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## FUEL COMBUSTION CONTROL SYSTEM

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This invention relates to improvements in fuel combustion control systems and has reference more particularly to a system of the type employing a high tension spark for igniting the fuel. Such systems are commonly used in bake ovens, domestic heating systems, etc.

Wherever fuel such as gas or oil is employed, and especially where intermittent heat is used, it is necessary to provide means for igniting the fuel and for this purpose pilot burners are extensively used.

It is also possible to employ a high tension spark for this purpose and several patents have been issued showing systems of this type. In systems for heating, which are controlled by thermostats, the fuel is intermittently cut off and turned on, and if the means, either a pilot flame or an electric spark, should not be available for igniting the fuel when it is turned on, it will continue to be fed into the combustion chamber with the result that when it is ignited by any means, serious explosions take place.

It is the object of this invention to produce a system employing a high tension spark for igniting the fuel. This system is also provided with means for controlling the flow of fuel to the burner.

It is quite obvious and is well understood, that where fuel such as oil or gas is employed, it is quite necessary that the ignition means be functioning properly before the fuel is turned on, because if the fuel is first turned on, explosions will occur when the ignition means becomes operative.

It is an object of my invention to produce a high tension ignition system that shall have means for controlling both the fuel flow to the burner and the high tension spark in such a way that the fuel will not be turned on unless the spark is properly functioning.

Another object of this invention is to produce a system of the type mentioned in which the fuel supply will be automatically discontinued in case the spark either stops entirely, or becomes too weak to be relied upon for ignition purposes.

Another object of this invention is to produce a system in which the switches or relays that control the electric current for the fuel supply, shall be operated by a direct or rectified current, instead of by an alternating current as has heretofore been common practice.

A still further object of the invention is to provide a system in which the electromagnetic valve that controls the fuel supply will not open until the spark is functioning and has the proper intensity to effect ignition.

A still further object is to provide a circuit breaker that shall cut off the current to the primary coil of the ignition transformer whenever the spark fails by virtue of a short circuit,

or an increase in the spark gap distance, or by reason of a ground or short, or for any other reason.

A still further object of the invention is to provide a system of the type indicated in which visual means is present for indicating to the operator the functioning of the spark so that in case the spark is unsteady and is fluctuating, he will be apprised of this by the action of the indicating means and be put in position to take such steps as may be necessary to correct the operation.

Having thus briefly described the objects of the invention, the latter will now be described in detail, and for this purpose reference will be had to the accompanying drawing in which the single figure is a schematic representation of the invention and shows the relationship of the several elements comprising the same.

In the drawing, reference numeral 5 indicates a burner which may be of the type used with oil or gas and reference numeral 6 represents a fan employed to provide the proper amount of air for combustion. The burner has been shown as mounted on a base 7 and projects into a combustion chamber which has been designated in a general way by dotted line 8. Reference numeral 9 designates an alternating current electric supply which may be the ordinary house lighting circuit or a power circuit, as the case may be. A conductor 10 connects wire 11 of the supply circuit with one terminal of the motor fan and with such magnetic control valves as may be found in fuel combustion systems of this type. The specific mechanism for controlling the motor and the fuel supply has not been shown in detail, because it is old and well known and no novelty is claimed for any of these parts. The fuel supply has, however, been indicated generally by pipe 12, which may convey fuel oil or gas to the system.

An electromagnetic valve 13 has been indicated in the fuel supply line as means for controlling the flow of fuel to the burner. In order to obtain the necessary high tension current for operating the spark gap, a transformer is employed which consists of a substantially rectangular core of laminated iron having spaced parallel sides 14, a primary coil core 15, a secondary coil core 16 and magnetic shunts 17 and 18. The shunts 17 and 18 are of smaller transverse area than the core 16 and serve to by-pass some of the flux during the operation of the transformer. The primary coil has been designated by reference numeral 19 and one end of this has been shown as connected to the conductor 11 of the electric supply circuit 9, by means of a wire 20. The other end of the primary coil is connected by means of a wire 21 to one terminal of a mercury switch 22 that is mounted on an arm 23, which is

rotatable about a pivot 24. The other terminal of the mercury switch is connected by means of a conductor 25 with a bimetallic thermostatic switch 26 that is located in the oven or other room to be heated. This switch is normally closed and is connected by means of a conductor 27 with a switch 28 which in turn is connected by a conductor 29 to the other wire of the supply circuit. A conductor 30 extends from the terminal of switch 28 to which wire 27 is connected, to an electromagnetic switch or relay 31 whose armature 32 is normally held in open circuit position by means of a spring 33. The energizing coil of switch 31 has been designated by reference numeral 34 and this is connected in series with a coil 35 of a circuit breaker having an armature 36. Coil 35 is connected by means of a conductor 37 with the middle point 38 of a full-wave rectifier comprising two half-wave rectifier units 39. The cathodes or filament electrodes of the rectifier units have been designated by reference numeral 40 and the anodes by reference numeral 41. The filaments 40 are connected in series with a coil 42 that makes one or more turns around the primary core 15. The secondary coil has been designated by reference numeral 43 and has its center point grounded as indicated at 44. The secondary coil is tapped at points 45 which are preferably equidistantly spaced from the grounded point and conductors 46 extend from these taps to the anodes 41 of the rectifier. The ends of the secondary coil are connected to electrodes 47 and these are positioned so that their tips terminate in or near the fuel stream so as to form a spark gap 48 by means of which the fuel is ignited.

Due to the presence of the magnetic shunts 17 and 18, the secondary core 16 will have a flux density that is less than the flux density of the primary core 15 or at least a fewer number of magnetic lines of force will pass through the secondary core than if the shunts were not present. It is common practice to provide ignition transformers with shunted secondary core and in such transformers the secondary winding can be short circuited indefinitely without burning out the transformer.

It is apparent that the secondary winding 43 operates as a tapped or modified auto transformer. That portion of the winding between the tap points 45 serves a double duty. Since the current used for operating the switch 34 and the circuit breaker coil 35 is rectified, the inductance of these windings does not produce a lag in that portion of the secondary winding between taps 45, therefore, the current in the secondary in both the high voltage portions thereof, as well as in the turns between the taps 45 will always be in phase with the electromotive force.

Attention is directed at this point to the fact already mentioned that the two coils 34 and 35 are operated by direct current, instead of alternating, as experiments have shown that due to the impedance of these windings, the number of turns must be small when A. C. is used, compared to the number of turns which can be used with direct current. This means that more current is necessary to actuate relays if A. C. is used. This increased amount of current weakens the main secondary current, available for the spark, out of proportion to the actual wattage used in the alternating current relays. This is due to the fact that if the relays were operated by alternating current, the relay current would be out of phase with the spark current and this, in

turn, would produce a lag in the flux in secondary core 16.

Another objection to alternating current relays is that they offer a greater impedance when the armature is in position against the magnetic core than they do when the armature is separated from it.

In a direct current relay, the position of the armature has no effect on the amount of current in the relay circuit. The action of alternating current relays is unfavorable to securing a release of the armature by current changes which may occur in the circuit due to variations of the spark from normal, for the above stated reasons.

Let us now assume that a fuel combustion system employing either gas or fuel oil is equipped with an ignition system of the type herein described. With the parts in the position shown in the drawing, the operator closes switch 28, thereupon an alternating current will flow through wires 27, 25 and 21 to the primary winding 19 and thence back to the circuit through wire 20. Immediately upon the passing of a current through the primary winding an alternating magnetic flux will be set up in the transformer core and the major portion of this will pass through the secondary core 16, thereby producing a high tension between the electrodes 47 whereupon a spark is caused to jump across the gap 48 and this spark will continue as long as the primary coil is energized. After the spark has begun to function properly, the fuel can be turned into the burner and this is effected in the following manner. As soon as the transformer is energized, a secondary current will be set up in coil 42 and this will heat the cathodes 40 to the point where electron emission takes place. The anodes 41 are energized by current from the secondary winding to which they are connected by conductors 46. A short time will elapse before the cathodes 40 attain the temperature necessary to make the rectifier operative. But as soon as this temperature is reached, current will pass in one direction through each rectifier unit and the rectified current will flow along conductor 37 through coil 35 and from thence through coil 34 to the ground G and will pass from this ground to ground G1 and return through conductor 44 to the midpoint of the secondary. The switch 31 and the circuit breaker 35 are so adjusted that the former will operate on a smaller current than the latter and the adjustment of switch 31 is such that when a proper spark is passing between the electrodes 47, the switch will close, thereby opening the control valve 13 and starting the fan 6. If for any reason the spark should not be of the proper intensity, as, for example, if carbon is present between the electrodes, the substantial short circuit thereby produced on the secondary will prevent the rectification of a sufficient amount of current to operate the switch 31 which will therefore remain open until the electrodes have been decarbonized and when this occurs the switch 31 will automatically close. If the spark should be extinguished for some reason, as, for example, if the spark gap has been lengthened to such an extent that the spark will not pass or if the spark becomes very weak, the decreased amount of current flowing in the secondary will produce an increased amount of rectified current, whereupon the coil 35 will attract armature 36 and allow the mercury switch 22 to tilt in a clockwise direction, thereby opening the circuit to the primary winding. After the circuit breaker has been operated it must be manually reset before operations will

again continue. If one of the electrodes 47 become grounded, this effects a short circuit of one-half of the transformer secondary and prevents the generation of sufficient current to operate the relay coil 34.

From the above description it will be seen that I have provided an electric ignition system for use with liquid or gas fuel which has inherent in its construction several important safety features. As above described, the fuel will not be turned on if the electrodes are short circuited by carbon or if one or both of them are grounded. If the electrodes are spaced too far apart to permit the spark to jump, the increased voltage set up in the secondary between the tap points 45 will increase the value of the rectified current to such an extent that the circuit breaker will open and in this way the parts can readily be so adjusted that no fuel will be fed to the burner until a spark is present, which is of sufficient intensity to ignite the fuel.

The rectifier units 39 are preferably of the type known as "half-wave, mercury, vapor, rectifier tubes" which are made from transparent material and when tubes of this type are operated, a blue flame extends downwardly from the anode to the cathode and whenever the spark is unsteady due to a strong draft, or to the fact that the spark gap is getting too long, this blue flame will be unsteady and the operator can therefore see that the spark gap is not operating properly and this visual indicating means serves as a warning signal which, if heeded in time, will prevent a stoppage of the furnace.

Rectifiers of the type mentioned have hot wire cathodes which take an appreciable time to heat and there is therefore an appreciable lag between the time when the spark begins to function and the time that the fuel is turned into the burner and this assures that no fuel will be fed until the spark is functioning to ignite the same.

It is possible to employ other types of rectifiers than those shown, such, for example, as copper oxide rectifiers, but in order to function properly rectifiers should be of such construction that an appreciable time will elapse between their energization and their functioning as rectifiers.

Having described the invention what is claimed as new is:

1. In a fuel combustion system, in combination, a source of alternating electric current supply, a fuel burner, a source of fuel supply, electrically operated means for controlling the supply of fuel to the burner, a transformer having a primary coil and a secondary high tension coil, means comprising a switch for controlling the flow of current from the supply circuit to the primary coil, a pair of spaced electrodes forming a spark gap and positioned adjacent the burner to ignite the fuel, the spark gap being connected in series with the secondary coil, a full wave heated cathode rectifier, means responsive to the flux conditions in the primary coil core for heating the cathodes, means responsive to the flux conditions in the core of the secondary circuit for energizing the anodes, an electromagnetically controlled switch in the circuit to the fuel supply control means, said last named switch being so connected with the rectifier as to obtain rectified current therefrom, and adjusted to close the circuit when the current attains a predetermined value whereby the fuel will not be turned on until after the filaments of the rectifier have attained the temperature necessary for rectification.

2. In a fuel combustion system, in combination, a source of alternating current supply, a fuel burner, a source of fuel supply, electrically operated means for controlling the supply of fuel to the burner, a transformer having a primary coil and a secondary high tension coil, means comprising an electromagnetic switch for controlling the current supply to the fuel control means, a switch controlled circuit connecting the primary coil to the current supply, a pair of spaced electrodes positioned adjacent the burner, said electrodes being in series with the secondary coil to form a spark gap for igniting the fuel, hot cathode rectifiers comprising two half-wave rectifiers arranged for full wave rectification, means comprising a coil surrounding the core of the secondary coil for energizing the anodes and means comprising a coil surrounding the primary core for heating the cathodes, the electromagnetic switch for controlling the fuel supply being connected in series with the output side of the rectifier, whereby its action will be delayed an appreciable length of time due to the time lag of the rectifier.

3. In a fuel combustion system, in combination, a source of alternating current supply, a fuel burner, a source of fuel supply, electrically operated means for controlling the supply of fuel to the burner, a transformer having a primary coil and a secondary high tension coil, means comprising an electromagnetic switch for controlling the current supply to the fuel control means, a switch controlled circuit connecting the primary coil to the current supply, a pair of spaced electrodes positioned adjacent the burner, said electrodes being in series with the secondary coil to form a spark gap for igniting the fuel, a rectifier, of the hot cathode type, means responsive to the flux in the secondary core for energizing the rectifier anodes, means responsive to the flux in the primary core for heating the cathodes, the electromagnetic switch controlling the fuel supply being connected in series with the output side of the rectifier, said rectifier, due to the time required to heat the cathodes, having a delayed action whereby the production of rectified current of sufficient value to operate the fuel supply control switch will take place an appreciable time after the spark has begun to function.

4. In an electrically controlled fuel feed system, an electrically controlled fuel feed means including a circuit, a transformer comprising a primary winding and a secondary winding, a pair of spaced electrodes in series with the secondary winding to form a spark gap to ignite the fuel, a full-wave rectifier of the heated cathode type, means for heating the cathodes comprising a coil surrounding the core of the transformer and responsive to the magnetic flux generated by the primary coil, operatively connected with the cathodes, means for energizing the anodes comprising a section of the secondary coil, an electromagnetic switch in the fuel feed control circuit, said switch being connected with the output of the rectifier, said switch closing when the rectified current attains a predetermined value, and a circuit breaker in series with the primary coil, said circuit breaker including means responsive to the rectified current and adjusted to open the circuit to the primary coil when the value of the rectified current increases above a predetermined amount due to spark deviation from normal.

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