United States Patent

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[45] Patented **Nov. 2, 1971**

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[54] **PLURAL ANTENNAS WITH IMPEDANCE MATCHING TO COUPLE TO SINGLE LEADIN**
10 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **343/727,** 343/792.5, 343/814
[51] **Int. Cl.** **H01q 21/00**
[50] **Field of Search** 343/724, 726, 730, 792.5, 810, 812, 814, 815, 727

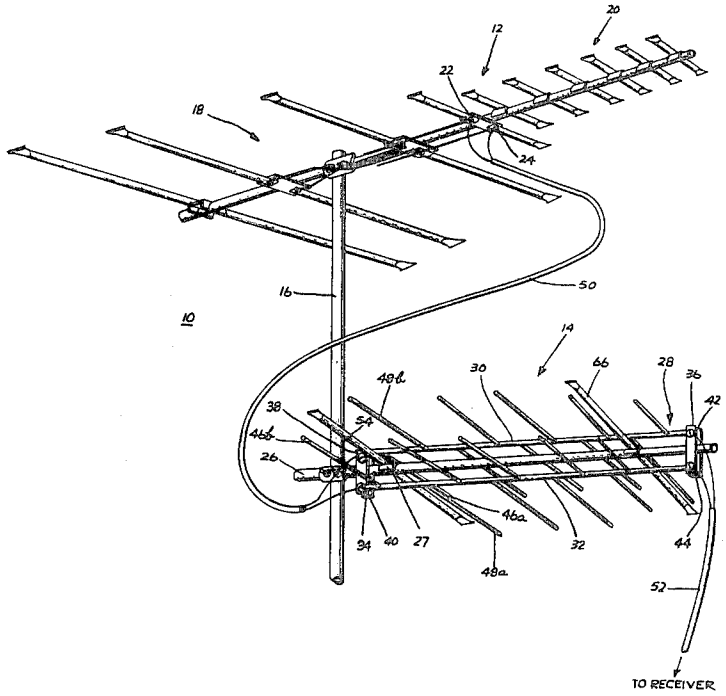
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ABSTRACT: An antenna array including a narrow band antenna tuned to a particular frequency and a transmission line type broadband antenna having a frequency response range which includes the frequency of the narrowband antenna. The transmission line of the broadband antenna is serially coupled between the narrowband antenna and reception apparatus. A parasitic element of a predetermined length is positioned at a predetermined point along the transmission line of the broadband antenna and serves to peak the frequency of the narrowband antenna thereby to pass signals from the narrowband antenna to the reception apparatus with minimum attenuation.



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SHEET 1 OF 2

FIG. 1

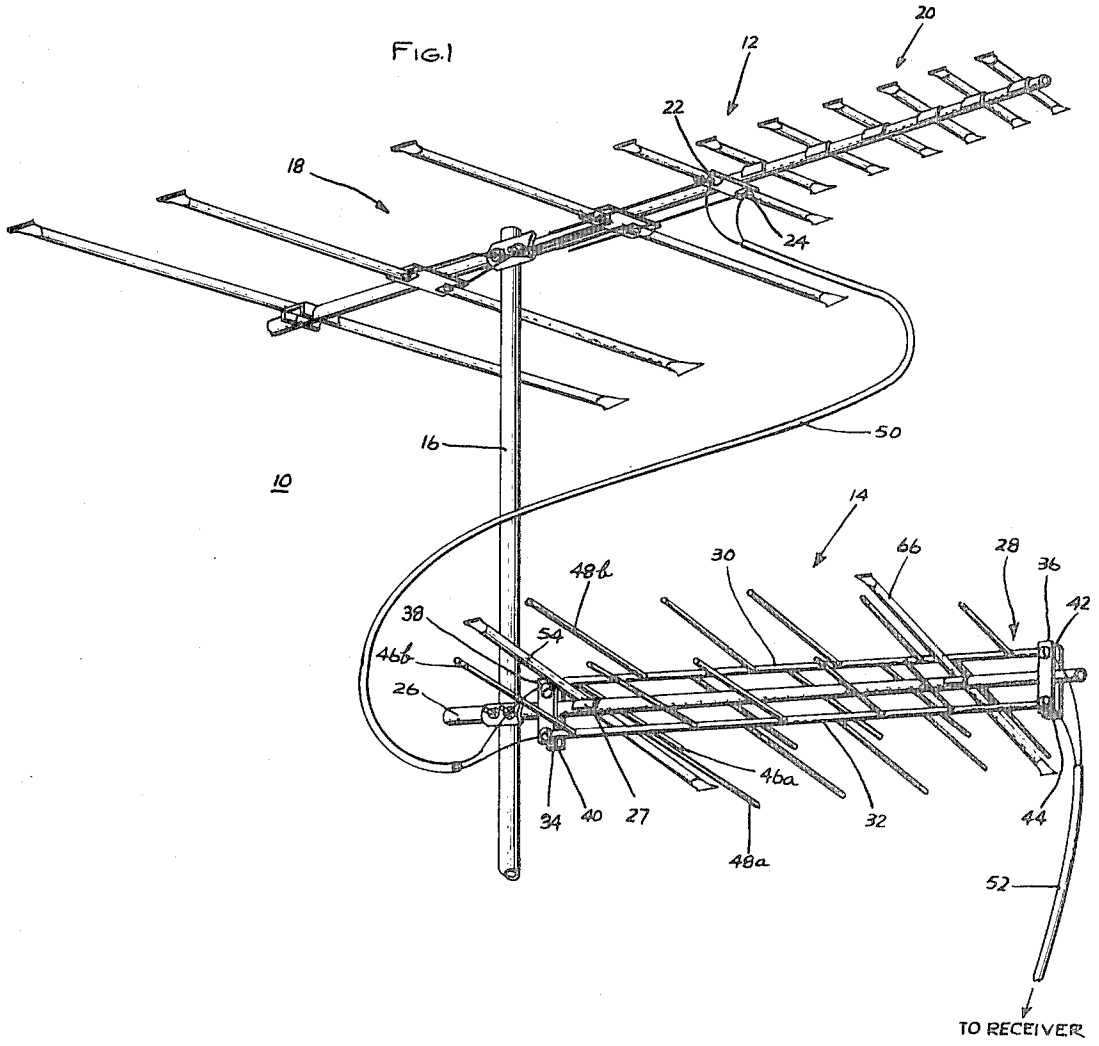
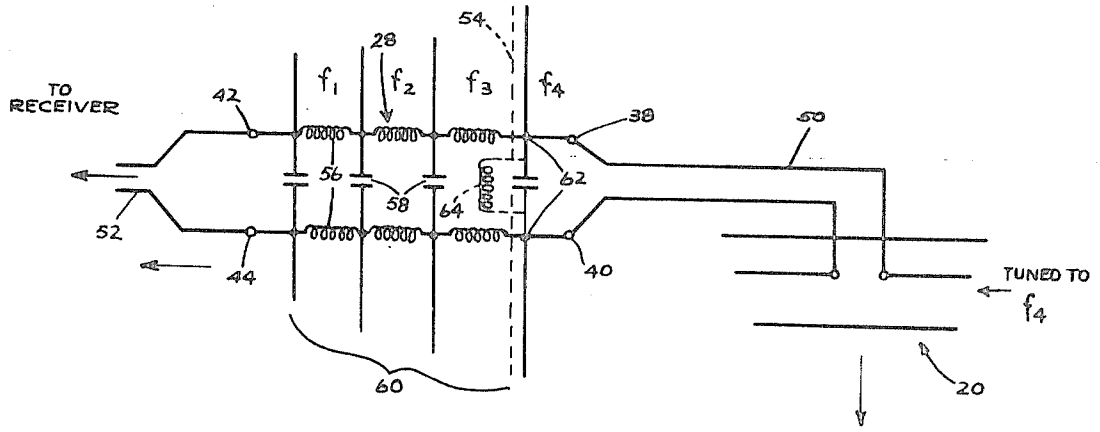


FIG. 4



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FIG. 2

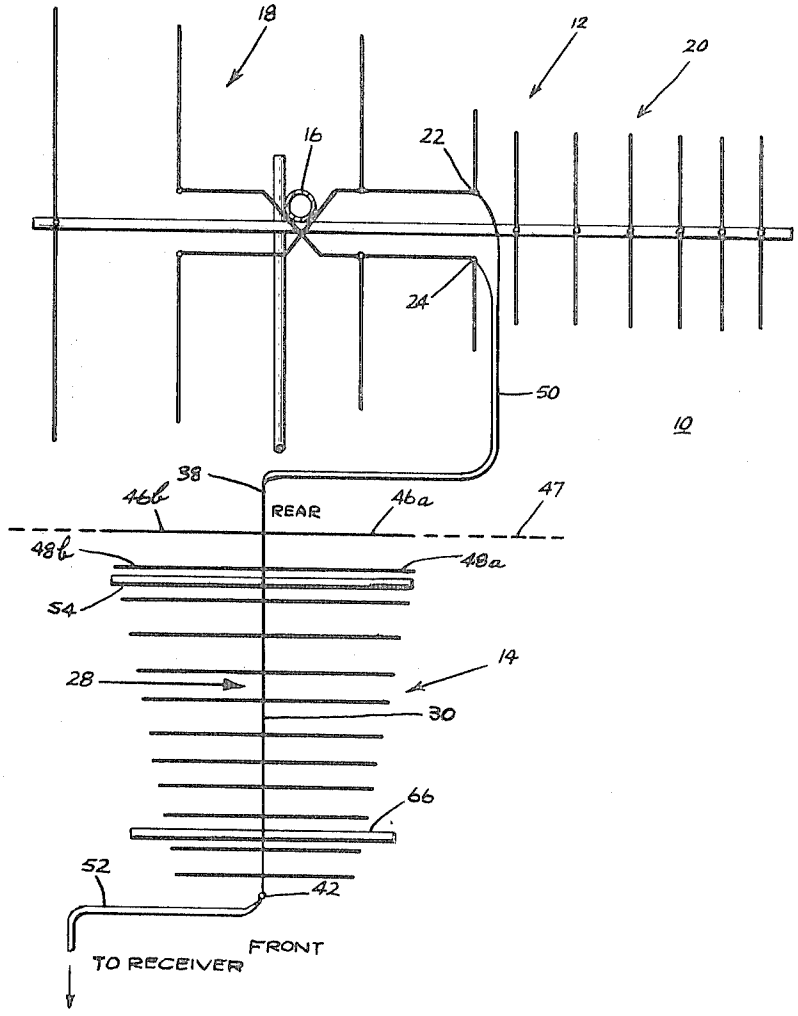
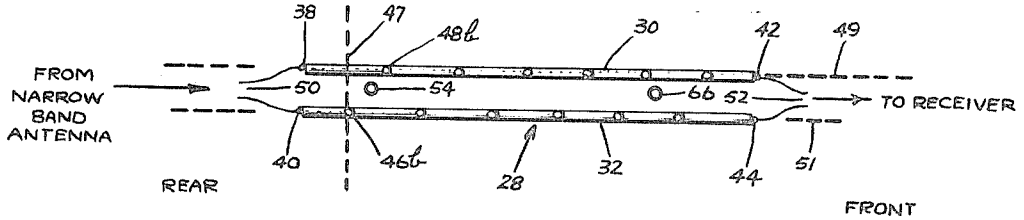


FIG. 3



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PLURAL ANTENNAS WITH IMPEDANCE MATCHING TO COUPLE TO SINGLE LEADIN

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to antenna arrays of the type employed for television reception, and more particularly to an array including a broadband antenna of the transmission line type.

2. Description of the Prior Art

In instances wherein it is desired to receive television transmissions from two widely separated transmitters, it has been common practice, particularly in the case of UHF reception, to employ two separate antennas mounted on the same mast, one of the antennas being directed to receive the transmission from one station and the other being directed to receive the transmission from the other station. In order to avoid impedance mismatching problems, and also so that a single transmission line can be employed for coupling the antenna array to the television receiver, it is known to employ an impedance-matching network mounted on the mast adjacent the two antennas with the two antennas being coupled thereto and a single transmission line then extending from the impedance-matching network on the mast to the television receiver. Such impedance-matching networks not only add appreciably to the overall cost of the antenna installation, but, further, they are tailored to the two particular frequencies involved.

Coupling between antennas for the purpose of having one down lead can also be accomplished by a critical length of transmission line between the two antennas with the feed to the reception apparatus taken at the terminals of one or the other antennas, or at some place on the transmission line between the terminals. This technique is often implemented in practice by the use of stiff wire delay lines attached to one or the other or both the antennas, with or without a crossover (180° phase shift) and in conjunction with open or closed-in stubs across either or each of the coupled antennas. These arrangements always introduce losses, mostly the result of mismatching (which in broadband antennas must always be a compromise between the signal frequency most desired and allowed VSWR) which deteriorate the signal from one or both of the antennas involved.

Narrowband, unidirectional antennas, such as the Yagi-type, are well known. Broadband, unidirectional antennas of the transmission line type are also well known. In such broadband antennas a two-conductor transmission line-type feeder is employed with a plurality of pairs of dipole elements at spaced intervals therealong, one element of each pair being connected to one conductor of the feeder and the other element of each pair being connected to the other conductor. In the so-called split boom-type antenna, the two conductors of the feeder are disposed in spaced, parallel relationship, thus forming the transmission line, with the dipole elements which are connected to one conductor alternately extending outwardly from opposite sides thereof, the dipole elements which are connected to the other conductor likewise alternately extending outwardly from opposite sides thereof.

It has been proposed to employ a transmission line-type antenna in a two-antenna array with the transmission line thereof serially coupling the other antenna to the receiver. However, if the other antenna is of the narrowband type and the frequency to which it is tuned is within the frequency response range of the broadband, transmission line-type antenna, it has been found that the signal from the narrowband antenna is seriously attenuated.

It may further be desirable in certain instances to tune or peak the frequency response of a broadband, transmission line-type antenna at a particular frequency within its frequency response range.

SUMMARY OF THE INVENTION

The invention in its broader aspects provides a broadband antenna including a transmission line with a plurality of spaced antenna elements coupled thereto. A parasitic element is provided located in the field between predetermined ones of the antenna elements and having a predetermined length thereby to tune the transmission line to pass signals of a predetermined frequency with minimum attenuation. Such a transmission line-type antenna may be coupled in series between reception apparatus and a narrow-band antenna tuned to a frequency within the frequency response range of the broadband antenna. The parasitic element associated with the transmission line of the broadband antenna has a predetermined length and location so that the transmission line passes signals from the narrowband antenna to the reception apparatus with minimum attenuation.

It is accordingly an object of the present invention to provide an improved broadband antenna of the transmission line type.

Another object of the invention is to provide a tuning and peaking system for a broadband antenna of the transmission line type.

A further object of the invention is to provide an improved two-antenna array, one of the antennas being of the transmission line type and being serially coupled between the reception apparatus and the other antenna.

The above-mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will be best understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view in perspective showing a two-antenna array incorporating the invention;

FIG. 2 is a top, somewhat schematic, view of the antenna array of FIG. 1;

FIG. 3 is a side view of the broadband, transmission line-type antenna employed in the array of FIGS. 1 and 2; and

FIG. 4 is a schematic diagram showing an equivalent circuit useful in explaining a theory of operation of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIGS. 1, 2 and 3 of the drawings, it being understood that the drawings are not to scale, there is shown an antenna array 10 comprising first and second antennas 12 and 14 mounted on a common mast 16. The upper antenna 12 is a common form of VHF-UHF antenna comprising a modified Yagi, broadband, VHF antenna 18 with UHF Yagi antenna 20 having its terminals 22, 24 at its rear end coupled to the frond end of VHF antenna 18. VHF antenna 18 and the narrowband, unidirectional UHF antenna 20, and their combination as shown, are conventional, it being understood that other conventional types of narrowband UHF antennas may be employed in the top antenna 12, either alone or in combination with a conventional form of VHF antenna.

Lower antenna 14 is shown as being of the broadband, transmission line, split boom type. Antenna 14 is mounted on boom 26 supported on mast 16. Antenna 14 includes a two-conductor transmission line-type feeder 28 comprising first and second elongated conductors 30 and 32 secured to horizontal boom 26 by transverse, elongated insulator supports 34, 36 and extending in spaced, parallel relationship on opposite sides of boom 26, conductors 30 and 32 defining a first vertical plane which includes boom 26. Transmission line conductors 30 and 32 respectively have rear terminal ends 38, 40 and front terminal ends 42, 44 secured to the insulator supports 34 and 36, respectively.

A plurality of pairs of progressively shorter dipole elements are provided at progressively shorter spaced intervals between the rear end and front end of feeder or transmission line 28, one element of each pair being connected to one conductor 30 and the other element of each pair being connected to the other conductor 32. Thus elements 46*a* and 46*b* which com-

prise the longest pair of dipole elements are respectively connected to conductors **30**, **32** and respectively extend outwardly therefrom in opposite directions. Similarly, elements **48***a* and **48***b* which comprise the next shorter pair of dipole elements are respectively connected to conductors **30**, **32** and respectively extend outwardly therefrom in opposite direction. Thus, each pair of dipole elements, such as **46***a*, **46***b*, lie in a common vertical plane perpendicular to the vertical plane of conductors **30**, **32**, as shown by the dashed lines **47** in FIGS. **2** and **3**.

It will be seen with reference to FIG. **2** that the dipole elements, such as **47***a* and **48***b*, which are connected to the top conductor **30**, alternately extend outwardly from opposite sides thereof. Similarly, the dipole elements, such as elements **46***b* and **48***a*, which are connected to the bottom conductor **32**, alternately extend outwardly from opposite sides thereof. Further, it will be seen with reference to FIG. **3** that the dipole elements, such as elements **46***a* and **48***b*, which are connected to the upper conductor **30**, lie in a common horizontal plane, indicated by the dashed line **49**, which includes conductor **30**, which is parallel with the axis of boom **26**, and which is perpendicular to the vertical plane defined by conductors **30** and **32**, and boom **26**. Similarly, it will be seen that the dipole elements, such as elements **46***b* and **48***a*, which are connected to the bottom conductor **32**, lie in common horizontal plane, indicated by the dashed line **51**, which includes the bottom conductor **32**, that plane being in spaced, parallel relationship with the plane **49** of the top dipole elements **46***a*, **48***b*, the boom **26** lying between these two horizontal dipole element planes. It will be understood that the dipole elements need not project outwardly from the respective conductors **30**, **32** perpendicularly thereto, but may be inclined forwardly toward the front end of the antenna **14**. Further, the dipole elements need not be straight, as shown but may have the distal ends bent therein, as is well known to those skilled in the art.

Terminals **22**, **24** of the top antenna **12** are serially coupled to the rear terminal ends **38**, **40** of transmission line **28** by a conventional 300-ohm line **50**. Front terminal ends **42**, **44** of transmission line **28** are serially coupled to the reception apparatus (not shown) by another conventional 300-ohm line **52**, or a matching transformer or balun may be connected to terminals **42**, **44** so that a coaxial transmission line may be used as a down lead to the reception apparatus. It will thus be seen that transmission line **28** of the broadband antenna **14** is serially coupled between the antenna **12**, and particularly the narrowband UHF antenna **20**, and the reception apparatus, transmission line **28** thus passing the signal from narrowband antenna **20** to the receiver. It will be understood that the narrowband UHF antenna **20** is tuned to a frequency within the frequency response range of the broadband UHF antenna **14**.

As previously indicated, it was found that with the array as thus far described, the signal from the upper narrowband UHF antenna **20** was seriously attenuated at the receiver, and the applicant's theory as to the reason for such attenuation is set forth below.

It has been found that such attenuation of the signal from the upper antenna **20** by the transmission line **28** can be eliminated by tuning the lower antenna **14** to the frequency of the upper antenna **20** with a barlike conductor or parasitic element **54** in the field of the transmission line **28**. This results in severe signal attenuation of the antenna **14** at the frequency of antenna **20**. Parasitic element **54** is supported at its midpoint and adjustably conductively secured on boom **26** by means of a bracket **27** for selective adjustment therealong between the rear and forward ends of transmission line **28**, thereby to position parasitic element **54** in the area of antenna **14** which responds to the frequency of antenna **20**. The length of the parasitic element **54** is also dependent upon the frequency of the signal to be enhanced, parasitic element **54** being longer when it is positioned toward the rear or lower frequency end of antenna **14** and shorter when it is positioned toward the forward or higher frequency end. It is not necessary to calculate the length of parasitic element **54** in advance since the basic element can be provided having a proper length for enhancement of the lowest frequency in the range of response of antenna **14**, and elements **54** can then be selectively cut to a shorter length to provide optimum signal enhancement after its approximate location along boom **26** has been determined. Precise final optimizing of the signal from antenna **12** is accomplished by a further slight adjustment along boom **26**. Thus, at the actual site of installation of the array **10**, with antenna **20** properly aimed toward the transmitting station and the receiver tuned to that frequency, parasitic element **54** may then be moved from the rear end toward the front end of transmission line **28** until the received signal is peaked, and the length of the parasitic element can be reduced by cutting small increments off the ends thereof until the received signal is still further peaked.

It will be observed that the parasitic element **54** is electrically isolated from conductors **30** and **32** of transmission line **28**, element **54** being disposed between conductors **30**, **32** and lying in a horizontal plane spaced between and parallel with the planes **49**, **51** of the upper and lower dipole elements, element **54** extending outwardly equal distances on opposite sides of the vertical plane defined by conductors **30**, **32** and being perpendicular thereto in the illustrated embodiment. While parasitic element **54** is shown as being formed as a unitary, straight metal rod, it will be understood that it may comprise two collinear elements connected together by means of an insulator. Further, if the dipole elements have a configuration other than that shown, i.e., such as being inclined forwardly, parasitic element **54** may either be straight, as shown, or have a configuration corresponding to that of the dipole elements.

Referring now to FIG. **4** of the drawings, it is the applicant's theory that the presence of the parasitic element **54** functions to optimize the coupling between the antenna **20** and the receiver by increasing the impedance between the two conductors **30** and **32** of transmission line **28** at the critical frequency of antenna **20**. In FIG. **4**, transmission line **28** is shown in its equivalent circuit form as comprising series inductances **56** and shunt capacitors **58**. Here, four dipole elements **60** are shown respectively tuned to frequencies f_1, f_2, f_3 and f_4. Assuming now that the narrowband antenna **20** shown as having a conventional Yagi configuration is tuned to the frequency f_4, it appears that the impedance of transmission line **28** between points **62**, to which the dipole is connected, is low, thus in essence short circuiting the signal from antenna **20**. By inserting the parasitic element **54** in the vicinity of points **62** and the dipole element f_4, and by selecting the length of the parasitic element **54** so that it resonates at the frequency f_4 of antenna **20** and dipole f_4, parasitic element **54** may be regarded as a tank circuit **64** operating at the resonate frequency f_4, the theoretical impedance of this tank circuit thus being infinity. Thus, the applicant believes that by positioning parasitic element **54** adjacent the dipole element f_4 and cutting it to the proper length, the impedance of transmission line **28** between points **62** is raised to infinity, the signal frequency f_4 of antenna **20** thereby being passed to the receiver with minimum attenuation.

It may be desirable to peak the broadband antenna **14** at an additional, different frequency. This may readily be accomplished by providing another parasitic element **66** having a suitable length at the proper location between conductors **30** and **32** of transmission line **28**, the applicant believing that in this instance the additional parasitic element **66** acts either as a director or a reflector, depending upon the active dipole elements of antenna **14** with which it is associated.

It will be readily understood that the upper VHF-UHF antenna assembly **12** and the lower broadband UHF antenna **14** may be oriented in different directions as clearly seen in FIG. **2**. It will further be readily understood that the upper VHF antenna **18** may be eliminated, leaving only the narrowband UHF antenna **20** and the broadband UHF antenna **14**. Further, a conventional VHF antenna may additionally be supported on the lower boom **26** with its front end connected

to the rear terminal ends 38, 40 of transmission line 28 of the broadband UHF antenna 14.

While the invention has been above-described in connection with the reception of television signals, it will be readily understood that the invention is not limited to reception applications, and it is equally applicable to transmitting applications. In a specific embodiment of the invention, broadband antenna UHF 14 was designed to receive the frequency range from channel 14 to channel 83. Conductors 30, 32 were each 20¾ths inches long and spaced apart by 2½ inches. Eleven pair of dipole elements 46*a* and 46*b*, 48*a* and 48*b*, et seq. were provided, respectively having the following lengths and spacing from the rear to the front end of the antenna:

	Length	Spacing
(46*a*, 46*b*)	6¼	1¼ (from rear terminal ends 38,40)
(48*a*, 48*b*)	5½	4¼ (from 46*a*, 46*b*)
	5⅛	7¼
	4¾	9½
	4¼	11¾
	4	13¾
	3⅝	15½
	3⅜	16¾
	3¼	17¾
	3⅛	18½
	3	19

With the narrowband UHF antenna 20 cut for channel 17, parasitic element 54 was 12 inches long and located 8¾ths inches from rear terminal ends 38, 40. In order, additionally to peak UHF antenna 14 for channel 28, parasitic element 66 was 10 inches long and located 17¾ths inches from rear terminal ends 38, 40.

While the two conductors 30 and 32 are disclosed as being parallel, it is to be understood that this is a special case and that the conductors may diverge or converge from the feed terminals 42 and 44 without departing from the spirit and scope of this invention.

While there have been described above the principles of this invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation of the scope of the invention.

What is claimed is:

1. An antenna array comprising an antenna having an elongated two-conductor transmission line-type feeder, said antenna being of the split boom type with said two conductors being in spaced, parallel relationship and lying in a first plane, a plurality of pairs of dipole elements at spaced intervals along said feeder, one element of each pair being connected to one conductor of said feeder and the other element of each pair being connected to the other conductor, and a parasitic element electrically isolated from said feeder and extending transversely thereto, said parasitic element being disposed between said conductors and intersecting said first plane at right angles, said parasitic element further having a predetermined length and position along said feeder in the field thereof so as to peak the frequency response of said antenna at a predetermined frequency.

2. The array of claim 1 wherein the dipole elements connected to said one conductor alternately extend outwardly from opposite sides thereof and lie in a second plane, the dipole elements connected to said other conductor alternately extending outwardly from opposite sides thereof and lying in a third plane, said second and third planes being in spaced, parallel relationship with said parasitic element therebetween and parallel thereto, said parasitic element extending outwardly on either side of said first plane.

3. The array of claim 1 wherein said antenna is of the broadband, unidirectional type, said pairs of dipole elements being of progressively shorter length.

4. The array of claim 1 wherein said two conductors of said feeder have first and second terminal ends, and further comprising a second antenna having a frequency response within the range of said first-named antenna, a transmission line serially coupling said second antenna to said first terminal ends, said second terminal ends being adapted to be serially coupled to reception apparatus, said two conductors of said feeder forming a transmission line in series between said first-named transmission line and said reception apparatus.

5. The array of claim 4 wherein said first-named antenna is of the broadband type, said second antenna being of the narrow band type tuned to a frequency within the frequency range of said first antenna, the length and position of said parasitic element being selected to tune said feeder to the frequency to which said second antenna is tuned whereby said feeder passes signals from said second antenna to said reception apparatus with minimum attenuation.

6. The system of claim 5 further comprising a second parasitic element electrically isolated from said feeder and extending transversely thereto, said second parasitic element having a predetermined length and position along said feeder so as additionally to peak the frequency response of said first antenna at a second predetermined frequency.

7. The array of claim 5 wherein said first antenna is of the unidirectional type, said pairs of dipole elements being of progressively shorter length from said first and to said second terminal ends.

8. The array of claim 7 wherein said first antenna is of the split boom type with said two conductors being in spaced, parallel relationship and lying in a first plane, said parasitic element being disposed between said conductors and lying in a second plane normal to said first plane and parallel with said conductors, said parasitic element extending outwardly on either side of said first plane, the dipole elements connected to said one conductor alternately extending outwardly from opposite sides thereof and lying in a third plane, the dipole elements connected to said other conductor alternately extending outwardly from opposite sides thereof and lying in a fourth plane, said third and fourth planes being in spaced, parallel relationship with said second plane therebetween, said parasitic element extending outwardly on either side of said first plane.

9. The array of claim 8 further comprising a second parasitic element electrically isolated from said feeder and extending transversely thereto, said second parasitic element being disposed between said conductors and lying in said second plane, said second parasitic element extending outwardly on either side of said fist plane, said second parasitic element having a predetermined length and position along sad feeder so as additionally to peak the frequency response of said first antenna at a second predetermined frequency.

10. A broadband antenna comprising a transmission line having front and rear terminal ends and a plurality of spaced antenna elements coupled thereto, and a parasitic element located in the field between predetermined ones of said antenna elements and having a predetermined length thereby to tune said transmission line to pass signals of a predetermined frequency from said front to said rear terminal ends with minimum attenuation, a narrow band antenna coupled in a series with said transmission line of said broadband antenna and tuned to a frequency within the range of said broadband antenna, said transmission line being adapted to be serially coupled to reception apparatus, said predetermined frequency being the frequency of said narrow band antenna whereby said transmission line passes signals of said predetermined frequency with minimum attenuation.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,618,103 Dated November 2, 1971

Inventor(s) Robert S. Ringland

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

IN THE SPECIFICATIONS

Column 3, Line 12, change "47a" to ---46a---
Column 3, Line 25, before "common" insert ---a---
Column 4, Line 3, change "elements" to ---element---

IN THE CLAIMS

Claim 9, Column 6, Line 50, change "fist" to ---first---
Claim 9, Column 6, Line 51, change "sad" to ---said---
Claim 10, Column 6, Line 61, after "in" delete "a"

Signed and sealed this 20th day of June 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

FORM PO-1050 (10-69)

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