Sept. 28, 1965 R. A. FELSENHELD 3,209,358

ELECTRONICALLY TUNABLE ANTENNA

Filed Sept. 24, 1962 3 Sheets-Sheet 1

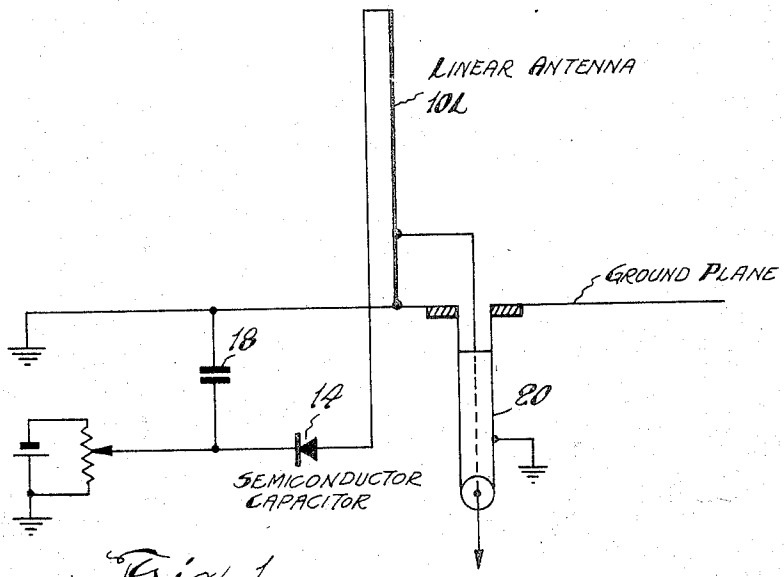


Fig. 1

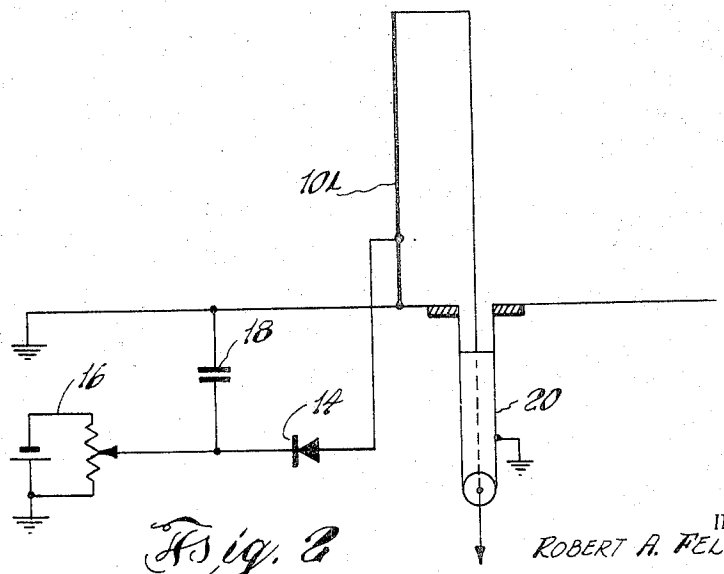


Fig. 2

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ELECTRONICALLY TUNABLE ANTENNA

Filed Sept. 24, 1962 3 Sheets-Sheet 2

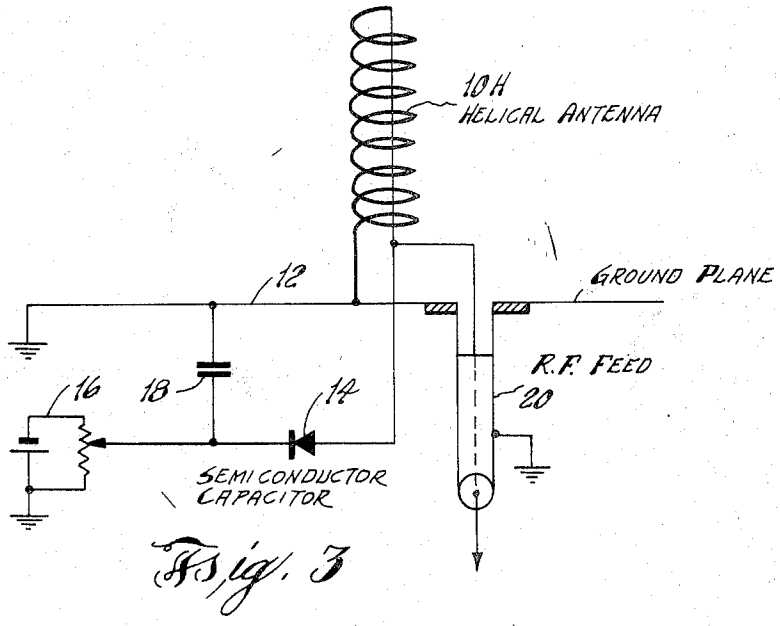


Fig. 3

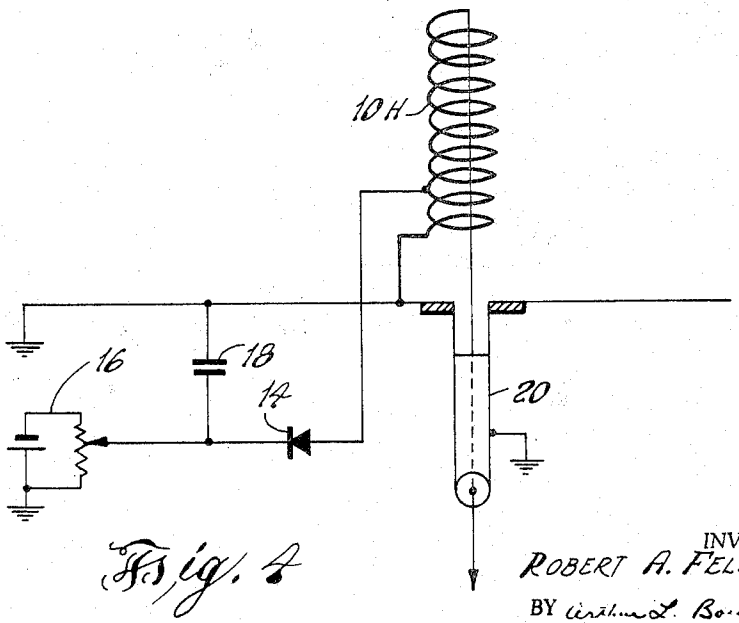


Fig. 4

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ELECTRONICALLY TUNABLE ANTENNA

Filed Sept. 24, 1962 3 Sheets-Sheet 3

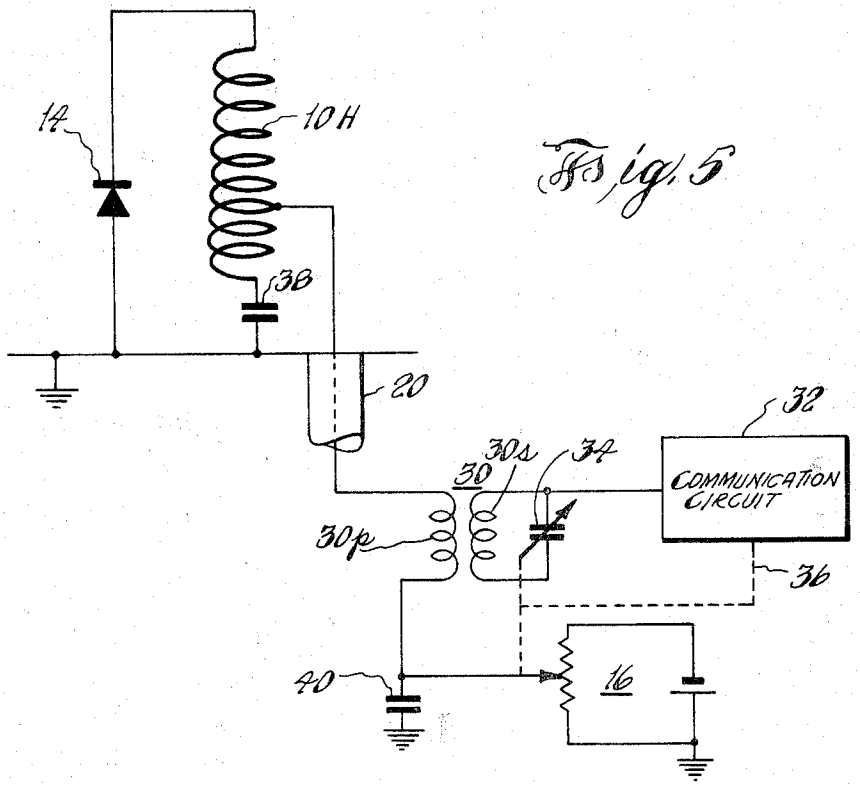


Fig. 5

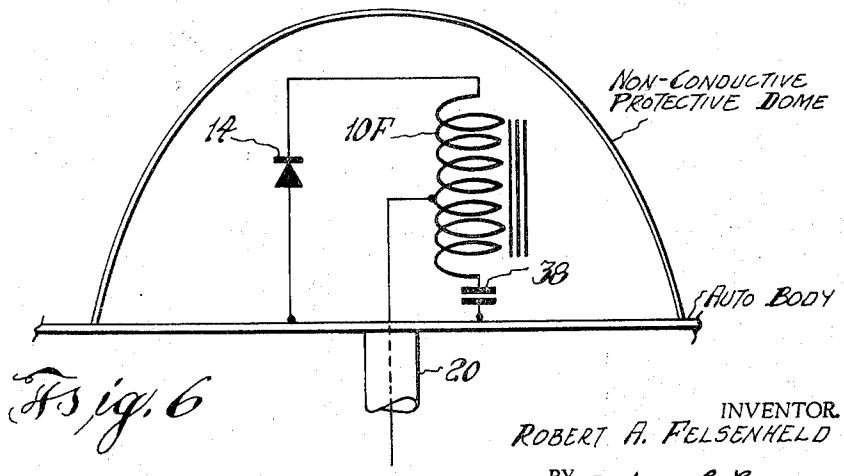


Fig. 6

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ELECTRONICALLY TUNABLE ANTENNA

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2 Claims. (Cl. 343—745)

This invention relates to tuning an antenna and more particularly to reducing antenna size for selected operating conditions and tuning the reduced size antenna remote from the antenna.

An object of this invention is to provide a communication circuit and antenna system wherein the antenna tuning tracks communication circuit tuning.

A further object is to provide a tunable antenna of more compact dimensions than antennas previously available for the same band.

A further object is to provide an antenna that is comparatively compact for the prescribed operating conditions, tunable remote from the antenna, comparatively inexpensive, simple to fabricate and operate, and generally superior to tunable antenna designs and methods known heretofore.

Other objects and advantages will appear from the following description of an example of the invention, and the novel features will be particularly pointed out in the appended claims.

FIGS. 1 and 2 illustrate tunable linear antennas and FIGS. 3 and 4 illustrate tunable helical antennas in accordance with this invention,

FIG. 5 illustrates a tunable antenna and communication circuit wherein the antenna tuning tracks the circuit tuning, and

FIG. 6 illustrates a compact antenna according to this invention for an automobile.

The embodiments of this invention shown in FIGS. 1–4 each include a parallel fed antenna, a linear antenna **10L** in FIGS. 1 and 2 and a helical antenna **10H** in FIGS. 3 and 4, mounted to extend normal to a ground plane **12**. A semiconductor capacitor **14**, also termed a semiconductor diode, and a selectively adjustable source **16** of constant direct voltage for applying negative or reverse bias to the semiconductor capacitor **14** are connected in a loop circuit including part or all of the antenna **10L** or **10H**. The direction of the bias source and the semiconductor capacitor may be as shown or may be reversed. A signal bypass capacitor **18** is connected in shunt across the bias source to prevent signal attenuation by the bias source. A radio frequency feed cable **20** is connected between the antenna and communication circuitry not shown. The antenna **10L** or **10H** is tunable over a considerable bandwidth by adjustment of the bias source, which may be carried out at the antenna or at a location a considerable distance from the antenna depending upon the chosen location for the bias source. The antenna is parallel fed in order that the path for the reverse bias may include ground and at least part of the antenna. In an installation, the semiconductor capacitor is supported by or adjacent to the antenna; if the bias source is located at a distance from the antenna, e.g., at the communication circuit chassis, utilizing a ground path for part or all of the distance to the tuning capacitor, the antenna is remotely tunable.

In its broader aspects, this invention is not limited to linear and helical antennas. It may be practiced with slot antennas, all forms of loop antennas, shortened dipole antennas, ferrite core antennas and others. Also, the invention is not limited to any specific frequency band or any specific bandwidth both being functions of the details of antenna design, capacity range of the semiconductor capacitor plus bias source. With the described

combination, it is possible to tune the antenna over a band, continuously as opposed to stepwise, with simple components and at a distance from the antenna.

Whether the feed cable is connected to that end of the antenna which is remote from ground or to some point intermediate the ends thereof, and whether the semiconductor capacitor is connected to that end of the antenna which is remote from ground or to some point intermediate the ends thereof are not material to the broader aspect of this invention being based upon known antenna design principles.

Another advantage of this invention exemplified by the embodiments shown in FIGS. 1–4 is that it renders practical the use of an antenna of smaller size than is dictated by known design considerations for operation in a selected frequency band. Compactness is realized to a substantial degree with a helical antenna or a ferrite core antenna having dimensions that are a small fraction of a wavelength.

Semiconductor capaictors used in this invention are described in the patent literature, e.g., class 307, subclass 88, and are marketed commercially. One commercial source of semiconductor capaictors that may be used in this invention is Pacific Semiconductors Inc. which labels its product with the trademark Varicap. A circuit as shown in FIG. 3 having Varicap V–20, reverse bias −0.5 to −20 volts, may be operated between 30 and 50 megacycles with a helix having dimensions that are small compared to a wavelength.

Semiconductor capacitors currently available are generally low power elements. Therefore, this invention is more practical in receiving antennas. However, semiconductor capacitor elements currently available may be used in very low power transmitting antennas. Furthermore, since the principles of semiconductor capacitors do not include an inherent limitation to the low power levels currently available it is expected that with the advent of elements of increased power capacity the utility of this invention for transmitting antennas will increase.

An automatic antenna tuning arrangement embodying the principles of this invention is illustrated in FIG. 5. A transformer **30** including a primary winding **30*p*** and secondary winding **30*s*** couples the antenna **10H** and a communication circuit **32**. A mechanically operable tuning capacitor **34** is connected across the secondary winding **30*s***. The movable elements of the bias source **16**, tuning capacitor **34** and other conventional tuning elements in communication circuit **32** are joined by a mechanical coupling arrangement **36** including one or more of elements such as levers, gears, cams, pulleys, and the like, for obtaining the properly related displacements so that antenna tuning automatically tracks circuit tuning. Direct current blocking capacitors **38** and **40** are connected between ground and the antenna **10H** and between ground and the primary winding **30*p*** respectively. The direct current path for the tuning voltage for the semiconductor capacitor extends through the transformer winding. A direct curent path between the reverse bias source **16** and the semiconductor capacitor includes primary winding **30*p*** coaxial feed cable **20**, the upper portion of the antenna to semiconductor capacitor **14** and thence, through ground to the reverse bias source.

In FIG. 6 there is shown part of the combination of FIG. 5 for use in an automobile or other mobile application where compactness is desirable and advantageous. Because this invention enables the use of a compact size antenna, an automobile antenna as in FIG. 6 may be mounted on the surface of the automobile body, e.g., roof, fender, or side, enclosed by a small protective dome of non metallic material, painted to conform to the color of the auto and be less cumbersome and less of an attractive nuisance than whip antennas in current use. In this

embodiment, the antenna 10F is a conductor wound ferrite core in the form of a short stub. The reverse bias may be obtained either from the auto battery though a high impedance potentiometer connected directly across the battery so as to minimize voltage change due to change in loading, or from a separate low power battery.

It will be understood that various changes in the details, materials and arrangements of parts and steps, which have been herein described and illustrated in order to explain the nature of the invention, may be made by those skilled in the art within the principle and scope of the invention as expressed in the appended claims.

I claim:

1. A wide band radio receiver equipment comprising a tunable signal circuit, an antenna, a direct current blocking capacitor electrically connected between one end of said antenna and a ground, a semiconductor capacitor whose capacitance is a function of direct voltage reverse bias, said semiconductor capacitor connected in a loop circuit with said antenna and blocking capacitor, a coupling transformer having two separate windings one of said windings being connected to said tunable signal circuit to function as signal input element of said signal circuit, a feed cable electrically connecting one end of the other winding to a selected point on the antenna and a blocking capacitor connected between the other end of the other winding and said ground, an adjustable source of direct voltage bias mechanically joined to said tunable signal circuit for providing an output voltage which has predetermined relationship with signal circuit tuning and electrical connected between said ground and a point along anyone of said second coil, lead in cable, antenna, connections therebetween, and connection between antenna and semiconductor capacitor, for applying bias voltage to said semiconductor capacitor in a predetermined relationship to signal circuit tuning whereby antenna tuning tracks signal circuit tuning over the frequency band of said receiver equipment.

2. In a radio receiver equipment for use in a selected frequency band having a tunable signal circuit, an antenna, means transferring signal energy between said antenna and said tunable circuit including a matching transformer and a tuning element connected across the circuit side of the transformer, that improvement for enabling the use of an antenna in said equipment having dimensions that are a small fraction of the largest wavelength in the selected frequency band comprising a voltage sensitive semiconductor capacitor connected across the antenna for tuning the antenna, a direct current blocking capacitor connected between the antenna and ground, another direct current blocking capacitor connected between the antenna side of the matching transformer and ground, a high impedance variable direct voltage source connected between said ground and the antenna, and means ganging the antenna tuning variable voltage source and said tuning element.

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