Jan. 20, 1970 R. W. CAMPBELL 3,491,361

ENDFIRE ANTENNA ARRAY HAVING LOOP DIRECTORS

Filed March 7, 1968 2 Sheets-Sheet 1

FIG. 1

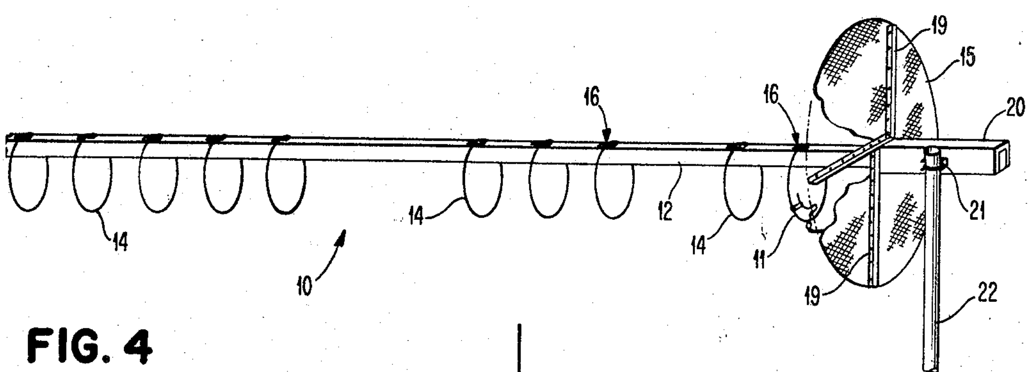


FIG. 4

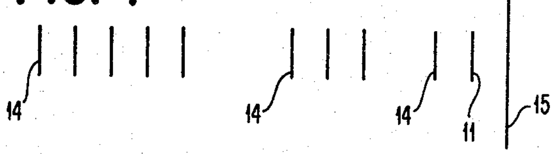


FIG. 3

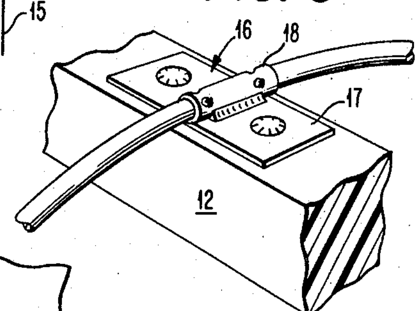


FIG. 2

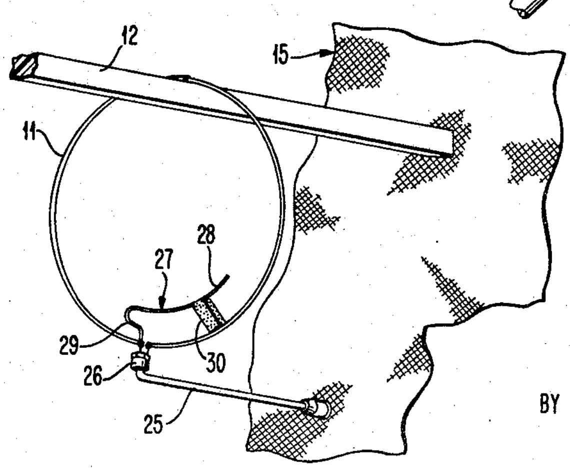



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FIG. 5

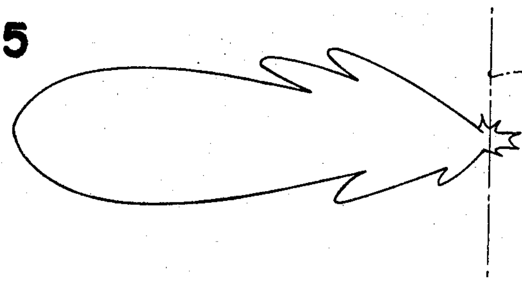



FIG. 6

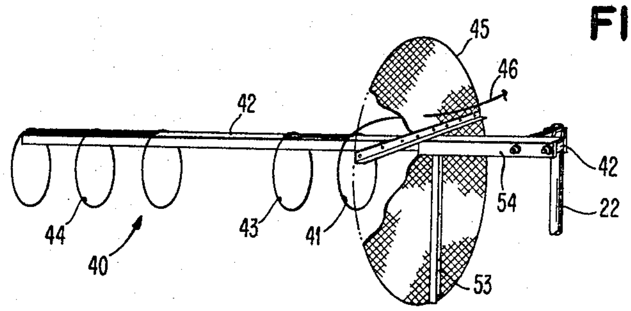



FIG. 7

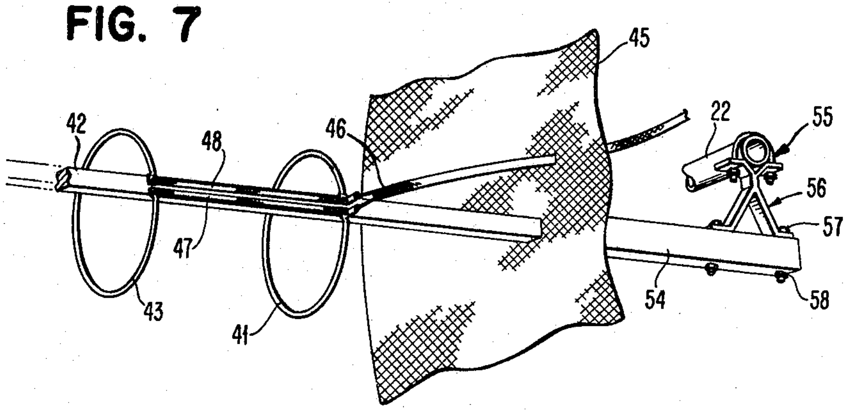



FIG. 9

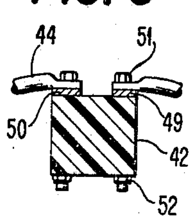
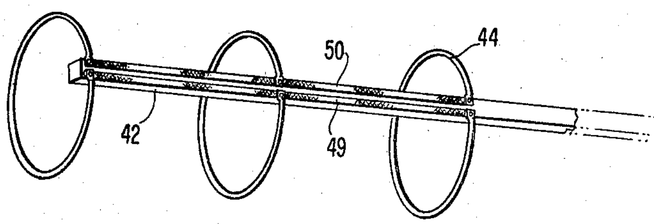



FIG. 8



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## ENDFIRE ANTENNA ARRAY HAVING LOOP DIRECTORS


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Continuation-in-part of application Ser. No. 687,600, Dec. 4, 1967. This application Mar. 7, 1968, Ser. No. 716,686

Int. Cl. H01q 11/12

U.S. Cl. 343—741 11 Claims



### ABSTRACT OF THE DISCLOSURE

An endfire antenna array has an insulated support member on which a plurality of circular shaped elements is disposed. A reflector is disposed on the support member at one end of the array and is spaced from a first of the elements. Each of the elements and the reflector has its center disposed on the same axis. The elements and the reflector are disposed substantially parallel to each other. Each of the elements has a circumference substantially equal to a selected wavelength. A second of the elements is spaced ¼ of the selected wavelength from the first element. The plurality of elements also includes a group of three elements with the first of the elements spaced ½ of the selected wavelength from the second element. The group of three elements has each element spaced ¼ of the selected wavelength from each other. At least the first element of the plurality of elements has its ends slightly spaced from each other for connection of a feed whereby the first element functions as a driven element.


This is a continuation-in-part of application Ser. No. 687,600, filed Dec. 4, 1967, now abandoned.

This invention relates to a directional antenna and, more particularly, to an endfire antenna array.

The receiving area range of UHF television stations has been rather limited because of the lack of a relatively inexpensive antenna for receiving UHF transmissions at a distance from the transmitter. Thus, the presently available antennas of a desirable size do not have sufficient gain to permit snow-free pictures to be received on a television receiver from a UHF transmitting station at a substantial distance therefrom.

While antennas are available in which reception of UHF signals may be received substantially snow-free at a substantial distance from the transmitter, these antennas are of such a size that they may not be readily mounted on the roof of a house or on an antenna tower. For example, a parabolic dish reflector with a five foot diameter and a single driven element would receive a snow-free UHF signal for a substantial distance from the station such as seventy-five miles, for example. However, this type of antenna is quite bulky and offers very high wind resistance. Thus, this type of antenna would tend to be more easily blown over during heavy winds. Therefore, this type of antenna has not been utilized for UHF reception even though it provides satisfactory reception of UHF signals at a substantial distance from the transmitter.

One type of antenna, which is presently used for receiving UHF signals, is known as a "bow-tie" antenna. However, the gain of this antenna is such that it does not provide at any substantial distance from the transmitter a snow-free picture on a television receiver. Therefore, while this type of antenna is satisfactory for receiving UHF signals when the transmitter is located within a few miles thereof, it will not receive UHF signals at a remote distance such as seventy-five miles, for example.

The present invention satisfactorily solves the foregoing problem by providing an antenna that will receive substantially snow-free UHF signals from a remote transmitter while still being relatively small and offering very slight wind resistance. Accordingly, the antenna of the present invention is readily usable for mounting on the roof of a house or on an antenna tower. There is no problem of wind resistance as the parabolic dish antenna would offer while there is still a gain substantially equal to that obtainable from the dish type antenna. Accordingly, the antenna of the present invention combines the desirable wind resistance and small size attributes of the "bow-tie" antenna while having the gain attribute of the parabolic dish type antenna.

Thus, the antenna of the present invention will permit snow-free signals to be received from a UHF transmitter at a distance where no signal is now received by "bow-tie" antennas. This is accomplished because the antenna of the present invention has a bigger aperture than the "bow-tie" antenna.

Another problem with an antenna using a parabolic dish reflector and a single driven element is the relatively high cost. The antenna of the present invention is relatively low in cost in comparison with an antenna comprising a parabolic dish reflector and a single driven element.

While various types of Yagi antennas have been utilized for reception of VHF television signals, these antennas are not effective for receiving snow-free UHF signals. This is because the Yagi type of antenna has a relatively small aperture. Since a relatively large aperture is important in order to receive UHF signals, the various types of Yagi antennas are not effective for reception of UHF signals. Thus, the present invention is a substantial improvement over the Yagi type of antenna for receiving television signals from a UHF station.

One form of the antenna of the present invention also has utilization in the telemetry field. Thus, one form of the antenna of the present invention will provide a narrow wave band for both receiving and transmitting telemetry signals.

One means of presently transmitting and receiving VHF telemetry signals is to utilize a helical antenna. However, the helical antenna has a twist problem in its polarization. That is, the helical antenna produces polarized waves of the same rotational sense as that of the helix and equivalent to a circular polarized wave with a twist. Thus, the helical antenna has a sense of rotation of either right-handed or left-handed.

The antenna of the present invention satisfactorily overcomes the foregoing problem by having circular polarization in which any twist is acceptable. Thus, the antenna of the present invention permits its signals to be received by any antenna irrespective of whether the receiving antenna is arranged for vertical polarization or horizontal polarization since the signals will be received by either type of receiving antenna.

There also exists a matching problem between the helical antenna and its feed line when the feed line is balanced. The present invention satisfactorily overcomes this problem since matching is easily accomplished between the driven element of the present invention and a balanced feed line.

An object of this invention is to provide an antenna for receiving substantially snow-free UHF signals at a substantial distance from the transmitter.

Another object of this invention is to provide an endfire antenna array having a relatively large aperture.

A further object of this invention is to provide an antenna having circular polarization.

A still further object of this invention is to provide an endfire antenna with a relatively high gain.

Other objects of this invention will be readily perceived from the following description, claims, and drawings.

This invention relates to an endfire antenna array comprising a reflector disposed at one end of the array. A plurality of elements is disposed on one side of the reflector with each of the elements having substantially the same shape. Each of the elements has a perimeter substantially equal to a selected wavelength. The elements are disposed substantially parallel to each other and to the reflector with each of the elements having its center disposed on the same axis as the center of the reflector. A first of the elements is disposed adjacent the reflector and spaced therefrom with a second of the elements being spaced ¼ of the selected wavelength from the first element. The plurality of elements includes a group of three elements spaced ¼ of the selected wavelength from each other. The group of elements functions as parasitic directors and has the first of the group of elements spaced ½ of the selected wavelength from the second element. At least the first element of the plurality of elements has its ends slightly spaced from each other for connection of a feed whereby the first element functions as a driven element.

The attached drawings illustrate preferred embodiments of the invention, in which:

FIGURE 1 is a perspective view showing one embodiment of the antenna of the present invention supported on a mast;

FIGURE 2 is a perspective view of the driven element and the reflector of the antenna of FIGURE 1 and showing the feed to the driven element and its passage into the reflector;

FIGURE 3 is an enlarged perspective view showing the connection between one of the circular elements and the support structure of the antenna of FIGURE 1;

FIGURE 4 is a schematic diagram showing the relation of the various elements of the antenna of the present invention to each other;

FIGURE 5 is a schematic representation of the lobe pattern in the horizontal mode for the antenna of FIGURE 1;

FIGURE 6 is a perspective view showing another form of the antenna of the present invention supported on a mast;

FIGURE 7 is an enlarged top plan view of a portion of the antenna of FIGURE 6 and showing the connection between the two elements to form the driven element for the antenna;

FIGURE 8 is an enlarged top plan view of a portion of the antenna of FIGURE 6 and showing the relation between the elements forming a group of parasitic directors of the antenna; and

FIGURE 9 is an enlarged sectional view showing the fastening arrangement for one of the elements to the support member of the antenna array of FIGURE 6.

Referring to the drawings and particularly FIGURE 1, there is shown an endfire antenna array **10**. The endfire antenna array **10** includes a driven element **11** supported on an insulating member **12**, which is preferably formed of high impact polyvinyl chloride. The antenna array **10** also includes a plurality of additional elements **14** that function as parasitic directors disposed on one side of the driven element **11** and a reflector **15** disposed on the other side of the driven element **11** at the end of the antenna array **10**.

The parasitic directors **14** are supported on the insulating member **12** in groups with the group closer to the driven element **11** having only one of the parasitic directors **14** while the next group has three of the parasitic directors **14**. The third group of the parasitic directors **14** would have five of the parasitic directors **14**. Thus, each of the groups contains an odd number of the parasitic directors **14** with each of the groups having two more of the parasitic directors **14** as the groups advance away from the driven element **11**.



The first group, which comprises only one of the elements or directors **14**, is spaced ¼ of a selected wavelength from the driven element **11** with the second group being spaced ½ of the selected wavelength from the first group. The third group of the parasitic directors **14** is spaced ¾ of the selected wavelength from the second group of the parasitic directors **14**. Thus, each group is spaced $n/4$ selected wavelengths from the preceding group where $n$ is equal to the number of the group from the driven element **11**.

The measurement of each of the groups from the preceding group is from the last of the parasitic directors **14** of one of the groups to the first of the parasitic directors of the next of the groups. In each of the groups, the parasitic directors **14** are spaced ¼ of the selected wavelength from each other.

Each of the driven element **11** and the parasitic directors **14** is formed of a single continuous member, which is preferably circular, with the circumference of the driven element **11** and each of the parasitic directors **14** being equal to the selected wavelength. It should be understood that the ends of the driven element **11** are spaced slightly from each other for connection to appropriate feed means while each of the parasitic directors **14** has its two ends connected together to form a closed loop. If desired, the circumference of each of the circular parasitic directors **14** could be reduced to 95% of the circumference of the circular driven element **11**.

The driven element **11** and each of the parasitic directors **14** are supported on the insulating member **12** by a saddle **16**. The saddle **16** includes a strap **17** (see FIGURE 3), which is secured to the insulating member **12** by steel pop-rivets. Each of the wires, which form each of the parasitic directors **14**, has its opposite ends disposed within a butt connector **18** of one of the saddles **16** and crimped connected thereto. The ends of the wire are then soldered to each other and to the butt connector **18** of the saddle **16** to provide an electrical connection between the ends of the wire so that each of the parasitic directors **14** forms a continuous closed member. The wire which forms the driven element **11**, has a portion, which is diametrically disposed to its spaced ends, connected to the butt connector **18**. As shown in FIGURE 1, the connection of the driven element **11** and each of the parasitic directors **14** is at twelve o'clock.

The ratio of the circumference of the wire, which forms the driven element **11** and each of the parasitic directors **14**, to its diameter is preferably eighty to one. At this ratio, the length in centimeters of the driven element **11** and each of the parasitic directors **14** is equal to $24{,}500 \times 10^6/F$ where F is the frequency of the selected wavelength in cycles per second. At other ratios, the length of the driven element **11** and each of the parasitic directors **14** would be determined from well-known formulae for determining the length of a wave.

The reflector **15** is preferably formed of aluminum mesh but it could be solid if desired. It is only necessary that the reflector **15** be capable of reflecting waves to the driven element **11** during reception and capable of reflecting waves from the driven element **11** to the parasitic directors **14** during transmission.

The reflector **15** is preferably circular shaped with a diameter equal to 1¼ of the selected wavelength. However, it could have a square shape, for example, with each of the sides equal to 1¼ of the selected wavelength.

When used to receive UHF signals, the reflector **15** could be circular with a minimum diameter of ⅝ of the selected wavelength. However, when used for VHF transmission and receiving, it is necessary that the reflector **15** be circular and have a diameter of 1¼ the selected wavelength.

The reflector **15** has a plurality of angle members **19** of aluminum, for example, secured thereto by suitable means such as rivets. The angle members **19** are secured to a U-shaped metallic channel **20**, which is preferably formed of aluminum, disposed to surround three sides of the insulating member **12**. The U-shaped channel **20** is secured to the insulating member **12** when the angle members **19** are connected to the channel **20**. This is because the rivets extend into the insulating member **12**.

The sides of the channel **20** and the insulating member **12** have two passages drilled therethrough to receive the legs of a U-shaped clamp **21**, which secures the antenna array **10** to a mast **22** for support thereof. A plate is disposed between the mast **22** and the side of the channel **20**. It should be understood that the ends of the legs of the clamp **21** are threaded to receive nuts on the side remote from the mast **22** to retain the antenna array **10** secured to the mast **22**.

The passages in the channel **20** and the insulating member **12** for the legs of the clamp **21** are selected so that the distance from the reflector **15** to half-way between the passages is equal to ¼ of the selected wavelength. Furthermore, the reflector **15** is disposed ¼ of the selected wavelength from the driven element **11**.

As shown in FIGURE 1, the driven element **11**, each of the parasitic directors **14**, and the reflector **15** are disposed substantially parallel to each other with all being substantially perpendicular to the longitudinal axis of the insulating member **12**. Since the longitudinal axis of the insulating member **12** is disposed parallel to the common axis of directivity of the antenna array **10**, the driven element **11**, each of the parasitic directors **14**, and the reflector **15** are disposed substantially perpendicular to the common axis of directivity of the antenna array **10**. Furthermore, the centers of the driven element **11**, each of the parasitic directors **14**, and the reflector **15** are disposed on the same axis, which is parallel to the longitudinal axis of the insulating member **12**.

As shown in FIGURE 2, the driven element **11** has its feed **25** connected thereto at six o'clock when the driven element **11** is supported on the insulating member **12** at twelve o'clock as are the parasitic directors **14**. When used for transmission and as shown, the feed **25** is preferably a coaxial line with its outer line connected to one end of the driven element **11** by a connector **26**. The inner line of the coaxial line, which forms the feed **25**, is connected to the other end of the driven element **11** as close as possible to the connection of the driven element **11** to the connector **26** but spaced therefrom. This provides DC continuity through the driven element **11**.

When the antenna array **10** is used for transmission, it is necessary to extend the feed **25** away from the driven element **11** so it does not protrude into the area defined by the driven element **11** and to pass the feed **25** through the reflector **15** perpendicular thereto. This insures that there is no interference between the feed **25** and the driven element **11**.

When used for transmission purposes, balancing between the driven element **11** and the feed **25** is obtained by utilizing a stub **27**, which has a length equal to ¼ of the selected wavelength. The stub **27** is formed with an arcuate portion **28** of sixty electrical degrees with the remaining thirty electrical degrees forming a bent portion **29** from the arcuate portion **28** to the feed **25**. When the feed **25** is a coaxial line, the connection from the stub **27** is preferably to the inner line of the coaxial line. The arcuate portion **28** of the stub **27** is held in spaced relation to the driven element **11** by an insulating member **30** formed of a suitable material such as polyvinyl chloride, for example.

With this arrangement for feeding the driven element **11** during transmission, circular polarization of the antenna array **10** is obtained. With circular polarization of the antenna array **10**, signals from the antenna array **10** may be received by any receiving antenna having either vertical or horizontal polarization.



When using only three of the groups of the parasitic directors **14** whereby the first group contains one of the parasitic directors **14**, the second group contains three of the parasitic directors **14**, and the third group contains five of the parasitic directors **14**, the endfire antenna array **10** of the present invention provides a power gain of 14 dbi. This measurement was obtained in the horizontal mode with the reflector **15** having a diameter equal to 1¼ of the selected wavelength.

The same gain would be obtained by an antenna using a driven element with a parabolic dish of five foot diameter. An eleven element Yagi antenna would provide only a twelve dbi. power gain in the horizontal mode while a six turn helical antenna would provide only ten dbi. gain. Thus, the power gain of the antenna of the present invention is greater than for other commercially available antennas for reception of UHF television signals. As previously mentioned, the large size of the five foot parabolic dish reflector, its high wind resistance, and its relatively high cost results in it not being practical for use as a receiving antenna for UHF television signals.

When the antenna array **10** of the present invention is used for reception, the feed **25** is preferably a balanced line. The driven element **11** is easily matched to the balanced line, and the stub **27** is not required.

When utilizing antenna array **10** of the present invention for VHF telemetry, the band width during transmission may vary from +5% to −10%. As previously mentioned, the reflector **15** must be circular with a diameter equal to 1¼ of the selected wavelength when used for VHF telemetry. As a result, this permits transmission of circular polarization waves without any twist.

While helix might have a slightly larger band width, there are certain other disadvantages with a helix. These include that it is difficult to match the helix to a balanced line for receiving while the antenna of the present invention is easily matched to a balanced line. Furthermore, circular polarization of the helix can be in only one direction of twist so that a special type of receiving antenna is required to obtain maximum gain.

While the present invention has been described with only three of the groups of the directors **14**, it should be understood that more of the groups of the directors **14** could be employed if desired. For example, the first of the directors **14** in a group of seven of the directors **14** could be spaced a distance equal to the selected wavelength from the last director **14** in the group of five of the directors **14**. Thus, it is only necessary to increase the number of directors in each group by two and space the first of the directors **14** of the new group of the directors **14** from the last of the directors **14** in the preceding group a distance equal to $n/4$ of the selected wavelength where $n$ is equal to the number of the new group from the driven element **11**.

The lobe pattern in the horizontal mode is shown in FIGURE 5 for the antenna array **10** in which the largest group of the directors **14** contains seven of the directors **14**. The beam width is 22°. This pattern provides a power gain of 18 dbi. It should be understood that this beam width of 22° is at 70.7% of the maximum length of the lobe.

While the driven element **11** and each of the directors **14** has been described as circular, it should be understood that they may have other shapes as long as all have the same shape and the directors **14** are continuous closed members. The directors **14** must have a perimeter no less than 95% of the perimeter of the driven element **11** and preferably equal thereto.

Referring to FIGURES 6–8, there is shown an endfire antenna array **40**, which is a modification of the endfire antenna array **10** and is adapted to be primarily utilized for receiving UHF signals. The endfire antenna array **40** includes a first element **41** supported on an insulating member **42**, which is similar to the member **12** and preferably formed of high impact polyvinyl chloride.

The antenna array 40 also includes a second element 43, which is spaced ¼ of the selected wavelength from the first element 41 and supported on the member 42. A plurality of additional elements 44 also is supported on the member 42. A reflector 45 is disposed on the other side of the first element 41 at the end of the antenna array 40.

Each of the first element 41, the second element 43, and the additional elements 44 is formed of a single continuous member, which is preferably circular, with the circumference of each being equal to the selected wavelength. It should be understood that the ends of each of the first element 41, the second element 43, and the additional elements 44 are spaced slightly from each other as shown in FIGURES 7 and 8.

The spacing of the end of the first element 41 and the second element 43 permits connection of the ends of the first element 41 and the second element 43 to each other and to a feed 46 whereby the first element 41 and the second element 43 function as the driven element of the antenna array 40. A conductive strip 47 (see FIGURE 7) connects one end of the first element 41 to one end of the second element 43. A second conductive strip 48 connects the other end of the first element 41 to the other end of the second element 43. Thus, the first element 41 and the second element 43 are connected to each other.

The feed 46 is preferably balanced with one line connected to one of the strips 47 and 48 and the other line connected to the other of the strips 47 and 48. The feed 46 extends from the first element 41 toward the reflector 45 and is connected to the strips 47 and 48 at the first element 41. The feed 46 passes through the reflector 45 substantially perpendicular thereto.

The additional elements 44 are supported on the insulating member 42 in a group of three elements to form a group of parsitic directors. The group of the three additional elements 44 is spaced ½ of the selected wavelength from the second element 43.

The spacing of the ends of each of the elements 44 allows connections of the ends of the elements 44 to each other. A conductive strip 49 (see FIGURE 8) connects one end of each of the elements 44 to each other while a conductive strip 50 connects the other end of each of the elements 44 to each other.

It should be understood that each of the elements 41, 43, and 44 is connected to the insulating member 42 by suitable fastening means such as screws 51 and nuts 52 (see FIGURE 9). This fastening means also secures the strips 47 and 48 to the elements 41 and 43 and the strips 49 and 50 to the elements 44.

While only the one group of the additional elements 44 is shown, it should be understood that additional groups of the elements 44 could be supported on the insulating member 42. The next of the groups would comprise five of the elements 44 while the third of the groups would comprise seven of the elements 44. Thus, each of the groups would contain an odd number of the elements 44 with each of the groups having two more of the elements 44 as the groups advance away from the second element 43.

The ends of each of the elements 44 of each of the additional groups would be slightly spaced from each other in the same manner as shown in FIGURE 8 for the first group. The ends would be connected to each other by conductive strips similar to the conductive strips 49 and 50.

Furthermore, the second group of the five elements 44 would be spaced ¾ of the selected wavelength from the first group. The group of the seven elements 44 would be spaced the selected wavelength from the second group. Thus, each group is spaced $\frac{1}{2}+n/4$ of the selected wavelength from the preceding group where $n$ is equal to the total number of the groups including the first group of the three elements 44.



The measurement of each of the groups from the preceding group is from the last of the elements 44 of one of the groups to the first of the elements 44 of the next of the groups. In each of the groups, the elements 44 are spaced ¼ of the selected wavelength from each other.

If desired, the circumference of each of the circular elements 44 could be reduced to 95% of the circumference of each of the first element 41 and the second element 43, which cooperate together to form the driven element of the array 40. The ratio of the circumference of the wire, which forms each of the first element 41, the second element 43, and the additional elements 44, to its diameter is preferably 80 to 1 in the same manner as previously mentioned with respect to the antenna array 10.

The reflector 45 is preferably formed of aluminum mesh but it could be solid if desired. It is only necessary that the reflector 45 be capable of reflecting waves to the first element 41 and the second element 43, which cooperate together to function as the driven element, during reception.

The reflector 45 is preferably circular shaped with a diameter dependent upon the number of the groups of the elements 44 that function as parasitic directors. Thus, the reflector 45 has a diameter equal to $\frac{1}{2}+n/4$ of the selected wavelength where $n$ is equal to the total number of the groups of the parasitic directors. Thus, with the arrangement shown in FIGURE 6, the diameter of the reflector 45 would be ¾ of the selected wavelength since there is only the single group of the elements 44 functioning as parasitic directors. If desired, the reflector 45 could have a square shape, for example, with each of the sides equal to $\frac{1}{2}+n/4$ of the selected wavelength where $n$ is equal to the total number of the groups of the parasitic directors formed by the elements 44.

The reflector 45 has a plurality of angle members 53 of aluminum, for example, secured thereto by suitable means such as rivets. The angle members 53 are secured to a U-shaped metallic channel 54, which is preferably formed of aluminum, disposed to surround three sides of the insulating member 42. The U-shaped channel 54 is secured to the insulating member 42 when the angle members 53 are connected to the channel 54. This is because the rivets extend into the insulating member 42.

The mast 22 is secured to the antenna array 40 by a U-shaped clamp 55 and a support member 56. The support member 56, which has the clamp 55 secured thereto, is connected to the antenna array 40 by bolts 57 and nuts 58. The bolts 57 pass through two passages, which are drilled through the insulating member 42 and the sides of the channel 54.

The passages in the channel 54 and the insulating member 42 for the bolts 57 are selected so that the distance from the reflector 45 to the axis of the mast 22 is equal to ¼ of the selected wavelength. Furthermore, the reflector 45 is disposed ¼ of the selected wavelength from the first element 41.

The first element 41, the second element 43, each of the additional elements 44, and the reflector 45 are disposed substantially parallel to each other with all being substantially perpendicular to the longitudinal axis of the insulating member 42. Since the longitudinal axis of the insulating member 42 is disposed parallel to the common axis of directivity of the antenna array 40, the first element 41, the second element 43, the additional elements 44, and the reflector 45 are disposed substantially perpendicular to the common axis of directivity of the antenna array 40. Furthermore, the centers of each of the first element 41, the second element 43, the additional elements 44, and the reflector 45 are disposed on the same axis, which is parallel to the longitudinal axis of the insulating member 42.

When using only the single group of the additional elements 44 as parasitic directors, the endfire antenna array 40 of the present invention provides an estimated power gain of 12 dBd. Thus, the power gain of the antenna array 40 is greater than for other commercially available antennas for reception of UHF television signals since dbi. ratings of the commercial antennas, which have previously been discussed, must be reduced by 2 when the power gain is measured with respect to a dipole rather than the isotropic.

While the first element **41**, the second element **43**, and the additional elements **44** have been described as circular, it should be understood that they may have other shapes as long as all have the same shape and the same connection arrangement between the elements exists. The elements **44**, which function as the parasitic directors, must have a perimeter no less than 95% of the perimeter of each of the first element **41** and the second element **43** and preferably equal thereto.

While the additional elements **44** have been shown as having their ends slightly spaced from each other, it should be understood that each of the elements **44** could be a closed member if desired. However, this would reduce the gain of the antenna array **40**.

An advantage of this invention is that it receives fringe UHF signals without any interference. Another advantage of this invention is that it substantially eliminates cross polarization effects in both the horizontal and vertical modes. A further advantage of this invention is that fading is reduced on rotated waves as in VHF telemetry, for example.

For purposes of exemplification, particular embodiments of the invention have been shown and described according to the best present understanding thereof. However, it will be apparent that changes and modifications in the arrangement and construction of the parts thereof may be resorted to without departing from the spirit and scope of the invention.

I claim:

**1.** An endfire antenna array comprising:
a reflector disposed at one end of said array;
a plurality of elements disposed on one side of said reflector with each of said elements having substantially the same shape, each of said elements having a perimeter substantially equal to a selected wavelength;
each of said elements being disposed substantially parallel to each other and to said reflector; each of said elements having its center disposed on the same axis as the center of said reflector;
a first of said elements being disposed adjacent said reflector and spaced therefrom;
a second of said elements being spaced ¼ of the selected wavelength from said first element;
said plurality of elements including a first group of three elements with said three elements being spaced ¼ of the selected wavelength from each other;
said first group of elements functioning as directors and having the first of said first group of elements spaced ½ of the selected wavelength from said second element; and
at least said first element of said plurality of elements having its ends slightly spaced from each other for connection of a feed whereby said first element functions as a driven element.

**2.** The antenna array according to claim **1** including:
said second element having its ends slightly spaced from each other;



means to connect the ends of said first and second elements to each other whereby said first and second elements function together as the driven element; and
means to connect said first group of elements to each other.

**3.** The antenna array according to claim **1** including:
said plurality of elements comprising at least one additional group;
said elements in each of said additional groups being spaced ¼ of the selected wavelength from each other; and
each of said additional groups having the first of said elements in its group spaced from the last of said elements in the preceding group $1/2+n/4$ of the selected wavelength where $n$ is equal to the number of said additional group from said first group.

**4.** The antenna array according to claim **3** including:
said second element having its ends slightly spaced from each other;
means to connect the ends of said first and second elements to each other whereby said first and second elements function together as the driven element; and
means to connect said elements in each of said groups to each other whereby each of said groups function as parasitic directors.

**5.** The antenna array according to claim **5** in which said reflector has a shape encompassing at least a circle with a diameter equal to $1/2+n/4$ of the selected wavelength where $n$ is equal to the total number of said groups.

**6.** The antenna array according to claim **1** in which said second element and said elements of said first group are closed members.

**7.** The antenna array according to claim **1** in which each of said elements has a substantially circular shape.

**8.** The antenna array according to claim **1** in which said first element is disposed ¼ of the selected wavelength from said reflector.

**9.** The antenna array according to claim **1** including:
an insulating member; and
each of said elements and said reflector being supported by said insulating member.

**10.** The antenna array according to claim **9** in which:
said insulating member has means to mount said array on a mast or the like; and
said reflector is disposed ¼ of the selected wavelength from the axis of said mounting means.

**11.** The antenna array according to claim **3** in which:
said second element is a continuous closed member;
each of said elements of each of said groups of elements is a continuous closed member.

**References Cited**

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ELI LIEBERMAN, Primary Examiner

U.S. Cl. X.R.

343—833, 835

## UNITED STATES PATENT OFFICE
# CERTIFICATE OF CORRECTION

Patent No. 3,491,361 January 20, 1970

Ralph W. Campbell

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

Column 4, line 41, after "wire" insert a comma. Column 6, line 27, after "utilizing" insert -- the --; line 34, after "While" insert -- a --. Column 7, line 16, "end" should read -- ends --. Column 9, lines 44 to 46, "each of said elements having its center disposed on the same axis as the center of sa reflector;" should appear as a separate paragraph. Column 10, line 50, after "member;" insert -- and --; line 26, "5", second occurrence, should read -- 4 --.

Signed and sealed this 17th day of November 1970.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, J
Commissioner of Patent