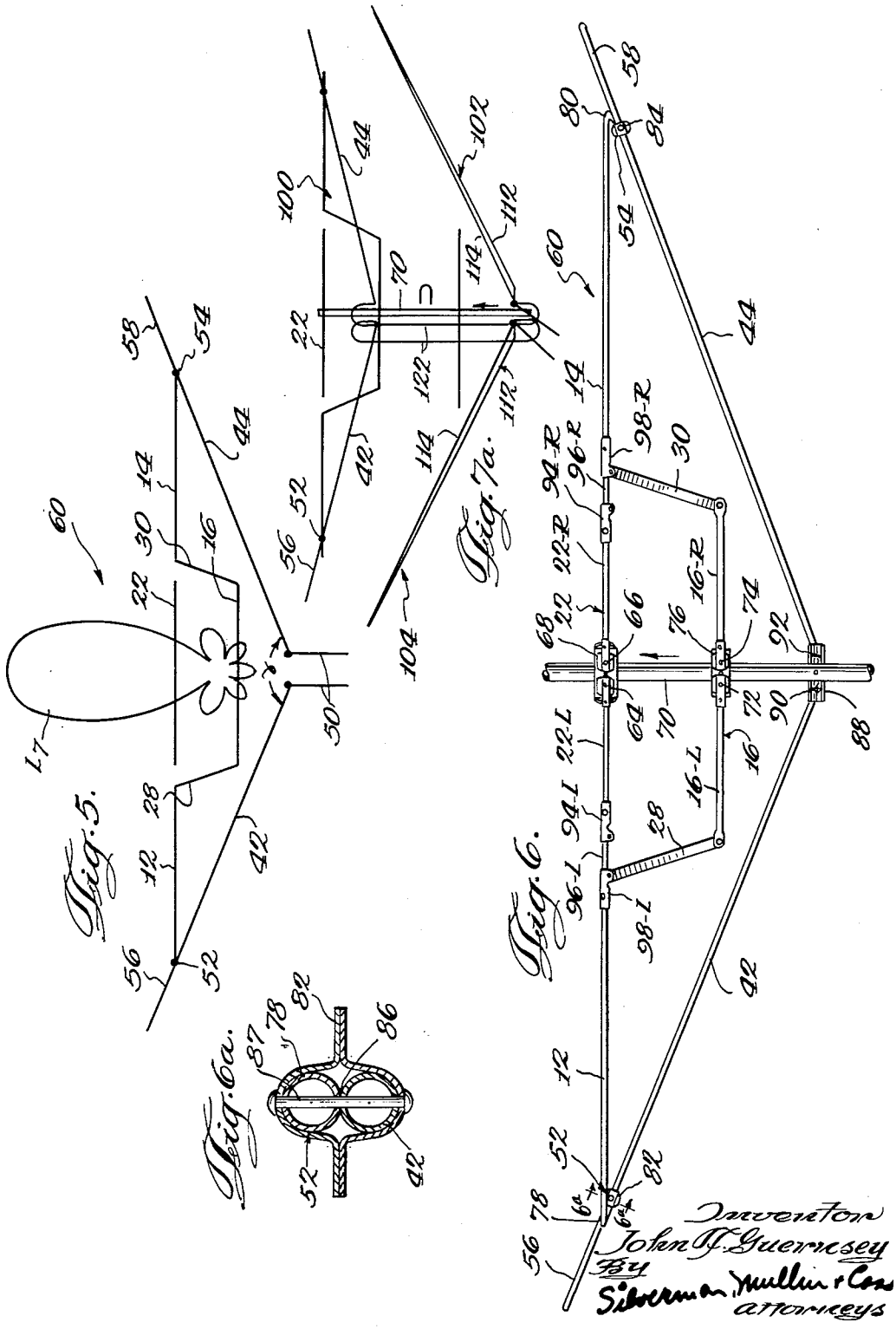
June 6, 1961 J. F. GUERNSEY 2,987,723

HIGH FREQUENCY TELEVISION ANTENNA

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HIGH FREQUENCY TELEVISION ANTENNA

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Fig. 7.

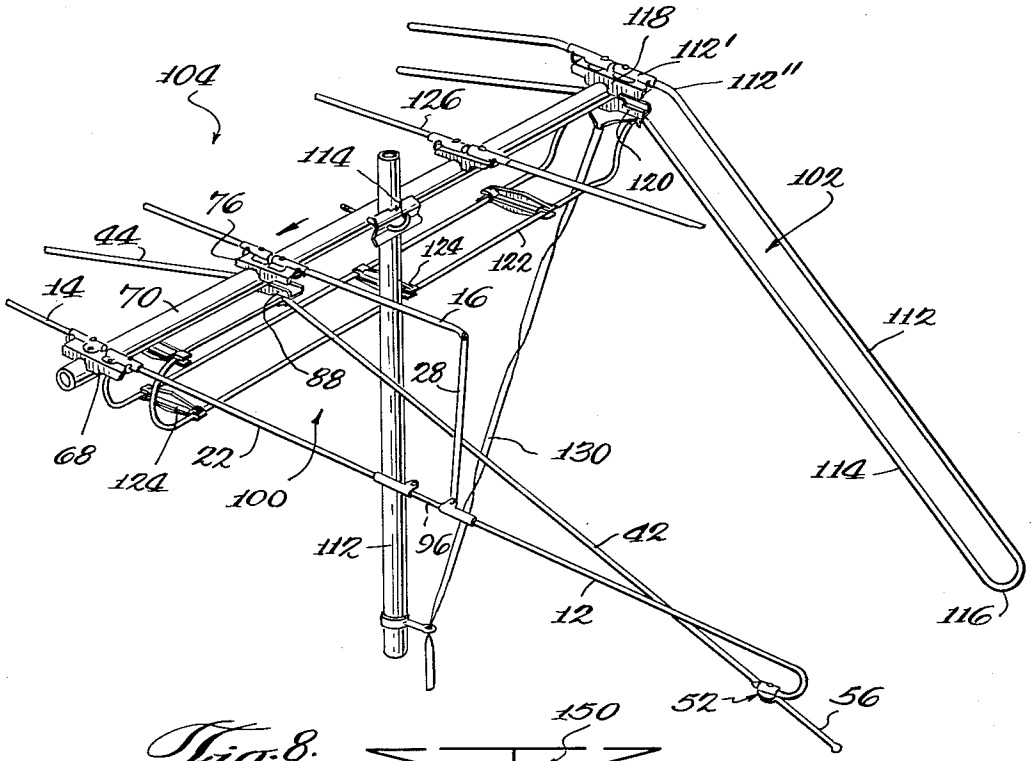
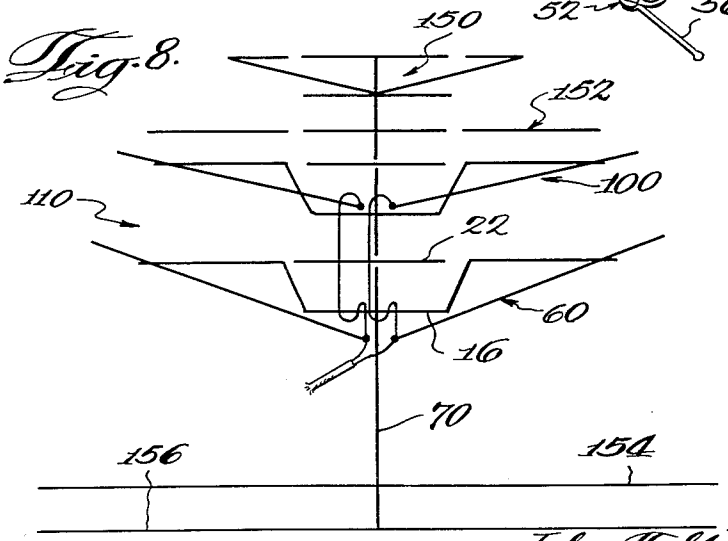


Fig. 8.



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Fig. 1.

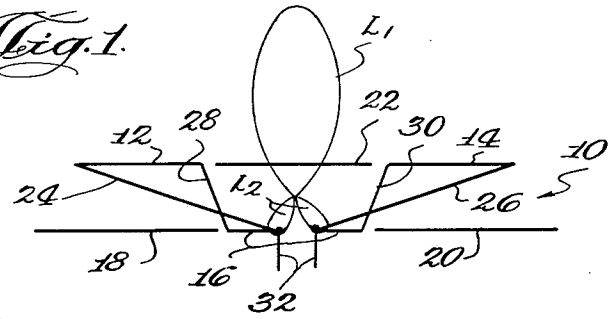


Fig. 2.

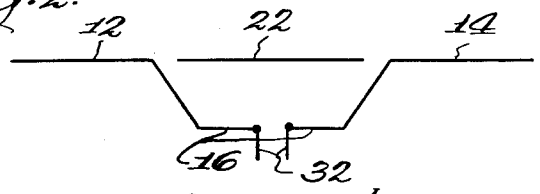


Fig. 3.

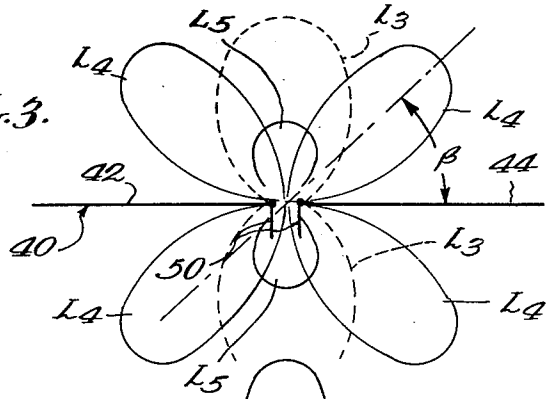
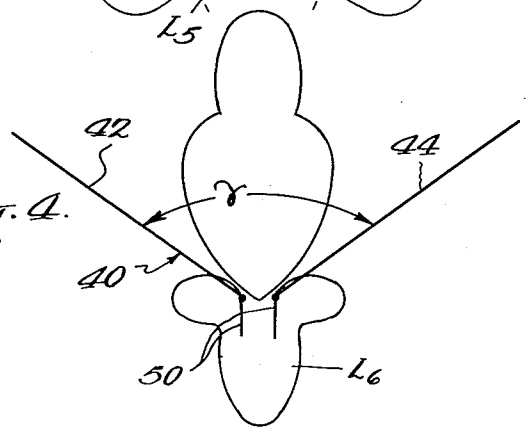


Fig. 4.



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2,987,723

HIGH FREQUENCY TELEVISION ANTENNA

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Filed Feb. 13, 1958, Ser. No. 715,043
22 Claims. (Cl. 343—813)

This invention relates generally to high frequency antennas especially intended for use over the present television frequency spectrum, but the invention is not limited to such frequencies.

The invention herein is specifically directed to improvement of the structures shown and described in U.S. Patent 2,772,413 issued November 27, 1956, to the applicant herein and to Arthur E. Vail and assigned to the assignee of this patent application. In that patent there was described and claimed a composite dipole which was resonant to several frequencies one of which was approximately a whole number multiple or harmonic of the other. The components which formed the composite dipole were arranged in a horizontal plane and advantageous results were achieved through the use of end-fire principles, through the electrical and mechanical connections of said elements, and the parasitic and driven relationships therebetween.

Considerable success was achieved commercially in marketing antennas which were constructed in accordance with the principles of said patent, and this was especially true of multiple arrays of said composite dipoles, arranged along horizontal booms and stagger-tuned, that is to say, arranged to be resonant at different frequencies over the entire spectrum in order to attempt to achieve substantially uniform gain for all frequencies in the high and low television bands. As well-known, these presently comprise a low band formed of channels 2 to 6 inclusive which encompass signals from 54 to 88 megacycles per second, and a high band formed of channels 9 to 13 inclusive which encompass signals from 174 to 216 megacycles per second (hereinafter sometimes designated by the abbreviation "mcs.").

Obviously the principal object of this invention is to provide a substantially improved antenna, not only with respect to the composite dipole, but in addition, with respect to the achievement of improved arrays of driven elements utilizing the improved dipole, the dipole of said U.S. patent, and other driven elements associated with various parasitic elements and phasing means.

There were several reasons why it was believed that the full capabilities of the end fire composite dipole as described in said U.S. patent were not being used. It was found especially that when used by itself, a composite dipole resonant at channel 2, the low end of the low band, did not give the optimum results at the extreme end of the high band, say at channels 11, 12 and 13. The requirements which complicated the likely solution to the problem included:

(*a*) Achieving an impedance as close to 300 ohms as possible.

(*b*) Improving the directivity for the high channels without destroying the gain of the low channels.

(*c*) Retaining the advantages of end-fire characteristics and thus not varying from the basic dimensions and spacing of the high frequency elements determined to be optimum.

(*d*) Arriving at the improved gain, directivity and impedance without providing any complex mechanical structures difficult and expensive to produce and to set up.

(*e*) Evolving a composite dipole which is simple and capable of being readily folded, for storage and shipment.

Obviously an important object of the invention is the

provision of a composite dipole which solves the problem and meets the requirements.

A more specific discussion of the requirements and why meeting them comprised a completely unobvious solution to the problem would be valuable at this point. It will be recalled that this concerns the construction of a composite dipole for use in small antennas, perhaps by itself with several parasitics, or with a second driven element, either of similar structure or slightly different. As will appear hereinafter, the solution was so excellent, that the structure applied to large antennas which use two and three of these new composite dipoles gives greatly improved results over the large antennas described in said patent.

A simple dipole has low impedance, and it requires additional folded-back elements to improve the impedance so that it approaches the 300 ohms of the conventional two wire transmission line in use today. Thus this must be provided. The front to back spacing of the high frequency elements used in an end-fire composite array according to the teachings of the said patent could not be substantially varied without adversely affecting the high frequency response, and when combined with the folded diagonal members, the angle of the diagonal members was limited to a certain amount by virtue of structure requirements. The desire to decrease the angle of the V-shaped configuration meant that structure had to be worked out which would enable the spacing of the high frequency elements to be substantially retained. Furthermore, the low frequency aperture and response had to be preserved. The V-shaped elements were lengthened beyond the overall length of high frequency elements, and a novel connection between the respective ends of the elements was provided.

It will thus be seen that through the retention of the basic structure with folded V-shaped elements, the characteristics of a folded dipole with its 300 ohm resistance were retained; the V-shape configuration enabled the high band directivity to be achieved with improvements also in the low channel response and the angle α of the V was made smaller than deemed possible with the structure of the said patented antenna; through the novel construction, the V-shaped configuration was provided without materially upsetting or changing the front to rear spacing of the high frequency end-fire elements and without changing their overall composite length; and all of this was accomplished in a simple manner and with structure enabling the folding of the antenna.

Objects of the invention comprise the provision of a composite dipole structure using these novel arrangements and achieving the attributes named.

The structure providing for extension of the length of the V-shaped dipole beyond the ends of the effective high frequency end-fire elements is achieved as a specific object of the invention, and also the swivel connection between the halves of the V-shaped dipole and the ends of the end-fire elements is a structure of importance.

Many other objects will occur to those skilled in this art and the advantages will become apparent with the descriptive details of the preferred embodiments which are set forth hereinafter in connection with the drawings.

In the said drawings there are illustrated two forms of the specific dipole of the invention herein as well as several antennas which combine the said dipoles with other driven and parasitic elements but the invention is capable of being embodied in many variants of these dipoles and the antennas illustrated. The drawings also include illustrations in diagrammatic form for explanatory purposes and for demonstrating the theory of operation of the invention, but no limitations are intended thereby.

The same reference numerals are used in different figures to illustrate or designate similar or equivalent elements or structural components.

In said drawings:

FIG. 1 is a diagrammatic top view of a composite dipole antenna constructed according to U.S. Patent No. 2,772,413 showing the general azimuth radiation pattern of gain thereof.

FIG. 2 is a diagrammatic view of the same antenna but showing only the so-called high band elements.

FIG. 3 is a diagrammatic view of a simple dipole antenna element showing the radiation pattern thereof when operated on a harmonic thereof of higher frequency than that for which the element is a half wave antenna.

FIG. 4 is a diagrammatic view of the dipole of FIG. 3 together with its radiation pattern in azimuth in which the antenna has been bent in one direction to form a V configuration.

FIG. 5 is still another diagrammatic representation of an antenna, but this view showing a composite of the elements of FIG. 4 and FIG. 2.

FIG. 6 is a top plan view of a composite dipole antenna assemblage of generally elementary form, that is to say a single composite, constructed in accordance with the invention herein.

FIG. 6*a* is a sectional view along line 6*a*—6*a* of FIG. 6 through a pivotal connection taken in the direction indicated.

FIG. 7 is a fragmentary perspective view of a television antenna in which one of the active or driven elements thereof is constructed in accordance with the invention, but comprises a modified form of the construction shown and described in connection with FIG. 6.

FIG. 7*a* is a diagrammatic representation of the antenna of FIG. 7 to show the general arrangement thereof and the relation of the parts.

FIG. 8 is a diagrammatic representation of another antenna comprising two composite dipoles constructed in accordance with the invention, using one such composite dipole of the form shown in FIG. 6 and one of the form shown in FIG. 7.

Initially the invention will be explained in connection with the diagrams of FIGS. 1 through 5 inclusive. These figures illustrate the antenna elements discussed as simple lines and are to be considered as viewed from above. The mechanical connections of element to element and the fastening means and insulators are for the most part omitted since many forms are possible.

As set forth hereinabove, a principal purpose of this invention is to improve the high frequency harmonic response of the composite dipole shown and described in U.S. Patent 2,772,413 without in any way impairing the low frequency response thereof.

In FIG. 1 there is illustrated the end-fire composite dipole **10** of said U.S. patent, which is formed of three driven elements **12, 14** and **16** resonant at some frequency in the high band of the television spectrum, say, for example, channels **11, 12** or **13**. The dipole is also intended to be resonant at some low band channel such as for example, channel **2**. The range is, of course, the greatest spread possible in the present television spectrum since channel **2**, at the low end of the low band has frequencies from 54 to 60 megacycles per second, while channel **13** at the high end has frequencies from 210 to 216 megacycles per second. The ratio of the high and low channels is certainly not a whole number, which adds to the difficulties of ordinary harmonic operation.

As explained in said U.S. patent, there are also three parasitic elements **18, 20** and **22** provided, and diagonal connecting members **24** and **26**. The elements **12, 22** and **14** are collinear, but not electrically connected. The elements **18, 16** and **20** are also collinear and not electrically connected. Instead, the elements **12** and **16** are connected by a link **28** and the elements **14** and **16** are connected by the link **30**. The inner ends of the halves of the element **16** are grounded to the boom (not shown) and the inner ends of the diagonals are connected to the transmission line **32**.

The usual pattern obtained from this composite dipole **10** operating at some high band frequency was generally as shown, comprising a relatively good forward lobe L_1 with two or more small minor lobes L_2 rearward and laterally. On the low frequencies, however, the gain of the antenna decreased, especially where only a single composite dipole was used for economy. The elements **18** and **20**, not always used, improved the pattern somewhat, but added to the cost.

Thus, in said U.S. patent, several arrangements of composite dipoles were assembled on booms, including one, two and three of the dipoles **10**. Where there are several such dipoles, the loss in gain was not as noticeable as where only one composite dipole was used, because the various dimensions could be easily adjusted for the various composite dipoles to encompass portions of the upper and lower bands of the spectrum. In a composite antenna which has three such assemblages, one was constructed to resonate at channel **6** of the low band and channel **13** of the high band; a second was constructed to resonate at channel **4** of the low band and channel **10** of the high band; and the third was constructed to resonate at channel **2** of the low band and channel **7** of the high band. In these composite dipoles, the ratio of high to low frequencies approached a whole number, giving fairly good results, but still leaving room for considerable improvement.

The dimensions of these composite dipoles could bear study for emphasizing the problem here. The overall length of elements equivalent to **12, 22,** and **14** for best resonance on channel **13** was found to be approximately 66 inches, the distance between the front and rear collinear elements being about 6 inches, and the length of the rear driven element equivalent to element **16** being approximately 21 inches.

On the other hand, the overall length of the elements corresponding to the diagonal elements **24** and **26** for best resonance at channel **2** was found to be about 48.5 inches, each, making the total physical length for channel **2** operation well over 96″. Obviously compromises were made for antennas which could only use one composite dipole, but at best the problem was not satisfactorily solved in every case.

Consider now the end-fire array of FIG. 2. For satisfactory high band operation, the dimensions of the elements **12, 14**, were found to be between 24 and 28 inches in length, emphasizing the more difficult to receive channels—namely those at the upper end of the band. Starting from this point it is necessary to examine the effects of such operation on the low band, especially the lowest end of the low band, such as for example channel **2**. (We omit elements **18** and **20**, since the economical version of the antenna will not include them, and they will not seriously affect the discussion of the theory.)

In FIG. 3 there is illustrated a simple dipole **40** made up of collinear quarter-wave lengths **42** and **44** which is either driven for transmission or exposed to high frequency signals for reception. (Only the latter willl be considered herein, although the electrical effects will be the same on transmission, not usually carried out on multiple frequency antennas.) The radiation pattern for the antenna when operated on a frequency f_1 at which the antenna is an electrical half wave in length is indicated by the two lobes front and rear shown in broken lines designated L_3. This is of course a pattern in a horizontal plane since the pattern is symmetrical about the axis of the dipole **40**, being a toroid, in free space.

This pattern is of course not satisfactory for unidirectional use, but we are not technically concerned with that particular point here. There are techniques for rendering the dipole directional, which include decreas-

ing the angle between the halves of the same, to form V shaped configurations.

Consider now the effect of operating the antenna **40** as resonant for a frequency f_2 which is a multiple harmonic of the frequency f_1, such as for example a third harmonic ($f_2=3f_1$). In this case, the antenna **40** is three dipoles collinearly connected insofar as the higher frequency is concerned, and the resulting radiation pattern, or polar diagram as it is sometimes referred to, is a well-known multiple lobe pattern, symmetrical front and rear. The most outstanding characteristic of the pattern is the existence of predominating lobes L_4 which are at an angle β with respect to the dipole **40**. This angle is of the order of 40° or so. There is usually a plurality of minor lobes symmetrically disposed front and rear, designated by a general lobe L_5 which has very little consequences.

The impedance of a simple dipole such as **40** at the transmission line **50** is of the order of 70 ohms, and when operated on third or fourth harmonic frequencies, the impedance is of the same order. It is desired for best operation that the antenna have an impedance which approaches 300 ohms, the characteristic impedance of most two-wire transmission lines used in television reception, to prevent high VSWR on the line and to decrease losses.

Modifying the antenna of FIG. 3 so that the dipole **40** is in the configuration of a shallow V as shown at **40** in FIG. 4 with the half dipole elements **42** and **44** forming an angle α which approximately approaches twice the angle β results in great improvement. The forward lobes L_4 tend to build up providing a forward pattern similar to that shown at L_5 in FIG. 4. Obviously with sufficient angle α a point can be reached where the lobes of the halves lie on top of one another and the lobe L_5 is more regularly teardrop in shape. The back end pattern comprises a multiplicity of minor lobes which combine to form the general pattern L_6.

Forming the dipole **40** to a V configuration results in the following:

(*a*) While the response pattern of the antenna for the higher channels, such as channel **13**, tends to be improved, the usual increase in impedance for V configurations does not seem to be greatly manifest for the high band channels.

(*b*) The characteristics of the antenna for broad band reception are improved on the channels of the low band, especially in channels **2** to **6**.

(*c*) The optimum angle α for maximum gain and best response pattern for frequencies in the high band was found to be about 100° to 120° for a dipole which was cut for normal resonance at channel **2**.

(*d*) The optimum angle α for maximum gain and best pattern for the high band channels so decreases the physical aperture of the antenna acting on channel **2** (that is, decreases the area subtended normal to the incident wave), that the gain of the antenna for channel **2**, and of course, the other channels of the low band would suffer.

(*e*) An angle α was chosen at approximately 140° which gave best overall performance, gain-wise and pattern-wise for all channels.

The combining of the high band elements of FIG. 2 with the V shaped configuration of FIG. 4 was accomplished (FIG. 5) in a novel manner. The desire for greater length of the diagonal halves of the low band elements **42** and **44** and the lesser angle α resulted in the provision of electrical connections **52** and **54** respectively at the junctions of the outboard ends of the elements **12** and **14** with the diagonal elements **42** and **44**. This gives rise to extended lengths **56** and **58** on the ends of the diagonal elements **42** and **44**. As in the case of the composite dipole **10**, the center of the element **16** is grounded to the boom (not here shown) and the antenna feeds into a transmission line **50** connected across the inner ends of the diagonal elements **42** and **44**.

Note that the spacing between the element **16** and the axis of collinear elements **12**, **14** and **22** may be chosen fairly independent of the physical dimensions of the remainder of the composite dipole. Note also that the overall length of the elements **42** and **44**, including their respective extensions **56** and **58** is readily adjusted without any physical difficulties arising because of the connections **52** and **54**.

The folding problem is solved by means described shortly, but suffice it to say at this point that the connections **52** and **54** are pivotal.

As may be understood from the above description the change of the construction of the composite dipole of the said patent from that shown at **10** in FIG. 1 to that shown at **60** in FIG. 5 was a great improvement because of the advantages achieved. It was discovered, however, that the advantages are even better than contemplated by the combination of FIGS. 2 and 4. The radiation pattern was vastly improved on the high band channels, as shown at L_7 in FIG. 5. The back lobes decreased considerably. Gain on channels **11**, **12** and **13** was improved by as much as 2db, on the 140° angle dipole using lengths resonant at channel **2** of the low band. The impedance of the antenna on the high band channels was also increased.

None of the changes made had the effect of impairing the ability of the antenna to receive channel **2**, which is a considerable achievement in view of the usual effects of modifications made to low band antennas in attempting to make them resonant also to high band channels.

FIG. 6 illustrates a preferred manner of building a practical version of the antenna element described. The antenna is substantially the same as that of FIG. 5, and hence will be designated **60**. The element **22** is exemplified in a pair of half elements **22**–L and **22**–R each pivotally mounted at its inner end at **64** and **66** respectively, to a metallic bracket **68** suitably fastened to the boom **70**. Likewise, element **16** is formed of halves **16**–L and **16**–R (left and right) pivotally secured at their inner ends at pivots **72** and **74** respectively also upon a metallic bracket **76** which is mounted to the boom **70**.

The outboard elements **12** and **14** have their outer ends return bent in bends **78** and **80** respectively, which are generally arranged in a vertical plane, each extending downwardly and engaging in the upper swivel half **82** and **84** of the pivot junctions **52** and **54** respectively. In FIG. 6*a* the pivotal connection **52** is illustrated and it will be seen that the bottom swivel half **86** is secured to the left hand end of the diagonal element **42**. The extension **56** is beyond the pivotal connection **52**. A pin **87** passes through all of the connected members and defines the swivel axis.

The inner ends of the elements **42** and **44** are mounted to a bracket **88** which is insulated from the boom **70**. The said inner ends are usually flattened and pierced, in a well-known technique, and engaged to said bracket at **90** and **92** respectively by means of some fasteners such as thumb screws, so that the leads from a transmission line may be connected thereto. Also, in disassembly, the element **42** and **44** may be disconnected from the bracket **88** to enable folding of the composite dipole **60**.

The outer ends of the members **22**–L and **22**–R are provided with sleeve clamps **94**–L and **94**–R, short insulating rods **96**–L and **96**–R effectively connecting the member **22** to the ends of the members **12** and **14** respectively by similar sleeve clamps **98**–L and **98**–R. The links **28** and **30** are pivotally connected between the clamps **98**–L or **98**–R and the ends of the members **16**–L and **16**–R, respectively.

It will be appreciated that the structure of the composite dipole **60** provides substantial improvement over the composite dipoles of the patent above referred to through several features, which, both combined and individually result in improvements which were not obvious

from the original study of the dipole **10**, for example, and the problems which it was desired to solve. The placement of the apex of the flat triangle defined by the elements **42**, **44**, **12**, **22** and **14** a substantial distance rearward (considering the maximum gain direction as the forward or front end of the composite dipole) is important. It enables the angle α to be decreased substantially, without greatly affecting the gain on the low end. The provision of the extensions **56** and **58** gave the benefits of low band reception without materially detracting from the high band reception which required the end-fire elements to be substantially shorter than the combined lengths of the low band dipole.

Obviously, the ability to be able to fold such an antenna is a consideration for storage and transportation, and hence the use of the swivels or pivotal connections **52** and **54** contributed to the making of the antenna practical, because of its foldability.

The principles of the described composite dipole **60** are applicable in a variety of ways, and it was discovered that the use of structures of this kind on assemblages of composite dipoles resulted in great improvement over the assemblages of said Patent 2,772,413, which used more than one composite dipole. In other words, although the problem which it was desired to solve was originally intended to cover a composite dipole which was to be used by itself in an antenna assemblage, the results discovered through the solution of this problem were found admirably suited to the use of the structure for improving antenna assemblages using two or more driven composite dipoles. The benefits were also applicable to antennas which used one or more driven dipoles of the composite structure of this invention, and one or more driven dipoles of other structures. For example, one commercial structure with which great success has been achieved, is an antenna assemblage which uses a composite dipole of a modified form together with a folded dipole that is bent in a V configuration. This is illustrated in FIGS. 7 and 7*a*.

As to those antennas which use multiple composite dipoles, the adjustments for improved gain directivity over the entire television spectrum can be made using the principles of this invention with less stringent requirements. The spectrum is not to be covered in one composite antenna, but is divided between two, three or even more such dipoles. FIG. 8 illustrates one such structure using two composite dipoles.

Referring now to FIG. 7, the principles of the invention are applied to an assemblage of two driven dipoles, **100** and **102** to form an antenna **104** of the so-called end-fire type. The forward composite dipole **100** is constructed substantially like that of FIGS. 5 and 6 with one important exception. The angle α of the dipole **100** is much greater than the same angle of the dipole **60** and hence the spacing between the apex of the triangle and the intersection of the element **16** with the boom **70** is much less. Economically, the boom has both the brackets **76** and **88** of dipole **100** secured at the same point, by the same rivets or bolts. An increase in this distance over that of the dipole **10** will improve the antenna characteristics because of the decreased angle α without damage to the response of the high band elements. In the composite dipole **60** as used in a practical antenna **110** in FIG. 8, the distance between the element **22** and element **16** was increased from 6 inches of dipole **10** to 8 inches. The distance from element **16** to the apex of the triangle (center of bracket **88** of FIG. 6) was 6 inches. In the composite dipole **100** of FIGS. 7 and 7*a* the distance between elements **22** and **16** was chosen at 8 inches. Other antennas have been constructed in which the distance from element **16** to the apex of the triangle is more than 6 inches, and obviously, considerable latitude is feasible in this as well as other dimensions.

The composite dipole **100** of antenna **104** is formed of the same elements as those of composite dipole **60** and hence the same characters of reference are applied. Note that the directional aspects of FIGS. 7 and 6 are reversed so that the forward direction for each antenna is represented by the large arrow alongside the respective booms **70**. The brackets **76** and **88** are mounted at the same position on the boom **70** which in turn is clamped to a mast **112** by the usual U-bolt and clamp arrangement shown at **114**.

The back end of the antenna **104** has a folded dipole **102** which is formed of upper elements **112** and lower elements **114** connected at their outer ends by reverse bends **116**. The elements are arranged in a V configuration for improved directivity and gain on the low band. The inner ends of the elements **112** are pivotally mounted to the metallic bracket **118** which is secured to the boom. The inner ends of the elements **114** are pivotally mounted to the insulating bracket **120** which is also mounted to the boom at the same place. An open wire transmission line **122** is connected between the inner terminals of the elements **114** and the inner terminals of the elements **42** and **44**, being provided along its length with suitable insulating spacers **124**. The length of the transmission line is chosen to properly phase the dipoles **102** and **100** to enable their response to receive signals to reenforce one another, hence the transmission line **122** comprises a phasing harness.

The signal produced by the antenna **104** is remarkably good over both bands of the television spectrum, only one parasitic director **126** being used to reenforce the response on the high band. The V configuration folded dipole **102** on the back end of the antenna makes the antenna highly uni-directional, gives improved low frequency gain, renders the antenna compact and easy to set up, provides good impedance match, and when combined with the composite dipole **100** takes care of the compromises which are dictated in the construction of said dipole **100** economically.

Spacing between driven composite dipoles of the antennas described herein to achieve the desired end-fire operation is $.1\lambda_1$ to $.3\lambda_2$, where λ_1 is the center wave length of the low band and λ_3 the center wave length of the high band.

In order to enable those skilled in the art to appreciate that the antenna **104** is a remarkably small antenna to be effective for fringe area reception, dimensions of a commercial version are set forth hereinafter:

The total length of the boom **70**	31 inches.
Elements **112**, **114** (Each half prior to forming)	100⅞ inches.
Element **126** (overall)	26 inches.
Element **16**	21 inches.
Element **22**	23½ inches.
Elements **12** and **14** (each)	23½ inches.
Insulators **96**	2 inches.
Elements **42** and **44** (each)	41 inches.
Distance bracket **118** to element **126**	9 inches.
Distance element **126** to bracket **76**	11 inches.
Distance bracket **76** to bracket **68**	8 inches.
Approximate end extension of boom	1½ inches.
Total length of transmission line **122** before forming	39⅞₁₆ inches.
Dipole **100** resonant at	70 mc. and 200–215 mc.
Dipole **102** resonant at	55 mc. and 180 mc.
Angle α for dipole **100**	Approx. 155°.

The angle α for the folded dipole **102** is approximately 135° to take advantage of the effect of forming the **V**. In order to achieve strength in the dipole **102** each upper

element **112** has a short straight portion **112'** at its inner end which cooperates with spring locking structure of the bracket **118** to firmly affix these inner ends. The spring locking structure of the bracket **118** is described in detail in said Patent 2,772,413. The angle is then achieved by the slight bend at **112''**. The lower element **114** has each inner end flattened and pierced to be engaged upon studs provided on bracket **120** and held in place with the terminals of the phasing harness **122** and the transmission lead-in line **130** by means of washers and thumb nuts.

The upper and lower elements of the folded dipole **102** are not in a perfectly vertical plane, although substantially so. This, however, instead of being detrimental, is believed to broaden the response of the rear end of the antenna, a characteristic greatly desired in the reception of color television. As shown in FIG. 7*a*, in top view the elements **112** and **114** diverge slightly from their ends inward, because of the structure described. This provides substantial strength for the element **102**, as stated above, and yet enables the element to be folded alongside of the boom, by disconnecting the inner ends of the parts **114** and then pivoting the entire dipole about the connection with bracket **118**.

The antenna **110** is shown in FIG. 8 only diagrammatically, but its construction should be readily perceived. The front end of the antenna is provided with a suitable director **150** which is of the construction shown and described in my copending application Serial No. 695,480 filed November 6, 1957 and entitled "Parasitic Antenna Assemblage," now U.S. Patent 2,864,084.

The boom **70** of the antenna is substantially longer than the boom of the antenna **104** and greater gain and directivity are possible with this antenna. Furthermore two of the composite dipoles are used, along with several parasitics. The element immediately behind the front end director **150** comprises a three element high band collinear director **152** with the individual element connected mechanically, but not electrically. The center element is of course mounted on a bracket (not shown) similar to bracket **68** of FIG. 7, and hence is metallically connected to the boom.

The next rearward element of the antenna **110** is a driven composite dipole whose construction is practically identical to that of the composite dipole **100**. In actual practice, the dimensions of the two are almost identical, except for the length of the diagonal elements **42** and **44**. In the antenna **110** these elements are a fraction of an inch shorter than the same elements of antenna **104**.

The next rearward element of the antenna **110** is a driven composite dipole which is substantially identical in construction to the dipole **60** of FIGS. 5 and 6. Note the spacing between the element **16** and the apex of the triangle formed by elements **42, 44, 12, 22** and **14**.

The two rear elements of the antenna are designated **154** and **156** and these are low band reflectors.

The antenna **110** gives greater gain, band width, and directivity than an antenna constructed with the composite dipoles **10** of FIG. 1, and this is especially true on the channels of the high band.

The practical example of the antenna **110** was constructed with the following dimensions:

Overall length of boom **70**	(Approx.) 80 inches.
Dimensons of director **150**	49 inches long, 6 inches along boom.
Distance between director **150** and element **152**	6 inches.
Overall length of element **152**	73 inches.
Individual elements	23 inches.
Distance between element **152** and composite dipole **100**	5 inches.
Composite dipole **100**	Same as previously described dipole **100**, with very slight variations.
Distance between dipole **100** and dipole **60**	8 inches.

Dipole **60**:

Elements **12, 14**	26 inches.
Elements **16, 22**	24 inches.
Elements **42, 44**	49⅛ inches.
Extended ends **56, 58**	9 1/16 inches.
Angle α	Approximately 140°.
Distance **16** to **22**	8 inches.
Distance **16** to apex	6 inches.
Distance apex of dipole **60** to the reflector **154**	22 inches.
Both reflectors **154** and **156**	110 inches.
Distance between reflectors	8 inches.
Phasing harness, length before forming	33 inches.
Dipole **60** resonant at	54–58 mc. and 180 mc.

There can be no question that an antenna which is required to receive all channels over the both bands of the television spectrum of frequencies must involve compromises, depending upon the extent to which the antenna is resonant to the channels to be received. With this invention, it is believed that the minimum of compromise is required in antennas which have only one of two driven composite elements. It follows that applying the principles of the invention to an antenna which uses three or four driven composite dipoles, it is practical to stagger tune the antenna for channels along the bands closely separated. The broad-banding character of the antenna will thus result in a frequency response, gain, and directivity which is substantially uniform for all channels. Such antennas have been constructed and successfully tested.

Attention is especially invited to the frequency characteristics of the dipole elements **60** and **102**. Note that the practical examples of dipole **100** had a high frequency range of almost 15 megacycles which is remarkably broad. The practical example of dipole **60** had a low frequency resonant range of about 4 megacycles. These resonant conditions are those at which for all practical purposes the gain is practically constant, and the effect is that for frequencies on either side of the resonant ranges, the gain drops off much less rapidly than in the case of ordinary driven elements. It is therefore possible to build antennas having unusually broad frequency characteristics without the need for a great number of driven elements and modifying parasitic elements.

The impedance of the driven dipoles in the antennas described was improved over the usual dipole to provide close matches to the usual 300 ohm transmission line almost universally used for the lead-in wire with present television antennas.

It is believed that those skilled in the art will understand the invention fully and realize that the structures illustrated are only preferred embodiments capable of wide variation. It is also desired to point out that the invention is primarily directed to the reception of television signals, and hence, structures which are described herein are resonant in the high frequency ranges of the present television spectrum. The principles of the invention, however, are applicable to other than the specific frequencies used for television in the United States today. Through dimensional modification the principles may be applied to high frequency antennas operating in both lower and higher bands for multiple frequency reception. Conceivably the antenna could be used for transmission of multiple frequencies as well, but obviously it is not a usual practice to use this type of multiple resonant antenna for transmission of high frequency signals.

I claim:

1. A broad band composite dipole especially for the reception of television signals and resonant at two fre-

quencies one of which is approximately an odd multiple of the second frequency comprising: at least four horizontally arranged short dipole elements each of a length resonant at the first frequency, three of the elements being collinear and mechanically connected, the fourth element being spaced from the middle short element in a horizontal plane therewith and having its ends electrically connected with the inner ends of the outboard pair of said collinear elements, the middle short element being parasitic, a pair of members forming a V-shaped dipole having a center connection with a transmission line and arranged in a V having its apex spaced rearward of the said middle short element and having a length rendering same resonant generally at said second frequency, the outer ends of said outboard pair having a metallic connection respectively adjacent the outer ends of said pair of members and there being a substantial length of each of said pair of members extending outward of said metallic connection.

2. A structure as claimed in claim 1 in which said composite dipole is mounted on a horizontal boom arranged in the center of said composite dipole, the middle short element and the parasitic element are divided in their centers and pivotally connected to said boom, the center of the pair of members forming said V-shaped dipole are removably and insulatedly secured to said boom, and the said metallic connections are pivotal.

3. A structure as claimed in claim 1 in which the angle of said V is approximately 100° to 155°.

4. A structure as claimed in claim 1 in which the angle of said V is approximately 140°.

5. A structure as claimed in claim 1 in which the angle of said V is substantially less than approximately 155° and the apex of said V is spaced rearwardly of said fourth short dipole element.

6. A broad band composite dipole mounted on a horizontal boom arranged in the direction of maximum directivity of said antenna and comprising: four short dipole elements resonant generally to the same frequency mounted on the boom with three arranged collinearly and mechanically connected end to end with the center one metallically secured to the boom and the fourth short dipole element in a horizontal plane and spaced rearwardly from the center short dipole element, but electrically connected with the outboard pair of short dipole elements, a long V-shaped dipole element resonant to a frequency which is approximately one-third the frequency of said short dipole elements, the inner ends of the halves of the V-shaped dipole element being mechanically mounted on said boom spaced a substantial distance rearward of the said fourth short dipole element, but insulated from said boom, and the outer ends of the outer pair of said collinear short dipole elements metallically connected therewith.

7. A composite dipole as claimed in claim 6 in which the said one and fourth short dipole elements are connected to one side of the said boom and the said inner ends of said V-shaped dipole are mounted on the opposite side of said boom.

8. A composite dipole as claimed in claim 6 in which the said one and fourth short dipole elements are connected to one side of the said boom and the said inner ends of said V-shaped dipole are mounted on the opposite side of said boom, and the said outer ends have relatively short return bends and said metallic connections are provided by said bends engaging with said V-shaped dipole in a plane slightly vertically spaced from and substantially parallel with said first mentioned horizontal plane.

9. A composite dipole as claimed in claim 6 in which the angle of said V-shaped dipole is substantially less than approximately 155°.

10. A composite dipole as claimed in claim 6 in which the angle of said V-shaped dipole is approximately 140°.

11. A broad band composite dipole mounted on a horizontal boom arranged in the direction of maximum directivity of said antenna and comprising: four short dipole elements resonant generally to the same frequency mounted on the boom with three arranged collinearly and mechanically connected end to end with the center one metallically secured to the boom and the fourth short dipole element in a horizontal plane and spaced rearwardly from the center short dipole element, but electrically connected with the outboard pair of short dipole elements, a long V-shaped dipole element resonant to a frequency which is approximately one-third the frequency of said short dipole elements, the inner ends of the halves of the V-shaped dipole element being mechanically mounted on said boom spaced a substantial distance rearward of the said fourth short dipole element, but insulated from said boom, and the outer ends of the outer pair of said collinear short dipole elements metallically connected therewith at points spaced substantially inward of the free ends of said halves of said V-shaped dipole.

12. A substantially uni-directional antenna array which is formed of two dipole assemblages, each assemblage being arranged in substantially the same horizontal level and being spaced from one another for substantially end-fire operation, a common metallic boom defining the direction of maximum directivity of the said array with the first assemblage mounted at the forward end of said boom considering the direction of maximum directivity as forward, and the second assemblage being mounted at the opposite end thereof at the rear end of said boom, considering said rear end as pointed opposite the direction of maximum directivity, said first assemblage comprising a first dipole element mounted at its center on the boom and metallically connected thereat, and having second and third collinear dipole elements respectively insulatedly connected at the ends of the first dipole element and being mechanically supported therefrom and forming outboard elements of a collinear grouping, a fourth dipole element spaced rearwardly from said first dipole element and parallel therewith and metallically connected at its center to said boom, a metallic connection between the outer ends of the said fourth dipole element and the respective inner ends of the outboard elements, and a pair of rigid conductor elements arranged in a V-shaped configuration having their inner ends forming the apex of said configuration and mounted upon said boom but insulated therefrom and from one another at a point spaced rearward of said first element with the configuration diverging forward and the outer ends of said outboard elements metallically connected with said conductor elements, said second dipole assemblage comprising a folded dipole arranged in V-shaped configuration diverging forward from the end of said boom and spaced from said first assembly by a maximum distance along said boom of .1 the wavelength of the low band, each leg of the V being formed in a substantially U-shaped configuration whose legs lie in a different vertical plane, and are supported by said boom whereby said V-shaped configuration is stabilized in a predetermined plane with respect to the first assemblage, phasing means connected between said folded dipole and the inner ends of said pair of rigid conductors and means for connecting transmission line means to said phasing means to drive said assemblages.

13. An antenna array as claimed in claim 12 in which said four dipole elements are each resonant at approximately a first frequency, said pair of rigid conductors is resonant at approximately a second frequency which is substantially one-third said first frequency, and said folded dipole is resonant at approximately a third and a fourth frequency which have a substantially three to one relation and said third and fourth frequencies being somewhat less than said first and second frequencies respectively.

14. An antenna array as claimed in claim 12 in which there is a parasitic element mounted to said boom between said assemblages.

15. An antenna array as claimed in claim 12 in which said outer ends of said outboard elements are connected to said conductor elements at points thereon spaced substantially inward of the ends of said respective conductor elements, whereby the effective electrical length of said pair of rigid conductors is substantially greater than three times the length of any one of said collinear dipole elements.

16. In an antenna array of the character described, which includes a boom having antenna elements thereon, a low band folded dipole at the rear end of said boom and on one side thereof and comprising, a bracket mounted on said boom having a pair of oppositely extending rods secured thereto in metallic connection, each rod having a short section normal to the boom and a forwardly bent elongate section integral therewith arranged at an acute angle to the boom, a second bracket mounted on the opposite side of the boom at said rear end and having a second pair of rods insulatedly secured thereto, said second pair of rods extending outwardly and forwardly from said boom each making an acute angle relative to the boom slightly different from said first mentioned acute angle, and the rod ends being joined in reverse bends with a respective one of said elongate sections whereby to form together a folded V-shaped dipole with the planes defined by the respective halves of said dipole meeting along a line which extends downward and forward of said end of said boom, said dipole serving as a reflector for the high band.

17. A structure as claimed in claim 16 in which the first pair of rods has its inner ends independently pivotally mounted on said first bracket, and said second pair of rods has its inner ends removably mounted on said second bracket, whereby upon removal of said inner ends of the second pair of rods, the halves of said folded dipole can be collapsed substantially parallel with said boom.

18. A broad-band substantially uni-directional antenna array which is formed of at least two dipole assemblages, each assemblage being arranged on the same level and being spaced from one another for reenforcing operation at signals of two high frequency bands one of which is generally three times the frequency of the other, a common metallic boom defining the direction of maximum directivity of said array, and each assemblage being mounted on said boom transverse thereof and each comprising, four dipole elements each resonant at a frequency of said high band, the first of said four dipole elements being parasitic and being metallically connected at its center to said boom and having the second and third dipole elements connected mechanically outboard of said first element but insulated therefrom, the fourth dipole element being connected also at its center metallically with said boom and parallel with and spaced rearwardly of said first element and having its ends electrically connected to the inner ends of said second and third dipole elements, and a fifth element resonant generally at a frequency of said low band and comprising a substantially V-shaped dipole having its apex spaced rearwardly of said first dipole element and its ends extending toward the ends of said second and third dipole elements, engaging the same and extending substantially outward thereof, transmission line means connecting said dipole assemblages for phased operation, and one assemblage being of dimensions slightly greater than the other.

19. An antenna array as claimed in claim 18 in which at least one of said dipole assemblages has its said apex spaced rearward of said fourth dipole element and the angle of said V-shaped dipole is between 100° and 150°.

20. An antenna array as claimed in claim 18 in which at least one of said dipole assemblages has an angle of approximately 140° formed by its V-shaped dipole.

21. A broad band composite dipole especially for the reception of television signals and resonant at two frequencies one of which is approximately an odd multiple of the second frequency comprising: at least four horizontally arranged short dipole elements each of a length resonant at the first frequency, three of the elements being collinear and mechanically connected, the three collinear elements comprising a pair of outboard elements and a middle short element, the fourth element being spaced from the middle short element in a horizontal plane therewith and having its ends electrically connected with the inner ends of the outboard pair of said collinear elements, the middle short element being parasitic, a pair of members forming a V-shaped dipole having a center connection with a transmission line and arranged in a V having its apex spaced rearward of the middle short element and having a length rendering same resonant generally at said second frequency, the outer ends of said outboard pair having a metallic connection respectively adjacent the outer ends of said pair of members and there being a substantial length of each of said pair of members, extending outward of said respective connection, each of said free ends of said outboard pair of short elements being return bent upon itself and engaging said V-shaped dipole at a point vertically spaced from the said horizontal plane, whereby the plane of said V-shaped dipole is slightly spaced from and substantially parallel with said horizontal plane, but effectively as though in the same plane therewith.

22. A broad band composite dipole especially for the reception of television signals and resonant at two frequencies, one of which is approximately an odd multiple of the second frequency comprising: at least four horizontally arranged short dipole elements each of a length resonant at the first frequency, three of the elements being collinear and mechanically connected, the three collinear elements comprising a pair of outboard elements and a middle short element, the fourth element being spaced from the middle short element in a horizontal plane therewith and having its ends electrically connected with the inner ends of the outboard pair of said collinear elements, the middle short element being parasitic, a pair of members forming a V-shaped dipole having a center connection with a transmission line and arranged in a V having its apex spaced rearward of the middle short element and having a length rendering same resonant generally at said second frequency, the outer ends of said outboard pair having a metallic connection respectively adjacent the outer ends of said pair of members and there being a substantial length of each of said pair of members extending outward of said respective connection, each of said free ends of said outboard pair of short elements being return bent upon itself and engaging said V-shaped dipole at a point vertically spaced from and substantially parallel with said horizontal plane, but effectively as though in the same plane therewith, each of said metallic connections being pivotal, there being a pin and a pair of engaged swivel members at each connection, the pin passing through the pair of swivel members and each swivel member having a crimp saddling one of the respective elements and members joined by said connections.

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