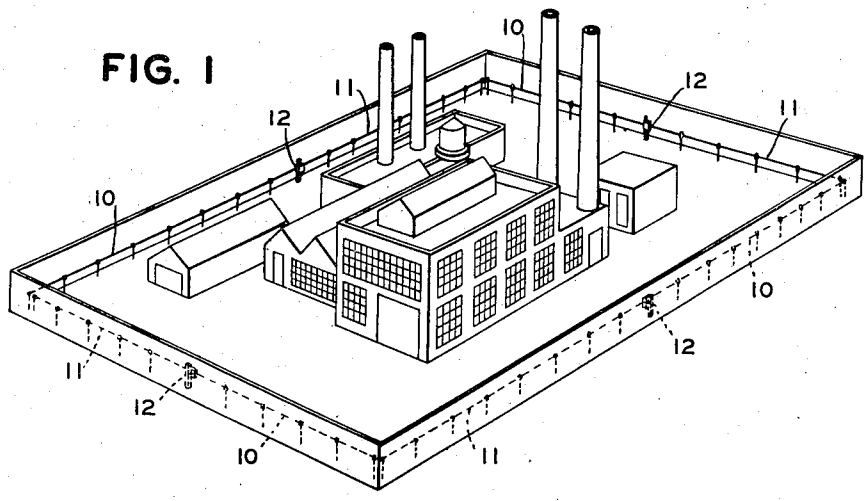
Dec. 7, 1948. M. H. A. LINDSAY 2,455,376

CAPACITY ALARM SYSTEM

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FIG. 1



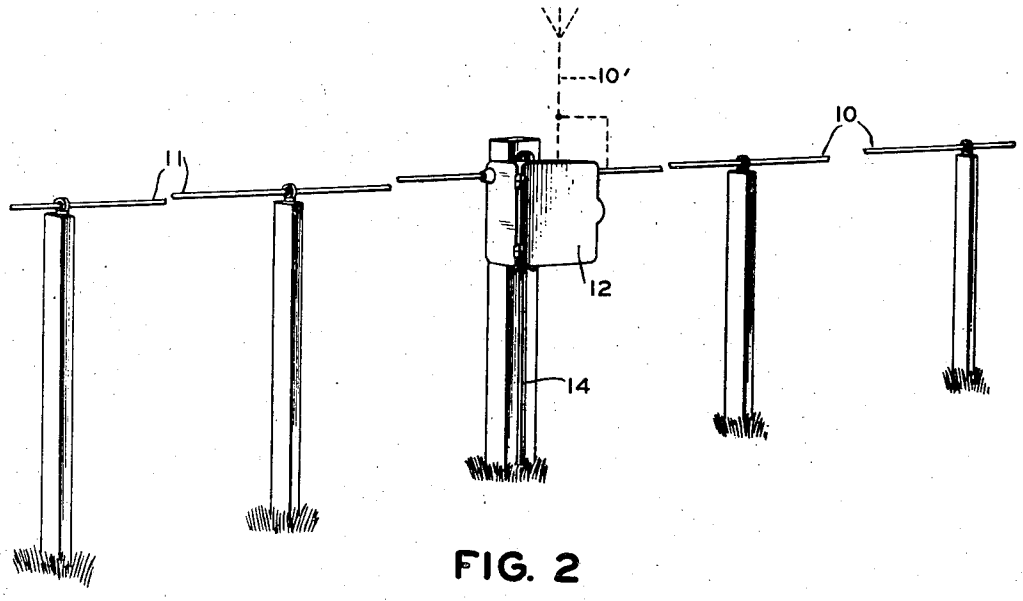


FIG. 2

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CAPACITY ALARM SYSTEM

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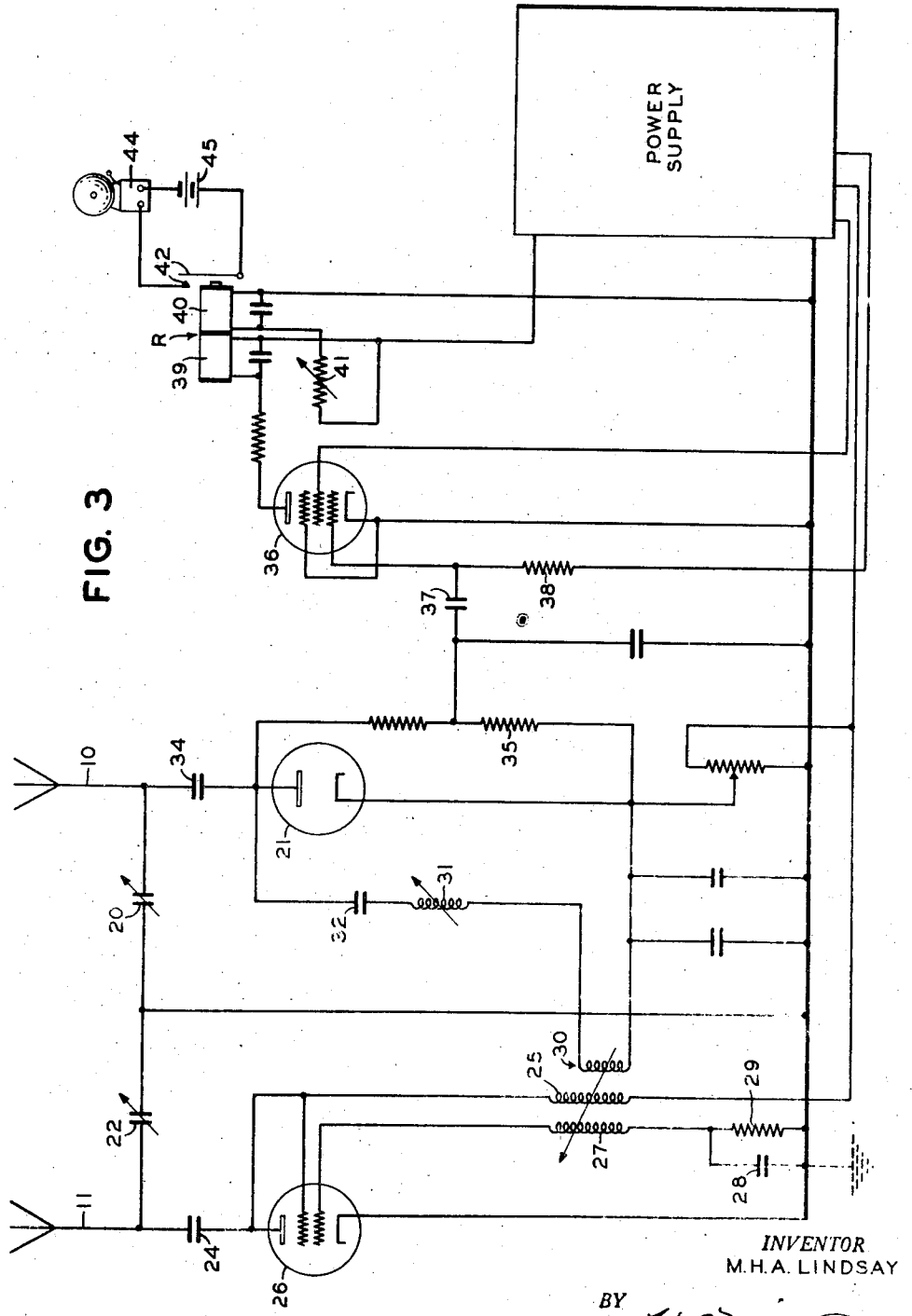


FIG. 3

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CAPACITY ALARM SYSTEM

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6 Claims. (Cl. 177—352.2)

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This invention relates to capacity alarm systems, and more particularly to burglar alarm or intrusion detection systems wherein variations of the electrostatic capacity between the protecting conductors or antennae, and ground, are used for the purpose of varying the normal signal strength in an amplifying system to create an alarm signal.

Heretofore various capacity systems have been designed for use as burglar or intrusion detection purposes, but all of such systems have possessed some objectionable features or weaknesses. It has been customary to utilize an oscillator in conjunction with a tuning circuit associated with an amplifier; and to employ one antenna either connected to the oscillator to cause a change in oscillator frequency upon the approach of an intruder to the antenna, or connected to the tuning circuit to cause a change in resonant tuning upon such approach.

If the only capacity change in these aforementioned systems was due to the capacity introduced through the intruder's approach, the frequency or the tuning, as the case may be, probably could be adjusted for all time to insure that the change could be detected. However, whenever an oscillating and tuning or "tank" circuit are critically related, there is always a relative "drift" in frequency between them, caused by certain changes in vacuum tube capacities, amplification, temperature, operating voltage, etc. To make such a system effective, an antenna must be connected as previously explained to provide means of detecting the intruder, and that antenna represents a certain, but by no means constant, electrostatic capacity. Such an antenna must be supported, and since temperature and humidity changes alter the relative positions of the antenna and ground, capacity changes result merely from the alterations in the geometry of the system. Furthermore, between such an antenna and ground there exists both a dielectric displacement current and a leakage current which vary with ambient atmospheric conditions. Ground conductivity in the vicinity of the antenna also varies with the weather, and sunlight influences the degree of ionization of the intervening air dielectric.

It will thus be apparent that no fixed output can be obtained from any such capacity detecting system, especially where a single extended protecting antenna is employed. Means must be provided, therefore, to compensate for the undesired changes, and yet these means must not impair the ability of the circuit to remain sensitive and capable of detecting with extreme accuracy the desired capacity change caused by human approach or intrusion.

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For this purpose some expedients have been devised and described in the aforementioned systems which attempt to compensate slowly and automatically for these deleterious effects by either restoring the frequency of the oscillator or restoring the tuning of the resonant circuit or providing a long time constant in the detecting and amplifying portion of the circuit so that some slow wandering of the operating point can occur and only rapid changes in tuning cause a variation in the direct current output. Unfortunately, in practice the first two methods, whether electromechanical or electronic, have their limitations, for in general they cannot compensate completely and sooner or later a point is reached where the required relationship between the oscillator and the resonant circuit to detect the desired change is destroyed; while, if the third method is utilized, the compensating feature may not be called upon to operate over its full length, but it may be that the speed of the change for which it has to compensate would exceed its capabilities. Under any of these conditions the system will fail.

Accordingly, an object of the present invention is to provide a capacity alarm system of such character as to overcome the defects hereinbefore set forth.

Another object of the invention is to provide a capacity alarm system of such character as to compensate automatically for capacity changes that normally occur or may be expected.

Another object of the invention is to provide a capacity alarm system employing separate antennae connected respectively to an oscillator and to a tuning circuit associated with an amplifier, the arrangement being so balanced that capacity changes occurring simultaneously and uniformly in connection with each antenna will not interfere with the balance of the system.

Another object of the invention is to provide a system as before described in which change of capacity in either antenna above a predetermined rate of change creates conditions setting up an alarm or the like.

A further object of the invention is to provide a system as aforesaid incorporating means for compensating for capacity changes in either antenna which may occur below a predetermined rate automatically without disturbing the conditions generating an alarm.

An additional object of the invention is to

provide a system as before described in which the antennae and inductances associated respectively therewith can be of such values as to provide oscillator and tuning frequencies of substantially equal value with the result that a change in capacity in either antenna system creates an alarm condition.

In carrying out the foregoing and other objects of the invention, use is made of two antenna having substantially equal capacities to ground and connected respectively to an oscillator and to a tuning circuit. The oscillator is linked to the tuning circuit, which in turn is connected to a rectifier feeding or controlling an amplifier or power tube which is so connected that changes in the normal operation thereof create an alarm. The oscillator and tuning circuit are so regulated that the frequencies thereof are substantially equal so that a change in the capacity to ground of the two antenna simultaneously maintains the system in balance and prevents the creation of an alarm, while a change in the capacity to ground of either antenna individually so unbalances the system as to create an alarm. Provision is made for compensating for any change in capacity of either antenna of a character not warranting the creation of an alarm.

Other features, objects and advantages of the invention will become apparent by reference to the following detailed description of the accompanying drawings, wherein:

Fig. 1 is a pictorial representation of a capacity type intrusion detecting system arranged to surround and protect an industrial plant;

Fig. 2 is an enlarged representation, partially fragmentary, of a part of one of the detection systems shown in Fig. 1; and

Fig. 3 is a circuit diagram of one of the systems employed in this invention.

Referring now to the drawings, and particularly to Fig. 1, it will be seen that the four sides of the boundary surrounding an industrial plant have associated respectively with each thereof a system involving the present invention, such system being made up of antennae 10 and 11 with detecting equipment mounted in a cabinet 12 located substantially midway between the ends of each side of the boundary. Since each system appearing at the respective boundary sides is similar to that appearing at the other sides, a single description will suffice.

Referring now to Fig. 2, fragments of an antenna 10 are shown leading to a cabinet 12, which also has the antenna 11 extending from the opposite side thereof. Under some conditions two antenna wires, one above the other, may be used on each side of the cabinet to improve the sensitivity of the system and raise the height of the protecting barrier. The operating parts of the system are enclosed within the cabinet 12, the power supply and the like being introduced thereinto through the conduit 14 which is normally extended to a central office, or the like.

Referring now to Fig. 3, it will be seen that the antenna 10, which has a capacity-to-ground of variable character represented by the variable capacitor 20, is connected to a tuning or resonant circuit composed of tuning inductance 31 through blocking condensers 32 and 34. Antenna 11 having a variable capacity-to-ground, represented by the variable capacitor 22, is connected through a similar blocking or isolating condenser 24 to the plate inductance 25 of the oscillator tube 26. Inductance 25 is inductively connected to the grid inductance 27, while the capacitor 28 and resistor 29 serve to supply "C" bias to the oscillator tube 26. Inductance 25 has associated therewith a link circuit 30 connecting the oscillator circuit to the tuning or resonant circuit.

The radio frequency voltage in the tuning circuit is detected by the diode rectifier tube 21, which is provided with a load resistor 35, and a connection is provided between the rectifier circuit and the grid of power tube 36, through the coupling condenser 37. A leak resistor 38 is included in the grid circuit of the power tube 36. Included in the plate circuit of power tube 36 is one winding 39 of a relay R, while the second winding 40 of relay R is wound to oppose the first winding 39 and has included in its circuit a rheostat 41. Power for the oscillator 26 and the power tube 36 is supplied by a power source with such ancillary equipment as may be necessary for proper regulation of the parts being shown, but not described in detail. Relay R is provided with contacts 42 adapted to be closed under certain conditions, such closing resulting in the energization of an alarm member 44 supplied with energy from a local battery or other suitable source of current 45.

The operation and use of a system as described briefly above is substantially as follows. In installing a number of such systems around an object to be protected, care is taken to so support the antenna 11 of each system a suitable distance above ground as to insulate them from ground and to isolate the antennae of one section of the boundary from those of other sections of the boundary. Under normal conditions, the respective antennae 10 and 11 of a system are made physically equal in length, if all other conditions are equal, but if ground or atmospheric conditions affect one more than the other then the relative lengths are adjusted to equalize such inequality.

With the antenna 11 connected as shown, the tube 26 will oscillate, since its plate circuit is inductively coupled to the grid inductance 27 by the inductance 25, and the frequency of oscillations will be determined by the value of the inductance 25 and the antenna-to-ground capacity 22. The series effect of the capacity 24 can be neglected. The radio frequency oscillations so generated are conducted by means of the link circuit 30 to the tuning or resonant circuit composed of the tuning inductance 31 and the antenna-to-ground capacity 20. Again assuming that the capacities 32 and 34 are large and the inductance of 30 is small, the resonant frequency of this tuning circuit is determined by the value of the elements 20 and 31. If the inductances 25 and 31 are substantially equal and the capacities 22 and 20 substantially equal, the oscillator will have substantially the same frequency as the resonant frequency of the tuning circuit. Furthermore, if the frequency of oscillations is substantially equal to the resonant frequency of the tuning circuit, a radio frequency voltage will appear across the inductance 31 which, when applied to the diode rectifying tube 21, will produce a direct current voltage across its load resistor 35. Under normal conditions, the coupling condenser 37 isolates the grid of the power tube 36 from the rectified voltage so that the plate current flow through the winding 39 of relay R has a normal fixed value depending upon the bias voltage through the grid leak 38. The rheostat 41 can be adjusted to cause the winding 40 to have the same current flow therethrough as occurs through

the winding 39 so that normally this relay is deenergized. But upon a slight increase or decrease in current flow through winding 39, as controlled by the tube 36, the relay will be energized, closing contacts 42 to actuate the alarm 44. Such slight changes in current flow through the winding 39 will occur upon the approach or departure under certain conditions of an intruder with relation to either antenna in the following manner.

In actual operation the oscillator frequency is adjusted to be slightly lower than the resonant frequency of the tuning circuit including elements 20 and 31 so that the rectified current flow through the diode load resistor 35, if plotted on the response curve of the tuning circuit, will be found to be approximately one-half of the peak value at resonance. Consequently, when capacity is added to antenna 11, the frequency of oscillations is decreased in proportion to the increase in capacity, causing radio frequency voltage and hence the diode current to decrease by a proportionate decrement. Similarly, the addition of capacity to antenna 10 likewise decreases the frequency of the tuning circuit, improving the tuning thereof so that the diode current increases by a proportionate increment. In this manner the approach of an intruder to either antenna introduces additional capacity to change the diode current in either of the manners just described. The comparatively rapid changes in the voltage drop across the diode load resistor 35 are transmitted as negative or positive pulses to the grid of the output amplifier tube 36 through the large condenser 37 and the leak 38, causing either a decrease or increase in current flow through winding 39 of relay R and a consequent production of an alarm by device 44. By adjusting frequency characteristics as before described, operation occurs on the straight part of the tuning circuit response curve, with equal capacity changes in either direction causing substantially equal change in diode current flow in either direction.

Should the alarm device be activated by the approach of an intruder to either of the antennae 10 or 11, and the capacity of such antennae remained in this changed condition for a predetermined length of time, the system will again become balanced due to the time constant of the input control circuit of tube 36, which time constant is of at least several seconds duration, depending upon the values of the condenser 37 and the resistor 38 which are normally large values. Thus, within the time limit set by the time constant of the input circuit of tube 36, the system will become again balanced with normal current flow through the winding 39 of relay R. Should the intruder depart from this antenna, thereby reducing the capacity-to-ground thereof, the opposite effect will occur, again creating an alarm in the manner before described. The time constant of the input circuit can be varied in any of several conventional manners, and if desired, condenser 37 can be made adjustable, or even the resistor 38 be made adjustable, so that the time required for a response initiating an alarm can be shortened as desired, or the interval required for the system to assume a balanced condition can be shortened or lengthened as conditions may warrant.

The present arrangement, moreover, possesses superiority over prior devices for the reason that any change in capacity affecting both antennae simultaneously and uniformly will not cause the creation of an alarm, but compensation will be

made automatically in the system for such changes. If it be assumed that the inductances 25 and 31 are of equal value and the capacities 22 and 20 are also of equal value, then the oscillator frequency will be equal to the resonant frequency of the tuning circuit. Consequently, any equal change in the capacities 22 and 20 will create equal changes in oscillator and tuning frequencies so that the balance of the system is undisturbed. However, as before pointed out, in practice the oscillator frequency is adjusted to be slightly lower than the resonant frequency of the tuning circuit, but even with such slight variations the differential change in frequencies caused by equal capacity changes in the two parts of the system will be negligible for all practical purposes. Thus, the present system, instead of opposing an adjustable or variable frequency such as an antenna against a fixed capacity as in prior devices, opposes two adjustable capacities or antennae, with the result that the operating range of the present device exceeds materially the possible operating range of any prior device.

While theoretically an intruder might approach a system as shown in Figs. 1 and 2 in such a manner as to cause a simultaneous equal change in capacities in the two antennae 10 and 11, such as by approaching the cabinet 12 at right angles to the run of the antennae, in practice it would be for all purposes impossible to cause such simultaneous change. However, even this possibility can be avoided by extending a portion of antenna 10, as shown at 10' in Fig. 2, whereby this extended portion is located above the cabinet so that even approach thereto would cause a more marked capacity change in antenna 10 than in antenna 11.

The relay R with opposed windings as disclosed operates in a manner sufficient for ordinary burglar or intruder alarm purposes, but if the invention is to be used for "controlling" purposes, then use may be made of a galvanometer relay so that distinctive signals can result from approach to the respective antenna. The relay contacts of such a galvanometer relay, each corresponding to one antenna, could then be incorporated into its own independent controlling circuit to operate a motor, valve, and so forth, for counteraction purposes.

The use of such a galvanometer relay will be particularly advantageous where the present invention is employed for detecting capacity changes in industrial systems such as, for example, in installations wherein it may be desired to control the path of motion of any object such as a vehicle, or to measure the degree of unbalance of chemical or other weighing scales, or for many other purposes for which the system is particularly adapted. In addition, this invention can be readily used for controlling the leveling of an airplane as it approaches the ground, since if one of the systems having the dual antennae arrangement be fastened to the underside of the fuselage from fore to aft and another system fastened to the wings from side to side, the pilot of the plane could readily notice any declination of the plane's position from the desired position. Other uses of the system will be obvious to those skilled in the art.

From the foregoing it will be seen that the present invention provides a capacity alarm or control system of such nature as to compensate automatically for normal capacity changes which may occur due to atmospheric or other conditions and which can be operated to provide a

maximum of lineal protection intrusion detection with a minimum of equipment. It is to be understood that the invention is capable of modification beyond the illustrated embodiment, and accordingly any limitations to be imposed thereupon are only those set forth in the following claims.

What is claimed is:

1. In a system of the type described, the combination of an oscillator, an antenna, connections whereby a change in capacity of the antenna varies the frequency of the oscillator, a tuning circuit linked to the output of said oscillator and being tuned substantially to the frequency of the oscillator, a second antenna, connections whereby a change in capacity of the second antenna changes the tuning of said tuning circuit, a control circuit path and means whereby the changes above a predetermined rate of change in either the frequency of the oscillator or the tuning of the tuning circuit causes a change from normal in the current flow in said path, current flow in said path remaining normal upon simultaneous corresponding capacity changes of said antennae and means intermediate said linked oscillator and tuning circuit and said control current path for varying the rate of capacity change required to cause a change from normal in current flow in said path.

2. In a system of the type described, the combination of a source of oscillations, an antenna, connections whereby a change in the capacity of the antenna varies the frequency of the oscillations generated by said source, a rectifier for said oscillations, a tuning circuit linked to the output of said source between said source and said rectifier and being tuned substantially to the frequency of said source, a second antenna, connections whereby a change in capacity of the second antenna changes the tuning of said tuning circuit, an amplifier responsive to rapid voltage changes in the circuit of said rectifier caused by change of capacity in either of said antennae above a variable predetermined rate of change, signal means activated by variations from normal in the output of said amplifier, and variable means for preventing response of said amplifier to voltage changes resulting from capacity change in either antenna within said predetermined rate of change, said variable means operating to restore the output of said amplifier to normal within a predetermined time after cessation of capacity change affecting said output.

3. In a system of the type described, the combination of an oscillator, an antenna, connections whereby a change in capacity of the antenna varies the frequency of the oscillator, a tuning circuit linked to the output of said oscillator and being tuned substantially to the frequency of the oscillator, a second antenna, connections whereby a change in capacity of the second antenna changes the tuning of said tuning circuit, a control current path, and means whereby change of capacity of either of said antennae above a predetermined rate of change causes a change from normal in current flow in said path, current flow in said path remaining normal upon simultaneous uniform capacity change in said antennae, said oscillator being adjusted to such a frequency other than the resonant frequency of said tuned circuit that equal capacity changes in either direction in either antenna cause substantially equal change in current flow in said path in either direction.

4. In a system of the type described, the combination of an oscillator, an antenna, connections whereby a change in capacity of the antenna varies the frequency of the oscillator, a tuning circuit linked to the output of said oscillator and being tuned substantially to the frequency of the oscillator, a second antenna, connections whereby a change in capacity of the second antenna changes the tuning of said tuning circuit, a control current path, and means whereby change of capacity of either of said antennae above a predetermined rate of change causes a change from normal in current flow in said path, current flow in said path remaining normal upon simultaneous uniform capacity change in said antennae, said oscillator being adjusted to a frequency slightly lower than the resonant frequency of said tuned circuit whereby equal capacity changes in either direction in either antenna cause substantially equal change in current flow in said path in either direction.

5. In a system of the type described, the combination of an oscillator, an antenna, connections whereby a change in capacity of the antenna varies the frequency of the oscillator, a tuning circuit linked to the output of said oscillator and being tuned substantially to the frequency of the oscillator, a second antenna, connections whereby a change in capacity of the second antenna changes the tuning of said tuning circuit, a control current path, and means whereby change of capacity of either of said antennae above a predetermined rate of change causes a change from normal in current flow in said path, current flow in said path remaining normal upon simultaneous uniform capacity change in said antennae, said means including apparatus for restoring current flow in said path to normal within a predetermined time after cessation of capacity change.

6. In a system of the type described, the combination of an oscillator, an antenna, connections whereby a change in capacity of the antenna varies the frequency of the oscillator, said antenna extending in one direction from a central point, a tuning circuit linked to the output of said oscillator and being tuned substantially to the frequency of the oscillator, a second antenna, connections whereby a change in capacity of the second antenna changes the tuning of said tuning circuit, said second antenna extending in another direction from said central point, a control current path, and means whereby change of capacity of either of said antennae above a predetermined rate of change causes a change from normal in current flow in said path, current flow in said path remaining normal upon simultaneous uniform capacity change in said antennae, one of said antennae being so arranged relative to said central point as to prevent approach to said system in a manner to effect equally the capacities of the two antennae.

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