being comprised of first and second elements spaced on opposite sides of said feeder line;

adjacent elements of said dipoles being connected to alternate sides of said feeder line;

a plurality of impedance-transforming networks each connecting an associated dipole element to said feeder line to provide maximum energy transfer between said feeder line and said elements;

said networks comprising transformer means for substantially matching the impedance of each element to the impedance of said feeder line;

said transformer means being a section of transmission line extending substantially parallel to said feeder line;

the length of each transmission line transformer means being approximately one-quarter of the length of the dipole arm to which it is connected;

the accumulated length of said first and second element of any one dipole plus the length of the transmission line transformer means connected to said first and second elements being of the order of one and one-quarter wavelength at a frequency within the operating band of the antenna array.

13. An antenna array providing high directivity values over extremely broad bands of operating frequencies comprising:

a two-wire feeder line;

a plurality of dipoles being arranged transverse to said feeder line at spaced intervals along the length thereof;

each of said dipoles being comprised of first and second elements spaced on opposite sides of said feeder-line;

the accumulated length of said first and second elements of any one dipole being substantially integer multiples of the wave length corresponding to the frequency to be received by said any one dipole;

adjacent elements of said dipoles being connected to alternate sides of said feeder line;

a plurality of impedance-transforming networks each connecting an associate dipole element to said feeder line to provide maximum energy transfer between said feeder line and said elements;

said networks comprising transformer means for substantially matching the impedance of each element to the impedance of said feeder line.

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HERMAN KARL SAALBACH, *Primary Examiner.*

E. LIEBERMAN, R. F. HUNT, *Assistant Examiners.*