

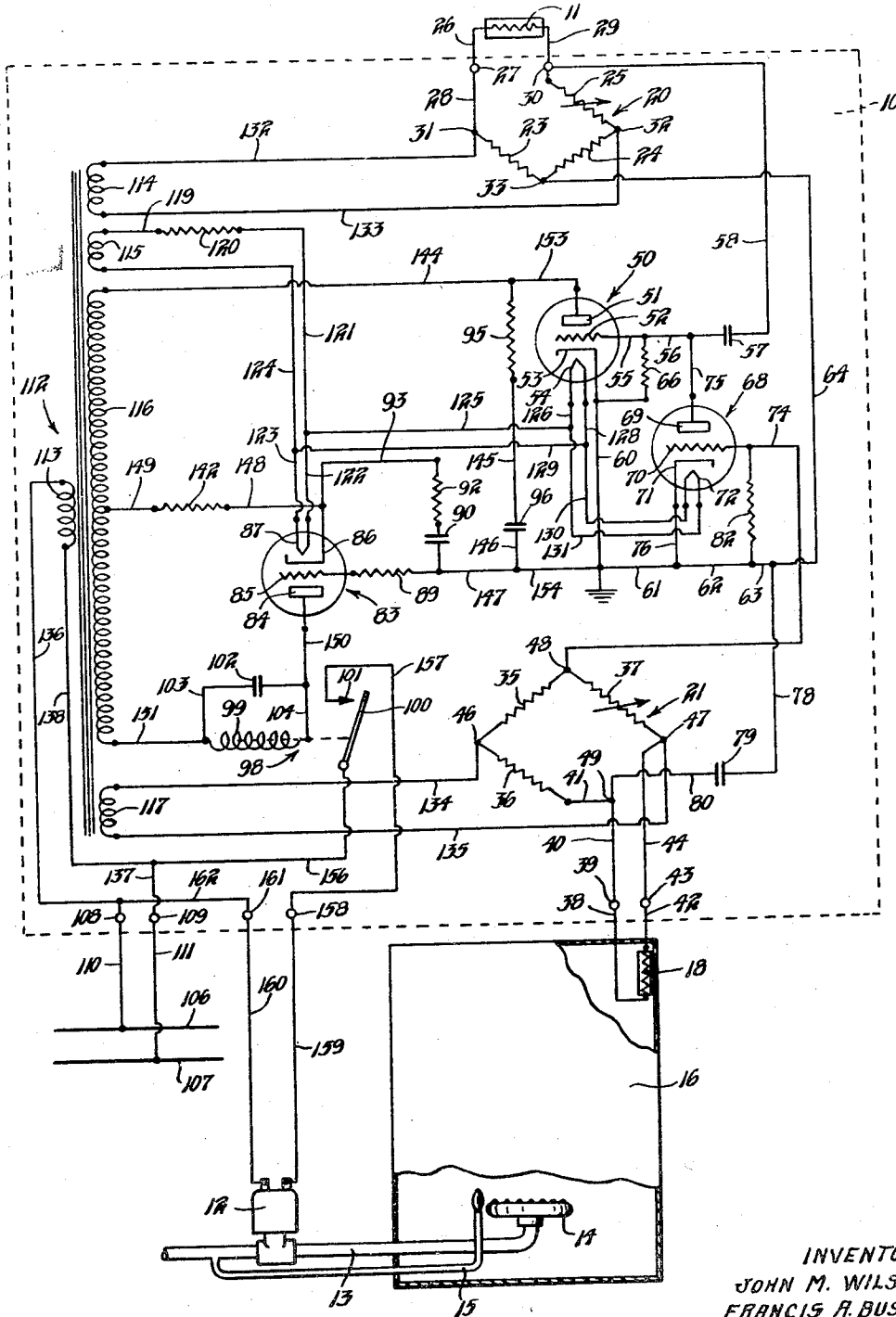
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CONDITION CONTROLLING APPARATUS

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CONDITION CONTROLLING APPARATUS

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The present invention is concerned with condition controlling apparatus and more particularly apparatus of the type employing an impedance element whose specific impedance varies with a controlling condition. A typical impedance element of this type is a resistance bulb having a relatively high temperature coefficient of resistance.

An object of the present invention is to provide in connection with condition controlling apparatus employing an impedance element whose specific impedance varies in accordance with the value of a controlling condition, means for securing, by means of a further impedance element whose specific impedance varies in accordance with a limiting condition, a limiting action only over a predetermined range of variation of the value of the limiting condition.

More specifically, an object of our invention is to provide an improved temperature controlling apparatus in which one resistance bulb is responsive to the value of a temperature controlling condition and another resistance bulb is responsive to the value of a limiting temperature condition, both resistance bulbs being capable of controlling the operation of the temperature changing apparatus, in which means is provided when the limiting condition is on the desired side of a critical value to prevent the last-named resistance element from affecting the operation of the temperature changing apparatus.

A still further object of the present invention is to provide an arrangement of the type set forth in the previous objects in which an electronic discharge device is associated with the first impedance element and is controlled by the second impedance element, this discharge device being effective to prevent the second resistance element from affecting the operation of the condition controlling apparatus when the value of the limiting condition is on the desired side of a predetermined value.

A still more specific object of our invention is to provide an arrangement in which the first impedance element forms an element of an impedance bridge and in which the electronic discharge device is connected in parallel with the output terminals of the bridge, this discharge device being non-conductive when the value of the limiting condition is within the desired range.

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

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the single figure is a schematic showing of a temperature control system employing our improved temperature controlling apparatus.

Referring to the drawing for a more detailed understanding of our invention, the condition controlling apparatus of our invention is shown as located within a housing 10 and will be referred to hereinafter in its entirety by that reference numeral. Associated with the apparatus within the housing 10 and forming a part of the condition controlling apparatus is a temperature responsive resistance element 11. This element is normally located so as to be subjected to the medium whose temperature it is desired to control. In the particular embodiment of the invention illustrated in the drawing, the resistance element 11 is located within a space to be heated.

A condition controlling apparatus is employed to control the operation of a gas valve 12 supplying gas through a pipe 13 to a gas burner 14. Associated with the gas burner 14 is a pilot burner 15. The gas burner 14 and pilot burner 15 form the combustion producing means of a furnace 16 which is designed to supply heat through any suitable heat transfer arrangement to the space in which the bulb 11 is located. It is to be understood that there is normally associated with the pilot burner 15 some means for detecting the presence of a pilot flame and which will prevent opening of the main valve 12 until it has been assured that there is a pilot burner flame. In order to simplify the present disclosure, this means has been omitted herein.

Located within the furnace 16 is a further temperature responsive resistance element 18. This element, like element 11, has a relatively high temperature coefficient of resistance. Element 18 is located so as to respond to the temperature of the furnace. If the furnace 16, for example, is a hot water furnace the element 18 will be located so as to respond to the temperature of the boiler water. If, on the other hand, the furnace is a warm air furnace, element 18 will be located in the bonnet of the furnace or at some other suitable point where it will respond to the temperature of the heated air.

Referring now to the apparatus located within the housing 10, the elements 11 and 18 form temperature responsive elements of resistance bridges generally indicated by the reference numerals 20 and 21, respectively. The bridge 20 comprises in addition to the temperature responsive resistance 11 fixed resistors 23 and 24 and an adjustable resistor 25. The resistors 23, 24 and

25 are preferably formed of a material which is relatively unaffected by temperature changes. The element 11 is connected by conductor 26, terminal 27 and conductor 28 to one terminal of resistor 23. The other terminal of resistor 11 is connected by conductor 29 and terminal 30 to one terminal of adjustable resistor 25. The junction of conductor 28 and resistor 23 and the junction of variable resistor 25 and resistor 24 constitute the input terminals of the bridge 20 and are designated by the reference numerals 31 and 32, respectively. The junction of resistors 23 and 24, designated by the reference numeral 33, and the terminal 30 constitute the output terminals of the bridge. The variable resistor 25 functions to adjust the output voltage for any given temperature of resistance bulb 11 and hence is employed to vary the temperature maintained by the apparatus.

Referring to bridge 21, this bridge in addition to the temperature responsive resistance 18 previously mentioned includes constant resistors 35 and 36 and a manually adjustable resistor 37. None of the resistors 35, 36 and 37 is in any way affected by temperature. One terminal of resistor 18 is connected by a conductor 38, terminal 39 and conductors 40 and 41 to one terminal of resistor 36. The other terminal of resistor 18 is connected by conductor 42, terminal 43, and conductor 44 to variable resistor 37. The junction of resistors 35 and 36, designated by the reference numeral 46, constitutes one of the input terminals of the bridge, and the junction of resistor 37 and conductor 44, designated by the numeral 47, constitutes the other input terminal. The junction of resistors 35 and 37 is indicated by the reference numeral 48 and the junction of conductors 40 and 41 by the reference numeral 49. Junctions 48 and 49 constitute the output terminals of the bridge.

The output of bridge 20 is employed to control the operation of a thermionic discharge device indicated by reference numeral 50. This device comprises an anode 51, a grid 52, and a cathode 53. A cathode heater 54 is associated with the cathode 53. The grid 52 is connected to output terminal 30 of bridge 20 by conductors 55 and 56, condenser 57 and conductor 58. The cathode 53 is connected to the output terminal 33 of bridge 20 by conductors 60, 61, 62, 63 and 64. A resistor 66 is connected between the grid and cathode 53 and serves as a coupling resistor between the bridge 20 and the discharge device 50.

Also connected between the grid 52 and the cathode 53 is a further discharge device 68. This comprises an anode 69, a grid 70, a cathode 71 and a cathode heater 72. The input circuit of this discharge device or tube is controlled by the output of bridge 21. The grid 70 is connected by conductor 74 to the output terminal 48 of the bridge, while the cathode 71 is connected by conductors 76, 62, 63 and 78, condenser 79, and conductor 80 to the output terminal 49. A resistor 82 is connected between the grid 70 and the cathode 71 by conductors 62 and 76.

The discharge device 50 controls the operation of a further discharge device 83, which comprises an anode 84, a grid 85, a cathode 86, and a cathode heater 87. Connected between the grid 85 and the cathode 86 of tube 83 are a resistor 89, condenser 90, resistor 92, and a conductor 93. Connected in parallel with the anode and cathode of tube 50 are a resistor 95 and a condenser 96.

The discharge device 83 controls the operation of a relay 98. This relay comprises a relay wind-

ing 99 and a switch blade 100 which cooperates with a switch contact 101. The switch blade 100 is normally biased out of engagement with contact 101 and is moved into engagement therewith upon energization of relay winding 99. A by-pass condenser 102 is connected in parallel with relay winding 99 by conductors 103 and 104. The by-pass condenser 102 serves to by-pass the A. C. component of the current supplied by tube 83.

Power is supplied to the entire temperature control system from line wires 106 and 107 leading to any suitable source of power (not shown). Line wires 106 and 107 are connected to line voltage terminals 108 and 109 by conductors 110 and 111, respectively.

Power is supplied to the individual units of the temperature responsive apparatus by means of a transformer 112. This transformer comprises a line voltage primary 113 and a plurality of secondary windings 114, 115, 116 and 117. Secondary winding 115 is employed to energize the various cathode heaters 54, 72 and 87. The secondary 115 is connected by conductor 119, resistor 120, conductors 121 and 122, and conductors 123 and 124 to the filament heater 87. The same secondary is connected to filament heater 54 by conductor 119, resistor 120, conductors 121, 125 and 126, and conductors 128, 129 and 124. Filament heater 72 is connected in parallel with filament heater 54 by conductors 130 and 131.

Secondary 114 is employed to supply power to the bridge 20, and the secondary 117 is employed to supply power to bridge 21. Secondary 114 is connected by conductors 132 and 133 to the input terminals 31 and 32 of bridge 20, while secondary 117 is connected by conductors 134 and 135 to the input terminals 46 and 47 of bridge 21.

The primary 113 of transformer 112 is connected by conductors 136, 137 and 138 to the power supply terminals 108 and 109.

In the description to date, no mention has been made of any of the various values of the elements of the apparatus. It is to be understood that these elements may assume various values consistent with the proper operation of the apparatus. In one particular embodiment of our invention, we found it desirable to employ a transformer in which the secondaries corresponding to secondaries 114 and 117 each had a 30 voltage output and the secondary corresponding to secondary 115 had a 7 voltage output. In the same embodiment the secondary 116 was a 600 voltage secondary. In this embodiment, the two tubes 50 and 68 were combined within a single envelope and a 7F7 tube was employed. In the same embodiment, the tube 83 was a 7N7 tube. The resistors 82 and 66 were both 5 megohm resistors, resistor 95 a one megohm resistor, and resistor 92 a 0.1 megohm resistor. The condensers 57 and 79 were each .01 microfarad condensers, and condensers 96 and 90 were one-half to one-fourth microfarad, respectively. The by-pass condenser 102 had a capacity of four microfarads. Resistor 142 had a resistance value of 3,000 ohms. The above values are given solely as values used in one typical embodiment of the invention and are not in any way to be construed as limiting the invention to apparatus employing elements having such values.

Operation

With the various elements in the position shown, the temperature maintained in the space is at or above the desired value. Under these conditions, a bias is maintained upon the grid

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85 of tube 83 such that the relay 98 is effectively deenergized. The gas burner 12 is hence deenergized so that no gas can flow to the main burner 14. The discharge device 83 is maintained non-conductive by reason of the fact that tube 50 is likewise non-conductive, being maintained in that condition by a bias supplied by an unbalance voltage of bridge 20. When the temperature is at or above the desired value, the bridge 20 is very substantially unbalanced in such a direction that the potential at output terminal 30 tends to approach the potential at input terminal 32. The input potential of terminal 32 is such that this terminal is negative with respect to terminal 31 when the anode 51 of tube 50 is positive with respect to the cathode. This will become more apparent with the subsequent description of the operation. The output terminal 30 is connected by conductor 58, condenser 57 and conductors 56 and 55, as previously explained, to the grid 52. Thus, an unbalance voltage of the bridge 20 is applied to grid 52, which unbalance voltage is out of phase with the voltage applied to the anode. The effect of this voltage is accordingly to bias the grid negative with respect to the cathode during the conductive half-cycle. During the conditions assumed to exist, the temperature of the furnace is also within the desired range. When this is the situation, the bridge 21 is likewise unbalanced in such a way that the potential of output terminal 48 tends to approach the potential of input terminal 46. The input terminal 46 is connected to the upper end of secondary 117 and tends to be positive during the half cycle in which anode 51 is positive. As previously explained, during the same half cycle the grid 52 of tube 50 is negative. Since anode 69 of tube 68 is connected by conductors 75, 56 and 55 directly to grid 52 of tube 50 and since the cathodes 71 and 53 of tubes 50 and 68 are connected by conductors 60, 61 and 76, it will be obvious that during the half cycle being considered, anode 69 of tube 68 is negative with respect to the cathode 71. It will be recalled that under the condition of unbalance existing in bridge 21, the output terminal 48 of bridge 21 tends to be positive with respect to the output terminal 49. Hence, since the output terminal 49 is connected to cathode 71 and the output terminal 48 to grid 70, the effect of this unbalance voltage will be to apply a voltage to the grid 70 tending to make it positive during the same half cycle in which the anode 69 is negative with respect to the cathode. Thus, the alternating output voltage applied by bridge 21 to the grid 70 is out of phase with the alternating voltage across the anode and cathode of tube 68 so as to exert a biasing effect upon the grid. Hence, the tube 68 is likewise non-conductive.

Under the conditions outlined above in which tubes 50 and 68 are both substantially non-conductive, the grid 85 is subjected to a biasing voltage sufficient to prevent enough current flowing through relay winding 99 to operatively energize relay 98. This is due to two effects. In the first place, a negative charge tends to be built up on that terminal of condenser 96 to which grid 85 is connected by reason of the current flowing through the following circuit: from the upper terminal of secondary 116 through conductor 144, resistor 95, conductor 145, condenser 96, conductors 146 and 147, resistor 92, grid 85, cathode 86, conductor 148, resistor 142 and conductor 149. Due to the rectifying action of the grid and cathode, current flows through this circuit only in the direction just traced. It is to be noted that

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this current flow is in such a direction that the upper terminal of condenser 96 tends to become positive and the lower terminal to become negative. Hence, since the grid 85 is connected to the lower terminal of condenser 96, this tends to maintain grid 85 at a negative potential with respect to cathode 86. Furthermore, current also tends to flow through the following path: from the upper terminal of secondary 116 through conductor 144, resistor 95, conductor 145, condenser 96, conductors 146 and 147, condenser 90, resistor 92, conductors 93 and 148, resistor 142, and conductor 149 to the center tap of secondary 116. The current flow through this path tends to impress across condenser 90 an alternating potential such that the grid 85 tends to assume the potential of the upper terminal of secondary 116 and the cathode the potential of the center tap. The anode 84 is connected through conductor 150, conductor 104, relay winding 99 and conductor 151 to the lower terminal of secondary 116. Thus, the upper terminal of secondary 116 to which grid 85 tends to be connected by reason of the circuit just traced is at a point whose phase relationship with respect to the cathode is opposite to that of the anode. Hence, the effect of this alternating potential across condenser 90 is to bias the grid 85 negatively during the half cycles in which tube 83 would otherwise be conductive. As a result of these two biasing effects, the tube 83 is under these conditions maintained non-conductive with the result that relay 98 is effectively deenergized as previously mentioned.

Now let it be assumed that the temperature of the space in which resistor 11 is located drops below the value it is desired to maintain. The effect of this drop is to cause the potential of terminal 30 to move toward the potential of the input terminal 31. In other words, the amount of the unbalance of the bridge is decreased. This in turn tends to decrease the bias voltage that is applied to grid 52 so as to render tube 50 conductive. When this happens, a new current path is established through condenser 90 as follows: from the upper terminal of secondary 116 through conductors 144 and 153, anode 51, cathode 53, conductors 60, 154 and 147, condenser 90, resistor 92, conductors 93 and 148, resistor 142 and conductor 149 to the center tap of secondary 116. Due to the fact that the tube 50 is conductive during only that half cycle in which the anode 51 is positive with respect to the cathode 53, current flow takes place through this last traced path only in the direction just traced. The direction of this current flow through condenser 90 is such as to tend to cause the lower terminal of condenser 90 to become positive with respect to the upper terminal. Due to the resistance in series with condenser 90, this charge is carried over alternate half cycles with no appreciable diminution. Since the grid 85 is connected to the lower terminal of condenser 90, this will raise the potential of grid 85 with respect to cathode 86 so as to cause tube 83 to become conductive during the alternate half cycles in which the anode 84 is positive. When this happens, relay winding 99 will be energized through the following circuit: from the lower terminal of secondary 116 through conductor 151, relay winding 99, conductors 104 and 150, anode 84, cathode 86, conductor 148, resistor 142 and conductor 149 to the center tap of secondary 116. This in turn will result in movement of the switch blade 100 into engagement with contact 101 to cause the following energizing circuit to be established to the gas valve: from

power supply terminal 109 through conductors 137 and 156, switch blade 100, contact 101, conductor 157, gas valve terminal 158, conductor 159, gas valve 12, conductor 160, valve terminal 161, and conductor 162 to the other power supply terminal 108. The energization of the gas valve 12 as a result of the establishment of the circuit just traced will cause valve 12 to move to open position causing a flow of gas to the main burner 14. This gas will in turn be ignited by the pilot burner 15. As previously noted, in an ordinary commercial embodiment of the system, some means would be provided for checking the presence of the flame at the pilot burner 15 before the main gas valve 12 is allowed to open. Since such a pilot checking means forms no part of the present invention, it has been omitted in order to simplify the disclosure.

The heating effect of the furnace resulting from the operation of the main burner 14 will eventually cause a rise in the temperature of the space in which resistor 11 is located so as to again increase the unbalance of bridge 20. This in turn will increase the voltage between grid 52 and cathode 53 which is opposite in phase to that applied between anode 51 and cathode 53. The grid 52 will accordingly be biased negatively so that the tube 50 will become effectively non-conductive. This in turn will interrupt the circuit previously traced through this tube and condenser 90. As a result, tube 83 will again become sufficiently non-conductive to cause the effective de-energization of relay 98. This in turn will cause separation of switch blade 100 from contact 101 to interrupt the energizing circuit to gas valve 12 and cause this valve to close.

The operation of the furnace will cause a rise in the temperature of bulb 18. This will increase the resistance between terminals 47 and 49 and will cause the potential of terminal 48 to more nearly approach that of input terminal 47. In other words, the unbalance of bridge 21 will be decreased. As previously explained, the unbalance voltage of bridge 21 is normally effective to bias the grid 70 of tube 68 sufficiently to cause tube 68 to be effectively non-conductive. This condition will exist so long as the temperature of the furnace is below the value at which it is desired to have limit control action begin to take place. Thus, so long as the temperature of bulb 18 is below a predetermined limiting value, the tube 68 will remain non-conductive and will have no effect upon the operation of the system.

As soon, however, as the temperature of bulb 18 rises above the predetermined selected value so as to indicate an undue rise in furnace temperature, the unbalance voltage of bridge 21 will be reduced to such a point that tube 68 will become conductive. As a result, during half of each complete cycle, current will flow through the following circuit: from the output terminal 30 of bridge 20 through conductor 58, condenser 57, conductor 75, anode 69, cathode 71, conductors 76, 62, 63 and 64 to the other output terminal 33 of bridge 20. Due to the rectifying characteristics of tube 68, current can flow only in the direction traced. The effect of this current flow is to impress across condenser 57 a voltage such as to cause the left-hand terminal of condenser 57 to become negative with respect to the right-hand terminal. It is to be noted that grid 52 of tube 50 is connected by conductors 55 and 56 to this left-hand terminal of condenser 57. Thus, the effect of current flow through condenser 57 and tube 68 is to drive the grid 52 negative with

respect to cathode 53. This tends to cause tube 50 to become non-conductive despite the fact that the unbalance voltage of bridge 20 may be sufficiently small as to otherwise permit tube 50 to be conductive. Thus, the tube 50 is rendered non-conductive to in turn render non-conductive tube 83 despite the fact that the temperature of the space may be sufficiently high that tubes 50 and 83 would otherwise be conductive. If the temperature of the furnace to which resistance 18 is subjected is sufficiently high, considering the temperature of space 20, tube 83 will be rendered sufficiently non-conductive to effectively deenergize relay 98 and stop operation of the burner. The value of the burner temperature at which relay 98 will be effectively energized will depend, of course, upon the temperature of the space 11 since if the temperature of the space 11 is extremely low, the tendency of tube 50 to be conductive will be sufficiently great that a substantial rise in the resistance of bulb 18 will be necessary to overcome this tendency. Furthermore, the unbalance voltage which is available for charging condenser 57 through tube 68 will be less so that the charge across condenser 57 is not as great as would be the case if the temperature of bulb 11 were higher. Thus, the setting of the limiting bridge 21 at which it is effective to shut down the burner is constantly raised as the temperature of the space is lowered. This is desirable since if the temperature of the space is extremely low, it is desirable to operate the furnace at the maximum possible temperature. If, on the other hand, the temperature of the space is extremely close to the desired value, then it is desirable to shut down the system when the furnace temperature first starts entering an undesirably high range. Thus with the arrangement of our invention, it is possible to employ a resistance bulb limit control which normally has an unlimited range of operation and at the same time cause it to be operative only when the limiting temperature is above a predetermined value. This, furthermore, is accomplished without the use of any switching mechanism responsive to furnace temperature.

Where we have referred to tube 83 as being non-conductive, it is to be understood that this is intended merely to mean that the tube is not sufficiently conductive to supply enough current to relay coil 99 to cause switch blade 100 to be moved into engagement with contact 101. Actually, when the tube 83 is in the condition referred to as "non-conductive," an appreciable current may flow through the tube to the relay coil 99.

While we have disclosed a specific embodiment of our invention, it is to be understood that this is only for purposes of illustration and that the invention is to be limited solely by the scope of the appended claims.

We claim as our invention:

1. In condition controlling apparatus, electrical means for controlling the operation of condition changing apparatus, a first condition responsive means controlling the energization of said electrical means and including an element responsive to the value of a controlling condition, a second condition responsive means controlling the energization of said electrical means and including an element responsive to a limiting condition, said limiting condition being of such character that a decrease in the effect of the condition changing apparatus is desirable when the value of the limiting condition is not on the desired

side of a predetermined value, said second condition responsive means being operative to supply a voltage dependent in value upon the value of said limiting condition, and means responsive to the voltage supplied by said second condition responsive means for preventing said second condition responsive means from affecting said electrical means as long as the value of said limiting condition is on the desired side of said predetermined value.

2. In condition controlling apparatus, electrical means for controlling the operation of condition changing apparatus, a first condition responsive means controlling the energization of said electrical means and including an element responsive to the value of a controlling condition, said first condition responsive means being operative to supply a voltage dependent in value upon the value of said controlling condition, a second condition responsive means controlling the energization of said electrical means and including an element responsive to a limiting condition, said limiting condition being of such character that a decrease in the effect of the condition changing apparatus is desirable when the value of the limiting condition is not on the desired side of a predetermined value, said second condition responsive means being operative to supply a voltage dependent in value upon the value of said limiting condition, and means responsive to the voltage supplied by said second condition responsive means for preventing said second condition responsive means from affecting said electrical means as long as the value of said limiting condition is on the desired side of said predetermined value.

3. In condition controlling apparatus, electrical means for controlling the operation of condition changing apparatus, a first resistance bridge controlling the energization of said electrical means and including a resistance element responsive to the value of a controlling condition, said first resistance bridge being operative to supply an unbalance voltage dependent in value upon the value of said controlling condition, a second resistance bridge controlling the energization of said electrical means and including a resistance element responsive to a limiting condition, said limiting condition being of such character that a decrease in the effect of the condition changing apparatus is desirable when the value of the limiting condition is not on the desired side of a predetermined value, said second resistance bridge being operative to supply an unbalance voltage dependent in value upon the value of said limiting condition, and means responsive to the unbalance voltage supplied by said second resistance bridge for preventing said second resistance bridge from affecting said electrical means as long as the value of said limiting condition is on the desired side of said predetermined value.

4. In a temperature controlling apparatus, electrical means for controlling the operation of temperature changing apparatus, a first resistance bridge controlling the energization of said electrical means and including a resistance element having an appreciable temperature coefficient of resistance and adapted to be located so as to be subject to a controlling temperature condition, said first resistance bridge being operative to supply an unbalance voltage dependent in value upon the value of said controlling temperature condition, a second resistance bridge controlling the energization of said electrical means and including a resistance element having

an appreciable temperature coefficient of resistance and located so as to be subject to a limiting temperature condition, said limiting temperature condition being of such character that a decrease in the effect of the temperature changing apparatus is desirable when the value of the limiting temperature condition is not on the desired side of a predetermined limiting value, said second resistance bridge being operative to supply an unbalance voltage dependent in value upon the value of said limiting temperature condition, and means responsive to the unbalance voltage supplied by said second resistance bridge for preventing said second resistance bridge from affecting said electrical means as long as the value of said limiting condition is on the desired side of said predetermined value.

5. In condition controlling apparatus; a control device for controlling condition changing apparatus; means for controlling said device including an impedance element whose impedance changes with the value of a controlling condition; further means for limiting the action of said last named means whenever the value of a limiting condition is beyond a predetermined value beyond which a decrease in the effect of the condition changing apparatus is desirable, said further means comprising a further impedance element whose impedance changes with the value of said limiting condition and an electronic discharge device having an anode, a cathode, and a control element; connections between said anode and cathode and said first named means, and further connections between said control element and said further impedance element; said discharge device and said further connections being such that when said limiting condition is on the desired side of said limiting value, said discharge device is effectively non-conductive.

6. In temperature controlling apparatus; a control device for controlling temperature changing apparatus; means for controlling said device including an impedance element having an appreciable temperature coefficient of impedance and subjected to a controlling temperature condition; further means for limiting the action of said last named means whenever the value of a limiting temperature condition is beyond a predetermined value beyond which a decrease in the effect of the temperature changing apparatus is desirable, said further means comprising a further impedance element having an appreciable temperature coefficient of impedance and subjected to said limiting temperature condition, said further means also comprising an electronic discharge device having an anode, a cathode, and a control element; connections between said anode and cathode and said first named means; and further connections between said control element and said further impedance element, said discharge device and said further connections being such that when said limiting temperature condition is on the desired side of said limiting value, said discharge device is effectively non-conductive.

7. In temperature controlling apparatus; a control device for controlling temperature changing apparatus; means for controlling said device including a resistance element having an appreciable temperature coefficient of resistance and subjected to a controlling temperature condition; further means for limiting the action of said last named means whenever the value of a limiting temperature condition is beyond a predetermined value beyond which a decrease in the effect of

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the temperature changing apparatus is desirable, said further means comprising a further resistance element having an appreciable temperature coefficient of resistance and subjected to said limiting temperature condition, said further means also comprising an electronic discharge device having an anode, a cathode, and a control element; connections between said anode and cathode and said first named means; and further connections between said control element and said further impedance element; said discharge device and said further connections being such that when said limiting temperature condition is on the desired side of said limiting value, said discharge device is effectively non-conductive.

8. In condition controlling apparatus; a control device for controlling condition changing apparatus; means for controlling said device including an impedance element whose specific impedance changes with the value of a controlling condition; connections between said impedance element and said device; means for limiting the action of said last named means whenever the value of a limiting condition is on an undesired side of a predetermined limiting value, said limiting condition being of such character that a decrease in the effect of the temperature changing apparatus is desirable when the value of the limiting condition is not on the desired side of said predetermined value, said further means comprising a further impedance element whose specific impedance changes with the value of said limiting condition and an electronic discharge device having an anode, a cathode, and a control element, connections between said anode and cathode and said connections between said impedance element and said device, and further connections between said control element and said further impedance element, said discharge device and said further connections being such that when said limiting condition is on the desired side of said limiting value, said discharge device is effectively non-conductive so as not to affect said connections between said impedance element and said device.

9. In condition controlling apparatus; a control device for controlling condition changing apparatus; means for controlling said device including an impedance network having an impedance element whose impedance changes with the value of said controlling condition and having output terminals, the voltage thereacross being dependent upon the impedance of said impedance element; an electronic discharge device having an anode, a cathode, and a control element, said anode and cathode being connected in parallel with said output terminals so that when said discharge device is conductive, said impedance network is partially shunted; and means including a further impedance element whose impedance changes with the value of a limiting condition for applying a voltage to said control element, said limiting condition being of such character that a decrease in the effect of the condition changing apparatus is desirable when the value of the limiting condition is not on the desired side of a predetermined limiting value, said last named means being effective whenever the limiting condition has a value on the desired side of said limiting value to apply a voltage to said control element such that said discharge device is effectively non-conductive.

10. In condition controlling apparatus; a control device for controlling condition changing ap-

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paratus; means for controlling said device including an impedance network having an impedance element whose impedance changes with the value of said controlling condition and having output terminals, the voltage thereacross being dependent upon the impedance of said impedance element; an electronic discharge device having an anode, a cathode, and a control element, said anode and cathode being connected in parallel with said output terminals so that when said discharge device is conductive, said impedance network is partially shunted; and means including a second impedance network including a further impedance element whose impedance changes with the value of a limiting condition for applying a voltage to said control element, said limiting condition being of such character that a decrease in the effect of the condition changing apparatus is desirable when the value of the limiting condition is not on the desired side of a predetermined limiting value, said last named means being effective whenever the limiting condition has a value on the desired side of said limiting value to apply a voltage to said control element such that said discharge device is effectively non-conductive.

11. In condition controlling apparatus; a control device for controlling condition changing apparatus; means for controlling said device including a resistance bridge having a temperature responsive resistance element adapted to be located so as to respond to a controlling temperature condition and having output terminals, the unbalance voltage thereacross being dependent upon the resistance of said resistance element; an electronic amplifier connected between said output terminals and said control device; an electronic discharge device having an anode, a cathode, and a control element, said anode and cathode being connected in parallel with said output terminals between said bridge and said control device so that when said discharge device is conductive, said bridge is partially shunted; and means including a further temperature responsive resistance element adapted to be located so as to respond to a limiting temperature condition for applying a voltage to said control element, said limiting condition being of such character that a decrease in the effect of the condition changing apparatus is desirable when the value of the limiting condition is not on the desired side of a predetermined limiting value, said last named means being effective whenever the limiting condition has a value on the desired side of said limiting value to apply a voltage to said control element such that said discharge device is effectively non-conductive.

12. In condition controlling apparatus; a control device for controlling condition changing apparatus; means for controlling said device including an impedance network having an impedance element whose impedance changes with the value of said controlling condition and having output terminals, the voltage thereacross being dependent upon the impedance of said impedance element; an electronic discharge device having an anode, a cathode, and a control element, said anode and cathode being connected in parallel with said output terminals so that when said discharge device is conductive, said impedance network is partially shunted; and means including a further impedance element whose impedance changes with the value of a limiting condition for applying a voltage to said control element, said limiting condition being of such

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character that a decrease in the effect of the condition changing apparatus is desirable when the value of the limiting condition is not on the desired side of a predetermined limiting value, said last named means being effective whenever the limiting condition has a value on the desired side of said limiting value to apply a voltage to said control element such that said discharge device is effectively non-conductive.

13. In apparatus for controlling the value of a condition, a control device for condition changing apparatus, a first resistance element whose specific resistance varies appreciably with a change in the value of a controlling condition and which is adapted to be exposed to said controlling condition, a second resistance element whose specific resistance varies appreciably with a change in the value of a limiting condition and which is adapted to be exposed to said limiting condition, said limiting condition being of such character that a decrease in the effect of the condition changing apparatus is desirable when the value of the limiting condition is not on the desired side of a predetermined limiting value, means including both said resistance elements for controlling said control device, and an electronic discharge device associated with said first resistance element and controlled by said second resistance element, said discharge device being operative whenever said limiting condition is on the desired side of said predetermined value to prevent said control device from being affected by variations in the resistance value of said second resistance element without affecting the effect of said first resistance element on said control device.

14. In apparatus for controlling temperature changing apparatus, a control device for temperature changing apparatus, a first resistance element having a relatively high temperature coefficient of resistance and exposed to a controlling temperature condition, a second resistance element also having a relatively high temperature coefficient of resistance and exposed to a limiting temperature condition, said limiting temperature condition being of such character that a decrease in the effect of the temperature changing apparatus is desirable when the value of the limiting temperature condition is not on the desired side of a predetermined limiting value, means including both said resistance elements for controlling said control device, an electronic discharge device associated with said first resistance element and controlled by said second resistance element, said discharge device being operative whenever the value of the limiting temperature is on the desired side of said predetermined value to prevent said control device from

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being affected by variations in the resistance value of said second resistance element without affecting the effect of said first resistance element on said control device.

15. In apparatus for controlling the temperature of a space, a control device for a furnace for heating said space, a first resistance element having a relatively high temperature coefficient of resistance and exposed to the temperature of said space, a second resistance element also having a relatively high temperature coefficient of resistance and exposed to a temperature of said furnace, means including both said resistance elements for controlling said control device, and an electronic discharge device associated with said first resistance element and controlled by said second resistance element, said discharge device being operative whenever the temperature of said furnace is below a predetermined value to prevent said control device from being affected by variations in the resistance value of said second resistance element without affecting the effect of said first resistance element on said control device.

16. In controlling apparatus, a source of controlling voltage, an electrical device to be controlled, an electronic amplifier connected between said source and said device and effective to energize said device in accordance with the value of said controlling voltage, an electronic discharge device having an anode, a cathode, and a control element, said anode and cathode being connected across said source of controlling voltage between said source and said amplifier so that when said discharge device is conductive, said source is partially shunted, and means responsive to a predetermined condition for controlling the voltage to said control element and effective as long as said predetermined condition is within a desired range of values to maintain the control element at a potential such that said discharge device is effectively non-conductive.

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