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CONTROL APPARATUS

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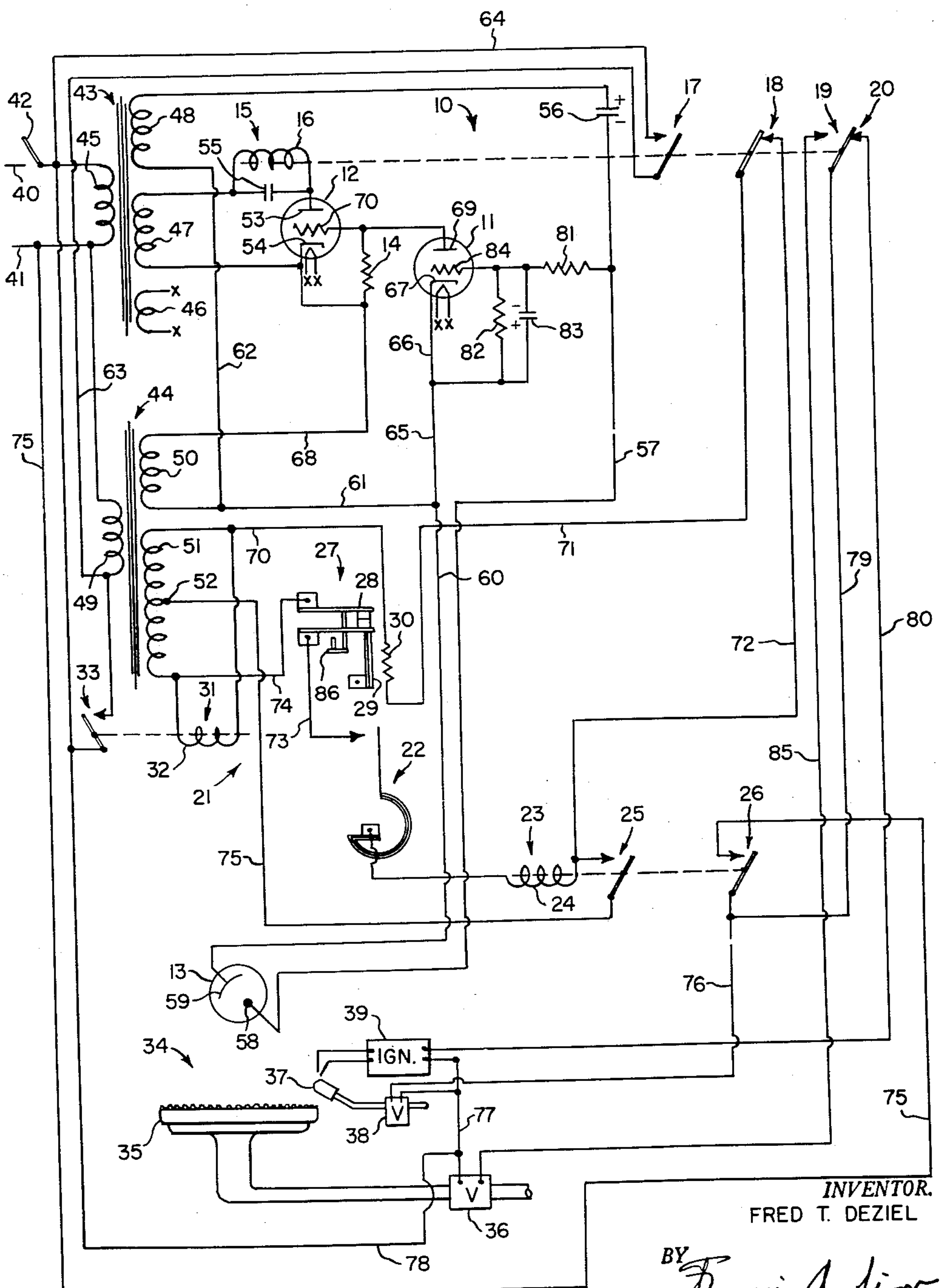

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CONTROL APPARATUS

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The present invention is concerned with an improved control apparatus and more particularly with an improved burner control apparatus utilizing a novel safe-start feature.

As is well known, electronic flame detectors have come into wide acceptance as the flame detector portions of combustion safeguard equipment which is used to monitor the proper operation of an associated fuel burner unit. These electronic flame detectors utilize electronic devices which may possibly fail in a condition where a flame is falsely indicated. As a result, a so-called safe-start feature or checking feature has been incorporated into such electronic flame detectors. In broad principle, these flame detectors operate such that upon the initial application of operating voltage thereto, conditions are such that the flame relay is energized in response to a simulated presence of flame. Upon the flame relay being so energized, a further means is energized which discontinues the simulated presence of flame and causes the flame relay to be de-energized. Circuits are now completed such that an associated fuel burner unit may be energized in an attempt to establish flame at the burner unit. With such a construction, the ability of the electronic flame detector to first sense the simulated presence of flame and to then sense the actual absence of flame is positively checked before the fuel burner unit is energized.

The present invention is directed to such a control apparatus and provides an improved checking or safe-start system.

Specifically, the present invention provides a construction whereby the flame relay, upon initially being energized due to the simulated presence of flame, causes the energization of a further means in the form of a safe-start relay which is provided with but a single switch connected to maintain the safe-start relay energized once it is initially energized and further discontinue the simulated presence of flame.

The construction provided by the present invention also provides means whereby a main burner control relay is energized by a circuit which is controlled by a single normally open switch of the safe-start relay such that if, due to contact contamination or the like, the single normally open switch of the safe-start relay should fail to make electrical contact, the fuel burner unit is not energized.

The present invention will be apparent to those skilled in the art upon reference to the following specification, claims, and drawing, of which the single figure is a schematic showing the preferred embodiment of the present invention.

Referring specifically to the single figure, the apparatus disclosed therein can be divided into three basic components. The first of these components is an electronic flame detector designated by the reference numeral **10** and having electron discharge devices **11** and **12**. The electronic flame detector **10** is in essence a two-stage amplifier in which the discharge device **11** forms the first stage and the discharge device **12** forms the second stage. The input of the electron discharge device **11** is controlled by a condition sensing means in the form of a photocell **13**. The output of discharge device **11** consists of a load in the form of resistor **14** which is connected to control the input of discharge device **12**. The output of discharge device **12** controls a flame relay **15** having a winding **16** and switches **17**, **18**, **19**, and **20**. With the apparatus as shown, flame relay **15** is de-energized and switches **17** and **19** are open while switches **18** and **20** are closed.

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The second basic component of the apparatus is identified by the reference numeral **21** and this component is a control network which is controlled by means responsive to the need for operation of a fuel burner unit in the form of a bi-metal operated thermostat **22**. Thermostat **22** controls the energization of a main burner control relay **23** having a winding **24** and switches **25** and **26**. Here again, relay **23** is shown in its de-energized condition wherein switches **25** and **26** are open. The reference numeral **27** identifies a safety lockout means in the form of a conventional bi-metal operated safety switch having a normally closed switch **28**, a bi-metal **29**, and a bi-metal heater **30**. Also incorporated within the control network **21** is a safe-start relay **31** having a winding **32** and a normally opened switch **33**. It will be noted that safe-start relay **31** is provided with but a single switch and, as will be apparent hereafter, this switch is connected to provide not only the safe-start feature for electronic flame detector **10** but also to supervise the energization of main burner control relay **23**.

The third main portion of the apparatus disclosed is the fuel burner unit identified by the reference numeral **34**. This fuel burner unit is provided with a main burner **35** having a valve **36**, a pilot burner **37** having a valve **38**, and ignition means in the form of an ignition transformer **39**. As will be apparent, upon a call for operation of the fuel burner unit **34** by thermostat **22**, the improved control apparatus first completes a checking cycle and thereafter pilot valve **38** and ignition transformer **39** are energized to establish flame at the pilot burner **37**. This flame is detected by photocell **13**, and in response thereto, ignition transformer **39** is de-energized and main valve **36** is energized such that fuel is admitted to the main burner **35** and is ignited by the pilot flame present at pilot burner **37**.

Operating voltage is supplied from power line conductors **40** and **41** through a master switch **42**, which is shown in the open position. Operating voltage for the electrical components of electronic flame detector **10** and control network **21** is derived from transformers **43** and **44**. Transformer **43** is provided with a primary winding **45** which is directly connected to power line conductors **40** and **41**, when switch **42** is in a closed position. This transformer is also provided with a secondary winding **46** which energizes the filament heaters of discharge devices **11** and **12**. The secondary winding **47** of this transformer supplies operating voltage for the second electronic stage including discharge device **12**. The secondary winding **48** of this transformer supplies operating voltage for photocell **13**.

The primary winding **49** of transformer **44** is adapted to be connected to the power line conductors **40** and **41**, initially by means of switch **17** of the flame relay **15** and to be maintained connected to the power line conductors by means of switch **33** of safe-start relay **31**. The operation of this portion of the circuit will be described.

Transformer **44** is also provided with a secondary winding **50** which is connected to supply operating voltage for discharge device **11**. This transformer is also provided with a secondary winding **51** which includes a tap at **52** and which provides operating voltage for the control network **21**.

Operation

The apparatus as disclosed in the single figure is in its completely de-energized position when master switch **42** is open. It should be mentioned that while the apparatus disclosed shows the use of a thermostat **22**, it may be desirable in some instances to provide a direct connection to replace thermostat **22** and provide a controller of one type or another to perform the function of master switch 42. In this case, master switch 42 would be closed upon a need for operation of the fuel burner unit. However, for the purposes of this explanation, it will be assumed that switch 42 is a line switch which is closed to place the apparatus in an operative condition under the command of thermostat 22.

Upon the closing of master switch 42, the primary winding 45 of transformer 43 is energized. As a result thereof, the secondary winding 46 is operative to energize the filament heaters of discharge devices 11 and 12. The secondary winding 47 applies an operating voltage to the anode 53 and the cathode 54 of discharge device 12 through a series circuit including the winding 16 of relay 15, which winding is shunted by a capacitor 55. Secondary winding 48 is effective to apply an energizing voltage to the photocell 13 through a circuit which can be traced from the upper terminal of the secondary winding through a capacitor 56, conductor 57, anode 58 and cathode 59 of photocell 13, conductors 60, 61 and 62 to the lower terminal of secondary winding 48.

It will be noted that at this stage in the operation of the improved control apparatus, discharge device 11 is inoperative due to the fact that an operating voltage is not applied thereto. Therefore, this discharge device remains nonconductive and in effect, insofar as discharge device 12 is concerned, a flame is simulated. In response thereto, discharge device 12 conducts to energize flame relay 15.

Furthermore, since a flame is not present at the fuel burner unit 34, photocell 13, which is a photo-emissive cell and acts as a unidirectional current conducting device, does not pass current through the above traced circuit including capacitor 56. Therefore, capacitor 56 is not charged at this stage of the operation of the improved control apparatus.

Energization of flame relay 16 causes its switches to move from their de-energized to their energized positions. The switches 19 and 20 perform no control function at this time since the main burner control relay 23 is de-energized. The opening of switch 18 insures that relay 23 may not be energized during this phase of operation of the control apparatus. The closing of switch 17 completes an initial energizing circuit for the source of operating voltage which energizes discharge device 11. This source of operating voltage is transformer 44 and the energizing circuit for its primary winding 49 can be traced from power line conductor 41 through primary winding 49, conductor 63, switch 17, and conductor 64 to power line conductor 40. As a result thereof, the secondary winding 51 of this transformer is immediately effective to energize the winding 32 of safe-start relay 31 to thereby cause switch 33 to move to its closed position. It will be noted that switch 33 shunts switch 17 of the flame relay and therefore the primary winding 49 is maintained connected to the power line conductors 40 and 41 and also the safe-start relay 31 is maintained energized independent of any further state of operation of the flame relay 15. However, in order for the safe-start relay 31 to be initially energized it is necessary that flame relay 15 respond to the simulation of the presence of flame.

The secondary winding 50 of transformer 44 is effective to apply operating voltage to the discharge device 11. The lower terminal of this secondary winding is connected by means of conductors 61, 65, and 66 to the cathode 67 of discharge device 11 and the upper terminal of this secondary winding is connected by means of conductor 68 and resistor 14 to the anode 69 of this discharge device.

Since a flame is not present at the fuel burner unit 34 at this time, discharge device 11 is rendered conductive. The current flow circuit of this discharge device can be traced from the upper terminal of transformer 50 through conductor 68, resistor 14, anode 69, and cathode 67, and conductors 66, 65, and 61 to the lower terminal of secondary winding 50. It can be seen that the voltage de-

veloped across resistor 14 is such that the cathode 54 of discharge device 12 is rendered positive with respect to the control electrode 70 of this discharge device. Therefore, discharge device 12 is cut off and flame relay 16 is de-energized. In this manner, the flame relay responds to the actual absence of flame at the fuel burner unit 34.

It is well to note at this point the advantage of energizing the circuit including photocell 13 from the first to the energized transformer 43. It will be remembered that in initially discussing the energizing circuit for photocell 13, it was pointed out that since a flame is not present at fuel burning unit 34, capacitor 56 is not charged. However, assume for the moment that some fault or unusual condition arises wherein this capacitor 56 becomes charged, for example, a high background light intensity from a source other than a flame may cause photocell 13 to conduct and charge this capacitor. Under such a condition, photocell 13 is unable to sense the presence or absence of flame due to this high background illumination and capacitor 56 in its charged state is effective to maintain discharge device 11 nonconductive after transformer 44 is energized. Therefore, flame relay 15 is maintained continuously energized and, as will be apparent, unless flame relay 15 is de-energized in response to the energization of transformer 44, the main fuel burner unit 23 may not be energized. In this manner, if a condition such as a high background illumination should exist, the fuel burner unit 34 remains de-energized even though thermostat 22 may be calling for operation of this unit.

In its normal operation, however, flame relay 15 is de-energized in response to energization of transformer 44. Upon this relay being de-energized, the switches 17, 18, 19, and 20 again assume their de-energized position as shown in the single figure. The apparatus is now in a standby condition wherein the electronic flame detector has correctly sensed the simulated presence of flame and then the actual absence of flame.

Assume now that there is a call for operation of the fuel burner unit 34 as evidenced by thermostat 22 closing its associated switch. The closing of thermostat 22 causes an initial energizing circuit to be established for the main fuel burner relay 23. This initial energizing circuit can be traced from the upper terminal of transformer 51 through conductor 70, heater 30, conductor 71, switch 18, conductor 72, winding 24, thermostat 22, conductor 73, safety-switch 28 and conductor 74 to the lower terminal of the secondary winding 51. From this above traced circuit it can be seen that in order for the relay winding 24 to be initially energized, it is necessary that the actuating heater 30 of safety-switch 27 have electrical continuity; in other words, this heater must be in an operative condition. Furthermore, the flame relay 15 must be in a de-energized condition indicating the absence of flame at the fuel burner unit to thereby close its switch 18.

Energization of control relay 24 causes its switches 25 and 26 to move to a closed condition. A closing of switch 25 completes a holding circuit for winding 23 which can be traced from the tap 52 of transformer 51 through conductor 75, switch 25, winding 23, thermostat 22, conductor 73, safety switch 28, and conductor 74 to the lower terminal of the secondary winding.

Closing of switch 26 completes an energizing circuit for the pilot valve 38 and the ignition transformer 39. This energizing circuit can be traced from power line conductor 41 through conductor 75, switch 26, conductor 76, pilot valve 38, and conductors 77 and 78 to power line conductor 40.

The energizing circuit for ignition transformer 39 extends from switch 26 through conductor 79, switch 20, conductor 80, ignition transformer 39, and conductors 77 and 78 to power line conductor 40. With the energization of the pilot valve 38 and the ignition transformer 39, a pilot flame is established at the pilot burner 37. This pilot flame is sensed by photocell 13 and a current flows to charge capacitor 56, as indicated in the drawing.

This charge on capacitor **56** is distributed through an RC filter network including resistors **81** and **82** and capacitor **83** to charge capacitor **83** as indicated. This then biases the control electrode **84** of discharge device **11** negative with respect to the cathode **67** and discharge device **11** thereby comes nonconductive. The cut off bias voltage normally developed across resistor **14** in the standby condition of the apparatus therefore no longer exists and discharge device **12** becomes conductive to energize the winding **16** of flame relay **15**.

Switches **17**, **18**, **19**, and **20** once again move from their de-energized to their energized positions. The opening of switch **18** opens the initial energizing circuit for the main burner control relay **23** which is now maintained energized through its own switch **25**. Furthermore, the opening of switch **18** de-energizes the actuating heater **30** of safety switch **27**.

In the event that a pilot flame had not been established, flame relay **15** would not have been energized and the heater **30** would be maintained energized to heat bimetal **29** such that its upper end warps to the right to cause the switch **28** to open, thereby de-energizing the main burner control relay **23**.

The opening of switch **20** de-energizes the ignition transformer **39** and the closing of switch **19** completes an energizing circuit for the main valve **36**. This energizing circuit can be traced from power line conductor **41** through conductor **75**, switch **26**, conductor **19**, switch **19**, conductor **85**, valve **36**, and conductor **78** to the power line conductor **40**. Fuel is now admitted to the main burner **35** and is ignited by the pilot flame at pilot burner **37**.

The apparatus is now in the running condition wherein a flame has been established at the fuel burner unit **34** and this flame has been sensed by the electronic flame detector **10**. Should this flame subsequently fail, the photocell **13** detects the absence of flame at the fuel burner unit **34** and discharge device **11** is once again rendered conductive to in turn render discharge device **12** nonconductive. The flame relay **15** thereby drops out and switch **18** closes to once again energize the actuating heater **30** of safety switch **27** whereas switch **19** opens to de-energize the main valve **36** and switch **20** closes to again energize the ignition transformer **29** in an attempt to re-establish flame at the fuel burner unit **34**. If a flame is not re-established, the safety switch **27** is effective after a predetermined time interval, for example sixty seconds, to de-energize the main burner control relay **23** which then causes switch **26** to open de-energizing the entire fuel burner unit **34**. It is now necessary to manually depress the reset button **86** to again place the apparatus in the standby condition.

From the above description it can be seen that I have provided an improved control apparatus wherein the single switch **33** of the safe-start relay **31** is effective to simulate the presence of flame and cause the second stage **12** of the electronic flame detector **10** to be energized upon initial energization of the apparatus. In this manner, flame relay **15** is energized.

The flame sensing means **13** is also energized at this time such that if a fault exists capacitor **56** is charged, as it should not be when a flame is absent at the fuel burner unit.

Furthermore, upon the flame relay correctly responding to the simulated presence of flame, switch **17** controlled by the flame relay energizes the second transformer **44** and causes the safe-start relay **31** to be energized. Switch **33** of this safe-start relay then shunts switch **17** of flame relay **15** and maintains transformer **44** thereafter continuously energized.

Safe-start relay **31** performs its safe start function with but a single switch and this switch is located in a high voltage circuit to thereby insure reliable switching. Energization of the transformer **44** removes the simulated presence of flame by rendering the first electronic stage **11** operative. Flame relay **15** is de-energized. However, the de-energization of flame relay **15** is dependent upon flame sensing means **13** properly sensing the absence of flame. Should a fault exist which causes capacitor **56** to be charged, then discharge device **11** is maintained in its nonconductive state so that flame relay **15** cannot be de-energized, which in turn insures that main relay **23** cannot be energized.

Furthermore, not only are both electronic stage **11** and safe-start relay **31** energized from transformer **44**, but also the main burner control relay **23** is energized from this transformer. In this way, should the switch **33** of safe-start relay **31** fail during the standby of the apparatus, for example due to contact contamination, the circuit which is arranged to energize the main burner control relay is immediately opened and relay **23** cannot be energized by action of thermostat **22**.

Other embodiments of this invention will be apparent to those skilled in the art and it is therefore intended that the scope of the present invention be limited solely by the scope of the appended claims.

I claim as my invention:

1. In an electronic flame detector having means constituting an input electronic stage which is controlled by flame sensing means and means constituting an output electronic stage controlling a flame relay, the improvement comprising a first source of operating voltage connected to energize the output stage and thereby cause the flame relay to be energized to check the proper operation thereof, a second source of operating voltage, means responsive to the energization of said flame relay to apply said second source of operating voltage to the input stage and thereby cause the flame relay to be de-energized, and further means responsive to said energization of the flame relay to maintain said second source of voltage.

2. In an electronic flame detector having means constituting a first electronic stage which is controlled by flame sensing means and which in turn controls means constituting a second electronic stage to render this stage nonconductive in the absence of flame, and in which the second electronic stage controls the energization of a flame relay which is energized in the presence of flame, the improvement comprising; circuit means adapted to energize said second electronic stage, further circuit means adapted to energize said first electronic stage controlled by a normally open switch of the flame relay such that the flame relay is initially energized in the absence of flame to check the proper operation thereof and said energization thereby causes said first electronic stage to be rendered operative, to cause the flame relay to be subsequently de-energized in response to the actual absence of flame, and a safe-start relay energized by said normally open switch of the flame relay, said safe-start relay having a normally open switch which shunts said flame relay switch to thereby maintain energization of said first electronic stage once said safe-start relay is initially energized.

3. A flame detector comprising; flame sensing means, a first controllable current conducting device having an input and an output, a second controllable current conducting device having an input and an output, means connecting the input of said first current conducting device to said flame sensing means to be controlled thereby, means connecting the output of said first current conducting device to the input of said second current conducting device, a flame relay having a winding and a normally open switch, means connecting said flame relay winding to the output of said second current conducting device, a first source of operating voltage connected to energize said second current conducting device and thereby cause said flame relay to be energized to check the proper operation thereof, circuit means including the normally open switch of said flame relay adapted to connect said first current conducting device to a second source of operating voltage to render said first current conducting device oper-

ative and subsequently cause said flame relay to be de-energized, and further means energized by said second source of operating voltage and adapted to substantially maintain current flow through said first current conductive device as initially established by the normally open switch of said flame relay.

4. Condition sensing apparatus comprising; flame sensing means, a first and a second electron discharge device each having an input and an output circuit, means connecting the input circuit of said first discharge device to said flame sensing means, means connecting the output circuit of said first discharge device to the input circuit of said second electron discharge device, a flame relay having a winding and a normally open switch, circuit means connecting said flame relay winding to the output circuit of said second discharge device, a first transformer having a primary winding connected to a source of alternating voltage and a secondary winding connected to supply operating voltage to said second discharge device, a second transformer having a primary winding adapted to be connected through said normally open flame relay switch to a source of alternating voltage and having a secondary winding connected to supply operating voltage to said first electron discharge device, said second discharge device thereby being rendered conductive upon initial application of voltage to the primary winding of said first transformer to cause said flame relay to be energized to check the proper operation thereof, whereupon said normally open flame switch causes said second transformer primary winding to be connected to a source of operating voltage which will in turn affect current flow through the secondary winding of the said second transformer to cause said first electron discharge device to be energized which will then cause said flame relay to be de-energized, and further means electrically connected with said second primary winding to be energized therewith and having means to maintain said second primary winding connected to the source of alternating voltage.

5. Condition sensing apparatus comprising; a first electron discharge device having an input circuit and an output circuit, condition sensing means, means connecting said condition sensing means to the input circuit of said first discharge device in a manner to render said first discharge device nonconductive in the presence of a given condition, a second electron discharge device having an input circuit and an output circuit, circuit means connecting the input circuit of said second discharge device to the output circuit of said first discharge device in a manner to render said second discharge device conductive only when said first discharge device is nonconductive, a relay having a winding connected to the output of said second discharge device to be energized thereby and having a normally open switch, a first transformer having a primary winding adapted to be connected to a source of alternating voltage and a secondary winding connected in circuit with the output circuit of said second discharge device and said relay winding, a second transformer having a primary winding adapted to be connected through the normally open switch of said relay to a source of alternating voltage and a secondary winding connected in circuit with the output circuit of said first discharge device, and further means energized coincident with said second transformer primary winding and effective when so energized to maintain said second primary winding connected to the source of alternating voltage.

6. An electronic flame detector comprising; electrically operable flame sensing means, a first controllable current conducting device having an output circuit and having an input circuit connected to said flame sensing means such that said first current conductive device is nonconductive in the presence of flame, a second controllable current conducting device having an output circuit and having an input circuit connected to the output circuit of said first current conductive device and arranged such that said second current conductive device is conductive upon said first current conductive device being nonconductive, a flame relay connected to the output circuit of said second current conductive device to be energized in the presence of flame, a first source of operating voltage, circuit means connecting said second current conductive device to said first source of operating voltage to thereby render said second current conductive device operative, further circuit means connecting said flame sensing means to said first source of operating voltage to render said flame sensing means operative, a second source of operating voltage, circuit means controlled by said flame relay and operative to connect said first current conductive device to said second source of operating voltage upon said flame relay being energized, and further means responsive to energization of said flame relay to maintain said first current conductive device connected to said second source of operating voltage.

7. A fuel burner control apparatus for use with a fuel burner unit, comprising; a main burner control relay adapted to control the energization of the fuel burner unit; flame sensing means arranged to be subjected to the flame at the fuel burner unit, an electronic flame detector having a first and a second controllable current conducting device each having input and output electrodes, circuit means connecting said flame sensing means to the input electrodes of said first current conducting device to render said first current conducting device nonconductive in the presence of flame at the fuel burner unit, circuit means connecting the output electrodes of said first current conductive device in a controlling relation to the input electrodes of said second current conductive device to render said second current conductive device conductive in the presence of flame, a flame relay having a winding and having a normally closed and a normally open switch, circuit means connecting said flame relay winding to the output electrodes of said second current conducting device to be energized in the presence of flame; a first source of operating voltage connected to provide energizing voltage to said second current conducting device; a second source of operating voltage, circuit means controlled by said normally open flame relay switch adapted to connect said second source of operating voltage to provide operating voltage for said first current conducting device and said main burner control relay; a safe-start relay having a winding connected to be energized in response to closing of said normally open flame relay switch, a further switch controlled by said safe-start relay arranged to maintain said second current conductive device connected to said second source of operating voltage and to maintain said safe-start relay energized; and an initial energizing circuit for said main burner control relay adapted to be controlled by means responsive to the need for operation of the fuel burner unit and including said normally closed switch of said flame relay such that said main burner control relay may not be energized until said flame relay has been initially energized and then de-energized to check the proper operation thereof.

References Cited in the file of this patent

UNITED STATES PATENTS

2,216,534 Kirk ---------------- Oct. 1, 1940