

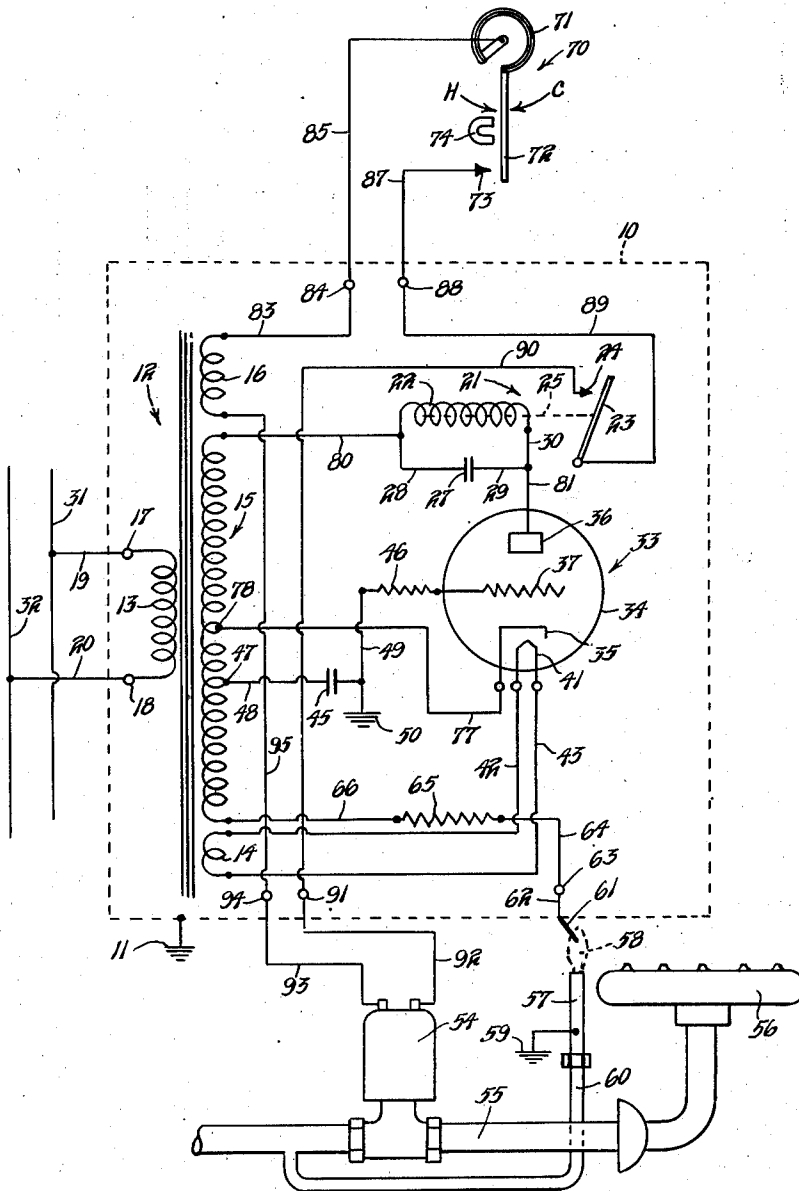
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ELECTRONIC CONTROL DEVICE

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ELECTRONIC CONTROL DEVICE

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The present invention is concerned with an electronic control device and more particularly with one designed to determine whether an impedance is rectifying or not.

In the co-pending application of Vilynn O. Beam, Serial No. 450,613, filed by July 11, 1942, there is described a control device which is adapted to determine whether an impedance connected across a gap is rectifying or not and to act in one manner when the impedance is rectifying and to act in another when the gap is either open circuited or is bridged by an impedance which is non-rectifying. In this circuit of the Beam application, a plurality of electronic triodes are employed, one of these triodes being employed as the main control triode and the other to function as a rectifier and to introduce certain phase shifting features. The presence of this last named triode increases the complication of the apparatus and adds to the number of auxiliary circuit elements which must be employed.

It is a general object of the present invention to provide a control device accomplishing the functions of the device described in the aforesaid Beam application by employing a single electronic discharge device having but one anode.

A further object of the present invention is to provide a control device of the electronic type having but a single electronic amplifier, which amplifier has only one anode, the control device including a first connection between the control electrode of the amplifier and a source of power to maintain the potential of the control electrode below the value at which the amplifier is effectively conductive and a second connection between the control electrode and a different point on the source of power, this second connection being such that it would normally also tend to maintain the control electrode potential below this value but having means associated with it which is effective upon a gap in the connection being bridged by a rectifying impedance to raise the potential of the grid above this value.

A further object of the invention is to provide a control device such as set out in the last object in which the means for raising the potential of the control electrode upon the impedance being rectifying is a condenser connected to the control electrode.

A further object of the present invention is to provide a burner control system embodying the control device of the previously named objects in which the means acting as a rectifying impedance is a means responsive to the burner flame and

rectifying only when it is exposed to a burner flame.

Other objects of the invention will be apparent from a consideration of the accompanying specification, claims, and drawing, of which

The single figure is a schematic view of my control device employed as a flame detecting apparatus for a burner control system.

Referring to the drawing, the control device of the present invention is shown as being located within a housing 10. This housing may be of any suitable form. If the housing is of metal it is desirable that it be connected to ground as at 11.

Disposed within the housing 10 is a step up, step down transformer 12 having a line voltage primary 13, a high voltage secondary winding 15 and low voltage secondary windings 14 and 16. The primary winding 13 is connected to terminals 17 and 18 and by conductors 19 and 20 to line wires 31 and 32 leading to any suitable source of alternating power (not shown). The low voltage secondary winding 16 is employed for energizing auxiliary apparatus to be controlled by the control device. The secondaries 14 and 15 are employed to energize the various elements of the control device. As far as the apparatus of the present invention is concerned, the transformer 12 constitutes the source of power and elsewhere in the specification and claims, the expression "source of power" is used to designate the means associated with the control device for supplying power at various potentials to the control device, even though this means must in turn be connected to some primary source of power.

A relay 21 comprises a relay coil 22 and a switch blade 23 adapted to engage a fixed contact 24. Switch blade 23 is associated with an armature 25 which in turn is associated with the relay coil 22. Switch blade 23 is normally biased by gravity or other suitable means away from contact 24. Upon energization of relay coil 22, however, the armature 25 is drawn to the left to move switch blade 23 into engagement with contact 24.

A condenser 27 is connected by conductors 28, 29 and 30 in parallel with relay coil 22. Condenser 27 acts as a shunt condenser to eliminate any pulsations in the current flowing through relay coil 22.

The energization of relay coil 22 is controlled by an electronic discharge device 33. This device comprises a conventional envelope 34 which encloses a cathode 35, an anode 36, and a control grid 37. The cathode 35 is of the indirectly heated type and has a heater 41 associated there-

with for heating the same. The heater 41 is connected to secondary winding 14 by conductors 42 and 43. The electronic discharge device 33 is so designed that the voltage amplification is relatively uniform when a voltage is applied to the output circuit of such magnitude that the amplifier is effectively conductive only when the potential of the grid is positive with respect to a cut off potential substantially negative with respect to the cathode. In other words, the discharge device is of the conventional type normally operated with a "negative cut off point." It is to be understood that the terms "cut off potential" or "cut off point," as used in the specification and claims refer to the grid potential at which the amplifier output is insufficient to energize the relay even though there still may be an appreciable current flow through the relay. In other words, at the "cut off potential," the amplifier is effectively non-conductive.

A condenser 45 and a current limiting resistor 46 are connected between the grid 37 and tap 47 of secondary 15 by conductors 48 and 49. The right hand terminal of condenser 45 is connected to ground as indicated at 50. The condenser 45 is employed to control the potential of the grid 37, as will be more fully explained later.

The relay 21 is illustratively shown as controlling an electrically operated gas valve 54. This gas valve is of the type which when energized permits a flow of gas and which upon deenergization interrupts such flow. The gas valve 54 controls the flow of gas through a pipe 55 to a main gas burner 56. Located adjacent to the main gas burner 56 is a pilot burner 57, the flame of which is indicated by the reference numeral 58. The pilot burner 57 is connected to ground as indicated at 59. The pilot burner is supplied with gas by a pipe 60 which is connected to the gas supply pipe 55 at a point on the upstream side of valve 54 so that the pilot burner 57 is normally constantly supplied with gas and hence normally constantly burning. A flame electrode 61 is mounted so that it extends into the flame 58, when present. This flame electrode is connected by conductor 62, terminal 63, and conductor 64 to a resistor 65. The resistor 65 is in turn connected by conductor 66 to the lower terminal of secondary 15.

The energization of valve 54 is not only controlled by relay 21 but also by a room thermostat 70. This room thermostat is of conventional construction and comprises a bimetallic element 71 to which is secured a contact arm 72. The contact arm 72 is adapted to be moved into and out of engagement with a fixed contact 73. As indicated by the legends C and H, the bimetallic element 71 is effective to move the contact arm 72 to the left in the direction of contact 73 upon a temperature fall and to the right away from contact 73 upon a temperature rise. A magnet 74 is associated with contact arm 72 to impart a snap action to the contact arm and to cause a suitable differential to exist between the temperature at which the contact arm 72 engages contact 73 and that at which it separates from contact 73.

The following values are the values which can be employed in one embodiment of the invention. The transformer 12 can be so designed that the voltage of secondary 16 is 24 volts and the voltage of each half of secondary 15, 300 volts. The tap 47 can be displaced approximately 24 volts from the center tap of secondary 15. The voltage of secondary 14 is dependent upon the type of

heating element 41 that is employed. The resistor 46 can have a resistance of 3 to 4 megohms and the resistor 65 a resistance of at least 12 megohms. An 0.02 microfarad condenser can be employed for condenser 45 and an 0.5 microfarad condenser for condenser 27. As previously indicated, however, it is to be understood that these values are merely illustrative values and that the invention is not in any way limited to the use of elements having these particular values, except as set forth in the appended claims.

OPERATION

When pilot burner is extinguished

The various elements are shown in the position which they occupy when the pilot burner is extinguished and when the temperature adjacent room thermostat 70 is at or above the desired value so that the thermostat 70 is "satisfied." Under these conditions, a charging circuit is established through condenser 45 as follows: from tap 47 of secondary 15 through conductor 48, condenser 45, conductor 49, resistor 46, grid 37, cathode 35, and conductor 77 back to the center tap 78 of secondary 15. Due to the fact that current will only flow from the grid to the cathode, current will flow through this circuit only in the direction just traced. The effect of the current flow in this direction is to charge condenser 45 so that a direct current potential exists across its terminals. The polarity of this potential is such that the right hand end of condenser 45 is negative and the left hand end positive. The grid 37, it will be noted, is connected to the right hand end of condenser 45 and the cathode 35 to the left hand end through the portions of winding 15 between taps 47 and 78. The effect of this charge is thus to bias grid 37 negatively with respect to cathode 35. Viewed in another light, the voltage phase of tap 47 with respect to cathode 35 is opposite to the upper terminal of secondary 15 to which the anode is connected, as will be presently explained. Thus, when the anode is positive, the tap 47 is negative with respect to the cathode 35. This connection of the grid 37 through condenser 45 to this point tends to maintain the grid at a potential 180° displaced in phase from the anode voltage and thus tends to bias grid 37 negatively. Regardless of the manner in which the effect of the connection including condenser 45 is explained, it is obvious that this connection acts to bias grid 37 negatively. The voltage existing between taps 47 and 78 is such that the grid is biased negatively below its cut off point.

Under these circumstances, the amplifier 33 is not conductive so that relay coil 22 is deenergized and switch blade 23 is separated from contact 24. With the relay deenergized, it is impossible to establish a circuit to gas valve 54.

With proper flame

Upon the establishment of a pilot burner flame 58, a second charging circuit can be traced through condenser 45 as follows: from the lower terminal of secondary 15 through conductor 66, resistor 65, conductor 64, terminal 63, conductor 62, flame electrode 61, flame 58, pilot burner 57, ground connection 59, ground connection 50, condenser 45, and conductor 48 to tap 47 of secondary 15. While current can flow through this circuit in either direction, the current flow is considerably greater in the direction traced than in the opposite direction due to the rectifying characteristics of the flame. As is well known, the flow of elec-

trons through a flame is greater in the direction of propagation of the flame. Thus, the conventional current flow is greater in the direction opposite to flame propagation, which was the direction in which the last traced circuit was followed.

The effect of the current flowing through the charging circuit just traced is to tend to charge condenser 45 in a direction opposite to that in which it was charged by the current flowing through the previously named charging circuit. Thus, the effect of this last traced charging circuit is to tend to cause the right hand terminal or grid terminal of condenser 45 to become positive with respect to the left hand end. This positive charge raises the potential of grid 37 despite the biasing effect of the alternating voltage between taps 47 and 78, to a value sufficiently above the cut off potential to render amplifier 33 conductive. As a result, current flows through relay 22 through the following circuit: from the upper terminal of secondary 15 through conductor 80, relay coil 22, conductors 30 and 81, anode 36, cathode 35, and conductor 77 to center tap 78 of secondary 15. The result of this current flow through relay coil 22 is that the switch blade 23 is moved into engagement with contact 24. The engagement of switch blade 23 with contact 24 results in the following circuit being established to gas valve 54: from the upper terminal of secondary 16 through conductor 83, terminal 84, conductor 85, bimetallic element 71, contact blade 72, contact 73, conductor 87, terminal 88, conductor 89, switch blade 23, contact 24, conductor 90, terminal 91, conductor 92, gas valve 54, conductor 93, terminal 94, and conductor 95 back to the lower end of secondary 16. As a result of the establishment of this circuit, the operating mechanism of gas valve 54 is energized with the result that the valve is moved to open position so as to permit gas to flow to the main burner 56. The gas flowing to the main burner 56 is ignited by the pilot burner 57.

Normally the burner 56 will remain ignited until the thermostat 70 becomes satisfied. When this happens, the contact arm 72 separates from contact 73, thus interrupting the energizing circuit to valve 54 and causing valve 54 to close.

If at any time during the operation of the system, the pilot burner 57 is extinguished, the control device of the present invention is effective to cause almost immediate closure of main gas valve 54. As soon as the pilot burner flame 58 is interrupted, current can no longer flow through the last traced charging circuit for condenser 45. As a result, the only charging circuit for condenser 45 is the one first traced. It will be recalled that the effect of this charging circuit is to produce a charge across condenser 45 which biases the grid 37 below the cut off potential. The time required for charging this condenser is extremely small. Thus, almost immediately after the pilot flame 58 is extinguished, the grid 37 is biased negatively below the cut off point so that the burner relay 22 is deenergized to cause an interruption of the circuit to main gas valve 54 so as to terminate the flow of gas to the main burner 56.

When flame gap is bridged

It occasionally may happen that the flame gap is bridged accidentally. In extreme cases, the flame gap may be completely short circuited such as would happen when the flame electrode engaged the pilot burner. Again, the flame gap may be bridged by some means having a resist-

ance comparable in magnitude to that of the flame itself. For example, carbon may deposit on the flame electrode until the point is reached where the carbon bridges the flame gap with an impedance of practically the same magnitude as a normal flame. It is very essential that the apparatus be able to distinguish between such a condition and that of a normal flame. The present control device is designed to distinguish between either of the types of conditions described in which the flame gap is bridged by an impedance, and a normal flame.

It will be recalled from the preceding operation that the establishment of a charge on condenser 45 of the correct polarity to raise the grid potential above the cut off value was dependent upon the rectifying action of the impedance connected between the flame electrode and the burner. As long as this gap is bridged by an impedance having no rectifying properties, the current flow through the second traced charging circuit is the same in both directions. In other words, it is an alternating current. As a result, the potential difference produced across condenser 45 as a result of this current flow is an alternating potential difference. Furthermore, since the right hand terminal of condenser 45 is connected to the lower terminal of secondary 15, the voltage phase of this terminal being displaced 180° from the voltage phase of the upper terminal of secondary 15 to which the anode is connected, this alternating voltage will be 180° displaced in phase from the anode voltage. In other words, this alternating voltage across condenser 45 will have such a phase relation with respect to the voltage applied to anode 36 that when the anode 36 is positive with respect to the cathode 35, the right hand end of condenser 45 will be negative with respect to the cathode. Viewed in another light, the control electrode 37 is connected to the lower terminal of secondary 15 through a connection including resistor 46, the gap between burner 57 and electrode 61, and resistor 65. This connection would normally tend to cause the anode 37 to assume a potential considerably negative with respect to the potential of cathode 35. Due to the presence, however, of condenser 45, this connection is actually effective to cause the grid bias to be raised in potential instead of lowered. This effect of condenser 45 is present, however, only when the impedance between electrode 61 and burner 57 is rectifying. If it is not rectifying, the connection is effective to lower the potential of grid 37 as would normally be expected with any connection between the grid 37 and a point whose voltage phase with respect to the cathode is opposite to that of the anode.

It will thus be seen from the above that upon the presence of any non-rectifying impedance between the flame electrode and burner 57, the grid 37 is subjected to a potential substantially below that of the cut off point. As a result, tube 33 is non-conductive so that relay 22 is deenergized. Thus, it is impossible to establish a circuit to the main gas valve 54.

The resistor 65 is essential in both preventing the grid potential from being lowered unduly and also in preventing an undesirable phase shifting effect from taking place. It will be noted that the grid 37 is connected to the junction of two legs, one of which contains condenser 45 and the other of which contains a flame gap. In other words, one of these legs contains a capacitive impedance and the other a resistance

impedance. The result is that there is considerable tendency for the grid 37 to be shifted in phase. This phase shifting effect becomes more pronounced as the resistance between the flame electrode and the burner decreases. If resistance 65 were not present, under extreme short circuited conditions, the phase displacement might be sufficiently close to 90° that the grid potential might actually be raised above the cut off point. By employing a sufficiently large resistor 65, however, it is assured that regardless of how small the impedance of the flame gap will be, the total impedance between the lower end of secondary 15 and ground connection 50 will still be relatively substantial in magnitude.

CONCLUSION

It will be seen that I have devised a control device particularly applicable for the control of a burner. This control device is extremely simple in construction and yet is able to distinguish between a rectifying impedance and an impedance which is not rectifying. While I have shown a flame gap as a means for providing a rectifying impedance, it is to be understood that the invention is not so limited. Even in the burner control art, other means may be employed. For example, a photo-electric cell may be employed in lieu of the flame gap. Such a photo-electric cell, when exposed to the light of a burner flame, becomes conductive in one direction only. In other words, the photo-electric cell acts as a rectifier. Thus, in the appended claims, where the expression "means responsive to a burner flame" is employed, it is to be understood that this expression is intended to be broad enough to cover both a flame gap and a photo-electric cell exposed to a burner flame. In general, while I have disclosed a specific embodiment of my invention, it is to be understood that this is for purposes of illustration only and that the invention is to be limited solely by the scope of the appended claims.

I claim as my invention:

1. In flame detecting apparatus having only one electronic amplifier, said amplifier comprising a cathode, only one anode, and a control electrode; a source of alternating power; an electrically operated device whose energization is to be controlled in accordance with the presence or absence of a flame; circuit connections for controlling said electrical device including said anode, said cathode, and a portion of said source of power and operative to cause said electrically operated device to be energized when the potential of said control electrode is positive with respect to a predetermined cut-off value which is substantially negative with respect to said cathode; a first connection between said control electrode and a point on said source of power and effective to maintain said control electrode at a potential negative with respect to said cut-off value; a connection between said control electrode and a second point on said source of power such that said connection would also normally tend to maintain the potential of said control electrode negative with respect to said cut-off value, said connection including a flame electrode forming one terminal of a gap adapted to be bridged by a flame; and means associated with said last named connection and effective when said gap is bridged by a flame to maintain said control element at a potential positive with respect to said cut-off potential by reason of the rectifying properties of the flame.

2. In flame detecting apparatus having only one electronic amplifier, said amplifier comprising a cathode, only one anode, and a control electrode; a source of alternating power; an electrically operated device whose energization is to be controlled in accordance with the presence or absence of a flame; circuit connections for controlling said electrical device including said anode, said cathode, and a portion of said source of power and operative to cause said electrically operated device to be energized when the potential of said control electrode is positive with respect to a predetermined cut-off value which is substantially negative with respect to said cathode; a first connection between said control electrode and a point on said source of power including a condenser and effective to maintain said control electrode at a potential negative with respect to said cut-off value; and a connection between said control electrode and a second point on said source of power such that said connection would also normally tend to maintain the potential of said control electrode negative with respect to said cut-off value, said connection having a portion thereof responsive to a flame and acting as a rectifying impedance when exposed to a flame; said condenser being effective when said portion is rectifying to maintain said control element at a potential positive with respect to said cut-off potential.

3. In flame detecting apparatus having only one electronic discharge device, said device comprising a cathode, only one anode, and a control electrode; an electrically operated device whose energization is to be controlled in accordance with the presence or absence of a flame; a source of alternating power; circuit connections for controlling said electrically operated device including said anode, said cathode, and a portion of said source of power and operative to cause said electrically operated device to be energized when the potential of said control electrode is positive with respect to a predetermined cut-off value which is substantially negative with respect to said cathode; a first connection between said control electrode and a point on said source of power and effective to maintain said control electrode at a potential negative with respect to said cut-off value; a connection between said control electrode and a second point on said source of power such that said connection would also normally tend to maintain the potential of said control electrode negative with respect to said cut-off value, said connection having a portion thereof responsive to a flame and acting as a rectifying impedance when exposed to flame; and means associated with said last named connection and effective when said portion is rectifying to maintain said control element at a potential positive with respect to said cut-off potential.

4. In flame detecting apparatus; an electrically operated device whose energization is to be controlled in accordance with the presence or absence of a burner flame; an electronic amplifier comprising a cathode, an anode, and a control electrode; a source of alternating power; circuit connections for controlling said electrically operated device including a connection from said anode to one point of said source of power and a connection between said cathode and a second point of said source of power, said circuit connections being effective to cause energization of said electrically operated device when the potential of said control electrode is positive with respect to a predetermined cut-off value which is substantially negative with respect to said anode; a condenser; a

connection between said control electrode and a third point of said source of power whose voltage phase with respect to said second point is opposite to that of said first named point to which said anode is connected, said connection including said condenser; a first charging circuit for said condenser consisting solely of said last named connection, said control electrode, said cathode, and said connection between said cathode and said second point of said source of power, said first charging circuit tending to cause said condenser to become charged in such a manner that the potential of the grid is negative with respect to said cut-off potential; and a second charging circuit for said condenser comprising a connection from said condenser to a fourth point of said source of power whose voltage phase with respect to said second point is also opposite to that of said first point, said last named connection having a portion thereof responsive to a flame and acting as a rectifying impedance when exposed to a flame; said condenser being effective when said portion of said connections is rectifying to assume a charge such as to cause the potential of the grid to assume a value positive with respect to said cut-off potential; and said first and second charging circuits being the only circuits in which said condenser is connected.

5. In flame detecting apparatus; an electrically operated device whose energization is to be controlled in accordance with the presence or absence of a burner flame; an electronic amplifier comprising a cathode, an anode, and a control electrode; a source of alternating power; circuit connections for controlling said electrically operated device including a connection from said anode to one point of said source of power and a connection between said cathode and a second point of said source of power, said circuit connections being effective to cause energization of said electrically operated device when the potential of said control electrode is positive with respect to a predetermined cut-off value which is substantially negative with respect to said anode; a condenser; a connection between said control electrode and a third point of said source of power whose voltage phase with respect to said second point is opposite to that of said first named point to which said anode is connected, said connection including said condenser; a first charging circuit for said condenser consisting solely of said last named connection, said control electrode, said cathode, and said connection between said cathode and said second point of said source of power, said first charging circuit tending to cause said condenser to become charged in such a manner that the potential of the grid is negative with respect to said cut-off potential; and a second charging circuit for said

condenser comprising a connection from said condenser to a fourth point of said source of power whose voltage phase with respect to said second point is also opposite to that of said first point, said last named connection comprising a gap adapted to be located in the path of a flame; said condenser being effective when said gap is bridged by a flame in the right direction to assume a charge such as to cause the potential of the grid to assume a value positive with respect to said cut-off potential; and said first and second charging circuits being the only circuits in which said condenser is connected.

6. In flame detecting apparatus; an electrically operated device whose energization is to be controlled in accordance with the presence or absence of a burner flame; an electronic amplifier comprising a cathode, an anode, and a control electrode; a source of alternating power; circuit connections for controlling said electrically operated device including a connection from said anode to a first point of said source of power and a connection between said cathode and a second point of said source of power, said circuit connections being effective to cause energization of said electrically operated device when the potential of said control electrode is positive with respect to a predetermined cut-off value which is substantially negative with respect to said anode; a condenser; a connection between said control electrode and a third point of said source of power whose voltage phase with respect to said second point is opposite to that of said first named point to which said anode is connected, said connection including said condenser; a first charging circuit for said condenser consisting solely of said last named connection, said control electrode, said cathode, and said connection between said cathode and said second point of said source of power, said first charging circuit tending to cause said condenser to become charged in such a manner that the potential of the grid is negative with respect to said cut-off potential; and a second charging circuit for said condenser comprising a connection from said condenser to a fourth point of said source of power whose voltage phase with respect to said second point is also opposite to that of said first point, said last named connection comprising an impedance of not less than 12 megohms in series with a gap adapted to be located in the path of a flame; said condenser being effective when said gap is bridged by a flame in the right direction to assume a charge such as to cause the potential of the grid to assume a value positive with respect to said cut-off potential; and said first and second charging circuits being the only circuits in which said condenser is connected.

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