Jan. 1, 1952 F. H. HIBBARD 2,581,188

OIL BURNER SAFETY CONTROL SYSTEM

Filed Aug. 2, 1948 2 SHEETS—SHEET 1

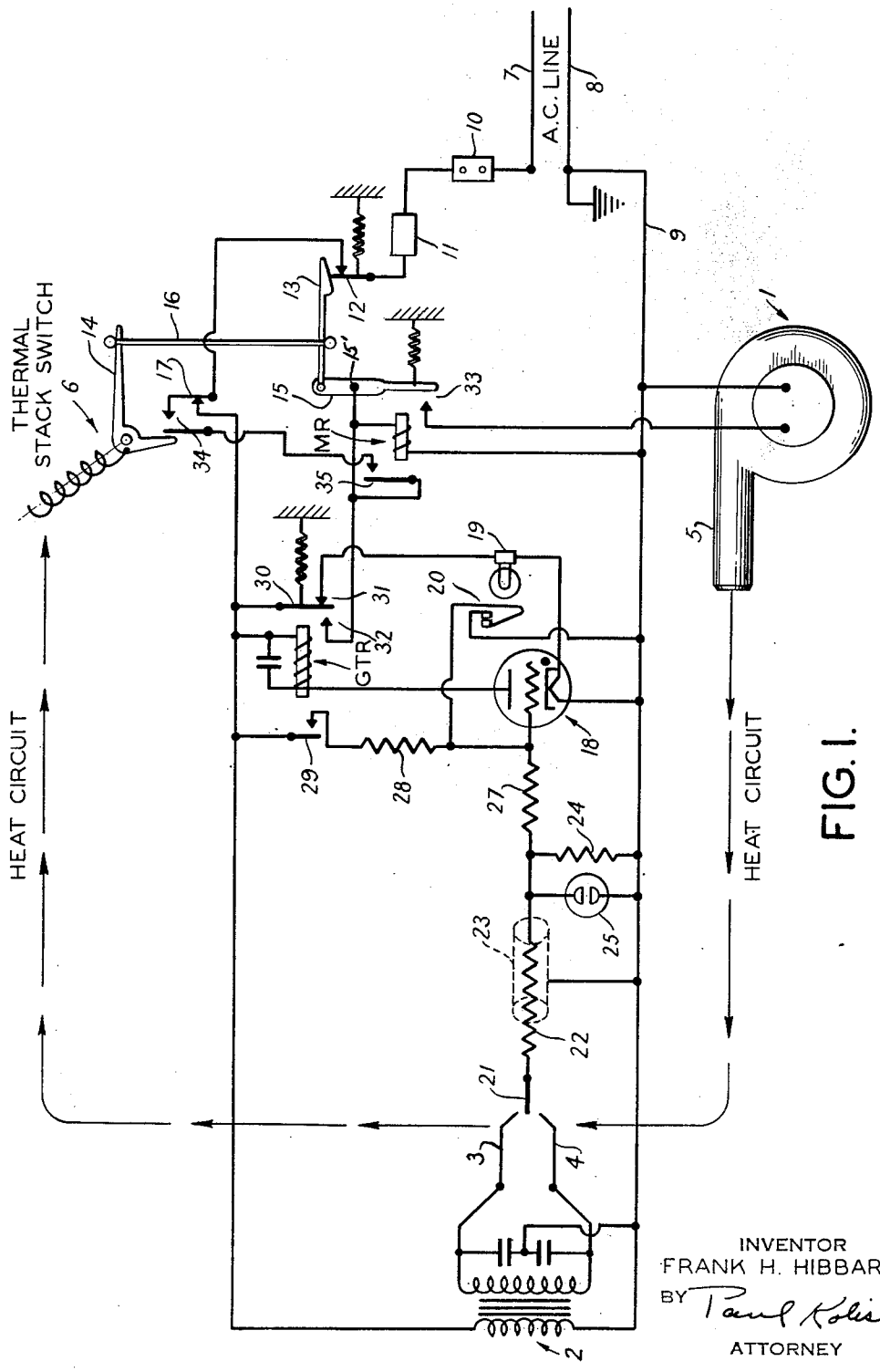


FIG. I.

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OIL BURNER SAFETY CONTROL SYSTEM

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FIG. 2.

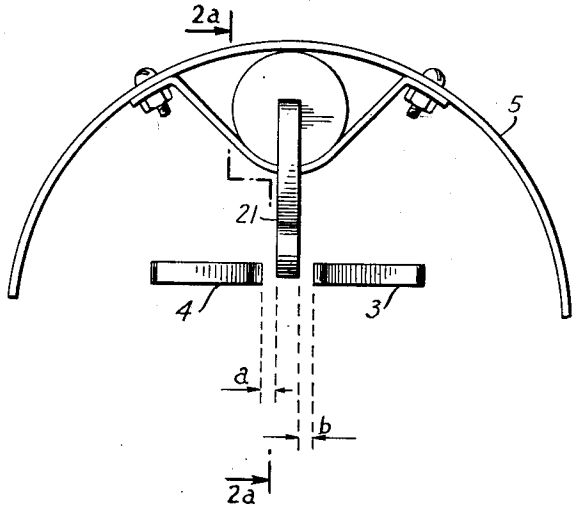
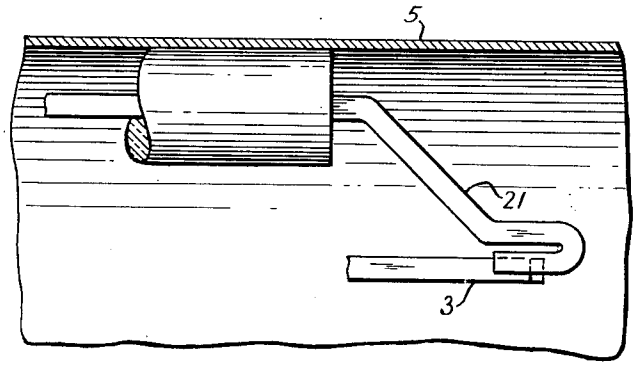


FIG. 2a.



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2,581,188

OIL BURNER SAFETY CONTROL SYSTEM

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Application August 2, 1948, Serial No. 42,023

13 Claims. (Cl. 158—28)

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This invention relates to improvements in safety devices. More particularly, it relates to improvements in safety devices for preventing certain dangerous conditions which may result from abnormal operation of oil burners.

It is well known that it is dangerous to allow unburned fuel oil to accumulate in the fire box of a heating plant. If the accumulated excess fuel is ignited, combustion will start with varying degrees of explosive violence. Hence, a delay in the operation of the ignition means, after oil has flowed, may, and often does, produce serious consequences.

In the most common kind of oil burner safety device of the prior art, the oil pump and the ignition means, usually an electrical spark, are turned on simultaneously. The power circuit for the pump includes a contact which normally opens within a predetermined time after the burner turns on thus limiting the period of deliberate risk-taking. If there is a flame within the predetermined time a stack switch responsive to the heat of the flame closes a circuit around said contact before it opens. If the oil is not set afire within said predetermined time the stack switch cannot operate and, therefore, at the end of this time the oil pump stops. In such devices oil is flowing throughout the risk-taking time and the sparking means, usually a high voltage transformer, is operating. For any number of reasons the spark may fail for a time, and then after oil has accumulated, it may appear, precipitating the dangerous conditions above described.

It has been known to reduce this hazard, by reducing the duration of the predetermined risk-taking time, but this is only a negative approach to the elimination of danger due to delayed ignition. If an operator undertakes to restart the burner, he may repeatedly introduce a flow of oil without combustion and thus accumulate a dangerous excess to be ignited when and if the spark does appear. It is a feature of the present invention that a positive means is provided for preventing any flow of oil until or unless a flow of spark current at the ignition electrodes has been established.

Photoelectric cells instead of thermal stack switches have been suggested to shorten the risk-taking period. However, such devices like those described above also approach the problem negatively. Photoelectric cells have the added disadvantage that they require amplifier circuits in order to utilize their small outputs for controlling electromechanical switches. Due to this requirement these safety devices are complex, expensive

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and difficult to service. Moreover, as described in U. S. Patent 2,416,781, many of the safety devices of this type are subject to an especially dangerous kind of failure. The high ambient temperatures in a boiler room often will affect the cathode coating in such a way as to cause the photo tube to develop internal leakage paths and the high ambient humidity which is prone to occur during periods when the burner is shut down often results in leakage paths around the tube base and socket. Internal and/or external leaks can cause spurious operation even through there is no flame, thus causing the pumping of unburned oil to continue indefinitely.

The safety device described in U. S. Patent 1,834,287, employs the mercury power switch which is operated directly by light from the oil flame without requiring the use of an amplifier. However, the simplification which this makes possible is offset by the fact that this special switch will only operate under carefully controlled conditions and therefore, cannot readily be applied as an attachment to existing oil burners. Moreover, this simplification does not alter the fact that the operation of this device is also based on the negative approach of risking the unwanted accumulation of unburned oil for a predetermined period of time (during which the special mercury switch tests for the presence of flame).

From the foregoing it will be evident that two separate conditions of failure or abnormal operation are risked each time an oil burner is started: (1) failure to produce a spark, and (2) failure of combustion even though a spark is present and the fuel pump is operating. It is the object of the present invention to prevent a flow of oil in the first condition and to reduce the risk-taking time during which oil flows in the second condition.

With this object in mind I have provided a safety device in which a probe associated with the spark gap is connected to the grid of a gas tube which in turn controls the oil burner. Thus depending upon whether or not a spark is present the oil burner will operate.

A feature of the present invention is that no oil is pumped into the fire box until the oil igniting means is operating properly.

Another feature of the invention is that a safety device for an oil burner of the type whose ignition means comprises a high voltage transformer and a spark gap, does not start pumping of oil until after the presence of a spark in the gap has been detected. The device after start-

ing the pump also tests for the presence of flame and turns off the pump if no flame is detected within a predetermined time, whereby it completely prevents any accumulation of unburned oil is cases of spark failure and limits the accumulation of unburned oil in cases where ignition failure occurs for some other reason despite the presence of spark.

According to still another feature of the invention power is continually applied to the ignition transformer for an indefinite period of time if a spark is not produced at once and a visual indication of spark failure is provided.

Other objects, features and advantages of the present invention will be apparent to those skilled in the art from the following detailed description of an embodiment of the invention and from the drawings, in which:

Fig. 1 is a schematic representation of a circuit embodying the invention; and

Figs. 2 and 2*a* represent end and side views of the spark-detector probe.

In Fig. 1 oil burner 1 comprises an electric motor driving both a pump which draws oil from a tank and forces it under pressure through an atomizing nozzle and a blower which projects a blast of air around the opening of the nozzle, all in a well-known manner. High voltage transformer 2 may also be a standard piece of equipment. It comprises a primary for receiving alternating current energy from a power line and a secondary for stepping up the line voltage to some suitable value for producing a sufficient spark to ignite the atomized oil. Ordinarily, some means is employed for grounding the center of the secondary winding. The means shown in Fig. 1 consists of two condensers of equal capacity connected in series across the secondary and grounded at their point of junction to each other. The two ends of the secondary of transformer 2 are connected respectively to electrodes 3 and 4, the ends of which are brought together to form a spark gap. The exact size of the gap will depend on the output voltage of transformer 2 and other conditions such as the average humidity and the strength of the natural draught of air which passes through duct 5 and to which the gap is subjected.

In most domestic oil burners this gap is of the order of a quarter inch wide. In practice electrodes 3 and 4 are inserted through an opening in the back end of air duct 5 and are pushed toward the front end until they are positioned near the opening of the atomizing nozzle. Since this physical arrangement is well known it is not shown in detail herein. Furthermore, in order to simplify the drawing, transformer 2 and electrodes 3 and 4 are placed in Fig. 1 in positions which are suitable primarily for laying out the electrical circuit. However, the physical relationship between the blast of vaporized oil delivered by burner 1 and the gap formed by electrodes 3 and 4 is indicated by a line of arrows used in Fig. 1 to represent the heat circuit. It will be seen that this circuit extends over a thermal stack switch 6 which, as is customary, may be installed in the stack between the fire box and the chimney. Conductors 7, 8 comprise a power line, for example, 110 volt 60 cycle line, delivering electrical energy for energizing transformer 2 and operating burner 1. In the arrangement shown herein this line also provides energy for operating the safety device disclosed herein. The conductor 8 of the power line which may be grounded is permanently connected over

conductor 9 to one of the inputs of the motor for burner 1 and to one side of the primary of transformer 2. Conductor 7 on the other hand will not be extended to deliver energy to these elements of the oil burner system unless heat is required. In the illustrative embodiment shown herein, an on-off manual switch 10 is inserted in series with conductor 7. Switch 10 is placed in its off position when no heat is required at all, and when switch 10 is placed in its on position the heat requirements will be determined automatically by a thermostat represented at 11. Thermostat 11 may be of any conventional kind and normally it will be manually adjustable. When the temperature in the room where the thermostat is situated drops below a value predetermined by its setting, it acts to extend a circuit from conductor 7 to elements of the oil burner system, either doing so directly over its own contacts, which are closed by a sufficient drop in room temperature, or indirectly over the contacts of a relay which it energizes over its own contacts. There is nothing novel herein about the arrangement or use of the thermostat.

From thermostat 11 line 7 is extended over spring-loaded switch 12 which comprises a rest contact and a movable armature normally urged against it. Associated with switch 12 there is a non-conductive lock-out latch 13 which is mechanically linked both to a rotatable arm 14 of stack switch 6 and to armature 15 pivoted at 15' of a motor relay MR. It will be seen below that motor relay MR becomes energized soon after the start of a cycle of operation of the burner and that if the cycle proves to be a normal one it will remain energized over a period of time during which the burner continues to operate until room temperature rises sufficiently to open thermostat 11. Each actuation of relay MR in turning on burner 1 rocks its armature 15 in a direction to move latch 13 into engagement with the armature of switch 12. Whenever, thereafter normal prompt combustion takes place the heat of the flame will operate stack switch 6 so that its rotatable arm 14 will act through a mechanical link 16 to raise latch 13 to a non-operating position where it cannot continue to engage the armature of switch 12. As a result a false lock-out of electrical power will be prevented when at the end of the normal heating cycle the room temperature has risen sufficiently; thermostat 11 has cut off power to unit 1 and to relay MR; and relay MR has released and drawn back latch 13. A false lock-out will be prevented since latch 13 will not be in position to pull back the armature of switch 12 so as to lock out the supply of electrical power to the system. On the other hand, for certain abnormal operational cycles latch 13 is intended to act to lock out electrical power. It will also be seen that after it has been energized for a predetermined time relay MR will be released if the cycle of operation which is under way proves to be not normal in that a flame is not produced within that time. In such a case the stack switch will not have operated and therefore upon the deenergization of relay MR and the return of its armature 15 to its rest position latch 13 will be drawn back and will pull the armature of switch 12 away from its rest contact to open the circuit and to lock out the supply of electrical power until latch 13 is manually raised to reset switch 12.

After its extension over normally closed switch 12, conductor 7 is further extended over a pair of normally closed contacts 17 of stack switch 6

to the other side of the primary of transformer 2. Therefore, when thermostat 11 closes its contacts (ordinarily this happens only when the furnace stack is cold) energy will immediately be applied to ignition transformer 2. If the transformer is operating properly a spark will instantly be produced in the gap between electrodes 3 and 4.

The present invention comprises a device for preventing a cycle of oil burner operation from proceeding to the turning on of the pump and blower unit until a spark is produced. Accordingly, the cycle of the oil burner is placed under the control of this device so that the oil pump and blower unit can only be started after the presence of spark at the spark gap has been determined by test; and when once started, the pump and blower can only operate for a maximum time interval, e. g. ten seconds, measured by this device. If combustion occurs within this measured time interval, the stack switch is actuated by the heat of combustion and the operation of the burner is continued.

The presence of spark is determined by spark testing probe 21 which is mounted in the gap between electrodes 3 and 4 and which is connected to th grid of tube 18 through dropping resistor 22 and voltage divider resistance 27. The connection between probe 21 and the grid of tube 18 extends through a grounded shield represented at 23. The purpose of shield 23 is to prevent direct pickup from stray fields which may exist in the area through which this conductor must pass. By reason of this shielding the tube is prevented from firing by capacity coupling between other conductors and probe 21. Tube 18 will be fired when a suitable voltage relative to ground is impressed on probe 21 connected to the grid of the tube. As will be described tube 18 must be fired to operate the relay GTR and relay MR and start the motor pump and blower. I have determined by extensive tests that when probe 21 is located approximately equidistant from electrodes 3, 4, the probe will have, impressed upon it, a sufficient voltage to operate tube 18 only if spark current is flowing between electrodes 3 and 4. I have found that when there is a spark between the electrodes the voltage impressed on probe 21 may vary from 15 volts to 5000 volts (using a 10,000 volt secondary transformer). The dropping resistor 22 and a voltage limiter 25 in association with voltage divider resistances 24 and 27, permit the passage of a sufficient current (approximately 1 microampere) to fire the tube on the minimum of 15 volts; and to limit the flow of current at 5000 volts to a value low enough to avoid damage to circuit components.

By way of example, I have found that the probe and electrodes may be made from 3/32 square inch stock whose ends may be cut off square, and that an average gap width, A+B, (Fig. 2) of approximately ¼" is satisfactory.

The appearance of the higher of voltages on the probe may be explained by considering the probe to be an approximate mid-point of a voltage divider formed by the two portions of the arc or ionized path on either side of the probe. This ionized path is naturally highly unstable in physical and electrical dimensions and the voltage divider formed by two such paths in series may be instantaneously and frequently greatly unbalanced. While the ionized path has too low a resistance to support such a voltage difference after gap breakdown, there is momentarily at the beginning of each cycle, a period of high path resistance during which the 5000 volt instantaneous peak may occur.

By the same variations it is obvious that the voltage divider may at other instants and without predictability, be substantially perfectly balanced, with the result that no impressed voltage with respect to ground, would appear on the probe 21. I have determined, however, that whether or not such a condition of complete balance occurs, no condition of zero potential on the probe is found when spark current is flowing through gap 3–4. This may be explained by phenomena known as anode and cathode drop, or the voltage consumed when electrons enter or leave the probe through the boundary layers at the surfaces of the probe metal. The complete circuit from electrode 3 to electrode 4 may be described as composed of the following elements in series, the ionized path from electrode 3 to the surface of the probe, the probe surface boundary layer which presents an anode drop (electrons entering), negligible internal metallic resistance of the probe, boundary layer of the probe in the direction of exit where the cathode drop is consumed, and finally, the second ionized path from probe surface to electrode 4. If the two ionized paths are exactly equal and if, as I believe, the anode drop is greater than the cathode drop, the probe will experience a difference of potential, even in the balanced gap condition, equal to the difference of anode and cathode drop. In this way I account for the presence of a minimum of about 15 volts potential on the probe relative to ground whenever spark current is flowing between electrodes 3 and 4. While this potential may in many cases approach 5000 volts, whenever spark current is flowing there will be a voltage on the probe relative to ground of not less than 15 volts which is sufficient to trigger the tube. The probe positively detects the presence of spark at the electrodes by transmitting sufficient energy to the grid of tube 18 to fire the tube.

I have found that in the absence of a spark, the voltages that might be capacitatively induced on probe 21 are unable to drive sufficient current through the impedances connected to the probe to energize tube 18.

In general, the following additional requirements should be considered in determining the value of resistor 22. It should be of such high resistance that the spark will tend to occur directly from one electrode to the other rather than from each of them to ground via the probe and over the grid circuit of tube 18. To generalize, for this purpose its resistance should be high with respect to the output impedance of transformer 2 at line frequency. On the other hand to avoid direct capacitive pickup it should be low with respect to the capacitive reactance between the probe and either electrode at the line frequency.

The heater-winding in th tube is in series with the anode-to-cathode discharge path. However, due to its low resistance its limiting effect on the discharge current is negligible and, on the other hand, due to the smallness of the discharge current as compared to the heater current, any change in cathode temperature which may occur when the tube is fired will be negligible. In the present embodiment no filament transformer is required for providing heater current for tube 18. Instead, an incandescent lamp 19 is employed as a voltage dropping resistor so that the heater may be energized directly from the

line over this lamp. I have found that a 100 watt incandescent lamp has an appropriate resistance value if the heater of tube 18 requires 6.3 volts. This arrangement has the additional advantage that the fact of a spark failure will be signalized by continued burning of lamp 19. For, as will be seen below, for each starting cycle in which a spark is produced successfully the operation of tube 18 and lamp 19 will only last a few seconds (first line voltage will be applied to the heater circuit, a few seconds will pass while the tube heats up, the tube will fire, its discharge current will actuate the gas tube relay which, in addition to energizing the motor relay, at the same time will open the heater circuit terminating the operation of tube 18 and lamp 19). On the other hand, in the event of a spark failure, tube 18 will not fire and therefore it will not operate its associated relay GTR and this relay will not open the heater circuit.

Upon a failure to spark, not only will lamp 19 burn continuously but in addition tube 18 will remain in a prepared condition, i. e. with its cathode heated, for detecting a delayed spark. This is particularly advantageous as it is a common phenomenon for the spark to fail at first only to be produced a little later after the transformer has warmed up somewhat. The safety device disclosed herein will give it plenty of time and yet during none of that time will any oil be pumped.

It will be seen that tube 18 after it has fired, will continue to draw anode-to-cathode current for a short period of time after its heater circuit is opened and that this delay is utilized to serve a useful purpose in the present arrangement. If the heater is brought up to its full operating temperature before the tube is fired, this delay will always be very close to ten seconds. However, in some experimental models it was discovered that the tube could be fired before the cathode was fully heated if a sufficiently strong signal were picked up from the spark gap and that in such an instance the delay between the opening of the heater circuit and the de-ionization of the tube could be very materially reduced. In order to prevent this a means is employed for grounding the control grid to eliminate all signals for a period of time during which the cathode may become fully heated. This means comprises a normally closed bimetallic switch 20 over which the grid is connected to ground. The contacts of this switch do not have to carry large currents and therefore it may be of such light construction that it requires but a small amount of heat to operate it. In a preferred embodiment of the invention bimetallic switch 20 is mounted adjacent to lamp 19 and is actuated by the heat from this lamp.

As is apparent from Figs. 2 and 2*a* the probe has quite large areas in planes transverse to the spark. This is to assure that it will intercept the spark. Since the natural draft of air through the blower duct will displace the spark forward and upward, the center of the probe area which should intercept the spark is similarly displaced with respect to the gap.

To insure that the average energy passing through the winding of GTR is adequate, a circuit is provided for applying a reliable and properly phase firing signal to tube 18 once it has fired. This signal is a portion of the line voltage and it is applied to the grid of tube 18 over normally open contacts 29 of relay GTR. This circuit comprises a voltage divider including grid resistor 24 which, of course, is grounded at one end, and in series therewith, resistors 27, 28 and normally open contacts 29. When relay GTR is first energized by a signal received from the spark gap contacts 29 are closed and the ungrounded end of the voltage divider is connected to the live extension of line conductor 7. The relative values of these series resistors are such that enough of the line voltage will be applied to the grid of tube 18 to maintain the firing of the tube.

From the foregoing it is seen that tube 18 will only fire if the ignition means is functioning properly and that when it fires it operates its associated relay GTR. At this time relay GTR moves its armature 30 from its back contact 31 to its front contact 32 and in so doing it opens the heater circuit of tube 18 and at the same time closes a loop applying line voltage across the winding of motor relay MR. Relay MR rocks its armature 15 closing the make contacts 33 thereof to apply line voltage to the motor of unit 1. As already described above armature 15 at the same time moves latch 13 into engagement with the armature of switch 12. Since the igniting means must be functioning properly before burner 1 can be turned on, the start of operation of the burner will immediately be followed by combustion for a very large percentage of starts. However, it is known that a small percentage of combustion failures is attributable to other causes than a failure of the ignition means. For example, there may be a temporary oil stoppage or there may be impurities in the oil or even improper atomizing of the oil. And, of course, if burner 1 continued to operate, where there is combustion failure for any of these reasons, the result can be an accumulation of unburned oil. For this reason, in the present safety device, means are provided whereby, even after the spark has been checked and found to be satisfactory, the pump and blower unit cannot continue to operate for more than a very short time unless a flame is detected in the fire box within that time. It is to this end that relay GTR is arranged to open the heater circuit of tube 18 at the same instant that it applies energizing potential to the motor relay. Tube 18 will not be de-ionized immediately as its cathode has a cooling time of about ten seconds. Therefore, for ten seconds relay GTR will continue to be energized over tube 18 and will continue to apply energy to energize the motor relay. However, only for this long will the motor relay be energized by GTR. Within these ten seconds it is essential that stack switch 6 be operated by heat from the flame so that it may act to provide an alternate circuit for energizing the motor relay. For this purpose stack switch 6 is provided with make contacts 34 which it will shut within the ten seconds provided a flame is produced immediately after unit 1 is turned on. When stack switch 6 operates line 7 is extended over make contacts 34 to the ungrounded side of the winding of motor relay MR via a make contact 35 of this relay. Since normally closed contacts 17 will be opened when stack switch 6 operates, line 7 will cease to be extended to transformer 2 and to tube 18 and the heater circuit will not be re-energized when armature 30 falls back on its rest contact 31.

There are three possible operating cycles: a normal cycle in which everything performs as

intended; an abnormal cycle in which the ignition means fails to operate, i. e., fails to produce a spark, and an abnormal cycle in which the ignition means operates properly but there is a combustion failure for some other reason.

The operation of the apparatus shown herein during a normal cycle is as follows: with switch 10 in its "on" position, thermostat 11 is operated by a drop in room temperature and extends line conductor 7 through normally closed switch 12 and normally closed contacts 17 of the stack switch to the ignition transformer, the anode circuit of tube 18, and the heater circuit of this tube. Incandescent lamp 19 will heat bimetallic switch 20 taking a longer time to operate it than is required for the cathode of tube 18 to become adequately heated. After a delay of twenty or thirty seconds, bimetallic switch 20 will unground the grid of tube 18 permitting this tube, in cooperation with probe 21, to test for the presence of a spark in gap 3, 4. Tube 18 will fire and operate relay GTR which will apply a 60 cycle holding signal to the grid of tube 18, will open the heater circuit of this tube and will close an energizing circuit for motor relay MR. While the cathode of tube 18 is cooling, i. e., for about ten seconds, relay GTR will continue to be energized by discharge current of the tube and in turn it will energize the motor relay. When it is energized the motor relay will close the power circuit for the motor of burner 1 and at the same time it will prepare its own holding circuit by closing its contacts 35. Combustion will commence and in less than ten seconds the stack switch, over its normally open contacts 34, will complete the holding circuit for relay MR and, by opening its rest contacts 17, will sever the extension of line conductor 7 to the ignition transformer, and the anode and heater circuits of tube 18.

In the present arrangement the risk-taking period is very short because of the novel means employed herein for determining this period by the relatively short cooling off period of tube 18 (instead of by the relatively slow action of an electrically heated bimetallic switch). The period of operation of the stack switch is from two to five seconds, this being easily attained by switches which are commercially available. When the stack switch operates it also raises latch 13 so that when eventually the operation of the heating plant raises the room temperature sufficiently to cause thermostat 11 to sever the extension of line conductor 7 thus deenergizing motor relay MR and turning off the burner, the armature of normally closed switch 12 will not be pulled open by latch 13 and the system will not be locked out from the supply of electrical power.

In the case of a spark failure the cycle commences in the same manner as that described above. However, tube 18 does not fire and none of the events which follow the firing of this tube can take place. Since tube 18 does not fire, relay GTR can neither act to energize the motor relay nor to open the heater circuit of tube 18. As a result tube 18 remains in a prepared condition for detecting a spark, lamp 19 remains lit to signalize a spark failure, and no pumping of fuel takes place. If after a time a spark is produced, the cycle will continue in the manner described above.

When there is a combustion failure despite the presence of a spark the stack switch will not operate during the cooling off of the cathode of tube 18. The result will be that about ten seconds after motor relay MR became energized and applied power to the motor of burner 1, it will be de-energized and cut off this power. The amount of unburned fuel would be very limited and insufficient to cause any damage if ignited. At the same time since latch 13 will have remained in its operating position due to the failure of the stack switch to raise it, the rocking back of armature 15 upon the de-energization of motor relay MR would pull open the armature of normally closed switch 12 to lock out all power to the burner. It would be impossible for the system to re-start itself until latch 13 is manually raised to reset switch 12. The lockout of switch 12 tell-tales the nature of abnormal condition of the burner, i. e., that there has been a combustion failure for some reason other than a spark failure. If desired, another signal lamp may be used, for example, the armature of switch 12 in its locked out position may engage a normally open contact and thereby close a circuit for a second signal lamp not shown.

It is seen that while the present arrangement makes use of a discharge tube, it does so without requiring a separate heater transformer or a direct current power supply for energizing the anode circuit and that the tube employed is of the gas filled type which has very positive switching action and does not require any amplifiers in order for it to operate a relay. Moreover, in the particular arrangement shown herein the discharge tube is employed so that in addition to performing its novel function in testing for the presence of a spark in the ignition means, it also serves at no additional expense as the means for determining the risk-taking period and it is capable of doing so more reliably and for shorter periods than has been economically possible by the means generally used in the prior art.

It is evident that if tube 18 should fail for any reason, for example, if its filament should burn out, if its envelope should be broken or if its emission should decrease so that it does not fire readily, the effect will be merely to prevent the oil burner from operating. Therefore, though its failure will entail some inconvenience it will not result in decreased safety.

Obviously, stack switch 6 may be replaced in the present device by photoelectric means for detecting a flame. In fact, due to the shortness of the risk-taking period in systems according to the present invention, such photoelectric means are especially appropriate in that they have the advantage of being capable of continuing the supply of power to the motor of burner 1 in cases where combustion occured very late in the short risk period, whereas this would not be true of a thermal switch even if it were unusually fast-acting.

What is claimed is:

1. An oil burner safety system including a high voltage transformer, two electrodes connected to the transformer to form a spark gap, a gas discharge tube having a cathode, a cathode heater, an anode, and a control grid, a probe supported within the gap substantially in the center of the pathway traversed by a spark produced therein, said probe of suitable area with respect to the gap such that when a spark is produced across the gap the probe picks up a signal voltage sufficient in magnitude to fire said tube, a shielded connection from the probe to the control grid over a resistance of higher value than the output impedance of the transformer at the frequency of the line voltage supplying the transformer, a relay in series with the anode-cathode discharge

path of the tube, means for connecting one conductor of an alternating curent power line to the anode of the tube over the relay, the cathode being connected to the other conductor of the line over said heater, means for connecting said first-mentioned conductor to the cathode-connected end of the heater over a dropping impedance for applying a fraction of the alternating current line voltage across the heater to produce both heat and bias for the cathode, and normally closed contacts opened by said relay when the tube is fired to sever the connection which applies a fraction of the alternating current line voltage across said heater whereby once the tube fires the relay will be energized and will remain energized until the tube de-ionizes due to cooling of its cathode.

2. A spark testing apparatus as in claim 1, in which said dropping impedance is the filament of an incandescent lamp for signalizing a condition in which the cathode is heated but the tube is not ionized.

3. A spark testing apparatus as in claim 1, in which said dropping impedance is the filament of an incandescent lamp, a bimetal thermal switch which has normally closed contacts and is responsive to heat from the lamp to open the contacts, and a circuit connecting the control grid to said other conductor of the line over the contacts of the thermal switch.

4. A spark testing apparatus as in claim 1, in which a cold cathode discharge device is connected between said shielded connection and said other conductor of the line on the side of said resistance which is furtherest from the probe, the cold cathode discharge device having the characteristic that the voltage drop across it while it is fired is large enough to overcome said cathode bias of said first-mentioned gas tube to an extent sufficient to fire said tube.

5. An oil burner safety system including an electrically operated oil pump, a source of power for the pump, a high voltage transformer, two electrodes connected to the transformer to form a spark gap for igniting oil, a probe made from similar material as the electrodes and located approximately in the center of said gap adapted to pick up an electrical triggering signal from a spark in the gap, control means connected to the probe for receiving said signal and for responding thereto to provide a connection for a limited period of time between said source of power and the pump, and means responsive to the heat produced by the ignited oil for maintaining the connection between the source of power and pump.

6. A safety system as in claim 5, in which said control means includes a gas discharge tube having a cathode heater, having a cooling time of approximately ten seconds during which the tube provides a connection between the source of power and the pump.

7. A safety system as in claim 5, in which said means responsive to the heat include a motor relay, a thermally controlled stack switch, normally open contacts on the relay included in the circuit of the pump and source of power, and interlock means between the relay and switch whereby the connection between the source of power and pump is maintained only while the switch is operated.

8. A safety device as in claim 5, in which said control means comprises a hot cathode gas discharge tube having a control grid, and an input circuit for receiving said triggering signal and applying it to the control grid to fire the tube.

9. A safety device as in claim 5, in which said means responsive to the heat comprises a normally-open holding circuit and a thermal stack switch located in the path of the heat from the burner to close the holding circuit in substantially less than said limited period of time thereby continuing the connection between the source and the pump.

10. A safety device as in claim 5, in which said control means comprises a hot cathode gas discharge tube having a control grid, an input circuit for receiving said triggering signal and applying it to the control grid to fire the tube, a relay which is in series with the anode-to-cathode discharge path of the tube and is energized by its discharge current, normally closed contacts for the relay which are opened when it is energized, a power supply circuit for the cathode heater of the tube which circuit is over the normally closed contacts and therefore is opened when the tube fires, and a circuit, which is completed by said relay between the time when the tube fires and the time when it de-ionizes due to the cooling off of its cathode, for providing said connection between said source of power and said pump for said limited period of time.

11. A safety device as in claim 5, in which said control means comprises a hot cathode gas discharge tube having a control grid, an input circuit for receiving said triggering signal and applying it to the control grid to fire the tube, a relay which is in series with the anode-to-cathode discharge path of the tube and is energized by its discharge current, normally closed contacts for the relay which are opened when it is energized, a power supply circuit for the cathode heater of the tube which circuit is over the normally closed contacts and therefore is opened when the tube fires, said supply circuit for the heater including an incandescent lamp in series with the heater for signalizing a condition in which the tube has its cathode heated but has not fired thereby to indicate that there is no spark in the gap, a circuit, which is completed by said relay between the time when the tube fires and the time when it de-ionizes due to the cooling off of its cathode, for providing said connection between said source of power and said pump for said limited period of time, means for shortcircuiting any trigger signals received for a period of time while the cathode is being heated including a normally closed thermal switch connected in a low impedance circuit between the grid and cathode, the thermal switch being near to said incandescent lamp for receiving heat therefrom when the heater supply circuit is closed and for responding thereto after a predetermined time to open the low impedance circuit.

12. A safety device as in claim 5, in which said control means comprises a hot cathode gas discharge tube having a control grid, an input circuit for receiving said triggering signal and applying it to the control grid to fire the tube, a relay which is in series with the anode-to-cathode discharge path of the tube and is energized by its discharge current, normally closed contacts for the relay which are opened when it is energized, a power supply circuit for the cathode heater of the tube which circuit is over the normally closed contacts and therefore is opened when the tube fires, said supply circuit for the heater including an incandescent lamp in series with the heater for signalizing a condition in which the tube has its cathode heated but has not fired thereby to indicate that there is no spark in the gap, a circuit which is completed by said relay between the

time when the tube fires and the time when it de-ionizes due to the cooling of its cathode, for providing said connection between said source of power and said pump for said limited period of time, a source of alternating curent energizing potential for the tube, means for connecting the last mentioned source across the anode-to-cathode discharge path of the tube, normally open contacts for said relay, and means including a circuit which is closed over the normally open contacts when said relay is energized, for applying to the grid as a firing voltage, of known phase and magnitude appropriate for firing the tube, a portion of said alternating current energizing potential.

13. A safety device as in claim 5, in which said control means comprises a hot cathode gas discharge tube having a control grid, an input circuit for receiving said triggering signal and applying it to the control grid to fire the tube, a relay which is in series with the anode-to-cathode discharge path of the tube and is energized by its discharge current, normally closed contacts for the relay which are opened when it is energized, a power supply circuit for the cathode heater of the tube which circuit is over the normally closed contacts and therefore is opened when the tube fires, said supply circuit for the heater including an incandescent lamp in series with the heater for signalizing a condition in which the tube has its cathode heated but has not fired thereby to indicate that there is no spark in the gap, a circuit, which is completed by said relay between the time when the tube fires and the time when it de-ionizes due to the cooling off of its cathode, for providing said connection between said source of power and said pump for said limited period of time, a motor relay which is

actuated temporarily over said last-mentioned circuit and thereafter is held during an operating cycle of the burner over an alternate energizing circuit controlled by said means responsive to the heat, the motor relay having normally open contacts which are closed when it is energized to provide said connection between said source and said pump, a normally closed switch in series with one of the line conductors of said source of power for the motor, the motor relay comprising a latch for engaging a movable element of said normally closed switch when the motor relay is energized and for moving it and opening the switch to lock power out from the burner when the motor relay is deenergized, and a link between said latch and said means responsive to a flame by which the latter means in responding to a flame will disengage the latch from said movable element to prevent it from opening the normally closed switch.

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