Nov. 3, 1970 L. H. WALBRIDGE 3,537,804

FUEL IGNITION AND FLAME DETECTION SYSTEM

Filed March 1, 1968

3 Sheets-Sheet 1

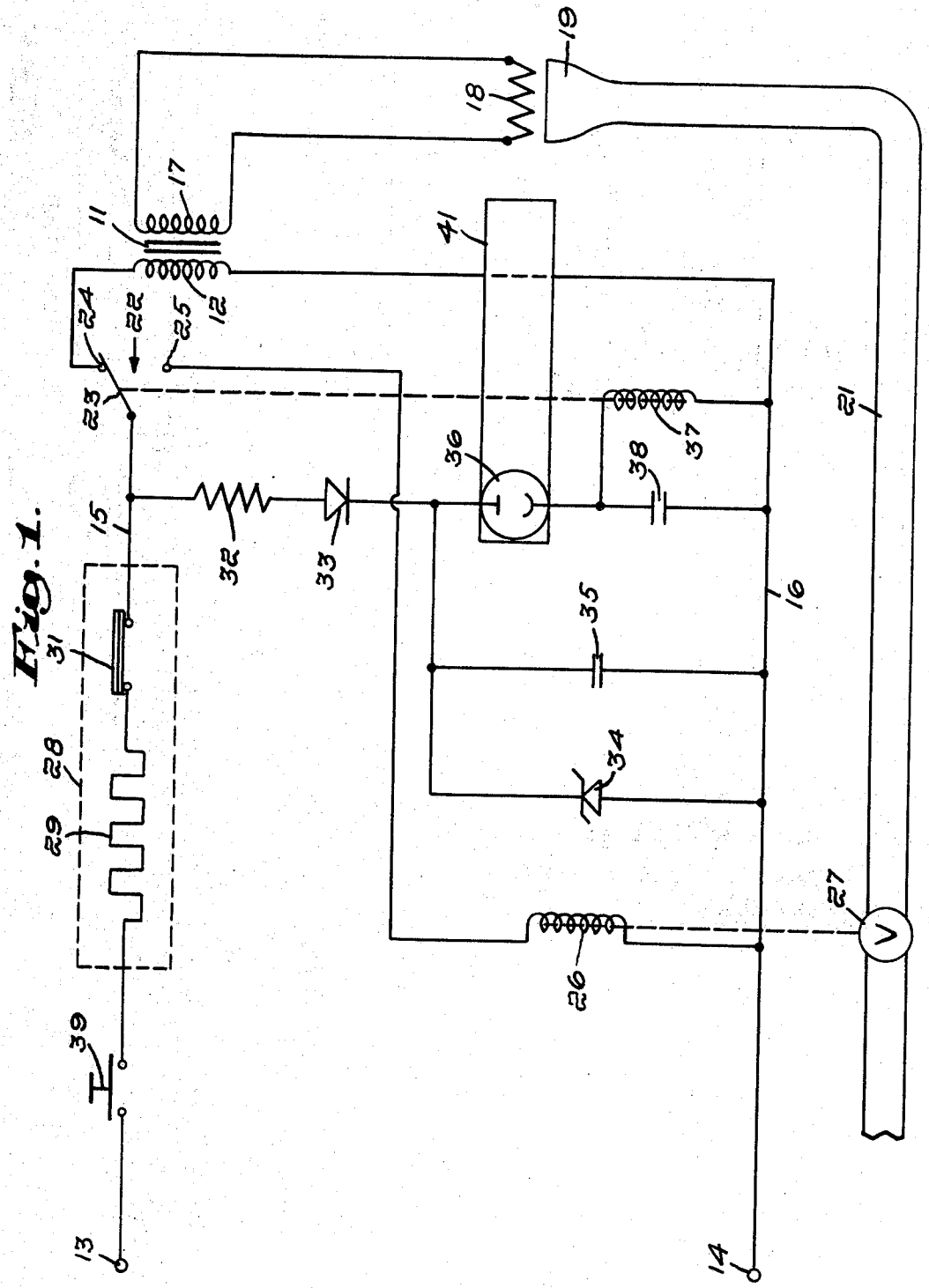


Fig. 1.

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3 Sheets-Sheet 2

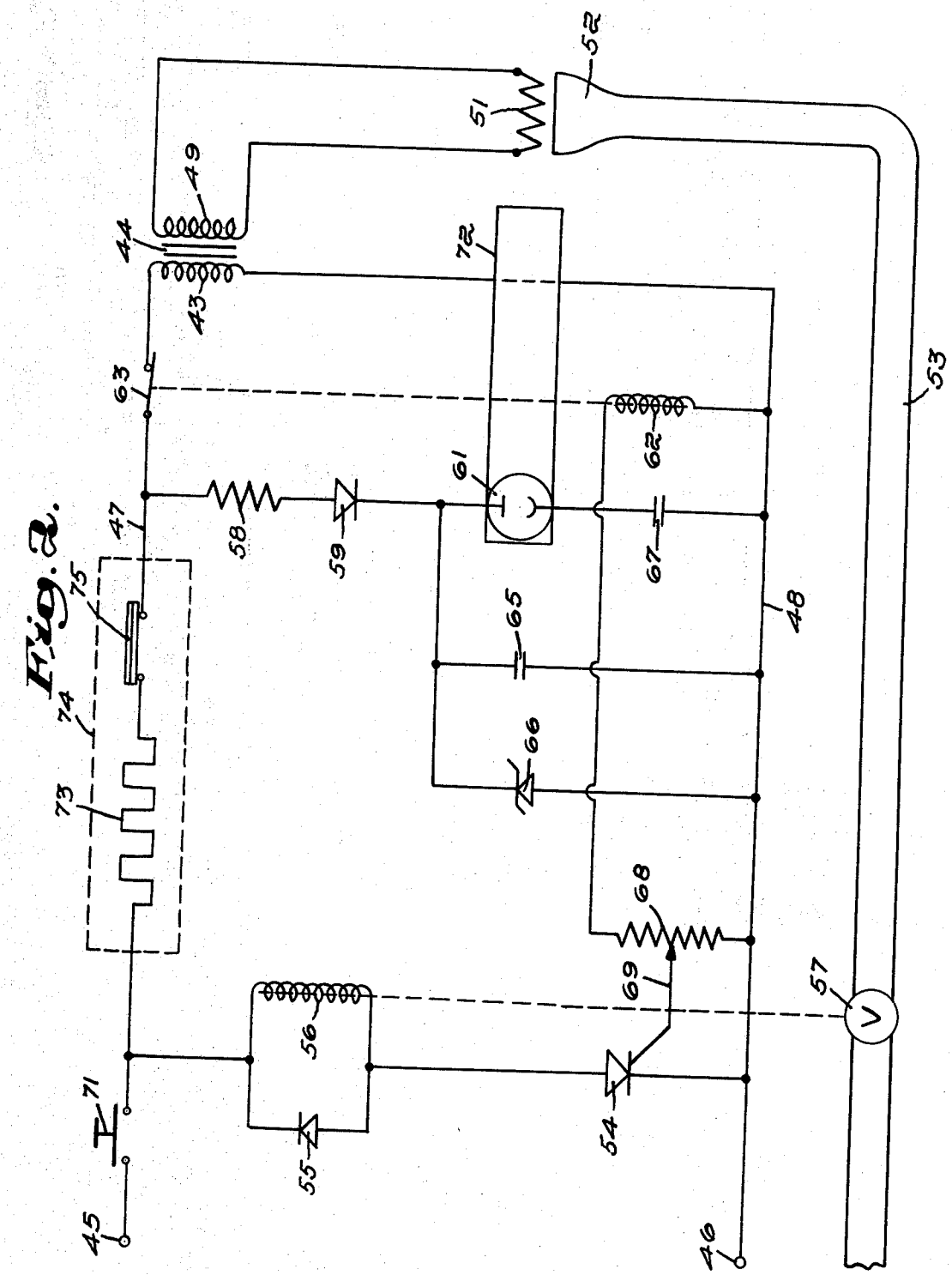


Fig. 2.

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FUEL IGNITION AND FLAME DETECTION SYSTEM

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Fig. 3.

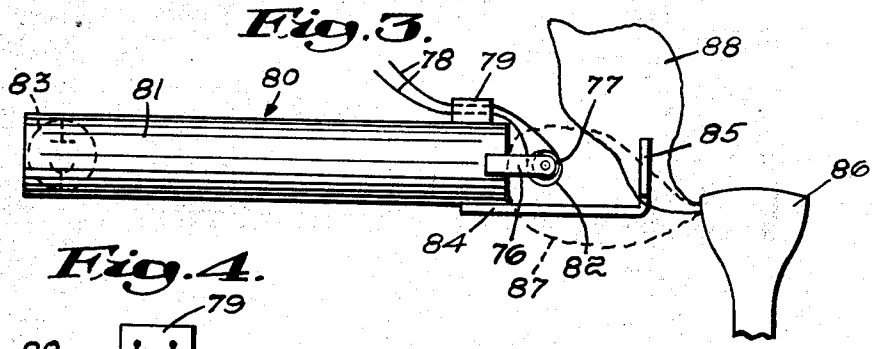


Fig. 4.

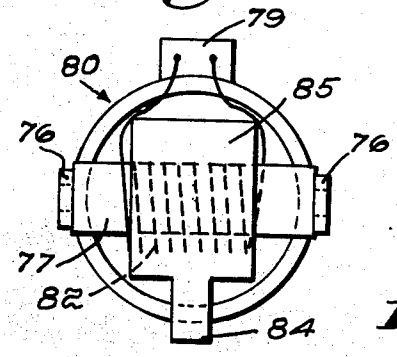


Fig. 5.

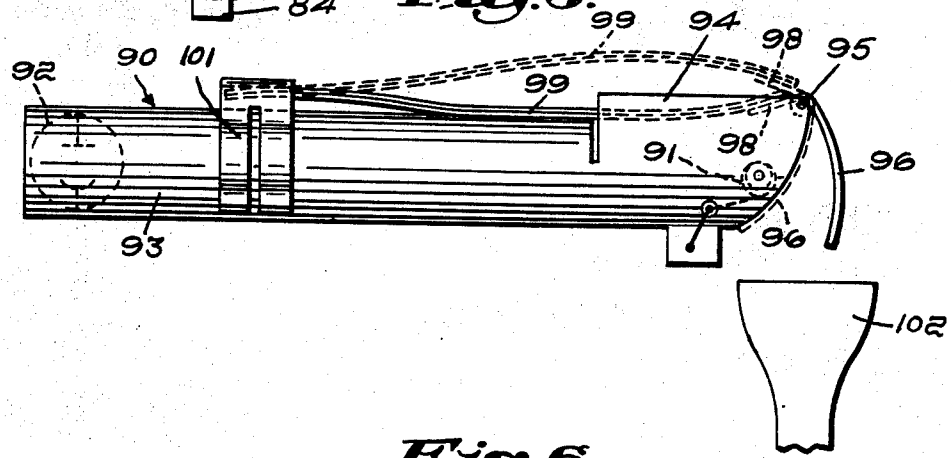
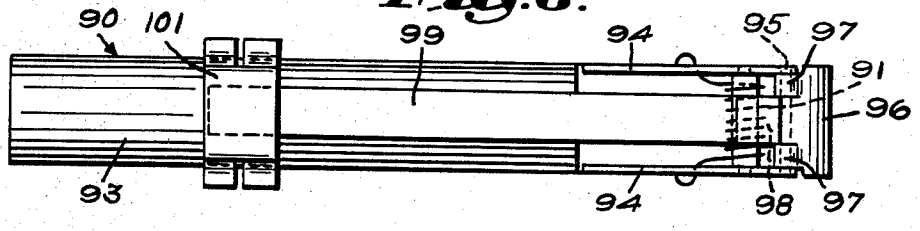


Fig. 6.



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FUEL IGNITION AND FLAME DETECTION SYSTEM

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Int. Cl. F23n 5/08
U.S. Cl. 431—66 24 Claims

ABSTRACT OF THE DISCLOSURE

A hot-wire ignition system including a photoelectric element that senses igniter temperature by detecting the radiant energy level emitted by the igniter wire. A control circuit responsive to the photoelectric element regulate both fuel flow to the burner and electrical energy flow to the igniter.

This invention relates generally to apparatus for igniting and detecting the flames produced by fuel burners of the types, for example, used in household and industrial gas appliances. More particularly, the invention relates to an improved flame ignition and detection apparatus utilizing a hot wire igniter.

Because of the substantial disadvantages associated with continuously burning pilot flames, electric fuel ignition has acquired increased commercial acceptance. The most common electrical ignition systems utilize either spaced electrodes that produce flame igniting sparks or hot wire igniters that are heated to fuel ignition temperature by electrical current. A comparison of these two demonstrates several superiorities of the hot wire igniter. For example, energization of hot wire igniters does not require either potentially dangerous high voltages or high frequency alternating currents that generate interference in certain frequency bands used for radio reception. Conversely, the primary drawback of the hot wire igniter and the principal reason for its relatively limited use is a susceptibility to thermal destruction at the high temperatures required for fuel ignition.

Various ignition control systems have been developed in attempts to alleviate the hot wire "burnout" problems. Basically, these systems have employed thermally responsive control elements or timing devices to limit the maximum temperature and/or duty cycle to which the hot wire is subjected. Although providing some improvement, existing control systems have not satisfactorily solved the nagging problem of limited igniter life.

The fundamental deficiencies of prior control systems have been slow response and an inability to detect the maximum temperature existing on the surface of the igniter wire. Because the thermal detectors such as thermocouples and thermistors used in previous systems respond primarily to conduction and convection heating, they are relatively slow acting. This is undesirable since even extremely short periods of excessive temperature can reduce the life of the ignited wire. In addition, because of the thermal sink provided by the detector's mass, the measured temperature of the directly adjacent igniter wire surface area portion can be lower than the temperature of other igniter surfaces area isolated thermally from the detector. Thus, maximum igniter surface temperature is not detected in all cases. This problem is accentuated in ignition systems utilizing a wire igniter of the type commonly known as a "glow coil." Since such coils of reasonable cost do not possess absolute uniformity, temperature gradients of as much as 1000° F. can exist in a single coil between those turns most closely and those least closely spaced.

The object of this invention, therefore, is to provide an improved fuel ignition system which extends the life of hot wire igniters.

CHARACTERIZATION OF THE INVENTION

The invention is characterized by the provision of a fuel ignition and flame detection system including a fuel burner, a fuel flow regulator for regulating fuel flow to the burner, a hot wire igniter adapted for energization to ignite fuel discharged by the burner, an energy regulator for regulating the flow of electrical energy to the igniter, a photoelectric sensor positioned to detect the level of radiant energy emitted by the igniter, and a control system responsive to the photoelectric sensor and adapted to control the fuel and energy regulators. The photoelectric sensor provides an extremely fast measurement of substantially the hottest surface area portion on the hot wire igniter.

One feature of the invention is the provision of a fuel ignition and flame detection system of the above type wherein the control system and energy regulator prevent the flow of electrical energy to the hot wire igniter in response to detection by the photoelectric sensor of radiant energy levels above a given maximum and the control system and fuel flow regulator produce fuel flow to the burner only in response to detection of radiant energy levels above a given minimum. According to this arrangement, both energy flow that would raise the temperature of the wire igniter to particularly harmful values above a predetermined maximum and unsafe fuel flow to the burner when the igniter is below a predetermined minimum temperature required to insure fuel ignition are eliminated.

Another feature of this invention is the provision of a system of the above featured type wherein in response to heat generated by burning fuel the igniter wire is adapted to emit radiant energy at a level above the given minimum. Here, the igniter wire exercises the additional function of a flame detector to both insure a continuous supply of fuel and prevent electrical energization of the igniter in response to the presence of a flame.

Another feature of the invention is the provision of a system of the above featured type wherein the maximum radiant energy level at which electrical heat can be applied to the detector and the minimum energy level required for fuel flow are equal. By controlling both the fuel flow regulator and the electrical energy regulator at the same temperature, the desired regulation is obtained with a relatively simple control system.

Another feature of this invention is the provision of a system of the above featured type wherein the control system comprises an electrical relay having a first set of contacts controlling the flow of electrical energy to the igniter wire and a second set of contacts controlling the flow of fuel to the burner and wherein energization of the relay produces actuation of the first contacts prior to actuation of the second contacts. This sequence of contact operation positively eliminates any simultaneous application of both electrical and flame energy to the igniter.

Another feature of this invention is the provision of a system of the first featured type wherein the minimum radiant energy level required for fuel flow is lower than the maximum radiant energy level that allows electrical energy flow. By making the control system responsive to different radiant energy levels, the flow of electrical energy to the igniter can be maintained for some period after initiation of fuel flow to the burner thereby permitting the use of igniters having extremely low mass.

Another feature of this invention is the provision of a system of the above featured types including an auxiliary target adapted to be heated by burning fuel discharged from the burner and to transmit radiant energy to the

photoelectric sensor. The use of an auxiliary target as a flame detector permits the system to operate as described above even though the igniter wire is cooled to relatively low temperatures during fuel burning periods.

Another feature of this invention is the provision of a system of the above featured types wherein the auxiliary target is positioned so as to be heated to a higher energy radiating level by burning fuel discharged from the burner than is the igniter wire. According to this arrangement, the igniter wire is positioned in a region permeated by fuel initially discharged from the burner but out of the primary region occupied by flames after ignition of the fuel while the auxiliary target is disposed directly in the flame area.

Another feature of this invention is the provision of a system of the next above featured type including a shield adapted to thermally isolate the igniter wire from burning fuel. Because of the thermal shield, the igniter can be maintained at low temperatures during fuel burning periods thereby prolonging its useful life.

These and other features and objects of the present invention will become more apparent upon a perusal of the following specification taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a schematic circuit diagram illustrating one embodiment of the invention;

FIG. 2 is a schematic circuit diagram illustrating another embodiment of the invention;

FIG. 3 is a schematic side view of an igniter assembly embodiment of the invention;

FIG. 4 is a schematic end view of the assembly shown in FIG. 3;

FIG. 5 is a schematic side view of another igniter assembly embodiment of the invention; and

FIG. 6 is a schematic top view of the assembly shown in FIG. 5.

Referring now to FIG. 1 there is shown the transformer **11** having the primary winding **12** connected to the power input terminals **13** and **14**, respectively, by lines **15** and **16**. Connected in series with the secondary winding **17** of the transformer **11** is the hot wire igniter **18** which is preferably of the glow coil type. The igniter **18** is positioned so as to ignite gaseous fuel fed to the burner **19** through the fuel line **21**.

Disposed in the line **15** is the switch **22** having the contact **23** adapted for selective engagement with either the first contact **24** or the second contact **25**. Engagement of movable contact **23** with the first contact **24** connects the primary winding **12** across the input terminals **13** and **14** while engagement with the second contact **25** connects the solenoid **26** across the input terminals **13** and **14**. The solenoid **26** actuates the valve **27** in the fuel line **21**. Also connected in line **15** is the overload breaker **28** having the heater element **29** and manually resettable warp switch **31**.

Connected in series between the lines **15** and **16** are the resistor **32**, the diode **33** and the parallel combination of the voltage regulating diode **34** and the capacitor **35**. In parallel with the diode **34** and the capacitor **35** are the series connected photocell **36** and the electromagnetic coil **37** that operates the switch **22**. The capacitor **38** is connected directly across the relay coil **37**.

To initiate operation of the system, the manual switch **39** is closed energizing the primary winding **12**. The resultant current flow in the secondary winding **17** produces resistive heating of the igniter coil **18** until a predetermined temperature of, for example, 2400° F. is reached. At that temperature the igniter coil **18** emits a given level of radiant energy which is transmitted to the photocell **36** through the hollow radiation shield tube **41**. The selected characteristics of the photocell **36** are such that, in response to the given radiant energy level, its resistance is sufficiently lowered to permit energizing current flow through the relay coil **37** after a slight delay produced by the capacitor **38**. Energization of the coil **37** opens contacts **23** and **24** and closes contacts **23** and **25** thereby opening the circuit to the primary winding **12** and closing the circuit to the electromagnetic valve solenoid **26**. Thus, energy flow to the igniter **18** in the form of induced secondary current is terminated and the fuel valve **27** is opened initiating fuel flow to the burner **19**. The fuel discharged by the burner **19** is ignited by the igniter **18** which, although deenergized, remains at a temperature above that required for ignition of the discharged fuel.

Heat generated by the burning fuel maintains the igniter coil **18** at an energy radiating level above that required for the above described response by the photocell **36**. Therefore, the coil **37** remains energized to both maintain fuel flow to the burner **19** and prevent electrical energy flow to the igniter **18**.

However, if for any reason, fuel ignition does not occur the igniter coil **18** quickly cools to a temperature below the range detectable by the photocell **36**. The resultant increase in the photocell resistance attenuates current flow through the winding **37** thereby causing switch contacts **23** and **25** to open and switch contacts **23** and **24** to close. Accordingly, valve solenoid **36** is deenergized to close fuel valve **27** and interrupt fuel flow and the transformer **11** is energized to resume flow of electrical energy to the igniter coil **18**. Thus, the ignition procedure described above automatically repeats until fuel ignition actually occurs. However, if ignition is not accomplished after a predetermined cycling period of, for example, **30** seconds the resistive heating generated in the heater element **29** causes opening of the warp switch **31** thereby terminating system operation. The switch **31** must then be manually reset to initiate a new ignition cycle.

Thus, the system automatically initiates fuel flow only when the igniter **18** reaches a given temperature required for fuel ignition, interrupts electrical energy flow to the igniter **18** in response to detection of that given temperature, repeats the ignition step if ignition does not occur, terminates the ignition procedure after a predetermined number of unsuccessful cycles and terminates fuel flow in response to flame extinguishment. These operations provide two extremely desirable results. First, the discharge of unburned fuel in dangerous amounts is prevented. Second, the igniter coil never is heated either simultaneously by both electrical energy and burning fuel or to above a given maximum temperature by electrical energy alone. By so limiting its thermal exposure, the useful life of the igniter coil **18** is substantially lengthened. Furthermore, these advantages are uniquely obtained by use of the radiant energy sensing photocell **36**. Because the photocell **36** detects instantaneously substantially the highest temperature existing on the surface of the coil **18**, the system alleviates the danger of coil destruction because of undeteced excessive temperatures existing in discrete sections of the coil.

Referring now to FIG. 2 there is shown another embodiment of the invention having the primary winding **43** of the transformer **44** connected to the input terminals **45** and **46**, respectively, by lines **47** and **48**. Connected in series with the secondary winding **49** of transformer **44** is the igniter coil **51** which is positioned to ignite fuel supplied to the burner **52** through the fuel line **53**. Between the input terminals **45** and **46** are connected the silicon controlled rectifier **54** and the parallel combination of the diode **55** and solenoid **56** that controls the fuel regulation valve **57** in the fuel line **53**. Also connected in series across terminals **45** and **46** are the resistor **58**, the diode **59**, the photocell **61** and the relay winding **62**. The relay winding **62** operates the switch contacts **63** that regulate flow of electrical energy through the primary winding **43**. Each connected in parallel with both the photocell **61** and winding **62** is the capacitor **65** and the voltage regulator diode **66**. The capacitor **67** and the variable potentiometer **68** are each connected across the relay winding **62**. Cou-

pled to the adjustable tap 69 of the potentiometer 68 is the control electrode of the rectifier 64.

To initiate operation of this embodiment, the manual switch 71 is closed producing current flow through the primary winding 43. The resultant secondary current in winding 49 energizes the igniter coil 51. In response to the increasing level of radiant energy received from the igniter coil 51 through the hollow radiation shield tube 72, the resistance of the photocell 61 decreases. At a predetermined minimum temperature of, for example, 2200° F. the photocell resistance is lowered to a value that permits sufficient current flow in the potentiometer 68 to gate the rectifier 54. This produces energizing current flow through the solenoid 56 which opens the fuel regulation valve 57 to thereby provide fuel flow to the burner 52.

At a slightly higher maximum temperature of, for example, 2400° F. the radiant energy level emitted by the igniter coil 61 reduces the resistance of the photocell 61 sufficiently to permjt energizing current flow in the relay winding 62. The resultant opening of switch contacts 63 interrupts current flow to the primary 43 and accordingly to the igniter coil 51. Even after termination of electrical energy flow to the igniter coil 51, the heat generated by the burning fuel maintains its temperature above the energy radiation level required to maintain energization of both the valve solenoid 56 and the relay winding 62. Therefore, the regulator valve 57 remains opened providing a continuous flow of fuel and the switch contacts 63 remain open preventing electrical current flow to the coil 51.

If for any reason fuel ignition is not accomplished, the temperature of the igniter coil 51 quickly falls to an energy radiating level below that required for either energization of the relay winding 62 or for gating of the rectifier 54. Consequently, the solenoid 56 is deenergized to close the fuel regulation valve 57 and the switch contacts 63 are closed to resume current flow to the transformer 44. Resultant energy flow to the igniter coil 51 again raises its temperature to above both the minimum and maximum values required for the control operations described above. These ignition cycles continue until either ignition occurs or the heater element 73 in the overload breaker 74 causes opening of the warp switch 75. Initiation of a new ignition cycle requires manual closing of the warp switch 75.

Thus, as in the embodiment of FIG. 1, the system shown in FIG. 2 automatically initiates fuel flow only when the igniter 51 has reached a predetermined minimum temperature necessary for ignition, terminates electrical energy flow to the igniter 51 in response to detection of a given maximum temperature, repeats the ignition procedures if ignition does not occur, terminates the ignition procedures after a predetermined number of cycles, and discontinues fuel flow in response to flame extinguishment. Therefore, the advantages discussed above in connection with FIG. 1 also are present here.

In addition, the separately activated rectifier 54 and relay winding 62 permit independent control of the fuel regulator valve 57 and energy regulating switch contacts 63. Consequently, the fuel flow and energy flow functions can respond to different temperature levels as in the above described operation wherein the temperature at which fuel flow is initiated is slightly lower than that at which current flow to the coil 51 is interrupted. This important feature eliminates any period prior to ignition wherein the coil 51 is actually cooling. Accordingly, the coil 51 can possess relatively little mass which allows it to quickly reach ignition temperature.

Referring now to FIGS. 3 and 4, there is shown a preferred igniter assembly 80 embodiment of the invention. Mounted on tabs 76 from one end of and axially aligned with the hollow radiation shield tube 81 is the ceramic rod 77. The igniter coil 82 is supported by the rod 77 and has ends connected to the leads 78 in the insulator block 79. Mounted in the opposite end of the shield tube 81 is the photocell 83 which receives radiant energy emitted by the igniter coil 82. Also supported by the tube 81 on the mounting bracket 84 is the target 85 aligned with the photocell 83 and the igniter coil 82.

The igniter assembly 80 is uniquely suited for use in the system embodiments shown in FIGS. 1 and 2. After the igniter coil 82 has been heated by electrical current to predetermined temperature levels, the photocell 83 responds, as described above, to both initiate fuel flow to the burner 86 and denergize the coil. Fuel is first discharged from the burner 86 in a pattern schematically illustrated by the dotted lines 87. That fuel engulfs the hot igniter 82 which prompts ignition. Because of the heat generated air currents, the resultant flame 88 is forced upward and away from the deenergized igniter coil 82 which, therefore, cools to below ignition temperature. However, the flame 87 is in close heat exchanging relationship with the auxiliary target 85 which is heated to a temperature substantially higher than that experienced by the igniter coil 82. The material, for example Inconel, for the target 85 is selected so as to transmit to the photocell 83 at the temperature produced by the flame 87, a radiating energy level sufficient to both maintain fuel flow and prevent electrical current flow to the igniter coil 82. Thus, in addition to insuring the various operating advantages described above, the igniter assembly 80 further reduces the thermal load on the igniter coil 82 during fuel burning periods. Because of the reduced thermal load, the life expectancy of a coil 82 is significantly lengthened.

FIGS. 5 and 6 illustrate another preferred igniter assembly 90 embodiment of the invention. As shown, the igniter coil 91 and photocell 92 are mounted in opposite ends of the hollow radiation shield tube 93. The tube 93 has one end portion longitudinally split forming the upward projecting ear members 94. Extending between the ear members 94 above the igniter coil 91 is the pin 95. The auxiliary target 96 has an upper end divided into outer leaves 97 rotatably supported by the pin 95 and center leaf 98 attached to one end of the elongated bimetal element 99. Vertically restraining the opposite end of the bimetal element 99 is the clip 101. As shown, the target 96 has a curved shape conforming to the adjacent edge of the tube 93.

The igniter assembly 90 also is uniquely suited for use with the systems shown in FIGS. 1 and 2. Energization of the igniter coil 91 to a predetermined minimum ignition temperature excites the photocell 92 to both initiate fuel discharge from the burner 102 and interrupt electrical energy flow to the igniter coil. The burning fuel heats the bimetal element 99 which bows upward and moves the target 96 into contact with the tube 93 as shown with dotted lines in FIG. 5. With the target in this position the igniter coil 91 is shielded from the burner flame and is therefore maintained at relatively low temperatures during fuel burning periods. However, the target 96 is fully heated by the flame to an energy radiating level sufficient to sustain excitation of the photocell 92 which responds by maintaining fuel flow to burner 102 and preventing electrical energy flow to the igniter coil 91. The hot target 96 also provides by conduction the heat necessary to maintain the bimetal element 99 in its bowed position. Thus, as in the embodiments of FIGS. 3 and 4, the igniter assembly 90 insures reduced temperatures for the igniter coil 91 during fuel burning periods thereby extending its useful life.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. For example, the individual features shown in the various embodiments can be used in combinations other than those shown. Also, it is to be understood that the term hot wire igniter used in the specification embraces all types of hot surface igniters including, for example, rods, bars, etc. Similarly, photoelectric sensing elements other than photocells can be used to detect the desired radiant energy levels. It is, therefore, to be understood

that within the scope of the appended claims the invention can be practiced otherwise than as specifically described.

What is claimed is:

1. A fuel ignition and flame detection system comprising a fuel burner, fuel flow regulator means for regulating the flow of fuel to said burner, igniter means adapted to be electrically heated to fuel ignition temperature and to ignite fuel discharged by said burner, energy regulator means for regulating the flow of electrical energy to said igniter means, photoelectric sensing means disposed to detect the level of radiant energy emitted by said igniter means, and control means actuated by said photoelectric sensing and adapted to control said fuel flow regulator means and said energy regulator means in response to the level of radiant energy emitted by said igniter means.

2. A fuel ignition and flame detection system according to claim 1 wherein said control means and said energy regulator means are adapted to prevent the flow of electrical energy to said ignition means in response to detection by said sensing means of radiant energy levels emitted by said igniter means above a given maximum, and said control means and said fuel flow regulator means are adapted to produce fuel flow to said burner only in response to detection by said sensing means of radiant energy levels emitted by said igniter means above a given minimum.

3. A fuel ignition and flame detection system according to claim 2 wherein said igniter means is adapted to be heated to a radiating energy level above said maximum and minimum levels by burning fuel discharged by said burner.

4. A fuel ignition and flame detection system according to claim 3 including an optical shield means adapted to transmit radiant energy to said photoelectric sensing means only along the rectilinear path joining said igniter means and said sensing means and wherein said maximum and minimum radiant energy levels are equal.

5. A fuel ignition and flame detection system according to claim 4 wherein said ignition means comprises a resistive element adapted to conduct electrical heating current.

6. A fuel ignition and flame detection system according to claim 5 wherein said energy regulator means comprises first electrical switch means, said fuel flow regulator means comprises an electrically operated valve and second electrical switch means, and said control means comprises electromagnetic means adapted to actuate said first and second electrical switch means so as to prevent current flow to said resistive element and open said valve in response to detection by said sensing means of said radiant energy level.

7. A fuel ignition and flame detection system according to claim 6 wherein said first switch means is adapted for actuation to interrupt current flow prior to the actuation of said second switch means to open said valve.

8. A fuel ignition and flame detection system according ot claim 3 wherein said energy regulator means and said fuel flow regulator means are independently controlled by said control means and said minimum radiant energy level is lower than said maximum radiant energy level.

9. A fuel ignition and flame detection system according to claim 8 wherein said ignition means comprises a resistive element adapted to conduct electrical heating current.

10. A fuel ignition and flame detection system according to claim 9 wherein said control means comprises one electrical actuator responsive to said sensing means and adapted to actuate said energy regulator means in response to detection by said sensing means of said maximum radiant energy level, and a second electrical actuator responsive to said sensing means and adapted to actuate said fuel flow regulator in response to detection by said sensing means of said minimum radiant energy level.

11. A fuel ignition and flame detection system according to claim 2 wherein said igniter means is disposed so as to be directly contacted by fuel discharged from said fuel burner and including target means adapted to be heated by burning fuel discharged by said burner and to supply radiant energy to said sensing means.

12. A fuel ignition and flame detection system according to claim 11 wherein said target is adapted for heating by said burning fuel to an energy radiating level above said maximum and minimum levels.

13. A fuel ignition and flame detection system according to claim 12 wherein said maximum and minimum radiant energy levels are equal.

14. A fuel ignition and flame detection system according to claim 13 wherein said ignition means comprises a resistive element adapted to conduct electrical heating current.

15. A fuel ignition and flame detection system according to claim 12 wherein said energy regulator means and said fuel flow regulator means are independently controlled by said control means and said minimum radiant energy level is lower than said maximum radiant energy level.

16. A fuel ignition and flame detection system according to claim 15 wherein said ignition means comprises a resistive element adapted to conduct electrical heating current.

17. A fuel ignition and flame detection system according to claim 12 wherein said target means is adapted to be heated to a higher energy radiating level by burning fuel discharged by said burner than is said igniter means.

18. A fuel ignition and flame detection system according to claim 17 wherein said maximum and minimum radiant energy levels are equal.

19. A fuel ignition and flame detection system according to claim 18 wherein said ignition means comprises a resistive element adapted to conduct electrical heating current.

20. A fuel ignition and flame detection system according to claim 17 wherein said energy regulator means and said fuel flow regulator means are independently controlled by said control means and said minimum radiant energy level is lower than said maximum radiant energy level.

21. A fuel ignition and flame detection system according to claim 20 wherein said ignition means comprises a resistive element adapted to conduct electrical heating current.

22. A fuel ignition and flame detection system according to claim 17 including heat shield means adapted to shield said igniter means from the heat produced by burning fuel discharging from said burner.

23. A fuel ignition and flame detection system according to claim 22 wherein said heat shield means is adapted for movement into a heat shielding position in response to heat generated by burning fuel discharging from said burner.

24. A fuel ignition and flame detection system according to claim 23 wherein said target comprises said heat shield means.

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EDWARD G. FAVORS, Primary Examiner

U.S. Cl. X.R.

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