Oct. 21, 1969 F. E. IRELAND 3,474,453

WHIP ANTENNA WITH ADJUSTABLE TUNING

Filed July 10, 1968 2 Sheets-Sheet 1

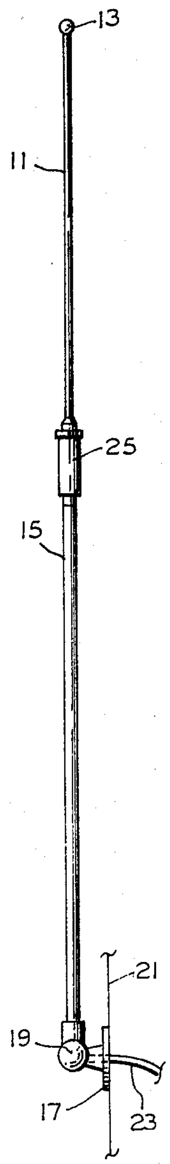

FIG.1

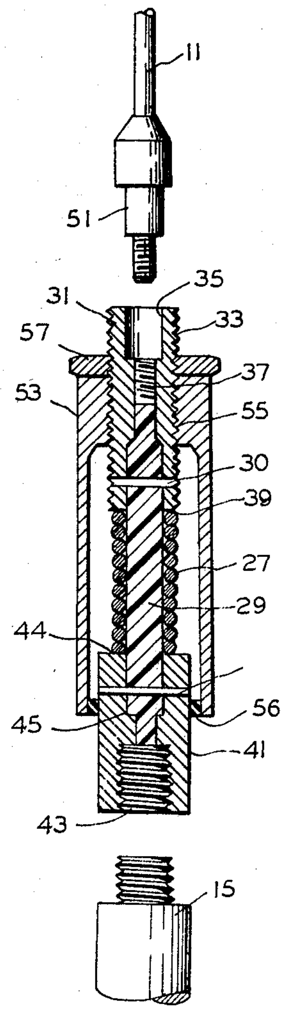

FIG.2

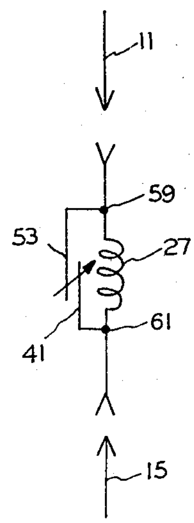

FIG.3

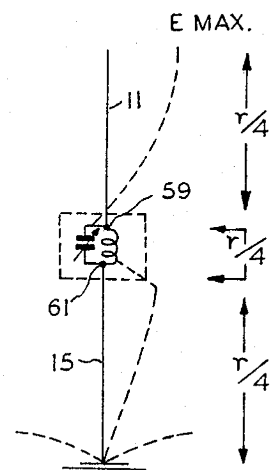

FIG.4

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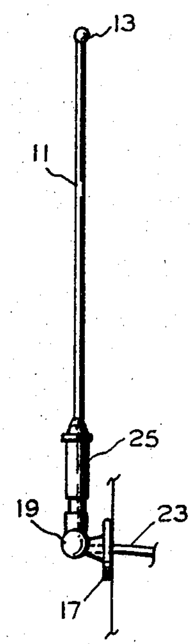

FIG.5

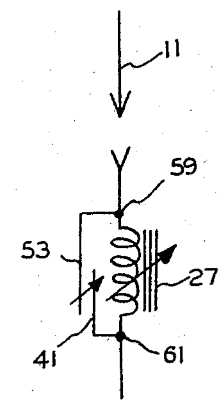

FIG.7

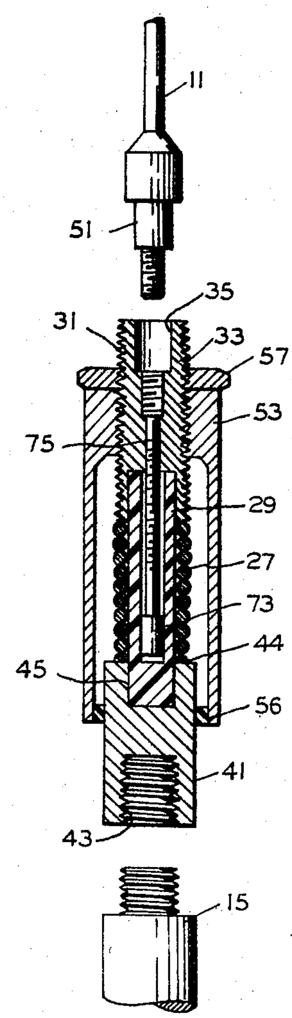

FIG.6

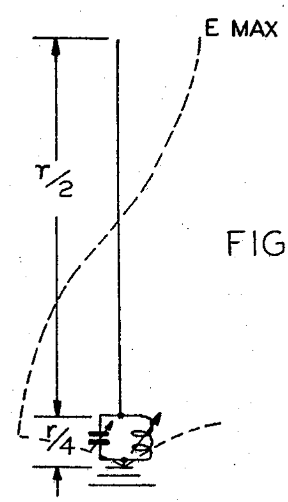

FIG.8

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WHIP ANTENNA WITH ADJUSTABLE TUNING

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Continuation-in-part of application Ser. No. 515,611, Dec. 22, 1965. This application July 10, 1968, Ser. No. 743,712

Int. Cl. H01q *9/06*

U.S. Cl. 343—745 16 Claims

ABSTRACT OF THE DISCLOSURE

This disclosure describes a high frequency antenna that includes a novel tuning means mounted in the antenna for tuning the antenna to a particular frequency band. The antenna includes at least one antenna element electrically connected to the tuning means. Electrically, the tuning means comprises a variable capacitor connected in parallel with an inductor. Mechanically, the tuning means comprises a tubular metallic shield mounted about an inductor coil. The shield is longitudinally movable, and, when moved, varies the capacitance between the shield and the coil and elements connected to the coil. Alternatively, a tuning slug is mounted in the coil and moves with respect to the coil so as to vary the inductance of the coil.

This application is a continuation-in-part of U.S. patent application Ser. No. 515,611, filed Dec. 22, 1965, now abandoned.

This invention relates to high frequency antennas and more particularly to a vertical mobile antenna having an improved radiating and/or receiving characteristic.

The prior art teaches that the well-known ground plane antenna composed of a vertical quarter-wave radiating and/or receiving element working against a quarter-wave characteristic horizontal ground plane has a high angle of radiation lobe pattern. It is also well known that a high angle of radiation is desirable for in flight communication with aircraft, but that there is a corresponding sacrifice in signal strength at ground level when such an antenna is used for ground level or mobile communications.

Even though vertical quarter-wave radiating element antennas have the foregoing ground level disadvantage, it is customary to mount such an antenna on a mobile vehicle for mobile communications. Such an antenna usually consists of a tubular electrically conducting structure which may rise to a height of 10 feet, for example. External means are usually provided for matching a load impedance to the antenna impedance for improving the radiating and/or receiving characteristic of the overall communications system at any one frequency.

It is also well known that it is often necessary to provide a single antenna of fixed length which is capable of satisfactory operation over a broad band of frequencies. To cover a desired band of frequencies, the usual practice is to provdie an external means for adjusting the impedance of a loading coil so that the antenna is nearly resonant at a particular frequency. It will be appreciated by those skilled in the art and others that this operation is not only time-consuming but also cumbersome since the radiating frequency may vary over a wide band or even different bands. Because of this variation, frequent adjustments are necessary.

In addition to teaching that a quarter-wave antenna element working against a horizontal ground plane having a quarter-wave characteristic radiates a vertical pattern, the prior art also teaches that a vertical antenna including a vertical half-wave element exhibits virtually right angle radiation provided that the base of the antenna is elevated above the reflective effect of the earth or other surrounding objects. It is impossible, of course, to meet these height requirements in mobile communiaction antennas. Consequently, the best of the prior art antennas are greatly effected by the presence of earth or surrounding structures.

It will also be appreciated that mobile antennas are subject to breakage and/or distortion as the result of striking the antenna against a foreign object. Hence, an electrically sectioned antenna composed of a plurality of parts is more economical and feasible than a solid antenna having the same radiating characteristics.

It is therefore an object of this invention to provide a vertical antenna having virtually right angle radiation or reception characteristics.

It is a further object of this invention to provide a vertical antenna having substantially right angle radiation or reception characteristics that is independent of earth ground when attached to a motor vehicle.

It is a still further object of this invention to provide a vertical antenna having substantially right angle radiation characteristics that is fed at one end to produce the highest maximum electro-magnetic field.

It is yet another object of this invention to provide a novel tuning device that cancels undesirable reactances.

It is yet another object of this invention to provide a tuning device suitable for use with an antenna that is mechanically rugged and electrically uncomplicated.

It is still another object of this invention to provide a tuning apparatus suitable for use with an antenna that is adapted to tune the antenna to radiate and/or receive signals in a predetermined frequency band.

In accordance with a principle of this invention, an antenna element is connected to a tunable means. The tunable means consists electrically of a capacitor connected in parallel with an inductor. The capacitor comprises a sleeve element mounted over an inductor coil. The sleeve element is axially movable so as to vary the area between the sleeve and the coil and elements connected to the coil. The variation in area creates a variable capacitance which varies the frequency of resonance of the parallel combination to thereby tune the antenna.

In accordance with another principle of this invention, the antenna element comprises a one-half wave length radiating element. The half-wave length element is separably attached to the tunable means at one end and the other end of the tunable means is connected to a suitable mounting means.

In accordance with a further principle of this invention, the antenna element consists of a pair of quarter-wave length elements. One quarter-wave length element is separably attached to one end of the turnable means and the other quarter-wave length element is separably mounted between the tunable means and a mounting means.

In accordance with yet another principle of this invention, the tunable means includes a slug mounted inside of the coil. The slug is movable with respect to the coil so as to vary the inductance of the coil.

It will be appreciated from the foregoing description that the invetnion provides a rather uncomplicated means for tuning an antenna. The tunable means is mechanically strong and electrically uncomplicated, merely consisting of a fixed ferrule and a movable sleeve mounted over a coil. The sleeve provides mechanical strength, ease of adjustment and a shield for the coil. But, most important, the sleeve provides a means of adjusting capacity to a critical value to effect exact reactance cancellation. That is, tuning the antenna cancels undesirable reactances to prevent power loss caused by undesirable reactances. In addition, by providing a movable core inside of the coil, additional adjustment is provided. Further, by forming the invention of separable components, the antenna elements can be easily exchanged for longer or shorter elements as desired. In addition, if one of the elements is broken, it can be easily replaced.

It will also be appreciated that when the antenna is mounted on a motor vehicle body, the body does not form a part of the overall antenna radiation system as it does with prior art antenna systems. That is, most existing vehicle antennas, whether one-quarter wave, one-half wave or five-eights wave, are dependent on the vehicle body as part of the radiating system. This invention provides an easily tunable antenna system for cancelling reactance with little or no antenna loss that is independent of a vehicle body as part of the antenna radiating system.

The novel features of the invention, as well as the invention itself both as to its organization and method of operation, will be best understood from the following description when read in connection with the accompanying drawings wherein:

FIGURE 1 is an assembled antenna illustrating one embodiment of the invention;

FIGURE 2 is an exploded cross-sectional view of one embodiment of the tuning means of the invention;

FIGURE 3 is an electrical schematic representation of the embodiment of the invention illustrated in FIGURES 1 and 2;

FIGURE 4 is a schematic representation of the voltage distribution of an assembled antenna of the type illustrated in FIGURE 1 when tuned for a specific frequency;

FIGURE 5 is an assembled antenna illustrating an alternative embodiment of the invention;

FIGURE 6 is an exploded cross-section of an alternate embodiment of the tuning means of the invention;

FIGURE 7 is an electrical schematic of the embodiment of the invention illustrated in FIGURES 5 and 6; and

FIGURE 8 is a schematic representation of the voltage distribution of an assembled antenna of the type illustrated in FIGURE 5 when tuned for a specific frequency.

FIGURE 1 is a view of an assembled antenna wherein an upper quarter-wave antenna element **11** is coupled to a lower quarter-wave antenna element **15** by a tuning element **25**. The upper quarter-wave element **11** has a corona insulator **13** mounted on the upper end thereof. The lower quarter-wave element **15** is movably attached to a mounting plate **17** by a universal connector **19**. Mounting plate **17** is shown as attached to a vehicle side **21**. A coaxial cable **23** connects the lower end of the element **15** with a transmitter/receiver (not shown).

One embodiment of the tunable portion **25** of the antenna is shown in detail in FIGURE 2. An insulated copper were **27** is wound to form a coil about a fiberglass insulating core **29**. A brass sleeve **31**, having external threads **33**, a counter bore **35**, and an internal tap **37**, is attached to the core **29** by a pin **30**, for example.

Electrical contact **39** is made between the coil **27** and the sleeve **31** by any of the well known methods such as brazing, spot welding, or silver soldering, for example.

A second tapped brass sleeve **41** having internal threads **43** and a counter bore **45** is attached to core **29** by a second pin **44**. Electrical contact **44** is made between the sleeve **41** and the coil **27** by any of the well known methods hereinabove set forth.

The internal threads **43** of the lower sleeve **41** are adapted to accept the threaded portion of the lower antenna element **15**. Likewise, the counter-bore portion **35** of the upper sleeve **31** is designed to accept a shoulder portion **51** of the upper antenna element **11**. A lower tapped portion of the upper element **11** is threaded into the tapped area **37** of the upper sleeve **31**.

An adjustable conductive sleeve **53** having internal threads **55** is cooperatively mounted on the outer threaded portion of the upper brass sleeve **31**. A locking nut **57** is also threaded on the upper brass sleeve **31** and cooperates to maintain the adjustable sleeve **53** in a desired position. An O-ring element **56** is mounted between the lower portion of the adjustable conductive sleeve **53** and the outer periphery of the lower brass sleeve **41**. This O-ring maintains a capacitive separation between the adjustable conductive sleeve **53** and the lower brass sleeve **41**. In addition, the O-ring adds to the lateral strength of the overall structure. The O-ring may be held in the adjustable conductive sleeve **53** by an internal peripheral slot, for example.

The adjustable sleeve **53** in combination with the brass sleeve **41** and the coil **27** forms an adjustable capacitor which is electrically connected in parallel with the coil **27**. This parallel circuit will resonate at a frequency determined by the adjustment of the sleeve. The electrical circuit which is representative of the foregoing mechanical interconnection is illustrated in FIGURE 3. That is, FIGURE 3 illustrates a variable capacitor connected in parallel with a fixed coil.

FIGURE 4 is a schematic representation of the instantaneous vector voltage of the antenna when tuned for maximum efficiency. More specifically, in order to achieve high radiating and/or receiving characteristics for the antenna, it is necessary that the antenna be tuned to cancel the reactance between points **59** and **61** shown in FIGURES 3 and 4. This cancellation is performed by adjusting the tuning element to a resonant or near resonant state for the frequency of operation. In addition to compensating for the reactance that occurs in an ideal situation, it will be obvious to one skilled in the art that slight deviations in reactance caused by incorrect antenna length is also compensated for by resonating the tuned circuit.

It will be appreciated by those skilled in the art and others that the primary purpose of the tuned element is to perform the function of a quarter-wave shorted stub line wherein a 180° phase displacement exists across the points of connection so that there is a non-radiating quarter-wave coupling between the two quarter-wave radiating elements. This results in a narrow radiation pattern that, as best understood, is caused by the distorted top and bottom lobes which combine to form in effect a vertical beam antenna. That is, the instant antenna is designed to lower the angle of radiation by separating the upper approximate quarter-wave radiating antenna element from the lower approximate quarter-wave radiating with a fixed coil and a variable air condenser which are mounted so as to form a parallel resonant circuit very close to the operating frequency. This resonant circuit (or closely resonant circuit) forms a tuned stub allowing maximum voltage to appear at the center of the coil with voltages of opposite instantaneous polarity appearing at both ends of the coil (or stub). This action separates the upper half of the antenna from the lower half of the antenna so two waves are radiated forming a single complex wave front having a flattened lobe and therefore greater effective voltage gain in the desired direction.

It will be appreciated that if either of the antenna elements **11** or **15** are damaged, they may be easily replaced with similar elements because of the separable nature of the mechanical construction of the invention.

It will also be appreciated that once the tuned circuit is tuned using the variable capacitance, the locking nut is tightened to prevent any change in tuning due to vibration and the like.

FIGURES 5–8 illustrate an alternative embodiment of the invention wherein the lower quarter-wave antenna element is eliminated and the upper quarter-wave antenna element is replaced by a one-half wave length element. In addition, the core is eliminate from the coil and a tuning slug **73** is inserted in a hollow space inside of the coil **27** and the core **29**. The tuning slug **73** is attached to a shaft **75** that is threaded in the upper sleeve **53**. By rotating the shaft **75** the slug **73** is vertically moved inside of the coil **27**. Movement of the slug **73** varies the inductive effect of the coil **27** in a manner well known in the art. If desired, a lock nut can be included for locking the setting of the slug in place. FIGURE 7 illustrates, electrically, the parallel arrangement of the variable capacitor sleeve arrangement heretofore discussed with respect to FIGURE 2 and the coil of variable inductance **27.** By providing an adjustable inductance in parallel with an adjustable capacitance, the range of the overall tuned circuit is increased. That is, the tuning element illustrated in FIGURES 5 and 7 can be tuned to frequencies over a greater range than the tuning element illustrated in FIGURES 1–3.

While the frequency range of the embodiment of the invention illustrated in FIGURES 5–8 is increased, the operation of the invention remains identical to the embodiment of the invention illustrated in FIGURES 1–4 hereinabove discussed. That is, the tuned circuit is adapted to tune the antenna so that undesirable reactance is cancelled. The one-half wave length element forms a pattern that has a flattened lobe and therefore greater voltage gain in the desired direction. The tuning element operates as a stub. And, the adjustable sleeve **53** provides a shield so that the radiation of the tuning element has no effect on the overall operation of the antenna.

It will be appreciated by those skilled in the art and others that applicant has provided a relatively uncomplicated and inexpensive tunable mobile antenna. Although specific structure has been described, it will be appreciated that the scope of this invention includes various changes and modifications not specifically discussed. For example, the tunable element illustrated in FIGURE 6 can be used with the embodiment of the antenna illustrated in FIGURE 1, i.e., an embodiment including two quarter-wave length elements. Alternatively, the embodiment of the tuning element illustrated in FIGURE 2 can be utilized with the embodiment of the antenna illustrated in FIGURE 5. Moreover, other tuning elements can be used. In addition, it will be appreciated that more than one tuned circuit can be utilized in the invention. That is, by properly stacking a plurality of tuned elements increased gain is provided. Further, wide variations in the size and shape of the inductive and capacitive elements fall within the scope of the invention. Moreover, bank winding, powdered iron cores and multiplate condensers can be used in the invention when low frequency ranges are to be covered by a transmitter and/or receiver connected to the antenna. Hence, the invention can be practiced otherwise than as specifically described herein.

It will also be appreciated that the invention provides a convenient and easy method of tuning an antenna through resonance. The critical point may be approached from either side with ease and the tuning sleeve may be locked in a selected position.

In addition to its use as an antenna tuning element, the tuning element **25** herein disclosed is useful in other environments. For example, it can be used as a filter to reject spurious signals. Alternatively, it can be attached to a tower, building, tank or other conducting structure and tuned to cancel unwanted reactance. And, it will serve as a tuning element in a gamma match stub.

What is claimed is:

1. An antenna tuning device comprising:

a longitudinal insulating core having a longitudinal axis;

a coil wound around the longitudinal axis of said core;

a first electrical conducting sleeve element mounted over one end of said core so that it is in electrical contact with one end of said coil;

a second electrical conducting sleeve element mounted over the end of said core so that it is in electrical contact with the other end of said coil; and

a movable sleeve element mounted for longitudinal movement along the outer periphery of said first electrical conducting sleeve, said movable sleeve element extending over said core and coil to said second electrical conducting sleeve.

2. An antenna tuning device as claimed in claim **1** wherein the outer periphery of said first electrical conducting sleeve is threaded and the inner periphery of said movable sleeve element is tapped.

3. An antenna tuning device as claimed in claim **2** including a lock nut coacting with said first electrically conductive sleeve element and said movable sleeve element to lock said movable sleeve element in predetermined positions.

4. An antenna tuning device comprising:

a coil having a longitudinal axis;

a slug movably mounted along said longitudinal axis of said coil;

a first electrical conducting sleeve element mounted so that it is in electrical contact with one end of said coil;

a second electrical conducting sleeve element mounted so that it is in electrical contact with the other end of said coil; and

a movable sleeve element mounted for longitudinal movement along the outer periphery of said first electrical conducting sleeve, said movable sleeve element extending over said coil to said second electrical conducting sleeve.

5. An antenna tuning device as claimed in claim **4** wherein the outer periphery of said first electrical conducting sleeve is threaded and the inner periphery of said movable sleeve element is tapped.

6. An antenna tuning device as claimed in claim **5** including a lock nut coacting with said first electrically conductive sleeve element and said movable sleeve element to lock said movable sleeve element in predetermined positions.

7. An antenna comprising:

a longitudinal insulating core having a longitudinal axis;

a coil wound around the longitudinal axis of said core;

a first electrical conducting sleeve element mounted over one end of said core so that it is in electrical contact with one end of said coil;

a second electrical conducting sleeve element mounted over the other end of said core so that it is in electrical contact with the other end of said coil;

a movable sleeve element mounted for longitudinal movement along the outer periphery of said first electrical conducting sleeve, said movable sleeve element extending over said core and coil to said second electrical conducting sleeve; and

an antenna element electrically connected to said first electrical conducting sleeve element.

8. An antenna as claimed in claim **7** wherein the outer periphery of said first electrical conducting sleeve is threaded and the inner periphery of said movable sleeve element is tapped.

9. An antenna as claimed in claim **8** including a lock nut coacting with said first electrically conductive sleeve element and said movable sleeve element to lock said movable sleeve element in predetermined positions.

10. An antenna as claimed in claim **9** wherein said antenna element is formed of two quarter-wave length elements, one quarter-wave length element electrically connected to said first electrical conducting sleeve element and the other quarter-wave element electrically connected to said second electrically conducting sleeve element.

11. An antenna as claimed in claim **9** wherein said antenna element is a one-half wave length element.

12. An antenna comprising:

a coil having a longitudinal axis;

a slug movably mounted along said longitudinal axis of said core;

a first electrical conducting sleeve element mounted so that it is in electrical contact with one end of said coil;

a second electrical conducting sleeve element mounted so that it is in electrical contact with the other end of said coil;

a movable sleeve element mounted for longitudinal movement along the outer periphery of said first electrical conducting sleeve, said movable sleeve element extending over said coil to said second electrical conducting sleeve; and

an antenna element electrically connected to said first electrically conducting sleeve element.

13. An antenna as claimed in claim **12** wherein the outer periphery of said first electrical conducting sleeve is threaded and the inner periphery of said movable sleeve element is tapped.

14. An antenna as claimed in claim **13** including a lock nut coacting with said first electrically conductive sleeve element and said movable sleeve element to lock said movable sleeve element in predetermined positions.

15. An antenna as claimed in claim **14** wherein said antenna element is formed of two quarter-wave length elements, one quarter-wave length element electrically connected to said first electrical conducting sleeve element and the other quarter-wave element electrically connected to said second electrically conducting sleeve element.

16. An antenna as claimed in claim **14** wherein said antenna element is a one-half wave length element.

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U.S. Cl. X.R.

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