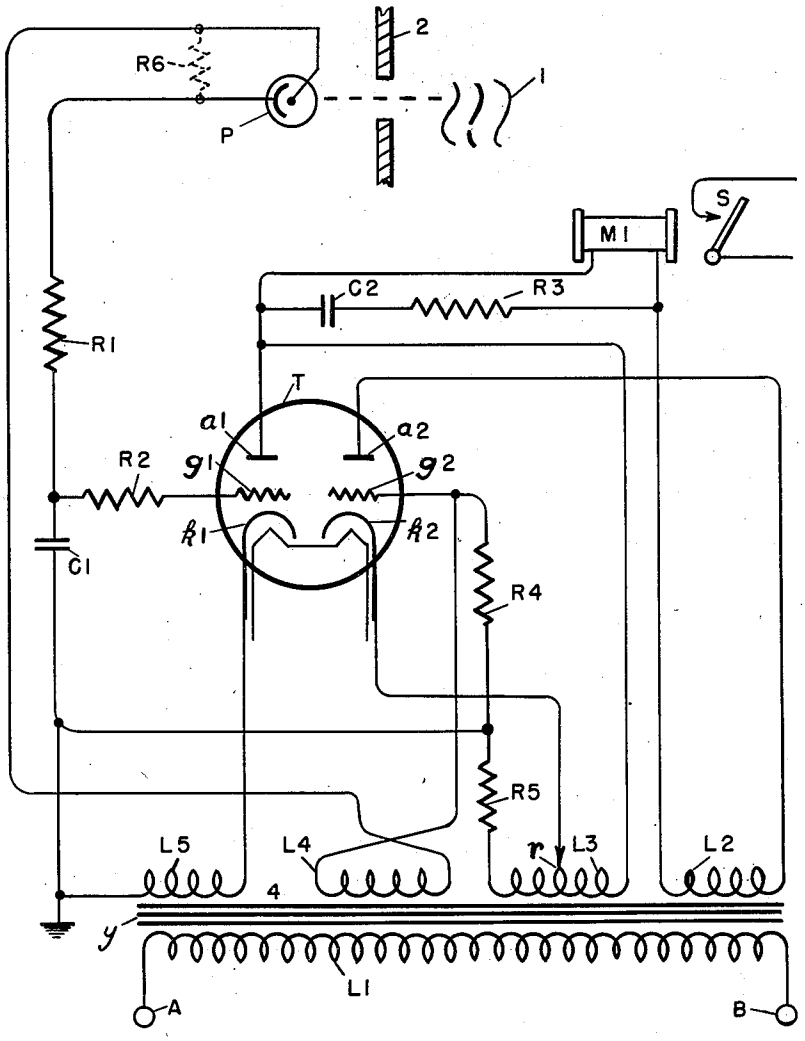
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FLAME FAILURE SAFEGUARD

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FLAME FAILURE SAFEGUARD

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1 Claim. (Cl. 250—214)

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This invention relates to safety devices for fuel burners, particularly to the type of devices known as flame failure controls, which operate to shut down a burner when the flame is accidentally extinguished.

Flame failure has long been recognized as one of the major hazards in automatic fuel burner operation. Many explosions have resulted in both home and industrial furnaces, from the injection of ignited fuel into the hot combustion chamber. For many years it has been customary to supply automatic burners with some type of flame detection devices which operate upon flame failure to shut down the fuel supply. One of the more common types of controls is the thermal or stack switch. These switches detect flame failure indirectly from the temperature drop, and so are subject to an inherent delay which has proved fatal in some instances. Direct flame detection by means of an electrode in contact with the flame is widely used in connection with the more volatile fuels such as gas, but is not entirely satisfactory for oil burners, because of the rapid accumulation of soot and oil on the flame rod.

More recently, the photoelectric type of control, which is operated by light from the flame, has come into use. This type of control is fundamentally superior in both reliability and speed of operation to the earlier types, but is also subject to certain failures under the conditions normally encountered in furnace installations. Because of the high internal impedance of the phototube, a relatively small deterioration in the insulating properties of the phototube base or socket, or in the insulation of the leads, gives rise to a current of the same order of magnitude as the current through the phototube in its illuminated condition, and may prevent proper operation of the control upon flame failure. Common sources of leakage are the deposit of moisture which accumulates on the phototube base and socket when the furnace is unused in a damp cellar for some time, and the conductive deposit which is likely to form on the interior of the phototube envelope as the result of evaporation of the cathode material, a process which is accelerated by exposure of the phototube to heat. Another objection common to many types of photoelectric controls is that failure of one of the amplifier tubes which leaves the circuit in such a condition as to permit continued operation of the burner upon flame failure. This condition is readily remedied, as is the practice in industrial installations, by periodic inspection

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and replacement of the tubes, but such regular service is not ordinarily available to the users of domestic furnaces.

The object of this invention is to eliminate these potentially dangerous conditions by providing a control which, although relatively insensitive to a certain amount of leakage across the phototube, shuts down the burner when the leakage becomes excessive or upon failure of any of the amplifier tubes, thus indicating the need for servicing the control. The device here disclosed has the further advantages of being simpler, less expensive to install and maintain, and more readily adaptable to different types of furnace installations than similar devices now in use. Other advantages will be apparent from the detailed description which follows.

The circuit here described was originally disclosed in co-pending application 622,059, filed October 12, 1945, which is now U. S. Patent No. 2,543,262, issued Feb. 27, 1951, of which this application is a continuation in part.

The drawing represents the device in electrical scheme.

The phototube P, which is the flame detecting element, is mounted by any suitable means so as to receive light from the flame 1 through an aperture in the furnace wall 2. Amplification is provided by two triodes, or preferably a double triode T, with anodes *a1*, *a2*, cathodes *k1*, *k2*, and control grids *g1*, *g2*. A relay M1 is connected in the output circuit of one section of the tube T, and operates to control desired contact arrangement, for example, a contact *s* which may be connected into any suitable circuit for controlling the burner fuel supply. An example of such a circuit is disclosed in the co-pending application referred to above. The control is supplied with power through a transformer 4, having a primary L1, which may be connected at terminals A and B to any suitable alternating current source, and independent secondaries L2, L3, L4, and L5. The tube heater may be energized in any conventional manner, for example, by an additional secondary winding on transformer 4. The phototube P is connected to the grid *g1*, as part of an input network consisting of resistance R1, capacitance C1, limiting resistance R2, resistance R4, and secondaries L4 and L5. Resistance R4 is also connected in the input circuit of grid *g2*.

In normal operation, when the phototube is illuminated by the burner flame, the resistance of the phototube in its conducting direction is relatively low. During the half cycle when point

y of transformer 4 is positive, the anode $a1$ of tube T is negative with respect to cathode $k1$ and anode $a2$ is negative with respect to cathode $k2$ so that neither section of tube T is conducting. Grid $g1$ being positive with respect to cathode $k1$ on this half cycle, grid current flows in the first section ($g1$ to $k1$) of the tube, charging condenser C1. Grid $g2$ also being positive with respect to its cathode, grid current flows from L3 through R5, R4, $g2$, $k2$ to tap r. The anode of the phototube being negative with respect to its cathode, no current flows through the phototube.

During the half cycle when point y is negative, anode $a1$ is positive with respect to cathode $k1$. The charge received by condenser C1 during the preceding half cycle and the potential of secondary L5 tend to make grid $g1$ negative with respect to cathode $k1$. On this half cycle, however, the anode of the phototube is positive with respect to its cathode and if the phototube P is illuminated, the current flowing through secondary L4, phototube P, R1 and R4 is sufficient to neutralize the charge on condenser C1. The potential of L5 is less than the cut-off bias of the tube. Current flows from the positive end of secondary L3 through the first section of tube T, secondary L5 and resistor R5 to the negative end of secondary L3. The current flowing in resistor R5 tends effectively to raise the potential of grid $g2$ with respect to cathode $k2$, and the current flowing in resistor R4 tends to lower the potential of grid $g2$. Since the current through R4 is merely the phototube current, which is relatively small even when phototube P is receiving light, the bias on grid $g2$ under normal operating conditions is above the cut-off value. Since plate $a2$ is positive with respect to cathode $k2$, current flows from the positive end of secondary L2 through the second section ($a2$ to $k2$) of tube T1, tap r, secondary L3, relay M1 to the negative end of secondary L2, and relay M1 becomes energized. This relay ordinarily operates one or more contacts which complete circuits necessary to maintain the burner fuel supply in operating condition, according to a number of well-known arrangements. Contact s, for example, might control the energizing circuits of a burner motor and fuel valve, either directly, or through a second relay. If flame failure occurs, light no longer falls on phototube P. During the half cycle when point y is positive condenser C1 becomes charged by the passage of current through grid $g1$ as before. During the half cycle when point y is negative, the impedance of phototube P being high, the current flowing through phototube P, resistors R1 and R4 and secondary L4 is insufficient to neutralize the charge on the condenser C1 so that grid $g1$ becomes biased below cut-off and the first section of tube T1 becomes non-conductive. Now no current flows through resistor R5, and under this condition grid $g2$ also becomes biased below cut-off, and the second section of tube T1 becomes non-conductive. Relay M1 then becomes deenergized allowing such of its contacts as are connected in the various burner control circuits to open and shut down the burner.

As previously discussed, one of the advantages of this circuit is its safe operation under conditions of gradually increasing leakage or sudden short-circuit across the phototube. The effect of leakage may be illustrated by considering the action of the control when a resistor R6 is connected in parallel with the phototube as indicated in dotted line form in the drawing. Assuming first that R6 is large, a small amount of current passes across the phototube on both half cycles. Since this current is alternating, it has no effect on the average charge of condenser C1. Condenser C1 becomes charged by grid current on the half cycle when y is positive and, if the phototube is illuminated, a rectified current is applied to C1 tending to neutralize the charge as previously explained. If the value of R6 is large compared to the impedance of the illuminated phototube, the control will continue to function. As R6 is gradually reduced to a value comparable with the reactance of the condenser C1, then R1, R6, and C1 would ordinarily tend to act as a voltage dividing network and the potential of $g1$ would become higher with respect to the potential of cathode $k1$ as the impedance of R6 became lower. As a consequence, if the phototube P were to be short-circuited, the first half of tube T (anode $a1$ to cathode $k1$) would remain conductive and the furnace would remain in operating condition upon flame failure. Provision is made in this circuit, however, to eliminate such an unsafe condition. The resistance R4 which is connected in the grid circuit of the second half of the tube (grid $g2$, cathode $k2$) is also connected in the supply circuit of the phototube P. The grid current flowing in the second half of the tube during alternate half cycles, gives rise to a rectified potential across R4. It will be noted that during the cycle when this potential exists, the phototube is in its non-conductive half cycle and the potential across R4 does not, under normal conditions, effect the charge on condenser C1. When the phototube is bridged by a non-rectifying impedance, however, such as R6, the rectified potential across R4 tends to apply a charge on C1 which is in such a direction as to drive grid $g1$ negative. As the resistance of R6 gradually decreases, the charge on C1 due to grid rectification current across R4 builds up until a point is reached where the negative bias on $g1$ is sufficient to cut off the first section of the tube. When the first section of the tube T becomes non-conductive, the positive bias supplied by R5 to grid $g2$ is eliminated and grid $g2$ becomes negative with respect to its cathode cutting off the second section of the tube. Relay M1 then becomes deenergized shutting down the burner. A short-circuit across the phototube results in deenergization of M1 in the same manner.

Furthermore, as R6 is gradually reduced in value, the current through the phototube for a given light intensity is correspondingly reduced. Under conditions of leakage exceeding a certain amount, therefore, both sections of tube T become and remain non-conductive regardless of the presence or absence of flame and the burner is shut down. Since relay M1 cannot become energized, the burner cannot be put into operation until the phototube has been replaced or the cause of short circuit removed.

The effect of bridging the phototube by any other type of impedance adapted to pass alternating current, for example, the capacity between the phototube leads, is similar to the effect of resistor R6. Since lead capacity for any cable length likely to be practicable for such a control is within the impedance range where the effect on the circuit is negligible, this circuit operates reliably with the phototube separated by such distances as fifteen feet or more from the other components of the circuit, a practi-

cal advantage for installation purposes. Similar devices hitherto employed cannot be operated with the phototube located more than a foot from the main control.

A further advantage, apparent from the foregoing description is that both sections of the amplifier tube, or, if two single triodes are used, both tubes, must be conductive to maintain relay M1 energized. If either tube or tube section burns out, the burner is shut down and cannot be operated until the necessary replacement is made. This feature insures against operation of the burner without proper flame failure supervision.

Since certain changes may be made in the above described article and different embodiments of the invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative only and not in a limiting sense.

What is claimed is:

A flame-failure control device comprising a first tube section having at least first anode, cathode and control grid electrodes, a second tube section having at least second anode, cathode and control grid electrodes, a photocell, a load impedance element for said photocell, a capacitor connected to the control grid-cathode space path of said first tube section and being charged by grid current therefrom, said capacitor being also connected in the energizing circuit for said photocell, a second load impedance element connected in the energizing circuit for the anode-cathode space path of said first tube section and to the cathode-control grid space path of said second tube section, a third impedance element connected to the control grid-cathode space path of said second tube section so that grid-current will flow therethrough and being also connected in the energizing circuit for said photocell whereby said capacitor is charged negatively in response to the shorting of said photocell, output means, and an alternating-current power supply source, said capacitor being charged positively in response to incident light energy upon said photocell so as to overcome a negative grid-current charge therein thereby causing current flow in the anode-cathode space path of said first tube section to develop a voltage drop across said second load impedance element which positively biases the control grid-cathode space path of said second tube section sufficiently to create sufficient current flow in the anode-cathode space-path of said second tube section to energize said output means.

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