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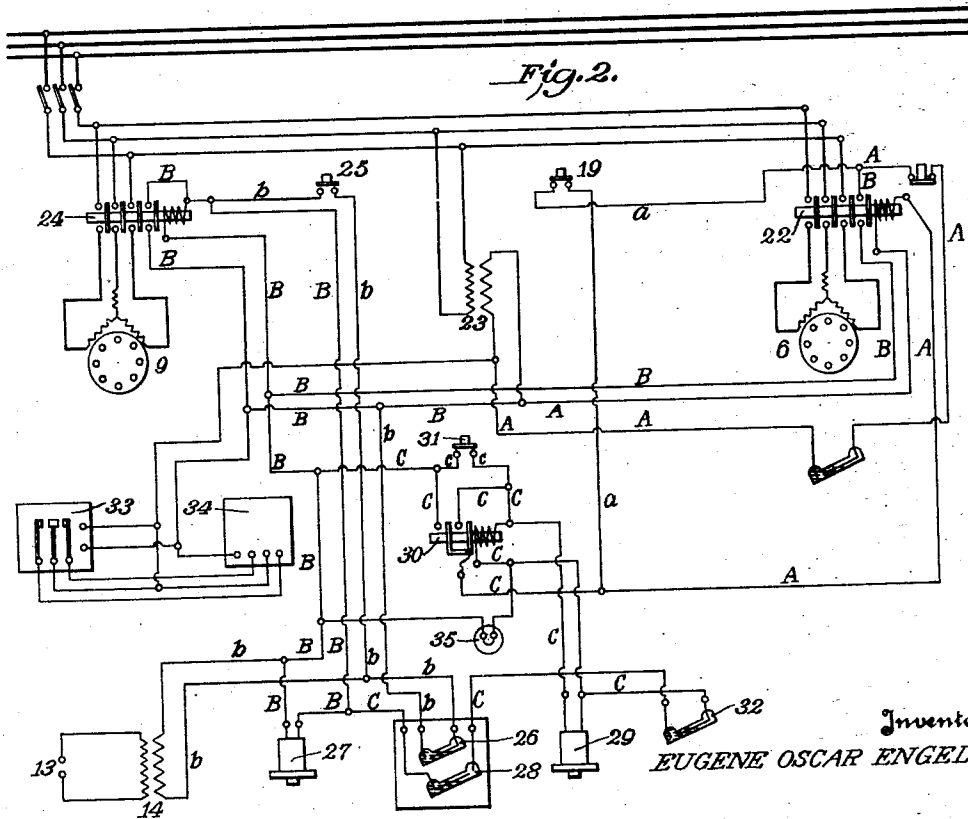
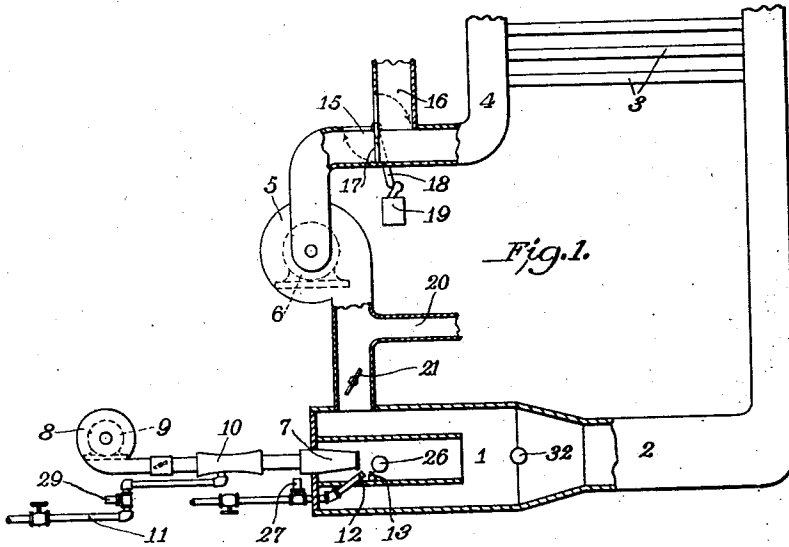
E. O. ENGELS

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CONTROL SYSTEM FOR BAKE OVENS AND THE LIKE

Filed July 29, 1932

2 Sheets-Sheet 1



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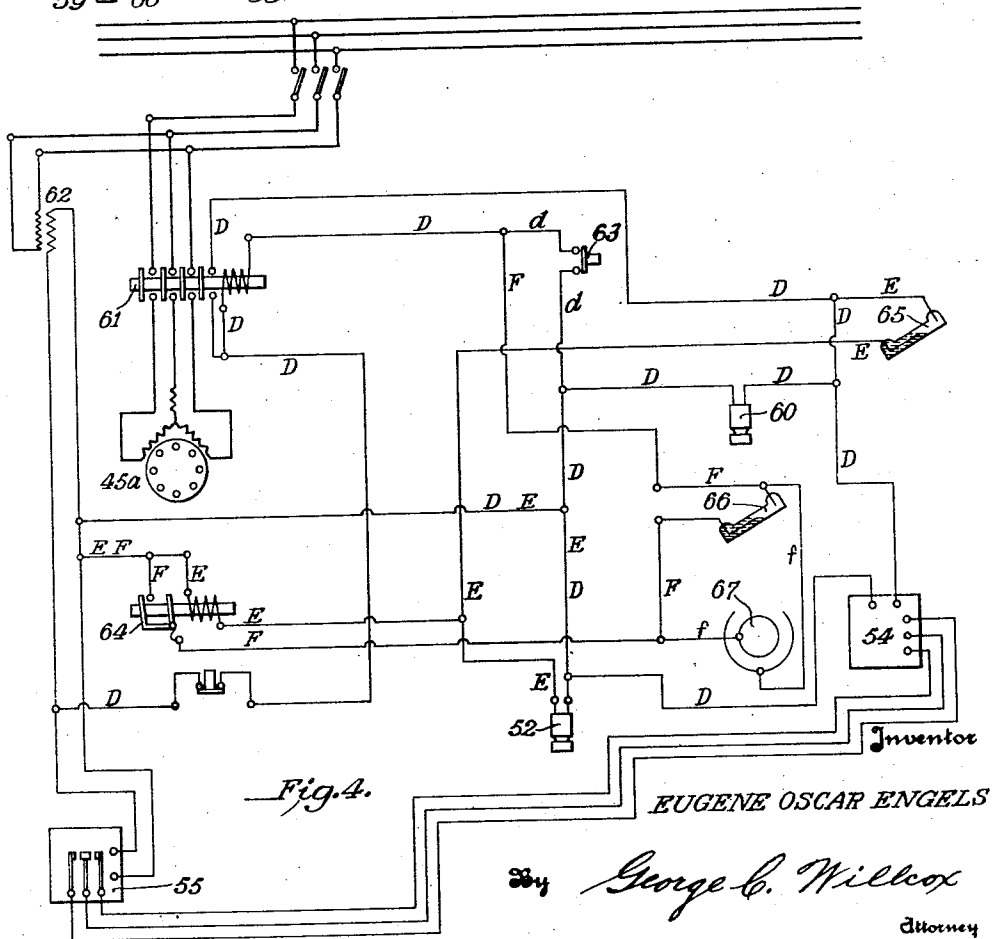
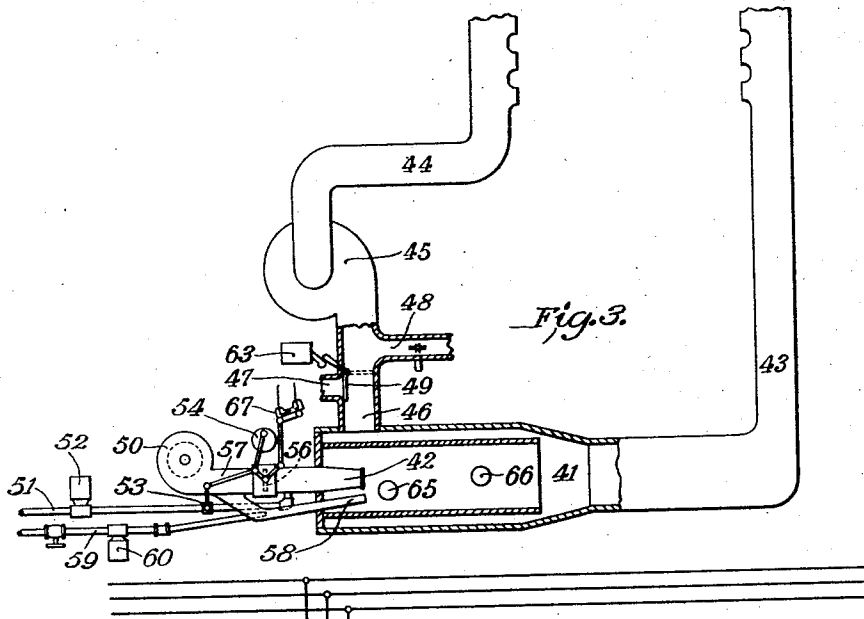
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CONTROL SYSTEM FOR BAKE OVENS AND THE LIKE

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2 Sheets-Sheet 2



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CONTROL SYSTEM FOR BAKE OVENS AND
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4 Claims. (Cl. 107-55)

This invention relates to heating systems for bake ovens, drying ovens, and the like, wherein the hot products of combustion from a furnace are employed to heat the oven chamber, either
5 by direct contact with the goods being treated or indirectly by circulation through radiating ducts within the oven. It has for its principal object the elimination of all hazards of explosion by the provision of a novel electrical control system comprising interdependent circuits for controlling the working elements of the system such as the means for circulating the hot gases, the ignition system and the fuel supply. Its object is to insure first, a thorough ventilation of the furnace and the radiating ducts or oven chamber
15 on starting up the system to remove or dilute any combustible vapors before the ignition means such as a spark plug or pilot light can be put in operation. Second, the risk of explosion is to be further eliminated by arranging the interdependent control so as to require that only the proper sequence of operations can be followed in starting the system. Third, the control system is arranged so that the failure of any operating element or factor will shut down the entire system and require the predetermined sequence of operations to be followed from the first step of ventilating the furnace and heating ducts. As a corollary to this third object the
25 control system insures that in the event of such failure of an element the system can not be put into operation unless the inoperative element be located and repaired.

The invention in its broadest aspect consists
35 in providing an electrical control circuit first, for starting the circulating impeller or fan to blow fresh air through the furnace and oven system, and second, for controlling directly or indirectly the ignition system so as to prevent the lighting of either the pilot or the main burner until the circuit is closed and the impeller operating. To insure this result the circuit is arranged to control the ignition current supply to a spark plug if one be used, or to control the
45 fuel supply to the pilot burner if that burner is to be lighted by hand. The operation of ignition is made separate from that of starting the fan to insure a time interval for the ventilating action of the fan. If electrical ignition be used, the ignition control switch is preferably located remote from the fan control starting switch so that they can not be closed simultaneously. Should manual ignition of a pilot light be provided for, the starting switch for the fan is

preferably located remote from the pilot light or the pilot fuel valve for the same purpose.

A special modification of the invention is applicable to oven-heating systems of the recirculating type, in which the spent gases from the oven or the oven radiating flues are fed back to the gas impelling fan, and thence to the furnace for reheating. To effect the preliminary ventilation of this system I provide a damper-controlled fresh air inlet, and in some types
65 of installations a special ventilating outlet also damper-controlled in addition to the regular stack outlet. The damper or dampers are arranged to prevent recirculation of the gases during the ventilating operation. The means for positioning the damper or dampers to ventilate the system is arranged to actuate the starting switch for the circulating fan, so that the fan can be started only by setting the damper control in its ventilating position to admit fresh
75 air to the circulating fan.

Another feature of the invention consists in the combination of the circulating fan control circuit, a second circuit dependent thereon, to control the operation of the furnace burner, and a third circuit dependent upon the second circuit and connected to the first circuit to supply holding current for the circulating fan power switch to keep the whole system in operation so long as all of the circuits remain closed.
85 The interdependency of the control circuits may be variously accomplished through direct electrical connections, by means of electrical relay switches controlled by the circuits, or thermostatic or mechanically actuated switches. Examples of these various devices will be described later in this specification.

As a further feature of the invention various known safety devices such as thermostatic temperature-limiting switches, gas or air pressure-responsive cut-out switches, etc., may be inserted in any one of the control circuits to shut down the entire system in the event of the failure or mis-functioning of various elements. Examples of certain of the safety devices usable
100 in this way will be described below.

Referring to the drawings:

Fig. 1 is a diagrammatic view showing a gas-burning heating system and the associated control elements according to my invention, wherein the oven is heated by radiating ducts through which hot gases are impelled, from which the spent gases are recirculated to the furnace.

Fig. 2 is a diagram of the control circuits for the system shown in Fig. 1.

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Fig. 3 is a diagrammatic view of a modification of the heating system in which light fuel oil is burned.

Fig. 4 is a wiring diagram for the system shown in Fig. 3.

Referring to Figs. 1 and 2, the system comprises a furnace 1 discharging hot products of combustion through a duct 2 into radiating flues 3 within the oven. The spent gases from the radiator flues 3 are returned through a duct 4 to a circulating fan 5 driven by a motor 6, and thence to the furnace.

Within the furnace 1 is a gas main burner 7. The combustion air for the burner is provided by a compressor 8 driven by an electric motor 9. The air from the compressor 8 entrains the gas in a Venturi mixer 10. The gas is led to mixer 10 by a supply pipe 11.

A gas pilot light 12 is located near the nozzle of the burner 7, and a spark plug 13, energized by a transformer 14, is provided to light the pilot burner. The pilot light may be lit manually if it is desired to omit the transformer and spark plug.

In the return duct 4 are provided an inlet 15 and an outlet 16 controlled by a swinging damper 17. When the damper is positioned as shown in the drawings the inlet 15 and outlet 16 are open and the duct 4 is closed. The operation of the circulating fan 5 causes air to be drawn in through the inlet 15, circulated through the furnace 1, duct 2 and flues 3, and then expelled through the outlet 16, sweeping out any combustible gases which may be in the system.

The starting of the burner is made dependent upon first opening damper 17 and starting the circulating fan by the following arrangement of the control switch and circuit. The opening of damper 17 by a lever 18 also actuates an electric switch 19 to start the circulating fan motor 6. The damper 17 is shown in the starting position.

After the oven has been ventilated and the system is in full operation the damper 17 is closed and another control circuit holds closed the power switch of the circulating fan, permitting the recirculating of the spent gases from the radiator ducts 3. On the outlet side of the circulating fan 5 is an exhaust stack 20. A damper 21 between the stack 20 and the furnace 1 is provided to control the proportion of gases vented to the stack, thus permitting a condition of suction to be maintained within the furnace and the circulating system.

The control circuits and the electrical devices actuated thereby consist of the following:

A control circuit A is arranged to close the magnetic switch 22 controlling the fan motor 6 and includes a starting sub-circuit *a* shunted across main circuit A. Sub-circuit *a* is controlled by the starting switch 19 which is closed when the ventilating damper 17 is opened. The current for circuit A is supplied by a transformer 23, or may be taken directly from the main power circuit if the voltage is suitable.

A second control circuit B includes the solenoid of the magnetic switch 24 controlling the motor 9 of the air compressor 8. Connected in parallel with the control circuit B is a starting sub-circuit *b* controlled by a push button switch 25. Circuit B and sub-circuit *b* are energized by circuit A through contacts on the magnetic switch 22, so that their current supply is dependent upon the closing of circuit A.

In parallel with circuit *b* is the high tension transformer 14 which supplies current to the spark plug 13 at the outlet of pilot burner 12. In series with circuit *b* is a thermostatic switch 26 actuated by the heat of the pilot light or main burner, which is closed when the thermostat is cool. Switch 26 operates to cut off the ignition transformer 14 when the pilot light is in operation.

In series with circuit B is a solenoid valve 27 controlling the gas supplied to the pilot burner 12. This solenoid can be designed either to open the valve automatically or to permit the valve to be opened manually.

A second mercury switch 28 is associated with the thermostat of switch 26, but it operates oppositely, being closed when the pilot or main burner is operating and open when the thermostat is cool.

A third control circuit C is connected to circuit B through switch 28, derives its current from circuit B, and is connected with a solenoid valve 29 controlling the main gas supply to the burner 7.

A three-way magnetic switch 30 controls circuit B, and is itself controlled by a shunt sub-circuit *c*. Sub-circuit *c* is closed by a push-button switch 31. Switch 30 is arranged when closed to shunt out sub-circuit *c* and switch 31 and maintain the holding circuit for its solenoid. When the magnetic switch 30 is closed circuit C is maintained, the solenoid valve 29 is held open and a connection is made to circuit A to keep the circulating fan switch 22 closed. This permits the opening of starting switch 19 by closing the ventilating damper 17.

In series with control circuit C is a safety thermostatic switch 32 in the furnace, which is opened in the event that the temperature in the furnace becomes excessive.

The operation of the burner is controlled by a conventional thermostat 33 and a motor valve 34 in the air line to the burner.

The operation of the system is as follows:

To start the furnace, the ventilating damper 17 is opened, closing starting switch 19 and sub-circuit *a*. This energizes the solenoid of the magnetic switch 22, starting the circulating fan 5 and permitting current to flow to control circuit B. Push button 25, preferably located at a point remote from the damper lever 18 and control switch 19 to insure a lapse of time after starting the fan, is then closed, energizing the starting sub-circuit *b* and the ignition transformer 14. The closing of circuit *b* energizes the solenoid of the magnetic switch 24 in the power line of the air compressor motor 9. When this switch is closed it also completes the control circuit B, energizing the solenoid valve 27, turning on or permitting the turning on of the gas to the pilot light 12. As soon as the pilot light is ignited its heat opens the thermostatic switch 26 and closes the associated switch 28. This cuts off the current to the ignition transformer 14 and permits current to flow to control circuit C. With switch 28, circuit C can now be closed by pressing the push button 31 in the shunt circuit *c*. This energizes the solenoid of magnetic switch 30, closing the switch and energizing the solenoid valve 29 in the main gas line, which can either turn on the gas for the main burner automatically or can permit it to be turned on manually. Magnetic switch 30 maintains its own holding circuit C through its solenoid and also makes a

connection from circuit C to the control circuit A. Since control circuit A now receives current from circuit C the ventilating damper 17 can be closed and the starting switch 19 can be opened. Connected between circuits B and C is a pilot light 35 which lights to indicate that the pilot burner is in operation and that switch 30 can be closed.

The system will not continue in operation if some part thereof should cease to function properly. For instance a thermostatic switch 32 is connected to control circuit C, to break the circuit if the furnace should overheat. Should the circulating fan 5 cease operating the temperature in the furnace would rise immediately, the thermostat would open switch 32 and break circuit C. This would interrupt circuits C, A and B, shutting off the air compressor motor 9 and the solenoid valve 29 for the gas. The entire system would shut down and could only be restarted by following the above described sequence of operations.

Another modification of the invention is shown in Figs. 3 and 4.

Referring to the drawings, the furnace 41, the burner 42 and the circulating system 43, 44, 45 and 46, for heating the oven, are the same as in Fig. 1. A different arrangement of damper and fresh air inlet are used to effect the preliminary ventilation of the furnace and radiator in the duct system.

The air inlet 47 is located in the duct 46 leading from the circulating fan 45 to the furnace 41, beyond the exhaust stack 48. A damper 49 is pivoted at one side of the duct so that it can close off the air inlet, or it can be swung to the position indicated in dotted lines, where it closes off the duct 46 and opens the air inlet. With the damper in this position air is diverted through the exhaust duct 48 and fresh air to replace the air expelled from the system is drawn in through the inlet 47. By this arrangement a suction is maintained within the furnace during the ventilating and starting operation of the furnace and heating system. The burner 42 and the fuel and air control devices associated with it are designed to use light oil for fuel. The burner is of the common domestic-heating type which operates intermittently to maintain the desired temperature.

Air for combustion is supplied to the burner from a source of compressed air 50, independent of the burner system in its operation. While a unit blower is shown, it may be replaced, especially in multiple burner installations, by a supply line leading from a central source of compressed air. An oil supply line 51 feeds the oil to the burner nozzle in known fashion, and is controlled by a solenoid shut-off valve 52 and a mechanically actuated valve 53 which is opened and closed by an electric control motor 54. This control motor is of the well-known reversible type operating in response to a conventional thermostatic switch or thermo-couple 55. The control motor 54 is connected also to a butterfly valve 56 in the air line 57. It thus controls simultaneously the air and oil supply to the burner 42.

A manually ignited gas pilot 58 is used to ignite the burner 42. The gas line 59 to the pilot is controlled by a solenoid valve 60.

The operation of the burner system is controlled by an electric control system according to my invention, now to be described.

Referring to Fig. 4, the circulating fan motor 45a is controlled by a magnetic switch 61. Current for the control circuits is obtained from a step-down transformer 62.

In series with the solenoid of the magnetic switch 61 is the first control circuit D having a shunt sub-circuit *d* for starting, which is closed by a switch 63. The switch 63 is arranged to be closed when the ventilating damper 49 is positioned to open the air inlet 47 and interrupt the circulation of air from the circulating fan through duct 46 to the furnace. The closing of magnetic switch 61 starts the fan 45 and energizes control circuit D. Circuit D is connected to supply current to the control motor 54 and to solenoid valve 60 in the gas line 59 to the pilot burner 58. Connected to circuit D and dependent on it for its current is a second control circuit E which is connected to the solenoid valve 52 controlling the oil supply to the burner. Circuit E is also connected to the solenoid of a magnetic switch 64 which is closed when circuit E is energized. Circuit E is controlled by a thermostatic switch 65 which is arranged to be closed by the heat of the pilot burner 58. Thus the main burner can not be lit until the pilot light is in operation.

Controlling the magnetic switch 61 is a third control circuit F. It is connected to the holding circuit D in shunt with the starting switch 63, so that when circuit F is closed current will be supplied to the solenoid 61 of switch 63 and the starting switch 63 can be opened without causing switch 61 to open and shut down the heating system.

Circuit F is controlled by a pair of switches 66, 67 connected in parallel with each other. Switch 66 is a thermostatic switch which is closed by the heat of the main burner. Switch 67 is actuated by the control motor 54 and it is arranged to maintain a holding circuit during the off periods in the intermittent operation of the burner.

When the burner is in operation switch 67 is opened and the thermostatic switch 66 is closed to maintain circuit F.

If the main burner flame should be extinguished thermo-switch 66 will open, circuit F will be interrupted and the magnetic switch 61 will be opened, shutting down the circulating fan and interrupting circuit D and hence throwing all the control circuits out of action. The fuel supplied to both the pilot and main burner will be cut off by solenoid valves 52 and 60.

The operation of the control system is as follows:

Damper 49 is drawn to its dotted position across duct 46 for ventilating the furnace and the circulating system. This movement of the damper 49 closes the starting switch 63 and energizes the sub-circuit *d*. The magnetic switch 61 is thus closed, starting the circulating fan motor 45a and closing the first control circuit D. The solenoid valve 60 in the gas line 59 to the pilot light 58 is opened, and the control motor 54 is put in operation by thermostat 55 to open the air and oil valves 56, 53. No fuel is fed to the burner since the solenoid valve 52 is still closed. The pilot light 58 at the furnace is now ignited by hand. Since it is located remote from the control lever of damper 49 and starting switch 63, a time interval of a few seconds between closing the switch and lighting the burner is compelled, during which

interval the air is completely changed in the furnace and radiating flues or in the oven chamber if direct heating is used. Thus no explosive gas can be present when the pilot is lighted.

- 5 When the pilot flame is burning its heat will cause thermostatic switch 65 to close, thus permitting current to pass from control circuit D into the second control circuit E. Simultaneously the solenoid valve 52 in the fuel line is
10 opened and the magnetic switch 64 is closed. The main burner 42 is then lighted by the pilot light and current will be supplied to the third control circuit F from the magnetic switch 64.

- When the main burner lights, its heat will
15 cause the thermostatic switch 66 to close, thus completing the circuit F and supplying current to the holding solenoid of the magnetic switch 61, permitting the ventilating damper 49 to be closed and the starting switch 63 to be opened.
20 When the heat in the oven has reached the temperature for which the thermostat 55 is set, the control motor 54 will close the oil and air valves 53, 56 and extinguish the main burner. At the same time, however, it will close switch 67 so
25 that sub-circuit F will be shunted around thermostatic switch 66. This will maintain circuit F during the off period of the burner. Should the thermostat 55 then call for more heat and the main burner fail to light, the switch 67 will be
30 opened by motor 54, but the switch 66 will fail to close. This will interrupt circuit F, de-energizing circuit D, and the main switch 61 will open, shutting down the entire system. Should
35 the pilot light be extinguished, the thermostatic switch 65 will be opened, interrupting the control circuit E, causing the magnetic switch 64 to open, interrupting circuit F with a similar result.

- While this modification of the invention differs in its operation from that shown in Figs. 1 and 2, it is fundamentally the same in that the circulating fan must be started before the pilot light or the burner can be started by making them dependent upon a control circuit (D)
45 closed by starting the circulating fan, and similarly through a second control circuit (E) the operation of the main burner is made dependent upon the operation of the pilot light. Through
50 a third control circuit (F) dependent upon the main burner, which holds the first circuit closed after the starting switch is opened, the failure of any element is caused to shut down the entire system. Thus the failure of the combustion air supply, a failure of fuel supply, a current
55 interruption, or, for example, a failure of the pilot light which would result in unburned gas for fuel being injected into the furnace, results in a stoppage of operation. The system can not be re-started except by opening the ventilating
60 damper, insuring that the circulating fan shall sweep out any such explosive gases before the pilot can again be ignited.

- Certain modifications in the arrangement of the heating system and in the details of the control system may be made without departing from the essential principle of the invention. For example, in Fig. 3, a heating system has been shown in which the oven chamber is heated directly by the admixture of the hot furnace
70 gases from the oven atmosphere. A further modification of this system is desirable in some forms of drying kilns, such as enameling ovens, wherein the gases from the oven are saturated with the vapor of the solvents, and it is desired to vent them directly to the stack. In

such a case the return duct 44 from the oven chamber, the exhaust stack 48, the ventilating inlet 47, and damper 49 will be omitted. Fresh air will be drawn into the circulating fan, passed through the furnace 41 to be mixed with hot gases of combustion, and the heated fresh air will be impelled into the oven chamber through duct 43. The operation of the control system will remain the same. The impeller fan 45 will be started by closing starting switch 63 and during the interval between starting the fan and lighting the pilot light the furnace and oven will be blown out with fresh air. If it is desired to further simplify the control system, sub-circuit d and starting switch 63 can be omitted. The system will then be started by manually closing the power switch 61, but its operation will remain unchanged.

Numerous modifications of the furnace mechanism proper are possible in any of the applications of the invention.

A burner of the atmospheric type, dependent upon suction within the furnace to draw in the air for combustion to the burner may be used. In this case certain of the control valves will be omitted or replaced by other devices.

In the system shown in Figs. 1 and 2 the air supply is controlled by the power switch 24 controlling blower motor 9. If this system be modified to omit motor 9 the air supply might be controlled by a butterfly valve arranged to be opened only if control circuit A were energized.

The essential interdependency of the control circuits may be accomplished in other ways than by direct electrical connections. For example, in Fig. 4 circuit D might be separately energized from transformer 62 and have no connection with switch 61. Its dependency upon the operation of blower 45 could then be arranged by having a switch in circuit D actuated by a flap-vane or pressure-responsive switch bellows in duct 46 or duct 43 to close the switch only when an air current of certain minimum velocity or pressure is passing through the duct.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. In a heating system for bake ovens and the like having a furnace, a burner, ignition means for the burner, and means for impelling hot gases of combustion through the oven chamber, a safety control system comprising in combination a starting switch controlling said impeller and a control circuit dependent upon the operation of said impeller for controlling the burner and its ignition means, said circuit operating when closed to permit but not to start the operation of said ignition means, said ignition means being put into action by a second operation separate from and performed after the closing of said starting switch, said starting switch and said ignition means located apart so that the switch must be closed and said impeller put in operation before said ignition means can be operated.

2. In a heating system as claimed in claim 1, wherein the gases from the oven are impelled in a closed circuit from the furnace through the oven and back to the furnace, an inlet for admitting fresh air to the system, and damper means for opening said inlet and interrupting the recirculation of gases to said furnace, said damper means operatively associated with said starting switch to close the switch when said fresh air inlet is opened.

3. In a heating system as claimed in claim 1, a second control circuit dependent upon the first control circuit and controlling the fuel supply to said burner, a switch in said second circuit adapted to be closed by the operation of said ignition means, a third control circuit dependent upon said second circuit and connected to supply current to said first control circuit, and a thermostatic switch in said third circuit arranged to close the circuit when said burner is in operation.
4. In a heating system for bake ovens comprising a furnace, ducts leading therefrom to the oven, a motor-driven fan for impelling hot gases from the furnace through the oven, a fresh air inlet to the furnace and oven, damper control means for said inlet, a main burner in the furnace, a gas pilot burner, an electrically controlled valve for the gas supply to said pilot burner, and electrical control means for the fuel supply to the main burner, a control system comprising in combination a starting switch arranged to be closed by the opening of said damper control means for the fresh air inlet, a first control circuit closed by the closing of said starting switch operating to open said valve for the pilot gas supply and to start said fan, a second control circuit dependent upon said first circuit arranged to open the said control means for the main burner fuel supply, a thermostatic switch controlling said second circuit and arranged to be closed by the heat of the pilot burner, and a third control circuit dependent upon said second circuit connected to said first control circuit to supply current thereto after said starting switch is opened, and a switch controlling said third circuit arranged to close the circuit when the main burner is in operation.

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