

Aug. 9, 1966

R. F. PLAMBECK

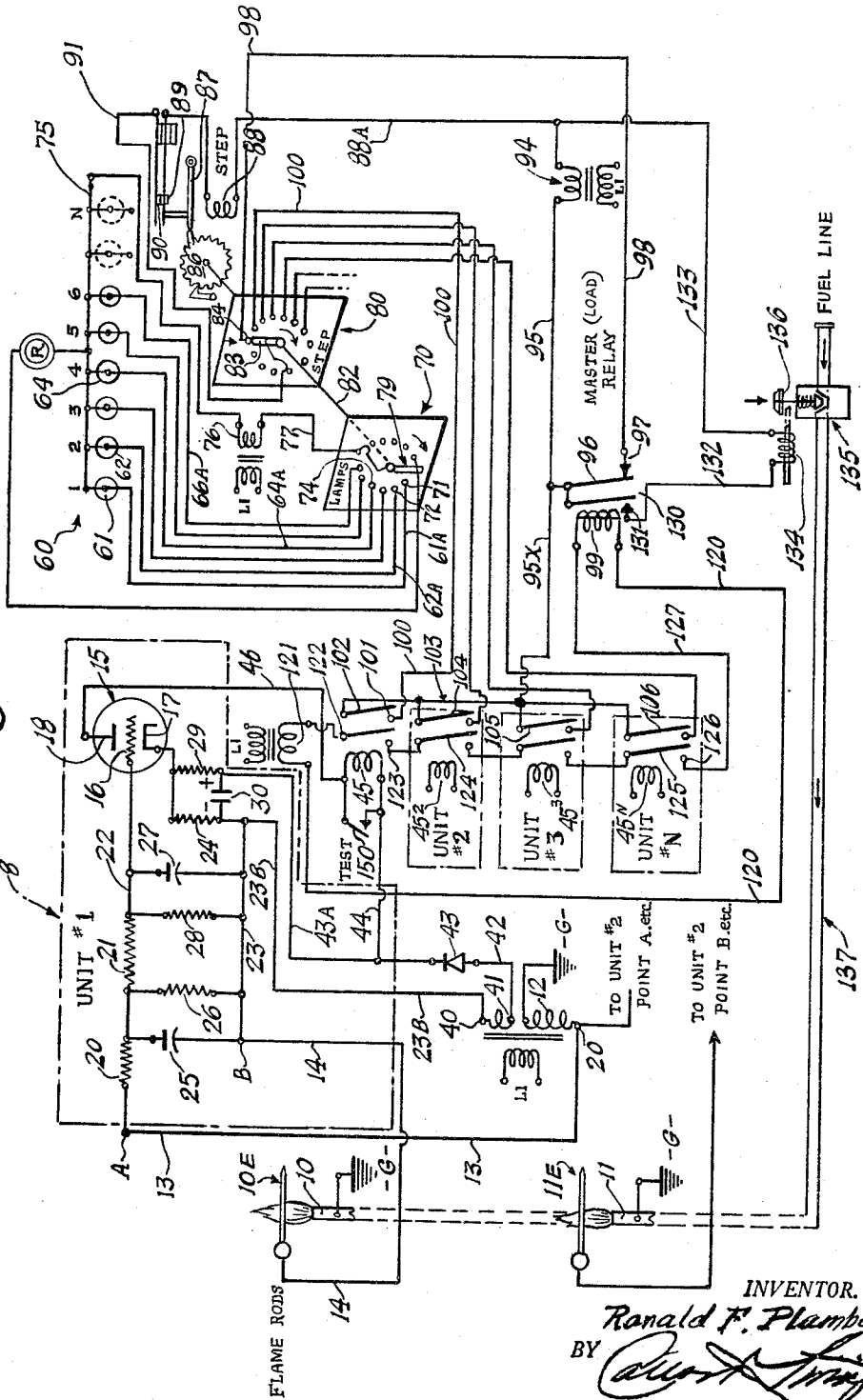
3,266,026

SUPERVISORY FLAME CONTROL

Filed March 4, 1960

2 Sheets-Sheet 1

Fig. 1.



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2 Sheets-Sheet 2

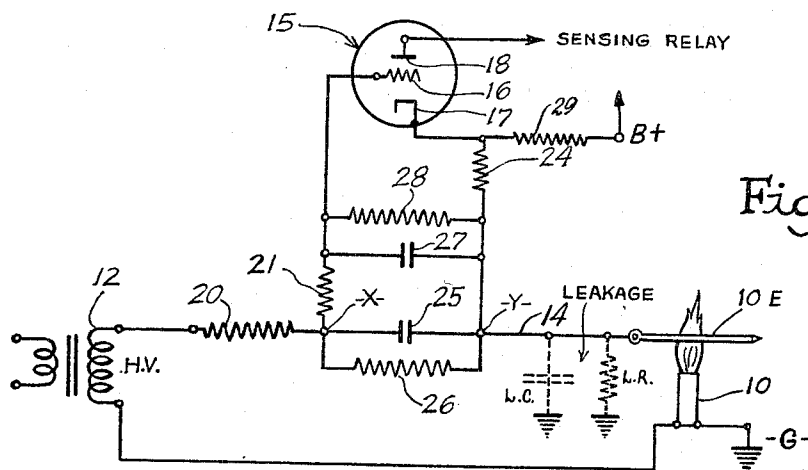


Fig. 2.

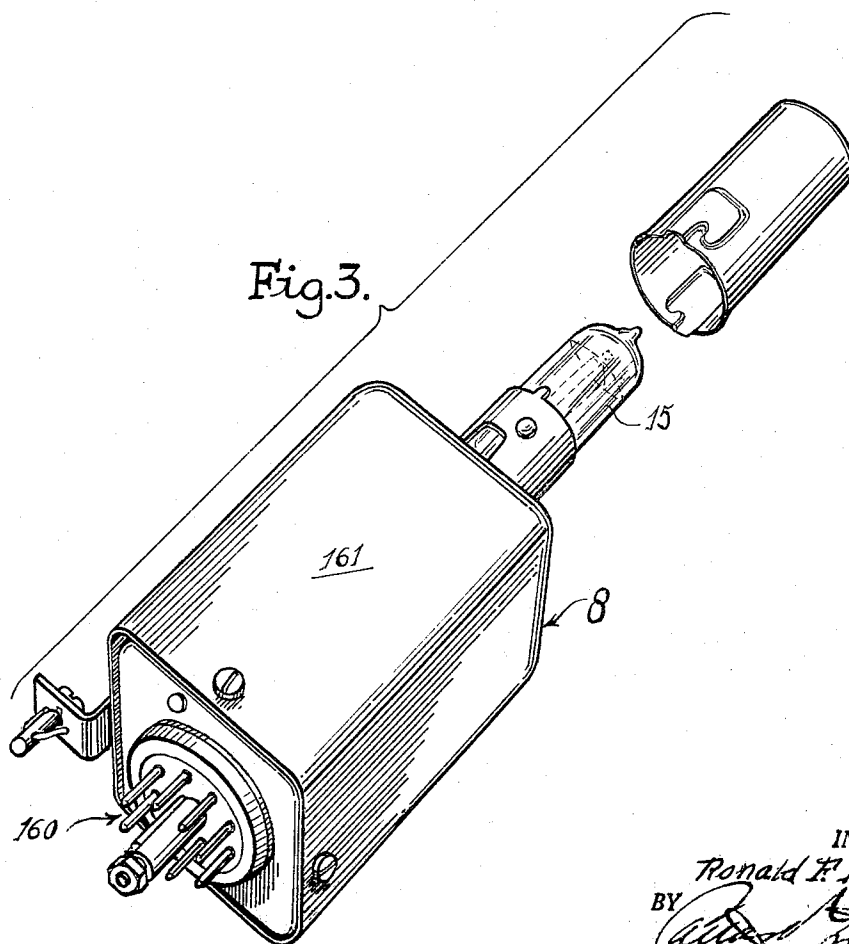


Fig. 3.

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1

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SUPERVISORY FLAME CONTROL

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This invention has as its principal object the provision of improvements in supervisory flame control apparatus for various types of industrial burner and furnace installations including particularly, but not exclusively, installations in which a plurality of burners for furnaces, boilers, heat-treating units and the like may be employed, each with its own burner, ignition, and control equipment respectively operable to ignite the flame, control the working temperatures thereof, monitor the presence or absence of the flame, and shut off the fuel supply automatically on failure to sense a proper flame.

One of the more specific objects of the disclosed improvements relates to the provision of a simple, reliable, and stable flame-sensing control and circuit means of the type which employs the current-rectifying properties of the burner flame to provide a go, no-go, bias for the control grid or electrode of an electronic valve device, and to do this in a manner which avoids certain undesirable effects of distributed capacity and circuit leakage from other causes in the flame-sensing part of such systems, the improved circuit means also providing a fail-safe margin of sensitivity with a stable response or drop-out time meeting all underwriters' requirements in these respects.

Another important feature of the system relates to the provision of a simple tell-tale apparatus cooperable with the aforesaid flame-supervisory circuit in conjunction with multiple burner installations for visually identifying any particular burner unit which has failed.

Other objects, advantages, and aspects of novelty and utility characterizing the disclosure relate to details of the embodiment of the apparatus and its operation as described hereinafter in view of the annexed drawing, in which:

FIG. 1 is a schematic equipment and circuit diagram;

FIG. 2 is a circuit detail of the grid input network;

FIG. 3 is a perspective detail of one of the plug-in units.

While the apparatus depicted in FIG. 1 is adapted to serve a multi-burner installation, it is sufficient for explanatory purposes to show only two flame sources or burners 10 and 11 with the understanding that any number -N- of such burners can be supervised by the disclosed system; it being also sufficient to describe in detail the control unit for one burner, since all such units are identical.

In flame-sensing apparatus of the general class to which the present disclosures pertain, burners such as indicated schematically at 10 and 11 (and more particularly the base portions thereof) themselves become part of the sensing circuit, and accordingly such base portions thereof are connected to a common return indicated as ground -G-. Projecting into the flame zone of each burner is an electrode or so-called flame rod 10E or 11E, and if a suitably high potential is applied across such electrodes and the appertaining burner base, a flame of adequate quality will conduct a weak current in one direction, and an alternating potential will be rectified and produce a unidirectional voltage and current which can be utilized to apply a supervisory control bias for an electronic valve device, which in turn can be arranged to control the fuel supply and signals relating to the operation of such a burner. A variety of control circuits of this general type are known, and those which could be regarded as successful generally involve circuitry and equipment which is both complex and expensive.

2

Safety being the primary objective in the use of such equipment, it follows that dependability is an essential attribute of all flame supervisory equipment, and by reason of the fact that the control or supervisory currents available in flame-conduction and rectification circuits are of such feeble magnitude (ranging from about 2 to 20 microamperes), that acceptable prior systems of this class have relied extensively upon relatively complex thermionic tube circuits involving considerable amplification of the sensed control signal or current; or they have utilized other involved equipment employing oscillatory sensing circuits; ionization-controlled sensing circuits, bridge circuits of one kind or another, and combinations of such arrangements with photoelectric flame detectors and/or thermostatic devices.

The present disclosures afford a relatively inexpensive flame-sensing unit employing only a single vacuum tube of the smaller type and simple associated circuit components all assembled in a plug-in pack small enough to fit in the hand and requiring only a power supply and a connection in a flame-rod circuit to give dependable response to the presence or absence of a flame, or a substantial change in quality of the flame, to operate a suitable supervisory control relay means, one such plug-in unit 8 being depicted in FIG. 3, such unit including the components enclosed in the dash-dot lines designated by the reference characters 8 in FIG. 1.

In FIG. 1 two flame sources or burners 10 and 11 are depicted, each with a corresponding flame rod or electrode 10E or 11E disposed in the path of the flame, the presence of which will cause a current flow between the flame rod and burner base when a suitably high potential is connected thereto, such potential being supplied (about 350 volts) by a secondary transformer winding 12, one terminal of which connects to a common return or ground -G- and the other terminal of which connects via conductor 13 to the grid input terminal -A- of the appertaining plug-in control unit 8, which is enclosed in dash-dot lines and is of the type depicted in FIG. 3, while the corresponding flame rod 10E connects via conductor 14 to the grid input terminal -B- of said control unit, which comprises a single electronic relay or valve device 15 in the preferred form of a simple thermionic triode (e.g. a tube of the 6C4 type) having a control electrode or grid 16, a cathode 17, and an anode or plate 18.

Terminal -A-, connecting as aforesaid with the high voltage transformer winding, in turn connects to the tube grid 16 through a first protective resistor 20 in series with a second loading resistance 21 connecting with the grid via conductor 22.

Terminal -B- of the control unit, to which the flame rod is connected via conductor 14, in turn connects via lead 23 and a biasing resistor 24 to cathode 17, a branch 23B of this cathode return lead also connecting to one terminal 40 of another transformer winding supplying the "B" or plate voltage, this supply circuit being completed from power transformer terminal 41, conductor 42 through a simple rectifier 43, conductor 44, and the winding 45 of a control or plate relay, to the tube anode 18 via conductor 46.

A branch 43A from the rectifier output conductor connects through a suitable filter resistance 29 (e.g. about 15K ohms) with the cathode, and a suitable ripple or filter condenser 30 is shunted across the rectifier output conductors 23B, 43A.

The bias resistor 24 is of a value (e.g. 680 ohms) to render the grid 16 sufficiently negative normally to cut-off or drop the anode current to a value which will drop out the plate relay, positive bias being supplied by the flame-sensing circuit and applied to the grid input network in magnitude to swing the grid sufficiently positive to pick up or operate said relay for purposes to appear.

Shunted between the grid side of the resistor 20 and the cathode return 23 is a first capacitor 25, which in turn is shunted by a first timing resistor 26; and shunted between the grid side of the second series resistor 21 and the cathode return lead 23 is a second timing capacitor 27, shunted by a second timing resistor 28. Thus, the grid input network consists basically of the resistors 20, 21, 26, 28, and capacitors 25 and 27, the resistor 24 being included for bias purposes unless some other source of biasing voltage be supplied.

The aforesaid input or sensing network is shown rearranged in a simplified equivalent form in FIG. 2, wherein the same reference characters are applied to the positionally rearranged circuit components, and from which it will appear that alternating high voltage from transformer secondary 12 is applied to the flame rod 10E through the first protective resistor 20 and series capacitor 25.

Since the flame rectifies the alternating voltage, resulting direct current will quickly charge the first capacitor 25 which has a certain time constant determined mainly by its shunt timing resistor 26; and the "signal" or sensing voltage is developed across this series-parallel combination of capacity and resistance, said voltage being applied across the grid 16 and cathode 17 by connections at points X and Y, the point X connecting through a high resistance to the grid and the point Y connecting to the cathode (through bias resistor 24), there being a second or storage timing capacitor 27 and its timing resistor 28 shunted across said grid circuit, that is between the grid and its cathode, and having a time constant calculated with respect to the time constant of the aforesaid series-parallel capacity and resistance combination 25-26, to produce a drop-out time of substantially four seconds, this drop-out time being in compliance with current practices and underwriters' specifications, and being defined as the delay between the failure of a flame (i.e. extinction or lessening in size or quality) and the actual dropping out of the appertaining relay.

In the input network shown in conjunction with a 6C4 type of tube, the components may have values such as these: resistor 20—100K ohms; resistor 21—5.6 megohms; resistors 26 and 28—10 and 22 megohms, respectively; capacitors 25 and 27 may each have a capacity of 0.1 mfd.; the bias resistor will have a resistance of about 680 ohms for a plate voltage of about 150 volts and an average stand-by plate current of about 2 milliamperes.

In FIG. 2 it will be observed that capacity L.C. and resistance L.R. is shown to ground in dotted lines to represent leakage losses arising from distributed capacity and ohmic resistance arising from the lead 14 to the flame rod and from such other sources as carbon soot deposits and the like providing leakage paths between the flame rod and burners, all of which tends to drop the A.C. voltage applied to the flame rod and to substantially weaken the available rectified control signal or current. Such losses can become very troublesome when long lengths of flame rod conductor 14 are necessary, such leads commonly extending a distance of 100 feet from the flame rod.

Prior flame rod systems have sought to overcome these difficulties by use of shielded cables in the flame rod circuit, and/or by resort to amplifiers and other special circuit contrivances, all of which increase the cost of the installation and frequently add to the maintainance and service problems.

Applicant's circuit, referring particularly to the input network of FIG. 2, overcomes the flame rod capacity and leakage difficulties by providing a low-impedance path for alternating current to the flame rod so that the maximum voltage appearing thereat can be utilized, the first capacity 25 being quite large (e.g. 0.1 mfd.) compared to the distributed capacity in the rod circuit, and being normally less than the ohmic leakage resistance across the burner. In addition, the first resistance 20, having a

low value of 100,000 ohms, affords protection against a dead short across the burner or input network which might apply the full 350 volts, yet this resistance does not unduly cut down the flame rod current.

In its D.C. "storage" function, the first capacitor 25 itself affords part of a relatively high impedance input for the grid circuit, and in conjunction with the second or load resistor 21 and second capacitor 27, completes the high-impedance D.C. load for the flame rod circuit, such that during negative excursions of the A.C. cycle, the necessary positive grid bias will hold up with sufficient smoothness and uniformity to hold-in the plate relay without drop-out or chattering, the very high (5.6 megohms) resistance between the first and second capacitors 25 and 27 being particularly effective in the latter respect.

On first appearance of the flame in a properly working installation, the plate relay will pull in promptly within the first few A.C. cycles, yet with a dead short at the burner the drop-out time will remain close to the required 4-second interval, and the system is thus properly sensitive to both starting and drop-out conditions, but stable against minor transient disturbances which otherwise cause false operation. In addition, any substantial lessening of flame quality will generally affect the D.C. bias sufficiently to drop out the relay within the required time interval, the result of such drop-out operation being to close a master fuel valve 135 for the system, as more fully described hereafter.

Means for indicating which burner has failed in a multi-burner installation comprises a bank of indicating lamps 60, including individual lamps 61, 62 . . . N, each correspondingly numbered to identify a particular burner, and selective lamp step-switch and searching switch means controlled by chain circuits through the several control or plate relays for causing the step switch means to operate and to search out any failed or dropped-out plate relay and to illuminate a corresponding one of the tell-tale lamps.

The lamp step switch means comprises a bank 70 of contacts 71, 72 . . . N, each corresponding to one of the tell-tale lamps and respectively connected in a power circuit to one terminal thereof by corresponding conductors 61A, 62A . . . 66A . . . N, the remaining lamp terminals being connected to a common bus conductor 75 and one terminal of a suitable power source such as the transformer winding 76, the remaining terminal of which connects via conductor 77 to the lamp contact wiper 79 of the lamp step switch. Thus, for example, lodgement of wiper 79 on a lamp contact 71 would complete an energizing circuit via conductor 61A to lamp 61; and wiper 79 on a different contact 74 would energize via conductor 64A the lamp 64.

Very rapid stepping of the lamp selector switch and the associated search switch is achieved by rotation of shaft 82 driving the lamp wiper 79 and a stepping wiper 83 and coupled to a ratchet wheel 86 which will be rapidly advanced step-by-step responsive to oscillation of a stepping pawl 87 effected by intermittent energization of stepping coil 88 under control of the chain-contact stepping pulse circuit now to be described, and including normally closed breaker switch contacts 89 and 90 which are opened whenever pawl 87 steps the ratchet wheel.

One terminal of the step coil 88 connects via conductor 88A to one terminal of a power source such as the transformer winding 94, another terminal of which connects via conductor 95 to a master relay contact 96 shown engaged with its normal or back contact 97, connecting via conductor 98 to index contact 84 on the ratchet stepping switch, with the result that whenever the master relay coil 99 is dropped or deenergized the master normal contacts 96-97 are closed and apply power from the power source or transformer winding 94 to the stepping coil 88 via conductors 88A and 98 and the closed breaker contacts 89-90 because contact 90 is connected via conductor 91 to the searching and stepping wiper 83, which will be nor-

5

manly lodged on said index contact 84. The searching and stepping contacts in the bank 80 will at least equal in number, plus one (i.e. the index contact 84), the number of lamps or control units to be monitored.

For example, when the searching wiper 83 steps off the normal or index contact 84, as a result of dropping out of the master relay responsive to a failure, it will lodge on the next succeeding search contact in bank 80, such contact being connected by conductor 100 to a "make" contact 101 on the plate relay of the first or #1 control unit, the companion relay contact 102 being looped by a conductor 103 with the similar plate relay contacts 104, 105, 106 on the other associated units #2, #3 . . . #N, etc., all connecting with a power lead 95X extended from the power source or transformer winding 94 via conductor 95.

Accordingly, all plate relays which are pulled in will render their corresponding search contacts on panel 80 "hot"; and that one of the plate relays which is dropped out on a failure will render the corresponding search contact "dead," and the stepping operation will stop whenever wiper 83 encounters a dead contact.

If it is assumed for example that the plate relay of the #1 unit drops out because of a flame failure and consequent lowering of the plate current through the relay coil 45 to a point where the relay will no longer hold in then the tell-tale contact 102 of this relay will drop back and open the power circuit through companion contact 101 to conductor 100 and the corresponding search contact on panel 80, as a result of which this particular contact will be dead.

Another immediate result of dropping out relay 45 in the foregoing example would be a breaking of the master chain circuit at relay contacts 122, 123, in consequence of which the master relay would be dropped out.

The coil of the master relay is normally energized when all burners are operating properly and all plate relays are pulled in to complete the master chain circuit, one terminal of the master relay coil 99 being connected by conductor 120 to one terminal of a power source such as the transformer winding 121, the remaining terminal of which connects to the first chain contact 122 on the #1 plate relay, the companion or "make" contact 123 of which connects to the second chain contact 124 on the #2 unit plate relay, and so-on through the plate relays of all units until the last or Nth one, whose chain contacts 125, 126 complete the power circuit via conductor 127 to the remaining terminal of the master relay coil 99.

Thus, when all flames are properly present, the several plate relays 45, 45², 45³ . . . 45^N, of all plug in control units #1, #2 . . . #N will all be energized and the power circuit 120, 121, 122, 123, 124, 125, 126, 127 . . . for master relay coil 99 will be completed through the aforesaid chain circuit, so that master (search-stepping) contacts 96, 97 will normally stand open and the fuel-valve contacts 130, 131 will normally stand closed; but on dropping out of any plate relay the said chain circuit will be broken and master contacts 96 will drop back with the result that the stepping switch will at once begin its rapid operation to locate and indicate the identity of the failed burner in the manner previously described, while at the same time opening of master relay valve contacts 130, 131 will shut off the fuel supply by breaking power from source 94 via conductors 132 and 133 to deenergize the trip coil 134 of a master fuel valve 135, which will trip out a pre-set spring-loaded valve poppet 136 to shut off the supply of fuel via line 137 to all burners. This is a fail-safe operation so that any failure of power in the system will shut off the fuel.

The stepping search-switch wiper will stop at the first dead contact encountered by wiper 83 on contact bank 80, the action being such that the elapsed time between actual failure of a flame shutting off the fuel to all other flames and the expiration of the 4-second drop-out period, will permit the condenser-storage means associated with the control units of all the other non-failed flames to

6

hold up while the very rapid advance of the stepping wiper 83 occurs, so that the searching or tell-tale contacts for the non-failed flames will remain hot at least during the 4-second drop-out period, by reason of which the searching wiper can continue easily to complete a full searching cycle of its travel, if necessary, to locate the dead contact which will signify the failed unit.

The usual fuel valves 135 are manually opened and releasably held in this condition by an electromagnetic latch means such as shown so that they cannot be automatically reopened once a failure has transpired; and any failure which once causes any of the supervisory control units to operate sufficiently to drop out any plate relay, whether due to actual flame failure or some component failure in the control unit, will produce a "fail-safe" operation to the extent of positively shutting off the fuel promptly and requiring manual intervention before the service can be resumed.

The simplicity and circuitry of the described grid input network in combination with flame-rectification affords a very high margin of fail-safe operation, it being found that shorting or opening of any of the network components, excepting two, will result in a fail-safe operation with dropping of its plate relay in the presence of a flame, the two exceptions being a shorting of the bias resistor 24 or an opening of the filter resistor 28; only in these two unlikely instances will the plate relay hold in and result in a "fail-unsafe" condition; but such eventualities are rendered unlikely in practice by use of high-quality over-rated components.

A simple test means is provided for each flame control unit in the form of a normally-open shorting switch 150 (shown only in conjunction with unit #1 but used on all units), which is shunted across the plate relay coil 45, and when manually closed will drop out the plate relay and check the operation of the fuel valve and the tell-tale equipment, and indicate as well the pick-up and drop-out response of such relay on closing and opening of such test switch. Once the fuel valve 135 has shut off any pick-up of the plate relay of any unit tested as aforesaid would indicate trouble of the character alluded to in the foregoing "fail-unsafe" conditions.

Thus, whether a failure be actual or simulated, as by operation of the aforesaid test means, the tell-tale means will operate to identify the failed unit, and a new unit, such as shown in FIG. 3, may be quickly substituted by reason of the compact plug-in socket-type connections 160 provided on the bottom of the canister housing 161 which houses the components embraced in the units 8, with tube 15 carried exteriorly, however, for convenient replacement or testing.

Thus, FIG. 2 depicts the rudimentary flame supervisory circuit to illustrate how a rectified or D.C. control voltage or signal is derived from the high-voltage, alternating-current flame circuit through a special input network consisting of the first resistance 20 in series with the first capacitor 25 and said flame electrodes, and having an optimum low impedance to the alternating voltage in the flame circuit, this network further including a second capacitor 27 shunted across the control electrode or grid 16 and the cathode 17 with these input electrodes (grid and cathode) shunted across the first capacitor through a second and very high resistance 21 in series with the grid side of this shunt, there being third and fourth high timing resistances 26 and 28 shunted respectively across the first and second capacitors 25 and 27.

Thus, this network comprises a series section consisting of the first resistor 20 in series with the first capacitor 25 and the flame circuit; and a shunt section across the first capacitor 25, and consisting of the circuit components 16, 17, 21, 24, 26, 27, 28 connected at X-Y, and having a very high impedance for deriving the signal voltage from the drop across capacitor 25, both capacitors 25 and 27 being shunted by high-value timing resistors 26, 28.

I claim:

1. In a flame supervisory system for a plurality of burners, and each including electrical flame-sensing means respectively operable to actuate a sensing relay responsive to the presence or absence of a flame at an appertaining burner, improvements comprising, namely: indicating means operably controlled by said sensing relay to search out and indicate which burner flame has failed, said indicating means including a plurality of indicating lamps, each designating a corresponding burner, an electromagnetically driven, rapid-acting stepping mechanism connected in a stepping circuit with a set of normally closed contacts on a master relay which are adapted to be opened on energization of said sensing relay, such that stepping occurs when said master relay is non-energized, and does not occur when said master relay is energized; a bank of search step contacts and a rotary search wiper cooperable therewith and actuated by said stepping mechanism, said wiper being connected in said stepping circuit to connect power thereto through any of said search contacts connected to power; contact means on each said sensing relay each connected to one of said search contacts and to a source of power and operable in a first predetermined operative condition of such sensing relay to connect stepping power to the appertaining search step contacts; chain contact means connected in a series circuit with said master relay and operable by each sensing relay in a second operative condition thereof to close an energizing circuit for the master relay whereby to hold the latter in actuated condition so long as all sensing relays are operated in the second-named condition and to drop out the master relay when any one of said sensing relays is in said predetermined first condition, such that stepping action as aforesaid will begin, and will continue, so long as said search and stepping wiper engages any search contact with power connected thereto by a sensing relay and will stop at the first search-step contact having no power thus connected thereto; a bank of lamp contacts and a lamp wiper cooperable therewith and driven by said stepping mechanism in step with said search wiper and connected in circuit with said lamps and lamp contacts to illuminate one of each of the same at each position corresponding to one of said search-step contacts; and dead index contact means included in said search-step contacts for automatically stopping said stepping action when all sensing relays are in the second-named operative condition.

2. In a multi-burner flame-detection circuit including a sensing relay for each burner connected for operation to a corresponding flame-sensing means associated therewith, and a master load relay connected for operation by a chain circuit completed through contact means controlled by each said sensing relay in flame-sensing operated condition, the combination therewith of a searching and indicating circuit comprising, namely: a cyclically-operable, electrically-actuated stepping switch having a plurality of sequentially arranged contacts in matching sets with one contact energizable in each set by connection with contact means on a corresponding one of said sensing relays in a non-flame sensing condition of the latter, and another matching contact in the same set connecting with a corresponding signal lamp; and an automatic stepping circuit for actuating said stepping switch and connected for operation by contact means closed by said master relay when dropped from operated condition by breaking of said chain circuit to start the stepping, said stepping switch including stepping contact means movable thereby from a starting position to successively engage said sets of contacts and control said stepping circuit to continue the stepping action from one set of contacts to the next, so long as energized stepping contacts are engaged in succession in each said set, said stepping circuit being interrupted as the result of engagement of a non-energized switch contact by said stepping contact means in at least two successive passes thereof, to stop the stepping contact means on the set of con-

tacts including the aforesaid non-energized contact and cause energization of the lamp associated with said contacts; said stepping switch contacts including one dead contact corresponding to a starting position at the end of said sequential arrangement for stopping the stepping when all sensing relays are operated.

3. A flame supervisory circuit comprising an electronic valve device having at least an anode, a cathode, and a control electrode for modifying anode current flow responsive to control voltage applied thereto; a flame-rectifier input circuit for said device comprising a source of alternating high voltage connected in a flame circuit to flame electrodes for conduction of a rectified unidirectional current thereacross, a first resistance connected in series with said flame circuit; a first capacitor in series with said first resistance, said first resistance and capacitor having a value providing a predetermined minimum impedance to alternating current flow in said flame circuit; said control electrode connecting through a second resistance many times higher in ohmic value than the first resistance to a junction with the first resistance and said first capacitor, said cathode connecting with said first capacitor in conjunction with the connection of the latter capacitor with one of said flame electrodes in said series circuit; and a second capacitor and third resistance respectively shunted across said control electrode and cathode, whereby said series circuit provides a low-impedance A.C. path for the flame electrodes, and said second and third resistances and second capacitor provide a high impedance signal input circuit for said control device to utilize rectified flame current derived from said series circuit to bias said control electrode positively at least a predetermined amount consistent with flow of substantial anode current to produce a first control condition; and means connecting with said cathode for rendering said control electrode substantially negative independently of rectifying action by said valve device in any part of said supervisory circuit, and in an amount at least equal to that of said positive bias to reduce the anode current to a desired minimum control value to produce a second control condition.

4. In a flame supervisory circuit, a pair of flame electrodes, and a high alternating-voltage flame circuit connected thereto and producing a rectified flame current in the presence of a flame sensed by said electrodes; an electronic translating device including at least an anode, a cathode, and a control electrode; an anode circuit including a source of anode potential and a control relay connected with said anode and cathode for actuation of said relay by flow of predetermined anode current; an input circuit comprising a resistance-capacitor network connected with said control electrode and cathode to apply a rectified flame potential thereacross to control said anode current, said network including an ohmic resistance and capacitor in series with said source of high alternating voltage and said flame electrodes and having an A.C. impedance of low value to maintain a predetermined optimum A.C. voltage on said flame electrodes; said network further including a second capacitor connected across said control electrode and cathode and second, third and fourth ohmic resistances of substantially higher ohmic value than said first resistance and respectively connected in series-parallel relationship with each other across said control electrode and cathode and said first capacitor to derive a positive rectified control voltage from said flame circuit and present an optimum high impedance thereto, and means in circuit with said control electrode and cathode for biasing the control electrode negative by an amount sufficient to suppress flow of anode-cathode current by a desired amount in the absence of said rectified positive control voltage.

5. In a flame supervisory circuit, in cooperative combination with a pair of flame-bridged electrodes, a control device including at least a cathode, an anode and a control electrode; a source of alternating supply voltage

connecting in a flame circuit with said flame electrodes to provide a rectified signal voltage in the presence of a flame bridging said flame electrodes; means connecting with said alternating supply voltage providing a single source of rectified D.C. voltage; means connecting said D.C. voltage in an output circuit with said anode and cathode to provide a cathode current for control by said control electrode; means providing an input circuit connecting said flame circuit to said control electrode to apply said signal voltage to said control electrode; and means providing a bias voltage for the control electrode including a voltage dividing network connecting across said D.C. voltage and having conductive connection from points of potential thereon to said input and output circuits which render the cathode substantially more positive than the control electrode and thereby render the control electrode more negative than the cathode without direct connection to the control electrode so as not to impair the sensitivity of said input circuit to said flame signal voltages.

6. Improvements according to claim 5 further characterized in that said voltage dividing network comprises an ohmic resistance having a first terminal connecting with one of said flame electrodes, a second terminal connecting with said D.C. voltage, and a connection interposed in the resistance path between said first and second terminals

and connecting with said cathode, the value of the ohmic resistance between said first terminal and cathode connection in relation to the ohmic value of the resistance between said cathode connection and said second terminal being selected to render the cathode more positive than the control electrode, substantially as set forth.

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