July 4, 1967 J. R. WINEGARD 3,329,960

COLLAPSIBLE PARABOLIC ANTENNA

Filed Oct. 1, 1964 4 Sheets-Sheet 1

Fig. 1

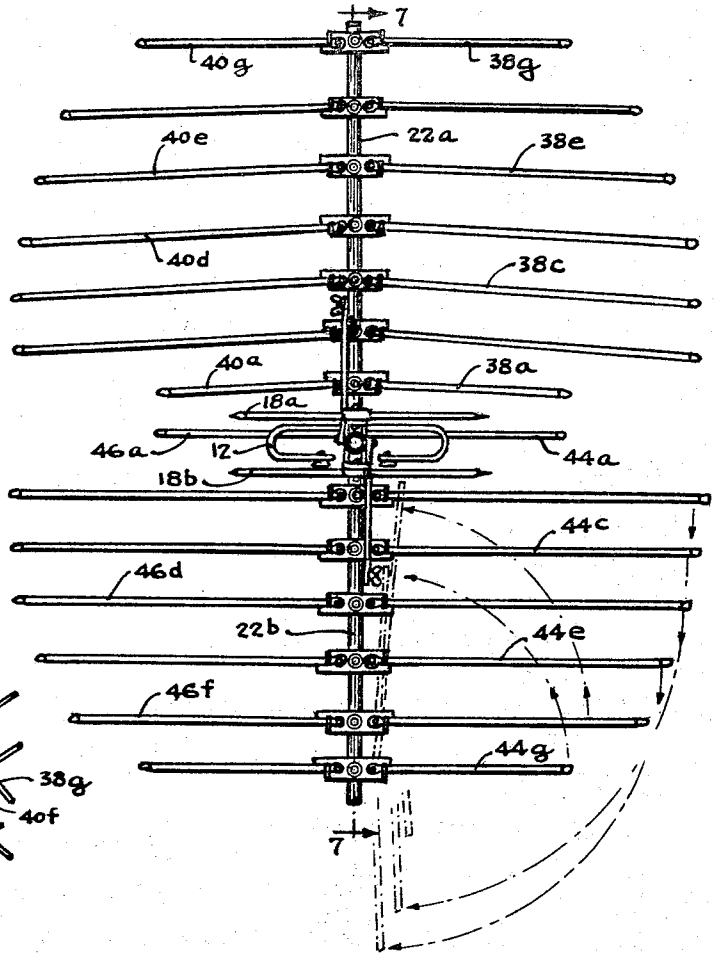
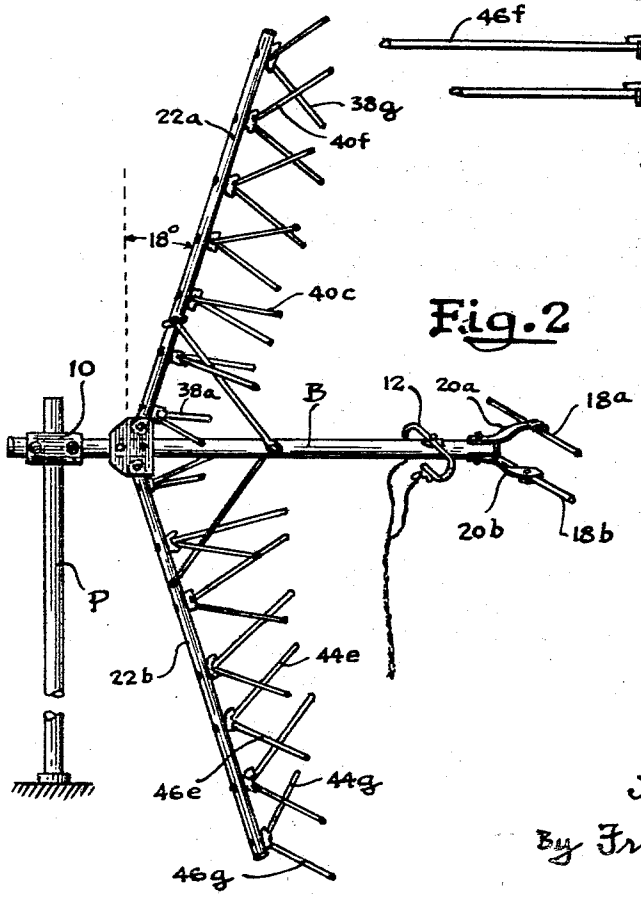



Fig. 2

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Filed Oct. 1, 1964 4 Sheets-Sheet 2

Fig.3

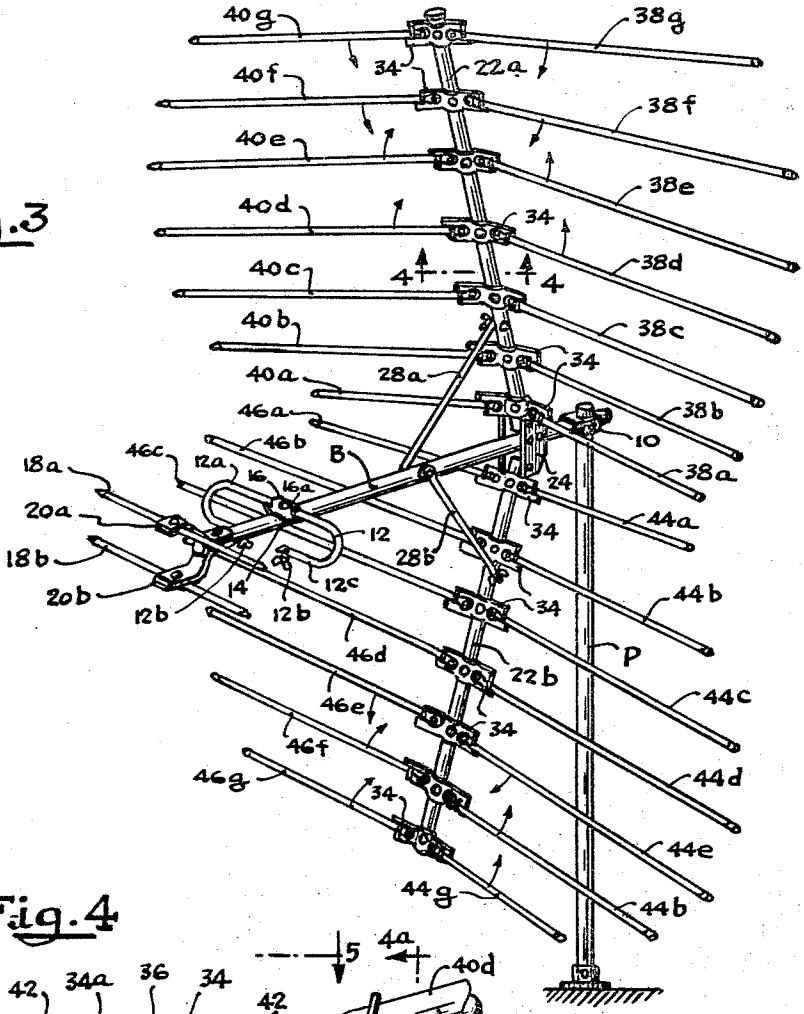



Fig.4

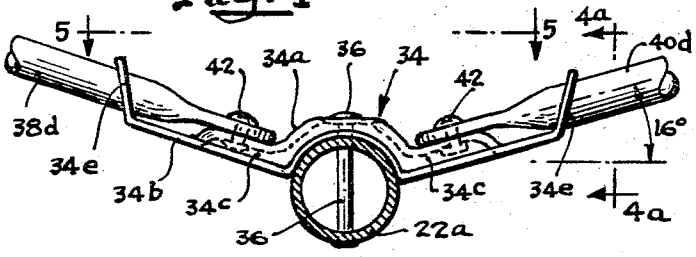



Fig.4a

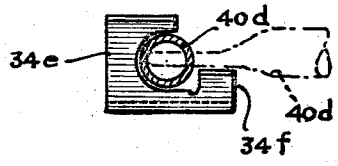
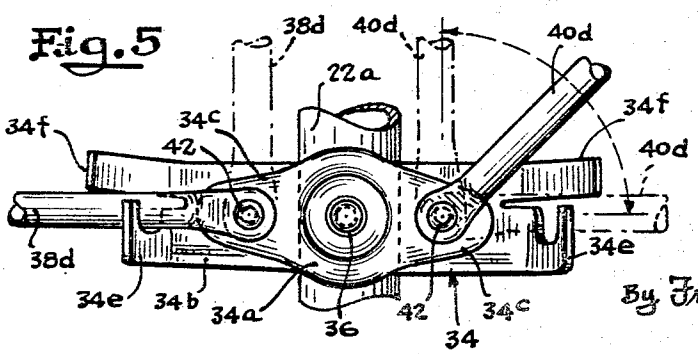



Fig.5

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July 4, 1967 J. R. WINEGARD 3,329,960

COLLAPSIBLE PARABOLIC ANTENNA

Filed Oct. 1, 1964 4 Sheets-Sheet 3

Fig.6

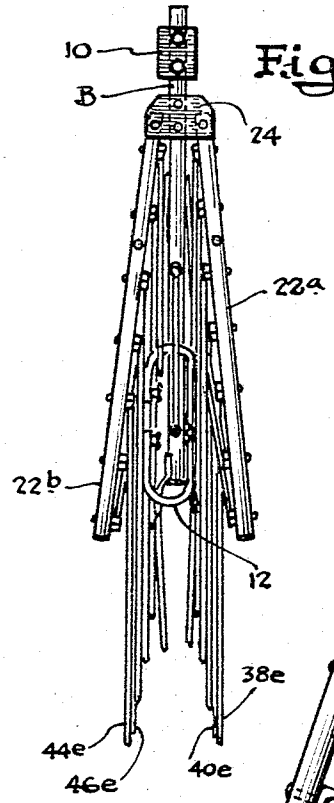


Fig.11

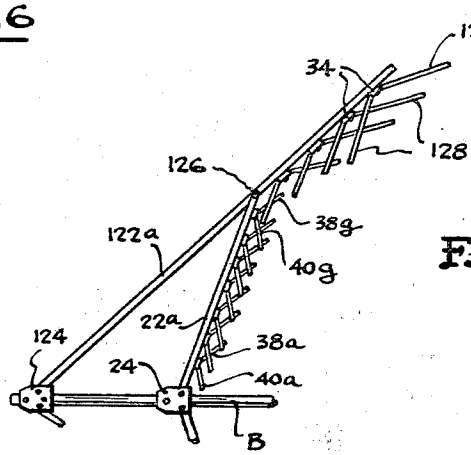


Fig.7a

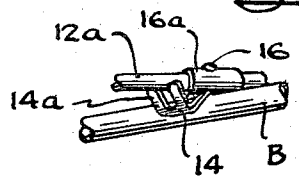


Fig.7




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July 4, 1967 J. R. WINEGARD 3,329,960

COLLAPSIBLE PARABOLIC ANTENNA

Filed Oct. 1, 1964 4 Sheets-Sheet 4

Fig. 8

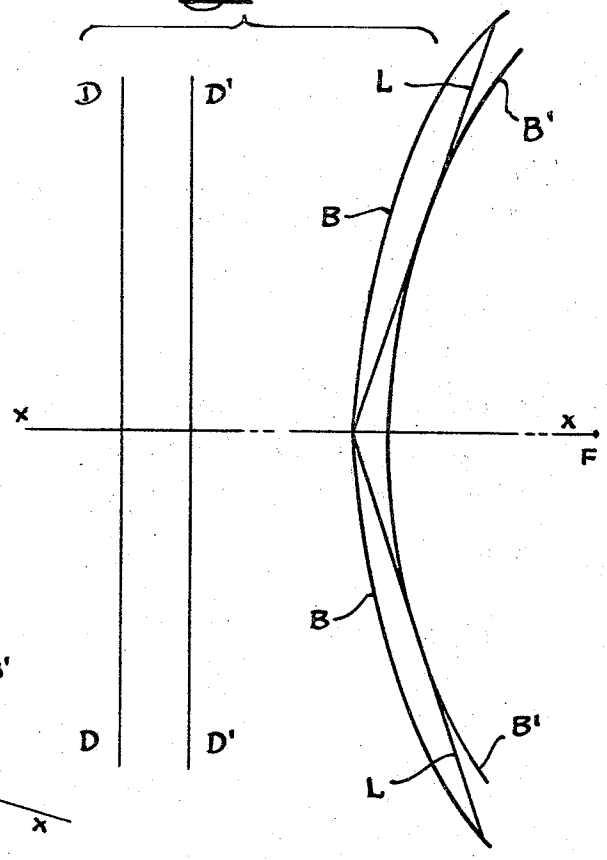
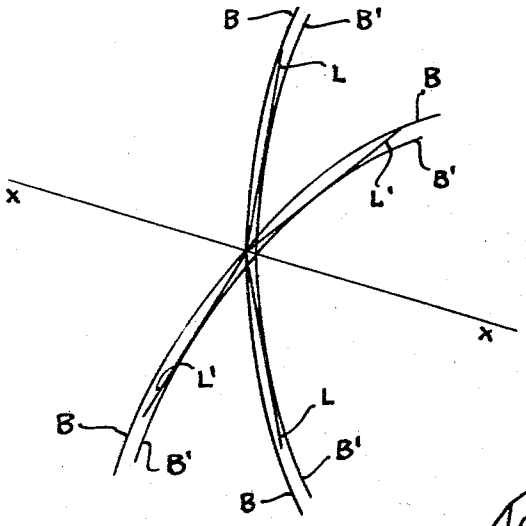



Fig. 9



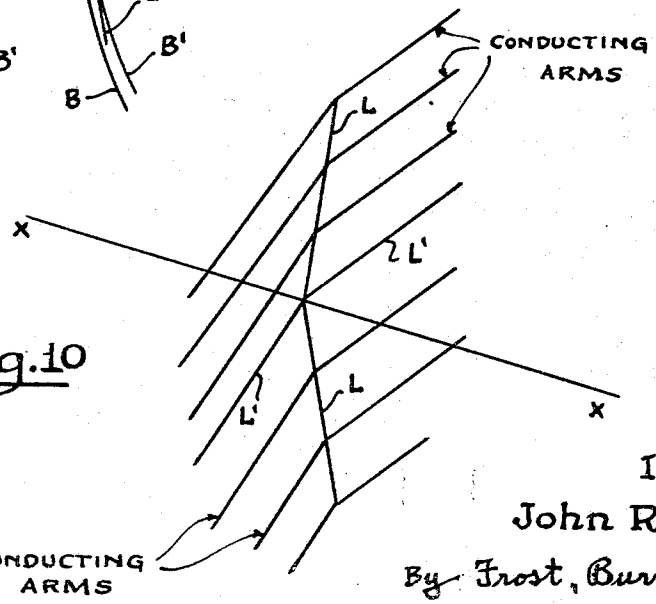




Fig. 10

CONDUCTING ARMS

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United States Patent Office

3,329,960
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1

3,329,960

# COLLAPSIBLE PARABOLIC ANTENNA

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Filed Oct. 1, 1964, Ser. No. 400,684
7 Claims. (Cl. 343—819)

This invention relates to an improved antenna suitable for use in the frequency range of 470 to 890 megacycles, that is, channels 14 to 83, inclusive. It is particularly characterized by the use of linear elements defining plane reflectors that approximate the performance of a reflector in the form of a paraboloid of revolution while at the same time being foldable for shipment and storage.

Television receiving antennas for the 470 to 890 megacycle range must, over the entire range, provide reasonable directivity and effective gain, and yet meet the practical requirements of reasonable cost and ease of manufacture and handling. Antennas based on the Yagi principle, which have proven satisfactory in the very high frequency range (channels 2–13), are not effective for this purpose. Antennas using plane reflectors and "bow tie" or other driven elements located in front of the same have had some measure of success, but their performance (especially sensitivity) is limited. Parabolic reflector antennas, whether in the form of an imperforate "dish" or in the form of a "dish" defined by close spaced conducting rods, are electrically effective for service in the 470 to 890 megacycle range. But for household television receiving use these are unduly expensive.

I have discovered that it is possible to approximate the performance of the true parabolic reflector antenna through the use of a reflector unit that combines at least four planar reflector elements. These elements are so oriented and positioned that they define four dihedral lines intersecting at the axis of the antenna. The dihedral lines are tilted in a common direction so as to form a concave surface pointing towards the driven element (located at the "focus"). While an arrangement of this type in theory should not provide the action of a parabolic reflector, it has been found that with the proper construction the difference between the performance achieved and that of a true parabolic reflector is insignificant and the essential advantages of a parabolic reflector antenna are obtained.

An antenna constructed in accordance with the principles of the present invention is not only characterized by the electrical capabilities of a true parabolic antenna but in addition it has the constructional advantages of an antenna made of linear elements. The arms defining the reflector unit can be made to fold down against two support arms coincident with two opposed ones of the dihedral lines. The support arms, carrying the folded reflector arms, can be made to fold against the boom. The entire antenna is thereupon folded to a lengthy shape having a small cross section and suitable for shipment in a carton in the same manner as most television receiving antennas are now shipped.

It is therefore a general object of the present invention to provide an improved television receiving antenna suitable for use in the 470 to 890 megacycle range and characterized by electrical performance approximating that of a parabolic antenna while using linear antenna elements.

An additional object of the present invention is to provide an antenna of the foregoing type in which the linear

2

antenna elements are so arranged that they may be folded against the boom without removal from the assembly to form a small structure for shipment and storage.

Still another object of the present invention is to provide an antenna of the foregoing type that is constructed and arranged in such fashion as to be simple and inexpensive to manufacture, easily opened from the folded to the operating conditions, has relatively small and balanced wind resistance, is of relatively light weight, and in other respects accommodates itself to the practical needs of home television use.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following description taken in connection with the accompanying drawings, in which:

FIGURE 1 is a view from the front along the axis of the boom of an antenna constructed in accordance with the preferred form of the present invention;

FIGURE 2 is a side elevational view of the antenna of FIGURE 1;

FIGURE 3 is a view in perspective of the antenna of FIGURES 1 and 2;

FIGURE 4 is a fragmentary enlarged cross-sectional view through axis 4—4, FIGURE 3;

FIGURE 4*a* is a fragmentary view through cross-section 4*a*—4*a*, FIGURE 4;

FIGURE 5 is a fragmentary view along axis 5—5, FIGURE 4;

FIGURE 6 is a view showing the antenna of FIGURES 1–5 in the folded condition for storage or transportation;

FIGURE 7 is a fragmentary enlarged cross-sectional view of the antenna as seen through axis 7–7, FIGURE 1;

FIGURE 7*a* is an enlarged fragmentary portion of FIGURE 7, in perspective;

FIGURE 8 is a diagram showing the physical relationship of the parts of the antenna of the present invention and a true parabolic configuration;

FIGURES 9 and 10 are diagrammatic views in perspective showing the physical relationships involved in the present invention; and,

FIGURE 11 is a diagrammatic view of a modified form of the antenna of FIGURES 1–7 having increased reflector area.

The general construction of the antenna of the present invention can best be understood by first considering the mathematical relationships involved in a true parabolic antenna as shown in the diagram of FIGURE 8. In a true parabolic antenna, the driven element is located at the focus of the parabola of revolution defined by the reflector. In FIGURE 8, the axis is indicated at X—X and the focus (and location of the driven element) by F. There are an infinite number of parabolas of revolution that have the particular axis and the particular focus, only one of which is employed on any specific true parabolic antenna. For each such parabola of revolution there is a specific directrix (a plane, which appears as a line in an axial cross-section, such as FIGURE 8). As to each directrix, the particular parabola defined in relation to the focus has an equal distance at all points from the directrix and the focus. Thus, in the diagram of FIGURE 8, we may take directrix D and focus F and obtain the parabola

B. Also, we may take directrix D' and focus F and obtain the parabola B'. Each of these parabolas (in the form of a parabola of revolution) provides the basic function of reflecting into the focus F all signals received from a direction parallel to the axis.

It will be understood that the diagram of FIGURE 8 is in reality one axial cross-section of the parabolic antennas represented, and that each and every other axial cross-section appears the same.

No plane surface can provide the true parabolic reflector action available with a reflector in the form of a parabolic reflector. However, it is possible to form a plane reflector so that along some selected axial cross-section the reflector is a line within the confines of two rather closely spaced true parabolas. Such a line is shown at L—L, FIGURE 8. As shown, it is in the form of a V with its apex at the axis and, within a predetermined length, lies within the envelope defined by the parabolic curves B and B'.

If, however, a true parabola of revolution is approximated by rotating the lines L—L of FIGURE 8 about the axis X—X, the resulting curve is a cone. This surface is curved and—like the true parabola of revolution—cannot conveniently be constructed from linear elements. It has been found, however, that this degree of approximation is not essential and that practically useful performance can be achieved by providing the configuration of FIGURE 8 on two planes normal to each other and through the axis X—X. This is shown diagrammatically in perspective in FIGURE 9. In this figure, the lines L—L of FIGURE 8 are shown in the vertical plane. In the horizontal plane, the corresponding lines that lie within the envelope defined by the parabolic curves B and B' are shown at L'—L'. Each set of adjacent lines L and L' forms a plane, making a total of four planes. It will be further observed that these planes form a concave shape. Through the use of linear elements, such as closely spaced parallel conducting arms as shown diagrammatically in FIGURE 10, it is possible to form a total of four plane reflector units, the adjacent ones of the units defining lines L and L', FIGURE 9 as dihedral lines. In this form it has been found that the reflector elements, though planar, are effective in reflecting incident waves onto a driven element located at the focus and provide very nearly the performance of a true parabolic reflector.

FIGURES 1–7, inclusive, illustrate a preferred form of an antenna constructed in accordance with the present invention. As seen best in FIGURE 2, the antenna elements are mounted on a boom B which is normally mounted in horizontal position on the upstanding post P. A clamp unit **10** of conventional construction serves detachably to secure the boom to the post.

The driven element is indicated generally at **12**, FIGURES 1–3 and 7. As seen best in FIGURE 3, it is in the form of a folded dipole, preferably of aluminum. It has an upper unitary dipole arm **12***a* which is secured to the boom B by a rivet **16**, FIGURE 7*a*, extending through the arm **12***a*, the spring saddle **14** and the boom B to sandwich the arm **12***a* and the spring saddle **14** between the head of the rivet and the boom. The spring saddle **14** may be any one of the constructions well known to the art and forms no part of the present invention. In the form illustrated in FIGURE 7*a*, it consists of a saddle part of spring steel that is sandwiched between the arm **12***a* (which is protected by a sleeve **16***a* directly over the boom B) and the boom B. Outboard the boom B, the saddle has an upstanding portion **14***a*, FIGURE 7*a*, that extends up into the plane of the arm **12***a* and is bifurcated to form two spring fingers that anchor the arm **12***a* in the plane normal to the axis of the boom B. The arm **12***a* can be released for folding the dipole **12** against the boom (dotted lines FIGURE 7) by flexing the fingers down as required to clear the arm **12***a* and then swinging the dipole about the axis defined by the rivet **16**.

The driven element **12** extends below the boom as shown in FIGURE 3 to define the terminals **12***b* to which the transmission line T (FIGURE 7) leading to the TV receiving set is connected. The driven element **12** is in the form of a folded dipole and thus has about 280 ohms impedance, which matches conventional 300 ohm twin lead transmission line. In the preferred form of the present invention illustrated, the driven element was substantially as shown in FIGURE 3 and had a total span of 10 inches in the horizontal direction and 2¼ inches in the vertical direction.

A pair of forward reflectors **18***a* and **18***b*, preferably of aluminum, are mounted on the boom B as shown in FIGURES 1–3 and 7. These reflectors are located in vertically spaced relationship and are parallel to the upper portion **12***a* of the driven element and the lower portion **12***c*, thereof. As shown, the reflectors **18***a* and **18***b* are mounted on brackets **20***a* and **20***b* that extend forwardly and upwardly (**18***a*) or downwardly (**18***b*) from the boom B. The reflectors **18***a* and **18***b* are thereby held substantially in planes parallel to the boom B and through the upper portion **12***a* and the lower portion **12***c* of the driven element **12**, respectively. In the preferred form of the invention specifically illustrated, the arms **18***a* and **18***b* are 14 inches in length and spaced in the vertical direction by 3⅜ inches. The support arms **20***a* and **20***b* terminate in spring snap elements, such as the saddle **14**, FIGURE 7*a*, that releasably secure the arms **18***a* and **18***b* in the operating position of FIGURES 1–3 while permitting the same to be rotated to parallel position in relation to the boom B for shipment and storage.

The antenna of FIGURES 1–7 further includes a pair of reflector support arms **22***a* and **22***b*. As shown best in FIGURES 3 and 7, these arms are sandwiched between the vertitcal support plates **24** at their inboard ends. These plates are secured on opposite sides of the boom B by the rivets **24***a*. The arms **22***a* and **22***b* are secured to the plates **24** by rivets **26**, FIGURE 7. These rivets extend through the plates and the respective arms **22***a* and **22***b* to define pivotal supports for the arms, permitting the same to be folded down and against the boom B for storage or transportation and folded up to the position of FIGURE 7 for use. The arms **22***a* and **22***b* are releasably secured at a predetermined angle to the boom B by the securing arms **28***a* and **28***b*, FIGURE 7. These arms are pivotally secured to the boom B by the rivet **30** which extends through the arm **28***a* on one side of the boom B, and then through the arm **28***b* on the other side of the boom B, thus forming a pivotal support. At the ends opposite the rivet **30**, the arms **28***a* and **28***b* each have openings which register with openings in the arms **22***a* and **22***b*, respectively, to receive a bolt and wing nut unit **32***a* and **32***b*, respectively, to secure the respective arms **22***a* or **22***b* in the predetermined angled position in relation to the boom B. The nature of this angle and its significance to the operation of the unit is discussed hereafter. In the preferred form of the antenna illustrated, the angle is about 18 degrees. Arms **22***a*, **22***b*, **28***a* and **28***b* are preferably of aluminum.

Each arm **22***a* and **22***b* carries a series of spaced saddle brackets indicated generally at **34**, FIGURE 7. One such bracket is shown in detail in FIGURES 4 and 5. As shown, the bracket consists of a rigid saddle bracket **34***a* and an associated spring bracket **34***b*, the latter seating on the under surface of bracket **34***a*. Both are secured to the arm **22***a* (or **22***b*) by the rivet **36** which sandwiches them against the arm **22***a* (or **22***b*). The bracket **34***a* defines a pair of angled wings **34***c* forming faces against which the reflector conductor arms **40***d* and **38***d* seat at their flattened inboard end portions. The conductor arms are pivotally secured to the wings **34***c* by the rivets **42**, as shown, permitting the rotation of these arms between the solid and dotted line positions shown in FIGURE 5. Outboard the bracket **34***a*, the spring bracket **34***b* extends upwardly into the plane of the arms **38***d* and **40***d* as shown in FIGURE 4 and indicated at **34**e to form stops that limit

the movements of the arm **40***d* in the clockwise direction of FIGURE 5and the arm **38***d* in the counterclockwise direction of FIGURE 5 to the perpendicular position in relation to the arm **22***a*, as shown. Opposite the portion **34***e*, the spring bracket **34***b* forms upstanding latching spring arms **34***f* that extend into the paths of the arms **38***d* and **40***d* to secure the same in the perpendicular position in relation to the arm **22***a* as shown at arm **38***d*, FIGURE 5. These spring arms may be flexed to clear the arms **38***d* and **40***d* and permit the same to be folded to the parallel positions in relation to arm **22***a* shown by the dotted lines in FIGURE 5. It will be understood that the other reflector arms attached to the arms **22***a* and **22***b* are releasably secured in the outward positions shown in FIGURE 3 by like mechanism.

It will be noted from FIGURE 4 that there is an angle between each of the arms **38***d* and **40***d* and the diametrically opposed positions of these arms. This angle, as indicated, is about 16 degrees in the preferred form of the invention illustrated.

The arms attached to one side of the support arm **22***a* are indicated as **38***a* to **38***g*, inclusive, FIGURE 3. Being attached at one end to the substantially straight arm **22***a* and extending in the same direction by reason of the substantially identical brackets **34**, these arms are disposed substantially in a common plane. They therefore define a plane reflector element capable of reflecting oncoming radiation and directing the same in the opposite direction, which in this case is towards the driven element **12**. The arms **38***a*–**38***g* are relatively closely spaced to simulate the effect of a sheet reflector. The similar reflector arms on the opposite side of support arm **22***a* are indicated as **40***a* to **40***g*, inclusive, FIGURE 3, and define an adjacent similar by differently directed plane reflector. It will be noted that these two plane reflectors define a dihedral line coincident with the support arm **22***a*. The brackets **34** joining the arms **38***f*, **38***g*, **40***f* and **40***g* to the support arm **22***a* are provided with spring bracket portions **34***b* arranged to permit swing in the opposite direction of the swing of the other arms, as shown by the arrows in FIGURE 3.

The support arm **22***b* similarly has attached to it a series of reflector arms **44***a* to **44***g*, inclusive, defining one plane reflector and a series of reflector arms **46***a* to **46***g*, inclusive, on the opposite side defining a second plane reflector. These are secured to the support arm in the same fashion as is shown in FIGURES 4 and 5, except that the spring brackets **34** for the arms **44***b*, **44***g*, **46***b*, **46***f*, and **46***g* are arranged to permit swinging of the arms in the opposite direction to that shown in FIGURES 4 and 5 to fold to minimum length of the complete unit.

Each arm in the series, **38**, **40**, **44**, and **46** is preferably of the same length as the corresponding other arm. In the preferred form of the antenna shown, the lengths are:

| | Inches |
|---|---|
| **38***a*, **40***a*, **44***a*, and **46***a* | 14.5 |
| **38***b*, **40***b*, **44***b*, and **46***b* | 24 |
| **38***c*, **40***c*, **44***c*, and **46***c* | 23.5 |
| **38***d*, **40***d*, **44***d*, and **46***d* | 23 |
| **38***e*, **40***e*, **44***e*, and **46***e* | 21.5 |
| **38***f*, **40***f*, **44***f*, and **46***f* | 19.5 |
| **38***g*, **40***g*, **44***g*, and **46***g* | 14.5 |

All of these arms are preferably of aluminum. Each is spaced from the adjacent arm by about 4 inches

It will be observed that the plane defined by the arms **38***a* to **38***g* and the plane defined by the arms **44***a* to **44***g*, form a dihedral line in the horizontal plane passing through the boom B as seen in FIGURE 3. The plane defined by the arms **40***a* to **40***g* and the plane defined by the arms **46***a* to **46***g*, similarly forms a dihedral line in the same horizontal plane. These dihedral lines intersect the boom B (and the axis of the antenna) at the same point that the dihedral lines coincident with arms **22***a* and **22***b* intersect the boom. Because of the angular relationship between the support arms and the boom B, the four planes defined by the conducting arms provide a concave configuration towards the driven element **12**.

FIGURE 6 shows the general conformation of the antenna of FIGURES 1–7 when in the folded condition. In this condition, the driven element **12** and the reflectors **18***a* and **18***b* are rotated so that their axes are parallel to the boom (see dotted lines, FIGURE 7, as to driven element **12**). Each of the arms **38***a* to **38***g*, **40***a* to **40***g*, **44***a* to **44***g*, and **46***a* to **46***g* is folded to substantially parallel relation with the arm **22***a* (or **22***b*). And the wing nuts of the units **32***a* and **32***b*, FIGURE 7, have been loosened to permit the arms **28***a* and **28***b* to release arms **22***a* and **22***b*, respectively, and allow all of these arms to fold down to substantially parallel relationship with the boom B and against the boom. The result is a completely folded unit in which the various arms are in substantially juxtaposed parallel relation to fit in a box or otherwise be secured for storage or shipment.

It will be observed that in the preferred form of the invention shown in FIGURES 1–7, the lines L—L, FIGURE 9, are defined by the arms **22***a* and **22***b*, respectively, which are coincident with the vertical dihedral lines formed by the planar reflecting surfaces. It will also be observed that the lines L'—L', FIGURE 9, are defined by the planes formed by elements **38***a*–**38***g* and **44***a*–**44***g* extended to their intersection and by the planes formed by elements **40***a*–**40***g* and **46***a*–**46***g* extended to their intersection.

FIGURE 11 shows a modified form of the antenna of the present invention in which the capture area of the reflector is increased by an extension of the arm **22***a* (and a like extension of arm **22***b*, not shown). As shown, the outboard extension is formed by an arm **122***a*, which is pivotally secured to the boom by the bracket **124** in the same fashion that bracket **24** pivotally secures arm **22***a*. A suitable bolt secures the arms **22***a* and **122***a* together at the outboard end of arm **22***a* as indicated at **126**. The arm **122***a* extends beyond this point and carries a series of brackets **34** which in turn carry additional conducting reflector arms **128** to reflect additional energy to the driven element. In this fashion the effectiveness of the antenna is increased while still retaining the construction from linear elements. The arm **122***a* is oriented to approximate the slope of a parabola having its focus at the driven element and passing through bolt **126**.

For effective operation in a manner simulating a true parabolic antenna, it is necessary for the antenna to conform to certain constructional characteristics. This is best expressed by the difference between the focal distance of the true parabola having its apex at the intersection of the dihedral lines and the boom and the true parabola that just touches the dihedral lines on the side towards the focus of the parabola. The location of the focus is the driven element (**12**, FIGURES 1–7). The focal distance is the distance between the focus (F, FIGURE 8) and the point the true parabola intercepts the axis (X—X, FIGURE 8). If the difference between these two focal distances is too great, the antenna departs from the operation simulating a true parabola and the performance is thereby degraded. These two parabolas are referred to herein as defining the parabolic envelope of the dihedral lines.

In the preferred form of the antenna shown in FIGURES 1–7, the distance from the intersection of arms **22***a* and **22***b* and the driven element **12** is about 19.5 inches. With the angular relations shown, the focal distance of the parabola that focuses on the driven element and just fits inside the arms **22***a* and **22***b* is about 17.5 inches, giving a difference of the focal distances of about two inches, which is about ten percent of the larger focal distance. This has been found highly effective. The diagram of FIGURE 8 is approximately to scale with respect to these distances.

The dihedral lines in the horizontal plane of FIGURE 3 formed by the extensions of the planes defined by arms **38***a*–**38***g*, **40***a*–**40***g*, **44***a*–**44***g*, and **46***a*–**46***g*, bear an angular relationship to the boom similar to that of the arms **22***a* and **22***b* and provide a plot similar to that of FIGURE 8. In other words, the differences between the focal distances of the two parabolas as seen in the horizontal cross-section is about an inch and about five percent of the larger focal distance.

It should further be noted that in order to obtain advantage from the antenna construction herein described it is necessary for the support arms **22***a* and **22***b* to be of sufficient length to provide substantial reflected energy at the driven element **12**. In the preferred form of the invention shown in FIGURES 1–7, the arms **22***a* and **22***b* are about 26.5 inches long. This length is shown to approximate scale in FIGURE 8 as the length of the lines L—L. It will be noted that this length is essentially the length of the lines L—L that lies inboard the parabola B, that is the parabola passing through the point the dihedral lines intercept the boom. A length of these arms (and the planes they define) of about the same length as the distance required to intersect the parabola B is preferred. Similarly, the longest of the arms **38***a*–**38***g* (and the corresponding arms of the **40***a*–**40***g* series, **44***a*–**44***g* series, and **46***a*–**46***g* series) should be of similar length. In the preferred form of the invention shown in FIGURES 1–7 this length was chosen at 24 inches, which, while less than 26.5 inches, is of the same general magnitude.

While I have shown and described specific embodiments of the present invention, it will, of course, be understood that various modifications and alternative constructions may be made without departing from the true spirit and scope thereof. I therefore intend by the appended claims to cover all such modifications and alternative constructions as fall within their true spirit and scope.

What I claim as new and desire to secure by Letters Patent of the United States is:

**1.** An antenna for the frequency range of about 470 to 890 megacycles, suitable for folding, and nevertheless approximating the performance of a paraboloid of revolution about an axis having a focal point thereon, said antenna comprising:

a boom located on said axis;

a dipole driven element having an axis and responsive to signals within said frequency range, said element being located on said boom substantially at said focal point with its axis in a plane normal to the axis of the boom, whereby signals in the region of said focal point energize said dipole; and,

a reflector unit approximating the performance of a paraboloid of revolution, said unit having at least four planar reflector elements defining a pair of four dihedral lines intersecting the boom at a common point and oriented substantially perpendicular to each other as seen in a plane normal to the boom, said dihedral lines each being tilted in relation to said last plane by an approximately equal angle to define a concave configuration towards the driven element, the reflector unit having support arms located at two opposed ones of said dihedral angles, and parallel conducting reflector arms extending out from said support arms to form said planar reflector elements, the parabolas having said axis and said focus and defining the parabolic envelope of the dihedral lines being spaced by a small distance in relation to their focal distances.

**2.** An antenna for the frequency range of about 470 to 890 megacycles, suitable for folding, and nevertheless approximating the performance of a paraboloid of revolution about an axis having a focal point thereon, said antenna comprising:

a boom located on said axis;

a dipole driven element having an axis and responsive to signals within said frequency range, said element being located on said boom substantially at said focal point with its axis in a plane normal to the axis of the boom, whereby signals in the region of said focal point energize said dipole; and,

a reflector unit approximating the performance of a paraboloid of revolution having at least four planar reflector elements defining a pair of four dihedral lines intersecting the boom at a common point and oriented substantially perpendicular to each other as seen in a plane normal to the boom, said dihedral lines each being tilted in relation to said last plane by an approximately equal angle to define a concave configuration towards the driven element, the reflector unit having support arms located at two opposed ones of said dihedral angles and swingable about axes adjacent the boom to fold thereagainst, said reflector unit further having parallel conducting reflector arms extending out from said support arms in a V-configuration to form said planar reflector elements, said arms being swingable about axes adjacent said support arms to fold thereagainst, the parabolas having said axis and said focus and defining the parabolic envelopes of the dihedral lines being spaced by a small distance in relation to their focal distances; and,

means to releasably secure the reflector arms and the support arms in positions defining said dihedral angles.

**3.** An antenna for the frequency range of about 470 to 890 megacycles, suitable for folding, and nevertheless approximating the performance of a paraboloid of revolution about an axis having a focal point thereon, said antenna comprising:

a boom located on said axis;

a folded dipole driven element having an axis and responsive to signals within said frequency range, said dipole element being located on said boom substantially at said focal point with its axis in a plane normal to the axis of the boom and having parallel spaced conducting portions as seen from said plane;

a pair of first reflectors located on one side of said driven element about five inches therefrom and located parallel to said spaced conducting portions thereof, respectively, and in planes parallel to the boom and through said conducting portions, respectively;

a reflector unit on the other side of said driven element approximating the performance of a paraboloid of revolution, said reflector unit having at least four planar reflector elements defining four dihedral lines intersecting the boom at a common point spaced about 19 inches from said dipole element and oriented substantially perpendicular to each other as seen in a plane normal to the boom, said dihedral lines each being tilted about 16 degrees in relation to said last plane to define a concave configuration towards the driven element, the reflector unit having support arms located at two opposed ones of said dihedral angles and swingable about axes adjacent the boom to fold thereagainst, said reflector unit further having parallel conducting reflector arms extending out from said support arms to form said planar reflector elements, said arms being swingable about axes adjacent said support arms to fold thereagainst, the parabolas having said axis and said focus and defining the parabolic envelopes of the dihedral lines being spaced by a small distance in relation to 19 inches; and,

means to releasably secure the reflector arms and the support arms in positions defining said dihedral angles.

**4.** An antenna for the frequency range of about 470 to 890 megacycles, suitable for folding, and nevertheless approximating the performance of a paraboloid of revolu-

tion about an axis having a focal point thereon, said antenna comprising:

a boom located on said axis;

a folded dipole driven element having an axis and responsive to signals within said frequency range, said dipole element being located on said boom substantially at said focal point with its axis in a plane normal to the axis of the boom and having parallel spaced conducting portions as seen from said plane;

a pair of first reflectors located on one side of said driven element about five inches therefrom and located parallel to said spaced conducting portions thereof, respectively, and in planes parallel to the boom and through said conducting portions, respectively;

a reflector unit on the other side of said driven element approximating the performance of a paraboloid of revolution, said reflector unit having at least four planar reflector elements defining four dihedral lines intersecting the boom at a common point spaced about 19 inches from said dipole element and oriented substantially perpendicular to each other as seen in a plane normal to the boom, said dihedral lines each being tilted about 16 degrees in relation to said last plane to define a concave configuration towards the driven element, the reflector unit having support arms located at two opposed ones of said dihedral angles and swingable about axes adjacent the boom to fold thereagainst, said reflector unit further having parallel conducting reflector arms extending out from said support arms to form said planar reflector elements, said arms being swingable about axes adjacent said support arms to fold thereagainst, the parabolas having said axis and said focus and defining the parabolic envelopes a distance no greater than about two inches; and,

means to releasably secure the reflector arms and the support arms in positions defining said dihedral angles.

5. An antenna for the frequency range of about 470 to 890 megacycles, suitable for folding, and nevertheless approximating the performance of a paraboloid of revolution about an axis having a focal point thereon, said antenna comprising:

a boom located on said axis;

a folded dipole driven element having an axis and responsive to signals within said frequency range, said dipole element being located on said boom substantially at said focal point with its axis in a plane normal to the axis of the boom and having parallel spaced conducting portions as seen from said plane;

a pair of first reflectors located on one side of said driven element and located parallel to said spaced conducting portions thereof, respectively, and in planes parallel to the boom and through said conducting portions, respectively;

a reflector unit on the other side of said driven element approximating the performance of a paraboloid of revolution, said reflector unit having at least four planar reflector elements defining four dihedral lines intersecting the boom at a common point and oriented substantially perpendicular to each other as seen in a plane normal to the boom, said dihedral lines each being tilted in relation to said last plane by an approximately equal angle to define a concave configuration towards the driven element, the reflector unit having support arms located at two opposed ones of said dihedral angles and swingable about axes adjacent the boom to fold thereagainst, said reflector unit further having parallel conducting reflector arms extending out from said support arms to form said planar reflector elements, said arms being swingable about axes adjacent said support arms to fold thereagainst, the parabolas having said axis and said focus and defining the parabolic envelopes of the dihedral lines being spaced by a small distance in relation to their focal distances; and,

means to releasably secure the reflector arms and the support arms in positions defining said dihedral angles.

6. An antenna for the frequency range of about 470 to 890 megacycles, suitable for folding, and nevertheless approximating the performance of a paraboloid of revolution about an axis having a focal point thereon, said antenna comprising:

a boom located on said axis;

a folded dipole driven element having an axis and responsive to signals within said frequency range, said dipole element being located on said boom substantially at said focal point with its axis in a plane normal to the axis of the boom and having parallel spaced conducting portions as seen from said plane;

a pair of first reflectors located on one side of said driven element and located parallel to said spaced conducting portions thereof, respectively, and in planes parallel to the boom and through said conducting portions, respectively;

a reflector unit on the other side of said driven element approximating the performance of a paraboloid of revolution, said reflector unit having at least four planar reflector elements defining four dihedral lines intersecting the boom at a common point and oriented substantially perpendicular to each other as seen in a plane normal to the boom, said dihedral lines each being tilted in relation to said last plane by an approximately equal angle to define a concave configuration towards the driven element, the reflector unit having support arms located at two opposed ones of said dihedral angles and swingable about axes adjacent the boom to fold thereagainst, said reflector unit further having parallel conducting reflector arms extending out from said support arms to form said planar reflector elements, said arms being swingable about axes adjacent said support arms to fold thereagainst, the parabolas having said axis and said focus and defining the parabolic envelopes of the dihedral lines being spaced by no more than about ten percent of the largest focal distance; and,

means to releasably secure the reflector arms and the support arms in positions defining said dihedral angles.

7. An antenna for the frequency range of about 470 to 890 megacycles, suitable for folding, and nevertheless approximating the performance of a paraboloid of revolution about an axis having a focal point thereon, said antenna comprising:

a boom located on said axis;

a dipole driven element having an axis and responsive to signals within said frequency range, said element being located on said boom substantially at said focal point with its axis in a plane normal to the axis of the boom, whereby signals in the region of said focal point energize said dipole;

a reflector unit approximating the performance of a paraboloid of revolution, said unit having at least four planar reflector elements defining a pair of four dihedral lines intersecting the boom at a common point and oriented substantially perpendicular to each other as seen in a plane normal to the boom, said dihedral lines each being tilted in relation to said last plane by an approximately equal angle to define a concave configuration towards the driven element, the reflector unit having support arms located at two opposed ones of said dihedral angles, and parallel conducting reflector arms extending out from said support arms to form said planar reflector elements, the parabolas having said axis and said focus and defining the parabolic envelopes of the di-

hedral lines being spaced by a small distance in relation to their focal distances; and,

four additional reflector elements outboard said first mentioned reflector elements said last reflectors being defined by a pair of support arms extending outwardly from the outboard ends of said first support arms and parallel conducting reflector arms extending out from the same.



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