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J. F. GUERNSEY

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BROAD BAND HIGH FREQUENCY ANTENNA

Filed June 18, 1957

2 Sheets-Sheet 1

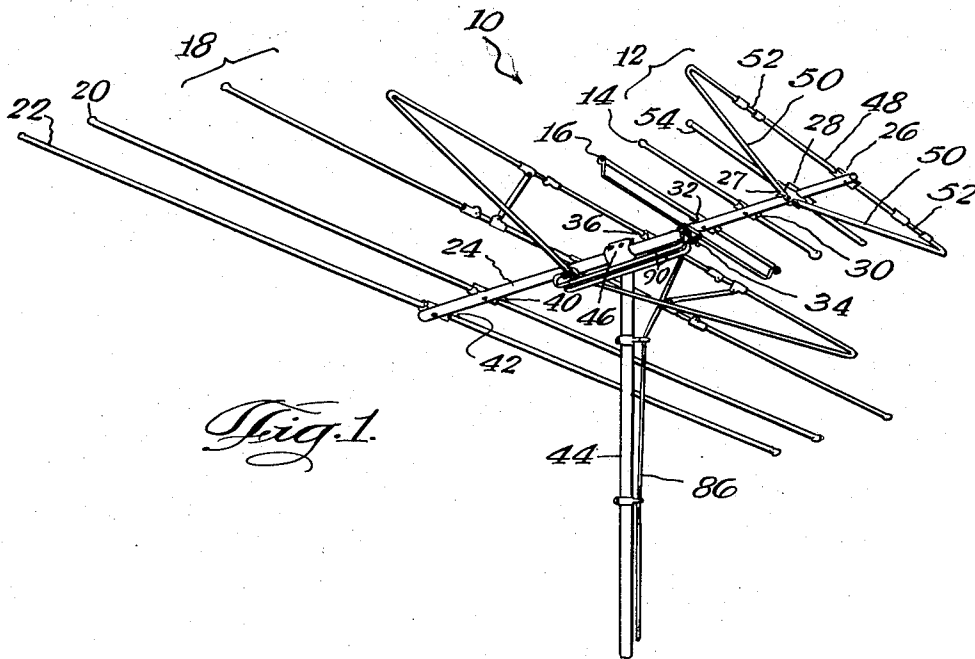


Fig. 1.

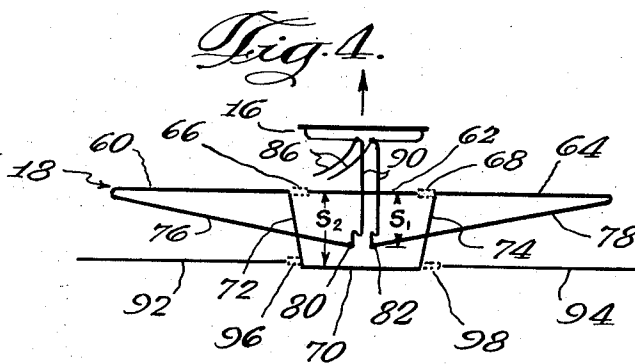


Fig. 4.

Inventor
John F. Guernsey
By Silverman, Mullin & Co.
attorneys

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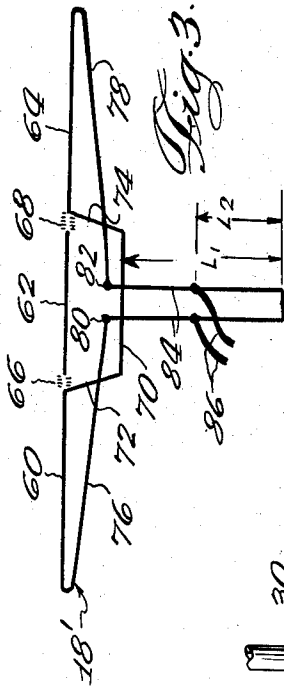
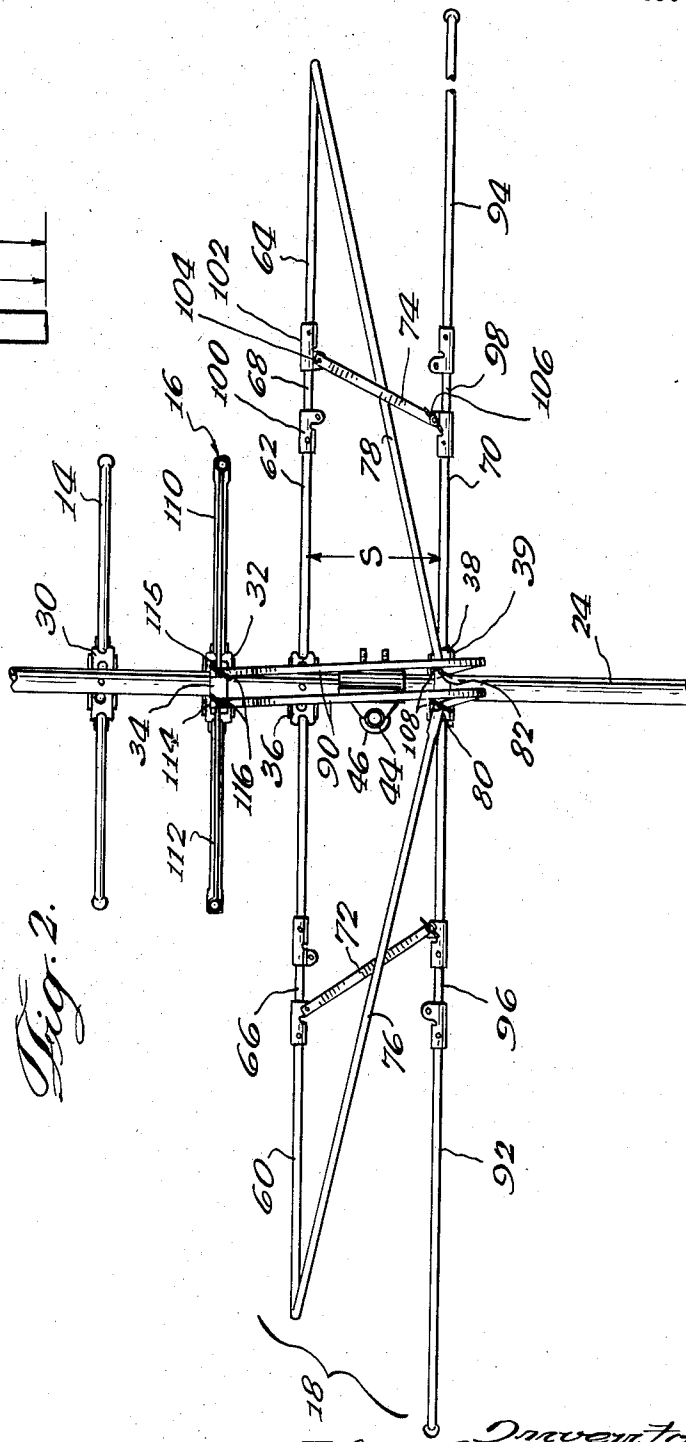


Fig. 2.



Inventor
John F. Guernsey
By Silverman, Mullin & Co.
Attorneys

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BROAD BAND HIGH FREQUENCY ANTENNA

John F. Guernsey, Griggsville, Ill., assignor to Trio Manufacturing Co., Griggsville, Ill., a corporation of Illinois

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13 Claims. (Cl. 343—803)

This invention relates generally to antennas and more particularly is concerned with the construction of a compact and highly efficient directive antenna for the reception of high frequency signals over a broad band.

The invention is especially applicable in the reception of television signals over the presently known high and low bands, the low band comprising channels 2 to 6 inclusive extending from 54 megacycles per second to 88 megacycles per second, and the high band comprising channels 7 to 13 inclusive extending from 174 megacycles per second to 216 megacycles per second. Obviously the teachings of the invention are of utility in other applications, and hence although the description will specifically refer to the reception of television signals, this is not intended as a limitation.

In U. S. Patent 2,772,413, issued November 27, 1956, to the applicant herein and Arthur E. Vail and assigned to the assignee of this patent application, there was illustrated and described a composite dipole multi-channel television antenna in which the composite dipole was formed of three collinear dipole elements of substantially the same length, a fourth element spaced from the middle element and electrically connected to the two outboard elements, and a folded dipole extension on the outboard elements reverse bent and connected to the transmission line at the boom. The center element of the collinear three was parasitic in nature.

The composite dipole described in said Patent 2,772,413 was therefore resonant to a low band channel, such as for example any one of the channels 2, 4 or 6, acting as a folded dipole on this channel. The proportions of the antenna elements being approximately three to one, that is the overall length of the two outboard elements and the spaced element being approximately three times the length of any one of the shorter elements, the antenna also resonated at a frequency three times its resonant frequency in the low band. The composite dipole therefore also resonated at channel 7, 10 or 13 depending upon the low band resonant channel.

The theory of operation of said composite dipole is fully explained in said patent, and hence suffice it to say that the antenna functions as a modified, end-fire, uni-directional element.

In said patent, it was explained that the single composite dipole was useful but better gain and coverage over the entire television spectrum could be obtained by using a plurality of such composite dipoles constructed to cover various portions of the bands. Antennas were described using two and three of such composite dipole elements.

This invention has as its principal object the provision of an antenna which uses the basic teachings of said patent in the construction of a composite dipole of the modified end-fire type, but through novel structure increases the gain and broad-band response of said composite dipole making it practical to utilize only one of such composite dipoles in an all-band television antenna.

Another object of the invention is to provide a high gain broad band antenna in which the low band gain

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and response is substantially improved through the use of a novel phasing line, but the phasing line is so constructed as to provide additional improvement on the high band as well.

Other objects will become apparent as the description proceeds in connection with which a preferred embodiment has been illustrated as required by the patent statutes.

In the drawing:

Fig. 1 is a perspective view of a complete antenna constructed in accordance with the invention.

Fig. 2 is a fragmentary bottom plan view of the same, but illustrating the composite dipole and converted stub.

Figs. 3 and 4 are diagrams used in explaining the theory of operation of the antenna.

Referring now to Fig. 1, the antenna illustrated is a structure which has as its principal active portion, a composite dipole constructed in accordance with the invention, and phased in the novel manner which will be explained. The antenna is designated by the reference character 10, and the parts thereof commencing with the front end are identified as a composite parasitic dipole 12, a high band parasitic director 14, a high band phasing element or dipole 16, the composite dipole element 18, a first low band reflector 20 and a second low band reflector 22.

The elements are mounted in the order named along the boom 24 through the use of suitable clamping devices which either provide an electrical connection with the boom 24 or not as the case may be. Thus, the element 12 is secured to the boom by means of clamping brackets 26, 27 and 28 which provide an electrical connection with the boom, 26 being in front on top, 27 rear bottom, and 28 rear top. The high band director 14 is mounted on a clamping bracket 30 on top of the boom 24 which provides electrical connection therewith. The dipole element 16 is electrically connected to the boom 24 through its top clamping bracket 32 but insulated therefrom by its bottom bracket 34. The composite dipole 18 has its front end electrically connected to the boom 24 by the clamping bracket 36 on top of the boom, but its rear is insulated on the bottom by the bracket 38 and grounded on the top of the boom by the bracket 39. Both of the rear reflectors 20 and 22 are electrically connected to the boom through their clamping brackets 40 and 42.

The exact construction of these brackets is a matter of choice, and the different constructions for providing either electrical or insulating connection with the boom are illustrated and described in said patent.

The elements of the antenna 10 are all mounted generally in a horizontal plane for minimum resistance to the wind and to take advantage of the end-fire principles upon which the improved operation of the antenna is based. The boom 24 is mounted upon a vertical mast 44 by suitable clamping means 46.

The front end of the antenna 10 is provided with the composite director 12 which is the subject matter of a co-pending application, Serial No. 616,710, filed October 18, 1956, and entitled Parasitic Antenna Assemblage. As described in said co-pending application, there is a high band parasitic element 48 having a pair of reverse folded elements 50 mounted on the outboard ends thereof and insulated therefrom by the insulators 52. At the point where the folded elements 50 meet the boom, at the bracket 28, there is a second high band director element 54. Obviously any other type of parasitic director element or elements may be used to replace the element 12.

The functions of the parasitic elements 14, 20 and 22 are all well-known, and hence need not be explained other than to state that the number and lengths of these elements and their spacing can be ascertained by any

suitable procedure common in the construction of multiple element antennas. The antenna designer will draw on his experience and make adjustments and measurements for optimum results.

Referring now to the composite dipole 18, and the phasing element 16, attention is first directed to Figs. 3 and 4 for the explanation of the theory of operation thereof. As explained previously, it was desired to construct an antenna small in size, utilizing the principles of operation of the composite dipole of the Patent 2,772,413. As usual in antennas which have a single-element resonant at one frequency the broad banding problem is serious because of the tendency of the gain to fall off on the adjacent channels by considerable amounts. This difficulty is believed to arise because of the decrease of resistance and increase of reactance for frequencies off the resonant frequency of the element.

The basic composite dipole 18' is shown in Fig. 3 comprising the collinear elements 60, 62 and 64 connected together by insulators 66 and 68. The elements 60 and 64 are the outboard elements. Spaced rearwardly of the element 62 is a fourth element 70 connected to the outboard elements 60 and 64 by diagonal links 72 and 74. The ends of the outboard elements have reverse bent extensions 76 and 78 which have terminals 80 and 82. The dimensions of the basic composite dipole 18' can be not much different from those of any of the composite dipoles of the Patent 2,772,413. The overall length of the antenna dipole 18' electrically would be the projected length of the elements 60, 64 and 70 in a plane perpendicular to the direction of the incident wave. This is approximately three times the length of one of the elements, and hence, the antenna will resonate at one frequency in the television high band and at another in the low band.

For an antenna using a single composite dipole, the logical frequencies would be chosen in the center of the bands, with perhaps some emphasis on the low end of the low band which is normally the weakest end of most single driven dipole antennas.

In an effort to bring up the gain on frequencies other than those to which the composite dipole 18' was resonant, it was discovered that a shorted stub connected to the terminals could be used to increase the resistance and decrease the reactance for frequencies on both sides of that to which the composite dipole 18' was resonant, picking off the desired match along the stub. Thus, in Fig. 3 the shorted stub 84 of conventional configuration was connected across the terminals 80 and 82, having a length L_1 , and the transmission line 86 was connected at a point L_2 from the shorted end. This construction comprises an impedance transformer between the transmission line 86 and the terminals 80 and 82, referred to herein as a "stub transformer" because of the closed end.

Although actual dimensions depend upon the frequencies for which the antenna is to be made resonant, the discussion will perhaps have greater clarity if the dimensions of a successful structure are given. In this case it was desired to have substantially flat gain over all of the channels 2 through 6 in the low band and 7 through 13 in the high band. The composite dipole 18' was thus cut for resonance in channel 4 and channel 10 approximately. When the stub 84 was connected having a length L_1 of 48 inches and a length L_2 of 26 inches, the gain on channels 2 and 3 was increased with very little adverse effect on channels 4, 5 and 6. Thus the desired effect was achieved in a simple manner readily embodied in a practical structure.

It was also desired to increase the gain on the high band, and since the distance L_2 is the proper length for a dipole resonant at a frequency in the high band, this was converted into a high band dipole. The length L_2 for the specific stub being 26 inches, this became a dipole resonant at channel 13. The resulting antenna is shown in Fig. 4. Here the composite dipole is designated 18

since as illustrated it is the electrical equivalent of the dipole of the actual structure illustrated in Figs. 1 and 2. The converted dipole 16 must have its ends short-circuited and hence, it has been formed as a folded dipole, giving better impedance match to a 300 ohm transmission line, and has been disposed in front of the dipole 18 instead of in back, to avoid shielding the high band dipole 16.

The dimension of the high band dipole 16 from the front end of the composite dipole 18 was found to be optimum at a distance somewhat less than the distance ($L_1 - L_2$) which was 22 inches in our example. Because of this, the portion of the stub 84 between the terminals 82 and the take-off point for the transmission line 86 was embodied in parallel strips of metal, termed phasing bars 90 of the proper physical and electrical length of 22 inches and curved and bent to give the desired front to back physical spacing.

The increase in gain on the high band was substantial because of the structure described, being from 1.5 decibels on channel 7 to 3 decibels on channel 13. This is to be expected, since the converted dipole is resonant at channel 13.

In order to have flat response, and bring up the gain of the low end of the high band, such as channels 7 and 9, two elements 92 and 94 were added, collinear with and connected on the outboard ends of element 70 and insulated therefrom by insulators 96 and 98. These elements 92 and 94 are effective to raise the gain of the antenna to render the response substantially flat over the high band. In the commercial structure, the gain on the high band (which included the use of directors normally added for high band operation) was 10 decibels .5 decibel over all channels 7 through 13.

Reference is made to this type of construction in said Patent 2,772,413, and it was pointed out therein that the length of each of the outboard elements was such as to render the same a reflector for a half wave dipole resonant at the low end of the high band, or channel 7. While these dimensions are still used, some effect additional to that with respect to the high band is achieved, because as a result of the addition of the elements 92 and 94, the gain over all of the channels of the low band, that is, from channel 2 through channel 6 was increased.

It is desired to point out that irrespective of the additional parasitic reflectors and directors such as the composite parasitic element 12 and the elements 14, 20 and 22, and even without the phasing stub and its converted dipole 16, the composite dipole as described has pronounced uni-directional characteristics. Treating the elements 92, 62 and 94 as parasitics and therefore making the element 62 slightly shorter than elements 60, 70 and 64, while making the outboard elements 92 and 94 slightly longer results in a pattern having a major lobe in the forward direction much greater than any of the minor lobes of the composite dipole. This is true over the entire spectrum of both television bands, and hence the action of the antenna elements is not readily resolved by theories based simply upon the lengths of the elements. In describing any theories, no limitations are intended.

The form of antenna shown in Fig. 4 has the terminals 80 and 82 spaced from the axis of the collinear elements 92, 70 and 94, the distance ($S_2 - S_1$). In the commercial example which is illustrated in Figs. 1 and 2, there is no such space, the positions of these parts being at a common point along the boom 24 and the distance S_1 and S_2 being the same, designated S in Fig. 2. It is feasible, however, and in certain cases desirable, to have the terminals 80 and 82 spaced rearward of the element 70, a condition which would increase the effective width of the low band portion of the composite dipole, thereby increasing the angle between the reverse folded members 76 and 78 and the elements 60 and 64. The resulting antenna has a lower "Q" but a higher band width. The members 76 and 78 obviously form a low band V-shaped

dipole, the angle of the V being decreased by this expedient.

Various refinements in the commercial structure are of interest. The insulators 66, 68, 96 and 98 are held in position by clamps such as best illustrated at 100 and 102 in Fig. 2. The links 72 and 74 are pivotally secured to such clamps to provide the cross connections between the elements 64 and 70, and the elements 60 and 70. The securement is by rivets as at 104 and bolts with wing nuts as at 106. The links may thus be separated from the ends of element 70 and swung in any direction required for folding the parts of the antenna.

The folding of the parts of an antenna such as 10 and for a dipole such as 18 is taught in said Patent 2,772,413 and hence need not be discussed here. Conveniently those elements which are secured to brackets on the boom are formed in halves, being pivotally mounted on the respective brackets. The members 76 and 78 are secured to the bottom bracket 38 by wing nuts 108 engaging terminals 80 and 82 so that these ends of the members 76 and 78, as well as the ends of phasing bars 90 are readily removable.

The converted dipole 16 is formed of an upper rod element 110 which is electrically connected to metallic bracket 32 by suitable pivotal connections. This enables the element which is in the form of two halves, to be folded on top of the boom 24. The ends of the element rod 110 are joined with the ends of the parallel wire or rod element 112 which has the required electrical discontinuation at its center. The inner ends of the halves of the wire element 112 are formed with eyes or the like and engaged upon suitable terminals of the insulated bracket 34 by wing nuts 116. The phasing bars 90 and transmission line 86 are connected at these terminals.

It is important to emphasize that the stub 84 does not provide an infinite impedance line to suppress the effect of the dipole 16 at any frequencies at which the composite dipole 18 may resonate. Its primary purpose is to improve the response of the composite dipole at low frequencies, and hence the transmission line is connected the distance L_2 from the stub end, this being a distance ($L_1 - L_2$) from the composite dipole terminals. This provides the desired increased resistance and decreased reactance for low band gain increase.

Considerable variation in details, arrangement of the parts, dimensions and the additional directors and reflectors of the structure of the invention, without in any way departing from the spirit or scope as defined in the claims which follow this specification. The specific example which is set forth in detailed dimensions hereinafter, is therefore not intended to limit the scope of the invention. Changes in the frequencies of the present television channels, in the number of channels in each band, in the ranges of the bands, and even the shifting of the bands to other positions of the spectrum either together or separately or relative one another would call for different dimensions than those set forth. The principles and the basic structure of the antenna would be the same, with variations within the skill of antenna engineers. Uses on other than television channels are contemplated by the invention.

For the antenna of Figs. 1 and 2, the pertinent dimensions of the composite dipole 18 and the accompanying converted dipole 16 are set forth hereinafter. The other dimensions may be ascertained from making proportional comparison, with these dimensions. Reflectors and directors are capable of being designed for various forms of the antenna, and hence little need be said about these, except to note that in the particular example, the boom 24 was about 64 inches long and the low band reflectors 20 and 22 were 100 and 110 inches long, respectively. It is thus apparent that the front to rear dimension of the antenna is very short compared to antenns presently known which are capable of comparative gain over both bands.

	Inches
Length of dipole 16.....	26
Length of phasing bars 90.....	22
Length of element 62.....	24½
Length of element 70.....	24¾
Length of elements 92 and 94.....	32
Length of elements 60 and 64.....	25¾
Overall length of composite dipole 18 to the ends of the elements 60 and 64.....	78
Overall length of composite dipole 18 to the ends of the reflectors 92 and 94.....	92¾
Spacing of composite dipole 18, dimension S.....	8
Spacing between terminals 114—115 and the terminals 80—82.....	13

What it is desired to secure by Letters Patent of the United States is:

1. A composite antenna for high frequency signals comprising a plurality of dipole elements all arranged in substantially a horizontal plane, there being three collinear dipole elements and the antenna being highly directive along an axis normal to the collinear dipole elements, a fourth dipole element centered on said axis spaced from and parallel with the middle one of the three collinear dipole elements, the four elements being substantially of the same electrical length, the said middle one of said collinear dipole elements being a director parasitic relative said fourth dipole element and the two outboard collinear dipole elements having their inner ends electrically connected to the ends of the fourth dipole, said antenna being resonant at a high frequency and a low frequency substantially three times said high frequency, and means connected to drive the two outboard collinear dipole elements and the fourth dipole element including a stub transformer having a closed end, connected thereto and a substantially constant impedance line interposed between said driven dipole elements and said closed end at a point providing optimum impedance to said antenna when resonant at said low frequency.

2. An antenna as claimed in claim 1 in which the electrical length of the stub transformer is approximately twice the electrical length of one of said driven dipole elements, and the point of insertion of said transmission line is more than half the length of said stub from said closed end.

3. An antenna as claimed in claim 1 in which there are two additional dipole elements collinear with the fourth dipole element but arranged outboard thereof and each reflector parasitic relative the respective first mentioned outboard collinear dipole elements.

4. An antenna as claimed in claim 1 in which that portion of said transformer between said point and said closed end is a folded dipole element spaced forward of and parallel with the said middle collinear dipole element.

5. A composite broad band antenna having substantially uniform gain over two frequency ranges the approximate center frequency of the lower of which is a whole number multiple of the approximate center frequency of the higher, said antenna being highly directive along a horizontal axis and having a plurality of elements generally arranged in a horizontal plane and the elements being normal to said axis and symmetrically arranged on opposite sides thereof, said elements including three high range dipoles collinearly arranged, a fourth high range dipole spaced from and parallel with the middle of said three dipoles and electrically connected at its outer ends with the inner ends of the outboard two of said three dipoles, the said middle high range dipole being a parasitic director element, a low range dipole element having its outer ends electrically connected with the outer ends of said outboard two high range dipoles and having its inner ends disposed at said axis and forming terminals for driving said outboard, fourth and low

range dipoles, a single matching stub having a closed end and connected to said terminals, and a transmission line connected to said stub between said terminals and said closed end.

6. An antenna as claimed in claim 5 in which that portion of said stub between said closed end and the point at which said transmission line is connected is formed as a folded dipole resonant at a frequency in said higher range.

7. An antenna as claimed in claim 5 in which the stub has an electrical length from said terminals to said closed end of the order of the wave length of a frequency at the high end of said higher range and that portion of said stub between said closed end and the point at which said transmission line is connected is formed as a folded dipole resonant at said frequency at the high end of the higher range.

8. An antenna as claimed in claim 5 in which there are provided fifth and sixth high range dipoles insulated from but collinearly outboard of said fourth high range dipole, and being parasitic reflectors relative said high range.

9. An antenna as claimed in claim 5 in which there are provided fifth and sixth high range dipoles insulated from but collinearly outboard of said fourth high range dipole, and being parasitic elements resonant at a frequency at the low end of said high range.

10. An antenna as claimed in claim 5 in which said low range dipole is V-shaped and said terminals are located at said axis at a point substantially common with the center of said fourth high range dipole.

11. An antenna as claimed in claim 5 in which said low range dipole is V-shaped and said terminals are located at said axis at a point spaced from the position of intersection of said fourth high range dipole with said axis.

12. A composite antenna for high frequency signals adapted for high directivity unilaterally and substantially uniform gain over a higher and a lower band of frequencies, the higher being substantially a whole number multiple of said lower, comprising a metallic boom coaxial with the direction of directivity, a first high band dipole element normal to the boom and in a horizontal

plane and metallically connected with the boom at its center, second and third high band dipole elements arranged outboard of, collinear with, and slightly spaced from the ends of said first high band dipole element, insulating means mechanically connected between each of the outboard elements and said first dipole element, a fourth high band dipole element parallel with the first dipole element in substantially the same horizontal plane, spaced axially therefrom along the boom and having its center metallically connected to said boom, a metal link connected between the each of the outer ends of the fourth dipole element and the inner ends of said outboard elements, a pair of conducting members extending respectively from the outer ends of the dipole elements to the boom at a point spaced axially along the boom from said first high band dipole element, means securing the inner ends of the pair of conducting members to the boom insulated from each other and said boom, a matching stub provided with a closed end and having the end opposite said closed end connected to said inner ends of the pair of conducting members, said matching stub comprising a folded dipole having a pair of parallel rods connected at their ends with the center of one rod metallically connected to said boom at a point spaced forwardly of said first high band dipole element and the other rod open at its center to provide a pair of terminals and parallel phasing bars connected between said pair of terminals and said inner ends of said pair of conducting members, and transmission line means connected to said pair of terminals.

13. A composite antenna as claimed in claim 12 in which there are fifth and sixth high band dipoles arranged collinearly outboard of said fourth dipole element and insulatedly spaced therefrom and acting as parasitic directors for said high band.

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