United States Patent

[11] 3,587,109

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[73] Assignee **said Martino, by said Blaese**

[54] **OMNIDIRECTIONAL COMMUNICATIONS ANTENNA HAVING CAPACITIVELY LOADED TOP**
14 Claims, 8 Drawing Figs.

[52] **U.S. Cl.** **343/792,** 343/830, 343/899
[51] **Int. Cl.** **H01q 9/16**
[50] **Field of Search** ..... 343/790-—792, 828—831, 890, 908, 899, 843, 874; 333/25, 26

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ABSTRACT: A communications antenna which includes a vertical conductive mast and a pair of one-quarter wave length conductors extending downwardly from a first reference level to a second reference level. The conductors are electrically connected at the second reference level and one of the conductors is electrically connected to the mast at the first reference level. A one-eighth wavelength conductor extends upwardly from the first reference level and is electrically connected to the mast at the first reference level. The one-eighth wavelength conductor is capacitively loaded at its top to act as a one-quarter wavelength conductor.

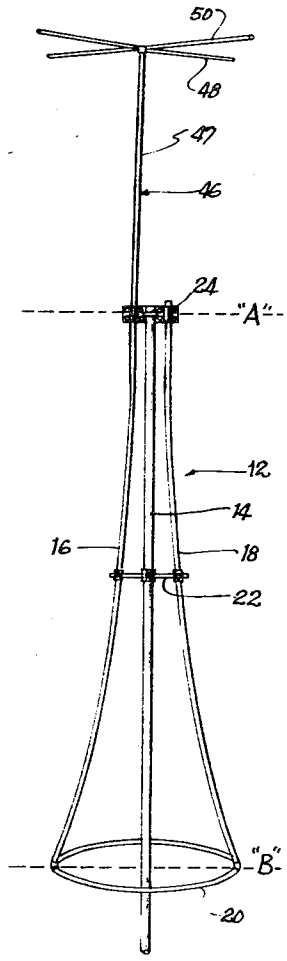


FIG. 1a
PRIOR ART

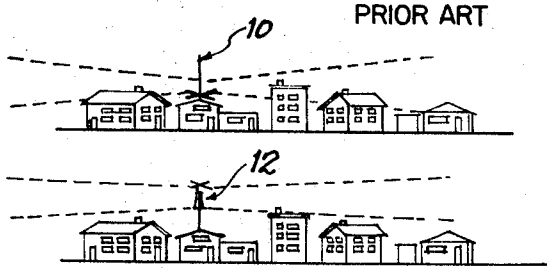


FIG. 1b

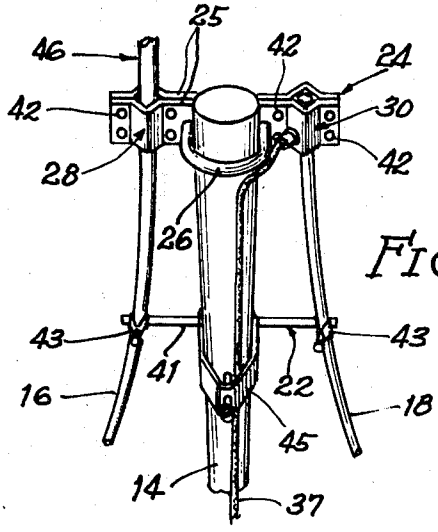


FIG. 3

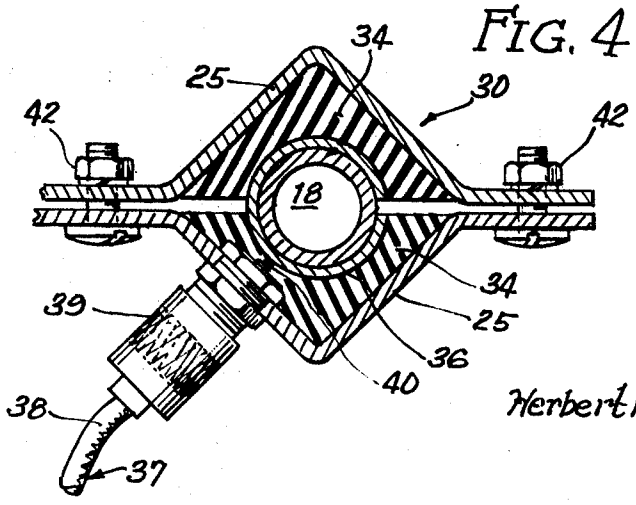


FIG. 4

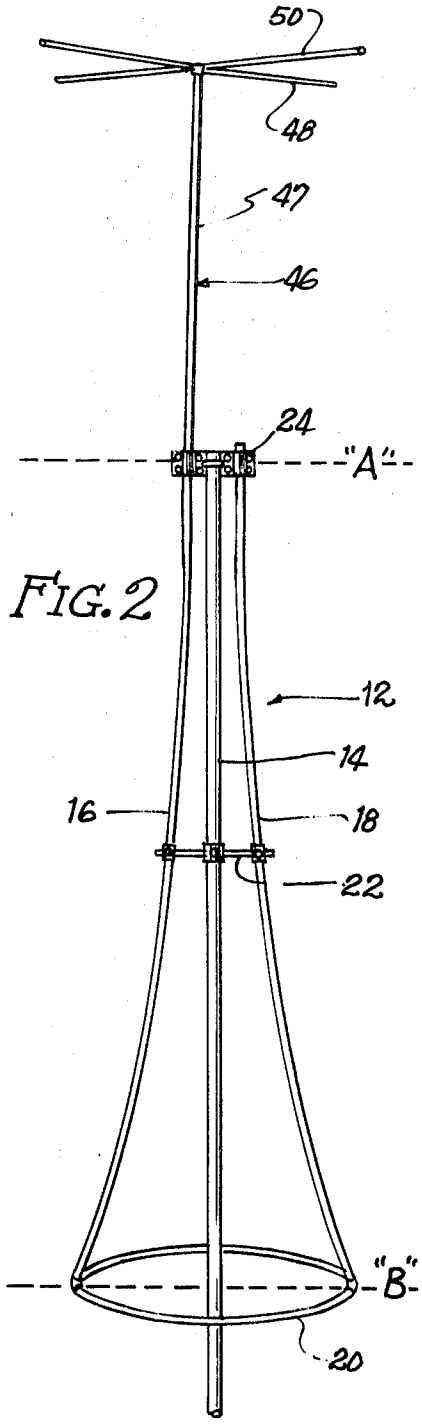


FIG. 2

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FIG. 7

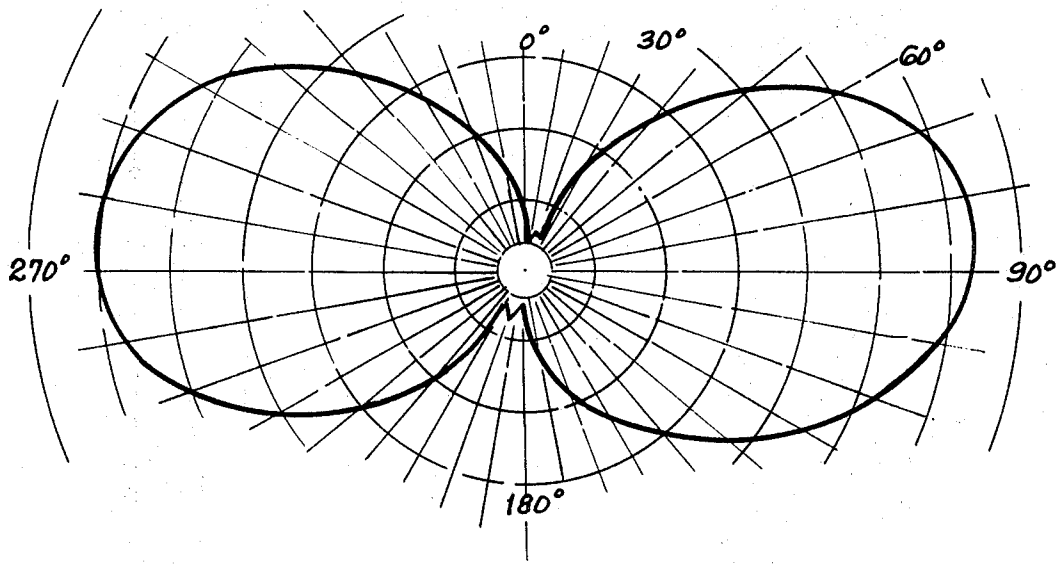


FIG. 5

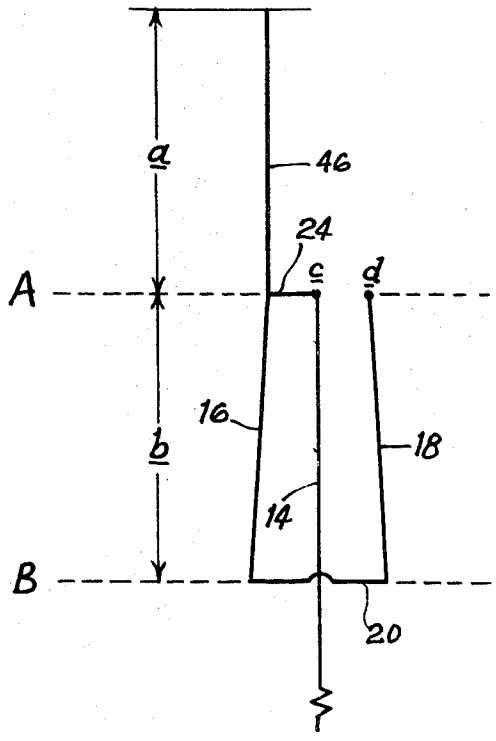
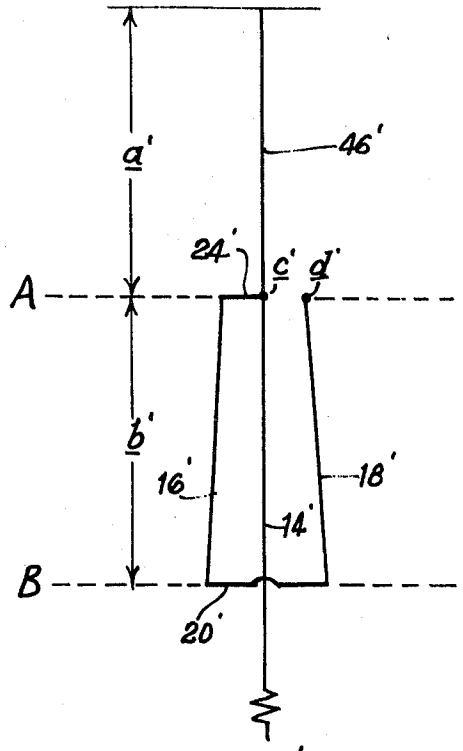


FIG. 6



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OMNIDIRECTIONAL COMMUNICATIONS ANTENNA HAVING CAPACITIVELY LOADED TOP

This invention relates to antennas, and more particularly to omnidirectional communications antennas which are especially useful for citizens band applications.

Present Federal Communications Commission regulations limit the height of citizens band antennas to 20 feet above the highest tip of one's property, and require direct line of sight radiation (with minimal ionosphere reflection). Prior art antennas for citizens band use generally comprise a one-half wavelength or five-eighth wavelength monopole which is loaded at the bottom. Because of such loading, prior art antennas of that type produce maximum current in the lower portion of the antenna, and, therefore, such antennas effectively radiate from their lower portions. It has been found that a citizens band antenna can be made which does not exceed the legal height limitation but which effectively radiates from its upper portion. This is extremely advantageous because it alleviates the problem of shadow caused by houses and other ground supported objects which may be located near such an antenna and which would otherwise tend to block its transmission and reception paths.

Tests on the antenna of one embodiment of the present invention have shown, among other things, that its construction provides a radiation pattern that is lower than the radiation pattern of prior art antennas. This, therefore, reduces scatter and produces higher gain. In use, the antenna of this invention yields a signal received at distant points that is stronger than the signal received using prior art antennas under identical conditions and at the same location. This and other advantages result from the practice of the instant invention.

In accordance with this invention there is provided a communications antenna having a variety of uses, but which has special application for citizens band (CB) use. The antenna of the illustrative embodiments of the invention comprises a vertical first conductor and a pair of conductor members on opposite sides of the first conductor and extending between parallel first and second horizontal levels. The first conductor terminates at the uppermost level and projects downwardly below the second level, the latter preferably a distance at least equal to the distance between the levels. The pair of conductor members are electrically connected at the lower level, and one of the conductor members is electrically connected at the upper level to the first conductor and to a projecting conductor which extends upwardly from that upper level. The projecting conductor has an effective electrical length equal to the length of the conductor members. Transmission or feed leads are provided at the upper level.

A more detailed explanation of the invention and of its advantages is provided in the following description and is illustrated in the accompanying drawings, in which:

FIG. 1*a* is a pictorial elevational view of a conventional prior art antenna in actual use;

FIG. 1*b* is an elevational view, similar to the view of FIG. 1*a*, showing in use an antenna according to the principles of the present invention;

FIG. 2 is a front elevational view of an antenna constructed in accordance with the principles of the present invention;

FIG. 3 is a fragmentary perspective view of a portion of the antenna of FIG. 2;

FIG. 4 is a fragmentary top plan view of a portion of the antenna illustrated in FIGS. 2 and 3;

FIG. 5 is a schematic diagram of the antenna of FIG. 2;

FIG. 6 is a schematic diagram of a modified antenna according to a second embodiment of the present invention; and

FIG. 7 is a polar diagram showing the radiation characteristics of an antenna of FIG. 2.

A typical prior art antenna is pictorially illustrated in FIG. 1*a*. In such an ordinary collinear or ground plane antenna **10**, radiation is spread near the junction of the radials and the vertical member at the base and little radiation is effected at the top of the antenna. Accordingly, interference from nearby objects is frequently encountered substantially reducing the signal strength of such an antenna.

A comparable environmental showing of an antenna **12** of this invention in use is pictorially illustrated in FIG. 1*b*. There it can be observed that maximum signal strength is developed at and near the top of the antenna and with a lower takeoff angle assuring maximum signal power (within legal limits on height) over nearby ground supported objects such as buildings, power lines, trees and difficult terrain that would interfere with or block performance of ordinary antennas. Because the maximum height of certain classes of antennas is restricted by law and governmental regulation, the provision of an antenna having the capacity to provide radiation from its upper portion is highly advantageous, particularly when the takeoff angle of the signal is low.

Referring now to a first embodiment of an antenna of this invention and to FIG. 2, antenna **12** comprises a first conductor **14**. As there illustrated, first conductor **14** is a vertical boom member or mast which is electrically conductive. An elongate second conductor **16** and an elongate third conductor **18** are positioned on opposite sides of conductor **14** and extend vertically downwardly generally from a first horizontal plane or level A to a second parallel horizontal plane or level B. Conductors **16** and **18** are equidistantly spaced from first conductor **14** and are oppositely positioned. They lie generally along a surface of revolution about first conductor **14** and flare downwardly and outwardly from level A to level B in which lies a fourth conductor **20** which as illustrated comprises a conductive loop encircling first conductor **14**. Fourth conductor **20** mechanically and electrically interconnects conductors **16** and **18**, as by sheet metal screws or nuts and bolts (not shown).

To position conductors **14**, **16**, **18** and **20**, other fastening means are provided. To that end a clamp assembly **24** is provided at level A. Clamp assembly **24** comprises a pair of clamping elements **25** which grip the ends of conductors **16** and **18** and which mount U-bolt **26** for anchorage of boom member **14** thereto. The complementary clamping elements define an end portion **28** for retaining conductor **16**, and a second end portion **30** for retaining conductor **18**. As shown in greater detail in FIG. 4, end portion **30** comprises insulative bushing means or bushing segments **34** and a split brass ring **36**. Ring **36** is provided for encircling and contacting the conductor **18**.

A coaxial transmission means or cable **37** runs up the vertical boom to level A and terminates in a coaxial connector **39** secured to the clamp assembly. A first transmission feed lead **38** of cable **37**, its braided cover, is electrically connected to clamping element **25** and the inner lead **40** is electrically connected to split brass ring **36** (hence to the third conductor **18** at level A). The third conductor **18** is insulated from the first and second conductors at level A at which the clamp assembly **24** lies by insulative segments **34**. Four bolts and nuts **42** are provided adjacent end portion **30** to compress segments **34** of the insulative bushing against each other to cause the split ring to engage conductor **18** tightly and to provide a secure electrical connection therebetween and at level A.

End portion **28** is configured to clamp directly to conductor **16**, thereby to electrically connect the first and second conductors, **14** and **16**, at level A. Four further nuts and bolts **42** are provided to anchor conductor **16** to the antenna assembly. Because U-bolt **26** firmly anchors and electrically connects vertical boom **14** to clamp assembly **24**, it will be apparent that clamp assembly **24** serves as a fifth conductor at level A. Mechanically, it is also clear that U-bolt **26** firmly anchors clamp assembly **24** and vertical boom **14** at level A so that all of conductors **14**, **16** and **18** are firmly interconnected mechanically at level or plane A.

To aid in providing the aforementioned flare for conductors **16** and **18**, the conductors are secured to the first conductor **14** by a suitable insulating spreader clamp **22**. Spreader clamp assembly **22** is preferably of fiber glass but may take any other form which will serve to insulate conductors **14**, **16** and **18**

from each other thereat. A suitable spreader clamp assembly is pictorially illustrated in FIG. 2 and is shown in greater detail in FIG. 3 to include a clamp band **45** surrounding vertical boom **14** and a fiber glass bar **41** secured thereto, the ends of which bar are mechanically secured as by loop clamps **43** to the conductors **16** and **18**. The length of the bar arms and the point of interconnection therealong to the conductors will determine the amount of flare of conductors **16** and **18** between levels A and B.

A sixth conductor **46** projects upwardly from level A and clamp assembly **24**. In the embodiment of FIGS. **2** and **3**, conductor **46** comprises a one-fourth wavelength assemblage, a straight vertically projecting component of which is integrally formed with second conductor **16**. The upwardly extending integral component **47** is one-eighth wavelength in length (one-half the length of conductors **16** and **18**) and is topped by capacitive loading means such as a transverse conductor means which is illustrated as crossed conductors **48** and **50**, which in the illustrated embodiment are about one-eighth wavelength long. Crossed conductors **48** and **50** are anchored as by threaded fastening means to the end of portion **47** to integrate the antenna assembly and to connect portion **47** and crossed conductors **48** and **50** to each other electrically and mechanically. By utilizing a one-eighth wavelength portion **47** with crossed conductors one-eighth wavelength long, an effective one-fourth wavelength projecting antenna portion is obtained above level A. Because principal radiation occurs between level B and the level of the crossed conductors, if a larger band width is desired, portion **47** may be increased in length and crossed conductors **48** and **50** reduced in length or eliminated to give the same effective wavelength, i.e., one-fourth wavelength.

The antenna illustrated in FIGS. **2—5** is shown to be vertically oriented which for many uses is the most desirable, for example for CB use. However, it is clear that is may be horizontally oriented and may, therefore, be supported by a horizontal boom member rather than the vertical boom member or mast **14**. In such a construction the horizontal planes or levels A and B would then be vertical parallel planes or levels.

Although in normal use the boom member **14** will be quite long, it has been found that the takeoff angle of the signal at maximum strength tilts upwardly more as the first conductor **14** decreases in length from one-half of the wavelength on which the antenna is intended to operate. Stated another way, the first conductor **14** should preferably project beyond level B a distance at least equal to about the length of conductors **16** and **18**. When the length of the first conductor **14** is so dimensioned, the takeoff angle at maximum signal strength is optimized for such as CB use and the like. It will be apparent, however, that where a steeper takeoff angle at maximum strength is to be desired in other environments, the length of conductor **14** may be reduced.

It will be observed that conductors **16** and **18** flare outwardly and downwardly. Their relative diameters and the spacing of them from each other and from the mast, as well as the flare, controls the impedance at *c*, *d* (FIG. **5**). This impedance preferably is 50 ohms in accordance with the typical construction described and for CB use. However, the diameters of the parts, the spacing and the flare may be varied to obtain either different impedances or the same impedance via variance of diameters, spacing and flare in a manner that will be understood by those skilled in the art for the antenna to operate most efficiently.

It has been found, however, that the flare affects not only the impedance, but also influences the takeoff angle at maximum signal strength. The flare of the construction described hereinafter provides a takeoff angle that is about the maximum reasonably allowable for most efficient CB use of this antenna. When the flare was omitted and the conductors **16** and **18** were tested parallel to the first conductor **14** it was found that the takeoff angle at maximum signal strength was as much as 10 ° to 15° below the horizontal. Although for certain uses, such a downward tilt may be desirable, it appears that the optimum disposition of conductors **16** and **18** lies between the parallel positioning of straight conductors **16** and **18** and the flared positioning of flared conductors **16** and **18** with respect to the conductor **14**, as described in conjunction with the specific embodiment illustrated in the drawings.

The electrical circuit of the antenna of FIG. **2** is illustrated schematically in FIG. **5**. Dimensions *a* and *b* are each one-fourth wavelength in electrical length, although, as stated above, conductor **46** may be actually shortened by capacitively loading the antenna at its top. Of course, with a citizens band antenna a shorter portion **47** effectively raises the signal pattern beyond that obtained with prior art CB antennas. The coaxial cable connections at level A are illustrated as being at points *c* and *d*.

It will be noted that conductors **18**, **20**, **16** and **24** define an open conductive loop having opposite side sections comprising conductors **16**, **18** and a loop segment or loop portion comprising conductor **20** electrically connecting the ends of the side sections at level or plane B. In that construction the conductive loop is fed by a first transmission lead or feed means adjacent the intersections of one side section of the conductive loop, the vertically projecting conductor and the first conductor, and by a second lead means to the other side section at plane A. A construction wherein points *c* and *d* are electrically coupled, but where the circuitry is otherwise similar, will produce a similar result, i.e., a closed conductive loop may also be used.

A modified antenna construction is shown in FIG. **6**, in which a "prime" is added to corresponding reference numerals. In the embodiment of FIG. **6**, the sixth conductor **46'** is an integral extension of the vertical boom **14'** rather than of conductor **16** as illustrated in FIGS. **2—5**.

In the embodiment of FIG. **6** the clamp assembly **24'** electrically connects conductor **16'** to conductor or mast **14'** at level A. It is preferred that conductor **46'**, which extends upwardly from base clamp **24'**, be one-eighth wavelength long and be loaded at the top with crossed conductors to form the equivalent of a one-fourth wavelength monopole above the base clamp **24'** as described previously. The coaxial cable connections *c'* and *d'* are comparable to those of FIG. **5**. Dimensions *a'* and *b'* are each one-fourth wavelength in electrical length in the embodiment of FIG. **6**, as with the embodiment of FIG. **5**.

The antenna of the present invention has been found to be particularly useful in citizens band operation at about 27—29.7 megahertz. It is to be understood, however, that the antenna may be used at other frequencies, for both propagation and reception. Maximum signal strength is at the top portion of the antenna, as contrasted with prior art antennas in which the maximum signal strength is well below the maximum legal height. As a result, maximum signal power can be transmitted and received over nearby buildings which would normally block and interfere with the transmission and reception of prior art antennas.

Performance tests on the FIGS. **2—5** antenna have shown that the antenna produces radiation at a low angle and with a relatively narrow lobe, thereby concentrating the signal at a more useful angle and level resulting in improved higher received signal level.

Indeed the antenna construction substantially counteracts the tendency of prior art antennas to tilt the radiated signals substantially upwardly. A polar diagram showing the radiation characteristics of the antenna of FIG. **2** is shown in FIG. **7**.

Performance tests resulting in the diagram of FIG. **7** were run. For one such test, an antenna scaled down to proportionate wavelength dimensions for operation at 146 megahertz was prepared. Thus the first conductor or mast **14** was 33.5 inches in length. The distance between levels A and B was 17.75 inches and the conductor **46** (unloaded) was 15.75 inches. Conductors **16** and **18** flared outwardly as described herein. The pattern was measured at a distance of about 100 feet from the antenna.

It is seen that the beam at maximum strength is tilted upwardly from horizontal only about 5° and that the radiation pattern lobes are of an optimum shape.

In other tests of the same installation, but with shorter mast lengths of 21.5 inches, 24.5 inches and 27.5 inches it was found that the radiation angle at maximum beam strength tilted upwardly substantially more. The conclusion to be drawn, therefore, was that a mast having a length below level B of about one-quarter wavelength, i.e., about the length of the conductors **16**, **18** gave an optimum takeoff angle.

A typical antenna now being made and marketed in accordance with the principles of this invention is adapted to be mounted to a mast **14** which may be a 20-foot steel or aluminum mast and which may be 1½ inches in diameter. A 4-foot section of one-half inch aluminum tubing which is flat at one end is provided with four 2-foot radial aluminum tube members each of which is three-eighth inch in diameter. Each is flattened at one end and bored to facilitate securance to the 4-foot section and to project radially therefrom to constitute conductor **46**. The 4 -foot section comprises conductor component or portion **47** and pairs of the 2-foot sections comprise the transverse component or crossed conductors **48**, **50**.

A pair of clamping elements **25** of aluminum are provided. Two 8-foot sections of one-half inch diameter aluminum tubing are positioned in the end portions **28**, **30**, one of the two 8-foot sections (conductor **16**) being proportioned to receive the end of conductor portion **47** at the clamp members and in end portion **28**. Each of the 8-foot sections is fabricated from a pair of 4-foot sections of tubing which sections are secured to each other at adjacent ends. These 8-foot sections then comprise conductors **16** and **18** and are clamped in end portions **28** and **30** constructed as described previously. From center-to-center, conductors **16** and **18** in end portions **28**, **30** are spaced apart approximately 6 inches. At the time conductors **16** and **18** are clamped in the clamp assembly **24**, conductor **46** is secured to the clamp assembly and made electrically integral with conductor **16**.

Next, two pairs of three-eighth inch aluminum tubing each piece being bent to a 90° arc are secured to each other by fasteners and by loop clamps and to the lower ends (level B) of the 8-foot sections **16** and **18**. This then provides a circular loop segment electrically connecting the lower ends of conductors **16**, **18** to each other and at a distance of about 30 inches center-to-center. Intermediate their lengths, i.e., at the 4-foot point, sections **16** and **18** are provided with a spreader clamp assembly **22** which includes a fiber glass rod **41** approximately 13 inches in length and three-eighth inch in diameter. This is secured to mast **14** by a stainless steel loop clamp **39** and to each of conductors **16** and **18** by loop clamps **43**. From center-to-center, conductors **16** and **18** are each spaced apart about 12 inches center-to-center on opposite sides of mast **14**. Of course, prior to securing the fiber glass rod to the mast, a U-bolt clamp **26** is positioned about the mast at the clamp assembly **24** to mount the antenna to the mast. Thereafter the fiber glass rod is secured to the mast. The clamping and proportioning provides a significant flare of the conductors **16**, **18**, which as previously described, influences both takeoff angle and impedance. The takeoff angle and impedance may be varied or altered, as described hereinbefore.

Of course, as explained, coaxial cable feed connections **38** and **40** are made to the clamp assembly and to the split brass ring and the cable **37** itself is suitably taped to the mast. It has been found that when an outer braided conductor forms the cover of the coaxial cable, this may serve as the first conductor. In such a case, the conductive mast **14** may be omitted and a nonconductive support substituted therefore. When that is done, it is important to make certain that the coaxial cable is positioned and centered properly with respect to the other conductor members described.

By way of summary, conductors **16** and **18** are each about 8 feet long, conductor portion **47** is about 4 feet long, conductors **48**, **50** are each about 4 feet long, and conductor **20** is approximately 8 feet in circumference. It is to be noted that each of the conductors **16** and **18** is very slightly under one-quarter wave length in length at 29.7 megahertz. The antenna, therefore, operates most efficiently and effectively at that frequency. It has been determined that the antenna described herein, wherein the one-quarter wavelength components are 8 feet long, operates efficiently and satisfactorily within the 27—29.7 megahertz range demonstrating that the antenna is effective where the quarter wavelength components approximate one-quarter wavelength in electrical length. This is especially so when the conductor **46** is one-quarter wavelength, for the efficiency drops somewhat for a broader band when the conductor **46** is capacitively loaded, as by the crossed conductors **48** and **50**.

An antenna constructed in accordance with the specific embodiment just described is 12 feet in length (except for the mast which desirably extends at least about 8 feet below level B) and weights about 3½ pounds. It is omnidirectional and has an impedance of 50 ohms, a power gain of about **4** db. over the isotropic radiator, will operate on powers of several kilowatts, is vertically polarized, is effective on a frequency band of 27—29.7 megahertz for such as CB use, and is particularly effective within that entire range when crossed conductors **48** and **50** are omitted and conductor **46** comprises a projecting conductor element **47** about one-quarter wavelength in length. It will be apparent that antennas of other physical sizes proportioned to the wavelength of other frequencies may also be constructed in accordance with this invention as well. It has a standing wave ratio (pretuned) of less than 1.4:1 on 23 CB channels.

It is to be understood that the embodiments of the invention that have been shown and described are merely illustrative, and that various substitutions and modifications may be effected by those skilled in the art without departing from the spirit and scope of the novel concept and principles of the invention. The principles of the present invention are applicable to antennas utilized for both the reception and propagation of electromagnetic energy. Further, the scope of the invention is not intended to be limited by any described frequency range or theory of operation.

What we claim is:

1. In a communications antenna having a first vertical conductor, a pair of spaced apart conducting members suspended at their tops from said vertical conductor on opposite sides of said vertical conductor, said conducting members extending downwardly from a first horizontal level at their tops to a second horizontal level at their bottoms, said pair of conducting members being equal in length, means electrically connecting the bottoms of said pair of conducting members, a vertical conducting element electrically connected to one of said pair of conducting members and extending vertically upwardly from said first horizontal level and to an elevation equal to at least one-half the length of each of said conducting members, and transmission leads, one of which is electrically connected to said vertical conductor at said first level and to the top of the conducting member to which said vertical conducting element is electrically connected and a second of which is electrically connected to the other of said conducting members at the first horizontal level.

2. In the antenna of claim **1** in which said vertical conducting element comprises a vertical component about one-half the length of each of said conducting members and a horizontal component having a horizontal extent of about one-half the length of each of said conducting members.

3. In a communications antenna; a first conducting element projecting in a first direction from a first reference plane towards a second parallel reference plane, a pair of spaced apart elongate conducting members each supported at one of their respective ends on said conducting element and spaced substantially equidistantly from said conducting element, said conducting members extending from said first reference plane at their said one ends to said second generally parallel reference plane at their other ends, said pair of conducting members being substantially equal in length, means electri-

cally connecting the said other ends of said pair of conducting members to each other, a projecting conductor electrically connected at said first reference plane to one of said pair of conducting members and extending in the direction away from said second reference plane a distance from said first reference plane that is equal to at least about one-half the length of said conducting members, and transmission lead means, one of which is electrically connected to said conducting element at said first plane and to the said one end of said one conducting member to which said projecting conductor is electrically connected, and the other of which is electrically connected to the other of said conducting members.

4. In the antenna of claim 3 in which said first conducting element extends beyond said second reference plane a distance at least equal to about the distance between said first and second planes.

5. In the antenna of claim 3 in which said projecting conductor comprises a straight section about one-half the length of said conducting members and capacitive loading means at the free end of said projecting conductor.

6. In the antenna of claim 3 in which said first conducting element is vertically oriented, and further embodying means for supporting said antenna in a vertical orientation.

7. In the antenna of claim 6 in which said first conducting element and said means for supporting said antenna in a vertical position are integrally formed as an electrically conductive elongate vertical boom member.

8. In a communications antenna comprising a first elongate conducting element projecting from a first reference plane toward a second parallel reference plane, a conductive loop generally parallel to said elongate conducting element and including opposite side sections disposed on opposite sides of said conducting element and a loop segment, said side sections extending between said first plane at one end of each side section and said second plane at the other end of each side section, at least one of said side sections being electrically coupled to said conducting element at said first plane, said loop segment electrically connecting the other ends of said pair of side sections at said second plane, a projecting conductor electrically connected to said one side section and extending from said first plane away from said second plane a distance equal to at least about one-half the length of each of said side sections, and transmission lead means comprising a first lead electrically coupled to said conducting element, the conductive loop and the projecting conductor in said first plane, and a second lead connected to the other of said side sections.

9. In the communications antenna of claim 8, wherein the conductive loop is an open loop.

10. In the communications antenna of claim 8, wherein the first conducting element is straight and said conductive loop side sections lie along a surface of revolution generated about the axis of said first conducting element.

11. In the communications antenna of claim 8, wherein said second lead is connected to said other side section at said first plane.

12. In the communications antenna of claim 8, wherein said first conducting element is vertically oriented and comprises an electrically conductive boom member extending below said second plane a distance equal to at least about the lengths of said side sections.

13. In the communications antenna of claim 8, wherein said side sections are generally concentric about a straight first conducting element and flare outwardly of said first conducting element from said first plane to said second plane.

14. In the communications antenna of claim 8, wherein said first conducting element is straight and said side sections are substantially straight and substantially equidistantly and oppositely spaced from said first conducting element.