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ELECTRICAL CONTROL AND INDICATION APPARATUS

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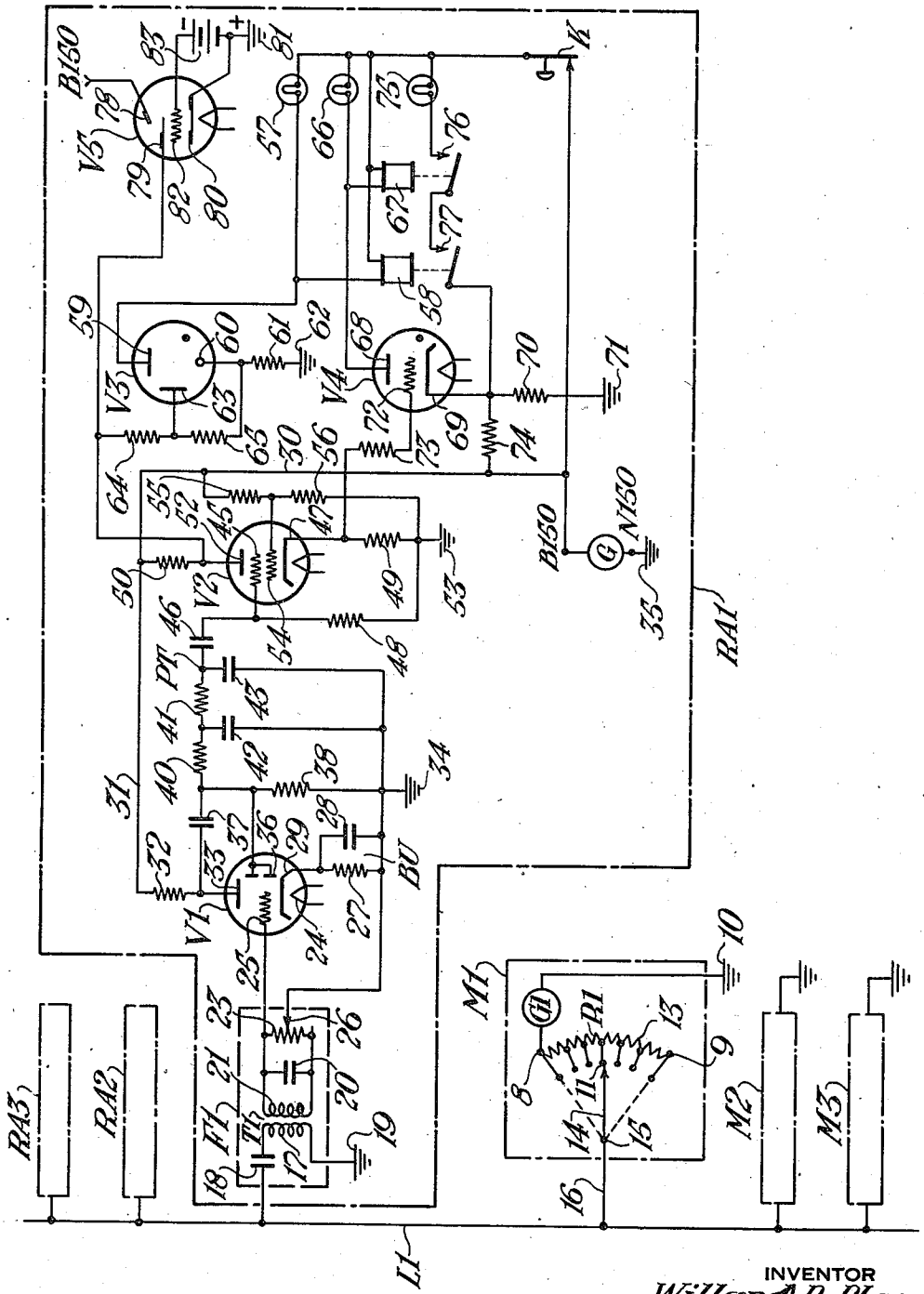

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ELECTRICAL CONTROL AND INDICATION APPARATUS

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My invention relates to electrical control and indication apparatus, and more particularly to apparatus to selectively control the operations of a plurality of devices or to selectively indicate the conditions of a plurality of devices.

A number of similar devices are frequently grouped to be controlled from a remote point through a single line circuit or for their conditions to be indicated at a remote point through a single line circuit. The control or indication, as the case may be, is usually accomplished by using a different electric current for each device, each such current having a characteristic preselected for the individual device. For example, the mines of a submarine mine field used to protect a harbor are provided with an indication at a shore office when a vessel is approaching, there being a separate indication for each mine so as to indicate which particular mine the vessel is approaching. All the indications are transmitted through a single line circuit including a metallic conductor and the ground path, and each indication is preferably of a first degree which serves as a warning indication when a vessel is some distance away and is of a second degree which serves as a firing indication when the vessel is within destructive area of the mine.

Accordingly, a feature of my invention is the provision of novel and improved apparatus responsive only to an electric current of preselected characteristics.

Another feature of my invention, is the provision of novel apparatus responsive to an alternating current when two different modulating characteristics are impressed on the current one after the other.

Again, a feature of my invention is the provision of novel apparatus responsive if an increase in the amplitude of an alternating current above a normal value is followed by a decrease or vice versa, and such variations occur at a rate not less than a preselected rate.

Other features, objects and advantages of my invention will appear as the specification progresses.

I attain the foregoing features and advantages of my invention by providing a source of current and a modulating element for each device of a group of devices. These current sources are connected in multiple to a single two-conductor line circuit. Each source supplies a current of an individual characteristic, and preferably each source supplies an alternating current of a frequency preselected for a corresponding device. Each modulating element is operable at times to impress two different characteristics one after the other on the current of the associated source. In a preferred arrangement, each modulating element is set for the associated source to normally supply to the circuit current of a voltage of a given value, and the element is operable at times to cause the value of the voltage to increase above the normal value, and then decrease below the normal value or vice versa, and such variations follow each other at a rate not less than a preselected rate.

At a remote point a plurality of receiving apparatuses, one for each device, are connected to the line circuit in multiple. Each such receiving apparatus includes a filter tuned to pass alternating current only of the frequency of the current source of the corresponding device. The energy passed by a filter is amplified and rectified, a diode-triode electron tube together with a circuit network comprising resistance and capacitance being preferably used for these functions. Thus, a substantially pure direct voltage which is a direct function of the strength of the received alternating voltage is produced. This direct voltage is applied to another amplifying tube through a condenser and the resultant direct voltage is used through voltage dividers to control two ionization type or gas filled tubes in multiple, one gas filled tube being preferably of the cold cathode type, and the other of the hot cathode type. Each gas filled tube is provided with an energized anode circuit but with each tube normally conditioned to be non-conductive. When the direct voltage derived from the received alternating voltage is of a constant value no control voltage is applied to the control grid of the second amplifier tube because of the condenser and no control voltage is applied to the control electrode of either of the gas filled tubes. When the received direct voltage increases in value and the increase takes place within a reasonably short time, energy is applied through the condenser to the amplifier tube and one of the gas filled tubes is controlled to break down. When the direct voltage decreases in value within a reasonable time, the other gas filled tube breaks down. Indication lamps or indication relays or both are governed by the anode circuits of the gas filled tubes, a particular indication or control being effected only when both tubes are conductive. That is, this particular indication is effected only when an increase of the received energy is followed by a decrease, or vice versa. I further provide the receiving

apparatus with means by which to deionize the gas filled tubes so that the receiving apparatus can subsequently be restored to its normal condition.

I shall describe one form of apparatus embodying my invention, and shall then point out the novel features thereof in claims.

The accompanying drawing is a diagrammatic view showing one form of apparatus embodying my invention when used to indicate the conditions of a group of devices.

Referring to the drawing, the dash-dot rectangles M1, M2 and M3 represent three devices of a group of devices. The specific construction of each of these devices is immaterial, and is not required for a full understanding of my invention. For example, these devices may be submarine mines used to protect a harbor and each would include a detonator for at times firing the mine. According to my invention each device M1, M2 and M3 is provided with an indicating source of current and a modulating element, the several current sources being connected in multiple to a line or transmitting circuit consisting of a conductor L1 as one side and the ground path as the other side, as will appear shortly.

Looking at device M1, a generator G1 and a rheostat R1 which serves as the modulating element are connected between conductor L1 and a ground electrode 10. One terminal of generator G1 is connected to an end terminal 8 of a resistor 13 and its other terminal is connected to ground electrode 10. A contact member 14 is pivoted at 15 and is operable to engage a series of intermediate terminals of resistor 13, spaced at intervals between the end terminals 8 and 9, the normal position of member 14 being that illustrated by a solid line where it engages a mid terminal 11. Pivot terminal 15 is connected to line conductor L1 through wire 16. Generator G1 supplies alternating current of a frequency made individual for device M1, and as an aid in understanding the apparatus I shall refer to the frequency of generator G1 as being a frequency $f1$. Contact member 14 can be operated manually or automatically in response to some predetermined condition with respect to the device M1, a complete operation of member 14 consisting of a counter-clockwise movement from the position illustrated by the full line in the drawing to a position illustrated by an upper dotted line where it engages terminal 8, and then clockwise movement to the position illustrated by a lower dotted line where it engages terminal 9, the rate of movement being not less than a preselected rate.

A voltage drop substantially equal to the full voltage of generator G1 exists between terminal 8 and ground electrode 10, and a correspondingly smaller voltage drop exists between each of the different intermediate terminals of resistor 13 and ground electrode 10. It is to be seen, therefore, that with contact member 14 set to engage mid terminal 11, a given voltage is applied to the line circuit from generator G1, due to the voltage drop of that portion of resistor 13 between terminal 8 and terminal 11, and which voltage is the normal voltage for the line circuit. The voltage applied to the line circuit increases to a maximum value when member 14 is moved counter-clockwise from its full line position to the position where it engages the terminal 8 and then the voltage decreases to a value below the normal value when the member is moved clockwise to the position where it engages terminal 9. The rate of movement of contact member 14 determines the rate at which the values of the voltage applied to the line circuit vary. For example, a preselected rate of movement of member 14 would cause a 30 per cent change in the value of the line circuit voltage in one minute. It is to be understood that my invention is not limited to any particular type of generator of alternating current or to any particular type of modulating element to cause a variation in the voltage supplied to the line circuit. It is also to be understood that the terminals and member 14 of rheostat R1 are disposed so that preferably no open circuit condition occurs during a movement of member 14.

Each of the other devices M2 and M3, as well as each of the remaining devices of the associated group would be provided with a similar generator of alternating current and modulating element, except for the frequency of the generator, each generator supplying a different frequency preselected for the associated device.

Receiving apparatuses RA1, RA2 and RA3 are associated with devices M1, M2 and M3, respectively, and are connected in multiple to the line circuit at some point remote from the devices. These receiving apparatuses are alike except for their tuning and a description of one will serve for an understanding of all.

The receiving apparatus RA1, associated with device M1, comprises a filter, F1, electron tubes V1, V2, V3 and V4, indication means and connecting circuits together with suitable current sources.

Filter F1 may be any one of several well-known arrangements, and as shown, it consists of a transformer T1, having a primary winding 17 connected across the line circuit by one terminal of winding 17 being connected to conductor L1, through a condenser 18, and the other terminal of winding 17 being connected to a ground electrode 19. A condenser 20 and a resistor 23 are connected in multiple across secondary winding 21, and the parts of the filter are proportioned to pass alternating current of the frequency of $f1$, that is, the frequency assumed hereinbefore to be that of the generator G1 associated with device M1, and to suppress all other frequencies.

Electron tube V1, disclosed as a diode-triode tube, is used to amplify and rectify the energy passed by filter F1. Filament 24 of tube V1 is constantly heated from a suitable source of current, not shown. A control grid circuit for tube V1 can be traced from control grid 25, through resistor 23 of filter F1, to an adjustable terminal 26, and thence through a biasing unit BU consisting of resistor 27 and condenser 28 in multiple to cathode 29 of the tube. The plate circuit for tube V1 receives energy from a generator G having positive terminal B150 and negative terminal N150, the plate circuit extending from terminal B150 through wires 30 and 31, resistor 32, plate 33 and intervening tube space to cathode 29 of tube V1, biasing unit BU and ground electrodes 34 and 35 to terminal N150. It is clear that that portion of the energy passed by filter F1 as preselected by the setting of terminal 26 of resistor 23 is amplified by the triode section of tube V1.

The diode element 36 of tube V1 is connected to plate 33 through a condenser 37 and to cathode 29 through a resistor 38 and the biasing unit BU, and the amplified alternating voltage is rectified by the diode section of the tube. The rectified voltage is in turn applied to a circuit network comprising resistors 40 and 41 and condensers 42

and 43, with the result a substantially pure direct voltage which is a direct function of the magnitude of the alternating voltage passed by filter F1 appears at a terminal PT of the circuit network.

Tube V2 is an indirectly heated amplifier tube the filament of which is constantly heated in the usual manner. Control grid 45 of tube V2 is connected to terminal PT of the circuit network associated with tube V1 through a coupling condenser 46, and is also connected to cathode 47 of the respective tube through resistors 48 and 49. A plate circuit for tube V2 extends from terminal B150 of generator G through wire 30, resistor 50, plate 52 and intervening tube space to cathode 47, resistor 49 and ground electrodes 53 and 35 to terminal N150. Screen grid 54 of tube V2 is provided with a suitable voltage by being connected to the mid terminal of resistors 55 and 56 which form a voltage divider connected across generator G. It is apparent that control grid 45 of tube V2 is provided with a negative bias voltage equal to the voltage drop of resistor 49 due to the plate current flowing therethrough, and as long as the direct voltage of terminal PT is of a substantially constant value no control voltage is applied to tube V2 through condenser 46 and the plate circuit current remains at a predetermined value so that normally the voltage between plate 52 and ground electrode 53 and between cathode 47 and ground are of predetermined values. For example, the voltage between plate 52 and ground is about 70 volts, and the voltage between cathode 47 and ground is about 3 volts, on the assumption the voltage of generator G is 150 volts. When the voltage at terminal PT increases several volts and the change takes place within a reasonably short time, a negative voltage is impressed on grid 45 through condenser 46 and the plate current of tube V2 is correspondingly decreased. If the voltage at terminal PT decreases several volts, and the change takes place within a reasonably short time, a positive voltage is impressed on grid 45 through condenser 46 and the plate current of tube V2 is correspondingly increased. An increase in the plate current of tube V2 causes a decrease in the voltage between plate 52 and ground electrode 53 due to the voltage drop in resistor 50, and an increase in the voltage between cathode 47 and electrode 53 due to the voltage drop in resistor 49. Conversely, a decrease in the plate current of tube V2 causes an increase in the voltage between plate 52 and electrode 53 and a decrease in the voltage between cathode 47 and electrode 53. Consequently, the voltage between plate 52 of tube V2 and electrode 53 varies directly with the variations in the amplitude of the alternating voltage of the line circuit and the voltage between cathode 47 and electrode 53 varies indirectly with the variations in the amplitude of the line circuit voltage.

Tubes V3 and V4 are ionization type gas filled tubes, tube V3 being disclosed as a cold cathode tube and tube V4 being disclosed as a hot cathode tube. Tubes V3 and V4 are provided with anode circuits which are connected in multiple to generator G, the anode circuit for tube V3 extending from terminal B150, through an indication lamp 57 and a winding of a relay 58 in multiple, anode 59 and tube space to cathode 60 of tube V3, resistor 61 and ground electrodes 62 and 35 to terminal N150; and the anode circuit for tube V4 extending from terminal B150 through indication lamp 66 and a winding of a relay 67 in multiple, anode 68 and intervening tube space to cathode 69 of tube V4, resistor 70 and ground electrodes 71 and 35 to terminal N150. The control electrode 63 of tube V3 is connected to the mid terminal of a voltage divider comprising resistors 64 and 65, the outside terminal of resistor 64 of this voltage divider being connected to plate 52 of tube V2 and the outside terminal of resistor 65 of this voltage divider being connected to ground through resistor 61 and electrode 62. Resistors 64 and 65 of this voltage divider are so proportioned that the normal voltage supplied to the control electrode 63 is well below that required to break down the tube when the anode voltage of the tube V3 is that supplied by generator G. For example, on the assumption that the plate 52 of tube V2 is normally about 70 volts above ground, that is, the negative terminal of generator G, a voltage of about 47 volts is impressed upon control electrode 63 through the voltage divider 64—65 and such voltage is well below the break down voltage of the tube V3. Consequently, indication lamp 57 is normally dark and relay 58 is normally deenergized. Control grid 72 of tube V4 is connected to cathode 47 of tube V2 through resistor 73, and cathode 69 of tube V4 is connected to the mid terminal of a voltage divider formed by resistors 74 and 70, and the parts are so proportioned that tube V4 is provided with a bias voltage that is ample to prevent the tube from normally breaking down. On the assumption used hereinbefore that the cathode 47 of tube V2 is normally about 3 volts above ground, the normal negative bias voltage for tube V4 is of the order of 6 volts due to the voltage divider 70—74. This negative bias voltage is sufficient to maintain tube V4 non-conductive and consequently indication lamp 66 and relay 67 are normally deenergized.

An additional indication lamp 75 is controlled by an obvious circuit including front contacts 76 and 77 in series of relays 67 and 58, respectively, and resistor 70. It is clear that indication lamp 75 is illuminated only when both tubes V3 and V4 are conductive so that the corresponding relays 58 and 67 are energized.

Receiving apparatus RA1 also includes an electron ray tube V5 to provide an additional visual indication, but tube V5 and its function may not be required. Tube V5 is of the standard type of electron ray tube and is interposed in the receiving apparatus by having its target electrode 78 connected to terminal B150 of generator G, control electrode 79 connected to plate 52 of tube V2, and its cathode 80 connected to terminal N150 of the generator through ground electrodes 81 and 35. Control grid 82 of tube V5 is connected to cathode 80 through a battery 83 disposed to make grid 82 negative in potential with respect to the cathode to a degree sufficient to render the triode section of tube V5 ineffective. The triode section of tube V5 is not needed since the voltage obtained from plate 52 of tube V2 is sufficient to govern the control electrode 79 without further amplification, but the triode section of the tube is shown due to a standard type of tube being used. Hence variations of the voltage of plate 52 of tube V2 in response to variations of the direct voltage appearing at terminal PT due to changes in the alternating voltage of the line circuit causes the shadow angle of the tube V5 to vary, such change in the shadow angle of tube V5 serving to provide an indication of a change

in the alternating voltage of the line circuit when such change is insufficient to cause indications at lamps 57 and 66.

Normally, that is, when the apparatus is in the position shown in the drawing, the voltage of the current applied to the line circuit from generator G1 is substantially of a constant value and the direct voltage at terminal PT of the receiving apparatus RA1 is of a constant value with the result no control voltage is applied to tube V2 and the gas filled tubes V3 and V4 are non-conductive, causing lamps 57 and 66 to be dark and the associated relays 58 and 67 to be deenergized. Also, the shadow angle of electron ray tube V5 is of normal degree. If in response to the preselected event at device M1, contact member 14 is moved first counterclockwise, so that the value of the alternating voltage applied to the line circuit is increased and then is moved clockwise so that the line circuit voltage is decreased, the direct voltage created at terminal PT of the receiving apparatus RA1 is increased several volts above normal within a given time and then is decreased several volts below normal value within a given time. Such increase in the direct voltage of terminal PT causes a negative voltage to be impressed upon control grid 45 of tube V2 through condenser 46 and the plate current of tube V2 is correspondingly decreased in value. This action makes the voltage of plate 52 more positive with respect to the negative terminal of generator G and consequently the voltage applied to control electrode 63 of tube V3 is increased sufficient to ionize that tube, and once tube V3 is broken down it remains conductive to cause lamp 57 to be illuminated and relay 58 to be energized. The subsequent decrease in the direct voltage of terminal PT results in the control grid 45 of tube V2 being driven in the positive direction to cause an increase in the plate current of that tube, with the result the voltage applied from cathode 47 of tube V2 to control grid 72 of tube V4 drives the grid 72 in the positive direction sufficient to break down tube V4, and once broken down the tube V4 remains conductive so that lamp 66 is illuminated and relay 67 is energized. With both relays 58 and 67 energized, lamp 75 is illuminated to indicate that both tubes V3 and V4 are conductive. Such variations in the plate current of tube V2 causes the voltage of plate 52 of the tube to vary with respect to the negative terminal of the generator G with the result that the shadow angle of electron ray tube V5 is correspondingly varied.

Operation of key K to open the anode circuits of the gas filled tubes V3 and V4 serves to deionize these tubes and return the tubes to their normal non-conducting conditions.

The sensitivity of the receiving apparatus RA1 can be adjusted by the voltage control interposed at filter F1 by the adjustable terminal 26 of resistor 23, the setting of terminal 26 determining the change in voltage at terminal PT in response to a given change of voltage of the line circuit. This adjustable feature compensates for variables due to different attenuations of different lengths of the line circuit, differences in the strength of the generated indication voltages and differences in the efficiency of the individual filters and aging of the electron tubes. The receiving apparatuses RA2 and RA3 are shown conventionally because they would be a duplication of that of the apparatus RA1, except for the tuning of the filters, the tuning of the filters being made to correspond to the frequency of the generators of the associated devices M2 and M3.

It is to be seen, therefore, that apparatus RA1 is selectively responsive to the indication current supplied from device M1, and is non-responsive to the currents applied to the line circuit at the other devices of the associated group.

Although I have herein shown and described but one form of electrical control and indication apparatus embodying my invention, it is understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. In combination with supply means including a source of alternating voltage and a modulating element connected to a line circuit to supply at times an alternating voltage that is characterized by increasing from a normal value and then decreasing from the normal value or vice versa, receiving means connected to said line circuit to receive such alternating voltage and including a rectifier to produce a direct voltage that increases and decreases in step with such variations of said alternating voltage, two gas filled tubes each provided with an energized anode circuit but conditioned to be normally non-conductive, a first circuit means including a first voltage divider to connect a control electrode of a first one of said tubes to said receiving means to break down that tube in response to said increase of said direct voltage, a second circuit means including a second voltage divider to connect a control electrode of a second one of said tubes to said receiving means to break down that tube in response to said decrease of said direct voltage, and means controlled by said anode circuits and made active only when both of said tubes are conductive.

2. In combination with a supply means including a source of alternating voltage and a modulating element connected to a line circuit to supply at times an alternating voltage that is characterized by increasing from a normal value and then decreasing from the normal value or vice versa, and with such variations occurring at a rate not less than a preselected rate, receiving means connected to said line circuit to receive such alternating voltage and including rectifying means to produce a direct voltage that increases and decreases in step with said variations of said alternating voltage, two gas filled tubes each provided with an energized anode circuit but conditioned to be non-conducting, a condenser, a first circuit means including a first voltage divider and said condenser to connect a control electrode of a first one of said tubes to said receiving means to break down that tube in response to said increase of said direct voltage at a rate not less than said preselected rate, a second circuit means including a second voltage divider and said condenser to connect a control electrode of a second one of said tubes to said receiving means to break down that tube in response to said decrease of said direct voltage at a rate not less than said preselected rate, and means controlled by said anode circuits and made active when both of said tubes are conductive.

3. In combination with supply means including a source of alternating voltage and a modulating element connected to a line circuit to supply at times an alternating voltage that is characterized by increasing from a normal value and then decreasing from the normal value, with such varia-

tions occurring at a rate not less than a preselected rate, receiving means connected to said line circuit to receive such alternating voltage and including rectifying means and a circuit network having resistance and capacitance to create at a given terminal of the network a direct voltage the value of which varies according to said variations of said alternating voltage, two gas filled electron tubes each provided with an energized anode circuit but conditioned to be non-conducting, a condenser, a first circuit means including a first voltage divider and said condenser to connect a control electrode of a first one of said tubes to said terminal of the network to break down that tube in response to an increase of said voltage at a rate not less than said preselected rate, a second circuit means including a second voltage divider and said condenser to connect a control electrode of a second one of said tubes to said terminal of the circuit network to break down that tube in response to a decrease of said direct voltage at a rate not less than said preselected rate, and means controlled by said anode circuits and made active when both of said tubes are conductive.

4. In combination with supply means including a source of alternating voltage and a modulating element connected to a line circuit to supply at times an alternating voltage that is characterized by increasing from a normal value and then decreasing from such normal value, receiving means connected to said line circuit to receive such alternating voltage and including a rectifier to produce a direct voltage that increases and decreases in step with such variations of said alternating voltage, an amplifier electron tube provided with a plate circuit and having a control grid connected to said receiving means to vary its plate current according to the variations of said direct voltage, a first gas filled tube provided with an anode circuit and having a control electrode connected to the plate of said amplifier tube to break down said first gas filled tube when the plate current of the amplifier tube is decreased, a second gas filled tube provided with an anode circuit and having a control electrode connected to the cathode of said amplifier tube to break down said second gas filled tube when the plate current of the amplifier tube is increased, and means governed by said anode circuits and made active only when both gas filled tubes are conductive.

5. In combination with supply means including a source of alternating voltage and a modulating element connected to a line circuit to supply at times an alternating voltage that is characterized by increasing from a normal value and then decreasing from such normal value, a diode-triode electron tube provided with a plate circuit and having a control grid coupled to said line circuit to amplify said alternating voltage, a diode element of said tube connected to said plate circuit to rectify said amplified alternating voltage, a circuit network comprising resistance and capacitance connected to said diode element to create a direct voltage in response to said rectified voltage, another amplifier tube provided with a plate circuit and having a control grid connected to said circuit network to vary its plate circuit current according to the variations of said direct voltage, a first gas filled tube provided with an anode circuit and having a control electrode connected to the plate of said other amplifier tube to break down said first gas filled tube when the plate current of said other tube is decreased, a second gas filled tube provided with an anode circuit and having a control electrode connected to the cathode of said other tube to break down said second gas filled tube when the plate current of said other tube is increased, and means governed by said anode circuits and made active only when both of said gas filled tubes are conductive.

6. In combination, an amplifier tube having a plate circuit including a current source and a first and a second resistor and proportioned for a given normal value of plate current, said first resistor disposed next to the plate of the tube and said second resistor disposed next to the cathode of the tube, a first and a second gas filled tube, an anode circuit for each of said gas filled tubes and each of said anode circuits including said current source, a first voltage divider connected between the plate of said amplifier tube and the cathode of said first gas filled tube and having a mid terminal connected to a control electrode of the first gas filled tube to break down said first gas filled tube due to the increase in the plate voltage of the amplifier tube when its plate current is reduced, a second voltage divider connected across said current source and having a mid terminal connected to the cathode of said second gas filled tube, a control electrode of said second tube connected to the cathode of said amplifier tube to provide said second gas filled tube with a normal negative bias voltage due to said second voltage divider and to break down said second tube due to an increase in the cathode voltage of the amplifier tube when its plate current is increased, supply means including a current source and operative at times to create a direct voltage characterized by increasing from a normal value and then decreasing from the normal value, said supply means connected to a control grid of said amplifier tube to increase and decrease its plate current in response to such variation of said direct voltage, and means governed by said anode circuits made active when both gas filled tubes are conductive.

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