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FLAME SAFETY AMPLIFIER

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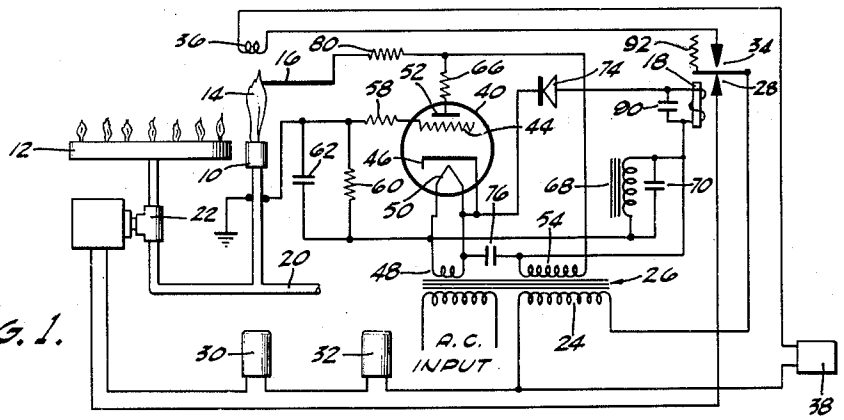
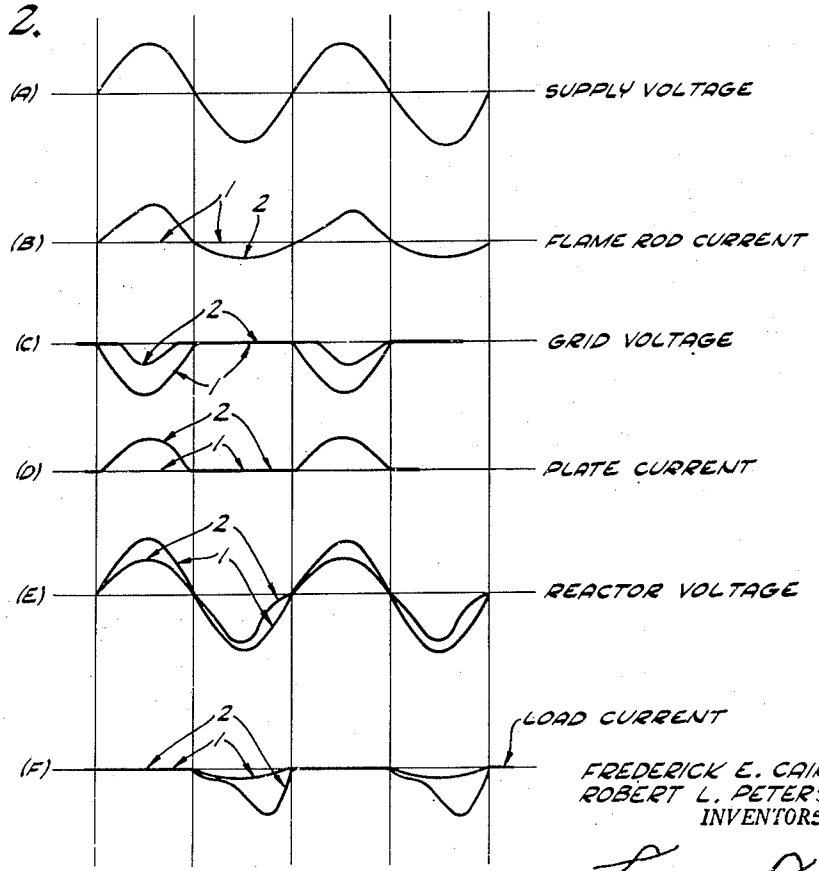


FIG. 1.

FIG. 2.



FREDERICK E. CAIRNS
ROBERT L. PETERSON
INVENTORS

BY Lyon & Lyon

ATTORNEYS

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FLAME SAFETY AMPLIFIER

Frederick E. Cairns, Glendale, and Robert L. Peterson, North Hollywood, Calif., assignors to General Controls Co., Glendale, Calif., a corporation of California

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8 Claims. (Cl. 323—89)

The present invention relates to an improved control system which includes an amplifier associated with a flame-sensing device.

Briefly, the arrangement described herein functions to cause a load, such as a relay winding, to be fully energized when a flame is present, the relay being automatically de-energized when the flame fails to continue to burn. The flame-sensing device, as shown herein, comprises a flame conduction rod with the flame serving as a uni-directional conducting device. It is understood, however, that the present invention, in its broader aspects, is not limited to this well-known characteristic of a flame, but other uni-directional conducting devices, such as photo-electrical cells, vacuum tubes, mechanical rectifiers and the like may be associated with the related amplifier circuitry in like manner. The amplifier circuitry, in general, comprises an amplifying tube connected in a novel manner with respect to a saturable reactor to control a relay. The tube is normally non-conducting but is rendered conducting upon the presence of a flame. The tube is energized with alternating current and the relay is likewise energized from the same alternating current source, but through a rectifier such that tube current and relay current flows during alternate half-cycles of the alternating current waves. When tube current flows, the saturable reactor is conditioned by such tube current in such a manner that a relatively large relay current flows during the succeeding half-cycle. The present control arrangement is characterized by the fact that it "fails safe" in that, should the terminals of the uni-directional conducting device, i. e., the flame rod, on the one hand and the burner on the other hand, be connected together through a short circuit, or partial short circuit (in the absence of a flame) the relay does not become energized, thus remaining in a de-energized condition. This is true even though the flame-conduction rod is connected to a point on the alternating current voltage source which is positive at the time the tube is conducting.

It is, therefore, a general object of the present invention to provide an improved control arrangement of the character described herein.

Another object of the present invention is to provide an improved control arrangement of this character which requires the use of only one tube.

Another object of the present invention is to provide an improved arrangement of this character which fails safe even though the flame conduction rod is connected to a point on the alternating current voltage source which is positive when the tube is in a conducting state, this being accomplished in a simple manner without the necessity of expensive components such as marginal relays which also require careful adjustment.

Another object of the present invention is to provide an improved control of this character which does not require a special winding on the power transformer to allow the control to fail safe.

Another object of the present invention is to provide improved amplifier circuitry.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. This invention itself, both as to its organization and manner of operation, together with further objects and advantages thereof, may be best understood by reference to the following description taken in connection with the accompanying drawings in which:

Figure 1 shows apparatus, partly in structural form and partly in schematic form, embodying features of the present invention.

Figure 2 shows a series of wave forms, all on the same time scale, showing different voltage and current conditions in the apparatus illustrated in Figure 1.

The apparatus shown in Figure 1 operates so as to allow the flow of gas to a pilot burner **10** and an associated main burner **12**, only so long as a pilot flame **14** is present between on the one hand the flame conduction rod **16**, and on the other hand the metal conduit which comprises the pilot burner **10**. As long as the flame **14** is present, the relay winding **18** remains energized, as shown in Figure 1, to allow gas to flow from the gas inlet line **20**, through the solenoid operative valve **22**, to the main burner **12**. This condition exists when the solenoid valve is energized with current which flows in the following serial circuit: The secondary winding **24** of transformer **26**, the relay switch **28**, the solenoid valve **22**, the thermostat **30**, and limit control switch **32**.

As indicated previously, when there is no pilot flame **14**, the relay winding **18** is de-energized in which case the relay switch **28** is opened and the relay switch **34** is closed. Such switch **34** is normally closed by, for example, spring means indicated by the tension spring **92**. In this particular condition, the gas escaping from the pilot burner **10** may be ignited by the electrically heated ignitor coil **36** which is supplied with heating current flowing in the following serial circuit: secondary winding **24**, switch **34**, ignitor coil **36**, and the conventional manually operable reset switch **38** having thermal cut-off.

In the absence of the flame **14**, the tube **40** is in a non-conducting state. This condition exists since the control grid **44** is maintained at a negative potential with respect to the cathode **46** by the transformer secondary winding **48** (which supplies heating current to the filament **50**) at the time the anode **52** is rendered positive with respect to the cathode **46** by the secondary transformer winding **54**. For this purpose, the control grid **44** is returned to the cathode **46** by circuitry which includes the following elements, namely: grid current limiting resistance **58**, the resistance **60** which is connected in shunt with the condenser **62**, and the transformer winding **48**; on the other hand, an energizing circuit is provided for the anode **52**, such circuit including the following elements, namely, current limiting resistance **66**, secondary winding **54**, saturable reactor **68** which is connected in shunt with the phase correcting condenser **70**, it being noted that one terminal of reactor **68** is returned to the cathode **46** through the secondary winding **48**. It is noted that the control grid **44** is connected through resistance **58** to the burner **10** which is usually at ground potential, as indicated in Figure 1, since usually the connecting gas lines are buried in the ground.

It is also noted that the relay winding **18** is serially connected with the secondary transformer winding **48** in a serial circuit which comprises the following elements, namely: the secondary winding **48**, the saturable reactor **68**, relay winding **18** and rectifier **74**; condenser **76** is connected in shunt with the serially connected windings **48** and **68**. Under these conditions (in the absence of the flame **14**), the tube **40** does not conduct, i. e., the reactor winding **68** is not conditioned by the space current of tube **40**, so that the reactor winding **68** offers a relatively high impedance to the flow of current to relay winding **18**,

such relay current being limited in sufficient amount to assure the closure of switch 34. However, when, as described later, the tube 40 is rendered conducting, the saturable reactor 68 is conditioned by the space current flowing through device 40 so as to allow full energization of the relay winding 18 and consequent closure of switch 28.

The flame conduction rod 16 is connected through resistance 80 to the junction point of resistance 66 and winding 54. This rod 16, of course, is, in the presence of flame 14, connected through such flame to the junction point of resistances 58 and 60, such junction point being grounded.

It is well-known that a gas flame has uni-directional conducting properties. Thus, a unidirectional current component flows in the following path, namely: from the winding 54, through resistance 80, through the flame 14, through the resistance 60, through the reactor winding 68, to the opposite terminal of winding 54 to thereby render the control grid 44 positive at the same time that the anode 52 is positive whereby the tube 40 is rendered conductive. It is noted that there is also an alternating current component flowing through the last-mentioned circuit which includes resistance 80. However, such component is effectively filtered as a result of the relative magnitudes of the impedance of resistance 80 on the one hand and condenser 62 on the other hand in that the condenser 62 has a relatively small impedance whereas resistance 80 has a relatively large impedance so that only a relatively small alternating current component appears in the grid cathode circuit of tube 40. The relative magnitudes of the impedance of elements 80 and 62 are considered of greater importance in providing a fail-safe arrangement as described later. The resistance 80 may, for example, have a value of 10 megohms, the condenser 62 may have a magnitude of one-tenth microfarad so as to function as described herein. These elements 80 and 62 may thus be considered as filter elements or components of an attenuating network.

Thus, when the tube 40 is rendered conductive, the space current of such tube 40 flows in a serial circuit which includes the winding 54, tube 40, winding 48, and saturable reactor 68 to thereby condition the magnetic core of such reactor. This flow of space current through saturable reactor winding 68 (which occurs in alternate half-cycles due to the unidirectional characteristics of tube 40) is in opposition to that current component produced by winding 48 and flowing in a serial circuit including the following elements, namely: winding 48, condenser 76 and winding 68. Thus the effective impedance of the winding 68 is lowered thereby causing a larger voltage drop across condenser 76. Since the voltage across the reactor is lower during the conductive half cyle of the tube 40, the core of the reactor saturates before the completion of the following half-cycle and a larger current flows through the relay winding 18.

The condenser 90, if desired, may be connected in shunt with the relay winding 18 to filter or smooth out current variations in the relay winding 18.

It is noted that the condenser 76, if desired, may be replaced by a resistor without changing the theory or mode of operation. However, when a resistance is used, the sensitivity is impaired slightly.

The condenser 70, as mentioned previously, functions as a phase compensator and in addition, it prevents the relay current from increasing as much as it would without condenser 70 in the event, for example, condenser 76 (or a resistance substituted therefor) were to fail and thus open a circuit. Likewise, in the event condenser 76 (or a resistor substituted therefor) were to short circuit, the relay current remains at a minimum.

The arrangement as described fails safe, i. e., in the absence of flame 14, and either a partial or a full short circuit between the elements 10 and 16, the relay winding 18 does not become energized sufficiently to open the switch 34. Thus, assuming the absence of the flame 14 and a resistance, or short circuit, connected between the flame rod 16 and the burner 10, insufficient alternating current voltage is coupled to the control grid 44 because of the relative magnitudes of resistance 80 and condenser 62. Since these two elements are connected in a voltage dividing network, the voltage is distributed in accordance with the relative impedance, a relatively large alternating current voltage being developed across the resistance 80 and a relatively small alternating current voltage being developed across the condenser 62. The voltage across the condenser 62 is insufficient to cause the tube 40 to conduct.

For a further explanation of the invention, reference is now made to Figure 2 which shows different voltages or currents existing in the system when under condition 1, there is no flame 14 and under condition 2 where the flame is established and the relay switch 20 is closed. The wave form A in Figure 2 represents the alternating current voltage appearing across either secondary winding 54 or the secondary winding 48, it being noted that whenever the righthand terminal of winding 54 is positive, the corresponding righthand terminal of winding 48 is also positive. As indicated at B, the curve 1 which is a straight line represents an absence of flame rod current; and the curve 2 indicates the unidirectional properties of the flame 14 in that there is a greater amount of current flowing during the positive half-cycle, i. e., the tube conductive half-cycle, than during the negative half-cycle. The voltage on the control grid 44 is represented at C, it being observed that the flame causes the control grid to be less negative in sufficient amount to cause the tube 40 to conduct. The space or plate current is represented at D, it being noted that when there is no flame there is no space current and when there is a flame the space current flows only during the positive half-cycles. The voltage across the reactor 68 is indicated at E, it being observed that the voltage across such reactor is smaller when there is a flame than when there is no flame and that, when there is a flame, the core of the saturable reactor saturates, as mentioned above, during the negative half-cycles, with the result that the relay current as represented at F, which flows only during the negative half-cycles, due to the poling of rectifier 74, increases in sufficient amount, in the presence of a flame, to cause the relay winding 18 to become fully energized.

While the particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from this invention in its broader aspects and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

We claim:

1. In an arrangement of the character described, a device having a cathode, a control grid and an anode, means normally rendering said device non-conducting, said means comprising a first transformer winding connected between said cathode and said control grid, a second transformer winding connected between said cathode and said anode and rendering said anode positive when the first mentioned winding renders said control grid negative, flame electrode means, one terminal of said flame electrode means being coupled to said control grid, a first filter element connected between the other terminal of said flame electrode means and a point on said second winding, a second filter element connected between said one terminal of said flame electrode means and said cathode, said first and second filter elements having, respectively, a relatively high impedance and a relatively low impedance and serving to prevent said device from becoming conducting when said flame electrode means are short circuited, a saturable reactor, said saturable reactor being serially connected with said second transformer winding, and said anode and said cathode of said device; said

second winding being serially connected with said flame electrode means and said saturable reactor; a voltage responsive device, rectifying means, and said voltage responsible device and said rectifying means being serially connected with said first transformer winding, and said saturable reactor.

2. In an arrangement of the character described, a device having a cathode, a control grid and an anode, a first transformer winding, a second transformer winding, said first transformer winding being connected between said cathode and said anode, said second transformer winding being connected between said cathode and said control grid and being so poled that said control grid is rendered negative by said second winding when said anode is rendered positive by said first winding, flame electrode means having one of its terminals connected to said first winding, the other terminal of said flame electrode means trode means and said first winding, and second filter means connected between said one terminal of said flame electrode means and said first winding, and second filter means connected between said control grid and said cathode to maintain said device in a non-conducting state when the terminals of said flame electrode means are connected together, a saturable reactor, a series circuit comprising said second transformer winding, said saturable reactor and the anode and cathode of said device, and voltage responsive means connected to said first winding and operated in accordance with the saturated condition of said saturable reactor.

3. In an arrangement of the character described, a device having a cathode, a control grid and an anode, a first transformer winding connected between said anode and said cathode, a second transformer winding connected between said cathode and said control grid for rendering said control grid negative when the first winding renders said anode positive to thereby maintain said device in a normally nonconducting condition, a saturable reactor serially connected with said first winding so that said saturable reactor conducts current when said device is rendered conductive, a load, a rectifier, a serial circuit comprising said second winding, said reactor and said load and said rectifier, with said rectifier being so poled that current is allowed to pass through said circuit only during those alternate half cycles when said device does not conduct due to its uni-directional conducting characteristics, flame electrode means having one of its terminals connected to said first winding and the other one of its terminals connected to said control grid, and filter means interposed, on the first hand, between the first terminal and said first winding and being disposed, on the other hand, between said first terminal and said cathode to prevent said device from becoming conductive when said electrodes are connected together.

4. In an arrangement of the character described, a device having a cathode, a control grid and an anode, a transformer winding connected between said cathode and said anode, a second winding connected between said control grid and said anode and being so poled with respect to said first winding that said control grid is rendered negative by said second winding when said first winding renders said anode positive, to thereby render said device normally nonconducting, a saturable reactor, a load, a rectifier, a serial circuit comprising said second winding, said saturable reactor, said load and said rectifier being so poled that current flows through said load only on alternate half cycles where said device is incapable of passing current, said saturable reactor being connected in a serial circuit with said device and said first winding, and means sensitive to the rectifying action of a flame coupled to said control grid for rendering said device conductive.

5. The arrangement set forth in claim 4 in which a condenser is connected in shunt with said saturable reactor, and an impedance is connected in shunt with the serial circuit which comprises said saturable reactor and said second winding.

6. The arrangement set forth in claim 4 in which the last mentioned means comprises flame electrode means, one terminal of said electrode means being connected to said first winding, the other terminal of said electrode means being connected to said control grid, and filter means disposed, on the one hand, between said first terminal and said first winding, said control grid and said cathode to maintain said device in a nonconducting condition when said terminals are connected together.

7. In an arrangement of the character described, a device having a cathode, a control grid and an anode, a saturable reactor, a first transformer winding serially connected with said saturable reactor and said anode and cathode of said device, flame electrode means connected to said control grid, said flame electrode means being serially connected with said first winding and said saturable reactor, a second transformer winding, a rectifying device, and a voltage responsive device connected serially with said second transformer winding, said rectifying device and said saturable reactor.

8. In an arrangement of the character described, a voltage responsive means, a saturable reactor connected to and controlling said voltage responsive means in accordance with the energized condition of said saturable reactor, a device having a cathode, an anode and a control grid, flame electrode means connected to said control grid, first means producing a unidirectional current flow through said saturable reactor and the anode and cathode of said device, and second means producing a unidirectional current flow through said saturable reactor and said flame electrode.

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