

Feb. 15, 1938.

F. G. KELLY, JR

2,108,202

DETECTOR SYSTEM

Filed May 12, 1933

2 Sheets-Sheet 1

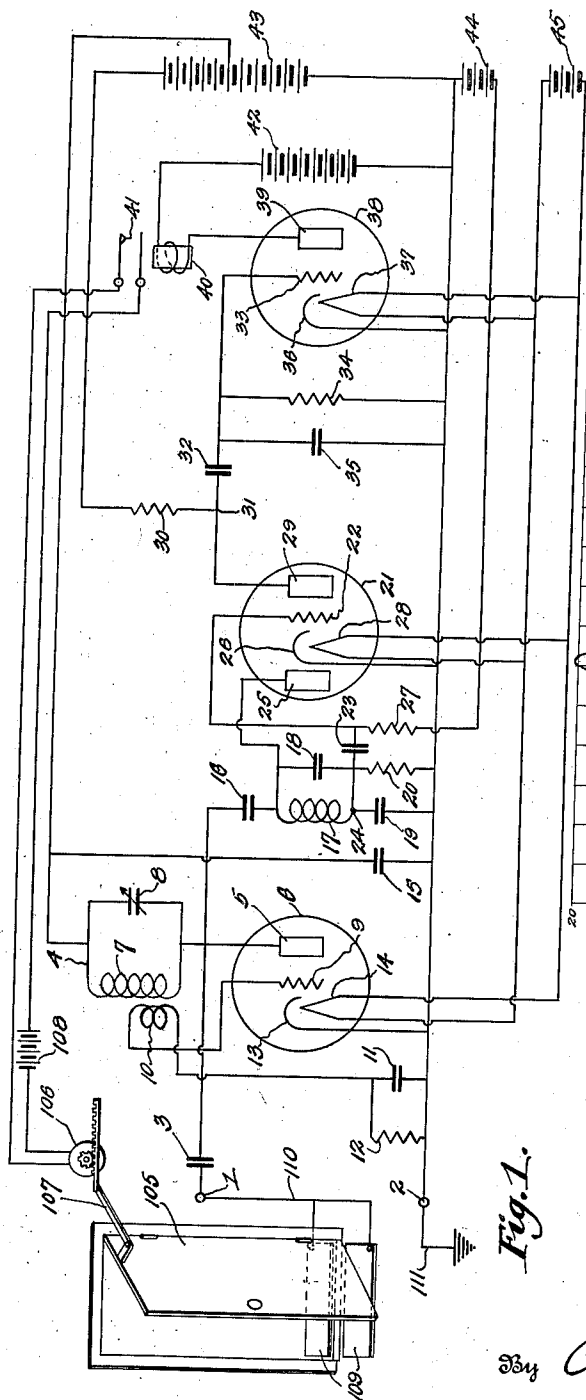


Fig. 1.

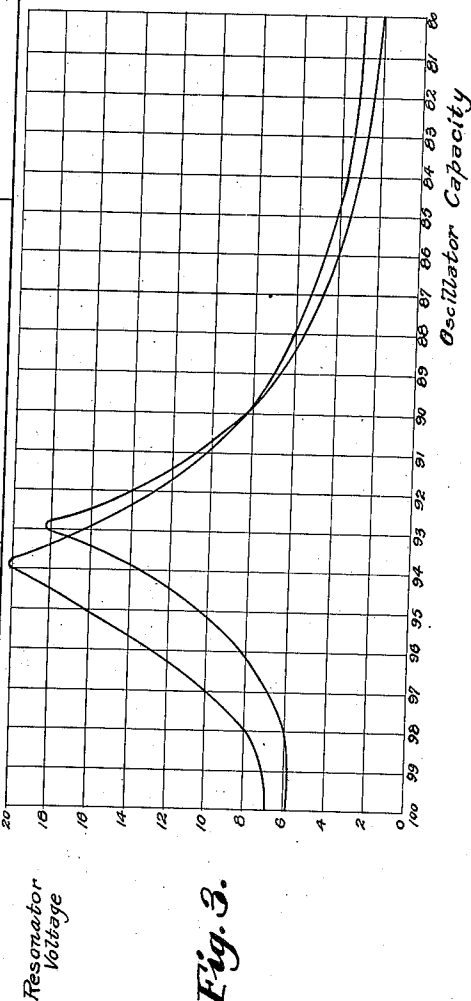


Fig. 3.

Inventor

Frederick G. Kelly, Jr.

By

Chas. M. Funkhouser

Attorney

Feb. 15, 1938.

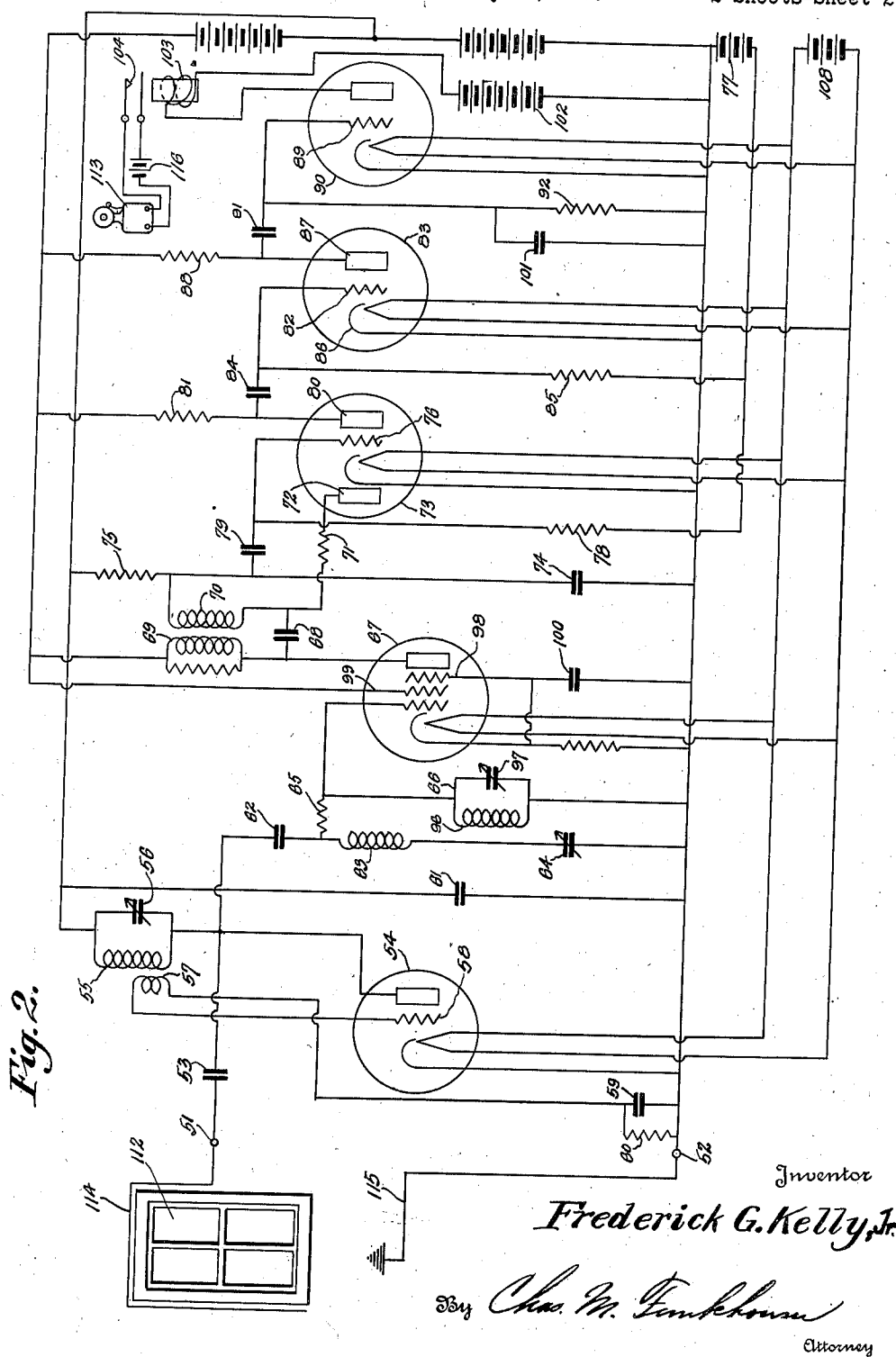
F. G. KELLY, JR

2,108,202

DETECTOR SYSTEM

Filed May 12, 1933

2 Sheets-Sheet 2



UNITED STATES PATENT OFFICE

2,108,202

DETECTOR SYSTEM

Frederick G. Kelly, Jr., Hamden, Conn., assignor
to American Teletector Corporation, New
Haven, Conn., a corporation of Connecticut

Application May 12, 1933, Serial No. 670,787

6 Claims. (Cl. 250—27)

This invention relates to detector and signaling systems and more particularly to an electrical system for detecting and amplifying any capacity variations occurring in the antenna-ground circuit.

An electrical system embodying the present invention includes apparatus which shall neglect the slow daily variations in capacity such as those due to changing atmospheric conditions, which capacity changes follow the variations in moisture and temperature.

The system may be employed to detect capacity variations caused by foreign bodies entering the antenna field, by sudden change of temperature, or by sudden changes in the moisture content in the dielectric of said field or any other object or condition which shall effect the capacity of the system.

More specifically, the invention contemplates a system in which the approach of a body towards a particular point shall cause a change in the electrical capacity of the system and this change is detected by the system. In order to accomplish these results, devices, which are affected by the approach of a body in such a manner as to change their capacity, must be located at or near places where the approach is to be detected. I call these devices the antenna. While any device having such a characteristic can be used, I will now briefly describe several kinds which I have found suitable in certain applications. If the system is used in window display work so that the display is illuminated when a shopper comes near the window, the antenna may be a fine wire strung across the inside of the window. If a sign is in the window inviting the shopper to step close and look at the display, a wire screen may be mounted in back of the sign and used as antenna. If the system is used to operate a mechanical door operator, a metal rod may be mounted above the path of approach of the person or vehicle. If used as a burglar alarm system, a wire or metal rod may be mounted under the window sills or near the doors. All of these are suitable antennas and whichever form of antenna is employed it forms one plate of a condenser and the earth the second plate. The surrounding materials, particularly the space occupied by the air, form the dielectric of the condenser, and when a body approaches the antenna field it displaces some of the air and substitutes a dielectric of higher dielectric constant thus increasing the capacity of the condenser. The rest of the system functions to

detect this change in capacity and to indicate it in any desired manner.

In addition to the antenna capacity changes caused by the approach of bodies in the antenna field, which the system must indicate, there are other changes due to changes in temperature, moisture, weather conditions in general, and also other gradual and seasonal changes. Naturally, these conditions also cause changes in antenna capacity but they should not cause indications. Accordingly, in the practical application of the system it must be able to distinguish between these changes and those caused by the approach of a body. In order to provide for these different changes, I make use of the difference between the several types of changes encountered. The seasonal, weather and daily temperature variations cause the antenna capacity to change at a low rate while on the other hand, the approach of a body towards the antenna causes a change at a relatively high rate. I therefore cause the system to indicate capacity changes of a high rate of change but discriminate against those occurring at a low rate. It will be understood that the setting of this limiting rate depends upon the relative values, or constants, of the component parts of the system. In the following detailed descriptions I have indicated constants and set a limiting rate of change value which I consider suitable but other constants may be chosen and limits may be set without departing from the spirit of the invention.

One important object of the present invention is to provide a detector system and a novel method of operating the same which shall detect the presence of foreign bodies or conditions which cause the antenna-ground capacity to suddenly vary.

Another object of the invention is to provide a system of the character designated which may be adjusted to discriminate against any slow variations in capacity.

A further object of the invention is to provide a system of the character designated which shall be more efficient in operation and able to reject the effects of any slow capacity variations occurring in the antenna field as a result of slow and normally unavoidable changes in the capacity field and at the same time remain susceptible to more abrupt variations due to the presence of any foreign bodies.

A further object of the invention is to provide a detector system of the character designated embodying a novel arrangement of capacity adjusting devices which may be adjusted

so as to render the system sensitive for a wide range of operating requirements.

A further object of the invention is to provide a system of the character designated which may be employed to control the operation of mechanisms associated with door operating devices, safety appliances, material testing and gauging apparatus and similar devices embodying a capacity-sensitive system.

A further object of the invention is to provide a detector system of the character designated in which the discrimination between the rapid and slow capacity variations is a variable factor determined by the time constants of a circuit included in said system.

These and other objects of the invention will be more manifest from the following specification when read in connection with the drawings, and more particularly set forth in the claims.

In the drawings:

Fig. 1 is a diagrammatic showing of one embodiment of my invention;

Fig. 2 is a diagrammatic showing of a circuit similar to the circuit shown in Fig. 1 and is designed for handling large antenna capacities, and

Fig. 3 shows the resonator voltage curves of the embodiment shown in Fig. 1.

Referring to the drawings there is shown in Figs. 1 and 2 circuits embodying the general principles of my invention and it is understood that certain circuit modifications may be made in order to provide for the most efficient operation under various operating conditions. For example, the circuit shown in Fig. 1 is particularly desirable where the capacity of the antenna system is relatively small and where conditions are such that changes in antenna capacity due to temperature, humidity, weather conditions in general and mechanical shifting of the antenna, etc., are small. The circuit shown in Fig. 2 however is suitable where the antenna capacity is large and where the gradual changes in the antenna capacity are large.

In both of the systems designated above, the antenna is connected through a buffer condenser to an oscillator which may be of any suitable type, although the oscillators as shown are of the plate circuit type. The oscillator furnishes an alternating output voltage varying in frequency according to changes in the antenna circuit capacity. This oscillator output is fed to a tuned resonating circuit which provides wide voltage variations in response to shifting frequencies. The output of this resonating circuit is rectified and then amplified, while all changes in the rectified voltage are amplified, only rapid changes are amplified efficiently enough to affect the succeeding circuits. The output circuit of the amplifier, for example, contains a relay which is actuated in response to these voltage surges, and which is used to place in operation any desired signalling, operating or indicating devices such as those heretofore mentioned.

Summarizing, it is apparent that sudden changes in antenna capacity manifest themselves in a change of oscillator frequency, causing a large change in both the resonator voltage and the rectified resonator voltage. Changes in the rectified voltage are then amplified and actuate suitable relay contacts which may be connected in any outside circuit and thus effect the desired control of associated mechanisms for which the system may be designed.

Referring to Fig. 1 in more detail, the values given provide a system in which the antenna ca-

capacity may go up to 100 mmf. and in which the expected gradual changes in antenna capacity will not exceed plus or minus 1 mmf. The abbreviation mmf. will be used to indicate micromicrofarads and mf. to indicate microfarads.

Any suitable antenna system is connected to the antenna terminal 1 and a good connection to ground is made at terminal 2. A buffer condenser 3 is interposed between the antenna terminal and an oscillator tuning circuit 4. One side of the oscillator tuning circuit leads to a source 43 of 45 volts positive, while the other side leads to the plate 5 of a vacuum tube 6. The oscillator circuit 4 is tuned by an inductance 7 of two millihenrys value and a variable condenser 8 of 100 mmf., connected in parallel. A control grid 9 of tube 6 is connected through a feedback coil 10 which is inductively coupled to coil 7, to a parallel circuit consisting of a condenser 11 of 100 mmf. and a resistance 12 of a half megohm. The other side of the condenser 11 and resistance 12 is grounded. This method of connecting the grid maintains a negative grid bias at the least value which will keep the grid from swinging appreciably positive and results in a particularly stable oscillator. The values chosen provide a minimum of grid circuit inductance and at the same time avoid "relaxation", periodic starting and stopping of oscillation. The cathode element 13 of tube 6 is grounded and an associated heater element 14 is connected to a suitable source of current supply 45 which is indicated as a battery.

Figure 3 shows two curves of voltage across the resonator plotted against oscillator capacity. These curves were obtained experimentally from actual systems. It will be noted that the points of resonance differ slightly due to slight variations in the circuit constants and tube characteristics, but if each system is adjusted to an oscillator capacity of 1 mmf. greater than the resonance capacity, the slope of the voltage curve for a variation in antenna capacity of 1 mmf. either side of this setting is the same. This portion of the curve may be called the range of the system.

The alternating output voltage of the oscillator is fed through a condenser 15 of 4 mmf. to a parallel resonating circuit consisting of an inductance 17 of .75 millihenry and a condenser 18 of 250 mmf. These values result in a resonance point of approximately 371,000 cycles, at which frequency the voltage across the inductance 17 is at a maximum, and any deviation from this frequency will lessen this voltage. Connected to this resonating circuit is a further parallel circuit including a condenser 19 of .1 mf. and a resistance 20 of one megohm.

The tube 21 has its control grid 22 connected through a grid coupling condenser 23 of two mf. capacity to a point 24 between condensers 18 and 19. When the system is shut off the resistance leak 20 discharges condenser 19 so that the point 24 is at ground potential. If the ground is considered the reference line, when the system is turned on, the oscillations, occurring with point 24 as reference point, will cause a rectifier plate 25 of tube 21 to swing alternately positive and negative. When rectifier plate 25 is positive with respect to the cathode 26 of tube 21, it draws electrons from it. These electrons accumulate in condenser 19, causing point 24 to become negative with respect to the cathode 26. This accumulation continues until the negative potential of point 24 is approximately equal to the peak potential across resonator coil 17. At that time, the rectifier plate 25 no longer swings appreciably

positive and point 24 remains at a constant negative potential. This negative potential equals about 90% of the resonator peak voltage because the resistance leak 20 continues to discharge condenser 19 and so some slight replacement current must come from rectifier plate 25 in order to balance the loss.

When the peak resonator potential drops in response to the system detecting the presence of a foreign body, it does so abruptly, and the resistance leak 20 immediately drains the opposing negative potential down to the new resonator peak voltage. The discrimination between seasonal variations and alarm variations is as follows:

The grid 22 of tube 21 is connected to point 24 through the coupling condenser 23 of 2 mf. This condenser is relatively large and any change in its potential can occur only by current flowing through the high resistance 27 of 3 megohms, which current flow requires an appreciable length of time, thus establishing a large time constant in this portion of the circuit. Any sudden change in potential of point 24 can cause condenser 23 to readjust itself to this change only after a long time interval, while a gradual change due to the effect of seasonal variations is able to leak through resistance 27 without appreciably altering the balance of potentials. Until this adjustment of potential in condenser 23 is accomplished, the potential of grid 22 is less negative causing an increase in output current of the tube 21. A negative bias of two volts from any suitable source 44 is applied to the grid 22 through resistance 27. A heater element 28 of tube 21 is energized by a suitable power source 45.

The plate current of tube 21 flows through a plate 29, the resistance 30 of 50,000 ohms to a 90 volt source 43, a battery in this instance. A point 31 between plate 29 and resistance 30, has a potential of about 25 volts due to the total resistance of the circuit. Point 31 is coupled to a control grid 33 of a vacuum tube 38 by means of a coupling condenser 32 of 4 mf. The grid 33 of tube 38 is connected to the cathode 36 through a resistance 34 of 3 megohms having a bypass condenser 35 of .01 mf. shunted across it. A heater element 37 of tube 38 is supplied with current from the common heater source 45.

The following action takes place: When equilibrium is reached the difference between the potential of the grid 33 and point 31 appears as a potential across condenser 32. An increase in plate current of the preceding tube 21 causes a drop in potential of the point 31. The condenser 32 cannot adjust itself instantly as the charge must leak through the high resistance 34, and there follows a drop in the potential of grid 33 resulting in a reduced output current of tube 38.

The plate 39 of tube 38 includes in its circuit a relay coil 40 and a voltage source 42. Sufficient current is normally flowing in this circuit to hold relay contacts 41 open, but when the current suddenly drops in response to a functioning of the antenna capacity detecting circuits, the relay is de-energized and its contacts drop closed, thus completing the outside circuit of an alarm or operating device. The de-energizing of relay 40 is caused by a change of antenna capacity of .1 mmf. occurring in $\frac{1}{4}$ second or less.

The system, as illustrated in Fig. 1 is suitable for such applications as window displays, door operating, etc. in other words, where the antenna capacity is comparatively small and where the seasonal variations in antenna capacity are small.

In other applications, such as burglar alarm work, when all points of entry to a home may have to be covered, a larger system handling a much greater amount of antenna capacity, but causing indications for the same absolute change in antenna capacity, is needed. One such modification of my invention is shown in Fig. 2.

In this embodiment, the system is designed to carry an antenna of 1000 mmf. capacity and able to adjust for seasonal changes up to plus or minus 200 mmf. and still maintain approximately uniform sensitivity over the entire range. This system will give an indication for an antenna capacity change of .1 mmf. occurring in $\frac{1}{4}$ second or less.

The system as shown in Fig. 2 employs the same general principle of operation as the system shown in Fig. 1, however the values of components differ in order to accommodate the different antenna capacity conditions. In this system, an antenna terminal 51 and a ground terminal 52 are provided and a condenser 53 of .1 mf. capacity is connected between the antenna terminal and an oscillator portion of this system which is of the same type as that shown in Fig. 1. A vacuum tube 54 is provided with an oscillator coil 55 and a variable tuning condenser 56 of 1000 mmf. capacity furnishing a frequency of 200,000 cycles. An oscillator feedback coil 57 is inductively coupled to coil 55, and is connected to a control grid 58 of tube 54. The other side of the feedback coil 57 leads to a parallel biasing circuit composed of a resistance 60 of 200,000 ohms and a condenser 59 of 250 mmf. capacity. The other side of the biasing circuit is grounded. A bypass condenser 61 keeps large circulating currents out of the remaining portion of the system.

The oscillator voltage is applied through a condenser 62 to a series resonator comprising a coil 63 of 10.4 mh. inductance and a variable condenser 64 of 50 mmf. capacity. A series resonant circuit is employed in this instance because the values of its component parts are more practical than those of a parallel resonant circuit under the given conditions and desired operating characteristics. Furthermore, in a series resonant circuit changes in supply voltage are less detrimental because the resonator voltage is a smaller percentage of the supply voltage than in the parallel type.

The series resonator is tuned to 220,000 cycles and the voltage across coil 63 varies from zero at resonance, to about 10% of the oscillator voltage at 180,000 cycles, or about one volt. Resistance 65 of 50,000 ohms, and a parallel coil and condenser circuit 66 comprise a trap circuit which removes the larger portion of oscillator harmonics. The tube 67 is a radio frequency amplifier stage which is connected in the conventional manner as shown in Fig. 2 and amplifies the output voltage of the resonator circuit.

The amplified resonator voltage is led through a condenser 68 to a resistance 71 connected to a rectifier plate 72 of the tube 73. Electrons flow from the cathode of tube 73 to the rectifier plate 72, through the resistance 71 and coil 70, to condenser 74 of .5 mf. value. This negative accumulation occurs only when the resonator voltage swings positive and continues until the negative potential is substantially equal to the peak of the amplified resonator voltage. The high resistance leak 75 of 10 megohms causes a slight loss of potential in the circuit, and rectifier plate 72 swings positive just enough to balance the loss through leak 75.

If a body approaches the antenna, causing an increase in antenna capacity, the oscillator frequency decreases causing an increase in resonator voltage. This voltage is amplified by the tube 67 and causes the rectifier plate 72 to swing more positive, increasing the negative charge on the condenser 74. The constants of the circuit are such that the adjustment of the charge on condenser 74 occurs almost instantly. The approach of the body, therefore, causes an immediate increase in the negative potential of condenser 74.

The difference in voltage between the grid 76 of tube 73 and the condenser 74 appears as a potential across condenser 79. The sudden increase in negative potential of condenser 74, caused by the approach of the body, results in a decrease in potential of the grid 76 since condenser 79 cannot instantly readjust its charge. The grid leak 78 must carry the current necessary to change potential on condenser 79, and the high resistance of leak 78 slows down the adjustment so that a suitable time lag is provided. The grid 76 being more negative during this interval causes a reduced plate current in tube 73. The potential of plate 80 of tube 73 rises due to its reduced plate current. A condenser 84 is connected between plate 80 and the control grid 82 of a tube 83. The rise in potential of plate 80 causes an increase in potential of grid 82 since condenser 84 cannot adjust its charge instantly through the delay action of grid leak 85, therefore an increased plate current with its consequent drop in plate potential occurs in tube 83 as a result. This decrease in plate potential is impressed upon a condenser 91 and causes the grid 89 of tube 90 to become momentarily more negative, and the plate current to decrease. A relay coil 103 in the output circuit of tube 90 is de-energized in response to the suddenly reduced plate current, and allows contact arm 104 to drop closed which completes an outside alarm or operating circuit.

Batteries have been shown as sources of energy supply, however a rectified alternating current may be used provided the direct current output is regulated so that the direct current voltage does not vary at a rate greater than the system can provide for.

A sudden drop in the voltage of the oscillator supply reduces the resonator voltage in precisely the same way it would be reduced by a sudden increase in antenna capacity. In other words, the system cannot distinguish between increase in antenna capacity and decrease in the supply voltage. Accordingly, either batteries or regulated rectified alternating current should be used, the regulation being such that changes in the alternating supply voltage, regardless of the rate at which they occur, will be slowed down so that the corresponding change in the direct current voltage will occur at a rate which is slower than the minimum rate at which the system will function.

For the purpose of illustrating a practical embodiment of the apparatus shown in Fig. 1, the outside circuit contacts 41 are arranged to control a door 105. The door operating device is shown diagrammatically by a motor 106 and lever connections 107. The motor 106 is connected in circuit with contacts 41 and a source of current 108 indicated as a battery. The antenna for the door is indicated by a pair of suitable metallic plates 109, 109 placed on opposite sides of the door and connected to the antenna

terminal 1 by leads 110, 110. A suitable ground connection or counterpoise 111, may be in close proximity to the door.

Should an object or person approach the door from either side and in close proximity to the antenna, the capacity of the system is affected as heretofore described, to close the contacts 41 and energize the motor 106 to operate the door.

Referring to the embodiment shown in Fig. 2, a window indicated by the numeral 112 is to be protected by a burglar alarm indicated by a bell 113 connected in an outside circuit with contacts 104. In this system, the window is provided with an antenna wire 114 which may be placed adjacent thereto in any desired manner, concealed in the casement, for example. A ground or counterpoise connection indicated by numeral 115 may be placed in close proximity to the window. The bell 113 is connected in circuit with the contacts 104 and a suitable source of current indicated by a battery 116. It will thus be noted that should any intruder or unauthorized person approach the window, the capacity of the system will be affected and close the contacts 104 as heretofore described, and energize the bell circuit.

While I have shown an antenna connection for only one window, it is obvious that all the windows and doors of a building or dwelling may be provided with similar antenna connections and thereby provide a reliable and efficient burglar alarm.

While I have shown and described the preferred embodiments of my invention it will be obvious that modifications and changes may be made therein without departing from the scope of the invention as defined in the following claims.

What I claim is:

1. In a vacuum tube apparatus, an antenna having a capacity to ground, means for discriminating against seasonal changes in said antenna-ground capacity comprising an oscillator connected to said antenna and having its frequency of oscillation variable in response to changes in antenna-ground capacity, means for establishing a source of direct current potential which varies in value with variations in oscillator frequency, a coupling circuit comprising a condenser and a resistance connected to said source and having a time constant smaller than the time duration of said seasonal changes in antenna-ground capacity, an amplifier connected to said coupling circuit, and translating means connected to said amplifier and responsive to the output thereof.

2. In a vacuum tube apparatus, an antenna having a capacity to ground, means for discriminating against seasonal changes in said antenna-ground capacity comprising an oscillator connected to said antenna and having its frequency of oscillation variable in response to changes in antenna-ground capacity, means including a rectifier for establishing a source of direct current potential which varies in value with variations in oscillator frequency, a coupling circuit comprising a condenser and a resistance connected to said source and having a time constant smaller than the time duration of said seasonal changes in antenna-ground capacity, an amplifier connected to said coupling circuit, and translating means connected to said amplifier and responsive to the output thereof.

3. In a vacuum tube apparatus, an antenna having a capacity to ground, means for discriminating

5 nating against seasonal changes in said antenna-ground capacity comprising an oscillator connected to said antenna and having its frequency of oscillation variable in response to changes in antenna-ground capacity, a resonating circuit
 10 connected to the output of said oscillator, means for establishing a source of direct current potential which varies in value with changes of the oscillating potential developed across said resonating circuit, a coupling circuit comprising a
 15 condenser and a resistance connected to said source and having a time constant smaller than the time duration of said seasonal changes in antenna-ground capacity, an amplifier connected to said coupling circuit, and translating means connected to said amplifier and responsive to the output thereof.

20 4. In a vacuum tube apparatus, an antenna having a capacity to ground, means for discriminating against seasonal changes in said antenna-ground capacity comprising an oscillator connected to said antenna and having its frequency of oscillation variable in response to changes in antenna-ground capacity, a resonating
 25 circuit connected to the output of said oscillator, means tuning said resonating circuit to the normal frequency of said oscillator, means for establishing a source of direct current potential which varies in value with changes of the oscillating potential developed across said resonating
 30 circuit, a coupling circuit comprising a condenser and a resistance connected to said source and having a time constant smaller than the time duration of said seasonal changes in antenna-ground capacity, an amplifier connected to said coupling circuit, and translating means connected to said amplifier and responsive to the output thereof.

35 5. In a vacuum tube apparatus, an antenna having a capacity to ground, means for discrim-
 40

inating against seasonal changes in said antenna-ground capacity comprising an oscillator connected to said antenna and having its frequency of oscillation variable in response to changes in antenna-ground capacity, a resonating circuit
 5 connected to the output of said oscillator, means tuning said resonating circuit to the normal frequency of said oscillator, a rectifier connected to said resonating circuit, means in said rectifier circuit for establishing a steady direct current
 10 potential which varies in value with variations in the oscillating potential across said resonating circuit, a coupling circuit comprising a condenser and a resistance connected to said source and having a time constant smaller than the time duration of said seasonal changes in antenna-ground capacity, an amplifier connected to said coupling circuit, and translating means connected to said amplifier and responsive to the output thereof.

20 6. In vacuum tube apparatus, an antenna, an oscillator connected with said antenna, means including said antenna for regulating the frequency of said oscillator, a resonating circuit connected to said oscillator and energized by the output thereof, means tuning said resonating circuit to substantially the normal frequency of said oscillator, a rectifier connected to said resonating circuit, resistance means connected in circuit with said rectifier whereby a steady direct current
 25 potential is established in said rectifier circuit, a coupling condenser having a terminal connected to one end of said resistance means, an amplifier having an input circuit connected to the other terminal of said coupling condenser, a second
 30 resistance connected in the input circuit of said amplifier, and translating means responsive to the output of said amplifier.

FREDERICK G. KELLY, JR. 40