Fig. 1.

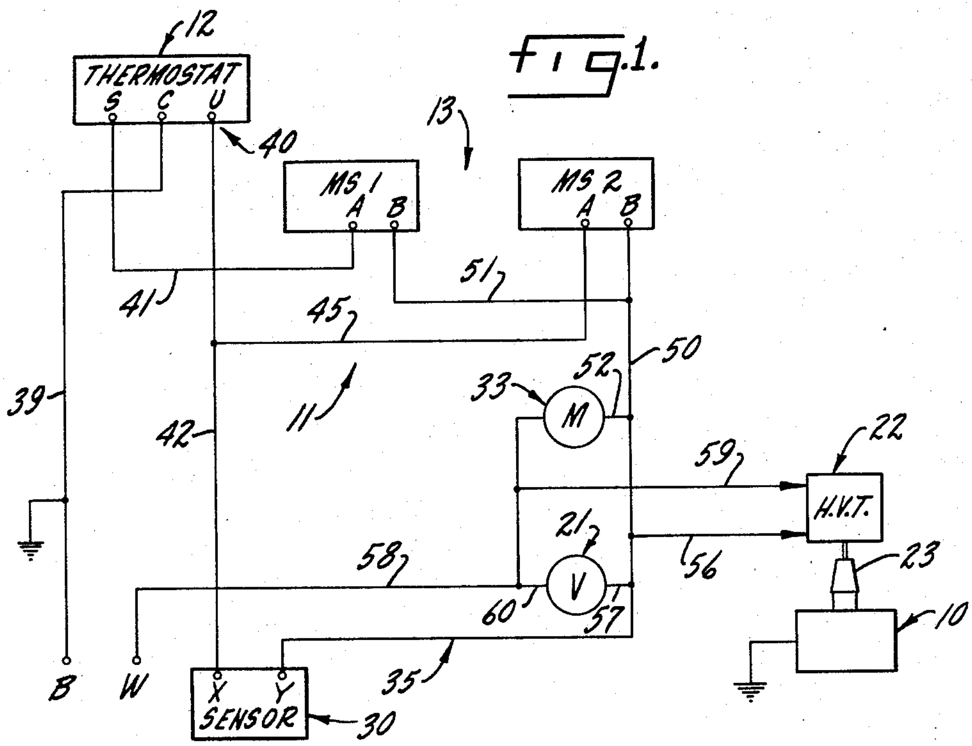

Fig. 2.

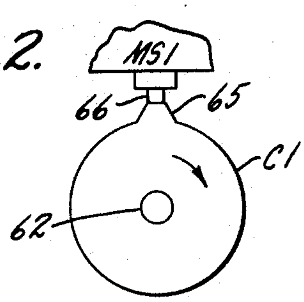

Fig. 3.

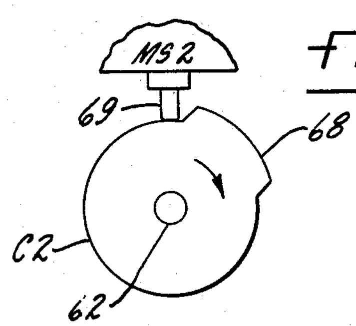

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Fig.4.

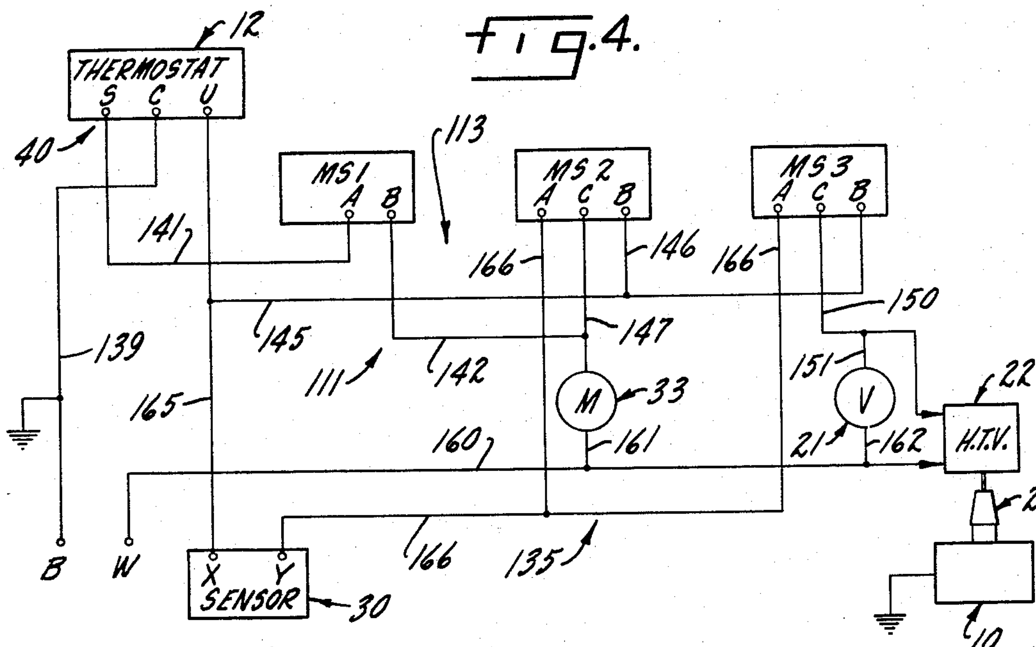
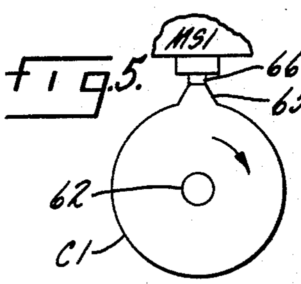
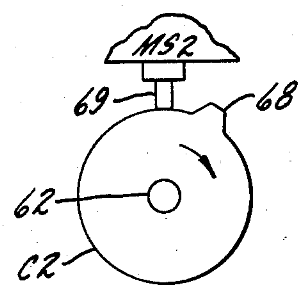


Fig.5.





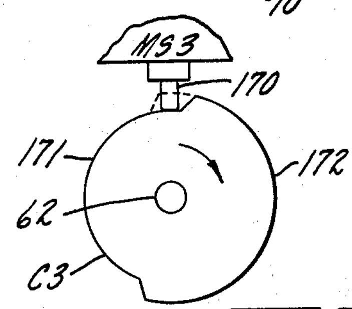


Fig.6. Fig.7.

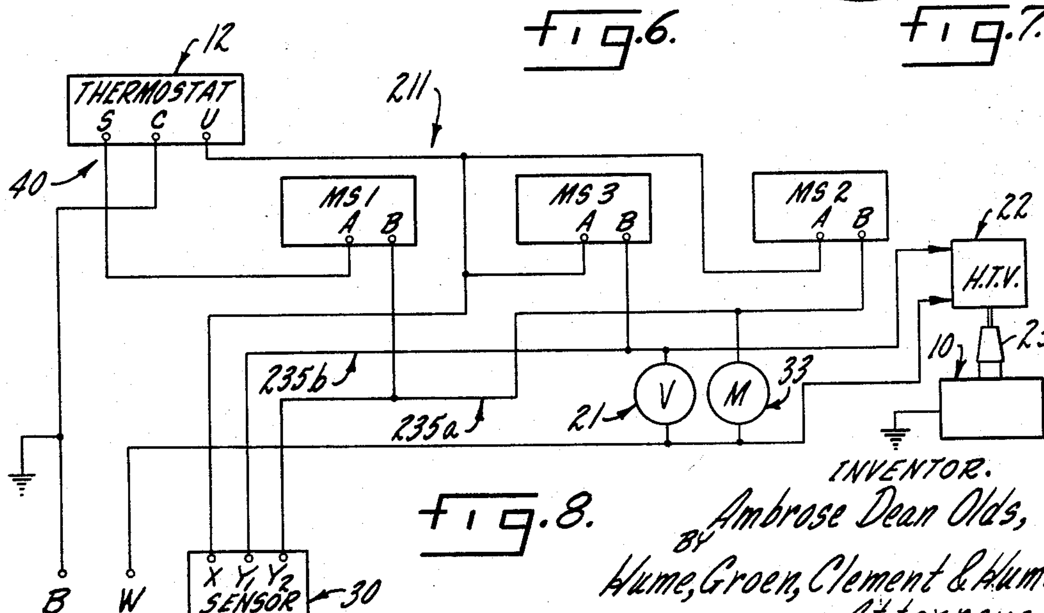


Fig.8.

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RESTARTER FOR THERMOSTATICALLY CONTROLLED OIL AND GAS BURNERS

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10 Claims. (Cl. 158—28)

This invention relates in general to burner ignition. It deals more particularly with a system for igniting and re-igniting a gas or oil burner or the like.

When circumstances indicate that it is desirable to ignite a burner such as a conventional warm air furnace, or a thermostatic device automatically calls for the burner's ignition, actuation of an ignition system is not always effective to achieve ignition. For example, on occasion the pilot flame has been blown out. Unburned fuel accumulates and poses a serious safety problem.

Electric ignition has partially solved this particular problem. Obviously, non-ignition of a burner upon actuation of an ignition system cannot occur due to "pilot outage" where a spark plug or coil is employed to ignite the fuel. Unfortunately, the great advantages of electric ignition are partially offset by inherent safety problems such as electric power failure, burned out ignition coils, fouled spark plugs, or even a plugged flue preventing the burning of fuel, although both fuel and ignition means are present. Obviously, protection against serious accumulation of unburned fuel is required even where electric ignition systems are employed.

The Underwriters' Laboratory and the American Gas Association recognize the dangers attendant to electric ignition. The Underwriters' Laboratory, for example, will not approve a burner unless it turns off the flow of fuel to the burner within ninety seconds after ignition is attempted, if flame is not sensed. An American Gas Association approved device must sense flame in from fifteen to 120 seconds after attempted ignition. Compliance with these requirements is generally achieved by electrically fired burners presently on the market, but, unfortunately, their electric ignition systems still leave much to be desired.

Accordingly, it is an object of the present invention to provide a new and improved ignition and re-ignition system for a burner or the like.

It is another object to provide an ignition and re-ignition system which precisely times a prescribed starting period and, if the burned does not fire within the period, locks out the flow of fuel and, accordingly, the burner.

It is still another object to provide an ignition and re-ignition system which simply and expeditiously can be remotely reset after lockout for another attempt at igniting the burner.

It is yet another object to provide an ignition and re-ignition system in which any selected time period can be established for reset of the system to attempt another ignition after lockout.

It is a further object to provide a system of the aforedescribed character which can be remotely reset by simple manipulation of a conventional wall thermostat in a home, for example.

It is yet a further object to provide a system wherein if ignition is successfully achieved, the system is automatically returned to a set or start condition for the next occasion that ignition is called for.

It is yet a further object to provide a new and improved ignition and re-ignition system wherein the precise timing of an ignition cycle is not effected by heat or voltage variation or the like.

It is another object to provide a system of the aforedescribed character which can be adjusted for constant

self-testing for operational readiness while the burner is operating properly.

It is still another object to provide a system wherein the timer's inoperativeness when ignition is called for is effective to prevent fuel flow and spark propagation.

The foregoing and other objects are realized in accord with the present invention by providing a system which electrically ignites a burner when heat is called for or, alternatively, "locks out" fuel flow to the burner after a prescribed period of time during which ignition of the burner is not achieved. Ignition cycle time is precisely measured regardless of temperature variation of the system or variation of circuit voltage. To attempt to restart the burner if it goes out during operation or if it does not start at all upon demand, a simple circuit manipulation from a suitable remote location is all that is required. If ignition does occur, the system automatically resets itself for a restart when ignition is called for at some subsequent time.

An additional aspect of the invention resides in its ability to be adapted readily for the use of any selected rest period after "lock out." In other words, if ignition is not achieved and lock out occurs, the reset period during which ignition cannot be attempted can be adjusted to suit requirements.

The invention, together with its organization and method of operation, taken with other objects and advantages thereof, is illustrated more or less diagrammatically in the accompanying drawings, in which:

FIGURE 1 is a schematic illustration of a basic form of ignition and re-ignition system embodying features of the present invention;

FIGURE 2 is an enlarged diagrammatic view of a cam operated switch incorporated in the system illustrated in FIGURE 1;

FIGURE 3 is a diagrammatic view of another cam operated switch in the system of FIGURE 1;

FIGURE 4 is a schematic view of a first modified form of an ignition and re-ignition system embodying features of the present invention;

FIGURE 5 is an enlarged diagrammatic view of a cam operated switch incorporated in the first modified system illustrated in FIGURE 4;

FIGURE 6 is a diagrammatic view of another cam operated switch in the first modified system of FIGURE 4;

FIGURE 7 is a diagrammatic view of still another cam operated switch in the first modified system of FIGURE 4; and

FIGURE 8 is a schematic view of a second modified form of ignition and re-ignition system embodying features of the present invention.

Referring now to the drawings, and particularly to FIGURE 1, a first or basic form of the system for igniting and re-igniting a conventional gas burner **10** according to the present invention is illustrated diagrammatically at **11**. The system **11** includes a conventional thermostat **12** which is manually adjustable to set a prescribed temperature below which the burner **10** is theoretically fired by the system **11**, and above which the burner is extinguished.

The thermostat **12** is connected to an electrical circuit **13** embodying features of the present invention and if the temperature in a home, for example, falls below a prescribed figure, the thermostat is effective through the circuit to open a magnetically operated valve **21** of conventional construction and supply gas to the burner **10**. At the same time, current is supplied to a high voltage transformer **22** in the circuit **13**, causing a spark plug **23** to fire and, theoretically, igniting the gas in the burner **10**. The burner **10** then operates until the thermostat **12** senses that the prescribed temperature has been reached, whereupon the fuel valve **21** in the circuit **13** is automatically shut off.

It is, however, only when the burner **10** is properly fired within a prescribed period of time that the system **11** continues to supply fuel to the burner through the valve **21**. In this light, when the burner **10** ignites, a conventional Wilcolator sensor **30** in the circuit **13** responds to heat produced by the burner flame and is effective upon its self-contained switch to cause the valve **21** to continue to supply fuel to the burner and current to the spark plug **23** for as long as the thermostat **12** is unsatisfied.

With the thermostat **12** as yet unsatisfied, and the burner **10** operating normally, a conventional synchronous motor **33** in the circuit **13** runs at a predetermined constant speed. It is the speed of the motor **33** which provides a precise measurement of the time period within which the system **11** must light the burner **10** or fuel flow to the burner is shut off. To this end, the motor **33** is effective to operate simple single pole, single throw microswitches **MS1** and **MS2** in the circuit **13** according to a predetermined schedule.

In the present illustration of the basic form of system **11**, the schedule calls for a fifty-second ignition period, followed by a mandatory ten-second "lockout." If the burner **10** is fired within fifty seconds after the thermostat **12** demands heat, the sensor **30** senses flame and is effective to place a "hold" on the circuit **13** and supply fuel to the burner **10** for as long as the burner flame is lit and the thermostat **12** unsatisfied. In other words, upon sensing flame, the sensor **30** is effective to close a holding circuit **35** in the circuit **13** and hold it closed as long as flame is sensed. The motor **33** continues to manipulate the switches **MS1** and **MS2** during normal operation of the burner **10**, maintaining the switches free of corrosion and the like without effecting the holding circuit **35**.

Once the thermostat **12** is satisfied by its environmental temperature, the system **11** automatically "resets" itself for another ignition cycle when such is called for, all according to the present invention through the circuit **13**. In other words, the motor **33** is automatically reset in its "start" or zero position for timing another starting cycle.

If the burner **10** does not fire and begins to operate properly within the fifty second ignition period, however, the sensor **30** is not effective to close the holding circuit **35** in the circuit **13**. Consequently, after fifty seconds, the motor **33** opens the switch **MS2** causing the circuit **13** to close the magnetically operated valve **21**. The sytsem **11** is thus "locked out" and no more fuel can flow to the burner **10**. No explosion can occur as a result of a dangerous accumulation of gas, for example.

To reset the system **11** for another attempt at igniting the burner **10**, the thermostat **12** is merely adjusted downwardly to demand a temperature lower than that in the home at the time; for example, 60° F. The thermostat **12** is thus satisfied by the temperature of its environment and the circuit **13** is effective to start the motor **33** running again. According to the present illustration, the motor **33** runs for ten seconds and then opens the switch **MS1** in the circuit **13** to stop the motor **33** once more.

The system **11** has now been reset in its zero or start position. At this point, the temperature setting of the thermostat **12** is raised to the higher desirable temperature, causing the circuit **13** to once again initiate operation of the motor **33**, which has returned to its zero position for re-timing anotber ignition cycle, as pointed out. The fifty second ignition cycle is repeated.

Turning now to the details of the system **11**, the circuit **13** includes a terminal W connected to a line (not shown) carrying 115 volt, sixty cycle current and a terminal B connected to ground. The terminal B is connected by a conductor **39** to the center terminal C of a conventional single pole, double throw switch **40** associated with the thermostat **12**. Bracketing the center terminal C in the switch **40** is the terminal S (satisfied), which is connected to the center terminal C by the thermostat when its temperature requirements are satisfied, and the terminal U (unsatisfied) requirement which is alternatively connected to the center terminal C by the thermostat when the temperature requirements of the thermostat are unsatisfied.

The terminals S of the switch **40** is connected by a conductor **41** to the terminal A of the switch **MS1**, while the terminal U is connected by a conductor **42** to the terminal X of the sensor **30** and by a branch conductor **45** to the terminal A of the switch **MS2**. The terminal B of the switch **MS2** is, in turn, connected by a conductor **50** to the terminal Y of the sensor **30**.

A branch conductor **51** from the conductor **50** is connected to the terminal B of the switch **MS1** while another branch conductor **52** from the conductor **50** is connected to one side of the motor **33**. Still another branch conductor **56** extends from the conductor **50** to the one terminal of the high voltage transformer **22**, while another branch conductor **57** connects the conductor **50** with the valve **21**.

The opposite side of the motor **33** is connected by the conductor **58** to the hot line terminal W. In turn, branch conductors **59** and **60** connect the opposite sides of the transformer **22** and valve **21**, respectively, to the conductor **58**. The transformer **22** is connected in a well known manner to the spark plug **23**.

Referring now to FIGURES 2 and 3, the shaft **62** of the motor **33** has two cams C1 and C2 mounted on it. The cam C1 has a uniformly recessed circular cylindrical periphery except for a single cam projection **65** wide enough only to hold the actuator **66** of the switch **MS1** open, as illustrated in FIGURE 2, when the motor **33** and therefore, the cam C1 is in its start or zero degree position.

The cam C2 on the other hand has a uniformly recessed circular cylindrical surface along only 300° of its periphery and a projection **68** extends along 60° thereof. With a motor **33** and accordingly, the cam C2 in its start or zero degree position, the actuator **69** of the switch **MS2** has just fallen off of the cam projection **68** (the cams rotate in a clockwise direction, as seen in FIGURES 2 and 3), placing the switch **MS2** in its normally closed relationship.

With the thermostat **12** satisfied, the motor **33** has automatically positioned the cams C1 and C2 in this start or zero position. The swtich **MS1** is open, the switch **MS2** is closed, the common terminal C of the single pole, double throw switch **40** associated with the thermostat **12** is in contact with the terminal S thereof, and the terminals X and Y of the sensor **30** are open. No current flows through the circuit **13**.

As the room cools below the preset temperature of the thermostat **12**, the thermostat **12** is effective upon the switch **40** to connect its center contact C with the contact U, disconnecting the contacts C and S. Circuits are immediately completed through the closed switch **MS2** to the motor **33**, the transformer **22**, and the valve **21**. Gas flows through the valve **21** to the burner **10** and a spark from the plug **23** is propagated to ignite the gas. The motor **33** turns the two cams C1 and C2 at a constant rate of one r.p.m. in the present illustration.

Once the motor **33** begins to rotate the cams C1 and C2, the cam C1 immediately permits the open switch **MS1** to go to its normally closed position. The switch **MS2** remains closed through 300° or fifty seconds of rotation of the motor **33** and cam C2 until the cam projection **68** engages the actuator **69** and opens the switch **MS2**. The completed circuits to the motor **33**, the transformer **22**, and the valve **21** through the switch **MS2** are opened and the system **11** has reached "lockout," unless the burner **10** has been ignited during these fifty seconds.

If the burner **10** is ignited during this fifty second period, the sensor **30** senses heat from the burner flame and is effective to connect the terminals X and Y in its self-contained switch and close the holding circuit **35** to the motor **33**, transformer **22**, and valve **21**. This holding circuit 35 is traced from hot line terminal W through the conductor 58, the branch conductors 33, 59, and 60 to the motor 33, the transformer 22 and the valve 21, respectively, the branch conductors 52, 56, and 57 to the conductor, 50, through the closed terminals X and Y of the sensor 30 to the conductor 42, the conductor 42 through the U and C contacts of the switch 40 associated with the thermostat 12 to the conductor 39, and then to the ground terminal B.

This holding circuit 35 supplies current to the motor 33, the transformer 22, and the valve 21, as long as the thermostat 12 is unsatisfied, regardless of the open or closed condition of the switches MS1 or MS2. The motor 33 continues to rotate the cams C1 and C2, opening and closing the switches MS1 and MS2 in each revolution of the motor. The switches MS1 and MS2 are, accordingly, constantly operated to avoid corrosion or the like which might result in a malfunction during use after long quiescence.

When the thermostat becomes satisfied once more by a suitable temperature increase, it manipulates the switch 40 to reconnect the C and S contacts. Accordingly, the holding circuit 35 through sensor 30 is broken and a circuit completed to the motor through closed switch MS1. Switch MS1 remains closed until cam projection 65 contacts and opens it within the next 60 seconds and then the entire circuit 13 is open. The system 11 is thus automatically reset for the next ignition attempt when it is called for, all according to the present invention.

Since the Wilcolator sensor 30 is conventional in all respects, it is not shown in detail. Briefly, however, the sensor 30 consists of a small bulb conected by a capillary tube to a bellows. When the bulb is heated, mercury held therein causes the bellows to operate a self-contained switch and close the circuit through terminals X and Y. The Wilcolator sensor 30 is a standard commercial product.

Returning now to a description of the operation of the system 11 when "lockout" occurs after fifty seconds, it will be remembered that the switch MS2 is permitted to open at this time. Since the sensor 30 has not sensed flame at the burner 10, the contacts X and Y are not closed and current to the motor 33, the transformer 22, and the valve 21 is shut off. This situation also occurs, of course, if power fails in the system 11; another feature of the present invention.

Referring to the normal "lockout" situation, it now becomes necessary to reset the system 11 for another attempt to start the burner 10. The thermostat 12 is manually reset below its environmental temperature so that it is satisfied. Accordingly, the thermostat 12 closes the contacts S and C of the switch 40, opening the contacts C and U. A circuit is immediately completed through the now closed switch MS1 to the motor 33. A circuit is also completed to the transformer 22 and the valve 21 in the basic system 11 (as will hereinafter be discussed in relation to the other forms of the present invention, the invention also contemplates initiating operation of only the motor 33 under these conditions). The motor 33 begins turning and turns the cams C1 and C2 through another ten degrees whereupon the switch MS1 is opened by the cam projection 65 on the cam C1, opening the circuit to the motor 33 once more. At the same time, the switch MS2 has closed since the projection 68 on the cam C2 has moved in a clockwise direction out from under the actuator 69. The system 11 is now in its starting position ready to cycle another ignition attempt when the thermostat 12 is turned back to a normal 70° F., for example, and consequently is unsatisfied.

Turning now to FIGURE 4, a second form of system for igniting and reigniting a conventional gas burner 10 is illustrated diagrammatically at 111. The system 111 embodies the same basic concepts as the system 11 hereinbefore described. It does, however incorporate certain modifications of the system 11 which might make it more attractive in practical application of the invention.

The system 111, for example, facilitates adjusting the ignition cycle time of the system and introducing a delay period after the ignition cycle during which the system remains at rest before it can be positioned for manual reset. The system 111 also provides for operating the motor 33 to time the manual reset period without coincidental operation of the high voltage transformer 22 and the valve 21.

As already recognized, the system 111 incorporated components identical to those described in relation to the system 11. As such, the system 111 includes a thermostat 12 a valve 21 a transformer 22 a spark plug 23 a Wilcolator sensor 30 and a motor 33. The motor 33 carries cams C1 and C2 on its output shaft 62 and the cams C1 and C2 are effective to operate a single pole, single throw microswitch MS1 and a single pole, double throw microswitch MS2. The cam C2 alternatively connects the front and back contacts B and A, respectively, of the switch MS2, with its center contact C by depressing or releasing its actuator 69 with the projection 68 on the cam.

The circuit in which the components are incorporated is slightly different than the circuit 13 hereinbefore discussed in relation to the system 11 and, accordingly, is identified by the reference numeral 113. The circuit 113 includes, in addition to those components hereinbefore referred to, another single pole, double throw microswitch MS3. Furthermore, a third cam C3 on the output shaft 62 of the motor 33 is effective to manipulate the actuator 170 of the switch MS3 to alternatively connect the center contact C of the switch MS3 with either the back contact A of the switch, or the front contact B thereof. The cam C3 has a recessed circular cylindrical periphery 171 in which the actuator 170 rides through the first 180° of clockwise rotation of the cam C3 from the start or zero position, and a raised circular cylindrical projection 172 up onto which the actuator 170 is forced during the last 180° of rotation of the cam C3. With the actuator 170 in the depressed periphery 171, the contacts C and B are connected. With the actuator 170 riding on the raised cam surface 172 during the last 180° of rotation of the cam, the contacts C and A are connected.

The circuit 113 further includes a conductor 139 which connects the B or ground terminal of the power source (not shown) with the C terminal of the switch 40 associated with the thermostat 12. A conductor 141 connects the S terminal of the switch to the A terminal of the switch MS1, while the B terminal of the switch MS1 is connected to one side of the motor 33 by the conductor 142.

A conductor 145 connects the terminal U of the switch 40 to the front terminal B of the switch MS3, while a branch conductor 146 interconnects the conductor 145 and the front terminal B of the switch MS2. The outer terminal C of the switch MS2 is connected to the conductor 142 and, accordingly, to the one side of the motor 33 by a conductor 147. The center terminal C of the third microswitch MS3 is connected with the conductor 150 to one side of the high voltage transformer 22, while a branch conductor 151 joins the conductor 150 to one side of the valve 21. The opposite side of the motor 33, the valve 21, and the transformer 22 are connected to the hot line terminal W by a conductor 160 and the branch conductors 161 and 162, as illustrated.

The only remaining undescribed portion of the circuit 113 comprises its holding circuit 135. The holding circuit 135 includes the sensor terminals X and Y, and a conductor 165 extending from the terminal X to the conductor 145. A branched conductor 166, in turn, connects the terminal Y with the back terminals A of the microswitches MS2 and MS3.

Turning now to the operation of the system 111, with the thermostat 12 satisfied the motor 33 has positioned the cams C1, C2, and C3 in their start or zero positions, as illustrated in FIGURES 5–7. Consequently, switch MS1 is open, the switch MS2 and the switch MS3 are positioned so their center contacts C and front contacts B are connected. The common terminal C of the switch **40** associated with the thermostat **12** is connected with the terminal S of the switch **40** and the terminals X and Y of the sensor **30** switch are unconnected. No current flows through the circuit **113**.

As the room cools, the thermostat **12** is effective on the switch **40** to connect its center contact C with the contact U. A circuit is completed through the closed contacts C and B of the switch MS2 to the motor **33**. At the same time, a circuit is completed through the switch MS3 via its closed center and front contacts C and B to the valve **21** and the transformer **22**. Gas flows through the valve **21** to the burner **10** and a spark from the plug **23** is propagated to light the fuel. The motor **33** turns the cams C1, C2 and C3 at a constant rate of 1 r.p.m.

The rotating cam C1 immediately permits the switch MS1 to close. The motor **33** continues rotating the cams C1–C3, gas continues to flow from the valve **21** to the burner **10**, and a spark continues to be propagated by the plug **23** until **30** seconds has passed in the present illustration and the projection **172** on the cam C3 forces the actuator **170** of the switch MS3 to connect the center contact C of the switch and the back contact A thereof, disconnecting the center contact from the front contact B. Circuits to the valve **21** and the transformer **22** are, consequently, broken and the system **11** is locked out.

If the burner **10** fires during this thirty second ignition cycle period, however, the sensor **30** senses heat from the flame and is effective to close the terminals X and Y of its self-contained switch. Accordingly, the holding circuit **135** through the sensor **30** and the microswitch MS3, via its back terminal A and center terminal C, completes a circuit to the valve **21** and transformer **22**. Fuel and spark continue to be supplied to the burner **10**. The circuit through the switch **40** and front contacts C and B of switch MS2 remains closed except for a 10 second period every 60 seconds to continue to run motor **33**. During that 10 second period the cam projection **68** switches MS2 to its back contact A connection and a holding circuit through conductor **166** keeps the motor **33** running during this time. Every thirty second as the single pole, double throw switch MS3 switches back and forth between its back contact A and its front contact B from the center contact C, the circuit to the valve **21** and the transformer **22** is transferred back and forth from the holding circuit **135** to the main circuit through the thermostat switch **40**, but this has no effect upon the operation of the system **111**.

When the burner **10** does not ignite during the first thirty seconds of operation of the system **111** seeking ignition of the burner, the valve **21** and transformer **22** are locked out in the manner described above. A circuit to the motor **33** is still closed, however, through the front contact B of the switch MS2, and the motor continues to rotate the cams C1–C3. After twenty more seconds or 120 additional degrees of rotation, the cam C2 switches the switch MS2 to its rear contact A, opening the circuit to the motor **33**. This is known as positioning for manual reset. At this time, after fifty seconds, the system **111** is entirely locked out if the sensor **30** has not sensed flame.

The system **111** is reset for another attempt to start the burner **10** in the same manner as described in relation to the system **11**. The thermostat **12** is manually reset at a temperature which is satisfied by environmental conditions. With the thermostat **12** satisfied, the switch **40** contacts C and S are closed, opening the contacts C and U, and completing a circuit through the closed switch MS1 to the motor **33**. The motor **33** turns the cams C1–C3 for sixty more degrees or ten seconds whereupon the cam C1 opens the switch MS1, deactivating the system **111** entirely. The system **111** is now in its starting position ready to cycle another ignition attempt when the thermostat **12** is turned back to a temperature where it is unsatisfied in its environment.

It will now be recognized that the system **111** has introduced another adjustable variable in its control of ignition and re-ignition of a burner **10**, for example. By varying the peripheral configuration of the cam C3, the initial ignition cycle time can be varied anywhere from ten to fifty seconds using a motor **33** which revolves at one r.p.m.

The system **111** retains the advantageous feature of automatic repositioning for re-start after the normal operation of a burner **10** has raised the environmental temperature to that sought. When the thermostat **12** is satisfied, the thermostat opens the contacts C and U of the switch **40** and closes the contacts C and S. Circuits to the valve **21** and transformer **22** are broken while a "back" circuit through microswitch MS1 to the motor **33** is closed. Consequently, the motor **33** continues to rotate the cam C1 until the projection **65** on the cam depresses the actuator **66** and opens the switch MS1. The system **111** is now at start or zero position ready for re-ignition when the thermostat **12** calls for increased environmental temperature.

Turning now to FIGURE 8, a third form of system for igniting and re-igniting a conventional gas burner **10** is illustrated diagrammatically at **211**. The system **211** performs in substantially identical fashion to the afore-described system **111**, but with slightly modified circuitry. Like the system **111**, the system **211** facilitates adjusting the ignition cycle time of the system and introducing a delay period after the ignition cycle during which the system is positioned for manual reset.

The system **211** incorporates components virtually identical to those described in relation to the system **11** and **111**. As such, the system **211** includes a thermostat **12**, a valve **21**, a transformer **22**, a spark plug **23**, a sensor **30**, and a motor **33**. The motor **33** carries cams C1, C2, and C3 on its outputshaft **62**, and the cams are effective to operate the single pole, single throw microswitches MS1, MS2 and MS3, respectively.

In contrast to the system **111**, the system **211** utilizes single pole, single throw microswitches MS2 and MS3. Furthermore, the sensor **30** is identical to a Wilcolator sensor in all respects except that it includes a single throw, double pole, self-contained switch rather than a single pole, single throw switch. As a result, separate holding circuits **235***a* and **235***b* are provided, (*a*) to the motor **33**, and (*b*) to the valve **21** and transformer **22**, respectively.

In operation of the system **211**, with the theromstat **12** satisfied, the motor **33** has positioned the cams C1, C2, and C3, in their start or zero position, as illustrated in FIGURES 5–7. Consequently, switch MS1 is open, switch MS2 is closed, and switch MS3 is closed. The common terminal C of the switch **40** associated with the thermostat **12** is connected with the terminal S of the switch **40** and the terminals X, Y_1 and Y_2 are unconnected. No current flows through the circuit **213**.

As the room cools, the thermostat **12** is effective on the switch **40** to connect its center contact C with the contact U. A circuit is completed through the closed switch MS2 to the motor **33**. At the same time, a circuit is completed through the closed switch MS3 through the valve **21** and the transformer **22**. Gas flows through the valve **21** to the burner **10** and a spark from the plug **23** is propagated to light the fuel. The motor **33** turns the cams C1, C2, and C3 at a constant rate of 1 r.p.m.

The rotating cam C1 immediately permits the switch MS1 to close. The motor **33** continues to rotate the cams C1–C3, gas continues to flow from the valve **21** to the burner **10**, and a spark continues to be propagated by the plug **23** until thirty seconds has passed (in the present illustration) and the projection **172** on the cam C3 forces the actuator **170** of the switch MS3 to open the contacts AB of the switch MS3, disconnecting circuits to the valve **21** and the transformer **22**. If the burner **10** doesn't fire during the thirty seconds, the projection

172 on the cam C3 forces the actuator 170 of the switch MS3 to open the contacts AB of the switch MS3, disconnecting circuits to the valve 21 and the transformer 22.

If the burner 10 fires during this thirty second ignition cycle, however, the sensor 30 senses heat from the flame and is effective to close the terminals X, Y_1 and Y_2 of its self-contained switch. Accordingly, holding circuits 235*a* through the switch MS2 to the motor 33, and 235*b* through the switch MS3 to the valve 21 and transformer 22, are closed. Fuel and spark continue to be supplied to the burner 10.

When the burner 10 does not ignite during the first thirty seconds of operation of the system 211 seeking ignition of the burner, the valve 21 and transformer 22 are shut off in the manner described above. The circuit to the motor 33 is still closed, however, through the switch MS2 and the motor continues to rotate the cams C1–C3. After twenty more seconds or 120 additional degrees of rotation, the cam C2 opens the switch MS2 opening the circuit to the motor 33. This twenty second period is referred to as "positioning for manual reset," as has previously been pointed out. At this time, after fifty seconds, the system 211 is entirely locked out if the sensor has not sensed the flame.

The system 211 is reset for another attempt to start the burner 10 in the same manner described in relation to the system 11 and 111. The thermostat 12 is manually reset at a temperature which is satisfied by environmental conditions. With the thermostat 12 satisfied, the switch 40 contacts C and S are closed, opening contacts C and U and completing a circuit through the closed switch MS1 to the motor 33. The motor 33 turns the cam C1–C3 for sixty more degrees or ten seconds, whereupon the cam C1 opens the switch MS1, deactivating the system 211 entirely. The system 211 is now in starting position ready to cycle another ignition attempt.

Like the system 111, the system 211 retains the advantageous feature of automatic repositioning for restart after the normal operation of a burner 10 has raised the environmental temperature to that sought. In other words if, as usually happens, the cams C1–C3 are not in their start or zero position when the thermostat switch 40 switches from "unsatisfied" to "satisfied" during normal operation of the system 211, a circuit to the motor 33 remains closed through the microswitch MS1 and continues to rotate the cams C1–C3 until they have reached their zero or start position, whereupon the entire system 211 is inactivated until the thermostat 12 again calls for increased temperature.

Both the systems 111 and 211 may be modified according to the present invention to provide yet an additional safety feature. This feature assures that if, for some reason, the motor 33 should fail to start upon its circuit being completed through operation of the switch 40 as energized by the thermostat 12 upon a demand for heat, fuel will not be supplied to the burner, nor will a spark be propagated. This safety protection is achieved by a slight angular adjustment or construction modification of the projection 172 on the cam C3.

For example, referring to FIGURE 7, it will be seen that rotation of the cam C3 counterclockwise on the shaft 62 for several degrees (to dotted line position) will cause the projection 172 to force the switch actuater 170 upwardly and open the switch MS3 (for system 211 or switch it to its back contact A for the system 111) when the system is in its zero or start position. Accordingly, until the shaft 62 is turned slightly clockwise from the start or zero position by operation of the motor 33, circuits to the valve 21 and transformer 22 are not closed. The length of the projection 172 can easily be adjusted, of course, to set any prescribed ignition period.

Referring to the setting of prescribed ignition periods and the like, it should also be recognized that the ignition period and rest period, for example, can also be changed by merely varying the speed of the motor. The systems 11, 111, and 211 have been described in the context of a motor 33 which turns the shaft 62 at one r.p.m., but any desired motor speed might be utilized to obtain an ignition period, for example, of prescribed length.

While several embodiments described herein are at present considered to be preferred, it is understood that various modifications and improvements may be made therein, and it is intended to cover in the appended claims all such modifications and improvements as fall within their scope.

What is desired to be claimed and secured by Letters Patent of the United States is:

1. A system for controlling the ignition and re-ignition of a burner comprising: circuit means including a source of current, electrical fuel control means, electrical fuel firing means, sensor means for sensing flame at the burner, timer means, operator switch means, and timer switch means, movement of said operator switch means into a first alternative condition when said system is in its normal start or zero position completing circuits to said timer means and to said fuel control means and said fuel firing means to attempt ignition of said burner, said timer means timing a predetermined ignition period, normal firing of the burner during said ignition period being sensed by said sensor means which then closes holding circuits to said timer means, and said fuel control means, said timer means continuing to operate as long as said burner is fired while cyclically operating said timer switch means, movement of said operator switch means into a second alternative condition while said burner is normally fired being effective to open the circuit to said fuel control means and complete another circuit to said timer means to operate said timer means until said normal start or zero position is reached once more, whereupon said timer switch means is effective to open the closed circuit to said timer means and prepare said system for another ignition attempt when said operator switch means again moves into said first alternative condition, said timer means manipulating said timer switch means if ignition is not successfully obtained during said predetermined ignition period to break the circuit to and lock out said electrical fuel control means, said timer means also manipulating said timer switch to break its own closed circuit and lock itself out after said unsuccessful ignition period, manipulation of said operator switch means into said second alternative condition after said lock out being effective to complete a circuit to said timer means to cause said timer means to time a prescribed reset period and then manipulate said timer switch means to open the circuit to said timer means once more at said normal start or zero position.

2. The system of claim 1 further characterized in that if ignition is not successfully obtained during said predetermined ignition period and said electrical fuel control means is locked out, said timer means continues to operate for a rest period of predetermined length during which ignition is not attempted before manipulating said timer switch means to break its own closed circuit and lock itself out, lock out of said fuel control means and said timer means occurring at a time before start position is reached equal to the length of said reset period, if ignition is not successful.

3. The system of claim 1 further characterized in that movement of said operator switch means into said first alternative condition when said system is in its normal start or zero position first completes a circuit to said timer means and subsequently completes circuits to said fuel control means and said fuel firing means only if said timer means becomes operative so that ignition will not be attempted if said timer means is inoperative.

4. The system of claim 1 further characterized in that said operator switch means comprises a temperature responsive thermostat, said first alternative condition is in effect when said thermostat is unsatisfied by environmental temperature and said second alternative condition is in effect when said thermostat is satisfied by its environ-

mental temperature, whereby said system is manipulated for attempted ignition of said burner after an unsuccessful ignition attempt by manually setting said thermostat in an unsatisfied condition.

5. The system of claim **1** further characterized in that said timer switch means comprises a plurality of switches interposed in said circuit means between said operator switch means and said timer means, said fuel firing means, and said fuel control means, said timer means comprising a constant speed electric motor driving a plurality of cams, said cams being effective to manipulate said switches and accordingly control operation of the timer means, the fuel control means, and the fuel fire means, according to a predetermined schedule.

6. The system of claim **5** further characterized in that there are three of said switches; switch one, switch two, and switch three, switches one and two cooperate to control operation of said motor, and switch three controls the operation of said fuel control means and said fuel firing means.

7. The system of claim **6** further characterized in that said switches are single pole, single throw switches, and said sensor means includes and is effective to operate a single pole, double throw switch in said circuit means.

8. The system of claim **6** further characterized in that switches two and three are single-pole, double-throw switches, and said sensor means includes and is effective to operate a single pole, single throw switch in said circuit means.

9. A system for controlling the ignition and re-ignition of a burner comprising: circuit means including a source of current, electrical fuel control means, electrical fuel firing means, sensor means for sensing flame at the burner, timer means, operator switch means, and timer switch means, movement of said operator switch means to a closed position when said system is in its normal start or zero position completing circuits to said timer means and to said fuel control means and said fuel firing means to attempt ignition of said burner, said timer means timing a predetermined ignition period, normal firing of the burner during said ignition period being sensed by said sensor means which then closes holding circuits to said timer means, and said fuel control means, said timer means continuing to operate as long as said burner is fired while cyclically operating said timer switch means, movement of said operator switch means to an open position while said burner is normally fired being effective to provide at least a circuit to said timer means to operate said timer means until said normal start or zero position is reached once more, whereupon said timer switch means is effective to open the closed circuit to said timer means and prepared said system for another ignition attempt when said operator switch means again moves into said first alternative condition, said timer means manipulating said timer switch means if ignition is not successfully obtained during said predetermined ignition

period to break the circuit to and lock out said electrical fuel control means, said timer means also manipulating said timer switch to break its own closed circuit and lock itself out after said unsuccessful ignition period, manipulation of said operator switch means after said lock out being effective to complete a circuit to said timer means to cause said timer means to time a prescribed reset period and then manipulate said timer switch means to open the circuit to said timer means once more at said normal start or zero position.

10. A system for controlling the ignition and reignition of a burner, comprising: circuit means including a source of current, electrical fuel control means, electrical fuel firing means, sensor means for sensing flame at the burner, timer means, operator switch means, and timer switch means, movement of an operator switch means into a first alternative condition when said system is in its normal start or zero position completing circuits to said timer means and to said fuel control means and said fuel firing means to attempt ignition of said burner, said timer means timing a predetermined ignition period, normal firing of the burner during said ignition period being sensed by said sensor means which then closes holding circuits to said timer means and said fuel control means, said timer means continuing to operate as long as said burner is fired while cyclically operating said timer switch means, movement of an operator switch means into a second alternative condition while said burner is normally fired completing another circuit to said timer means to operate said timer means until said normal start or zero position is reached once more, whereupon said timer switch means is effective to open the closed circuit to said timer means and prepare said system for another ignition attempt when said operator switch means again moves into said first alternative condition, said timer means manipulating said timer switch means if ignition is not successfully obtained during said predetermined ignition period to break the circuit to and lock out said electrical fuel control means, said timer means also manipulating said timer switch to break its own closed circuit and lock itself out after said unsuccessful ignition period, manipulation of manual means after said lock out being effective to complete a circuit to said timer means to cause said timer means to time a prescribed reset period and then manipulate said timer switch means to open the circuit to said timer means once more at said normal start or zero position.

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