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X 5481R

Feb. 15, 1966

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3,235,805

OMNIPOLE ANTENNA

Original Filed April 1, 1957

9 Sheets-Sheet 1

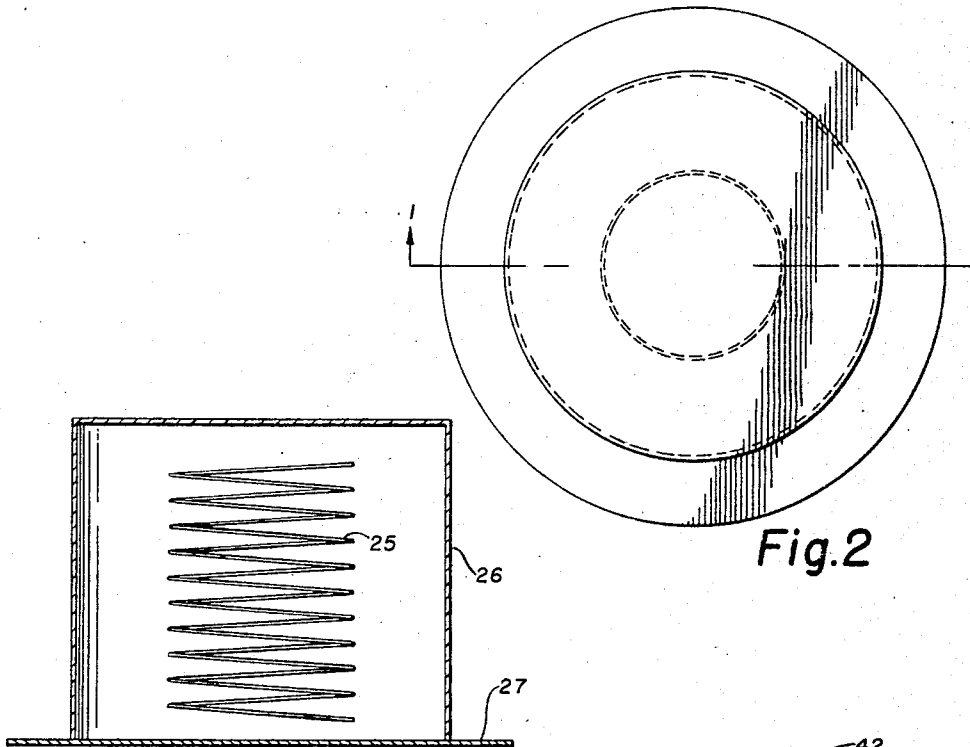


Fig. 1

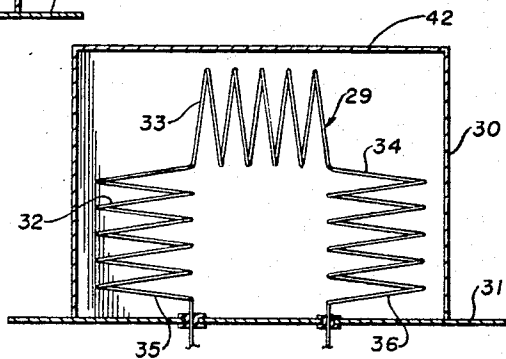


Fig. 3

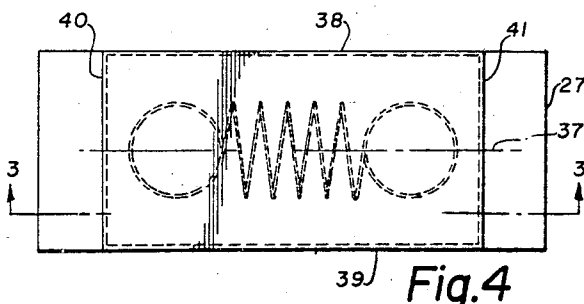


Fig. 4

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coil

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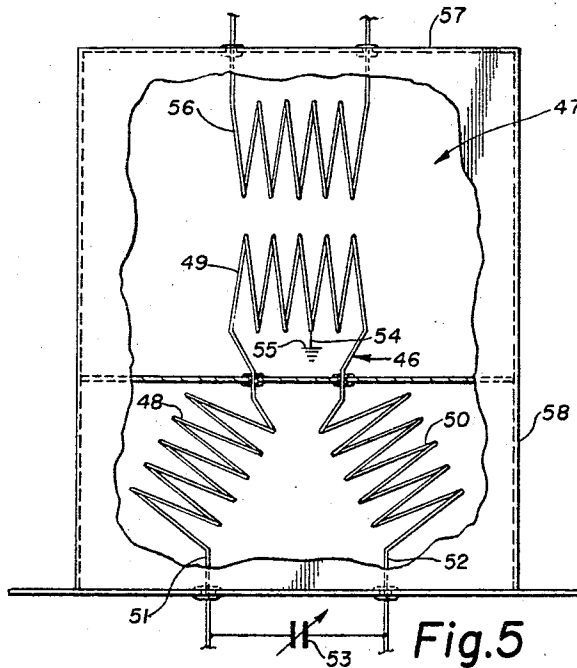


Fig. 5

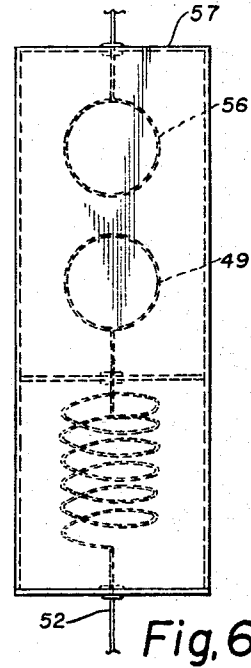


Fig. 6

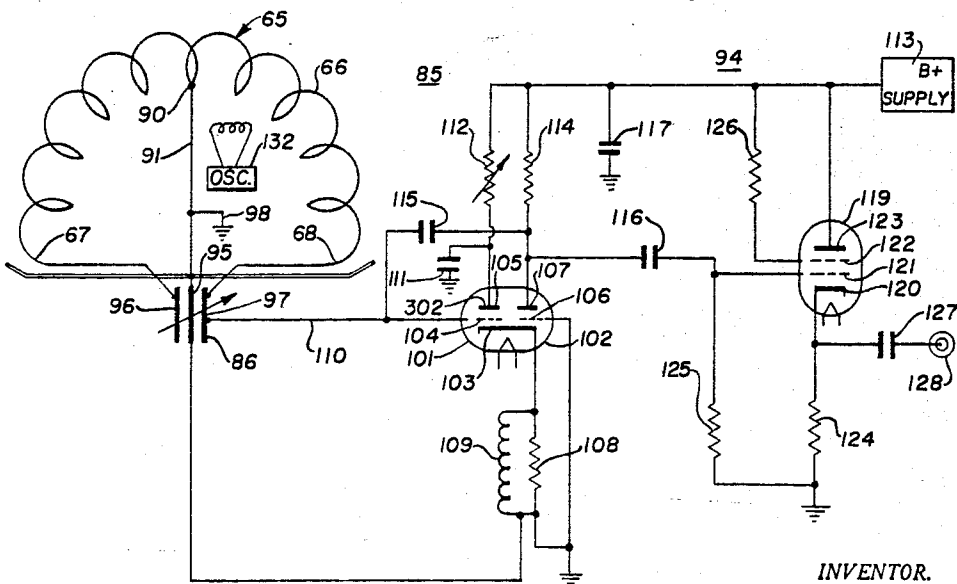


Fig. 10

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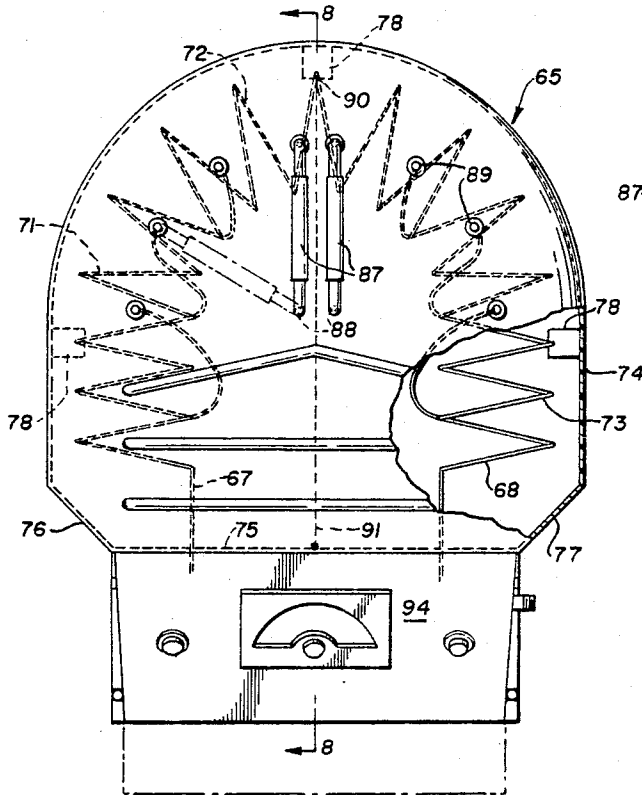


Fig. 7

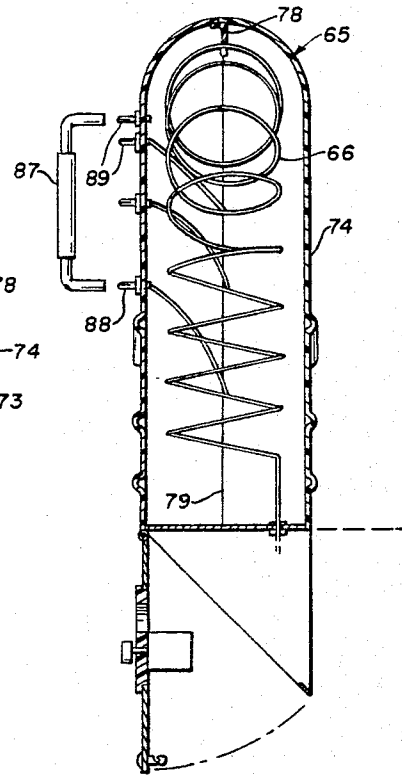


Fig. 8

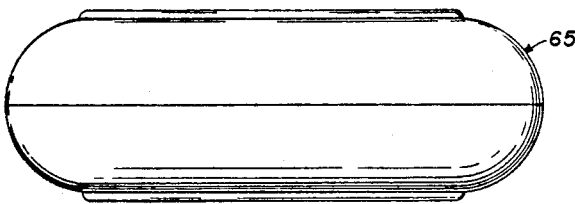


Fig. 9

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9 Sheets-Sheet 4

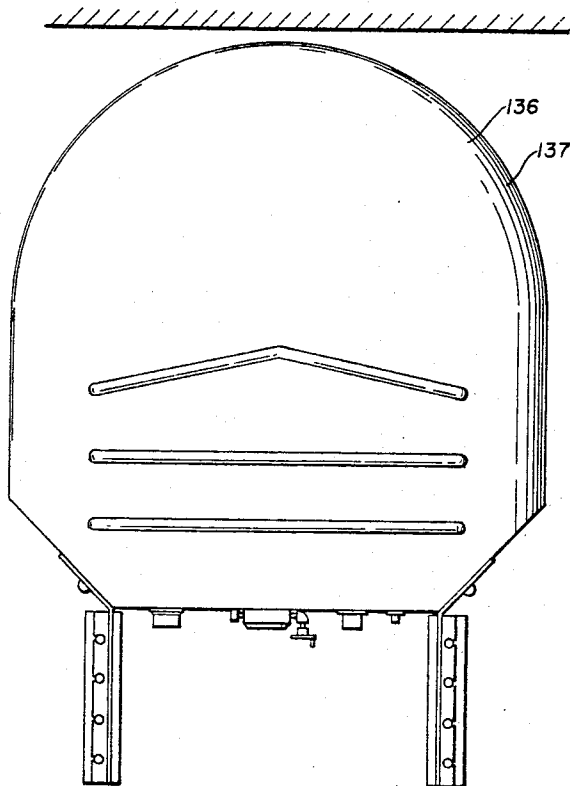


Fig. 11

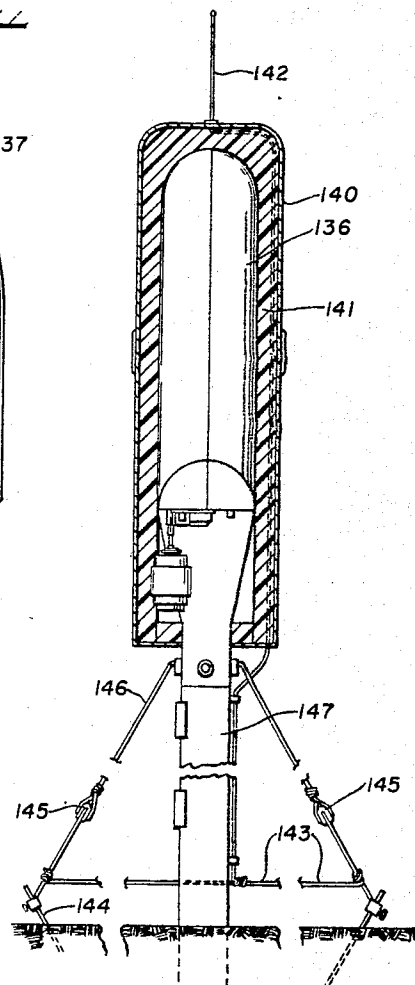


Fig. 12

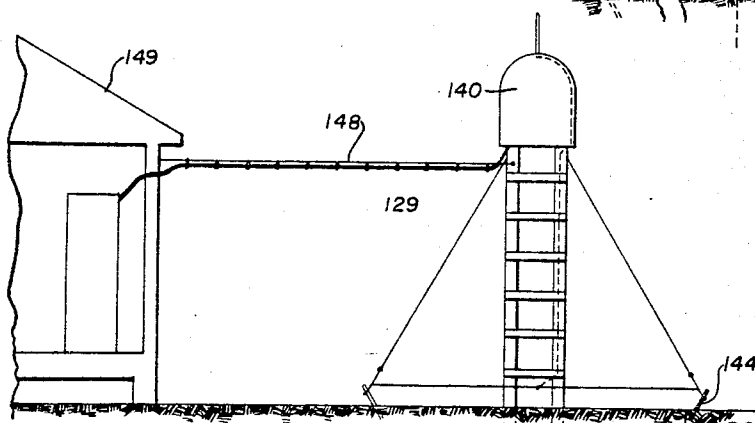


Fig. 13

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9 Sheets-Sheet 5

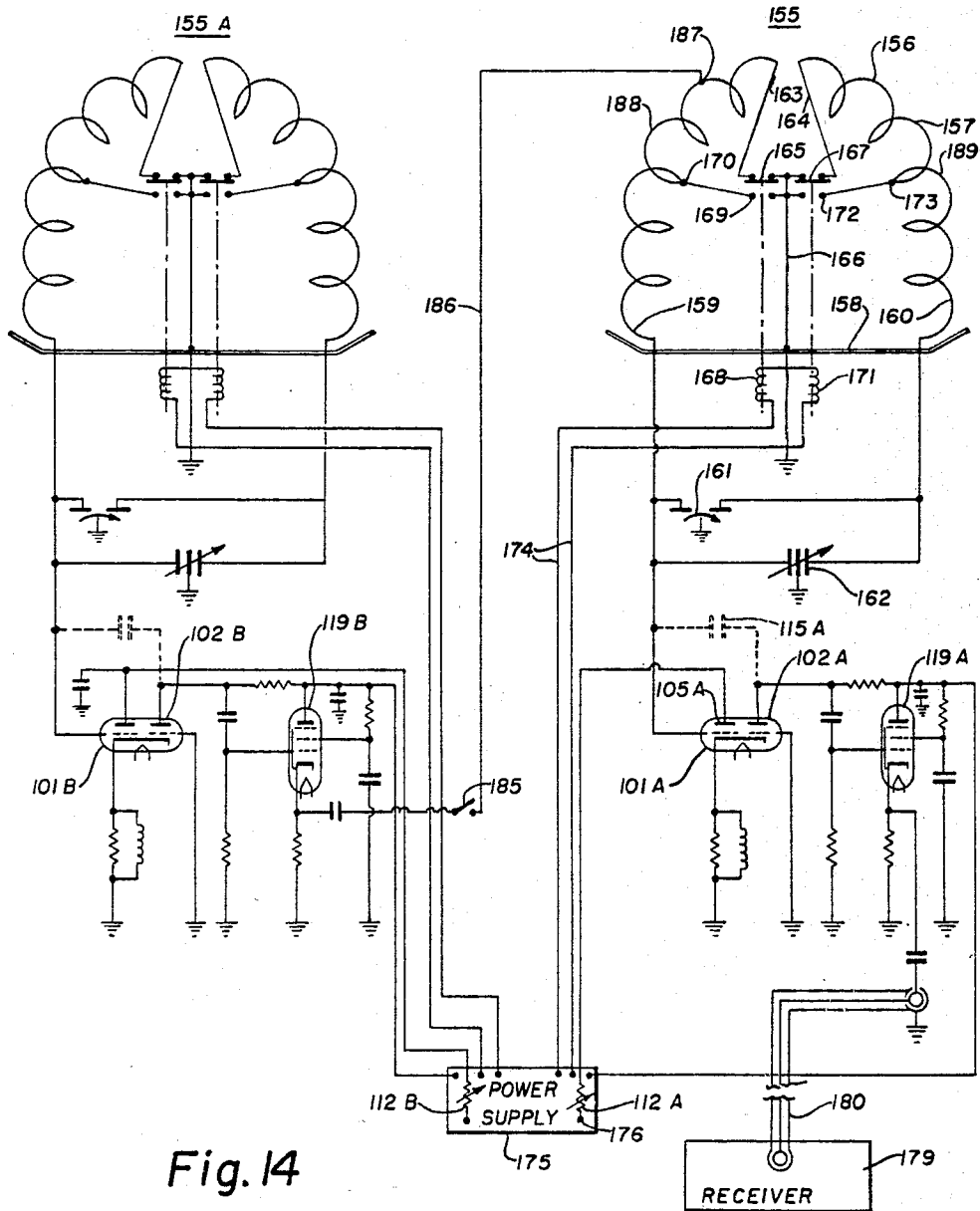


Fig. 14

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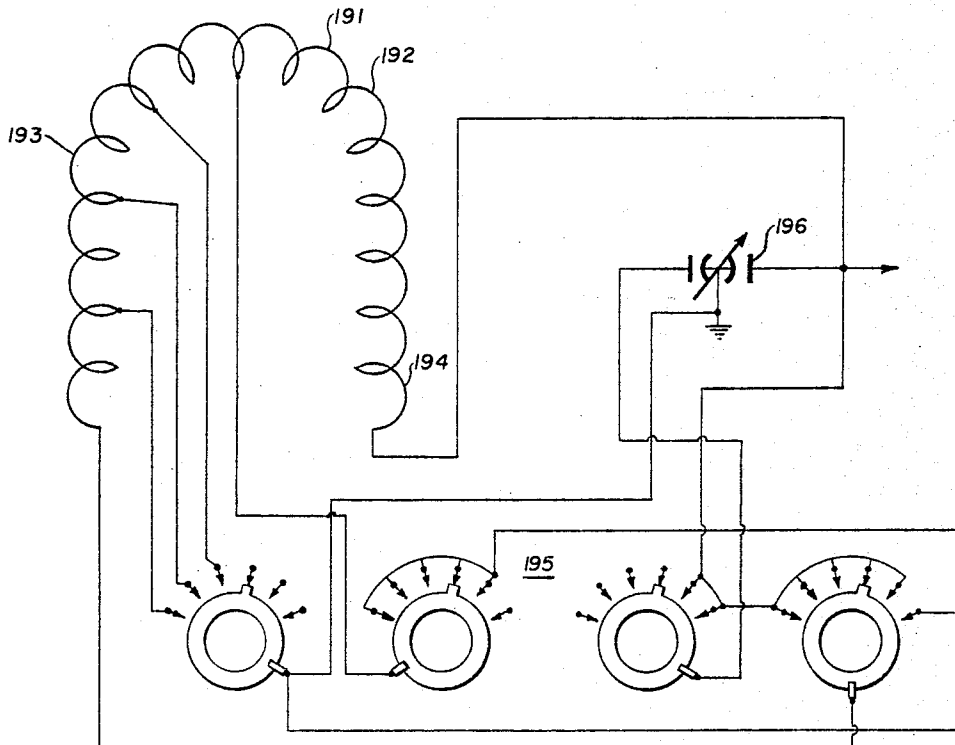


Fig. 15

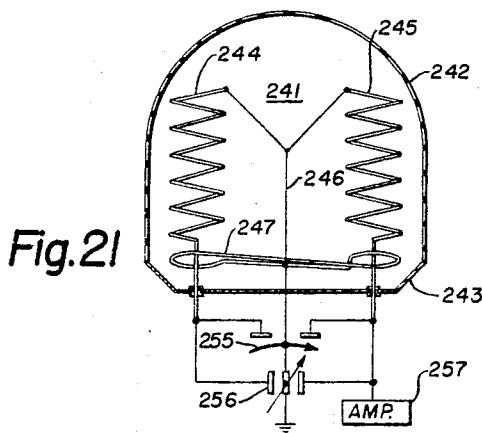


Fig. 21

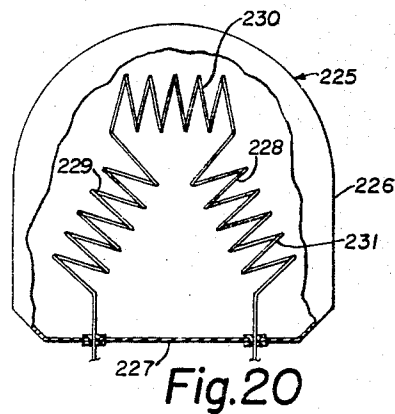


Fig. 20

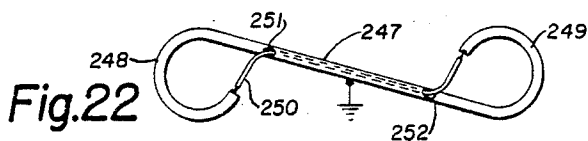


Fig. 22

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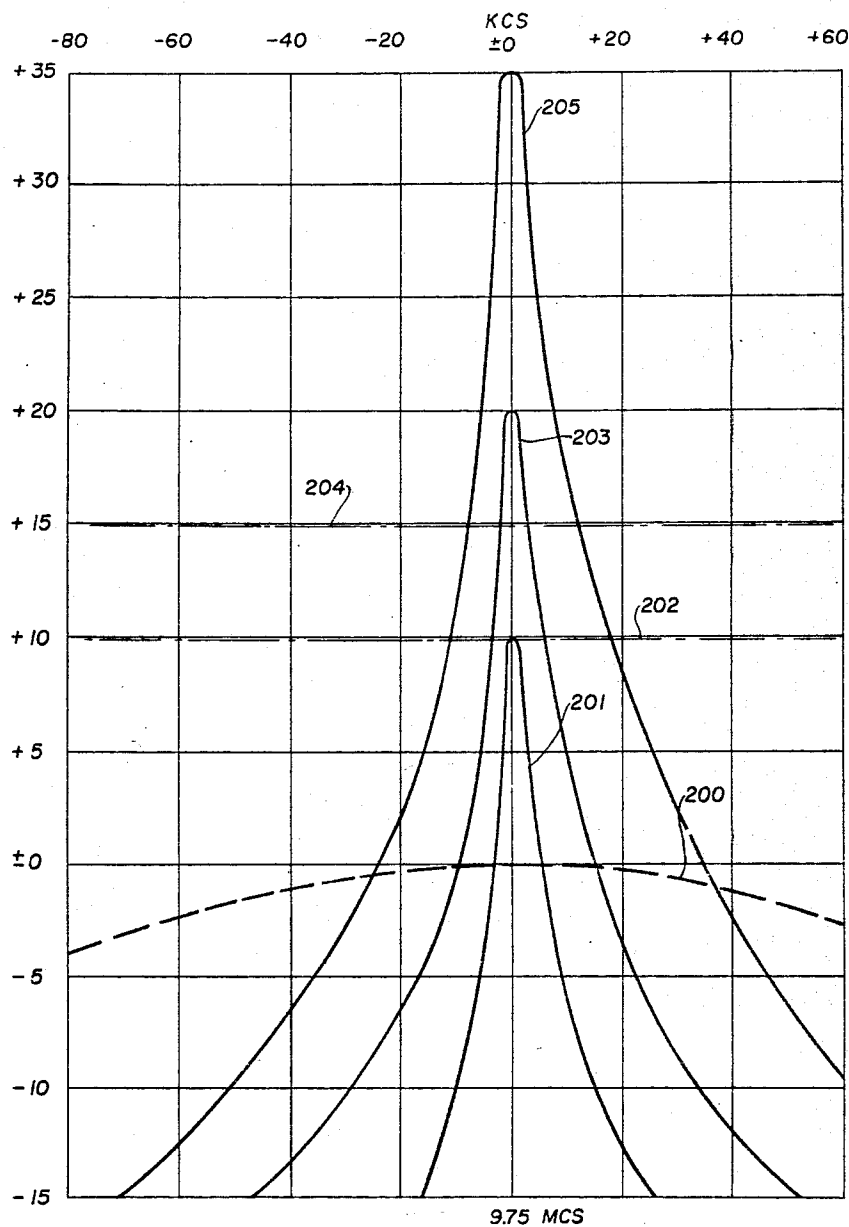


Fig.16

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9 Sheets-Sheet 8

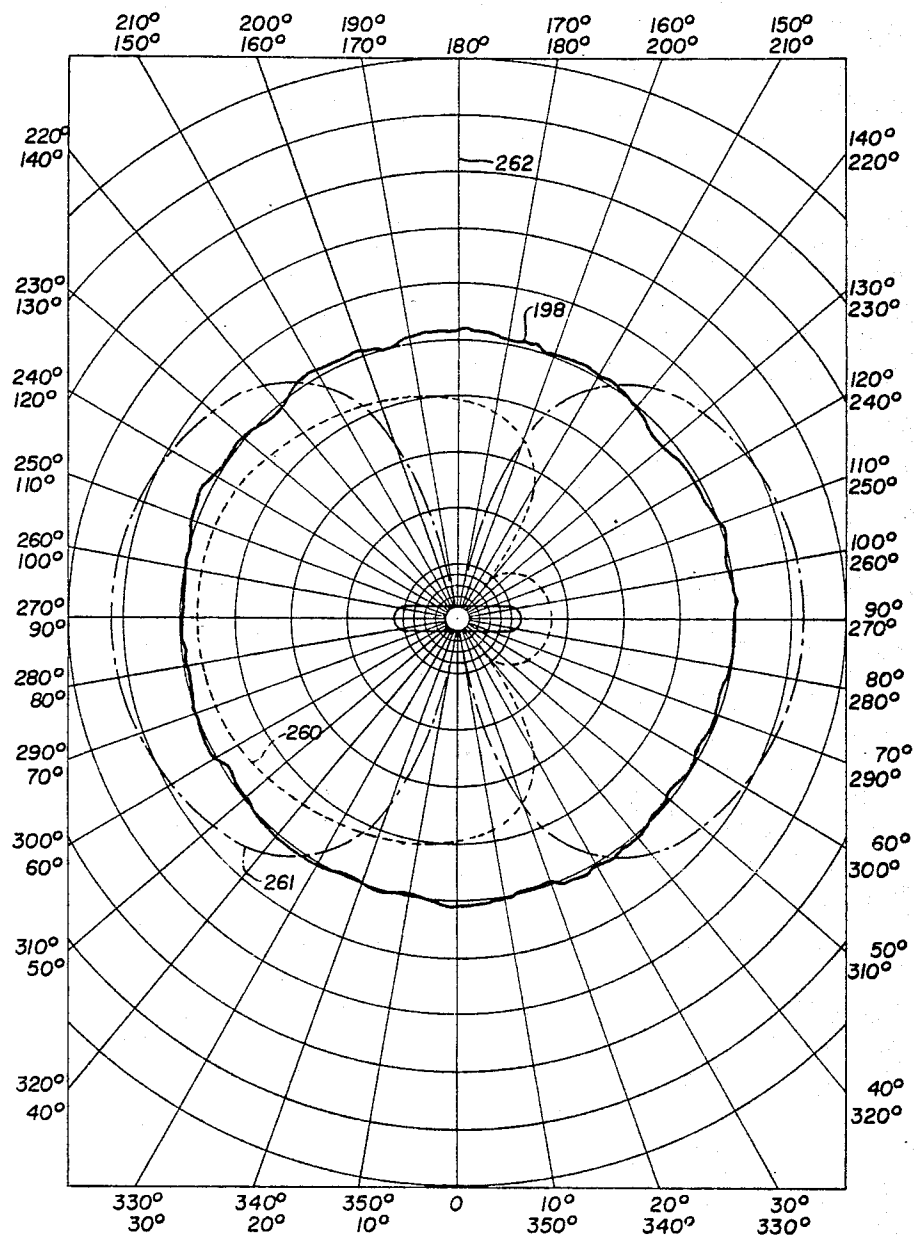


Fig.17

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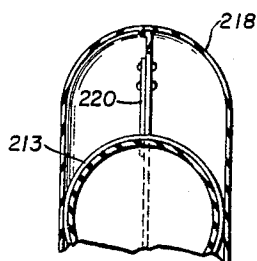


Fig. 19

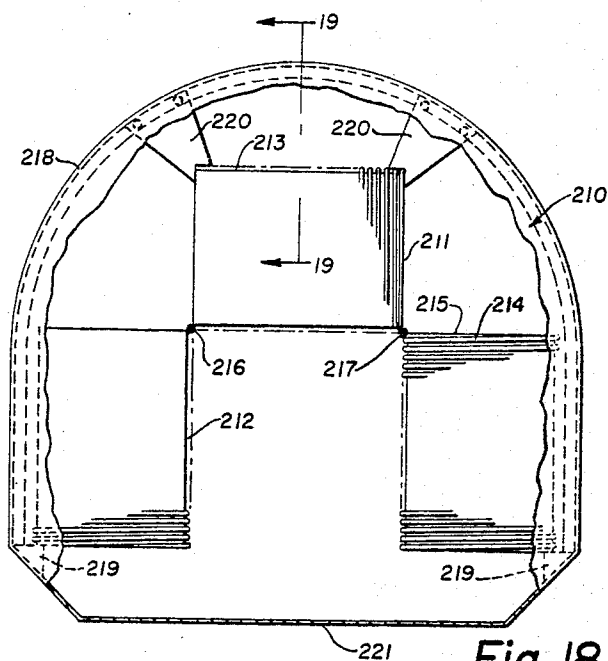


Fig. 18

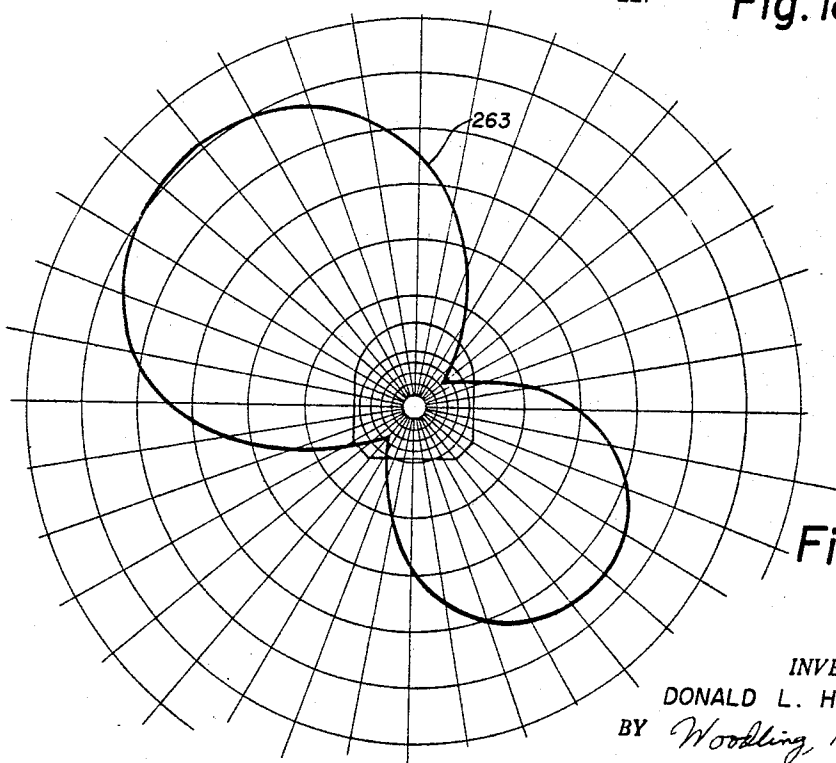


Fig. 23

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## OMNIPOLE ANTENNA

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Original application Apr. 1, 1957, Ser. No. 649,695.  
Divided and this application Sept. 20, 1961, Ser.

No. 139,445

13 Claims. (Cl. 325-374)

This application is a division of my application, Serial No. 649,695, filed April 1, 1957, entitled "Inductive Winding," now abandoned in favor of this application.

The invention relates in general to the use of an inductive winding as an antenna and more particularly to such windings having a high "Q" and a generally U-shape to act as a directional or an omni-directional antenna.

One feature of the present invention is to provide inductance coils with higher Q than formerly obtained, yet achieved in a smaller physical space. A correlated feature is the use of inductive windings as a radio antenna which occupies much less space than a corresponding dipole and far less space than a V or rhombic antenna, yet which outperforms such antennas. By relative placement of the coils and with linkage to control elements, these inductive antennas may be tuned to provide directional or omnidirectional reception of radio signals.

The prior art has shown antennas for use in the VHF band which are relatively small in size because a half wave length at such frequencies is only from one-half to five meters. However, in the high frequency band a half wave length is from five to fifty meters, and thus self-supporting dipole antennas are generally out of the question and often V and rhombic antennas are used when high gain is desired. Such antennas are useful only from fixed ground to ground communication systems and are highly directional and are not rotatable to receive or send signals from any other than a single direction.

Accordingly, an object of the invention is to provide a resonant inductance utilizing a dielectric core to obtain a relatively high Q factor.

Another object of the invention is to provide an inductance having a reduced diameter and a non-linear length to produce a relatively high Q factor.

Another object of the invention is to provide a resonant inductive winding having a multiplicity of coils each dimensioned for a maximum Q factor and arranged in a plane ninety degrees to the adjacent coil to form a complete inductance with a combined Q factor greater than with a single linear coil.

Another object of the invention is to provide a means for obtaining a high Q from a compact inductance design utilizing a dielectric core.

Another object of the invention is to provide an inductance mounted in a housing and which may be used either as an inductive reactance or as an antenna, and wherein the housing cooperates with the inductance to either increase the Q thereof or at least not to detract from the Q of the inductance.

Another object of the invention is to provide a special form of inductance for obtaining high Q; and when used as an antenna, to introduce Q to the natural resonant period of the antenna.

Another object of this invention is to use an inductance winding design having a naturally high Q and then to utilize it as a radio antenna and then feeding back energy in phase to the antenna to artificially raise the Q thereof.

Another object of the invention is to provide an antenna with artificially increased Q to permit the antenna to work in a confined space with sufficient increased efficiency so that it may perform as well or better on a speci-

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fied frequency than a prior art linear antenna of normal size for that frequency.

Another object of the invention is to provide an inductance with a housing surrounding it, which housing may be of dielectric material to create a capacity higher than that of air on the outer perimeter of the inductance which electrically effectively increases the diameter of the coil and hence permits relatively small diameter coils to have relatively high Q.

Another object of the invention is to provide a generally U-shaped inductive winding with a conductive panel adjacent the two ends of the inductance as an electrostatic path for the resonant electrostatic energy of the inductance.

Another object of the invention is to provide a small directional or omnidirectional antenna having high gain, and where this antenna may be operable in either the high frequency or low frequency bands.

Another object of the invention is to provide an antenna with high Q to have a narrow band width so that the antenna is as selective as the radio receiver with which it is used.

Another object of the invention is to provide an antenna having a high Q so as to reject much external noise and thus to permit intelligent reception of signals at a far lower voltage level than formerly.

Another object of the invention is to provide an antenna with an improved signal-to-noise ratio by balancing out vertically polarized signals or noise from two of three dimensions.

Another object of the invention is to provide an antenna for use on high and low frequencies which may be positioned relatively closely to the ground with respect to a quarter wave length, yet which will outperform the prior art linear type of antennas even when positioned at an optimum height such as one quarter wave length.

Another object of the invention is to provide a dual antenna system wherein a first antenna feeds a second antenna to in effect double the selectivity and intercept area of the entire antenna system.

Another object of the invention is to provide an antenna system which is selectively directional or non-directional by a simple tuning of the antenna.

Another object of the invention is an antenna interception system to receive radio signals from more than one location with two or more selective antennas.

Another object of the invention is to provide a radio wave interception system having a first antenna coupled to a second antenna with the output of the second antenna combining the intercepted signal from both antennas when effectively tuned to the same frequency to produce a highly selective interception system to reduce fading and to reject noise such as from atmospheric disturbances and side band signals.

Another object of the invention is to utilize a regenerative amplifier as a part of a resonant antenna to artificially raise the Q of the antenna, and also wherein heterodyning between the received signal and a local signal may produce a lower frequency carrier containing the received intelligence all as part of the entire antenna system.

Another object of the invention is to provide an inductive winding design having a higher Q than the prior art cylindrical coil design or toroidal coil design.

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

FIGURES 1 and 2 are top and sectional views of a prior art shielded inductance;

FIGURES 3 and 4 are top and sectional views of a

shielded inductance made in accordance with the present invention;

FIGURE 5 is a front view of a shielded inductance with the shield broken away to show the internal construction;

FIGURE 6 is an end view of the inductance of FIGURE 5;

FIGURE 7 is a front view of an antenna of the present invention;

FIGURE 8 is a sectional view on the lines 8—8 of FIGURE 7;

FIGURE 9 is a top view of FIGURE 7;

FIGURE 10 is a schematic diagram of an antenna system 85;

FIGURE 11 is a front view of another embodiment of the invention;

FIGURE 12 is a sectional view of the embodiment of the invention of FIGURE 11;

FIGURE 13 is an elevational view of an embodiment of the invention;

FIGURES 14 and 15 are schematic diagrams of two further embodiments of the invention;

FIGURE 16 is a graph of performance curves of antennas of the invention;

FIGURE 17 is a polar graph of field patterns of antennas of the invention;

FIGURE 18 is an elevational view of another antenna of the invention;

FIGURE 19 is a sectional view on lines 19—19 of FIGURE 18;

FIGURE 20 is an elevational view of another antenna of the invention;

FIGURE 21 is an elevational view of another antenna of the invention;

FIGURE 22 is a plan view of a coupling link; and FIGURE 23 is a vertical pattern of the antenna of FIGURE 21.

FIGURES 1 and 2 show a standard form of prior art air core radio frequency inductance 25 mounted in an electrostatic shield 26. The shield is an electrically conducting member to contain the electrostatic field of the inductance 25 and is a right cylinder having a base plate 27.

The FIGURES 3 and 4 show an inductance 29 made in accordance with the present invention also enclosed within an electrostatic shield 30 having a base plate 31. The inductance 29 includes first, second, and third coil portions 32, 33, and 34 connected in series in generally a U-shape. The entire inductance 29 has first and second ends 35 and 36 which are disposed closely adjacent the base 31 of the electrostatic shield. The three coil portions 32, 33, and 34 each have an axis lying in a plane 37, and the shield 30 is rectangular and has sides 38 and 39 parallel with the plane 37. The shield 30 also has ends 40 and 41 and the axes of the coil portions 32 and 34 are parallel to the ends 40 and 41. The shield 30 has a top 42 with the coil portion 33 parallel to this top 42.

In this preferred embodiment the three coil portions are disposed at ninety degrees relative to each other but still form an inductance of generally a horseshoe or U-shape.

In the inductance 29 of the present invention five turns are used in each of the coil portions. The drawings of FIGURES 1 to 4 show the inductances 29 and 25 to the correct shape and proportions relative to the dimensions of the enclosing electrostatic shields. An inductance in accordance with the invention and in accordance with the drawing shown in FIGURES 3 and 4 was actually constructed and was measured as to Q. Also, an inductance in accordance with the prior art teachings and as shown in FIGURES 1 and 2 was constructed and measured as to Q. In the inductance 25, as shown in FIGURES 1 and 2, it had a length of two inches, a diameter of one and one-half inches, and was mounted

within a can or shield 26 of three-inch diameter and two and one-half inches in length. Ten turns were used in the inductance 25 and the Q was measured and determined to be 200. In the actually constructed inductance 29, as shown in FIGURES 3 and 4, each of the coil portions 32, 33, and 34 had five turns with each coil portion having a length of one inch, a diameter of three-fourths of an inch, and with this inductance 29 mounted in a shield two inches high, three inches long, and an inch and a half-thick. The Q was measured and was determined to be 300. This increased Q for smaller diameter coils is against the prior art teachings. Radio Engineers' Handbook, by Terman, First Edition, at page 47, states:

"Inductance has the dimensions of length. It will be found that in all inductance formulas the inductance is proportional to a linear dimension and to the square of the number of turns when the shape of the inductance is kept constant."

In a comparison of the inductances of FIGURE 1 and FIGURE 3, we note that the shape is kept constant, comparing inductance 25 with each of the coil portions 32, 33, and 34. One finds that in FIGURE 3 the number of turns has been halved and the length has been halved. Therefore, according to the prior art, the inductance or inductive reactance of one of the coil portions, 33 for example, should be one-half times one half squared of the inductive reactance of that of inductance 25, or in other words it should be one-eighth that of inductance 25. Since three coil portions are used in the inductance 29, this would mean that the total inductive reactance of inductance 29 should be three-eighths that of inductance 25. Now as to the resistance of one of the coil portions, 33 for example, relative to the inductance 25, it will be noted that it is one-half the length and one-half the circumference, or one-fourth the total wire length for each coil portion, or three-fourths the wire length for the three coil portions making up the inductance 29. Therefore, since the Q of the coil is equal  $WL/R$ , one would expect the Q of FIGURE 3 to be three-eighths divided by three-fourths times the Q of inductance 25. This would be one-half of the Q of inductance 25. Since inductance 25 had an actual measured Q of 200, one would expect the Q of inductance 29 to be 100; yet actually, when it was measured, it was found to be 300.

Coils such as these are used as air core coils in many radio circuits, and generally a coil may not be much larger than the vacuum tube with which it is used. With the trend toward miniaturization in all radio and electronic circuits, the vacuum tubes have been getting smaller but the coils or inductances used with them have had to remain the same size in order to maintain the Q of the coil. As shown in FIGURES 1 and 2, such a prior art inductance with a Q of 200 took up a space three inches by three inches on the chassis of the radio equipment. Now, according to the present invention, an inductance, also shielded, may take up a space only three inches by one and one-half inches, yet have a Q of 300 rather than only 200, hence saving half the space on the radio chassis and producing an even better radio circuit because of the higher Q. A possible explanation as to the operation of the inductance 29 to give this superior performance in a smaller space is that the three coil portions 32, 33, and 34, form a partially closed path for the field of the inductance 29, also the distributed capacity between turns is reduced, and the electrostatic field terminates near the base plate 31 which is a planar electrically conducting panel so as to achieve an efficient path for the electrostatic field.

The inductance 29 may be considered as part of a toroid, yet toroidal coils ordinarily do not have particularly good Q's as stated in Terman at page 77;

"The Q's obtained with toroidal coils are always appre-

ciably lower than for ordinary single-layer or multi-layer of corresponding physical dimensions."

The inductance 29 of FIGURES 3 and 4 may be used in any number of ways well known in the radio electrical art; and as is usual in many cases, one may connect a capacitor such as a variable capacitor across the ends of this inductance 29 for providing parallel resonance at a particular frequency or range of frequencies. The inductance 29 may also be used as an auto transformer merely by tapping off at any suitable point, or may be used as an inductive transformer by placing another inductive coupled coil within the electrostatic shield 30 and in the field of the inductance 29.

The FIGURES 5 and 6 show another form of the invention wherein an inductance 46 is a part of a transformer 47. The inductance 46 includes first, second, and third coils 48, 49, and 50 connected in series with these coils disposed in a single plane and with the coils 48 and 50 disposed perpendicular to each other and with adjacent ends closely spaced. The entire inductance 46 has first and second ends 51 and 52 across which may be connected a variable capacity 53 for providing parallel resonance over a range of frequencies.

The coil 49 is center tapped at 54 and the center tap is connected to ground 55. The transformer 47 includes a fourth coil 56 inductively coupled to the second coil 49, and the coils 49 and 56 are enclosed within a first electrostatic shield 57 with the first and third coils 48 and 50 enclosed within a second electrostatic shield 58. This arrangement of an air core transformer 47 has also been found to provide high Q for its size, and again there is found an inductance 46 which is made up of three serially connected coils disposed other than in a straight line and with at least two of these coils at right angles and with ends closely spaced and with the two ends of the entire inductance terminating close to an electrically conducting panel which forms a part of an electrostatic shield for the inductance.

The fourth coil 56 has been inductively coupled to the second coil 49 for convenience because this one has the lowest potential to ground since its center tap is grounded. The field of the second coil 49 has been removed from the field of the first and third coils 48 and 50, yet the fields of coils 49 and 56 are inductively coupled. It has been found that the second coil 49 carries a greater current load and has a greater field than do the first and third coils 48 and 50; and therefore, this second coil 49 should be more heavily dimensioned, that is, wound from a larger cross sectional area conductor. Inversely, the inductance 46 does not require the larger dimensioning throughout as in a single coil design such as that shown in FIGURES 1 and 2.

The inductances shown in FIGURES 3 and 4 and in FIGURES 5 and 6 have been shown as single-layer cylindrical air core inductances. However, the invention is not limited to this construction and the coils forming the inductances may be wound on dielectric forms where the wire is not of sufficient stiffness for self-support. Also, the coils forming inductances may be multi-layer constructions rather than single-layer in order to increase the inductance as desired for any particular purpose.

The present invention of a new inductance winding design has been applied with exceptional results to an antenna such as a radio receiving antenna. FIGURES 7, 8, and 9 show the physical construction of an antenna 65 incorporating the present invention. This antenna 65 includes a generally U-shaped inductance 66 having first and second ends 67 and 68, and this inductance 66 may be considered as being made up of first, second, and third coil portions 71, 72, and 73. The inductance 66 is housed within a dielectric enclosure 74, and an electrically conducting base panel 75 with sloping ends 76 and 77 forms with the dielectric housing 74 a complete enclosure for the inductance 66. This inductance 66 may be formed of copper tubing, for example, so as to be relatively rigid

and almost self-supporting, and in practice it has been found necessary to support the inductance 66 only at three locations, such as the flanges 78 which are dielectric flanges positioned at the longitudinal parting line 79 of the two-part housing 74. The antenna 65, as actually constructed, was contained in a dielectric housing 74 about twenty-eight inches across the face, about twenty-nine inches high overall, and about eight inches thick. The inductance 66 was formed of about twenty-one turns of copper tubing having a total length of about forty-two feet, and the diameter of the coil portions 71, 72, and 73 was each about seven inches. By utilizing a variable capacitor connected across the ends 67 and 68, it was found that this antenna 65 tuned from about three to fifteen megacycles, and hence, was in the high frequency spectrum.

FIGURE 10 shows a schematic diagram of an antenna system 85 utilizing an antenna 65, as shown in FIGURES 7, 8, and 9. Here there is shown a variable capacitor 86 connected across the inductance 66 for providing parallel resonance over a range of frequencies. The FIGURES 7, 8 and 9 show band selector jumpers 87 which engage sockets 88 and selectively engage sockets 89 to short out selective portions of the center of the inductance 66. The inductance 66 is center tapped at 90, and this center tap is connected to the electrically conducting panel 75 by a conductor 91, and this center tap 90 and conducting panel 75 are grounded in actual use. The selective shorting out of different lengths of the center of inductance 66 provides a changeable length inductance so as to resonate with the capacitor 86 over different frequency ranges so as to cover the entire three to fifteen megacycle frequency band.

FIGURE 10 schematically shows the antenna 65 in an antenna system 85 which includes an amplifier network 94. The antenna 65 includes the variable capacitor 86 which, because of the grounded center tap 90, is preferably a split stator construction. A rotor 95 co-operates with first and second stator sections 96 and 97 with the rotor 95 being connected to ground 98.

The amplifier network 94 includes a first amplifier 101 and a second amplifier 102 contained in a common envelope. The first amplifier 101 has a cathode 103, a control electrode or grid 104, and an anode 105. The cathode 103 serves also for the amplifier 102 which has a control electrode 106 and an anode 107. The cathode 103 is connected to ground through a paralleled resistor 108 and a radio frequency choke 109. The grid 104 is connected by a conductor 110 to the second end 68 of inductance 66. Anode 105 is connected to ground through a radio frequency by-pass capacitor 111 and is connected through a rheostat 112 to a B-plus supply 113. The anode 107 is connected through resistor 114 to the B plus supply 113 and is connected through a feedback capacitor 115 to the grid 104. Grid 106 is connected to ground and a capacitor 116 is a coupling capacitor coupling the output of the second amplifier 102 to the input of a third amplifier 119. Another radio frequency by-pass condenser 117 keeps radio frequency energy out of the B-plus supply 113.

The third amplifier 119 has a cathode 120, a control grid 121, a screen grid 122, and an anode 123. The cathode 120 is connected to ground through a resistor 124, and the control grid 121 is connected to ground through a resistor 125. The screen grid 122 is connected to the B-plus supply 113 by the resistor 126, and the anode 123 is also connected to this supply 113. The third amplifier 119 has a cathode drive output from the cathode 120 to a coupling capacitor 127 to a coaxial cable 128.

A local oscillator 132 may be used to advantage in many cases. In operation the oscillator 132 may be set to produce a small radio frequency carrier, such as 5.1 megacycles, with the antenna inductance 66 and the capacitor 86 set to be resonant for the incoming radio signal

wave at 5 megacycles. The two signals heterodyne in the parallel resonance of the antenna circuit producing sum and difference frequencies as well as the two fundamental frequencies. These are all passed to the input 104 of the first amplifier 101. This first amplifier amplifies all these signals producing an output across the cathode impedances 108 and 109. The second amplifier 102 is a ground grid amplifier having cathode drive from the impedances 108 and 109, and hence, produces an amplified anode current in accordance with the incoming signal. The capacitors 111 and 117 by-pass to ground the radio frequency signals, in this case 5 and 5.1 megacycles. These by-pass capacitors will be low impedance for the fundamental and sum frequencies but will be relatively high impedance for the difference frequency, for example, 100 kc. Thus, this 100 kc. output is passed by the coupling capacitor 116 to the third amplifier 119. The 100 kc. output of the second amplifier 102 is amplified by the third amplifier 119 and passed to the coaxial cable 128. Here it may be fed to an ordinary receiver such as a communications receiver so that the intelligence thereon may be obtained by conventional means.

The second amplifier 102 may be considered as a feedback amplifier because energy from the anode 107 is fed back through capacitor 115 to grid 104 in the right phase to become a regenerative feedback. This is because of two one hundred eighty degrees reversals of phase in the two stages. The rheostat 112 acts as a Q control or feedback control because it controls the gain of the first stage 101, and hence, the overall gain of the two stages 101 and 102.

The antenna 65 of FIGURES 7, 8, and 9, and as used in FIGURE 10, has been found to have a natural Q of about 450. This is because of large diameter conductors and large diameter coil portions 71, 72, and 73. Also, it is believed that the dielectric housing 74 having a dielectric constant of 4 or 5, since it completely surrounds the inductance 66 except for the grounded panel 75, materially contributes to the high natural Q of this inductance 66 used as an antenna. With the feedback from the amplifier network 94, it is found that the Q of the antenna may be artificially raised up to 700 to 1200. This compares with an ordinary high frequency receiving antenna Q of about 30 for a quarter wave antenna, and of a Q of about 50 for an ordinary dipole.

This antenna system 85 is used on the high frequency band of 3 to 30 megacycles or 10 to 100 meters. At these frequencies an ordinary dipole antenna becomes quite cumbersome. A half wave dipole is therefore around eighteen to one hundred eighty feet long and, hence, is hardly self-supporting. At these frequencies for ground to ground communication systems, often V or rhombic antennas are used. These to be efficient must be three to four wave lengths long or in the order of six hundred feet in length. They also must be positioned in the order of one-half wave length above the ground which means they are supported on tall poles. Despite the great physical size of the V or rhombic antennas at these frequencies, the antenna system 85 of the present invention has been found to outperform such antennas in receiving a greater signal strength in microvolts relative to external noise or atmospherics.

Formerly, about a one microvolt signal was the minimum which could be consistently "read" or the intelligence received therefrom. This was because external noise caused by atmospherics and static would override any signal weaker than one microvolt. The present antenna system 85 has opened new thresholds of antenna performance by the extremely high Q which produces a narrow band with to be highly selective to the signal and to reduce external noise.

FIGURE 11 shows a front view of an antenna 136, electrically the equivalent of antenna 65, yet which does not include any external band selector jumpers 87. The antenna 136 is mounted in a dielectric housing 137

similar to housing 74 and, like antenna 65, is designed for mounting on a standard nineteen inch rack or may be mounted on a wall or on a ceiling, such as in a receiver building. Thus, the antenna 136 and 65 may be used indoors under generally constant temperature conditions and, hence, may be positioned very closely adjacent to the communications receiver fed by the coaxial cable 128. Thus, the fact that the antenna is close to the operator means that this operator may easily switch bands so as to cover the entire range of frequencies without the necessity of going outside to make arduous changes to the prior art type of antennas.

FIGURE 12 shows a sectional side view of the antenna 136 mounted within a weatherproof hood 140 with insulation 141 therebetween. The hood 140 may have a lightning rod 142 connected to a counterpoise 143 mounted above ground and interconnecting stakes 144 below insulators 145 on guy wires 146. The wires 146 support a framework 147 for the weatherproof hood protected antenna 136. The hood 140 is advantageous to insulate the antenna coils in refrigeration conditions, such as in the arctic regions, to improve performance.

FIGURE 13 shows the antenna of FIGURE 12 and shows that the electrical cables for power supply and the coaxial cable 128 may be carried on a messenger wire 148 to a receiver hut 149 containing the receiver. This outside location of the antenna 136 improves the operation thereof since the antenna has been removed from any stray fields within the receiver hut. Because of the extremely high Q both natural and artificial of the antenna 136, this removed location has been found to be preferable for extremely weak signals.

FIGURE 14 shows an antenna system 155 which includes an omnidirectional antenna 156 which may be similar to antennas 136 or 65. The antenna 156 has an inductance 157 in a generally U-shape again with an electrically conducting base panel 158 and with first and second ends 159 and 160. A trimming capacitor 161 and a tuning capacitor 162 are connected across the ends 159 and 160. The center of the inductance 157 is split and has two adjacent ends 163 and 164. End 163 is connected through a normally closed relay contact 165 to a ground conductor 166. End 164 is connected through a normally closed relay contact 167 to this ground conductor 166. A relay 168 controls relay contact 165 and also controls the normally open contacts 169 to selectively connect a tap 170 on inductance 157 to the ground conductor 166. Similarly, a relay 171 controls the normally closed contacts 167 and also controls normally open contacts 172 which selectively connect a tap 173 on the inductance 157 to the ground conductor 166. The relays 168 and 171 are controlled by control lines 174 from a power supply 175.

The end 159 of the antenna 156 feeds the input of a first amplifier 101A which has a cathode drive output for feeding the input to a second amplifier 102A, and this amplifier in turn feeds the input of a third amplifier 119A. These amplifiers may be essentially the same as the amplifiers described for FIGURE 10 except that in this antenna system 155 no injected carrier from a local oscillator is used. This means that the three amplifiers 101A, 102A, and 119A amplify without any heterodyning the received signal on the antenna 156. A capacitor 115A has been shown from the anode of amplifier 102A to the input of amplifier 101A, but this capacitor 115A may not be a physical capacitance, rather it may be leakage capacity caused by the close physical spacing of the amplifiers 101A and 102A to the antenna 156. This close physical spacing can cause regenerative feedback merely through the small capacity between conductive parts of the entire antenna system. Because of the extremely high Q of the antenna 156, it has been found that a physical capacity 115, as in FIGURE 10, is not always necessary and merely the inter-conductor capacity 115A may replace it.

The antenna system 155 feeds a receiver 179 from a

coaxial cable 180 which is connected to the output of amplifier 119A. The anode 105A is connected through a rheostat 112A in the power supply 175 to a terminal 176. This provides control of the gain of amplifier 101A and, hence, control of the amount of feedback. By placing this feedback control at the power supply 175, it means that this power supply may be positioned remotely from the antenna 156 so that the operator need not go to the antenna 156, but may have the power supply 175 in some convenient location. The antenna 156 may be such as the antenna mounted on a framework, as shown in FIGURE 13, with the control lines 174 also carried on the messenger cable 148 from the receiver hut 149. In such case the power supply 175 would be within the receiver hut as well as the receiver 179. By applying suitable power to the control lines 174, the relays 168 and 171 may be actuated to close the contacts 169 and 172 and open the contacts 165 and 167. This shorts the middle section of the inductance 157 and connects this short circuit to ground to effectively make a smaller inductance. This means that the tuning capacitor 162 may tune at least over a two to one ratio of frequency for a remotely controlled frequency band. The trimming capacitor 161 normally is adjusted and then set at the time of installation so that the two halves of the inductance 157 are balanced. The tuning capacitor 162 may be adjusted by hand or may be connected by a flexible drive cable carried on the messenger cable 148 and operated from inside the receiver hut 149 or may be operated by a servomotor such as self-synchronous motors with the transmitter of these synchronous motors in the receiver hut 149 for full remote operation.

The antenna system 155 is a complete system fully operative; however, if a switch 185 is closed, this connects in cascade an antenna system 155A to the antenna system 155. The switch 185 connects the output of an amplifier 119B by a conductor 186 to the inductance 157. It has been found that tapping on at one turn above ground potential has been a satisfactory impedance match, as at the tapping point 187.

The antenna system 155A is also supplied from the power supply 175. The amplifier 119B is again fed from an amplifier 102B in turn fed from an amplifier 101B. The anode of this amplifier 101B may again be supplied with power through a rheostat 112B for gain or feedback control.

This FIGURE 14 shows two antenna systems 155 and 155A connected in cascade, and it will be noted that the output from the first antenna amplifier is connected in some manner to the input of the second antenna system. In this respect, connection onto a tap about one turn above ground potential on the antenna inductance itself is a convenient way to apply the output of the first antenna system in cascade to the input of the second antenna system.

FIGURE 15 schematically shows an antenna 191 which may be used in remote locations. This antenna has an inductance 192 again in a generally U-shape, in this case including a coil 193 and a coil 194. These coils are connected to various contacts on a gang switch 195 having four sections each with six positions. By selecting any of the six positions, one may choose anything from the full inductance 192 to a part of the inductance to various parts parallel in order to get various combinations connected to a variable tuning capacitor 196. This provides band switching by selected positioning of the gang switch 195 with the gang switch and the tuning capacitor 196 remotely controllable by any known means so that the antenna 191 may be placed on a mountain top, for example, unattended, and therefore with consequent saving in expense and personnel.

FIGURE 16 is a graph of performance curve of this omnidirectional antenna, and FIGURE 17 is a horizontal field strength pattern polar diagram of this omnidirectional antenna such as antennas 65, 136, 156, and 191. With

the plane of the antenna vertical, then the horizontal field strength pattern 198 is shown in FIGURE 17 to be very nearly circular and hence omnidirectional in a horizontal plane. The pattern, as actually measured, was found to be circular within plus or minus .5 db.

The FIGURE 16 shows a curve 200 of selectivity and sensitivity of an average dipole. This is a half wave dipole positioned relatively high above the earth's surface, for example, a quarter wave length in height. The antenna 65, as shown in FIGURES 7, 8, and 9, or the antenna 136, as shown in FIGURE 11, when mounted indoors, has a performance curve 201, as shown in FIGURE 16, which shows that this antenna has at least a 10 db gain over a conventional dipole, and this with the antenna 65 or 136 of the present invention located only six or eight feet above ground. This is for a frequency on the high frequency band, in this case 9.5 megacycles. Thus, this six or eight foot height above ground is only about .06 or .08 of a wave length; and if the prior art dipole were to be positioned at this low height, it would have even poorer performance than normal so that the antenna 65 or 136 of the present invention would show even greater db gain relative to this dipole than that shown in a comparison of curves 201 and 200.

A comparison of curves 200 and 201 show a further difference; namely, that the curve 201 is far more selective than the curve 200 for a dipole. Curve 201 at 10 db down is only about nine kilocycles wide. This shows that the antenna of the present invention is one which is as selective as the rest of the circuits in the receiver with which it is used and, hence, rejects noise and atmospheric disturbances right at the antenna without waiting for this signal to enter the radio receiver proper and then to attempt to reject such noise or interference in the radio receiver. This achieves much better radio reception because the great majority of external noise is eliminated right at the antenna and does not enter the set to shock the input to even greater band widths so as to be even more receptive to these external noise disturbances.

The FIGURE 16 shows a curve 202 which is essentially a straight line showing the selectivity and sensitivity of an ordinary sloping V antenna. The antenna of the present invention is just as sensitive as an ordinary V which might be 300 to 600 feet in length; and thus the compactness of the present antenna, wherein the antenna can be located directly at the communications receiver, for example, is made all the more evident.

Curve 203 on FIGURE 16 is a selectivity and sensitivity curve for the antenna such as that shown in FIGURES 12 or 13, wherein the antenna is mounted outside on a short framework 147 about ten feet high and free of disturbing electrical fields. The performance is increased over that when it is mounted indoors close to other electrical equipment. The curve 203 shows that the outdoor antennas of FIGURE 12 or 13 have a 20 db gain over an average dipole to exceed the sensitivity of ordinary rhombic antennas which have a performance curve 204 as shown in FIGURE 16. Both curves 202 and 204 of V and rhombic antennas are practically straight lines on the graph of FIGURE 16 because they are both extremely broad band antennas. This means that they are highly receptive to atmospheric noises whereas curve 203 shows that at 10 db down it is only a nine or ten kilocycle band width, and even at 20 db down it is only about twenty-four kilocycles band width. This great selectivity means reception essentially only of the carrier and the intelligence thereon and rejection of practically all of the atmospheric noise.

The FIGURE 14 showed two antenna systems 155 and 155A operated in cascade and the performance curve of this dual antenna system is shown as curve 205 on FIGURE 16. This dual antenna system has a 35 db gain over an average dipole and the selectivity is such that the performance curve is only eight kilocycles in band width at 10 db down and only twenty kilocycles in band width

at 20 db down. Even at this 20 db down point, it is still as sensitive as a good rhombic to thus show the tremendously increased performance in using the dual antenna system of FIGURE 14 of the present invention. The two antennas of FIGURE 14 should be separated by fifty or one hundred feet, for example, so that each is beyond the field of the other so as to be independent. Preferably the two antennas should be on a line directed toward the transmitter and the strongest signal on either antenna will be the one which predominates at the grid 101A of the amplifier on the antenna system 155. This greatly reduces fading due to atmospheric conditions.

More and more communication systems are going to automatic operation rather than using radio operators, and the antennas and receivers are being used to operate teletype machines directly. In such automatic systems it is imperative that the signals be always much greater than the incoming external noise. While an operator might be able to read a one microvolt signal through a one microvolt external noise input, an automatic machine cannot "read" the message at these relative voltage levels. It has been normally considered that one microvolt of signal is about the minimum signal input for a readable signal even by a radio operator; yet with the present antenna system of FIGURE 14, it has been found that .01 microvolt of signal will still provide a readable signal. This is about one hundred times as good as former good antenna systems, and yet the antenna of the present invention is far more compact and may far more readily be changed in frequency to a new selected frequency within the frequency band. For a single antenna such as at that shown in curves 201 or 203, it has been found that the signal to external noise over internal noise ratio has been improved by approximately 7 db at six megacycles and that this signal improves with increased frequencies. These figures are for the antenna of the present invention being located relatively close to the ground and with the prior art dipole at a quarter wave length height.

A comparison of FIGURES 16 and 17 show that the antennas of the present invention not only achieve high gain and high selectivity but are also omnidirectional. This in contrast to V and rhombic antennas, which are highly directional and at these frequencies are not movable so as to be receptive to signals from any other than a single direction. Thus, the antenna, as shown in FIGURES 7, 8, and 9, 11, 12, or 13, may be used as a standby antenna in an antenna farm system, for example, so that the antenna may be available to be used on any frequency on the high frequency band at a moment's notice since it may very easily be tuned to the desired frequency and will receive signals from any direction in the horizontal plane. With the antenna system 155 of FIGURE 14 or the dual antenna system 155 and 155A of FIGURE 14, full remote operation of the antenna systems may be achieved with the antennas themselves and their preamplifiers located at a favorable antenna location such as on a mountain top, and then the radio frequency carrier supplied over the coaxial cable 180 for considerable distances, even up to ten miles down to the receiver located where the receivers 179 are located, which is a much more practical arrangement for radio operators since the antenna location on the mountain top may be completely unattended.

The FIGURES 18 and 19 show a low frequency omnidirectional antenna 210 according to the invention, which includes an inductance 211 formed of first, second, and third coils 212, 213, and 214. Each of these coils is wound on a dielectric coil form 215 with these coil forms interconnected at 216 and 217 for mutual support, and with the entire inductance supported within a dielectric housing 218 very similar to the housings 74 and 137. This housing may be a glass fiber reinforced thermosetting resin with a dielectric constant of four or five to help secure improved performance for the entire antenna 210. Dielectric supports 219 support the low-

er end of the inductance 211, and dielectric arms 220 support the upper end of the inductance 211. The coils 212 to 214 may engage the side walls of the dielectric housing, as shown in FIGURE 19, for added support.

5 The antenna 210 has been found to be omnidirectional and is in the low frequency band from one hundred to five hundred kilocycles. For this purpose an antenna constructed with three coils 212 to 214, each eight inches in diameter and ten inches long with No. 10 wire spaced half the wire diameter, has been found to be a very satisfactory antenna. The antenna 210 also includes an electrically conducting panel 221 as in the high frequency omnidirectional antenna with the ends of the inductance 211 terminating near this electrically conducting panel and again the ends of the inductance 211 would be adapted to be connected to a capacitor such as a variable capacitor for achieving parallel resonance to tune the antenna to a desired frequency. The antenna of FIGURE 18 has a naturally high Q because of the 15 large diameter coils 212 to 214 and because of the high dielectric constant of the surrounding housing 218. This naturally high Q of the antenna may be increased still further artificially by use of the feedback amplifiers as shown in FIGURE 10 or 14.

25 FIGURE 20 shows an antenna 225 mounted in a dielectric housing 226 having an conducting ground panel 227. The antenna 225 includes an inductance 228 comprised of first, second, and third coils 229, 230, and 231. The physical shape of the inductance 228 is similar to inductance 46 of FIGURE 5, and in this FIGURE 20 the three coils are mounted in a single plane with coils 229 and 231 being generally perpendicular with adjacent ends, however, with all three coils connected in series to form the entire inductance 228. Again a capacitor 30 would be used across the ends of the inductance for tuning to a desired frequency, and the ends of the inductance 228 cooperate with the conducting ground panel 227 to provide a naturally high Q antenna which may by increased artificially by feedback, as shown in FIGURE 10 or 14.

40 The inductances of FIGURES 3 and 4 and FIGURES 5 and 6 have high Q's and this is thought to be because of the generally U-shaped with the electrostatic field completed by the ground panel 31 or a ground panel 59. These ground panels form part of the electrostatic shields surrounding the coils. When the inductances of the present invention are used as antennas, such as in FIGURES 7 to 15 and 18 to 20, this inductance is also found to have high Q which is believed to be caused 50 by the generally U-shape of the three coils or coil portions with the ends of the inductance terminating near an electrically conducting panel which generally is grounded. The panel 75 in FIGURES 7, 8, and 9, for example, may be an aluminum base panel and preferably is 55 grounded through the grounded receiver with which the antenna is used. In the antennas of FIGURES 12 and 13 the electrically conducting panel at the bottom of the antenna is also preferably grounded and, as shown, an additional counterpoise 143 may be used as an artificial 60 ground to which the lightning rod may be attached.

The invention herein is directed generally to inductances whether used merely to supply an inductive reactance or whether used as an antenna. In both cases the inductances are other than in straight lines, and in many cases may be characterized as being in generally a U-shape. In either the inductive reactances or in the antennas, these inductances may be formed of three coils or coil portions which are single-layer cylindrical air core coils or as shown in FIGURES 7, 8, and 9, for example, 70 it may be one generally semi-circular inductance which may be considered to be made up of three separate coil portions, and in that instance the middle coil portion especially is not cylindrical, rather it is curved. It has been found that slightly higher Q's are obtainable by making the inductance in the form of three cylindrical 75

coils, as shown in FIGURES 3 and 4, for example; however, in the case of the antennas of the invention, an omnidirectional pattern in the horizontal plane is also desired and the domed or semi-circular form of a coil has been found better for this purpose.

The antenna 156 of FIGURE 14 is comprised of the inductance 157. This inductance is made up of first and second coil portions 188 and 189 each about a ninety degree arc. It has been found that if the first coil portion 188 is a helix wound in a first direction and the coil portion 189 is wound in the opposite direction, then the antenna 156 may be much improved. The trimming capacitor 161 may be of split stator construction as shown and is of small capacity relative to the main tuning capacitor 162. If only one of the coil portions 188 or 189 is connected to its particular half of the trimming capacitor 161, and then this coil portion 188, for example, tuned exactly with a grid dip meter to a particular inductive reactance value, and then the other coil portion 189 carefully tuned with its half of the capacitor 161 to the same inductive reactance value, then the two coil portions of the inductance 157 will be correctly balanced. This has been found to give a very marked improvement in performance of the antenna, especially by rejection of local noise or interference. High tension power lines, local overhead lines, and fluorescent lights were examples of some sources of local noise. By carefully balancing each half of the inductances 157 to a predetermined inductance value, and with the two halves of the inductance 157 wound oppositely, it was found that this local noise was greatly reduced. The main tuning capacitor 162 would, of course, then be used to tune the antenna 156 across the band.

FIGURE 21 shows a still further antenna 241 which again may be mounted within a dielectric housing 242 having a conducting ground panel 243. The antenna 241 includes a primary coil 244 and a secondary coil 245 which have their upper ends connected together and to a ground line 246. The lower ends of these coils 244 and 245 are linked or coupled together by a reverse link 247. This reverse link is shown better in plan view in FIGURE 22 and includes first and second loops 248 and 249 positioned coaxially with the primary and secondary coils, respectively. The reverse link 247 is made from conductive tubing, and from the end of the first loop 248 an insulated wire 250 is connected which passes in an insulated manner through a hole 251 through the link 247 and emerges from another hole 252 to be connected to the end of the second loop 249. The two loops 248 and 249 are reversed relative to each other to be wound in the same direction as the primary and secondary coils 244 and 245, respectively, and these two coils are wound oppositely relative to each other.

The lower ends of the primary and secondary coils 244 and 245 are connected to a differential trimmer capacitor 255 and the ends are also connected to a main tuning capacitor 256. The lower end of the secondary 245 is also connected to an amplifier 257 or other device utilizing the radio signals received on the antenna 241.

The antenna 241 is basically similar to the antenna 156 of FIGURE 14. However, in this case the two coils 244 and 245 are of the straight or solenoid type of coil. The antenna 241 has the advantage of being selectively directional or omnidirectional. The antenna of FIGURE 21 is designed for operation on the high frequency band and the tuning capacitor 256 may tune this antenna to resonance for operation at a desired working frequency within this high frequency band. In operation at some particular frequency, e.g., five megacycles, the differential trimmer capacitor 255 may be tuned to balance the two coils 244 and 245, and in such case the antenna is substantially non-directional or omnidirectional in the horizontal plane as shown in curve 198 in FIGURE 17. However, it has been discovered that if the primary coil 244 is tuned to

be resonant at a slightly higher frequency than that of the secondary 245, that is, with a leading phase, with this tuning effected by the differential capacitor 255, and with the secondary coil 245 resonant at the desired working frequency, then the antenna 241 becomes directional with a lobe pointing in the direction from the secondary to the primary coil. This is shown in curve 260 of FIGURE 17. This is generally a cardioid pattern, and is the horizontal pattern for sky wave signals. The antenna 241 has also been found to differentiate between sky wave signals which are desired, and local noise or generally vertically polarized waves. The horizontal field strength pattern for local interference or noise is shown on FIGURE 17 by curve 261. The outline of the dielectric housing 242 has been shown on FIGURE 17 with the primary coil 244 on the left side of this figure. It will be noted from a comparison of curves 260 and 261 that the antenna 241 has a horizontal reception pattern for noise which is substantially symmetrical about a plane 262 which is perpendicular to a line between the primary and secondary coils 244 and 245. There is a null to the noise reception along this plane 262, yet it will be noted that on curve 260 for sky wave reception quite a strong signal is received, about eighty percent of the maximum signal strength along the main lobe. The antenna 241 is physically small, for example, about thirty inches in width, and thus it is easily rotatable so that the null of curve 261 may be directed toward a source of local noise; yet as long as the direction to the desired signal is within the one hundred eighty or two hundred forty degree arc of the main lobe of curve 260, satisfactory reception of sky wave signals will be had.

FIGURE 23 shows a curve 263 of a vertical pattern for sky wave reception of signals, e.g., five megacycles. This curve 263, when compared with curve 260 of FIGURE 17, shows that the main lobe of the horizontal pattern is generally directed upwardly so as to be receptive to the sky wave signals which are reflected from the various layers of the ionosphere. It also shows that the backward lobe of curve 260 is directed downwardly so as to minimize reception from this direction.

Curve 261 of FIGURE 17 is also generally the curve obtained on the vertical pattern of the antenna 241 for noise reception and shows that this FIGURE 8 pattern of curve 261 is in the vertical as well as the horizontal plane.

This directional characteristic of the antenna 241 is achieved when the primary coil 244 is tuned to a slightly higher resonant frequency than that of the secondary coil 245, by means of the trimmer 255. This may be about a ten to thirty kc. difference. When the main tuning capacitor 256 is changed to tune the antenna 241 to a higher frequency; namely, to the frequency at which the primary coil 244 is resonant, this will make the secondary coil 245 tuned a little above resonance. Under these conditions, the antenna 241 is substantially non-directional and the horizontal pattern 198 of FIGURE 17 applies. Thus, the simple expedient of changing the main tuning capacitor 256 to resonate either the coil 244 or 245 effects a change of the antenna from directional to non-directional. Directional arrays in the high frequency band, e.g., five megacycles, have not been heretofore obtainable without gigantic rotatable arrays or by rotatable yagi type antennas for frequencies above about ten megacycles. The tuning of the trimmer capacitor 255 determines the frequency separation of resonance of the coils 244 and 245, and this permits varying degrees of front to back ratio and front to side ratios of directional patterns of curves 260 and 263 and also alters the null characteristics of these polar patterns. These directional characteristics reduce broad band noise of local origin, as it is not received off the sides of the antenna as shown by curve 261, and also noise is much reduced which is received above and below the center line of the coils. This indicates that the horizontal coil spacing of coils 244 and 245 is

not sensitive to vertical polarization from noise in the plane 262.

The two coils 244 and 245 are wound in opposite directions for opposition fields, and it will be noted that the antenna 156 (FIGURE 14), because it makes a one hundred eighty degree bend, has the two ends wound in opposite directions, that is, when viewed from the top, one end of the coil will be wound clockwise and the other end of the coil will be wound counterclockwise. For this reason the antenna 156 is basically similar to the antenna 241; and when differentially tuned by the trimmer capacitor 161 to make the second coil portion 189 resonant to a slightly higher frequency than the first coil portion 188 so that the second coil portion 189 acts as a primary, then that antenna 156 can also act as a directional antenna as described above for antenna 241. In the case of the antenna 156 the coupling between coils is accomplished by the upped end thereof being closely spaced, and in the case of the antenna 241 of FIGURE 21 the coupling is effected by the reverse link 247. The coil or coil portion which is not connected to the amplifier 101A or 257 is considered to be the primary. The other coil or coil portion is the secondary, and it is the primary which should be tuned to the higher resonant frequency in order to obtain the directional characteristics. If the primary is tuned at the desired working frequency, then the antenna will be non-directional whether the secondary is resonant either at the desired working frequency or at a slightly lower frequency.

With the directional pattern there is a mutual gain on both coils in the direction of the primary coil. This applies to the average sky wave reflected from the ionosphere which arrives on angles close to the earth's surface. This directivity of the curves 260 and 263 has a broad lobe but has a high front to back ratio in the order of 20 db. When the antenna may be oriented so that the null of the noise curve 261 points toward the noise source with the signal ninety degrees thereto along the maximum of the main lobe, the noise may be rejected by more than 25 db relative to the signal. This shows that local interference occurs from vertically polarized waves; and as the coil circuits present a one-turn loop for vertical polarized signals, these primary and secondary coils will receive only off the ends and not off the sides. Also, as they establish opposition fields, they will not receive from above or below. This is shown by the curve 261 which applies to both vertical and horizontal patterns. The cancellation of noise is due not only to the polar pattern, but is also influenced by the combined input of the two coils into the amplifier 101A or 257. The interference is always a broader band than the desired signal due to its local origin. When interference or impulse noise appears on the signal frequency, the equivalent envelope of noise is impressed on the primary coil at the higher resonant frequency but with inverse polarity. This inverse primary coil interference is balanced by the on frequency secondary coil interference for cancellation at the amplifier. The directional antenna 241 thus provides an antenna system which discriminates between desired weak signals and strong local noise by their difference in angle of arrival to the antenna as well, of course, as the difference in azimuthal direction. If one considers that space is defined by three mutually perpendicular directions, then it will be seen that the antenna 241 provides improved signal-to-noise ratio by balancing out vertically polarized signals or noise from two of these directions; namely, azimuthal direction and angle of reception.

The FIGURES 21 and 22 show a construction wherein the link 247 is an electrically conductive means and in such case the electrically conductive panel 243 may in many cases be eliminated since this link 247 is grounded. This link 247, since it is an electrically conductive means, may provide a multiple function of having a part which provides a coupling between the coils 244 and 245 and

has a part which provides an electrostatic path for the electrostatic field of the inductance or antenna 241 and also has a part which may be grounded. The part which provides the electrostatic path is disposed closely adjacent ends of the coils 244 and 245 to accomplish this purpose.

Although this 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 the scope of the invention as hereinafter claimed.

What is claimed is:

1. An antenna comprising, first and second coil portions each having an axial length dimension, means for connecting said coil portions in series, means for mounting said coil portions with the length dimensions thereof in a single plane and disposed substantially parallel, a main tuning capacitor connected to said two coil portions and to ground, and a differential trimmer capacitor connected to said two coil portions and to ground.

2. An antenna operable at a working frequency and wavelength, comprising, a primary coil and a secondary coil each disposed with the axes thereof generally parallel and spaced apart in a given plane a small percent of said wavelength, means coupling together said coils, capacitor means connected in parallel with said primary and secondary coils, said capacitor means tunable to establish said secondary coil resonant substantially at said working frequency and said primary coil resonant to a slightly higher frequency than said secondary coil, whereby said antenna is directional in said given plane.

3. An antenna operable at a desired working frequency and wavelength, comprising, a primary coil and a secondary coil each disposed with the axes thereof generally parallel and spaced apart in a given plane a small percent of said wavelength, means coupling together said coils, first and second capacitor means connected respectively in parallel with said primary and secondary coils, and means for supplying an output from said secondary, said first and second capacitor means tunable to a first condition to establish said secondary coil resonant substantially at said working frequency and said primary coil resonant to a slightly higher frequency than said secondary coil, whereby said antenna is directional in said given plane, and said first and second capacitor means tunable to a second condition to establish said primary coil resonant substantially at said working frequency and said secondary coil resonant to a frequency no higher than said working frequency whereby said antenna is substantially non-directional in said given plane.

4. An antenna comprising, in combination, first and second coil portions disposed spaced apart with substantially parallel axes,

coupling means inductively coupled to each of said first and second coil portions,

capacitor means to tune said second coil portion to resonance at a given frequency and to tune said first coil portion to a slightly higher frequency of resonance,

and an electromagnetic wave utilization device connected directly to said second coil portion.

5. An antenna comprising, first and second coil portions each having an axial length dimension, means for coupling together said coil portions, means for mounting said coil portions with the length dimensions thereof in a single plane and substantially parallel and spaced apart, means establishing an electrostatic ground shield adjacent an end of each coil portion, and capacitive means connected to each coil portion and having a grounded portion to tune each said coil portion.

6. An antenna as set forth in claim 5, wherein said coupling means includes a grounded portion disposed

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centrally between said first and second coil portions and connected to said electrostatic ground shield.

7. An antenna as set forth in claim 5, wherein said first and second coil portions are wound in opposite directions as viewed from one axial end of both said coil portions.

8. An antenna as set forth in claim 5, including a dielectric housing together with said electrostatic ground shield substantially enclosing said coil portions, ~~amplifier means having output means and having input means~~ 10 connected to one end of said second coil portion, and regenerative feedback means from the output means to the input means of said amplifier means to artificially raise the Q of said antenna.

9. An antenna as set forth in claim 5, including a weatherproof hood surrounding said dielectric housing, and lightning rod means mounted on top of said hood and connected to ground.

10. An antenna as set forth in claim 5, including a first amplifier having an input connected to said antenna 20 and having an output,

a second antenna comprising third and fourth coil portions each having an axial length dimension, means for mounting said third and fourth coil portions with the length dimensions thereof substantially 25 parallel and spaced apart, means for connecting the output of said first amplifier to said second antenna.

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a second amplifier having an input connected to said second antenna, and an output for the antennas from said second amplifier.

11. An antenna as set forth in claim 5, wherein said coupling means includes a third coil portion having a length dimension disposed generally perpendicularly to each of said first and second coil portions.

12. An antenna as set forth in claim 11, wherein said third coil portion is curved and is directly connected to one end of each of said first and second coil portions.

13. An antenna as set forth in claim 11, wherein the center of said third coil portion is grounded.

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