

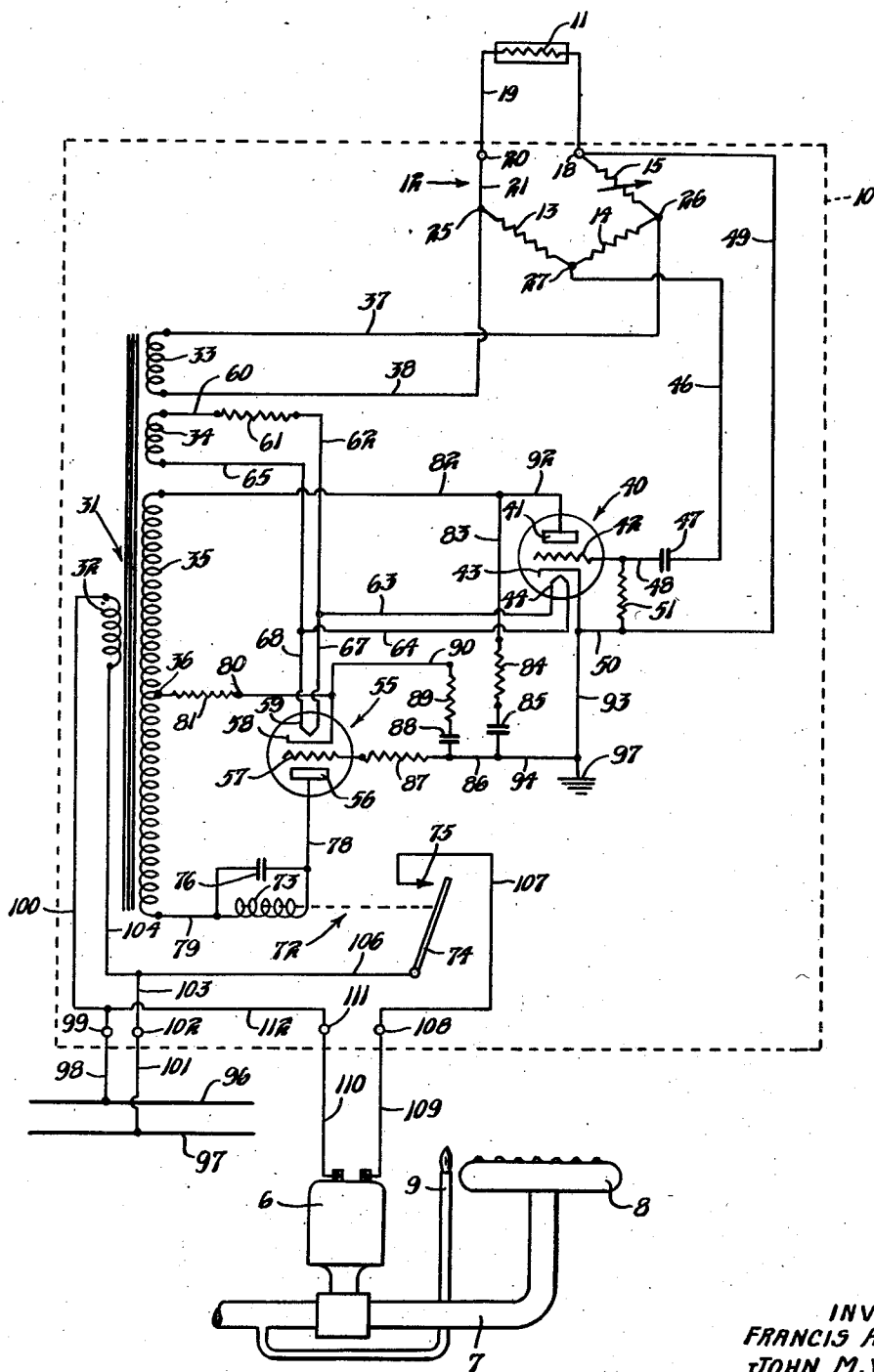
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CONDITION CONTROL APPARATUS

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CONDITION CONTROL APPARATUS

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1

The present invention is concerned with a condition control system and more particularly one of the type employing an electronic amplifier for controlling a condition responsive device in accordance with a signal voltage varying with the value of a controlling condition.

The object of the present invention is to provide in connection with a condition controlling system an arrangement for amplifying without the use of a direct current source of power, but by means of a relatively simple amplifier, a relatively weak voltage signal varying in accordance with the value of a controlling condition, so as to make possible the control of a device controlling the operation of a condition changing apparatus.

A still further object of the present invention is to provide such an arrangement in which a rectifying impedance is connected in parallel with a biasing circuit of a thermionic amplifier, the conductivity of the rectifying impedance being controlled in accordance with a condition responsive device.

A further object of the present invention is to provide an arrangement such as set forth in which a signal varying with the value of a controlling condition is varied in accordance with an impedance element whose impedance varies with the value of the condition.

A still further object of the present invention is to provide an arrangement in which a signal voltage responsive to the value of the condition is obtained from an impedance bridge and is dependent upon the unbalance of the bridge.

A still further object of the present invention is to provide an improved type of amplifier having an extremely high gain.

A still further object of this invention is to provide a high gain amplifier in which the output circuit of an electronic discharge device is connected in parallel with a portion of a biasing circuit of a further discharge device and is effective upon the first discharge device being conductive to impress on an impedance element between the grid and cathode of said further discharge device a voltage such as to render said further discharge device conductive.

A still further object of the present invention is to provide an arrangement such as set forth in the last object in which the impedance between the grid and cathode of the further discharge device is a condenser which upon the first discharge device becoming conductive, is charged by the unidirectional current flowing through said first discharge device.

2

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 showing of a condition controlling apparatus employed in connection with the control of a gas burner.

Referring to the drawing for a more detailed understanding of the present invention, the reference numeral 10 is employed to designate our improved condition controlling apparatus. Associated with this apparatus is a resistance element 11 having a relatively high temperature coefficient of resistance. The apparatus 10 is employed to control in accordance with the resistance value of resistor 11 the operation of a gas valve 6 controlling the flow of gas through pipe 7 to a burner 8. The gas valve 6 may be any type of electrically operated gas valve in which the valve is opened when power is supplied thereto. Such a gas valve may be operated by an electric rotary motor through a gear train or by an electro-magnet. The details of the gas valve form no part of the present invention. Associated with the main burner 8 is a pilot burner 9 which is shown as constantly burning. If desired, the pilot burner may be intermittently operated. In any event, some means would normally be employed to check the flame of the pilot burner before valve 6 is energized. In order to simplify the disclosure, such conventional means is not shown in the present case.

Referring specifically to the condition controlling apparatus 10, the resistance 11 is connected so as to form a unit of a resistance bridge 12 comprising in addition to resistor 11, resistors 13, 14, and 15. Resistor 11 is connected to resistor 15 by conductor 17 and terminal 18. Resistor 11 is connected to resistor 13 by conductor 19, terminal 20, and conductor 21. Terminals 25 and 26 constitute the input terminals of the resistance bridge, and terminals 18 and 27 the output terminals. The resistor 15 is an adjustable resistor which may be manually adjusted to control the temperature setting of the apparatus. Resistors 13 and 14 are preferably of material having a negligible temperature coefficient of resistance.

Power for operation of the apparatus is supplied by a transformer 31 comprising a primary winding 32 and secondary windings 33, 34, and 35. The secondary winding 35 is tapped at an intermediate point 36.

The secondary winding 33 is provided for the purpose of supplying power to the resistance bridge 12. The upper terminal winding 33 is

3

connected by conductor 37 to input terminal 26 and the lower terminal of secondary 33 to the other input terminal 25 by conductor 38.

The reference numeral 40 is employed to indicate an electronic discharge device comprising anode 41, a control grid 42, a cathode 43, and a cathode heater 44. The grid 42 is connected to the output terminal 27 of resistance bridge 12 by conductor 48, condenser 47, and conductor 46. The other output terminal 18 of bridge 12 is connected to cathode 43 by conductors 49 and 50. The condenser 47 is provided for the purposes of increasing the impedance of the grid circuit on the input side of the grid and cathode terminal to match the impedance between the grid and cathode. A resistor 51 is connected to grid 42 and cathode 43 to serve as a coupling resistor between the bridge 12 and the control grid 42.

A reference numeral 55 is applied to indicate a second electronic discharge device. This device comprises an anode 56, a control grid 57, a cathode 58, and a cathode heater element 59. The discharge device 55 as well as device 40 are both preferably of the vacuum type.

The secondary winding 34 supplies current to the cathode heaters 44 and 59, the upper terminal of secondary 34 being connected to cathode heater 44 by conductor 60, current limiting resistor 61, conductors 62 and 63 and conductors 64 and 65. The cathode heater 59 is connected to secondary 34 by a circuit extending from the upper end of secondary 34 through conductor 60, current limiting resistor 61, conductors 62 and 67, cathode heater 59, and conductors 68 and 65, back to the other terminal of secondary 34.

The discharge device 55 controls the energization of a relay generally indicated by the reference numeral 72. This relay comprises a relay winding 73 and a switch blade 74 which cooperates with a contact 75. Switch blade 74 is biased out of engagement with contact 75 and is movable into engagement therewith upon energization of relay winding 73. Connected in parallel with relay winding 73 is a by pass condenser 76 which serves to smooth out the current supplied to winding 73 by the discharge device 55. The anode 56 is connected to the lower terminal of secondary 35 through conductors 78, relay winding 73 and conductor 79. The cathode 58 is connected to the intermediate tap 36 of secondary 35 through a conductor 80 and a resistor 81. The relay winding 73 is thus connected in a circuit extending from the lower terminal of secondary 35 through conductor 79, relay winding 73, conductor 78, anode 56, cathode 58, conductor 80 and resistor 81 to the intermediate tap 36.

Grid 57 is supplied with an alternating out of phase biasing voltage by a connection which extends from the upper terminal of secondary 35 through conductors 82 and 83, resistor 84, condenser 85, conductor 86, and protective resistor 87. It will be noted that this connection between grid 57 and the secondary 35 is to the upper terminal of secondary 35 whose phase relationship with respect to the cathode 58 is opposite to that of the anode connection. The effect of this connection is to accordingly tend during the half cycle in which the anode is positive to render grid 57 sufficiently negative with respect to the cathode 58 so as to reduce the current flowing through tube 55 to an extent sufficient to operatively deenergize relay 72.

Grid 57 is connected to the cathode 58 at all times by a connection including resistor 87, a

4

condenser 88, a resistor 89, and a conductor 90. It will be obvious that any charge existing on condenser 88 will effect the voltage existing between grid 57 and cathode 58.

The discharge device 40 is so connected into the circuit as to charge condenser 88 under certain conditions of operation. The anode 41 is connected by conductors 92 and 82 to the upper terminal of secondary 35. Cathode 43 is connected by conductors 93 and 94, and 86, and resistor 87 to grid 57. It will be noted that anode 41 and cathode 43 are respectively connected in parallel with resistor 84 and condenser 85. The lower terminal of conductor 93 is connected to ground at 97.

Power is supplied to the condition controlling apparatus from line wires 96 and 97, leading to any suitable source of power (not shown). Line wire 96 is connected by conductor 98, line voltage terminal 99, and conductor 100 to one terminal of primary winding 32. Line wire 97 is connected by conductor 101, line voltage terminal 102, and conductors 103 and 104 to the other terminal of primary winding 32.

Operation

The various elements of the system are shown in the positions which they assume when the temperature to which resistor 11 is subjected is at or above the desired value. Let it be assumed that resistor 11 is located within a space which temperature is to be controlled, and which is heated by burner 6. Under these conditions, bridge 12 is unbalanced by reason of the ratio of the resistance values of the resistors 11 and 15 being greater than the ratio of the resistance of resistors 13 and 14. Under these circumstances, terminal 18 is at a potential closer to that of the upper end of secondary 33 while terminal 27 is closer to that of the lower end of the secondary 33.

Since the upper end of secondary 33 is in phase with the upper end of secondary 35, the effect of this unbalance is to impress a voltage between grid 42 and cathode 43, which is out of phase with respect to the voltage which is applied to anode 41 through the following circuit: from the upper terminal of secondary 35 through the conductors 82 and 92, anode 41, cathode 43, conductors 93, 94, and 86, condenser 88, resistor 89, conductors 90 and 80, and resistor 81 to the tap 36. When the temperature of the medium to which resistor 11 is subjected is at the value presumed to exist, namely that slightly above the desired value, the magnitude of the alternating biasing voltage is such that discharge device 40 is essentially nonconductive. Under these conditions, tube 55 is like nonconductive due to the biasing connection from the grid 57 through condenser 85 and resistor 84 to the upper terminal of secondary 35. Since tube 55 is nonconductive, relay 72 is de-energized.

Now let it be assumed that the temperature of the medium to which resistor 11 is exposed, drops to a value below that desired. The effect is to decrease the value of resistor 11 and more nearly restore the bridge 12 to balanced condition. This in turn reduces the amount of the alternating biasing voltage that is applied to grid 42, to a point where the discharge device 40 becomes conductive. Thereupon, a current flow is established through this device and through conductor 88 over the circuit traced in the preceding paragraph. Due to the rectifying characteristic of tube 40, this current flow can take place only in

the direction traced. It is to be noted that this current flow is through condenser 88 in such a direction as to impress a charge on condenser 88 tending to make the lower terminal of that condenser positive with respect to the upper terminal. The grid 57 is connected through resistor 87 to the lower terminal. Thus, the effect of current flow through the discharge device 40 is to counter-act the tendency of the biasing connection provided by conductor 83, resistor 84, condenser 85, and to raise the potential of grid 57. This in turn will render the discharge device 55 conductive so that the current flows through relay winding 73 over the circuit previously traced.

The energization of relay winding 73 causes switch blade 74 to move into engagement with contact 75 with the result that an energizing circuit is established to gas valve 6 as follows: from line wire 97 through conductor 101, line voltage terminal 102, conductor 103, conductor 106, switch blade 74, contact 75, conductor 107, valve terminal 108, conductor 109, valve 6, conductor 110, valve terminal 111, conductor 112, line voltage terminal 99, and conductor 98 to line wire 96. The energization of valve 6 as the result of the establishment of the circuit just traced causes valve 6 to move to open position permitting gas to flow through pipe 7 to burner 8, which gas is ignited by the flame from pilot burner 9.

The burner will continue in operation until such time as the operation thereof results in the temperature of the medium surrounding resistor 11 being raised above the desired value. When this happens, the unbalance of the bridge 12 is again increased to the point where the alternating voltage that is impressed between the grid 42 and the cathode 43 is sufficient to render the discharge device 40 nonconductive. When this happens, the condenser 88 is able to discharge through the following circuit: from the lower terminal of condenser 88 through resistor 87, grid 57, cathode 58, conductor 90, and resistor 89 to the upper terminal of condenser 88. The only voltage then existing on grid 57 will be that due to the biasing connection previously traced. Hence, the discharge device 55 will become nonconductive with the result that relay winding 73 will be deenergized. This, in turn, will cause deenergization of gas valve 6, to interrupt the flow of gas to the main burner 8.

The resistor 84 connected in series with condenser 85 is provided for the purpose of insuring the correct phase relationship between the biasing voltage impressed upon grid 57 by the connection including resistor 84 and condenser 85 and the voltage impressed upon anode 56. The resistor 89 functions to provide the correct time constant for the charging of condenser 88 so as to secure the proper rate of response of tube 55 to a change in the value of resistance 11. As previously noted, the resistor 87 is provided for the purpose of limiting the current flowing between the grid and cathode.

While the invention is in no way limited to an arrangement employing elements having any particular values, in one particular embodiment of our invention, we found it particularly desirable to employ 14N7 and 7F7 tubes for discharge devices 55 and 40. In the same embodiment, resistors 13 and 14 were each 500 ohm resistors, resistor 11 a 420 ohm resistor, and resistor 15 a 250 ohm resistor. An 0.02 microfarad condenser was employed for condenser 47 and a 5 megohm re-

sistor for resistor 51. In this embodiment a 5 megohm resistor is employed for resistor 84 and the 0.3 megohm resistor for resistor 89. Condenser 85 was a 0.005 microfarad condenser and condenser 88 a 0.2 microfarad condenser. Resistor 87 has a resistance value of 10 megohms. A resistor of 2000 ohms is employed for resistor 81. By pass condenser 76 is a 1 microfarad condenser.

With a circuit having the values given above, we were able to obtain a voltage gain of 3200 to one as measured between the output terminals of the bridge and the terminals of relay winding 73. Such a high gain makes possible the maintenance of the desired temperature to a very high degree of accuracy.

Where we have referred to tube 55 as being non-conductive, it is to be understood that this is intended merely to mean that the tube is not sufficiently conductive to energize or to supply enough current to relay coil 73 to cause switch blade 74 to be moved into engagement with contact 75. Actually, when the tube 55 is in the condition referred to as "nonconductive," an appreciable current may flow through the tube to the relay coil 73.

It will be seen that we have provided an improved condition controlling apparatus by which a very small voltage responsive to a condition change is employed to give a desired controlling effect. This is accomplished by the use of an extremely simple amplifier requiring no rectifier or other means of obtaining direct current power. While we have shown a specific form of our apparatus it is to be understood that this is for purposes of illustration only and that the scope of the invention is limited solely by the appended claims.

We claim as our invention:

1. In condition control apparatus; an electrically energized device for controlling the operation of a condition changing means; an impedance network including an impedance element variable in accordance with the value of a condition indicative of the need for operation of said condition changing means; an electronic discharge device having an anode, a cathode, and a control element; a source of power; means including said anode and cathode and said source of power for energizing said electrical device whenever the potential of said control electrode is above a predetermined value; a further impedance connected to said control electrode for controlling the voltage applied thereto; a biasing connection between said source of power and said control element; means including a rectifying variable impedance connected in parallel with a portion of said biasing connection independently of said source of power and effective when said impedance has a sufficiently low impedance value to impress across said further impedance a voltage such as to raise the potential of said control element above said predetermined value; and means for varying the impedance value of said rectifying impedance in accordance with the value of said impedance element.

2. In condition control apparatus; an electrically energized device for controlling the operation of a condition changing means; an impedance network including an impedance element variable in accordance with the value of a condition indicative of the need for operation of said condition changing means; an electronic discharge device having an anode, a cathode, and a control element; a source of power; means in-

7

cluding said anode and cathode and said source of power for energizing said electrical device whenever the potential of said control electrode is above a predetermined value; a condenser connected to said control electrode for controlling the voltage applied thereto; a biasing connection between said source of power and said control element; means including a rectifying variable impedance connected in parallel with a portion of said biasing connection independently of said source of power and effective when said impedance has a sufficiently low impedance value to charge said condenser in such a manner as to raise the potential of said control element above said predetermined value; and means for varying the impedance value of said rectifying impedance in accordance with the value of said impedance element.

3. In condition control apparatus; an electrically energized device for controlling the operation of a condition changing means; an impedance network including an impedance element variable in accordance with the value of a condition indicative of the need for operation of said condition changing means; an electronic discharge device having an anode, a cathode, and a control element; a source of power; means including said anode and cathode, and said source of power for energizing said electrical device whenever the potential of said control electrode is above a predetermined value; a condenser connected to said control electrode for controlling the voltage applied thereto; a biasing connection between said source of power and said control element; a further electronic discharge device having an anode, a cathode, and a control element; means including the anode and cathode of said further discharge device connected in parallel with a portion of said biasing connection independently of said source of power and effective when said further discharge device is sufficiently conductive to charge said condenser in such a manner as to raise the potential of said control element above said predetermined value; and means for applying a voltage to the control element of said further discharge device variable in accordance with the value of said impedance element so as to correspondingly vary the conductivity of said discharge device.

4. In condition control apparatus; an electrically energized device for controlling the operation of a condition changing means; an impedance network including an impedance element variable in accordance with the value of a condition indicative of the need for operation of said condition changing means; an electronic discharge device having an anode, a cathode, and a control element; a source of power; means including said anode and cathode and said source of power for energizing said electrical device whenever the potential of said control electrode is above a predetermined value; a condenser connected to said control electrode for controlling the voltage applied thereto; a biasing connection between said source of power and said control element including a second condenser; means including a rectifying variable impedance connected in parallel with said second condenser and effective when said impedance has a sufficiently low impedance value to charge said first named condenser in such a manner as to raise the potential of said control element above said predetermined value; and means for varying the impedance value of said rectifying impedance in ac-

8

cordance with the value of said impedance element.

5. In combination; first and second electronic discharge devices each having an anode, a cathode, and a control element; a source of power; connections between the anode and cathode of one of said discharge devices and spaced points of said source of power; a biasing connection between said control element and a point on said source of power whose polarity with respect to said cathode is at all times opposite to that of said anode, said connection including a first impedance element; a further impedance element connected between said control element and said cathode; means for applying a signal potential to the control element of said other discharge device; and means connecting the anode and cathode of said other discharge device in parallel with said first impedance element independently of said source of power and in series with said further impedance element effective when the control element potential is such as to render said other discharge device conductive to impress across said further impedance element a voltage such as to render said first named discharge device conductive.

6. In combination; first and second electronic discharge devices each having an anode, a cathode, and a control element; a source of power; connections between the anode and cathode of one of said discharge devices and spaced points of said source of power; a biasing connection between said control element and a point on said source of power whose polarity with respect to said cathode is at all times opposite to that of said anode, said connection including an impedance element; a condenser connected between said control element and said cathode; means for applying a signal potential to the control element of said other discharge device; and means connecting the anode and cathode of said other discharge device in parallel with said impedance element independently of said source of power and in series with said further impedance element effective when the control element potential is such as to render said other discharge device conductive to charge said condenser so as to render said first named discharge device conductive.

7. In combination; first and second electronic discharge devices each having an anode, a cathode, and a control element; an alternating current source of power; connections between the anode and cathode of one of said discharge devices and spaced points of said source of power; a biasing connection between said control element and a point on said source of power whose phase relationship with respect to said cathode is opposite to that of said anode; a condenser connected between said control element and said cathode; means for applying a signal potential to the control element of said other discharge device; and means connecting the anode and cathode of said other discharge device in parallel with a portion of said biasing connection and in series with said condenser independently of said source of power and effective when the control element potential is such as to render said other discharge device conductive to charge said condenser so as to render said first named discharge device conductive.

8. In combination; first and second electronic discharge devices each having an anode, a cathode, and a control element; an alternating current source of power; connections between the

anode and cathode of one of said discharge devices and spaced points of said source of power; a biasing connection between said control element and a point on said source of power whose phase relationship with respect to said cathode is opposite to that of said anode, said connection including a first condenser; a second condenser connected between said control element and said cathode; means for applying a signal potential to the control element of said other discharge device; and means connecting the anode and cathode of said other discharge device in parallel with said first condenser and in series with said second condenser and effective when the control element potential is such as to render said other discharge device conductive to charge said condenser so as to render said first named discharge device conductive.

9. In combination; first and second electronic discharge devices each having an anode, a cathode, and a control element; a transformer including a secondary winding; a connection between the anode of one of said discharge devices and one terminal of said source of power; a further connection between the cathode of said discharge device and an intermediate tap of said secondary winding; a biasing connection between said control element and the opposite terminal of said source of power, said biasing connection including a first condenser; a second condenser connected between said control element and said cathode; means for applying a signal potential to the control element of said other discharge device; and means connecting the anode and cathode of said other discharge device in parallel with said first condenser and in series with said second condenser and effective when the control element potential is such as to render said other discharge device conductive to charge said con-

denser so as to render said first named discharge device conductive.

10. In combination; first and second electronic discharge devices each having an anode, a cathode, and a control element; an alternating current source of power; connections between the anode and cathode of one of said discharge devices and spaced points of said source of power; a biasing connection including an impedance between said control element and a point on said source of power whose phase relationship with respect to said cathode is opposite to that of said anode; a condenser and resistor connected in series between said control element and said cathode; means for applying a signal potential to the control element of said other discharge device; and means connecting the anode and cathode of said other discharge device in parallel with said impedance independently of said source of power and effective when the control element potential is such as to render said other discharge device conductive to charge said condenser so as to render said first named discharge device conductive.

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