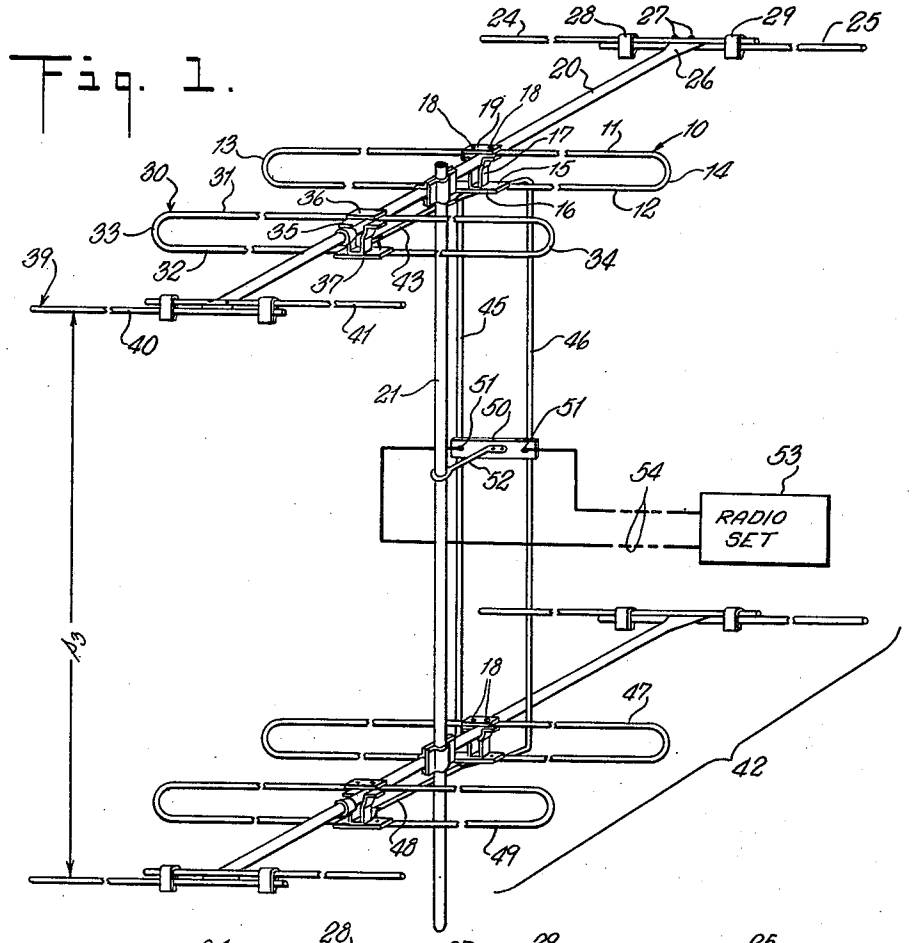
May 27, 1952 K. H. LIPPITT 2,598,005

HIGH-GAIN DIRECTIONALIZED ANTENNA

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Fig. 1.



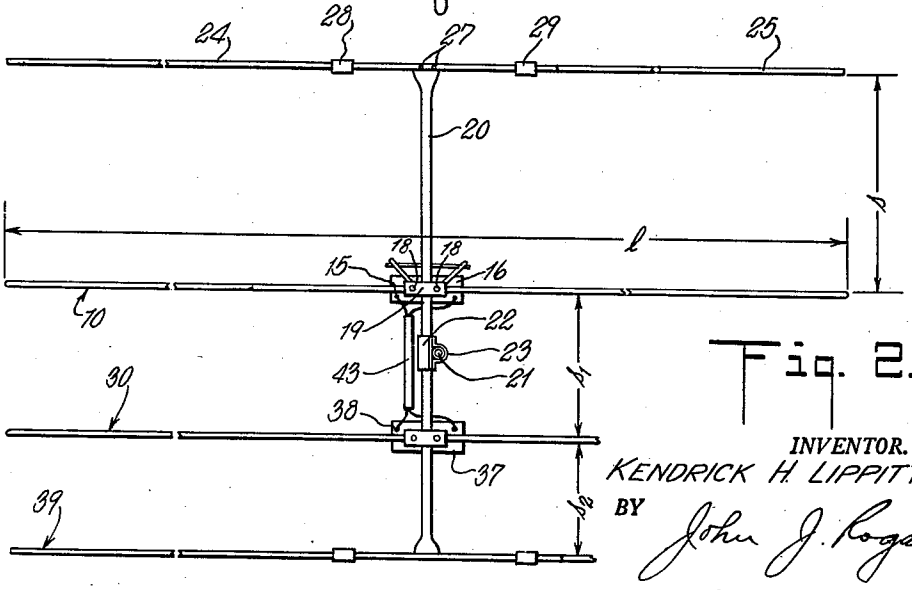


Fig. 2.

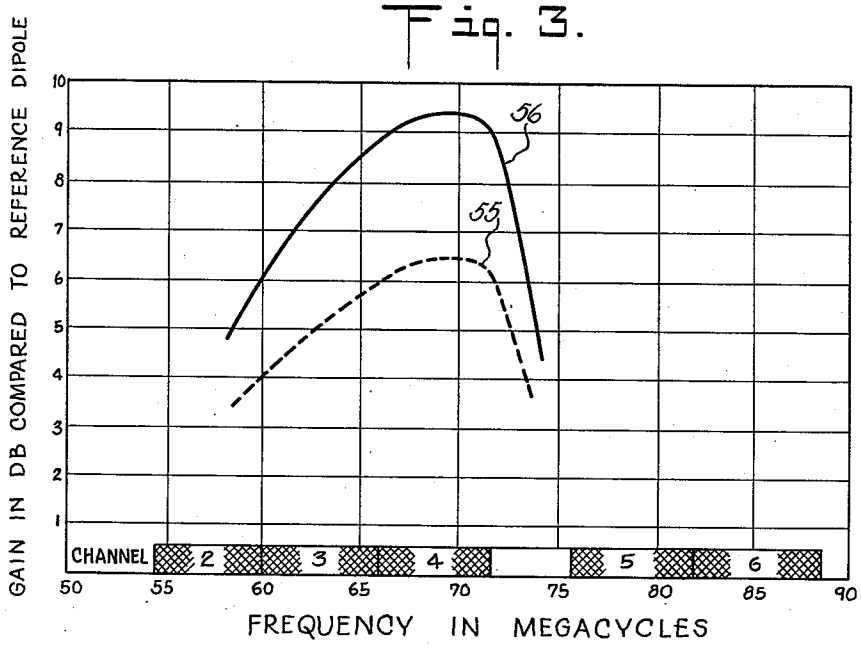
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Fig. 3.



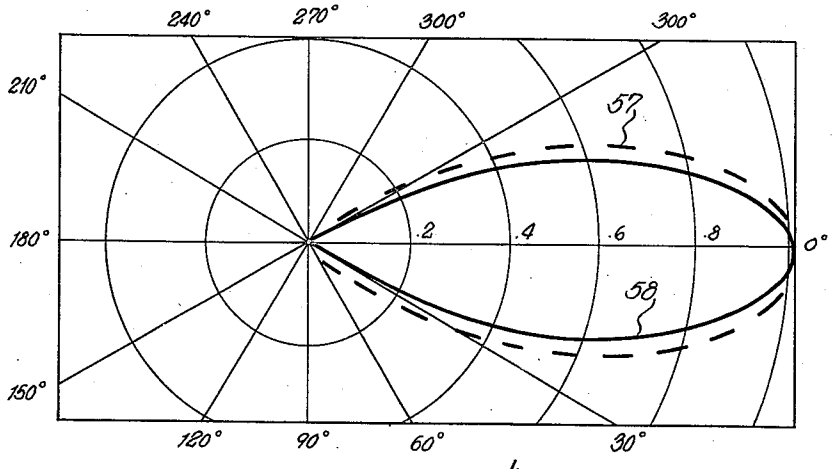


Fig. 4.

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Patented May 27, 1952

2,598,005

UNITED STATES PATENT OFFICE

2,598,005

HIGH-GAIN DIRECTIONALIZED ANTENNA

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Application January 13, 1950, Serial No. 138,356

1 Claim. (Cl. 250—33.57)

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This invention relates to directionalized antennas, and more particularly to antennas for operation at ultra-high-frequencies.

A principal object of the invention is to provide a directionalized antenna of the "Yagi" type, and particularly useful in television systems and the like.

Another object is to provide an improved directionalized antenna array of the kind employing one or more director elements.

Another object is to provide an improved antenna of the "Yagi" type.

A feature of the invention relates to an antenna array of the "Yagi" type, wherein at least one of the director elements is driven or connected to the feeder or transmission line which also excites the main antenna element of the array.

Another feature relates to an antenna array of the "Yagi" type, wherein at least one of the director elements is connected physically in circuit with the main antenna element whereby optimum current-phase relations can be obtained throughout the various elements of the "Yagi" array, while maintaining the desired directional sensitivity and gain characteristics of the "Yagi" antenna.

A further feature relates to an improved antenna of the "Yagi" kind, which has a much higher operating impedance than the conventional "Yagi" array. As a result of this feature, it is possible to use either one or more stacked arrays of "Yagi" units, while permitting an impedance match to a high impedance feeder line, such for example as the standard 300-ohm wave transmission line.

A still further feature relates to the novel organization, arrangement and relative location and interconnection of parts which cooperate to provide an improved antenna of the "Yagi" type.

In the drawing,

Fig. 1 is a perspective view of an antenna array embodying features of the invention.

Fig. 2 is a top-plan view of Fig. 1.

Figs. 3 and 4 are respective coordinate and polar graphs explanatory of the operation of the antenna array of Figs. 1 and 2.

As is well-known in the antenna art, the "Yagi" antenna comprises a main antenna element in the rear of which is mounted a reflector which is electrically floating and adjusted in length, and spaced from the main element a distance of between .1 and .2λ, where λ is the wavelength of the radiation to be transmitted or received by the antenna. The conventional "Yagi" antenna also

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has a series of director elements mounted in front of the main antenna element, these director elements electrically floating so as to be parasitically excited from the main antenna element. For a detailed description of such a typical "Yagi" antenna, reference may be had to "Radio Engineers' Handbook" by F. E. Terman, First Edition, pages 811 and 812, published by McGraw-Hill Book Company, Inc., New York, 1943. While such "Yagi" antennas have pronounced directional characteristics, because of the spacing and parasitic excitation of the reflector and directors, the antenna array as a whole has an operating impedance of extremely low value, for example of the order of 15 ohms. On the other hand, in certain installations, for example in television systems, it is desirable to use a feeder or wave transmission line of relatively high characteristic impedance, for example 300 ohms, and still be able to maintain an impedance match between the antenna and transmission line without using complicated impedance matching networks. This problem of impedance matching to the feeder or transmission line is even more difficult where the "Yagi" antenna comprises a series of stacked units which are connected in parallel to the feeder line. In such a case the parallel connection renders the operating impedance of the "Yagi" array even smaller, and depending upon the number of bays in the stacked array.

According to the present invention, it is possible to provide a "Yagi" antenna having the desired directional features, while providing the antenna with a characteristic impedance upwards of 250 ohms. In fact, it is possible to provide an impedance approximating 600 ohms, so that two such arrays can be stacked and connected in parallel to a common feeder line.

Referring to the drawing which shows a two stack array, each array, according to the invention, comprises a main antenna element 10, preferably, although not necessarily, in the form of a folded dipole comprising spaced horizontal legs 11, 12, directly united at their opposite ends by the end sections 13, 14. The lower leg 12 is discontinuous at its center and is fastened by suitable bolts 15, to an insulator strip or block 16. This block 16 also has fastened thereto a U-shaped metal bracket 17 having lateral lugs which are adapted to be fastened, for example by bolts 18, to a metal bar or strip 19, and with the center of leg 11 also clamped therebetween. Bracket 17 is suitably fastened to a tubular metal cross arm 20, which in turn is fastened in any suitable manner to a tubular metal mast 21. This fastening

may comprise, for example, a horizontal channeled member 22, and a vertically channeled member 23, respectively clamped to each other and to the members 20, 21, by suitable screws or bolts (not shown).

Mounted on the cross arm 20, in spaced relation to element 10, is an adjustable parasitically excited reflector, comprising for example a pair of overlapping metal rods 24, 25. These rods may be anchored to the flattened end 26 of arm 20 by suitable screws 27, and are preferably bound by a pair of metal bands 28, 29, to hold them together as a unit. Mounted in front of the main element 10 is a first director element 30, preferably, although not necessarily, in the form of a folded dipole having the spaced legs 31, 32, with integral end sections 33, 34. This director can be adjustably attached to the cross arm 20 by a U-shaped metal bracket 35 and clamping plate 36 located at the center of the leg 31, the bracket 35 being also fastened to the cross arm 20 by suitable screws (not shown). The bracket 35 carries an insulator strip 37 to which the central gapped ends of the leg 32 are fastened by suitable bolts 38. Attached to the arm 20 in front of the director 30, is another director 39 which may comprise a pair of overlapped metal rods 40, 41, similar to rods 24 and 25, and similarly attached to the arm 20.

The main element 10 has a physical length l equal to approximately $\lambda/2$. Preferably also, the director 30 has approximately the same length as the main element 10. The reflector is spaced from the main antenna element a distance s between 0.1λ and 0.25λ. The first director 30 is spaced from the main antenna element 10 a distance s_1 equal to approximately 0.12λ, and the second director 39 is spaced from the first director 30 approximately 0.1λ. It will be understood, of course, that these particular spacings are not critical, and can be adjusted within substantial ranges, depending upon the impedance that is desired. In any event, the spacing between each adjacent pair of elements should be substantially less than 0.25λ. Also mounted beneath the above-mentioned array is a similar array 42, and further detailed description thereof is not required. Preferably however, the vertical spacing s_3 between the two stacked arrays in approximately 0.5λ. It will be understood, of course, in order that the mast 21 and the cross arm 20 may be of metal, all the elements are attached at their centers or voltage nodal points to the respective cross arm, and preferably all the elements of each array are mounted on a common plane, and with the elements of one array in planar alignment with the corresponding elements of the other array.

In accordance with one feature of the invention, the gapped ends of the main element 10 are connected to the corresponding gapped ends of the director 30 by wave transmission line section 43 having an electrical length equal to $.12\lambda$, and having a characteristic impedance equal to 300 ohms. The bolts 16 and 38 may be used as binding posts for this connection. Also connected to the gapped ends of the leg 12, are two vertically-extending spaced parallel metal rods 45, 46. These rods at their lower ends are likewise connected to the gapped ends of the main antenna element 47, and through the two-wire transmission line section 48, to the corresponding gapped ends of the director 49. The rods 45 and 46 are held in fixed predetermined spaced relation by means of an insulator bar 50, which is fastened to the said rods by suitable screws or bolts 51. The block 50 carries a metal spacer arm 52 that is anchored to the mast 21, preferably at a point midway between the upper and lower arrays. The rods 45 and 46 thus constitute a half-wavelength line or two $\lambda/4$ matching transformers between the two stacked units of the array. A suitable radio set, either transmitter or receiver 53, is connected to posts 51 by a feeder or transmission line 54 of the proper characteristic impedance to avoid the setting-up of standing waves thereon.

From the foregoing, it will be seen that the directors 34 and 49, instead of being parasitically excited, are connected to the same feed line 54 to which the main elements 10 and 47 are connected. I have found that by this arrangement it is possible to employ for the line 54, one which has a high characteristic impedance, for example as high as 300 ohms, and it is possible to adjust the elements of each "Yagi" array so that each respectively has a characteristic impedance of approximately 300 ohms, so that by using $\lambda/4$ transformers from each array to the block 50, the combined impedance at the points 51 is approximately 300 ohms. It will be understood, of course, that the invention is not limited to any particular adjustment or characteristic impedance, since in any event a much greater impedance can be obtained when the director 30 and the main element 10 are physically connected to the same transmission line or feeder, as compared with the conventional "Yagi" arrangement, where the director is merely parasitically excited. In order to understand how this is effected, it should be noted that when the conventional parasitic director element is placed 0.1λ from the element 10, a considerable change is effected in the input impedance of element 10, because of the space inductive transformer-like action between it and the parasitic element. It is this reaction which reduces the operating impedance of a conventional "Yagi" system to an extremely low value. The twin-driven main and director array according to the invention, is not affected by this conventional parasitic coupling condition, because the main element feeds the first director through the impedance-matching line 43, whose length is approximately 0.12λ, and in any event is less than $.025\lambda$.

In one particular antenna array that was found to be highly efficient in the allotted television channels 2–6 (frequency range approximately 54 to 88 megacycles) and peaked at the center of the band, the main element 10 had an end-to-end length of 90 inches; the spacing between the legs 11 and 12 was three and one-quarter inches; the director 30 had an end-to-end length of approximately 90 inches with a spacing between the legs 31, 32, of approximately three and one-quarter inches; the parasitic reflector 24—25 had a length of approximately 92 inches; the parasitic director 39 had a length of approximately 78 inches; the spacing s between the main element and the parasitic reflector was approximately 33 and one-half inches; the spacing s_1 between the driven director 30 and the main element 10 was approximately 20 inches; the spacing s_2 between the parasitic director 39 and the driven director 30 was approximately 17 inches; and the spacing s_3 between the upper array and the lower array 42 was approximately 90 inches.

It will be understood, of course, that the invention is not limited to the particular dimensions

and impedance relations above mentioned, as will be clear to those familiar with the antenna art. However the driven director **30** and the parasitic director **40—41** are preferably chosen of such a length that the reactance imposed upon the main element **10** by the space inductive coupling or transformer-like coupling between the various elements, is a conjugate of the reactance at the driving point produced by the reflector system.

Likewise, the invention is not limited to the use of a plurality of stacked "Yagi" arrays, since desirable directional and gain characteristics are obtained with a single "Yagi" array. Furthermore, while the drawing shows a single parasitic director in front of the driven director **30**, it will be understood that more than one such parasitic director may be employed.

Fig. 3 is a graph showing the relation between the operating frequency in megacycles, and the gain in decibels, compared to a standard or reference dipole. The dotted-line graph **55** in Fig. 3 represents the characteristics of a single array such as shown in the upper portion of Fig. 1. The full-line graph **56** represents the relation between operating frequency and decibel gain, where a two-bay stacked array such as shown in Fig. 1 is employed.

Fig. 4 shows the corresponding polar field pattern diagram under these two conditions; the dotted-line graph **57** representing the single array, and the full-line graph **58** representing the two-bay stacked array of Fig. 1.

While certain specific embodiments and dimensions have been referred to herein, it will be

understood that the invention is not limited thereto, and that various changes and modifications may be made therein coming with the purview of the appended claim.

What is claimed is:

In an antenna array of the Yagi type, the combination of a main antenna element, a parasitic reflector element, a series of director elements, and a feeder line connected in parallel to said main element to the first director element which is ahead of said main element, said first director element having a physical length substantially the same as the length of the main element and spaced therefrom a distance substantially less than one-quarter wavelength at the operating frequency of the array, said main element and said first director element being in the form of folded dipoles having their gapped central sections connected in parallel to said feeder line.

KENDRICK H. LIPPITT.

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