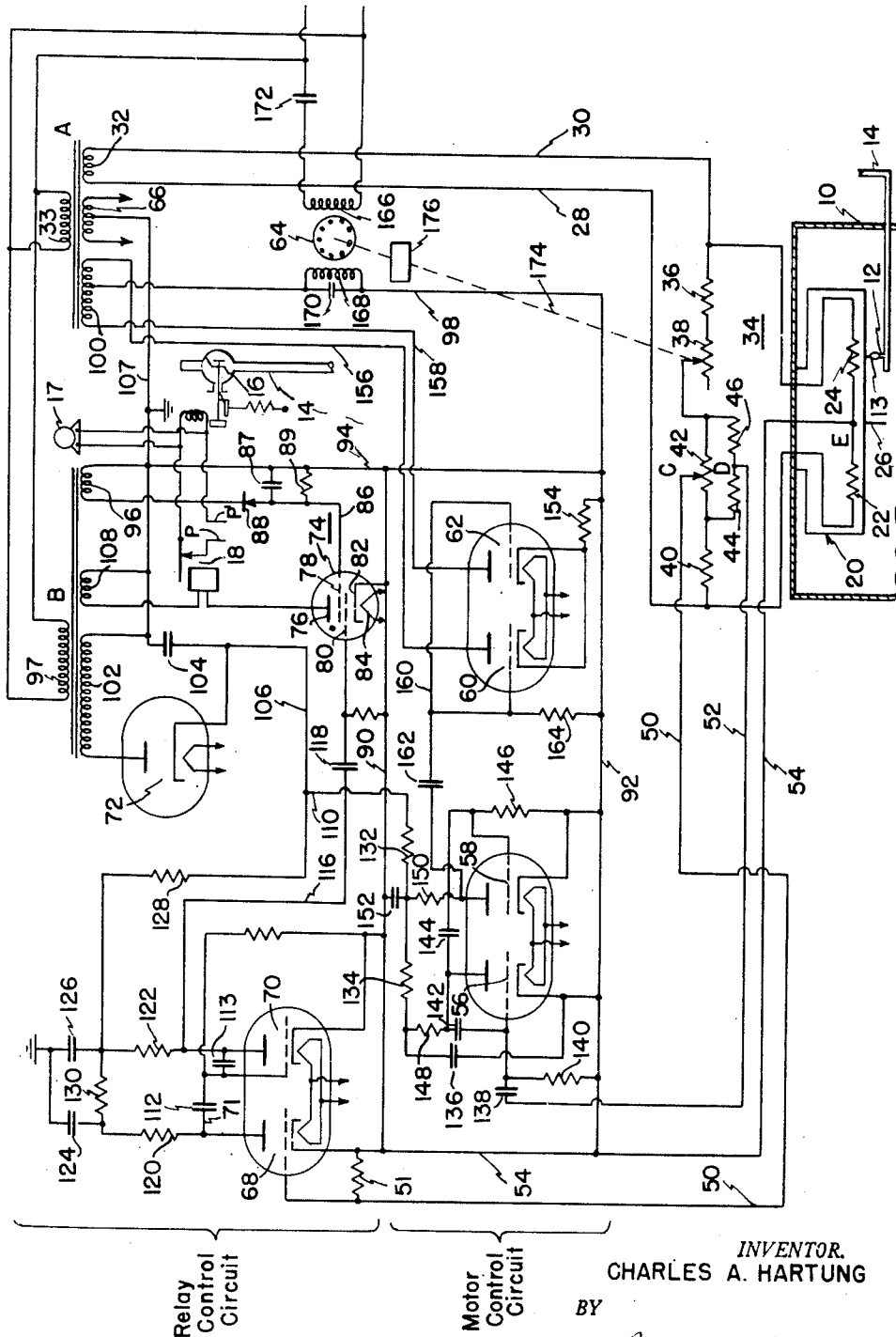


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FLAME FAILURE CONTROL

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FLAME FAILURE CONTROL

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The present invention relates to safety control systems for fuel burners and has particular reference to shutting off the supply of fuel gas in the event that the flame is extinguished or in such condition that extinction is likely to occur. The invention is particularly applicable to industrial combustion systems such as gas fired burners and boilers and is applicable to such installations whether they are manually or automatically controlled.

Safety control systems to be practical must take into account normal conditions of operation and should fail to shut off the fuel supply so long as conditions are normal. In a system subject to either manual or automatic operation, it is quite normal that temperatures in the system should vary, sometimes through quite considerable ranges, depending upon desired operating conditions and load. It will be evident, therefore, that a mere drop in temperature cannot be taken as indicative of extinction of the flame.

Furthermore, it is not unusual for the flame to fluctuate rapidly and a proper safety control must not shut down the system merely because of the occurrence of normal fluctuations.

It is the general object of the present invention to provide a safety control for a fuel burner which provides complete safety under conditions of flame extinction but which is consistent in its operation with normal operating conditions which may exist. The attainment of this object together with the attainment of further objects relating particularly to details of construction and operation will become apparent from the following description read in conjunction with the accompanying drawing in which the figure is a wiring diagram of apparatus provided in accordance with the invention showing diagrammatically a furnace.

A furnace is conventionalized at 10 as provided with a burner 12 supplied with fuel gas from a pipe 14. The supply is controlled by a fuel control valve 16 of the trip type requiring manual resetting, and this valve and an alarm 17 are controlled by a circuit including the supply lines P and P' and the contacts of a relay 18 which are closed when the relay is energized. When this relay is deenergized the circuit is opened causing closure of the valve 16 and sounding of the alarm 17.

A housing 20 within the furnace encloses a pair of temperature-sensitive resistors 22 and 24 which may have equal resistance values. One of these, 24, is directly affected by the flame 13, while the other, 22, is more remote from the flame and is responsive to the general ambient temperature conditions existing in the furnace as a result of the flame. A shield 26 is indicated as substantially isolating the resistor 22 from the direct action of the flame. The resistances 22 and 24 are in a bridge circuit including the fixed resistances 36 and 40 which may be remote from the furnace and, at any rate, should be unaffected by the temperature in the furnace, a variable resistance 38, a potentiometer 42, and a pair of resistances 44 and 46, all of these elements being similarly isolated from the temperature effects of the furnace. The bridge is energized with alternating current through connections 28 and 30 to the secondary 32 of a transformer A the primary of which is indicated at 33. A ground connection 54 is connected to the junction E of resistances 22 and 24. Bridge outputs are provided between ground and the connection 50 to the variable contact of potentiometer 42, indicated at C, and between ground and the connection 52 to the junction D of resistances 44 and 46.

The output between connection 50 and ground is am-

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plified by the cascade arrangement of triodes 68 and 70. A resistance 51 is connected between the grid of triode 68 and its grounded cathode, and the output of this triode 68 is taken on connection 71 through condenser 112 to the grid of triode 70, the connection 71 being to the junction of the anode of triode 68 with its load resistor 129. The anode of triode 70 is connected to the load resistor 122 and a condenser 113 between the anode and grid of triode 70 provides a feedback to suppress high frequency disturbances. The output from triode 70 is delivered through connection 116 from the junction of its anode and load resistor through condenser 118 to the control grid 80 of a thyatron 74 which is provided with the usual cathode 82, screen 78 and anode 76, the cathode being grounded and heated by the heater 84. The screen 78 is provided with a positive direct potential from the transformer secondary 96 which is connected to a rectifier 88 and suitable filter provided by condenser 87, there being a resistance 89 connected between the screen and ground. The anode 76 of the thyatron is connected through the relay 18 to one terminal of a transformer secondary 108 the other terminal of which is grounded. The amplifying triodes 68 and 70 are provided with direct potential from the secondary 102 of the transformer B which is connected to a rectifying diode 72 and a filtering arrangement provided by condensers 104, 126 and 124 and resistance 130. The primaries 33 and 97 of the respective transformers A and B may be supplied with the usual 60 cycle commercial current.

The other connection 52 from the bridge provides an input to a two-stage amplifier comprising the triodes 56 and 58. The input to the grid of triode 56 is provided through condenser 138, this grid being connected to ground through resistance 140. The anode of triode 56 is connected to the load resistor 148 and is also connected through condenser 142 to the control grid to provide a feedback to suppress high frequencies or transients. The anode of triode 56 is connected through condenser 144 to the grid of triode 58, the anode of which is connected to load resistor 150 and provides its output through condenser 162. The anodes of the two triodes 56 and 58 are also connected to the direct power supply through a filter arrangement comprising the condensers 152 and 136 and resistances 132 and 134, the connection to the cathode of rectifier 72 being indicated at 110.

The output from the amplifier just described, delivered through condenser 162 passes to the phase-sensitive arrangement of a pair of triodes 60 and 62, the grids of which are connected together at 160 and to ground through resistance 164. The cathodes of these triodes are also connected together and to ground through the cathode resistance 154. The anodes of the triodes 60 and 62 are connected to the respective terminals of a secondary 100 of the transformer A through connections 156 and 158. A center tap of the secondary 100 is connected to ground through the field coil 168 of an induction motor indicated at 64, the field coil being shunted by a condenser 170 arranged to bypass undesired frequency components. A second field coil 166 of the motor is connected to the supply line through a condenser 172 which provides a proper phase of its current to secure conventional operation of the motor. The motor through reduction gearing 176 serves to traverse the contact of the variable resistor 38 which is connected to the output shaft 174 of the reduction gearing.

The normal speed of the motor 64 may be relatively low, for example, 18 R. P. M. and the reduction gearing may have a high reduction ratio of, for example, 300 to 1 to secure a slow traverse of the contact of the resistor 38.

The motor arrangement is of well known type and such that the direction of rotation of the rotor depends upon the phase relationship of the current flowing through coil 168 to the phase of the current through coil 166. A reversal of phase through field coil 168 serves to reverse the motor.

The operation of the described arrangement is as follows:

There may be first considered the matter of automatic control of the bridge through motor 64 and its input connections. Briefly stated, the operation here involved

is the maintenance of bridge balance through a predetermined range of variation and at a predetermined relatively low rate. When a difference of temperature occurs between the resistances 24 and 22, which is reflected by a change in the resistance values, the bridge becomes unbalanced and the action of motor 64 is such as to restore balance at a predetermined low rate by variation of the resistance at variable resistor 38. As is well known, the unbalance of a bridge energized by alternating current is attended with an alternating output the phase of which reverses as the bridge passes through the point of balance. The bridge output amplified by triodes 56 and 58 is delivered to the phase-sensitive arrangement provided by triodes 60 and 62 by reason of the connections of the anodes of these triodes to the two end terminals of the transformer secondary 100. The result is reversal of phase of current through the field 168 as the bridge passes through balance, and the arrangements are made in conventional fashion so that the alternate phase conditions will drive the motor 64 in directions to restore balance of the bridge. Two normal conditions which are involved are those of rapid fluctuations of the flame 13 and of slow variations of the flame, the latter depending upon manual or automatic control of furnace temperatures. Rapid fluctuations which are normal produce only small changes of the resistance value of resistance 24 due to the fact that the resistance is enclosed within a housing 20, and such rapid fluctuations will not produce substantial movements of the contact of variable resistor 38 because of the slow action of motor 64 in changing this resistance. In short, the setting of resistor 38 remains approximately at an average condition corresponding to these fluctuations. Hunting by the motor is thus avoided. Under all normal circumstances the temperature of resistance 24 will be higher than that of resistance 22. If the size of the flame changes under ordinary manual or automatic control conditions, the temperature of resistance 24 will change relatively to the temperature of resistance 22, more rapidly than the change of temperature of the latter, but at a relatively slow rate, such that the unbalance of the bridge which is produced will cause the motor 64 to effect correspondingly slow rebalance. Under these normal conditions, therefore, the bridge will be essentially at all times substantially balanced, the value of resistance 38 being changed to secure this condition. As will shortly appear, this establishes a variable operating condition, deviations form which effect control of the relay 18.

Considering now the control effected by the output of the bridge through connection 50, it may be first noted that the output is subject to initial adjustment by the potentiometer contact at C. This means that the balance of the bridge so far as this output connection is concerned may be varied independently of balance existing at connection D. A preliminary adjustment for desired operating conditions is therefore made manually at C. The output on line 50 is amplified through triodes 68 and 70 and the amplified output is applied to the control grid of thyatron 74. As will be evident, thyatron 74 also represents a phase-sensitive device. If at the time the anode 76 is positive, the control grid is not sufficiently negative, as determined by the direct potential of the suppressor grid, the thyatron will fire and accordingly a pulsating anode current will flow through relay 18 to maintain its contacts closed and consequently the valve 16 open and the signal 17 inoperative. This is the normal condition and exists whenever the temperature of resistance 24 is higher than that of resistance 22. This condition also exists when the temperature of resistance 24 is lower than that of resistance 22 and the lower condition has been compensated for by the balance automatically effected through motor 64. This condition also exists when the temperature difference has been sufficiently partially compensated by the action of motor 64.

When, however, the bridge is sufficiently out of balance to produce a reverse phase of potential of the control grid of the thyatron relative to the potential of the anode 76, i. e. so that the control grid becomes sufficiently negative when the anode is positive to prevent firing, then the relay 18 will be deenergized, the valve 16 will close, and the signal 17 will become effective. The conditions just described will occur if the flame 13 is extinguished. When this occurs, the resistance 24 will cool rapidly compared to the resistance 22 and while the motor 64 will attempt to compensate for this by attempting to maintain the

bridge in balance, the balancing action will be so slow that the output of the bridge will be of a phase to secure a non-firing condition of the thyatron as just described. This condition will also occur when the flame 13 is extinguished because the cooling will take place to such extent that the bridge is unbalanced beyond the possibility of rebalance through the action of motor 64, the contact of resistor 38 passing beyond the limit of effective variation of resistor 38. Thus, extinction of the flame or the lowering of the gas flow to a dangerous value at which the extinction of the flame might be imminent will effect cutting off of the gas supply.

It will be evident that starting will involve conditions which will maintain the thyatron in firing condition during positive half cycles of its anode by reason of the fact that the temperature of resistance 24 will be higher than the temperature of resistance 22. The valve 16 is manually held open during the lighting of the burner and until resistance 24 is heated.

I claim:

1. In combination, a burner normally providing a predetermined flame but subject to the possibility that the flame might abnormally decrease to a condition of danger of extinction, means for supplying fuel to the burner, and means for controlling the last named means comprising a balanceable circuit including a pair of temperature-sensitive resistances located to be heated by the flame of the burner with one more directly exposed to the heating action of the burner flame than the other, means for energizing said circuit, slow acting means receiving an electrical output of said circuit and controlled thereby to effect substantial balance of said circuit from a predetermined range of unbalance under normal flame conditions of burner operation, and fast acting means receiving an electrical output of said circuit and controlled thereby when the circuit is out of balance beyond said predetermined range due to abnormal decrease of the flame of said burner to cut off supply of fuel by said supplying means.

2. In combination, a burner normally providing a predetermined flame but subject to the possibility that the flame might abnormally decrease to a condition of danger of extinction, means for supplying fuel to the burner, and means for controlling the last named means comprising a balanceable circuit including a pair of temperature-sensitive resistances located to be heated by the flame of the burner with one more directly exposed to the heating action of the burner flame than the other, means for energizing said circuit with alternating current, phase sensitive slow acting means receiving an electrical output of said circuit and controlled thereby to effect substantial balance of said circuit from a predetermined range of unbalance under normal flame conditions of burner operation, and phase sensitive fast acting means receiving an electrical output of said circuit and controlled thereby when the circuit is out of balance beyond said predetermined range due to abnormal decrease of the flame of said burner to cut off supply of fuel by said supplying means.

3. In combination, a burner normally providing a predetermined flame but subject to the possibility that the flame might abnormally decrease to a condition of danger of extinction, means for supplying fuel to the burner, and means for controlling the last named means comprising a balanceable circuit including a pair of temperature-sensitive resistances located to be heated by the flame of the burner with one more directly exposed to the heating action of the burner flame than the other, means for energizing said circuit, slow acting means including a reversible motor receiving an electrical output of said circuit and controlled thereby to effect substantial balance of said circuit from a predetermined range of balance under normal flame conditions of burner operation, and fast acting means receiving an electrical output of said circuit and controlled thereby when the circuit is out of balance beyond said predetermined range due to abnormal decrease of the flame of said burner to cut off supply of fuel by said supplying means.

4. In combination, a burner normally providing a predetermined flame but subject to the possibility that the flame might abnormally decrease to a condition of danger of extinction, means for supplying fuel to the burner, and means for controlling the last named means comprising a balanceable circuit including a pair of temperature-sensitive resistances located to be heated by the flame of the burner with one more directly exposed to the heating

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action of the burner flame than the other, means for energizing said circuit with alternating current, phase sensitive slow acting means including a reversible motor receiving an electrical output of said circuit and controlled thereby to effect substantial balance of said circuit from a predetermined range of unbalance under normal flame conditions of burner operation, and phase sensitive fast acting means receiving an electrical output of said circuit and controlled thereby when the circuit is out of balance beyond said predetermined range due to abnormal decrease of the flame of said burner to cut off supply of fuel by said supplying means.

5. In combination, a burner normally providing a predetermined flame but subject to the possibility that the flame might abnormally decrease to a condition of danger of extinction, means for supplying fuel to the burner, and means for controlling the last named means comprising a balanceable circuit including a pair of temperature-sensitive resistances located to be heated by the flame of the burner with one more directly exposed to the heating action of the burner flame than the other, means for energizing said circuit, slow acting means

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receiving an electrical output of said circuit and controlled thereby to effect substantial balance of said circuit from a predetermined range of unbalance under normal flame conditions of burner operation, and fast acting means receiving an electrical output of said circuit and controlled thereby when the circuit is out of balance beyond said predetermined range due to abnormal decrease of the flame of said burner to provide a signal of said decrease of the flame.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
15 2,139,504	King -----	Dec. 6, 1938
2,215,805	Wills -----	Sept. 24, 1940
2,327,690	Ackerman -----	Aug. 24, 1943
2,338,786	Sparrow -----	Jan. 11, 1944
2,370,847	Dempster -----	Mar. 6, 1945
20 2,490,534	Mesh -----	Dec. 6, 1949
2,531,887	Nehrbas -----	Nov. 28, 1950