July 5, 1966 R. O. BYKERK 3,259,901

SHORT HALF-WAVE ANTENNA WITH PLURAL LOADING COILS

Filed Jan. 2, 1962 2 Sheets-Sheet 1

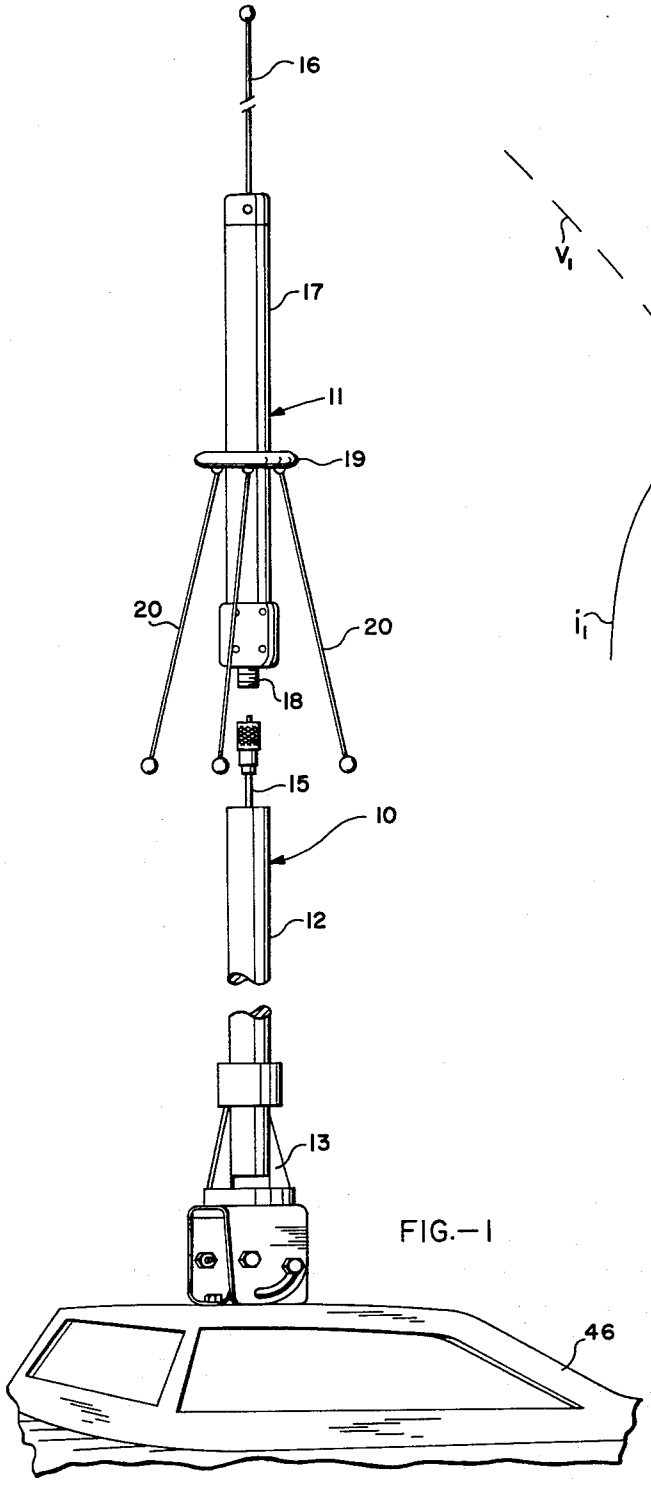

FIG.-1

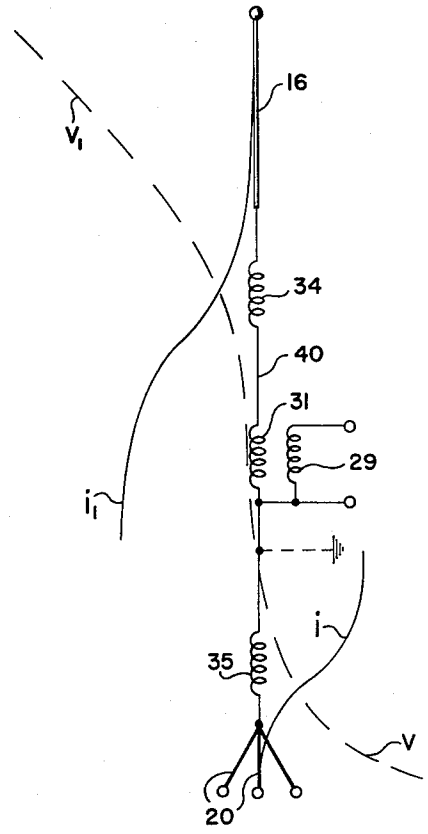

FIG.-2

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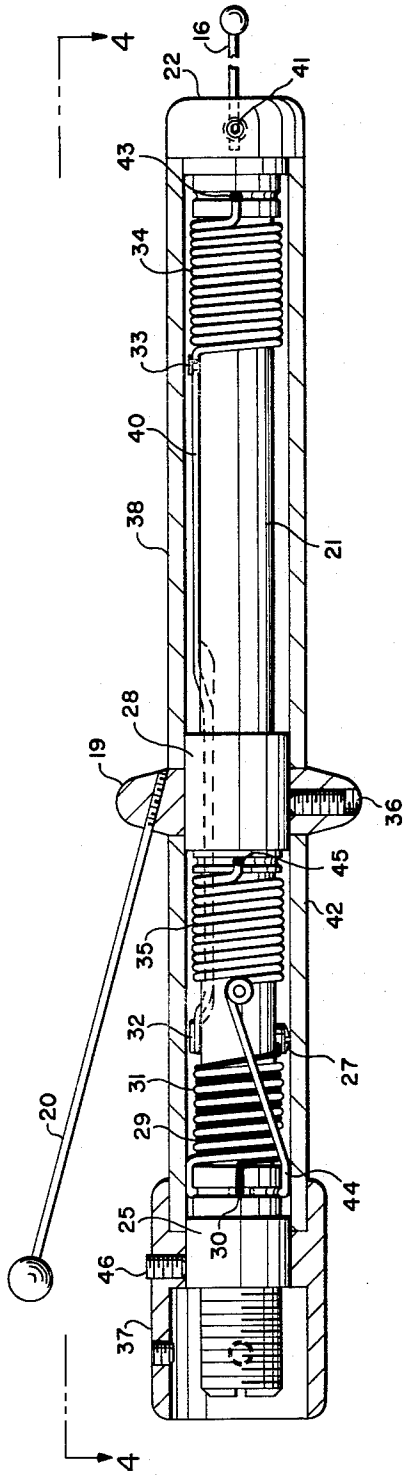

FIG. - 3

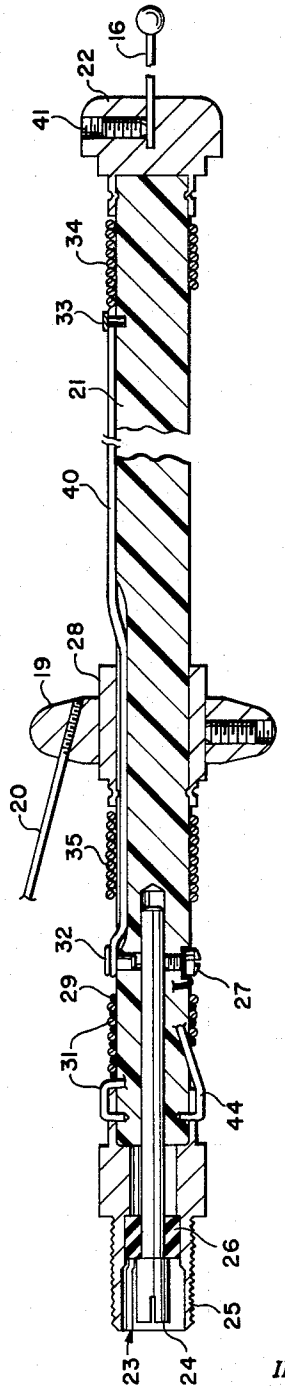

FIG. - 4

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SHORT HALF-WAVE ANTENNA WITH PLURAL LOADING COILS

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This invention relates to antennas, more particularly to a short half-wave antenna.

Ideally, the length of a communication antenna should be exactly the length of a natural half-wave in the particular communication frequency being used. In the 27 mc. citizens band, for which the invention is preferably designed, the physical length of the natural half-wave is seventeen feet, four inches.

Where the antenna is to be used with mobile communication equipment, a seventeen foot, four inch radiating element is obviously undesirable and impractical. Moreover, section fifteen of the F.C.C. regulations requires that a mobile or base station communication antenna must not exceed sixty inches when used with unlicensed 100 milliwatt equipment.

In base station installations, which are permitted to use longer antennas, the available space often imposes limitations on the size antenna which can be used. For these reasons it is necessary to provide an antenna which in length is physically shortened, but electrically equivalent to the length of a natural half-wave.

Accordingly, it is an object of this invention to provide a new and improved physically shortened electrical half-wave antenna.

It is another object of this invention to provide a physically shortened half-wave antenna which is efficient and has a negligible decibel loss.

Other objects and a fuller understanding of the invention may be had by referring to the following description and claims taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a partially exploded view of a completed antenna assembly employing the antenna of this invention and is exaggerated with respect to the vehicle upon which it is mounted;

FIGURE 2 is a schematic representation of the electrical configuration of the antenna of this invention;

FIGURE 3 is a foreshortened detail view of the antenna with parts broken away and removed; and ,

FIGURE 4 is a partial section with parts removed, taken at 4—4 of FIGURE 3.

Referring now to FIGURE 1, a complete antenna assembly is indicated generally by reference character **10**. The antenna assembly **10** includes an antenna structure **11**, a supporting tube **12**, and a mounting bracket assembly **13**. For illustration purposes, the antenna assembly **10** has been exaggerated in size with respect to a supporting vessel or vehicle **46**.

Referring again to FIGURE 1, the antenna **11** includes a whip radiating element **16** protruding from one end of a coil assembly **17**. A connector **18** is provided at the other end of coil assembly **17**. The connector **18** will be fastened to a coaxial cable **15** for connection to mobile communication equipment carried on board the vehicle. A metallic ring **19** surrounds the coil assembly at a point off center and near the connector end. A plurality of radials **20** extend outwardly from the metallic ring **19** in the direction of the connector end of the coil assembly **17**.

The electrical circuit configuration for the antenna **11** is shown in FIGURE 2. Electrically, the antenna **11** may be considered as an off-center fed single element antenna. Mutually coupled primary and secondary coils **29**, **31** supply the antenna with radio frequency energy from a transmitter. The coils **29**, **31** are positioned in the antenna element at a point off-center between its ends where the impedance of the antenna matches the output impedance of the transmission line.

The energy supplied to the primary coil **29** induces a current in secondary coil **31**. The current induced in secondary coil **31** travels in conductor **40** to an inductive loading coil **34**. The inductive loading coil **34** performs the function of electrically lengthening the very short physical structure of the antenna. Current in the coil **34** travels to the whip **16** which is the radiating element. The mutually coupled coils **29**, **31**, the conductor **40**, the coil **34** and the whip **16** are relatively dimensioned to be electrically equivalent to a natural quarter-wave of the particular communication frequency in use.

Inasmuch as a counterpoise equivalent must be provided for the antenna to be independent of any associated area, a second loading coil **35** and the capactive inductive radials **20** are provided as a very short, tuned counterpoise electrically equivalent to a quarter-wave length of the frequency in use.

The physical structure of the coil assembly **17** is shown in FIGS. 3 and 4. FIG. 4 shows the coil form portion of a partially completed coil assembly. The coil form **21** is a solid rod and made preferably of a synthetic plastic material. A brass end cap **22** is mechanically secured to one end of coil form **21**. A connector assembly mechanically secured at the other end of the coil form **21** is indicated by the general reference number **23**.

The connector assembly **23** includes a center pin connector **24** and an outer shield **25**. The pin connector **24** is electrically insulated from the shield **25** by the insulation material **26**. When the connector assembly **23** is secured to the end of the coil form **21**, the pin connector **24** extends into the center of the coil form **21** so as to be axially coextensive therewith.

A sleeve member **28** is mechanically secured around the coil form **21** at a point off-center and near the connector end. A connector screw **27** is provided and is mounted in the outer surface of the coil form so as to contact the inserted end of the pin connector **24**.

FIGURE 3 shows a completed coil assembly. The primary coil **29** is wound on the coil form **21** near the connector end. One end of the primary coil **29** is soldered on the shield portion **25** of the connector assembly at **30**. The other end of the primary coil **29** is electrically connected to the pin connector **24** by means of the connector screw **27**. The secondary coil **31** is coupled therewith. One end of the secondary coil **31** is also soldered to the shield **25**. The other end of the secondary coil **31** is bent around eyelet **32** and extends along the length of the coil form **21** to eyelet **33** near the end cap **22**. The inductive loading coil **34** provided to electrically lengthen the antenna is wound on the coil form **21** adjacent the eyelet **33**. The free end of the coil **34** is soldered to the end cap **22** at **43**.

A socket is provided in the top of the end cap to receive the whip element **16**. The whip element **16** is inserted into the socket and secured to the end cap **22** by set screw **41**. Thus the end cap **22** serves to electrically connect the whip element **16** to the loading coil **34**.

As suggested above, in order to properly tune the antenna the second inductive loading coil **35** is wound around the coil form **21** in a lumped position in that it is located between the primary coil **29** and the sleeve **28**. This lumped arrangement of the coil **35** with the mutually coupled coils **29**, **31** greatly shortens the antenna structure. The lumped arrangement also assures that the "quality factor" of loading coil **35** will not be destroyed.

One end **44** of the second loading coil **35** is soldered to the shield **25** to form a common base for the antenna with the similarly soldered ends of the mutually coupled coils **29, 31.** The other end **45** of the second loading coil **35** is soldered to the sleeve **28.**

A metallic ring **19** is removably secured around the sleeve **28** by a set screw **26.** A plurality of radials **20** (FIGS. 1 and 3) extend outwardly from the metallic ring **19.** The length and number of radials will depend upon the capacitance and the inductance needed to tune the couunterpoise formed by the radials **20** and the loading coil **35.**

A supporting sleeve **37** is provided to rigidly secure the antenna **10** to the supporting tube **12** (FIG. 1). The supporting sleeve **37** is removably secured to the connector end of the coil form by means of set screws **46.**

Plastic jackets **38** and **42** are provided to weatherseal the completed unit. The jacket **38** surrounds the coil assembly between the end cap **22** and the metallic ring **19.** The jacket **42** surrounds the coil assembly between the metallic ring **19** and the supporting sleeve **37.**

The distribution of current and voltage along the antenna is also shown in FIGURE 2. It is to be noted that the current i_1 is at a maximum in the working area of the coils **29, 31** and drops off sharply towards the end of coil **34.** The distribution of voltage v_1 is just opposite to that of the current. The voltage is low along the working area of the antenna and rises sharply at the end of the coil **34** to a maximum at the end of the whip radiating element.

The current and voltage curves of FIG. 2 appear to be non-sinusoidal. This factor is brought about by the mechanical arrangement of the inductors **34, 35** which are primarily the current areas of the antenna. In actual electrical configuration, however, a sinusoidal wave does stand on the antenna as an electrical half-wave as normally expected in a tuned circuit representing a half-wave antenna.

Although the specification describes the invention in detail it is believed to comprise essentially a physically shortened, half-wave antenna having means to feed radio frequency energy to the antenna at a point off-center between the antenna ends. The antenna includes a first impedance means to electrically lengthen the top half of the antenna including the off-center feeder point to a quarter-wave length of the frequency F_1 and a second impedance means to electrically lengthen the counterpoise to be equivalent to a quarter-wave length of the frequency F_1.

Although the invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and scope of the invention as hereinafter claimed.

What is claimed is:

1. An antenna comprising, a top half portion including a radiating element, first impedance means connected to said top half portion to electrically lengthen it to a quarter-wave length of the frequency in use, a counterpoise portion, feeder means, electrically connected off-center between said top half portion, and said counterpoise portion to transmit radio frequency energy to and from the antenna, said counterpoise portion including a second impedance means mechanically disposed between said first impedance means and said off-center feeder means to electrically lengthen the counterpoise portion to be equivalent to a quarter-wave length of the frequency in use.

2. A physically shortened half-wave antenna element for the frequency F_1 comprising a connector having a shield portion and a central pin connector portion, a primary coil, a secondary coil inductively coupled with said primary coil, one end of each of said primary and said secondary coils being connected to the shield portion of said connector, the other end of the primary coil being

removably secured to the central pin connector portion of said connector, a conductor having a first and second end, the other end of the said secondary coil being connected to said first end of the conductor, an antenna whip, a first loading coil, said first loading coil having one end connected to the second end of the conductor and the other end connected to the antenna whip, a second loading coil, said second loading coil being disposed between said secondary coil and said first loading coil but substantially closer to said secondary coil and having one end connected to the shield portion of said connector to form a common antenna base with the similarly connected ends of the primary and secondary coils, at least one radial extending in a direction opposite to that of the antenna whip and connected to the other end of said second loading coil, said primary and secondary inductively coupled coils, said conductor means, said first loading coil and the antenna whip all being relatively dimensioned so as to be electrically equivalent to the natural quarter-wave length of the frequency F_1, said second loading coil and said at least one radial being relatively dimensioned to provide a very short tuned counterpoise electrically equivalent to the quarter-wave length of the frequency F_1.

3. A physically shortened electrical half-wave antenna for a communication frequency F_1 comprising, a coil form, said coil form comprising a solid nylon cylinder member having a first and second end, an end cap, said end cap being mounted on the first end of said coil form and having a socket in the top thereof to receive an antenna whip, an antenna whip which is longer than said coil form, said antenna whip being mounted in the socket in said end cap and removably secured therein, a connector having an outside shield portion and an elongated pin connector center portion insulated from the outside shield portion, said connector being mounted on said second end of said coil form so that the pin connector portion extends into a center bore in said coil form, a sleeve member being circumferentially mounted on said coil form between said end cap and said connector but substantially closer to the connector, a connector screw, said connector screw being removably mounted intermediate the connector and the sleeve member in the outside surface of said coil form and engaging the end of the elongated pin connector, a primary coil being wound around the coil form near the connector and having a first and second end, said first coil end being soldered to the shield portion of said connector and said second coil end being removably secured to said elongated pin connector by means of said connector screw, a secondary coil being wound around said coil form near the connector so as to be interwound between the turns of said primary coil to provide a mutual coupling therewith, said secondary coil having one end soldered to the shield portion of said connector, a conductor being connected to the other end of said secondary coil and extending, substantially, along the entire length of said coil form to a point near said end cap, a first loading coil, said first loading coil being wound around said coil form near the first end thereof and having one end connected to said conductor means and the other end soldered to said end cap, a second loading coil, said second loading coil being wound around said coil form between said primary coil and said sleeve member, one end of said second loading coil being soldered to said shield portion of the connector to form with the similarly soldered ends of said primary and said secondary coils a common base for the radiating element, the other end of said second loading coil being soldered to said sleeve member, a metallic ring member, said metallic ring member being removably mounted circumferentially on said sleeve member, a plurality of radials removably mounted in said metallic ring and extending outwardly and in the direction of the second end of said coil form, the mutually coupled primary and secondary coils, the conductors means, the first loading coil, and the whip all being relatively dimensioned so as

to be electrically equivalent to the natural quarter-wave length of the frequency F_1, the second loading coil and the radials being relatively dimensioned to provide a very short tuned counterpoise electrically equivalent to the quarter-wave length for the frequency F_1, a second and supporting sleeve member, said supporting sleeve member surrounding said connector and being removably secured to the shield portion thereof, said supporting sleeve member being adapted to be mounted on a supporting tube which carries the antenna in its preferably vertical operating position, a first and second plastic jacket surrounding said coil form and the coils wound thereon, and weather-sealing the entire coil assembly, said first plastic jacket extending between said end cap and said metallic ring member, said second plastic jacket extending between said metallic ring member and said supporting sleeve member.

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