April 28, 1959 G. H. DEWITZ ET AL 2,884,632

ANTENNA TUNING SYSTEM

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FIG. 1.

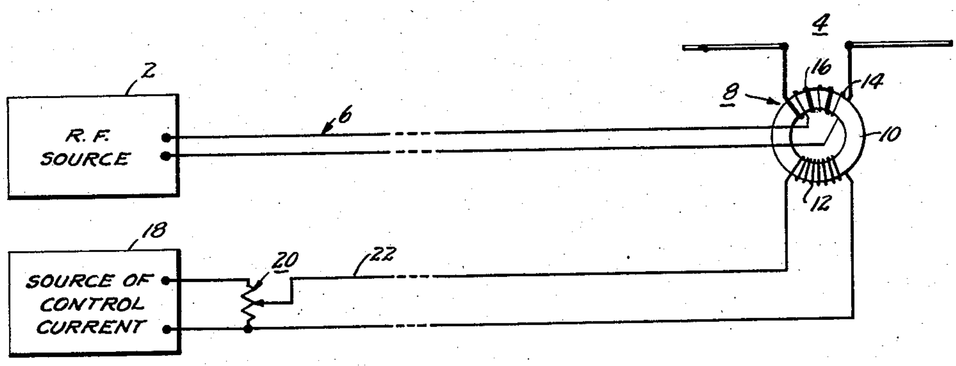


FIG. 2.

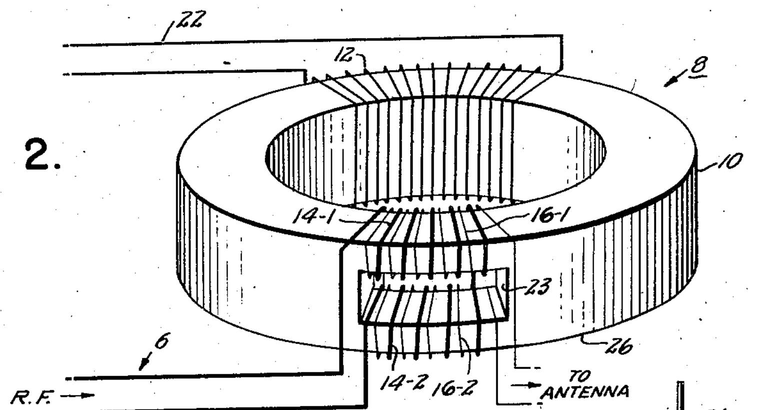
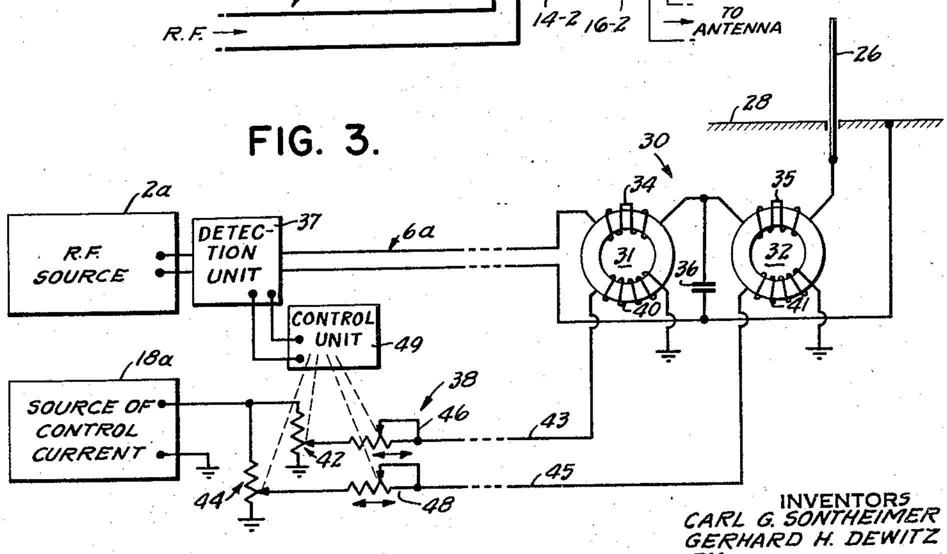


FIG. 3.



INVENTORS
CARL G. SONTHEIMER
GERHARD H. DEWITZ
BY
Curtis, Morris & Safford
ATTORNEYS

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FIG. 4.

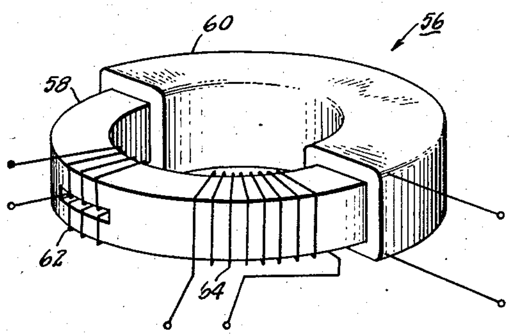


FIG. 5.

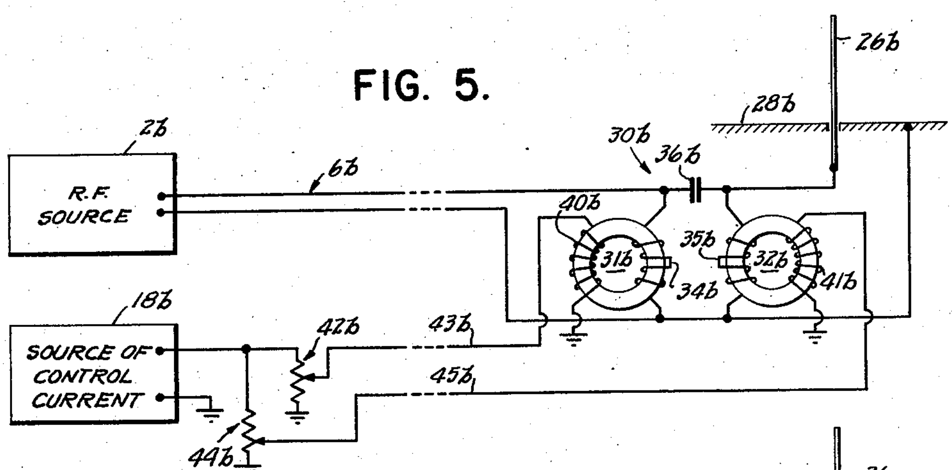
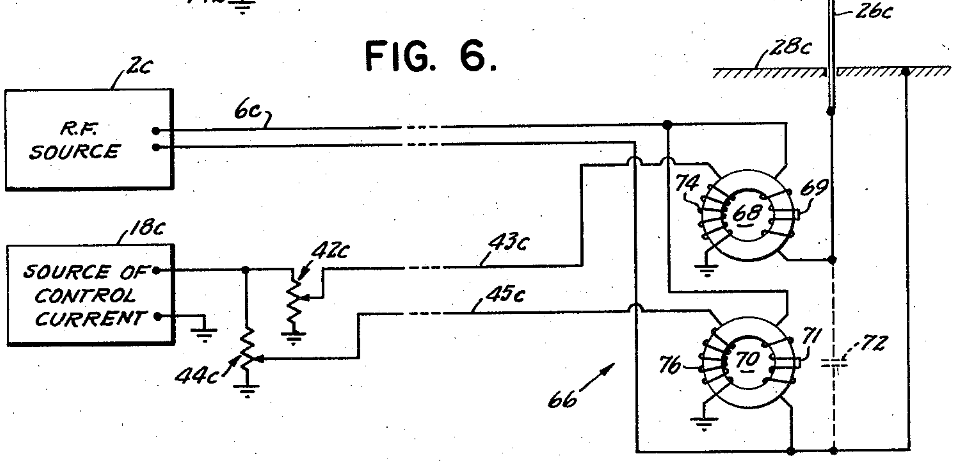


FIG. 6.



INVENTORS
CARL G. SONTHEIMER
GERHARD H. DEWITZ
BY
Curtis, Morris & Safford
ATTORNEYS

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ANTENNA TUNING SYSTEM

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FIG. 7.

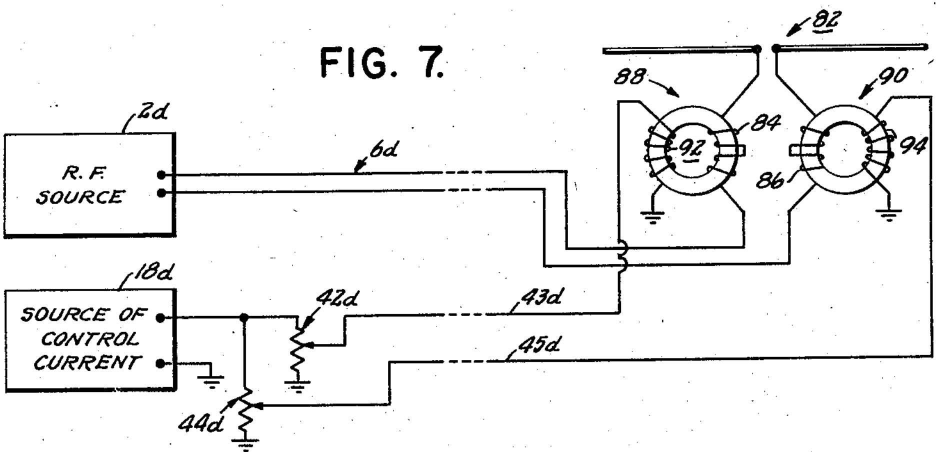


FIG. 8.

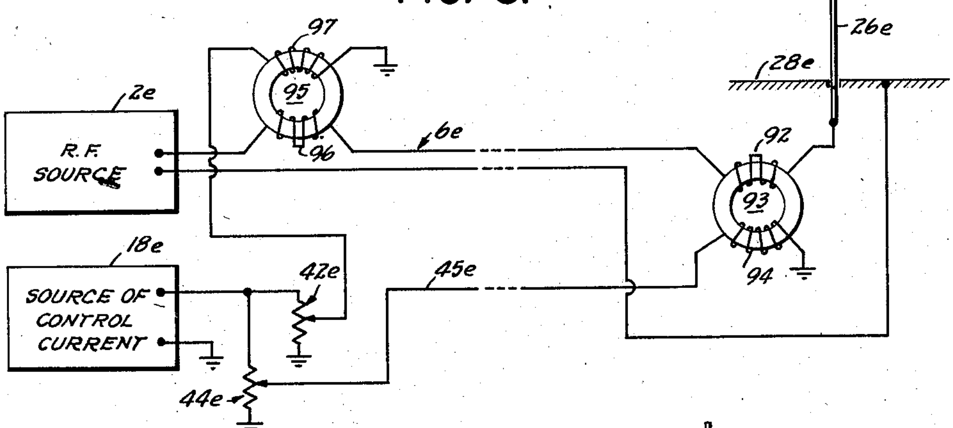
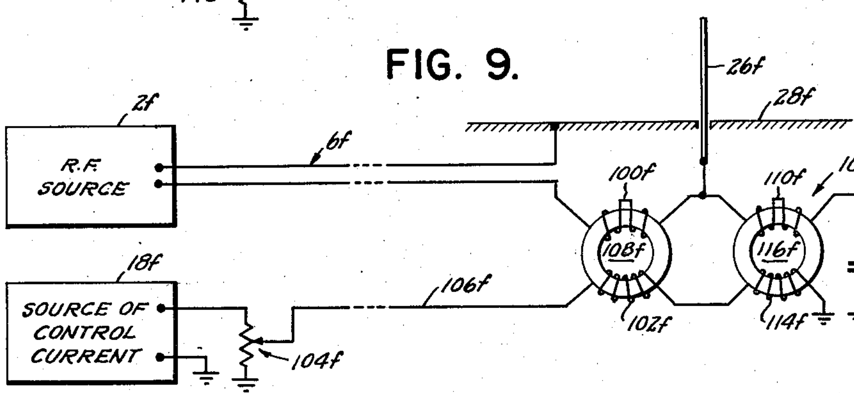


FIG. 9.



INVENTORS
CARL G SONTHEIMER
GERHARD H. DEWITZ
BY
Curtis, Morris & Safford
ATTORNEYS

FIG. 10.

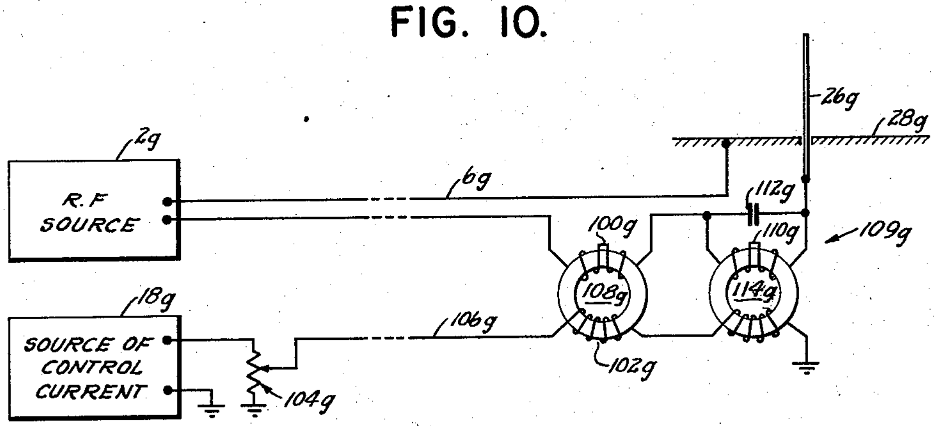
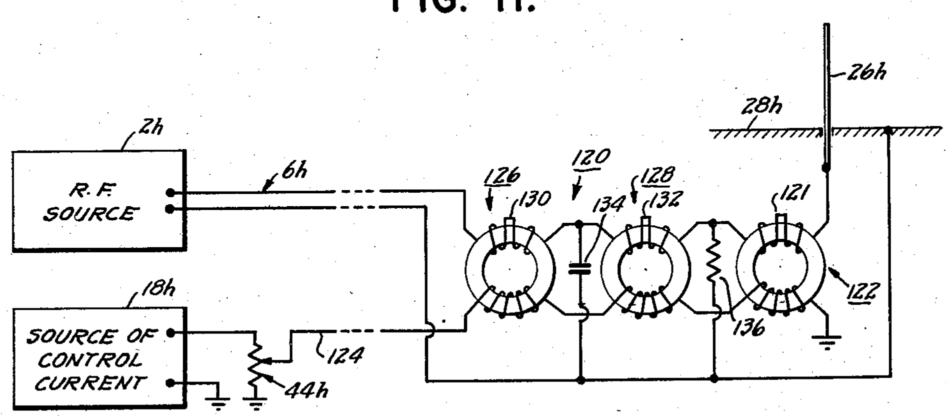


FIG. 11.



INVENTORS
CARL G. SONTHEIMER
GERHARD H. DEWITZ
BY
Curtis, Morris & Safford.
ATTORNEYS

United States Patent Office 2,884,632
Patented Apr. 28, 1959

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2,884,632

ANTENNA TUNING SYSTEM

Gerhard H. De Witz and Carl G. Sontheimer, Stamford, Conn.; said Sontheimer assignor to C.G.S. Laboratories, Incorporated, Stamford, Conn., a corporation of Connecticut

Application August 6, 1952, Serial No. 302,962

11 Claims. (Cl. 343—850)

This invention is in connection with antenna systems incorporating electrically controllable inductance units. The invention is particularly useful where a single antenna system is used over a wide frequency range and the antenna is located remotely from the transmitter or receiver; the tuning and matching adjustments of the controllable inductor are done electrically and require no moving mechanical parts.

In radio systems of this type, the efficiency of operation and the operating characteristics are affected adversely by improper impedance relationships between the transmission line and the antenna and between the transmitter and the transmission line. It is not difficult to secure the desired impedance relationships over narrow frequency ranges or in locations where adequate room for the antenna is available. However, in aircraft and other installations it is desirable for reasons of economy of space and weight to use a single antenna system and its feedline over the widest possible frequency range and to keep the physical dimensions of the antenna structure as small as possible.

Such antennas usually have a large reactance component and low radiation resistance. The reactance of the antenna can be overcome by the addition of compensating reactance, and the antenna impedance can be matched to the feedline by a suitable impedance matching network.

If fixed matching networks and tuning elements are used, good operation is usually achieved only over a relatively narrow range of frequencies.

Moreover, to be effective, such matching networks and tuning elements usually must be located at the center of the antenna if it is a dipole or at the base of the antenna if it is a grounded wire. This makes it impractical in most instances to increase the operating range by the use of multiple fixed control elements with selective switching arrangements or by the use of mechanically variable elements requiring as they do the use of complicated control devices for mechanically adjusting the remote matching networks and tuning elements.

The present invention provides a compact efficient and relatively simple remotely-controlled arrangement which permits minimum antenna dimensions and maximum operating frequency range.

A preferred embodiment of the invention provides for automatic or remote manual tuning of the antenna system without the use of mechanically moving parts at the antenna; the tuning system operating at high frequencies, over a wide frequency range, and with high efficiency. The system provides for maintaining a desired impedance compensation of the antenna, and/or a desired impedance match between the transmission line and the antenna and possibly a desired impedance transformation between the transmission line and the transmitter output. The system is also useful in the suppression of harmonics or other undesired signals. Another aspect of this invention permits these impedance relationships to be controlled remotely and automatically according to any one or more of several optimum criteria such as maximum radiated power, minimum reflected energy, etc. In another aspect of this invention, electromagnetically controllable inductors adjust the phase of currents in individual antennas utilized in an array, whereby the polarization or shape or direction of the directive pattern of emission is influenced. Furthermore, the invention may be used where relative output or input levels of two antennas are alternately or independently controlled as for example in some types of diversity receiving or transmitting systems. In that case, only the desired antenna is tuned to optimum conditions, whereas the other is deliberately detuned and made substantially inoperative.

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Under most conditions, antenna systems can be considered to be reversible in accordance with the terms of the well-known reciprocity theorem. Therefore, it is to be understood that reference to the transmission of energy and transmitting apparatus also embraces corresponding reception of energy and receiving apparatus, thus simplifying the explanation of the invention.

The foregoing objects, aspects, and advantages of the invention will be in part pointed out and in part apparent from the following description considered in conjunction with the accompanying drawings, in which:

Figure 1 is a diagrammatic representation of a remotely-tuned dipole antenna system utilizing a controllable impedance transformer coupling at the junction of the antenna and the transmission line;

Figure 2 is an enlarged perspective view of a controllable inductor useful in the circuit of Figure 1;

Figure 3 diagrammatically shows a remotely tuned antenna system in which the tuning is continuous and entirely automatic;

Figure 4 is a perspective view of a variable inductor suitable for use in the circuit of Figure 3;

Figures 5, 6, 7 and 8 show other systems for remotely tuning the antenna element; and

Figures 9, 10 and 11 are diagrammatic representations of various antenna tuning and filter arrangements.

Figure 1 shows a transmitting system in which radio signals from a transmitter **2** are radiated by a remotely-positioned dipole antenna **4**. The signals are fed from the transmitter **2** to the antenna structure through a transmission line or cable **6** which, for example, may be an open wire line or a coaxial cable. The signal from this line is coupled to the antenna through a variable-impedance transformer **8**, which also inserts an inductive reactance, whose magnitude is controllable, that compensates for the capacitive reactance of the antenna.

This transformer includes a core **10** of ferromagnetic material carrying a control winding **12** and two signal windings **14** and **16**. The control winding is connected to a source **18** of direct current which flows through the control winding **12** and partially saturates the core **10** and thereby varies the inductance of the signal windings **14** and **16**. A potentiometer **20** is arranged to regulate either manually or automatically the magnitude of this current so that as the operating frequency of the system is changed, the changes in control current provide the optimum value of antenna compensating reactance at these various operating frequencies.

Figure 2 shows the physical construction of the controllable impedance device **8**. To isolate the control winding **12** from the radio frequency alternating signals of the signal windings **14** and **16**, the latter windings are each divided into two equal series-connected portions, as indicated at **14—1** and **14—2** and **16—1** and **16—2**, respectively, which are wound through an opening **23** and around opposite rim portions of the ring-shaped core **10**. The individual portions of the windings **14** and **16** are each connected in such direction that the alternating magnetic flux lines induced in the core encircle the opening 23 and do not link with the control winding 12. The two windings 14 and 16 are interwound to insure close coupling at all times.

With this arrangement, the antenna can be tuned for each frequency of operation by varying the D.-C. control current in the winding 12. For example, as this control current is increased, the magnetic saturation of the core 10 increases, thus reducing the reactive impedance of the signal windings 14 and 16. The slidable connection of the potentiometer 20 can be adjusted manually each time the frequency of operation is changed to produce the optimum impedance relationship or any desired automatic control circuit or device may be utilized to control the current through the winding 12.

In order to permit high frequency operation without prohibitive losses in power, the core 10 preferably is formed of ferromagnetic ceramic material such as is described by Snoeck in U.S. Patents 2,452,529; 2,452,530; and 2,452,531. This material maintains a high Q even when subjected to substantial magnetic saturation and also provides a very wide range of inductance variation.

As an alternative arrangement in place of the controllable impedance transformer as shown, the winding 14 may be omitted and the line 6 can be tapped into the winding 16 at balanced points equidistant from the ends of the winding 16 so that this winding acts in effect as an auto-transformer winding of controllable impedance for coupling the line and antenna. With this latter arrangement the winding 14 may be included for the purpose of providing a tuned filter to remove undesired harmonics from the system. Thus, a condenser is connected across the winding 14 and is proportioned to resonate with the winding 14 at the harmonic frequency which is desired to be excluded. As the control current through winding 12 is changed for different operating frequencies, the resonant frequency of the winding 14 and condenser changes so that it follows the changes in operating frequency and continues to remove the undesired harmonics of the operating frequency.

In certain instances, parts performing generally corresponding functions and appearing in different figures of the drawings are referred to by the same numbers followed by different letters.

Figure 3 shows a stub-type antenna 26 which projects from a ground conductor 28, which, for example, may be the metallic covering of an aircraft or a portion of the hull of a ship, or the like. Radio frequency energy from the source 2*a* is fed to the antenna through the transmission line 6*a* and an automatically-controlled antenna tuning section 30. This tuning network utilizes two controllable inductors 31 and 32 which permit separate and independent control of the antenna compensating reactance and the impedance transformation between the antenna 26 and the transmission line 6*a*.

The signal windings 34 and 35 of the inductors 31 and 32, respectively, are connected in series with the stub antenna 26 and in conjunction with a shunt condenser 36 to form a T-section network. The principles of the automatic control system indicated diagrammatically in Figure 3 are set forth in a copending application of Carl G. Sontheimer, Serial No. 781,834, filed October 27, 1947, now U.S. Patent No. 2,611,030. In order to detect the electrical conditions along the transmission line 6*a*, a detection unit 37 is connected to the line 6*a* near the source 2*a*, and is connected to automatic control equipment, generally indicated at 38, which is used to control the antenna tuning inductors 31 and 32.

A source 18*a* of direct current is connected to supply current to the control windings 40 and 41 of the controllable inductors 31 and 32. A potentiometer 42 connected to the output of the source 18*a* provides an adjustable voltage that is connected through a line 43 and the common ground circuit to the control winding 40. A similar potentiometer 44 provides an independently adjustable voltage for the control winding 41 through a line 45.

Periodic variations in the control current through the windings 40 and 41 are produced by continually varying variable resistors 46 and 48, respectively, connected in series with the lines 43 and 45 and ganged mechanically to a control unit 49. The resulting changes in the tuning adjustment of the antenna 26 produce corresponding variations at the detection unit 37 which in turn actuate the control unit 49 so as to produce and maintain the proper adjustments of the main control potentiometers 42 and 44. Reference is made to the above-identified Sontheimer application for a more complete disclosure of the automatic control feature.

It will be clear, however, that the impedance-matching relationship and the antenna compensating reactance can be adjusted separately and independently even though each of the inductors 31 and 32 will affect both conditions.

With a T-section of this type, the impedance transformation between the base of the antenna 26 and the adjacent end of the transmission line 6*a* is a function of the ratio of the inductances of the signal windings 34 and 35 while the reactance at either of these points is a function of the sum of these inductances. Hence, the impedance match therebetween and the reactance at either of these points can be separately controlled to produce the optimum operating condition, for example maximum radiated power, or minimum reflected energy and standing wave ratio, or maximum efficiency.

The inductors 31 and 32 are each generally similar to the variable impedance matching transformer 8 (see Figure 2), except that they have only a single signal winding 34 and 35, respectively, which are each divided into two portions, wound through a slot (not shown in Figure 3) and connected in such directions as to de-couple them from the control windings 40 and 41, respectively, in a manner similar to either winding 14 or 16.

These periodic variations in the tuning adjustment of the antenna 26 can be provided in a variety of ways, for example, Figure 4 shows a variable inductor 56 which may be used in an alternative arrangement of the system shown in Figure 3. The inductor 56 includes a core 58, a control winding 60 and the signal winding 62, which for example corresponds with either of the signal windings 42 or 44 of the variable inductors 31 and 32 shown in Figure 3. Additionally, an auxiliary control winding 64 for providing these periodic variations is wound on the core as shown. A pair of such inductors can be incorporated into a tuning section, such as the section 30, and periodic variations in the auxiliary control currents, which, for example, may be provided by a pair of auxiliary potentiometers connected to the source 18*a*, are sent through the auxiliary control windings.

The antenna tuning system of Figure 5 is similar to the one shown in Figure 3, except that the automatic control equipment is omitted, and the tuning section 30*b* is arranged as a π-section. The signal windings 34*b* and 35*b* of the variable inductors 31*b* and 32*b* are connected in shunt with the transmission line 6*b* near the base of the antenna 26*b*, and the condenser 36*b* is connected in series with the antenna and its feedline. As discussed above, the impedance transformation and the antenna compensating reactance can be separately controlled by the magnitudes of the D.-C. currents flowing from the source 18*b* through the leads 43*b* and 45*b* as determined by the adjustment of the potentiometers 42*b* and 44*b*. During operation, these potentiometers are manually or automatically adjusted to provide optimum antenna compensating reactance and impedance match between the antenna and line 6*b*.

The antenna tuning system of Figure 6 is similar to Figure 5 except that the tuning section 66 includes a controllable inductor 68 having a signal winding 69 in series with the feedline 6C and a controllable inductor **70** having a signal winding **71** shunted across this line. A tuning condenser **72** may be connected in shunt across the line 6C between the base of the antenna **26c** and the ground conductor **28c**. The inductance of these windings **69** and **71** are separately controlled by the magnitudes of the D.-C. control currents from the source **18c** adjusted by the potentiometers **42c** and **44c** and fed through the leads **43c** and **45c** to the control windings **74** and **76**. With this arrangement, the impedance matching relationships between the antenna **26c** and the line **6c** and also the antenna-compensating reactance can each be separately adjusted either manually or automatically to provide optimum operating characteristics. In Figure 6 the shunt winding **71** is connected to the transmitter side of the series winding **69**, an alternative arrangement which also provides separate and independent control of the impedance match and compensating reactance is to connect winding **71** on the opposite side of the winding **69**.

Figure 7 shows a balanced remote antenna tuning system suitable for dipoles and other balanced antenna elements. The two poles of the dipole antenna **82** are connected to opposite sides of the transmission line **6d** through the signal windings **84** and **86** of variable inductors **88** and **90**. These windings **84** and **86** serve to introduce antenna-compensating inductance in series with each side of the line **6d**, and the value of this inductance is controlled by the currents through each of the control windings **92** and **94**, respectively, to produce the desired optimum conditions within the system depending upon the desired operating characteristics. For example, the antenna compensating inductance of windings **84** and **86** may be adjusted to equal values for producing the same phase relationships in both elements of the dipole, or the phases of the two elements can be varied by regulating the inductances of the windings **84** and **86** to different values in order to change the directivity of the antenna. Also, the relative output (or input) from each of the elements of the antenna **82** can be alternately or independently controlled by the variable inductors **88** and **90**.

The system shown in Figure 8 controls the reactance component at both ends of the transmission line to produce optimum conditions in both places. In order to provide the antenna-compensating reactance, the signal winding **92** of the variable inductor **94** is connected in series with the ungrounded side of the transmission line **6e** near the base of the stub antenna **26e**. The inductance of the winding **92** is controlled by the magnitude of the D.-C. current, which is adjusted by the potentiometer **44e** and sent through the control winding **94**. It is adjusted to produce optimum antenna compensating reactance. At the transmitter end of the line, a similar inductor **95** has its signal winding **96** connected in series with the transmission line **4e**. Its inductance is controlled by the magnitude of the current flowing through the control winding **97**, which is adjusted by the setting of the potentiometer **42e** to provide an optimum value of reactance presented by the transmission line to the transmitter **2e**.

Figures 9 and 10 show alternative remotely controlled antenna tuning and filter systems, in which the signal windings **100f** and **100g** of the variable inductors **108f** and **108g** insert series inductance of controlled value into the transmission lines **6f** and **6g** near the base of the antenna **26f** and **26g**. The values of the antenna-compensating industances, which are inserted in series with the lines **6f** and **6g**, are controlled by the currents flowing from the sources **18f** and **18g** through the potentiometers **104f** and **104g** and along the lines **106f** and **106g** through the control windings **108f** and **108g**, respectively, and may be manually or automatically adjusted to optimum values. In Figure 9, this control current also regulates the setting of a tuned filter circuit **109f** connected from the base of the antenna element **26f** to ground. This filter circuit includes the variable inductance signal winding **110f** connected to ground through a condenser **112f**. By setting the value of the fixed condenser **112f** so that this filter circuit is in series resonance at a predetermined harmonic of the signal, this harmonic is filtered from the system both during transmission and reception. When the control current is changed to alter the reactance loading of the line for antenna compensation at different operating frequencies, this same change in current affects the control winding **114f** of the variable inductor **116f** and hence changes the inductance of the winding **110f** to retune the filter **109f** to the same harmonic of the new operating frequency. Thus, the filter **109f** "tracks" the operating frequency and suppresses a predetermined harmonic in the system irrespective of variations in the operating frequency.

An alternative filter arrangement may be used wherein the inductor **116f** is replaced by an inductor of the general form shown in Figure 2 with one of the signal windings thereof being connected between the base of the antenna and ground and the other winding is connected to opposite terminals of the condenser **112f**.

In Figure 10, the filter circuit **109g** includes the condenser **112g** connected in parallel with the variable inductance winding **110g**, and both being connected in series with the transmission line **6g**. This parallel filter combination **109g** is tuned to be at resonance to present a high impedance at the frequency of the harmonic which is desired to be excluded from the system. The magnitude of the control current through the control winding **102g** regulates the antenna-compensating inductance in series with the line **6g** and also controls the inductance of the winding **110g** to cause the filter **109g** to "track" the operating frequency in a manner similar to the system shown in Figure 9.

An alternative filter arrangement may be used wherein the inductor **114g** is replaced by an inductor of the general form shown in Figure 2 with one of the signal windings thereof being connected in series with the line and the other signal winding is connected to opposite sides of the condenser **112g**.

In the system of Figure 11, a T-type tunable low-pass filter **120** and the signal winding **121** of a variable inductor **122** are connected in series with each other and with the transmission line **6h**. This filter **120** is tuned to block any frequency components significantly above the frequency of the desired transmitted signals. The filter and the antenna reactance compensating inductor **122** are controlled by the magnitude of a D.-C. current flowing from the source **18h** over the line **124** so that they "track" each other through various operating frequency ranges. Thus, the filter is always properly tuned to block undesired frequency components above the signal frequencies being used. The filter comprises a pair of variable inductors **126** and **128** with their signal windings **130** and **132** connected in series with each other and with the line **6h** and a condenser **134** shunted across the line **6h** at their junction. A resistor **136** may be shunted across the transmission line between the T-section filter and the antenna-compensating inductance **121**.

The controllable inductors incorporated into the systems shown in Figures 5 through 11 are generally similar to the inductors **31** and **32** shown in Figure 3. For example, these inductors may be similar to the inductor **56** shown in Figure 4, except that the auxiliary winding **64** is omitted. It is to be understood that the principles set forth above in connection with controllable inductors having single cores apply equally well to multiple core structures. For example, each controllable inductor may comprise a pair of cores with control and signal windings thereon, with at least one of said windings being formed in two sections of turns. A section is placed on each core, and they are connected in series in such direction that the flux from the other winding links each of said sections of turns in opposite directions. Thus, the windings are isolated from each other and have no net effective mutual flux linkages; however, one of these windings is used to control the inductance of the other winding by regulating the degree of magnetic saturation of the cores.

In the various arrangements shown, additional circuit elements may be used where required. For example, fixed transformers may be added either between the transmission line and the controllable impedance device or between the antenna and this device, condensers or inductors may be connected to the line or used in various tuned harmonic traps, etc.

Various remotely controllable antenna tuning systems, some including filter arrangements, have been described, and from this description it will be apparent that antenna tuning systems embodying the present invention are well adapted to attain the ends and objects set forth herein and that the various embodiments of the invention shown herein can be modified so as to produce operating characteristics best suited to the needs of each particular use. Moreover, in certain more critical applications, the range or stability of the variable inductance units may be increased by equipment as is described in the applications of William D. Gabor, Serial No. 234,581, filed June 30, 1951, now Patent No. 2,755,446, and Serial No. 279,825, filed April 1, 1952, now abandoned.

We claim:

1. An antenna tuning system comprising an antenna unit, a radio transmitter unit, an energy transmission line for conveying radio signals between said transmitter and said antenna unit, a controllable inductor having a core of ferromagnetic material with a control winding and a signal winding wound on said core, said control winding being substantially isolated from the signals in said signal winding, the inductance of said signal winding being controlled by the current through said control winding, said signal winding being connected to said transmission line near said antenna to control the impedance presented to said line by said antenna, a source of control current near said transmitter, means for varying said current, a conductor between said current varying means and said control winding for conveying control current to said winding, a detection unit connected to said line near said transmitter for sensing the conditions on said line, and a condition-responsive control connected to said detection unit and arranged to control said current varying means.

2. An antenna tuning system comprising a ground conductor, a stub type antenna projecting from said ground conductor, a source of radio frequency for energizing said antenna, an energy transmission line extending between said source and said antenna, an electrically controllable inductor positioned near the base of said antenna, said inductor having a core of ferromagnetic material, a signal winding on said core, a control winding on said core for varying the degree of magnetic saturation thereof in accordance with variations in control current flowing through it, said control winding being substantially isolated from said signal winding, the inductance of said signal winding being controlled by this saturation, said signal winding being connected to said transmission line near the base of said antenna to control the impedance relationships between said antenna and said transmission line, a source of D.C. control current near said radio frequency source, conductor means extending from said current source to said control winding, and control means near said sources for varying said control current, whereby said impedance relationships can be remotely controlled by varying the current through said control winding.

3. An antenna tuning system comprising a ground conductor, a stub type antenna projecting from said ground conductor, a source of radio frequency for energizing said antenna, an energy transmission line extending between said source and said antenna, an antenna tuning section position near the base of said antenna, said section including a pair of electrically controllable inductors and a condenser connected to said transmission line near the base of said antenna, each of said inductors having a core of ferromagnetic material, a signal winding on said core and connected to said transmission line near the base of said antenna, and a control winding on said core for varying the degree of magnetic saturation thereof in accordance with variations in a control current flowing through it, the inductance of said signal winding being controlled by this saturation, each of said control windings being substantially isolated from the signal winding on its respective core, a source of direct control current near said radio frequency source, a conductor extending from said current source to each of said control windings, and means near said sources for separately varying the control currents through each of the control windings, whereby the impedance matching relationship between said antenna and the line and the reactance presented to the end of the line near said antenna can be remotely and separately controlled by varying the currents through said control windings.

4. An antenna tuning system as claimed in claim 3 and wherein said antenna tuning section is a T-section having said signal windings connected in series with said transmission line near the base of said antenna, and having said condenser connected across said transmission line between said signal windings.

5. An antenna tuning system comprising an antenna, a radio transmitter unit, an energy transmission line for conveying radio signals between said transmitter and said antenna unit, an antenna tuning section positioned near said antenna, said section including a pair of electrically variable inductors, each of said inductors having a core of ferromagnetic material with a control winding and a signal winding wound on said core, said control winding being substantially isolated from the signals in said signal winding, the inductance of each of said signal windings being controlled by the current through the control winding on the same respective core, each of said signal windings being connected to said transmission line near said antenna to control the impedance match between said line and said antenna and the reactance presented to said line by said antenna, a source of control current near said transmitter, main control means for adjusting said control current, auxiliary control means arranged to cyclically and separately vary the saturation of said cores by relatively small amounts, a conductor between said control means and each of said control windings for conveying control currents to said windings, a detection unit connected to said line near said transmitter for sensing the changing conditions on said line produced by said cyclic variations and a condition-responsive control connected to said detection unit and arranged to control said main control means to maintain optimum an impedance match between said line and said antenna unit and also an optimum reactance at the end of said line near said antenna.

6. In a system for transmitting or receiving radio energy over a wide range of frequencies wherein the antenna is positioned remotely from the transmitter and is coupled thereto by an energy transmission line and wherein the antenna is utilized over said wide range of frequencies, an antenna tuning and matching system comprising an antenna, a transmitter, an energy transmission line for conveying radio energy over said wide range of frequencies between said transmitter and said antenna, at least two controllable inductors each including a ferromagnetic core having thereon a control winding and a signal winding, said signal and control windings in each inductor being substantially isolated from each other, each of said signal windings being connected to the transmission line near the antenna, a source of direct control current connected to each of said control windings, each of said control windings being arranged to vary the degree of magnetic saturation in its respective associated core in response to the magnitude of the control current therein, thereby to vary the inductive reactance of its

associated signal winding, and control means arranged to regulate the magnitude of the control current in each of said control windings, whereby said variable inductors provide a wide range in inductive reactance to compensate for the reactance of said antenna over said wide range of frequencies and to match said antenna to said transmission line over said wide range of frequencies.

7. An antenna tuning system comprising an antenna unit, a radio transmitter unit, an energy transmission line for conveying radio signals between said transmitter and said antenna unit, a first controllable inductor having a core of ferromagnetic material, a control winding, and a signal winding wound on said core, said control winding being substantially isolated from the signals in said signal winding, the inductance of said signal winding being controlled by the current through said control winding, said signal winding being connected to said transmission line near said antenna to control the impedance presented to said line by said antenna, a second controllable inductor having a second core of ferromagnetic material, a second control winding, and a second signal winding wound on said core, the inductance of said second signal winding being controlled by the current through said second control winding, said second signal winding being connected to said transmission line, a source of control current, means for varying said current, conductor means between said current varying means and said control windings for conveying control current to said control windings, a detection unit connected to said line near said transmitter for sensing the conditions on said line, and a condition-responsive control connected to said detection unit and arranged to control said current varying means.

8. An antenna tuning system comprising an antenna unit, a radio transmitter unit, an energy transmission line for conveying radio signals between said transmitter and said antenna unit, first and second controllable inductors each having a core of ferromagnetic material with a control winding and a signal winding wound thereon, each of said control windings being substantially isolated from the signals in said signal windings, the inductances of said signal windings being controlled by the current through said control winding, both of said signal windings being connected to said transmission line near said antenna to control the impedance presented to said line by said antenna, a condenser connected to said transmission line adjacent said signal windings, a source of control current, means for varying said current, conductor means between said current varying means and said control windings for conveying control currents to said control windings, a detection unit connected to said line near transmitter for sensing the conditions on said line, and a condition-responsive control connected to said detection unit and arranged to control said current varying means.

9. An antenna tuning system and harmonic filter means tracking therewith comprising an antenna unit, a radio unit, an energy transmission line for conveying radio signals between said radio unit and said antenna unit, a first controllable inductor having a core of ferromagnetic material, a control winding, and a signal winding wound on said core, said control winding being substantially isolated from the signals in said signal winding, the inductance of said signal winding being controlled by the current through said control winding, said signal winding being connected to said transmission line near said antenna to control the impedance presented to said line by said antenna, a second controllable inductor having a second core of ferromagnetic material, a second control winding, and a second signal winding wound on said core, the inductance of said second signal winding being controlled by the current through said second control winding, a condenser, said second signal winding and said condenser forming harmonic filter means and being connected to said transmission line, a source of control current, means for varying said current, conductor means between said current varying means and said control windings for conveying control current to said control windings, said current varying means simultaneously changing the inductance of said first and second signal windings, thereby to track said harmonic filter means with said first signal winding, a detection unit connected to said line near said radio unit for sensing the conditions on said line, and a condition-responsive control connected to said detection unit and arranged to control said current varying means.

10. An antenna tuning system as claimed in claim 3 and wherein said antenna tuning section is a π-section having each of said signal windings connected across said transmission line near the base of said antenna, and having said condenser connected in series with said transmission line between adjacent terminals of said signal windings.

11. An antenna tuning and filter system for operation over a wide frequency range comprising a ground conductor, a stub-type antenna projecting from said ground conductor, a source of radio frequency for energizing said antenna, an energy transmission line extending between said source and said antenna, an antenna reactance compensating electrically variable inductor and a filter section positioned near the base of said antenna, said section also including first and second electrically variable inductors and a condenser, each of said inductors having a core of ferromagnetic material, a signal winding on each of said cores and a control winding on each of said cores for varying the degree of magnetic saturation of its respective core in accordance with variations in a control current flowing through it, the inductance of each of said signal windings being controlled by this saturation of its respective core, each of said control windings being substantially isolated from the signal winding on its respective core, the signal winding of said antenna compensating inductor being connected to said transmission line near said antenna, the signal windings of said first and second inductors being connected in ladder tuned filter circuit with said condenser, said tuned circuit being connected in series with said line and arranged to filter undesired frequencies from said line, a source of direct control current near said radio frequency source, conductive means extending from said current source to each of said control windings, and control means near said sources arranged to regulate the control current flowing through each of said control windings, whereby said antenna compensating inductor can be remotely controlled by said control means to produce optimum reactance at the end of said line near said antenna, and said filter section can be remotely controlled by said control means to filter out undesired signals, and whereby said reactance compensation and said filter "track" each other as the operating frequency of said system is changed.

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