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SPARK RESPONSIVE SAFETY CONTROL SYSTEM FOR GAS BURNERS

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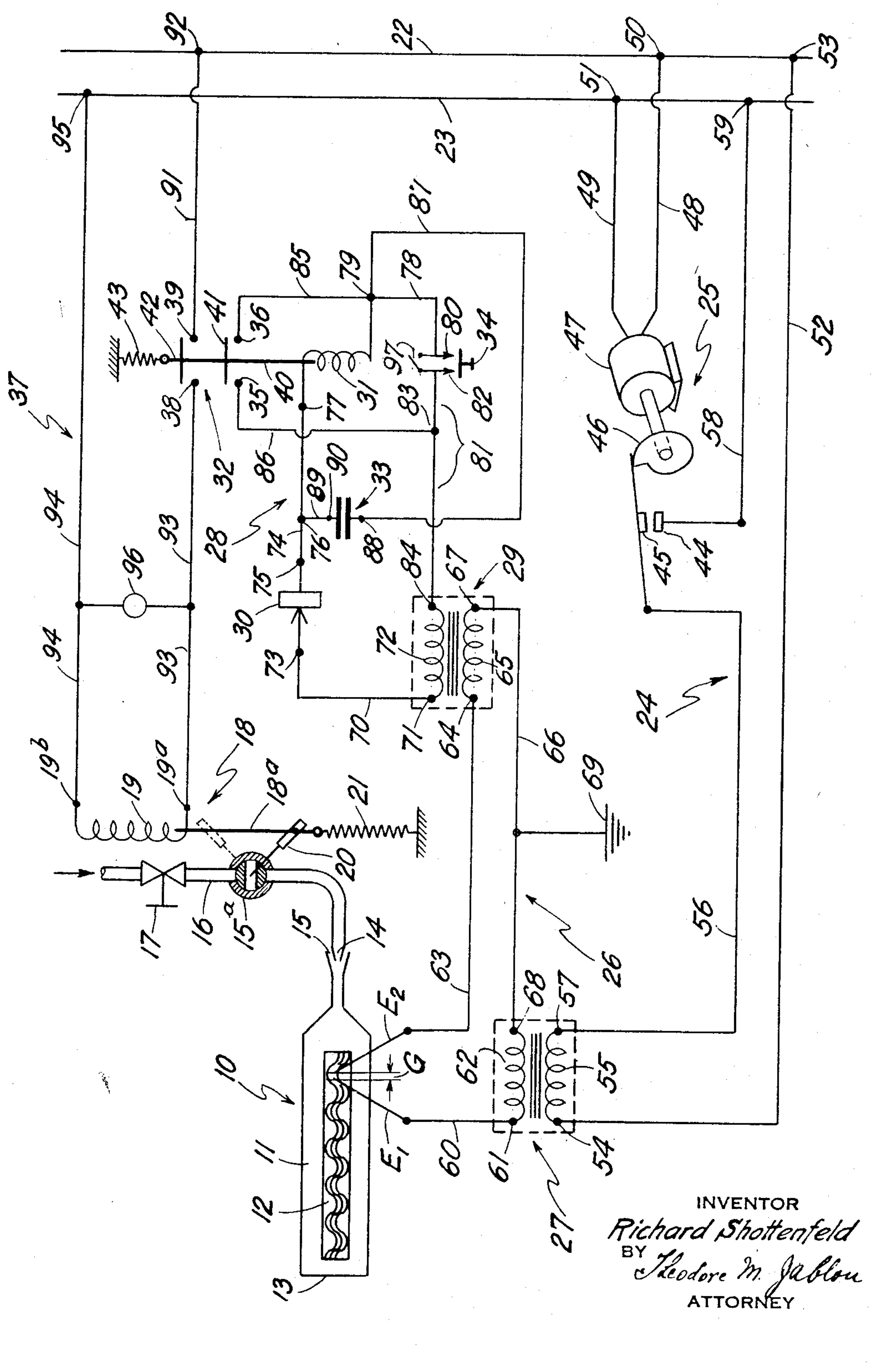

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SPARK RESPONSIVE SAFETY CONTROL SYSTEM FOR GAS BURNERS

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2 Claims. (Cl. 158—128)

This invention relates to gas burners provided with ignition by electric spark for currently insuring ignition of the gas; more specifically this relates to safety devices for automatically shutting off the gas supply to the burner when the ignition spark fails for example due to power failure. Normally the spark is produced by current from a so-called ignition transformer which delivers an alternating current of high enough voltage to cause a spark to jump the air gap between a pair of electrodes as long as such current is being delivered to the electrodes.

According to one aspect, this invention relates to what may be termed interrupted spark operation, namely a mode of operation in which the spark-producing current is interrupted rhythmically as by an interrupter for the current that feeds the ignition transformer. In this way, brief periods during which the spark is alive alternate with similarly brief periods during which the spark is dead. These periods will herein be termed the on-periods and the off-periods or the live- and the dead-periods of the spark.

The purpose of interrupted spark operation is to reduce power consumption, reduce wear of the electrodes, and to reduce the average load on the transformer so that smaller electrical conductors may be employed. To be thus effective the lengths of the off- and on-periods are so proportioned that the off-period is too short to allow for the escape of a dangerous amount of gas from the burner in the absence of a flame, while the on-period is long enough to provide a reasonable length of time for ignition yet short enough to minimize power consumption and load. To meet these requirements suitable proportions are of the order of 3 seconds for the off-periods and of the order of 3 seconds for the on-periods.

While a variety of automatic safety devices or safety control systems in general are known for shutting off the gas in case of spark failure, a problem lies in rendering such devices properly responsive where a system of interrupted spark operation is employed. The problem lies in devising means for rendering the safety device non-responsive during the off-periods, but responsive to shut off the gas whenever the spark remains off longer than the normal off-period provided for by the interrupter.

Another problem lies in devising such a safety control system that will be secure against rendering an erroneous or uncalled for response in case of any fault within the system itself. That

is to say, if any component or element of the safety control system should fail, the response should invariably be on the safe side, namely to shut off the gas.

It is among the objects of this invention to provide a safety control system which is simple and inexpensive to manufacture, for preventing gas shut-off during the off-periods of the spark, yet to shut off the gas promptly when the spark remains off for a length of time appreciably in excess of the normal off-period; to provide such a system that is fool proof in the sense that it is safe against rendering uncalled for response in case a fault develops in the system, in other words to provide a system in which any fault in the system itself will assuredly cause the gas to be shut off; to provide such a system in which the spark must be restored manually as by push button operation; and to provide a system that is fool proof in regard to the push button operation, in the sense that irrespective of the length of time the push button is held pressed for opening the gas valve the closure of the gas valve will nevertheless be assured when the spark is absent.

According to the invention these objects are attained by providing a system in which an alternating current detector or monitor circuit is dependent upon and coupled through a step-down transformer, herein termed the detector transformer, with the spark-producing high voltage circuit. The term detector or monitor circuit is herein used to mean that it is energized while the spark is functioning properly and is dead when the spark is dead. This detector circuit, according to the invention, carries an alternating current which is rectified for energizing the solenoid of a direct-current operated relay switch for opening and closing an independent energizing circuit for activating a solenoid that opens and closes the gas supply valve for the burner in accordance with the opening and closing of the independent energizing circuit.

Associated with the solenoid of the relay switch is a condenser so dimensioned as to store up, during each on-period of the spark, sufficient energy adapted in turn to discharge from the condenser in a solenoid-energizing direction for holding the relay solenoid energized and the relay switch closed during the off-periods of the spark, but not for any length of time appreciably in excess of the length of the off-period of the spark.

According to one feature the detector circuit has in it a rectifier, the condenser is connected across the relay solenoid coil, a push button switch is provided and operable to close the detector circuit, and the relay switch comprises switch contacts which close when the relay switch is energized to close, so as to hold the detector circuit closed as long as the spark is operating normally although with the prescribed interruptions.

A safety control system embodying the invention comprises a primary power supply circuit with interrupter; a high voltage spark-producing circuit with spark electrodes for the gas burner and coupled through the ignition transformer with the supply circuit; a detector circuit coupled through the detector transformer with the spark-producing circuit, and having a rectifier in circuit with the solenoid of the relay switch as well as a condenser connected in parallel with the solenoid coil; and a relay controlled power supply for energizing the solenoid that operates the gas valve for the burner by the closing and opening of the relay switch of the detector circuit.

As this invention may be embodied in several forms without departing from the spirit or essential characteristics thereof, the present embodiment is therefore illustrative and not restrictive, since the scope of the invention is defined by the appended claims rather than by the description preceding them, and all changes that fall within the metes and bounds of the claims are therefore intended to be embraced by those claims.

The drawing figure shows the burner with solenoid-actuated gas supply valve diagrammatically, as well as an associated wiring diagram embodying the invention.

A tube-shaped gas burner 10 is indicated by a burner tube 11 having a longitudinal gas port 12 producing a ribbon-like flame when the burner is lit. The burner tube is closed at one end 13 and is supplied with gas at the other end from a gas nozzle 14 surrounded by an annular passage 15 through which the gas jet from the nozzle draws combustion air. Associated with the burner is a pair of spark electrodes E_1 and E_2 presenting between them a spark gap G.

The gas supply to the nozzle 14 is by way of a solenoid-controlled valve 15^a provided in a gas supply pipe 16 having a hand-operated main shut-off valve 17. An electromagnetically operated mechanism, for example solenoid 18 for opening and closing valve 15^a comprises an armature 18^a and a solenoid coil 19 having terminals 19^a and 19^b, the armature engaging a valve-actuating arm 20. The valve 15^a is held closed by a spring 21 acting upon the armature in a valve closing direction when the solenoid coil 19 is deenergized, while energization of the solenoid coil 19 will pull the armature upwardly against the tension of spring 21 to open the valve and to keep it open as long as the solenoid coil remains energized.

The system is supplied with operating current from supply lines 22 and 23 furnishing a suitable alternating current, for example of 110 volts. In terms of a general outline the system for producing the control effects comprises a primary power supply circuit 24 with an interrupter 25, a spark-producing circuit 26 with electrodes E_1 and E_2 and supplied from circuit 24 through a step-up transformer 27 herein termed the ignition transformer having a step-up ratio of the order of 110 volts to about 5000 volts for jumping the spark gap G; a detector circuit 28 coupled with the spark producing circuit 26 through a step-down transformer 29 herein termed the detector transformer, this circuit having a rectifier 30 in circuit with the solenoid coil 31 of a relay switch 32, and a condenser 33 connected across the solenoid coil 31, which detector circuit may be closed by a starting switch shown in the form of a push button 34 adapted to close and open a pair of contacts 80 and 82, which starting switch is in parallel with a pair of contacts 35 and 36 adapted to be closed and to be held closed by relay switch 32; and a relay-controlled supply circuit 37 for energizing solenoid 19 which circuit is adapted to be closed and to be held closed by the relay switch 32 closing a pair of contacts 38 and 39. When the spark across gap G functions normally although rhythmically interrupted, the relay switch 32 will be held closed so that solenoid coil 19 is energized without interruption and armature 18^a held constantly in valve-closing position.

The relay switch 32 comprises an armature 40 actuated by the solenoid coil 31 and has a pair of switch members 41 and 42 whereby it simultaneously closes and opens contacts 35 and 36 as well as contacts 38 and 39. A spring 43 acting upon armature 40 holds these contacts open when coil 31 is de-energized.

The interrupter 25 comprises a pair of contacts 44 and 45, contact 44 stationary and contact 45 movable. These contacts are rhythmically opened and closed by a rotary cam member 46 engaging the movable contact 45, the cam member 46 being rotated as by a motor 47 supplied with current through conductors 48 and 49 leading to points 50 and 51 respectively on supply lines 22 and 23.

Now follows a more detailed description of the safety control system in terms of the circuits just outlined, namely the primary power supply circuit 24, the spark-producing circuit 26, the detector circuit 30 and the relay-controlled power supply circuit 37.

The primary power supply circuit 24 comprises a conductor 52 leading from a point 53 on power line 22 to a terminal 54 of a primary transformer coil 55 of the ignition transformer 27, a conductor 58 leading from a terminal 57 of transformer coil 55 to movable interrupter contact 45, a conductor 58 leading from stationary interrupter contact 44 to a point 59 on power line 23.

The spark-producing circuit 26 comprises a conductor 60 leading from a terminal 61 of secondary coil 62 of ignition transformer 27 to spark electrode E_1; a conductor 63 leading from spark electrode E_2 to a terminal 64 of primary coil 65 of detector transformer 29; a conductor 66 leading from a terminal 67 to a terminal 68 of secondary coil 62 of ignition transformer 27, conductor 66 being grounded as at 69. The characteristics of the ignition transformer 27 are such that when a spark is maintained across gap G then the spark producing circuit 26 operates substantially as a constant current circuit in which variations of impedance do not effect appreciable changes in the magnitude of the spark producing current. Therefore the term ignition transformer herein connotes a transformer having the characteristics just defined.

The detector circuit 28 comprises a conductor 70 leading from a terminal 71 of secondary coil 72 of detector transformer 29 to a terminal 73 of rectifier 30 which may be in the nature of a selenium rectifier; a conductor 74 leading from a terminal 75 of the rectifier by way of point 76 to a terminal 77 of relay solenoid coil 31; a conductor 78 leading from a terminal 79 of solenoid coil 31 to a contact 80 of push button switch 34; a conductor 81 leading from a contact 82 of the push button switch by way of point 83 to a terminal 84 of secondary coil 72 of detector transformer 29, a conductor 85 leading from point 79 to relay switch contact 36 and a conductor 86 leading from relay switch contact 35 to point 83, so that relay switch contacts 35 and 36 can be closed in parallel with push button contacts 80 and 82; a conductor 87 leading from point 79 to a terminal 88 of condenser 33 and a conductor 89 leading from a terminal 90 of the condenser to point 76.

The relay-controlled power supply circuit 37 comprises a conductor 91 leading from a point 92 on power line 22 to relay switch contact 39; a conductor 93 leading from relay switch contact 38 to terminal 19a of solenoid coil 19; and a conductor 94 leading from terminal 19b of solenoid coil 19 to a point 95 on power line 23. A signal light 96 connected across solenoid coil 19 is lit to indicate the gas valve being open with spark operation being in order, the light being extinguished when due to failure of the spark to operate normally or due to any fault in the system the solenoid 19 is de-energized and the gas valve 15a is shut.

Operation

In order to start the burner as well as the spark, with the main gas valve 17 open, the 110 volt power from lines 22 and 23 is fed to the ignition transformer 27 by way of interrupter 25 so that a spark will appear across gap G between electrodes E_1 and E_2 at rhythmic intervals. For example the function of the interrupter 25 may be such as to produce alternating on- and off-periods of the spark with on-periods of about 3 seconds and off-periods of about 3 seconds duration.

The spark-producing current derived from the ignition transformer 27 energizes the primary coil of detector transformer 29, while the detector circuit 28 is open due to the then open condition of relay switch 32 and the open condition of push button switch 34, 80, 82. This push button switch represents a switch device for holding a pair of contacts normally open and for momentarily closing them through manual operation. Hence, even though the spark is functioning in its normal rhythmically interrupted manner, the gas valve 15a still remains closed because of the then de-energized condition of solenoid coil 19, as indicated by the full-line closed position of valve lever 20 thus held by spring 21.

In order to light the burner the operator must press the push button 34 normally held open by a spring, to effect the closing of contacts 80 and 82 to establish the detector circuit 28 from contact 82 through conductor 81, secondary coil 72 of detector transformer 29, conductor 70, rectifier 30, conductor 74, relay solenoid coil 31, point 79, and conductor 78 to terminal 80.

The closing of push button switch 34, 80, 82 energizes relay solenoid coil 31 pulling in the armature 40 against the tension of the spring 43, thereby closing switch member 41 upon contacts 35 and 36 and switch member 42 upon contacts 38 and 39. Push button 34 may then be released as relay coil 31 remains energized by reason of the closing of contacts 35 and 36, while simultaneously solenoid coil 19 is energized by the closing of contacts 38 and 39, and draws in or pulls up the armature 18a against tension of spring 21, thus opening the gas valve 15a as is indicated by the dot-and-dash line position of the valve actuating lever 20. The condenser 33 connected across the relay solenoid coil 31 is provided to store up energy while the relay solenoid coil is energized, and to discharge the stored up energy in a coil-energizing direction so as to continue the energization of coil 31 even after current in the detector circuit proper will have ceased to flow during the off-period of the spark when the spark producing circuit 26 as well as the power supply circuit 24 is dead. The capacity of the condenser is so dimensioned as to store during a single on-period and to discharge during a single off-period sufficient energy for holding relay solenoid coil 31 energized and relay switch 32 closed until another on-period of the spark will have started due to the closing of interrupter contacts 44 and 45. In this way, even though the spark is operated with rhythmic interruptions, the gas valve 15a will nevertheless remain open continuously that is through the on-periods as well as the off-periods of the spark.

Yet, the capacity of condenser 33 is so dimensioned that it requires only a moderate extension of the off-period of the spark to allow the relay solenoid coil 31 to become de-energized allowing spring 43 to open the relay switch 32 and thereby to open both the detector circuit 28 as well as the power supply circuit 37, thereby de-energizing the solenoid coil 19 and allowing spring 21 to close the gas valve 15a. Thus, if the off-period of the spark is unduly extended, the gas valve will shut and will not open again irrespective of whether or not normal operation of the spark is re-established. However, if such normal spark operation has become re-established, it is necessary to initiate the opening of the gas valve again by pressing the push button 34.

While the embodiment so far described requires manual operation as of the push button switch 34 to reestablish the spark and to re-light the gas burner once the gas valve has been shut, for instance when the power supply has failed, it may be desired to have the spark restored automatically to re-open the gas valve directly when the power supply is restored. To this end there is shown a switch 97 which may be closed to bridge the normally open push button switch contacts 80 and 82. With switch 97 closed the restoration of the power supply from lines 22 and 23 will at once restore the spark operation, energize relay solenoid 31, and thus close relay switch 32 causing solenoid 19 to be re-energized and thus gas valve 15a to be opened.

Since it is one of the features of this invention that the system is fool proof against rendering false control effects with respect to the gas valve irrespective of any fault that may develop within the system itself, there will now be presented a discussion of possible break-downs or faults in the system along with reasons why such break-downs or faults will in any instance assure the automatic closing of the gas valve irrespective of whether the starting push button switch 34 is being held closed.

Such possible break-down or faults are present

(*a*) If the primary coil 55 of ignition transformer 27 be open; then no energy enters the secondary coil 62, and the system is dead causing gas valve 15a to be closed by spring 21.

(*b*) If the primary coil 55 be shorted, then the effect is the same as in (*a*).

(*c*) If the secondary coil 62 of ignition transformer 27 be open, then no current is supplied to primary coil 65 of detector transformer 29, and relay circuit through secondary coil 72 is dead, allowing relay switch 32 to be opened by spring 43, thus causing gas valve 15ª to close.

(d) If the high tension conductor 60 leading to the spark electrode E_1 be grounded, then there is no spark at the gap G and no current in conductor 63 and coil 65 of detector transformer 29, so that the system beyond the spark producing circuit 26 is dead causing gas valve 15ª to close.

(e) If low tension conductor 63 be grounded, then whether or not a spark exists across spark gap G, the detector transformer 29 will nevertheless subsequently remain de-energized causing gas valve 15ª to be closed by spring 21.

(f) If primary coil 65 of detector transformer 29 be shorted, then the effect is the same as in (e) when conductor 63 is grounded.

(g) If conductor 60 or 63 or transformer coil 65 or conductor 66 be open, or if the spark gap G becomes too wide to allow a spark to jump, then the detector transformer 29 will be de-energized, causing the gas valve 15ª to be closed by spring 21.

(h) If any one of the elements of relay circuit 28 (that is transformer coil 72, conductor 73, rectifier 30, conductor 74, solenoid coil 31, conductor 78, contacts 80 and 82, or conductor 81) be open, then relay solenoid 31 receives no current, the relay switch 32 opens, and consequently the gas valve 15ª is shut by spring 21.

(i) If secondary coil 72 of detector transformer 29 be shorted, no energy is delivered to the detector circuit 28, so the relay solenoid 31 is de-energized causing gas valve 15ª to be closed by spring 21.

(j) If rectifier 30 be shorted, then alternating current is impressed across condenser 33 in parallel with relay solenoid coil 31, but solenoid coil 31 being built for direct current operation does not respond to alternating current, and condenser 33 now represents in effect a short circuit across solenoid coil 31 for this impressed alternating current, so that solenoid coil 31 remains de-energized causing gas valve 15ª to be closed by spring 21.

(k) If condenser 33 be short-circuited, then the relay solenoid 31 receives no energy, causing spring 43 to open relay contacts 35 and 36, and gas valve 15ª to be closed by spring 21. No damage can result to the system, as a result of operation with shorted condenser 33, since the very shorting of the condenser acts to choke off any supply of energy from detector transformer 29. In other words, with a shorted condenser 33 the rectifier 30 being placed directly as an excessive load across transformer coil 72 has the effect of lowering the impedance of primary coil 65 so that less energy is abstracted from the spark producing circuit 26, since the spark producing current in that circuit is maintained substantially constant by virtue of the characteristics of ignition transformer 27.

(l) If condenser 33 be open, then relay solenoid coil 31 receives pulsating direct current in the form of half-wave impulses, which is insufficient and ineffective for keeping relay contacts 35, 36 and 38 and 39 closed, thus causing gas valve 15ª to be closed by spring 21.

(m) Or if any one or more of the foregoing faults occur, then the gas valve 15ª will be closed due to de-energization of relay solenoid coil 31.

(n) If relay solenoid 31 be shorted or open, then relay contacts 35, 36 and 38, 39 will remain open, causing gas valve 15ª to be closed by spring 21.

What I claim is:

1. In combination with a gas burner having a gas valve operable to open and close the gas supply to the burner, a pair of ignition spark electrodes, a solenoid coil controlled armature for so operating the valve, a power supply circuit for controlling the solenoid coil, a step-up ignition transformer the secondary coil of which supplies alternating current to the spark electrodes for sustaining a spark passing between the electrodes, current interrupting means for intermittently supplying current to the primary coil of the ignition transformer whereby spark on-periods of a controlled length alternate with spark off-periods of a controlled length; a safety control system for shutting the gas valve when the spark fails for a length of time appreciably in excess of the length of its off-period, which system comprises a step-down detector transformer having a primary coil in circuit with the secondary coil of the ignition transformer as well as in circuit with said electrodes to constitute a spark circuit, a detector circuit comprising the secondary coil of said detector transformer, a rectifier, a relay solenoid coil and a starting switch, a condenser connected in parallel with said relay solenoid coil, a current holding connection including a pair of switch contacts in parallel with said starting switch and adapted to be opened or closed, an armature controlled by said relay solenoid coil to close said current holding switch contacts when the solenoid is energized and to open said current holding switch contacts when the solenoid is de-energized, a second pair of switch contacts disposed to be closed and opened by said last mentioned armature for thereby closing and opening said power supply circuit concurrently with the closing and the opening respectively of said current holding switch contacts, said condenser being dimensioned and adapted to receive a charge of energy by said rectified current during the on-period of the spark, which energy is adapted to discharge through the relay solenoid coil in a solenoid energizing direction and is sufficiently large and effective to hold both said pairs of contacts closed at least until a subsequent on-period of the spark has started and is insufficiently large to keep the solenoid energized appreciably longer than the length of the off-period of the spark, so that said gas valve is kept open by the energization of its controlling solenoid during normal interrupted functioning of the spark, and is allowed to close by the de-energization of the controlling solenoid when the spark remains off for a length of time appreciably in excess of the length of the off-period of the spark.

2. The combination according to claim 1, with the addition of a ground connection in the spark circuit, said ground connection being disposed directly between the secondary coil of the ignition transformer and the primary coil of the detector transformer whereby the primary of the detector transformer is placed at low potential to ground.

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