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Lomax

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[54] SMOKE AND FUMES ABATEMENT APPARATUS

[75] Inventor: **George F. Lomax,** Waco, Tex.

[73] Assignee: **Fred E. Mosley,** Waco, Tex.

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[52] **U.S. Cl.** .....**110/8 A,** 110/8 C

[51] **Int. Cl.**.....**F23g 5/12**

[58] **Field of Search**.....110/8 R, 8 A, 8 C; 23/277

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Primary Examiner—Kenneth W. Sprague

Attorney—Bertram H. Mann, Frank B. Pugsley, James G. Ulmer et al.

[57] **ABSTRACT**

Smoke, fumes, and odors are reduced in or eliminated from combustion products from a burn box, incinerator, or furnace by being directed through an exhaust duct to a secondary burner chamber wherein the exhaust products are caused to spiral in one direction along the wall of the secondary burner chamber in a vortex, thence are reversed and directed in the opposite direction through the center of the vortex before being discharged to a scrubber for further treatment or directly to the exhaust stack. Air is added to the primary burning box and to the mentioned exhaust duct in accordance with the temperature of the gases in the duct while the temperature of the secondary burner chamber is controlled, further, in accordance with the temperature of gases emerging therefrom.

15 Claims, 3 Drawing Figures

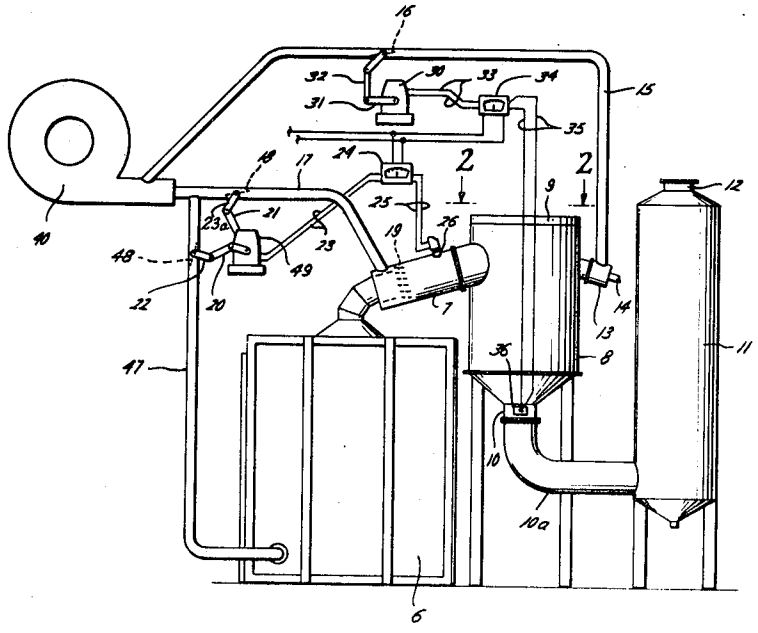


Fig. 1

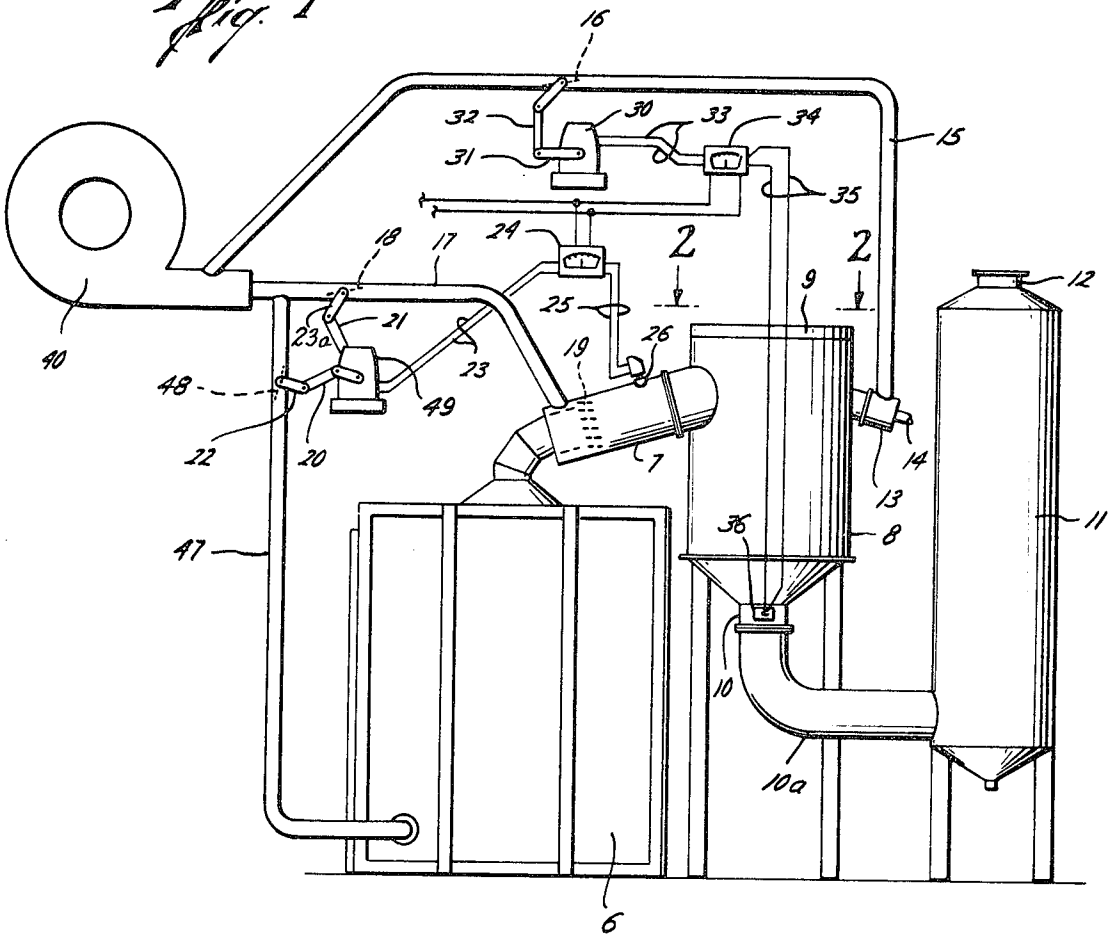
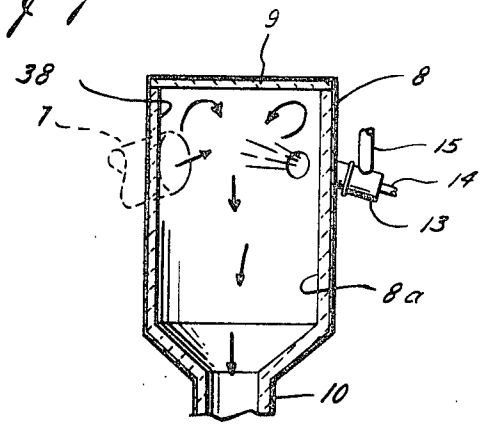


Fig. 3



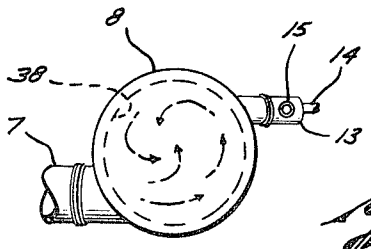


Fig. 2

George F. Lomax
INVENTOR.

BY Bertram M. Wilson
ATTORNEY

SMOKE AND FUMES ABATEMENT APPARATUS

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates to antipollution apparatus and methods and consist particularly in novel apparatus and methods for abating or substantially eliminating objectionable smoke, fumes and/or odors from combustion products.

As the density of populations and industry increases, it becomes more imperative that gaseous emanations from such industry be as free as reasonably possible of noxious or otherwise objectionable contents tending to endanger the health and well-being of industrial workers as well as surrounding populations. In particular, the elimination of such ingredients discharged from smoke stacks and other exhausts is becoming increasingly essential. Yet, equipment available for this purpose is not wholly successful from a functional point of view or is otherwise objectionable.

Accordingly, an object of the present invention is to provide a novel apparatus for more effectively eliminating objectionable constituents of combustion products.

Another object is to provide a novel method of handling combustion products for more efficiently eliminating smoke, fumes and odors therefrom than has been heretofore achieved.

Another object is to provide novel control means for treating such combustion products so as to most efficiently eliminate the noxious ingredients thereof.

Still another object is to provide a novel afterburner device for use in treating noxious gases discharged from a primary burner so as to eliminate substantial constituents thereof before discharge into the atmosphere.

In accordance with the present invention there is provided a novel, generally cylindrical afterburner device, preferably arranged upright, into which smoke or fume laden combustion products are directed from an exhaust duct, in a generally tangential and upward direction. A burner is mounted in the chamber wall and directed, similarly, in a generally tangential and upward direction so that the combustion products are caused to swirl about the heated secondary burner chamber in a vortex. The secondary chamber is closed at one end, for instance, the top, so that the swirling gases upon striking the chamber end or top wall are damped and reversed and caused to pass at reduced speed through the center of the vortex prior to discharge from the bottom of the secondary chamber. Primary air added to the primary burn box or furnace and secondary air added to the combustion products emitted therefrom, before entry into the secondary burner, are supplied at rates in accordance with the temperature of the exhaust products prior to admission into the secondary burner chamber. The secondary burner, itself, is controlled in accordance with the temperature of gases emerging from the secondary chamber so that combustible products, which mostly make up the visible smoke and fumes and odors in such combustion products are efficiently consumed.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings which illustrate the invention,

FIG. 1 is a schematic representation of the novel apparatus, including electrical wiring.

FIG. 2 is a top view of the secondary chamber with the gas flow in the chamber symbolized by arrows, and

FIG. 3 is a vertical transverse section through the secondary burner chamber also illustrating schematically the gas flow therein.

DETAILED DESCRIPTION OF THE DRAWINGS

A primary or main furnace or burning box is illustrated at **6** and is provided with any suitable charging and burning means (not shown). Primary air to the burn box is supplied through a pipe **47** having a butterfly type control valve **48,** and combustion products from box **6** are discharged through an exhaust duct **7** into a secondary burner chamber **8** of generally cylindrical form, and provided with refractory lining **8***a*. The secondary chamber, preferably, is arranged upright and has a closure wall **9** at its top end and a reduced outlet **10** at its lower end leading through pipe **10***a* to the bottom of a conventional scrubber device **11** in which the exhaust gases may be further subjected to water or chemical treatment, for instance, for eliminating particulate matter and corrosive fumes not otherwise abated or converted during the burning step. The now harmless and invisible gases are discharged from the scrubber through outlet connection **12,** as to the usual stack or other exhaust pipe. Secondary burner chamber **8** is equipped with a secondary burner of conventional design, as at **13** to which is connected a fuel pipe **14** and an air passage **15,** the latter equipped with a butterfly type control valve **16.** A secondary supply of air is led through a pipe **17** with a butterfly type control valve **18** to exhaust duct **7.** Spiral vanes are provided in duct **7,** as at **19** to insure thorough mixing of the combustion products from chamber **6** and secondary air therein prior to discharge into secondary burner chamber **8.** A fan **40** supplies air to all of the air lines **7, 15,** and **17.** An induction fan (not shown) preferably will be provided in or adjacent scrubber **11.**

Primary and secondary air control valves **48** and **18** are modulated by a motor **49** through cranks **20** and **21** and valve levers **22** and **23***a*. Motor **49** is energized by wires **23** connecting the motor to a thermostat **24** which, in turn, is connected by wires **25** to a temperature sensitive element **26,** for instance, a thermocouple, mounted on the wall of duct **7** and exposed to the gases therein for producing electrical current variations in accordance with, that is, sensing, the temperature of such gases. Burner air control valve **16** is modulated by a motor **30** through crank **31** and link **32.** Motor **30** is connected by wires **33** to a thermostat **34** which is connected by wires **35** to a second temperature sensing element **36** mounted on outlet fitting **10** and exposed in sensing relationship to the gases emerging from the secondary burner chamber.

More or less schematic FIGS. **2** and **3** indicate by arrows the direction of combustion products from duct **7** and from burner **13** in directions approximately tangentially and upwardly in a vortex about the chamber wall wherein the two combustion products streams are mixed and then, upon striking top end wall **9,** are substantially damped and reversed to flow downwardly through the center of the vortex and ultimately through outlet **10** and pipe **10***a* to the scrubber **11** or directly to the stack (not shown). The refractory lining **8***a* becomes highly heated by the flame from burner **13**

and this heat plus the initial heat of the entering gases and the direct heat from the flame ignites carbon and other visible and noxious elements discharged from exhaust duct 7 and converts these to substantially inert and non-noxious elements, as water vapor and carbon dioxide. The swirling or vortex action of the gases in the upper part of the secondary chamber serves to thoroughly mix these gases, while the passage of the mixed gases at reduced rate downwardly through the center of the vortex serves to substantially increase the dwell time of the gases in the secondary burner chamber. The result of this is that thorough burning is insured without excessive heating of the gases which might tend to form the extremely objectionable nitrogen oxides. While the afterburner is provided with a single smoke duct connection and a single burner, these may be multiplied and spaced about the afterburner, for instance to obtain greater capacity.

I have found that accurate control of secondary air through passage **17** to duct **7** is extremely critical, not only in insuring an adequate supply of oxygen for burning the combustion products in the secondary chamber, but in preventing over-heating of the mixture as it enters the secondary burner chamber which, in turn, tends to prevent excessive reduction of the density of air in the exhaust mixture. I have also found that the primary air supply to burn box **6** bears a definite relationship to the secondary air supply through pipe **17** so that both valves **48** and **18** may be regulated, as illustrated, by the same motor. Heat sensitive device **26**, of course, acts through thermostat **24** and motor **19** for modulating valves **48** and **18** to maintain the desired heat level in exhaust duct **7**. Also, most efficient burning within secondary chamber **8** is aided by control of the flame from burner **13**, in the present case, by control of motor **30** through thermostat **34** and element **36** sensing the temperature at the outlet from the secondary chamber. Due to the high temperature of gases in the secondary burner chamber, there may be a tendency of the gases to flow from chamber **8** back into the primary burn box. This tendency may be counteracted by a very high stack, or the insertion of an induction pump between the scrubber **11** and the stack. In fact, the supply of secondary air through pipe **17** may be adjusted, without use of upstream valve **18**, by control of the latter induction fan. In such case, exhaust duct sensing thermostat **39** and a control motor, as at **49**, will be utilized, for instance, to control the outlet damper of the fan and thereby adjust the pressure downstream of the afterburner, rather than upstream in passage **17**, as in FIG. **1**. These alternative controls are generally equivalent for adjusting the pressure differential across the afterburner and, thereby the flow of air therethrough.

In an exemplary test apparatus, thermocouples were located at **36** and **26** to monitor, respectively, the temperatures in outlet **10** from the secondary burner chamber and exhaust duct **7** leading into the latter chamber. In one run, thermostat **24** reached 1,475°F and smoke emanated from the exhaust burner outlet which became heated to a cherry red. When the afterburner flame was decreased, thereby decreasing the temperature and pressure in the afterburner by means of an air rich flame, the temperature in exhaust duct **7** dropped and smoke disappeared from exhaust pipe **10*a*** and the stack. The secondary burner flame was then increased and smoke reappeared in the exhaust stack.

In a second test, the smoke/air temperature in exhaust duct **7** was closely monitored. As the primary air through pipe **47** was increased, it was noted that a trace of smoke appeared when thermostat **24** registered a temperature of 780°F. As this temperature increased, the density of smoke emerging from the secondary chamber also increased. Primary air through passage **47** was then decreased, whereupon the smoke/air temperature in duct **7** dropped immediately and the smoke emerging from the secondary chamber disappeared as the duct temperature dropped below 800°F. Consequently, it is assumed that the ignition point of the combustion products in duct **7**, during burning of the particular type scrap material, was 800° – 850°F. At this temperature level, the smoke particles became too oxygen-starved for complete combustion in the afterburner; also, it was noted that higher velocities of gases occurred in the afterburner due to increased gas specific volumes therein. By comparison, ignition temperatures of other combustible products, in the same general temperature range are as follows (from STEAM, ITS GENERATION AND USE, by Babcock and Wilcox, pages 4–5, Table 4):

Sulfur	470°F	Acetylene	580°–825°F
Charcoal	650°F	Ethane	880°–1165°F
Fixed Carbon (Bituminous coal)	765°F	Ethylene	900°–1020°F
Fixed Carbon (Semi-bituminous coal)	870°F	Kerosene	490°–560°F
Fixed Carbon (Anthracite)	840°–1115°F	Gasoline	500°–800°F

In the above two tests scrap insulated wire was burned in box **6**. In the first test 237 pounds of initial wire were reduced to 154 pounds, for a weight loss of 83 pounds in 2 hours. Maximum burn box temperature was 1,385°F, which occurred after the flame in the exhaust duct **7** was extinguished by readjusting the afterburner flame. In the second test, 164.5 pounds of initial wire were reduced to 117.5 pounds, for a loss of **47** pounds in 53 minutes. Maximum burn box temperature was 1,750°F.

It was concluded therefore that the temperature of the air - combustion products mixture entering the afterburner has a critical upper limit which, at least for the type of scrap burned in the test noted, corresponds to its ignition temperature. The test also illustrated the necessity of closely modulating the positioning of air valves **48, 18,** and **16.**

Various features and arrangements and method steps may be modified as will occur to those skilled in the art and the exclusive use of all such modifications as come within the scope of the appended claims is contemplated.

I claim:

1. The combination in a smoke and fume abatement system including a source of combustion products, an afterburner, an exhaust duct connecting said source and said afterburner, and a discharge pipe leading from said afterburner, of

an air passage communicating with said duct,

air supply means in said system for causing even flow from said air passage through said secondary burner and said discharge pipe,

means for sensing the temperature of combustion products in said duct downstream of said air passage, and

an operative connection between said temperature sensing means and said air supply means for con-

trolling the proportions of the air and combustion product mixture in said duct and the temperature and combustibility of the mixture entering said afterburner.

2. Smoke abatement apparatus as described in claim 1 in which said air supply means comprises a valve in said air passage and actuating means therefor.

3. Smoke abatement apparatus as described in claim 1 further including a burner within said afterburner having fuel and air connections, a control valve for at least one of said connections, actuating means for said control valve, means for sensing the temperature of gases in said discharge pipe, and an operative connection between said latter temperature sensing means and said valve actuating means for controlling the temperature of said gases.

4. Smoke abatement apparatus as described in claim 1 further including a second air passage leading to said source, a valve controlling said second passage and actuating means for said second valve, and an operative connection between said temperature sensing means and said latter actuating means.

5. Smoke abatement apparatus as described in claim 1 further including a burner in said secondary chamber and a wall across the upper part of said chamber, said burner and said duct being directed approximately tangentially and upwardly along the inner wall of said secondary chamber and said discharge pipe emerging from the lower part of said chamber whereby combustion products from said duct and said burner first spiral upwardly in a vortex, then are diverted downwardly through the center of said vortex and thence pass into said discharge pipe.

6. Smoke abatement apparatus as described in claim 4 in which said operative connections are adapted to modulate said valves between their open and closed positions for close control of the proportions and temperature of the mixture in said duct.

7. Smoke abatement apparatus as described in claim 4 further including a second air passage leading to said source of combustion products, a third valve controlling said second passage and third valve actuating means for said third valve, and an operative connection between said first mentioned temperature sensing means and said third actuating means.

8. Smoke abatement apparatus for use in combination with a primary burning chamber, a primary air passage leading thereto, and a discharge stack comprising

a secondary burner chamber having communication with said stack and having a burner therein,

an exhaust duct connecting said primary and secondary chambers,

means for sensing the temperature of combustion products in said duct,

a secondary air passage leading to said duct upstream of said temperature sensing means,

valves controlling said primary and secondary air passages,

motor means modulating said valves and

operative connections between said temperature sensing means and said motor means for adjusting the supply of air to said primary chamber and said duct and thereby the temperature of the combustion products in said duct and said stack.

9. Smoke abatement apparatus, as described in claim 8 further including connections for supply of fuel and air to said burner, valve means for controlling at least one of said connections and motor means therefor, means for sensing the temperature of combustion products in said stack communication and an operative connection between said latter temperature sensing means and said latter motor means for assisting in the control of the temperature of the combustion products in said stack.

10. An afterburner for smoke and fume abatement comprising a chamber having a generally cylindrical side wall, a transverse wall at one end and an outlet at the opposite end thereof, at least one inlet for smoke and fumes leading into an intermediate portion of said chamber, and at least one burner projecting into said chamber between said ends, said duct and said burner being directed generally tangentially of the chamber side wall and toward said transverse wall so as to cause combustion products from said duct and said burner to travel spirally about said cylindrical wall in a vortex and against said transverse wall, thence in a reverse direction toward said outlet through the middle of said vortex.

11. The method of abating smoke and fumes in combustion products which comprises the steps of directing said products through at least one exhaust duct into a generally cylindrical secondary burner chamber, heating said secondary chamber, causing said products to spiral about and along the chamber wall in a vortex, thence reversing the direction of said products at one end of said chamber to cause the same to travel through the middle of said vortex to extend the period of dwell of the products in said chamber, and discharging said products from the opposite end of said chamber.

12. The method described in claim 11 including the further step of adding air to said duct and controlling the supply of such added air in accordance with the temperature of the mixture of air and products in said duct.

13. The method described in claim 11 including the further step of controlling the heating of gases in said chamber in accordance with the temperature of gases discharged therefrom.

14. The method described in claim 12 further including the step of controlling the heating of gases in said chamber in accordance with the temperature of the gases discharged therefrom.

15. The method described in claim 12 including the further step of adding primary air to said combustion products before entry into said duct and controlling the supply of said primary air in accordance with the temperature of gases in said exhaust duct.

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