

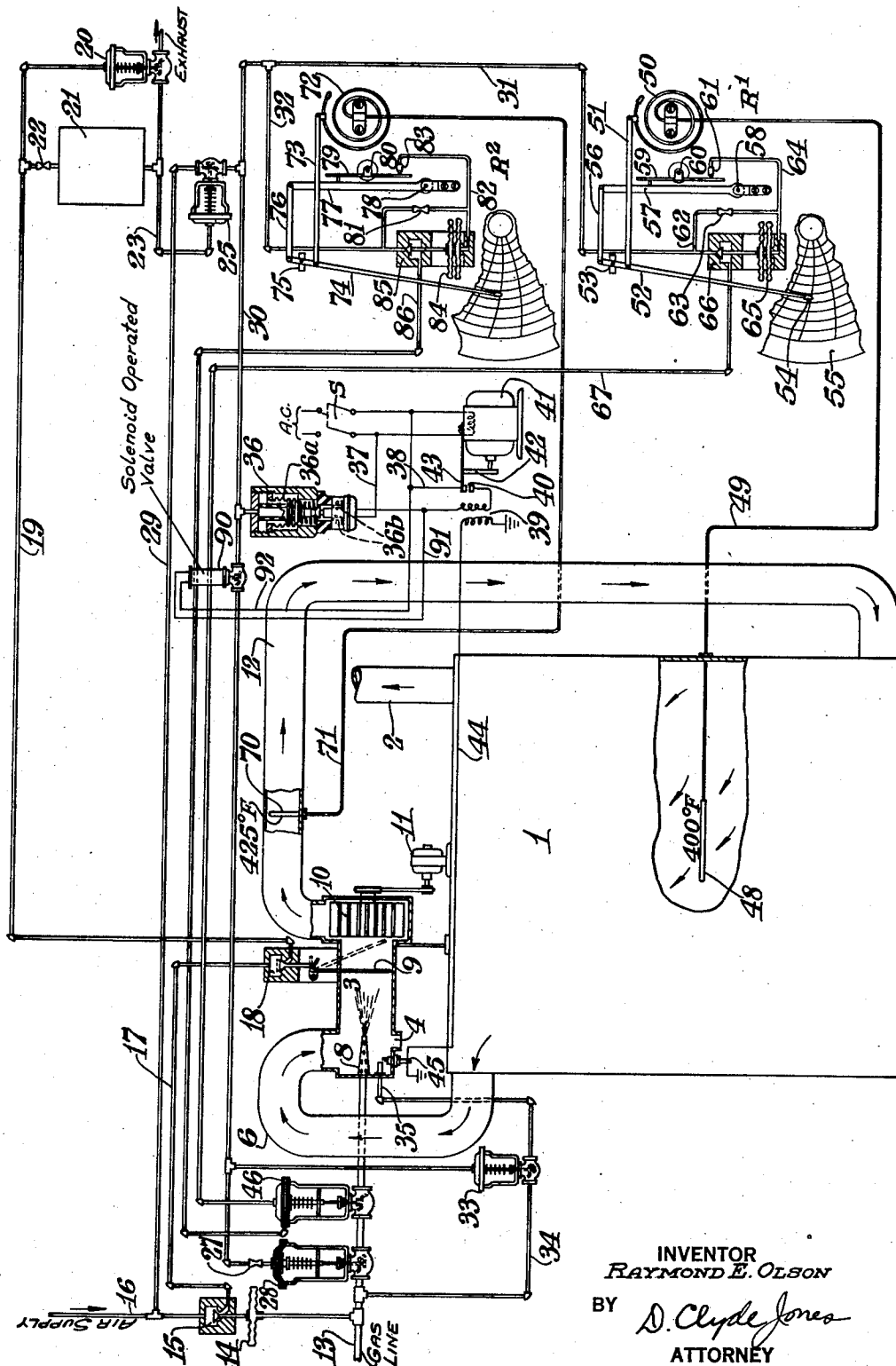
May 12, 1936.

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2,040,328

HEAT REGULATING SYSTEM

Filed March 1, 1935



UNITED STATES PATENT OFFICE

2,040,328

HEAT REGULATING SYSTEM

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Application March 1, 1935, Serial No. 8,945.

12 Claims. (Cl. 34-19)

This invention relates to heat regulating systems for drying ovens.

In certain types of ovens, particularly in lacquer or enamel drying ovens wherein explosive mixtures are generated in the course of drying processes, it is necessary to provide various safeguards to prevent explosions resulting from such mixtures.

The main feature of the present invention therefore relates to a novel arrangement for regulating the temperature of a drying oven while affording complete security against explosions within the oven.

Other features of the invention will appear from the detailed description and claims when taken with the single drawing which diagrammatically illustrates the invention. In this drawing 1 designates a drying oven, such as is used in the drying of enameled articles, which is provided with a stack 2 for the escape of fumes. This oven is heated by air circulated through the oven but heated externally thereof in a heater 3 to which fresh air is supplied through the intake 4 of the heater. Since the circulating air from the oven contains explosive fumes, it is desirable to heat this air by direct contact with an exposed flame to consume these fumes as they are generated. However, if the air circulation stops for any appreciable interval, an explosive mixture from the drying lacquer or enamel will accumulate in the oven and on contact with the flame in the heater, will cause an explosion. In order to prevent such an explosion it is required that the oven be purged, that is, all of the vapors therein must be removed therefrom before the gas flame can be ignited and the regulating system made effective. This purging of the oven is effected since fresh air to the amount of ten per cent of the volume of the system is introduced at the intake 4, and also since the recirculation is rapid, the entire oven atmosphere being passed through the heater not less than twice per minute and in some cases as often as six times per minute. With ten per cent fresh air introduced at the intake and consequently ten per cent of the gas-laden air exhausted through the stack 2 at each recirculation and if the air is recirculated twice per minute, it will be appreciated that the entire atmosphere within the oven will be purged or cleared of dangerous fumes within a predetermined time interval, herein assumed to be eight minutes.

It is believed that the various safeguarding features will best be understood by describing the operations involved in starting the oven into op-

eration and in regulating the temperature thereof, as well as setting forth the various controlling operations which take place when any abnormal condition arises in the system. It has been mentioned that the oven 1 is heated by air circulated in piping extending from the outlet of the oven through the pipe 6, through the heating chamber 3, past the flame at the gas jet 8 as well as past the vane 9, and thence through the circulating fan 10, which is driven by the motor 11, and through the pipe 12 to the inlet of the oven. Let it be assumed that the gas pressure in the pipe 13 leading to the jet 8 is at a normal predetermined value under which condition the capsular diaphragm or bellows 14 will be expanded to open the valve 15 in the compressed air line, but if the gas pressure drops below the predetermined value the valve 15 will close as will hereinafter be described, to shut off the operation of the oven. In accordance with a further safeguarding feature, the fan 10 in the pipe 12 must be operated for a predetermined interval, sufficiently long to remove all of the explosive gases from the oven. For purposes of this invention, it is assumed that the oven can be completely cleared of explosive gas in a period of eight minutes and this time interval will be referred to by way of example throughout the specification. When, therefore, it is desired to start the oven into operation, the fan 10 is started and the air supply is introduced into the conduit 16, thereafter the regulating system automatically effects complete heat regulation within the oven to a desired temperature.

Under the condition above-named, compressed air flows through the conduit 16, valve 15, conduit 17, and the vane-operated valve 18, and thence through conduit 19 to the diaphragm of the motor valve 20 which controls the exhaust pipe leading from an air reservoir 21. Compressed air flowing through the conduit 19 also passes slowly through the constriction 22 into the reservoir 21 and since the exhaust pipe from this reservoir is now closed, air pressure will slowly build up in the reservoir until this pressure has reached a predetermined value, for example, nine pounds per square inch.

Since the fan 10 must be in operation preferably for eight minutes before the heating gas can be supplied to the jet 8 and ignited, the constriction 22 should be of such size that pressure in the reservoir 21 will not reach nine pounds per square inch until the end of the eight-minute interval.

It should be mentioned that the air relay valve 18 is the vane-operated type, that is, when the

vane is hanging vertically as shown in full lines, the valve 18 is closed but as soon as a stream of circulating air flows past the vane, it moves to its position shown in dotted lines, wherein the valve 18 will be opened. It will thus be seen that before the reservoir 21 and the constriction 22 start to measure the prescribed time interval, the vane-operated valve 18 must be opened which can only be effected as a result of the operation of the circulating fan 10 to remove explosive fumes from the oven.

When the air pressure in the reservoir 21 reaches a value of nine pounds per square inch, this pressure will be applied through the conduit 23 to the diaphragm top of the motor valve 25. When the motor valve 25 is thus operated, compressed air is supplied through conduit 30, through the normally closed solenoid valve (now assumed to be open) and through constriction 27, to the diaphragm top of the motor valve 28. The constriction 27 in the conduit 30 is provided to insure that the motor valve 28 will not operate until a predetermined interval following the operation of the motor valve 25, as will be set forth.

Conduit 30 also supplies compressed air through the branch conduit 31 to the primary regulating unit R1 and through the branch conduit 32 to the secondary regulating unit R2. The conduit 30 further communicates with the diaphragm top of the motor valve 33 in the branch 34 of the gas line leading to the pilot jet 35 and, in addition, communicates with the electro-pneumatic switch 36, of well-known construction which includes a metal bellows 36a operating in response to air pressure changes to control the closure of its switch contacts 36b. This switch on closing completes a circuit, including the conductors 37 and 38 connected in series with the primary winding of the transformer 39 and a source of electric current. When the system is in operation, this circuit is periodically interrupted at the contacts 40 and 43 of a switch of any well-known construction. As herein shown this switch is indicated as being of the sign flasher type, that is, the motor 41 has mounted on its shaft a cam 42 which periodically moves contact 43 out of engagement with the fixed contact 40 of the switch. Thus with the electro-pneumatic switch 36 closed and the valve 33 opened, to permit gas to flow through the conduit 34 to the pilot jet 35 on each make and break of the primary circuit of the transformer 39, current will flow from the ground through the secondary winding of the transformer, conductor 44, spark plug 45, to ground. This periodically generates a spark at the spark plug 45 to ignite the pilot light at jet 35 in the event that it has been extinguished accidentally. It has been mentioned that the operation of the motor valve 28 in the gas line is delayed for a brief interval after the operation of the motor valve 25. This insures that the pilot light at jet 35 will be burning at the time that the valve 28 opens the gas line leading to the jet 8.

Since the oven is cold, the valve 46 in the gas line 13, is open so that gas flows to the jet 8 where it burns to heat the circulating air flowing to the oven, to a predetermined temperature. As the air in the circulating system including the oven flows past the jet 8 in the heating chamber 3, the fumes therein are burned to prevent the accumulation of an explosive mixture and the air is suitably heated so that eventually the temperature in the oven 1 rises to the predetermined

temperature which is herein assumed to be 400° F. As soon as this temperature is reached, the tube system of the primary regulating unit R1 takes up the control of the temperature of the oven. This tube system, as is well-known, includes a bulb 48 communicating through a capillary 49 with a Bourdon spring 50, which tube system contains a heat-sensitive medium such as a liquid, a vapor, or a combination of both. When the temperature in the oven fluctuates, the filling medium in the tube system expands or contracts and thereby causes the Bourdon spring 50 to unwind or to wind up. The free end of this spring which is connected by a link 51 to a pen arm 52, swings this pen arm about its pivotal mounting 53 on the frame of the unit. This pen arm is provided at its lower end with a stylus 54, which is in operative relation to a graduating chart 55 arranged to be actuated by suitable clock mechanism (not shown) so that a temperature record in the form of a line is drawn on this chart. The upper end of the pen arm 52 is connected by a link 56 to the upper end of an arm 57 which is pivoted at 58 on the frame so that the movement of the pen arm causes a corresponding movement of the arm 57. The arm 57 is arranged to actuate a baffle 59 pivoted at 60 on the frame of the instrument. The baffle 59, except when thus moved away by the arm 57, engages the ends of the nozzle 61. It will be understood that compressed air flowing through the conduit 31, branch conduit 52, constriction 63 and conduit 64, escapes slowly through the nozzle 61, except when its escape is impeded by the baffle 59. The branch conduit 64 also communicates with the capsular diaphragm or bellows 65 which controls the operation of a pilot valve 66.

When the temperature in the oven 5 reaches the predetermined value, that is, 400° F., the filling medium in the tube system will actuate the Bourdon spring which through the link 51, pen arm 52 and link 56, swings the arm 57 clockwise so that the lower end of the baffle 59 is moved away from the nozzle 61. Air pressure in the branch conduit 64 is thereby reduced, owing to the unimpeded escape of air through the nozzle 61, to cause the capsular diaphragm 65 to contract, thereby permitting compressed air to flow through the branch conduit 61, conduit 67, to one of the diaphragm chambers at the top of the motor valve 46. This tends to cause the valve 46 to close, reducing the flow of heating gas through pipe 13 to the jet 8.

It will be understood that the regulating instrument R1 will operate in the manner just described to throttle the valve 46 so that the proper amount of gas reaches the jet 8 in order to maintain the temperature of the circulating air at such a value that the oven 1 is maintained at 400° F.

As a further safeguard for maintaining the oven within a reasonable operating temperature range, a second regulating unit R2 is provided which has operating mechanism substantially identical with that disclosed in the instrument R1. This unit is also provided with a tube system including a bulb 70 communicating through the capillary tube 71 with the Bourdon spring 72, which tube system is likewise filled with a suitable heat-sensitive medium of the same character as that provided in the regulating unit R1. The bulb 70 of the unit R2 is mounted in the pipe 12 in the path of the circulating air and the unit R2 is preferably adjusted so that it will maintain the temperature of the air passing through this pipe at a value slightly higher than that nor-

5 mally maintained by the bulb 48 in the oven, for example, a temperature of 425° F. It will be understood that the regulating unit R1 normally effects the desired heat regulating within the oven, but if for any reason this unit fails to maintain the desired temperature, the regulating unit R2 will immediately take up the heat regulation of oven when the temperature reaches 425° F., and thereby prevent this temperature from rising beyond safe limits.

10 Let it be assumed that the instrument R1 fails to operate so that the temperature within the pipe 12 rises to 425° F. When this temperature is reached, the filling medium in the tube system, including the bulb 70, expands and thereby causes the Bourdon spring 83 to unwind. This spring which is connected by link 73 to the pivoted pen arm 74, swings this pen arm clockwise about its pivot 75. This movement of the pen arm which is connected by a link 76 to the upper end of the baffle actuating arm 77, moves the actuating arm about its pivot 78. Arm 77 swings the baffle 79 about its pivot 80 in a clockwise direction.

25 It will be understood that during the operation of the system, compressed air present in the branch conduit 32 passes through the constriction 81 to the branch conduit 82. This conduit communicates with the opening in the nozzle 83, but since the baffle 77 normally impedes the escape of air through this nozzle, the pressure in the branch conduit 82, will be such that the cap-sular diaphragm 84 is expanded to close the relay valve 85. This permits compressed air to flow from the branch conduit 32 through the relay valve 85, conduit 86, to the second diaphragm chamber at the top of the motor valve 46, thereby tending to close this valve. In this manner the unit R2 operates to throttle the motor valve 46 in the gas line 13 to maintain the flame at the jet 8 of such size that the temperature at the bulb 70 is held at 425° F.

45 If the gas pressure in the pipe 13 falls below the predetermined value, valve 15 will close. Likewise, if the fan 10 fails to operate the vane 9 will swing to its vertical position and thereby close the valve 18. On the closure of either of these valves, compressed air will be cut off from the conduit 19 with the result that the spring of the motor valve 20 will immediately open this valve so that the air in the reservoir 21 is almost immediately exhausted. When this takes place, air pressure will immediately be removed from the diaphragm top of the motor valve 25 and its spring will immediately close this valve. This results in the cutting off of air pressure from the conduit 30. As a result of the drop in air pressure in conduit 30, the motor valves 28 and 33 are immediately operated by their respective springs to close the gas pipes leading to the jet 8 and the branch gas pipe 34 leading to the pilot jet 35. The closing of valve 25 also causes the electro-pneumatic switch 36 to open so that no spark is generated at the spark plug 45.

65 In order to ensure that the double throw switch S in the power circuit supplying current to the igniter, is closed before the oven is started in operation and in order to stop the operation of the oven in the event of electric power failure, the previously mentioned electrically operated valve 90 is provided in the conduit 30 as indicated. This valve is of the type which is normally closed, that is, it is open only when its solenoid is energized. During the operation of the oven, while the switch S is closed and while the pneumatic switch 36 is also closed, the solenoid of

valve 90 is energized so that this valve is open. The energizing circuit for opening the valve, is traceable from one side of the alternating current source, through one blade of the switch S, conductor 37, contacts 36b of the switch 36, conductor 91, winding of the valve 90, conductor 92 and through the other blade of the switch S, to the other side of the alternating current source. By this arrangement, if current is not supplied to the igniter either due to the fact that the current supply has failed, or to the fact that the operator has neglected to close the switch S, or due to a failure of the electro-pneumatic switch 36, the solenoid of the valve 90 will not be energized and the valve will be closed. This will prevent compressed air flowing through the conduit 30 to the diaphragm top of the motor valve 28 in the gas supply line, or to the diaphragm top of the motor valve 33 in the gas pilot line so that both of these valves will be closed to cut off the flow of gas, until the electrical circuit to the igniter is positively completed.

When normal conditions have been restored so that the oven can again be put into operation, the fan 10 must be operated for an eight-minute interval before the gas jet can be ignited. This result is effected in the same manner as when starting the furnace originally; in other words, on any failure of the fan 10 or low gas pressure, both gas jets 8 and 35 are extinguished immediately, but before these jets can be relighted it is necessary for an interval of at least eight minutes to elapse. By this arrangement, accurate temperature regulation is effected with complete security against gas explosions.

I claim:

1. In a system of the class described, an oven, a heater therefor, a pipe supplying gas to said heater for heating said oven; a valve controlling the flow of gas through said pipe, means for igniting the gas at said heater, means for withdrawing a stream of air and fumes from said oven, means for measuring a predetermined time interval following the initiation of the flow of said stream of air and fumes, said time measuring means including a reservoir and a source of pressure fluid, means responsive to the flow of said stream of air and fumes for supplying fluid from said source to said reservoir through a restricted orifice, means responsive to a predetermined pressure in said reservoir for opening the valve in said gas line and for operating said igniting means, and thermo-responsive means controlling the flow of gas through said pipe whereby the temperature within the oven is maintained at a predetermined value.

2. In a system of the class described, a source of pressure fluid, an oven, a gas pipe supplying gas to a flame for heating said oven, a pressure-fluid operated valve controlling the flow of gas through said pipe, means for withdrawing a stream of air and fumes from said oven in contact with said flame for consuming said fumes, timing means for measuring a predetermined time interval following the initiation of the flow of said stream of air and fumes, flow-responsive means controlled by said stream for starting said timing means, and means operated by said timing means to control the application of pressure fluid from said source to said valve for opening the same.

3. In a system of the class described, a source of pressure fluid, an oven, a gas pipe supplying gas to a flame for heating said oven, a pressure-fluid operated valve controlling the flow of gas

through said pipe, means for withdrawing a stream of air and fumes from said oven in contact with said flame for consuming said fumes, timing means for measuring a predetermined time interval following the initiation of the flow of said stream of air and fumes, flow-responsive means controlled by said stream for starting said timing means, means operated by said timing means to control the application of pressure fluid from said source to said valve for opening the same, and thermo-sensitive regulating means responsive to the heat supplied to said oven for controlling the flow of gas through said pipe whereby the temperature within the oven is maintained at a predetermined value.

4. In a system of the class described, a source of pressure fluid, an oven, a gas pipe supplying gas to a heater for heating said oven, a pressure-fluid operated valve controlling the flow of gas through said pipe, means for withdrawing a stream of air and fumes from said oven, timing means for measuring a predetermined time interval following the initiation of the flow of said stream of air and fumes, means responsive to the flow of said stream of air and fumes for causing the operation of said timing means, and means operated by said timing means to control the application of pressure fluid from said source to said valve for opening the same.

5. In a system of the class described, an oven, a gas pipe supplying gas to a flame for heating said oven, a valve controlling the flow of gas through said pipe, means for withdrawing a stream of air and fumes from said oven, means for measuring a predetermined time interval following the initiation of the flow of said stream of air and fumes, said measuring means including a reservoir, a second valve controlling the outlet of said reservoir and a source of pressure fluid, means responsive to the flow of said stream of air and fumes for supplying fluid from said source to said reservoir through a restricted orifice and to said second valve to operate the same for closing said outlet, and means responsive to a predetermined pressure in said reservoir for opening said first-mentioned valve.

6. In a system of the class described, an oven, a gas pipe supplying gas to a heater for heating said oven, a first valve controlling the flow of gas through said pipe, means for withdrawing a stream of air and fumes from said oven, means for measuring a predetermined time interval following the initiation of the flow of the stream of air and fumes, said measuring means including a reservoir, a valve controlling the outlet of said reservoir and a source of pressure fluid, means responsive to the flow of said stream of air and fumes for supplying fluid from said source to said reservoir through a restricted orifice and to said second valve to operate the same for closing said outlet, means responsive to a predetermined pressure in said reservoir for controlling the opening of the valve in said gas line and responsive to a drop in said pressure below said predetermined value for closing said first valve.

7. In a system of the class described, a source of pressure fluid, an oven, a gas heater for heating said oven, a gas pipe supplying gas to said heater, a regulating valve in said pipe, means for withdrawing a stream of air and fumes from said oven, timing means for measuring a predetermined time interval following the initiation of the flow of said stream of air and fumes, flow responsive means controlled by said stream for starting said timing means, means operated by

said timing means to control the application of pressure fluid from said source to said valve for opening the same, and thermo-responsive means including a second pressure-fluid operated valve in said pipe controlling the flow of gas there-through whereby the temperature within the oven is maintained at a predetermined value.

8. In a system of the class described, an oven, a gas pipe supplying gas to a flame for heating said oven, a first valve controlling the flow of gas through said pipe, means for withdrawing a stream of air and fumes from said oven in contact with said flame for consuming said fumes, means for measuring a predetermined time interval following the initiation of the flow of said stream of air and fumes, said measuring means including a reservoir, a second valve controlling the outlet of said reservoir and a source of pressure fluid, means responsive to the flow of said stream of air and fumes for supplying fluid from said source to said reservoir through a restricted orifice and to said second valve to operate the same for closing said outlet, means responsive to a predetermined pressure in said reservoir for opening the valve in said gas line, and thermo-responsive means controlling the flow of gas through said pipe whereby the temperature within the oven is maintained at a predetermined value.

9. In a system of the class described, an oven, a gas pipe supplying gas to a flame for heating said oven, a first valve controlling the flow of gas through said pipe, means for withdrawing a stream of air and fumes from said oven in contact with said flame for consuming said fumes, means for measuring a predetermined time interval following the initiation of the flow of said stream of air and fumes, said measuring means including a reservoir, a second valve controlling the outlet of said reservoir and a source of pressure fluid, means responsive to the flow of said stream of air and fumes for supplying fluid from said source to said reservoir through a restricted orifice and to said second valve to operate the same for closing said outlet, means responsive to a predetermined pressure in said reservoir for opening the valve in said gas line, primary thermo-responsive means controlling the flow of gas through said pipe whereby the temperature within the oven is maintained at a predetermined value, and secondary thermo-responsive means controlling the flow of gas through said pipe and set into operation by the failure of said primary thermo-responsive means whereby the temperature within said oven is maintained at a predetermined value.

10. In a system of the class described, an oven, a gas pipe supplying gas to a flame for heating said oven, a first valve controlling the flow of gas through said pipe, means for withdrawing a stream of air and fumes from said oven in contact with said flame for consuming said fumes, means for measuring a predetermined time interval following the initiation of the flow of said stream of air and fumes, said measuring means including a reservoir, a second valve and a source of pressure-fluid, a vane-controlled valve responsive to the flow of said stream of air and fumes for controlling the flow of fluid from said source to said reservoir through a restricted orifice and to said second valve to operate the same for closing said outlet, and means responsive to a predetermined pressure in said reservoir for opening the valve in said gas line.

11. In a system of the class described, a source of pressure fluid, an oven, a gas pipe supplying gas to a flame for heating said oven, a pressure-fluid operated valve controlling the flow of gas through said pipe, means for withdrawing a stream of air and fumes from said oven in contact with said flame for consuming said fumes, timing means for measuring a predetermined time interval following the initiation of the flow of said stream of air and fumes, flow-responsive means controlled by said stream for starting said timing means, means operated by said timing means to control the application of pressure fluid from said source to said valve for opening the same, a source of electric current, and means including said current source for periodically applying an igniting spark to said gas.

12. In a system of the class described, a source of pressure fluid, an oven, a gas pipe supplying

gas to a flame for heating said oven, a pressure-fluid operated valve controlling the flow of gas through said pipe, means for withdrawing a stream of air and fumes from said oven in contact with said flame for consuming said fumes, timing means for measuring a predetermined time interval following the initiation of the flow of said stream of air and fumes, flow-responsive means controlled by said stream for starting said timing means, means operated by said timing means to control the application of pressure fluid from said source to said valve for opening the same, a source of electric current, means including said current source for periodically applying an igniting spark to said gas, and means responsive to the failure of said current for closing said valve.

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