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[54] **CONTROL METHOD FOR FUME INCINERATORS**

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[51] **Int. Cl.** **B01d 53/34**

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[56] **References Cited**

UNITED STATES PATENTS

1,995,723	3/1935	Van Denberg	110/8 A
2,546,013	3/1951	Peck et al.	23/281 X
3,472,498	10/1969	Price et al.	431/5 X
3,595,181	7/1971	Anderson et al.	110/8 A

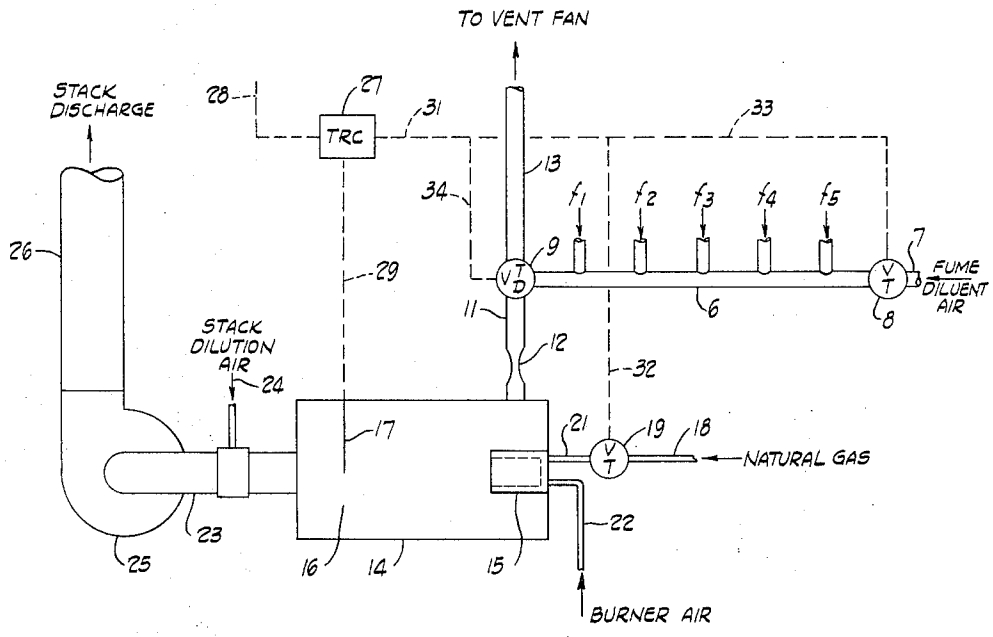
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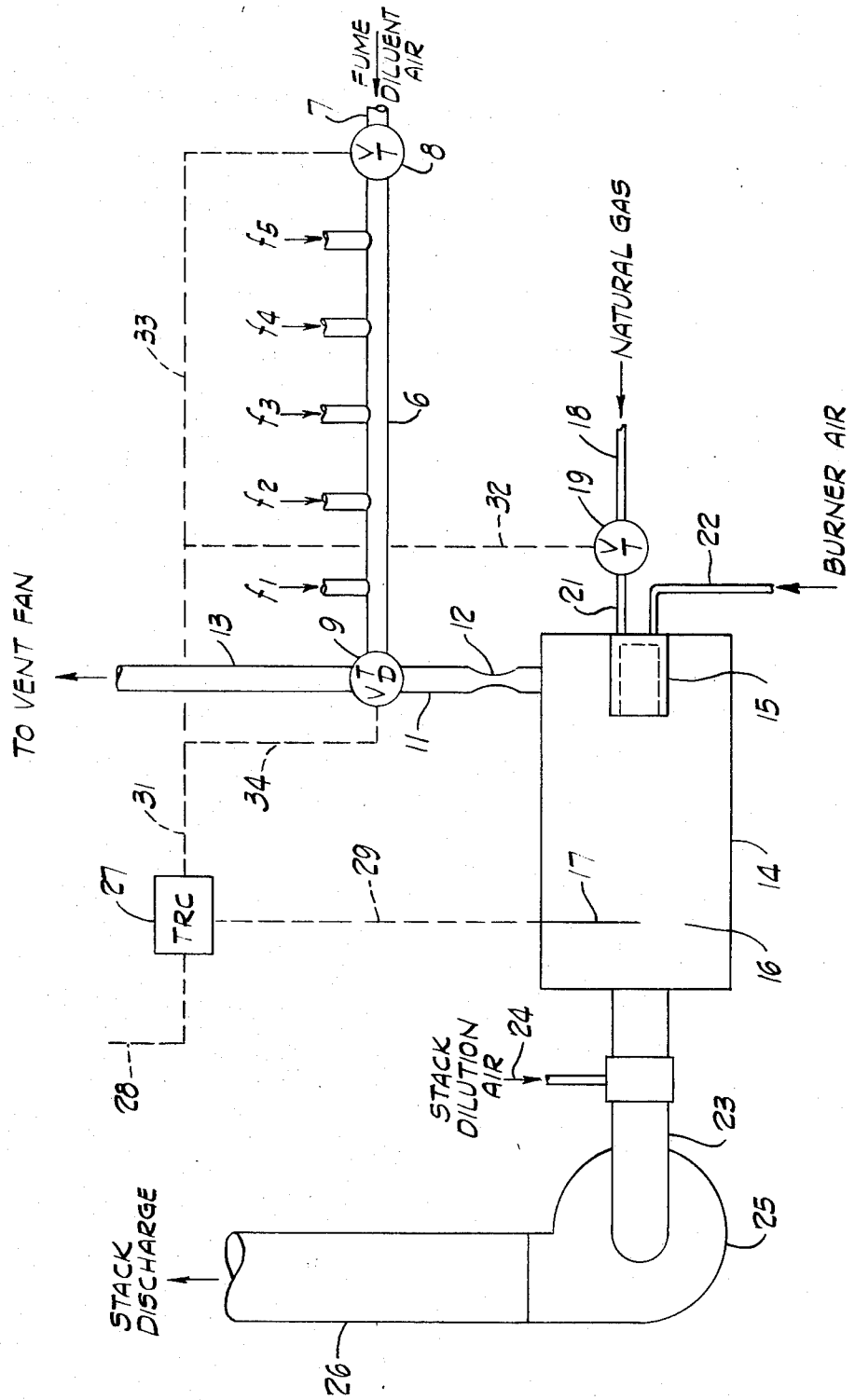
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[57] **ABSTRACT**

Improved process and apparatus are shown for incineration of combustible fumes to suppress deleterious, uncontrolled combustion of said fumes from the occurrence of an adventitious, transient fume overload. In response to upward deviation from a preselected incineration temperature, the fume feed flow is automatically throttled to bypass the incineration zone while the flow of primary incineration fuel has been automatically diminished, but at most only to a point short of the extinction of its combustion, thereby relieving the overload condition without disruptive operational discontinuity. An automatic temperature controller provides the particular sequential throttling control impulse to automatic throttling valves on primary fuel and bypass for this purpose, and also to an automatic throttling valve on flow of fume diluent vapors, if desired.

12 Claims, 1 Drawing Figure




FUME DILUENT AIR
7
8
V T
NATURAL GAS
18
19
V T
22
BURNER AIR
21
f5
f4
f3
f2
f1
33
6
32
TO VENT FAN
13
9
V T D
12
11
15
34
31
27
TRC
29
17
14
16
28
STACK DILUTION AIR
24
23
25
STACK DISCHARGE
26

INVENTOR.

BY

CONTROL METHOD FOR FUME INCINERATORS

This invention relates to improved method and apparatus for fume incinerators, and more particularly to incinerators for combustible fumes wherein deleterious, uncontrolled combustion of said fumes from the occurrence of an adventitious, transient fume overload is suppressed.

It is customary to incinerate combustible fumes such as solvent fumes, reactor fumes, etc. for disposal into the atmosphere. Conventionally the fumes are fed into or drawn into a controlled temperature incineration zone wherein at least the initial heat for incineration is provided by the hot combustion products from the burning of a controlled flow of a primary fuel. Ordinarily the apparatus is designed to handle normal, foreseeable overloads and incinerate them continuously. However, there can be from time to time accidental or unscheduled fume overloads for such apparatus even exceeding its design overload capacity (which can be as much as 300–500 percent of the normally-expected peak load). Normally such accidental overloads beyond design capacity are infrequent and adventitious, and are referred to herein as "transient overloads". They usually occur from an accident, a mistake, a spill, or the like.

The conventional method and apparatus for handling such transient overloads involves bypassing the fumes away from the apparatus through a safety vent and turning off the flow of primary fuel to the incineration zone completely, then restarting the incineration operation a short time later when the transient overload condition has passed and the temperature of the incineration zone has declined substantially to or below a selected temperature.

It is at this time in such operation that flashbacks, equipment explosions, and other deleterious uncontrolled combustion of the fumes are most likely to occur, and occasionally do occur with sometimes disastrous results, because an accumulation of fumes in a feed line close to the incinerator sometimes can be present. Thus, when the combustion of primary fuel is restarted manually or automatically from shutoff, or even from a small pilot flame, such disruptive combustion can happen. Various prior art safety devices installed near the incinerator such as screen-type or wet flame arresters, high velocity fume inlet to the incinerator, steam purges and blankets, etc. can be helpful in suppressing such deleterious combustion, but they are not always foolproof. They can be used in connection with this invention; however, it is capable of handling transient overloads quite safely and efficiently in the general absence or failure of such conventional safety devices.

In one aspect this invention is an improvement in process for suppressing such deleterious, uncontrolled combustion of fumes from the occurrence of an adventitious, transient fume overload which comprises:

while the flow of primary fuel is throttled down, but at most only to a point short of the extinction of its combustion, and in response to upward deviation of the incineration temperature in the incineration zone from an upper limiting preselected value, automatically diverting with throttling control thereon at least a portion of the flow of fumes to bypass away from said incineration zone,

thereby relieving the transient overload condition, but maintaining the combustion of the primary fuel so as to incinerate effectively all fumes coming into the apparatus, safely disposing of unburned accumulations therein, and avoiding possibly disruptive operational discontinuity.

In another aspect the invention is an improvement in incineration apparatus which has an incineration zone wherein the hot combustion products from the burning of a flow of primary fuel are supplied to the zone together with a flow of fumes for incineration in said zone, and which has also an automatic temperature controller capable of sequentially operating automatic flow control means, said controller having a temperature sensing element in the zone, said controller being disposed to adjust automatic flow control means regulating flow of the primary fuel for the purpose of directing the temperature in said zone towards a predetermined incineration value sensed by said element, and said controller being disposed also to actuate flow diverting means for bypassing the fumes away from the zone under conditions of an adventitious, transient overload. The improvement in such apparatus comprises:

a. as the automatic flow control means regulating flow of the primary fuel during the incineration operation, an automatic valve capable of diminishing flow of said primary fuel responsive to throttle control impulse therefor from the controller, but only to a point short of the extinction of the combustion of said flow of primary fuel;

b. as the fume flow diverting means, another automatic valve capable of bypassing at least a portion of said flow of fumes away from said zone responsive to throttle control impulse therefor from the controller, and

c. said controller is adapted for delivering a sequential throttle control impulse to each of said automatic valves for:

i. first initiating the throttling of said flow of primary fuel, then

ii. initiating the bypass of said flow fumes in response to a rise in temperature tending to exceed the control value as sensed by the temperature sensing element in the incineration zone.

Throttling control of an automatic valve should be understood as being consistent with the instrumental flow control art, that is, decreasing and increasing a flow through such valve in response to control impulse, not just decreasing it.

The drawing is a schematic flow diagram showing the basis of design for incineration of waste fumes in a paint plant wherein the installation from this design has successfully handled a variety of transient fume overload conditions for several months. It illustrates the various aspects and elements of the invention and is more fully described in the following example.

Frequently the fumes for incineration are collected from a plurality of sources which provide them as a fluctuating load for the incinerator. This sort of fume supply is one of the most difficult to incinerate safely, but the instant invention is capable of handling it. Thus, the fume load is not necessarily constant in quantity or quality, as from a plurality of batch reactors which can have a variety of combustible fumes peaking in volume and changing in quality at assorted times, or, occasionally, coincidentally, with peaks being sched-

uled or random. While such incinerator ordinarily is designed to accommodate expected major overloads, there can occur occasionally the adventitious, transient fume overloads spoken of hereinabove.

Typically the fumes comprise combustible hydrocarbons, esters, aldehydes, ketones, soot, dust, mist, and/or generally degradation products of organic compounds. They can tend to condense near ordinary room temperature, or be substantially non-condensible at such temperature. They can contain some materials that are substantially non-combustible in themselves (in the sense that they will not support combustion when burned in air) but are desirably incinerated for their destruction, and in some cases their possible collection. However, the fumes essential for incineration in connection with this invention, whether straight or mixed with various diluents, are those which as fed to the incinerator can support combustion in air and actually do so combust exothermically in the incineration zone.

Gaseous fuel such as natural or producer gas is the preferred primary incineration fuel because of simplicity of its flow control. However, other fuels can be used as primary incineration fuels, e.g., normally liquid hydrocarbon oils, powdered coal, or fluid streams that will burn effectively with air to establish the desired temperature in the incineration zone. Ordinarily the incineration temperature in the incineration zone is set to be controlled between about 800 and 2,500°F., often between about 1,000° and about 1,400°F., and usually most suitably at about 1,200°F. The temperature sensing element in the incineration zone ordinarily is a thermocouple, customarily inserted in a thermowell protruding into the zone. Other conventional sensing apparatus such as thermistors, optical pyrometers, etc. can also be used.

The automatic temperature controller and the automatic valves for this invention are conventional. Suitably these are pneumatically-operated, although they can be electrically-operated or even mechanically-operated, if necessary or desirable. Such valves can operate directly on line to restrict or enlarge flow rate in such line, or act to shunt flow variably from a particular line into another, thereby varying the flow rate in such particular line. Preferably the valves adjusting primary fuel and fume diluent air act directly on those lines, whereas the fume bypass valve is a diverter valve. The temperature controller receives the temperature signal from the sensing element in the incineration zone, and, when such temperature is tending to or actually has risen past the predetermined limiting value, the controller sends out throttling control impulse, e.g., a change in control air supply pressure, to the various automatic valves it is controlling to return or maintain incineration temperature at the desired, preselected (set point) value.

Frequently it is advantageous to use a flow of diluent vapor for blending into and carrying the fumes to the incinerator. Such diluent vapor generally will be ordinary, unheated, ambient air, but it also can be a flue gas or other non-condensible, and it could even contain steam or other normally condensible vapor in some cases. A flow containing molecular oxygen such as air provides oxidant for burning the fumes in the incineration zone beyond any excess of oxygen fed into the incinerator for burning the primary fuel. Typically the flow of air brought in for burning the primary fuel is maintained at a constant rate for simplicity and for effective incineration, while the flow of primary fuel is varied in response to the temperature controller impulse with the flow rate of primary fuel being regulated between maximum and minimum limits to burn effectively at all rates without being blown out at its lowest controlled flow rate. The flow of a fume diluent vapor such as ambient air not only helps to provide oxygen for combustion of the fumes, but it also helps to maintain temperature in the collection apparatus at a safe low value, and, as temperature of the incineration zone tends to rise above the desired set point, such diluent flow can be increased automatically in proper sequence as a coolant-diluent to help arrest such temperature rise. In the preferred installation the flow of such fume diluent is increased substantially to its maximum rate prior to any substantial bypassing of the fumes away from the incineration zone. Customarily such fumes bypassed are drawn by a fan to atmosphere, but they also can be delivered into a gas holder, an auxiliary incinerator, a scrubber, a condenser, an absorber, or other conventional apparatus when necessary or desirable.

All of the elements of the incinerator and its controller are conventional. The incineration zone itself usually is lined with firebrick, and the incinerated products are educted customarily from the zone with a fan or by stack convection and discharged from a stack into atmosphere. Air often is drawn into the suction of such fan to dilute the exit stream of incinerated products and lower its temperature. Occasionally it is necessary or desirable to scrub the incinerated products with a conventional scrubber such as a water scrubber, a caustic soda solution scrubber, a chemical absorber, an adsorber, or the like for removal of ingredients such as solids, or for further destruction, recovery, or chemical change as to part or all of the incinerated products.

The following example shows how the invention has been practiced, but should not be construed as limiting the invention. In the specification all temperatures are in degrees Fahrenheit, and all parts are parts by weight, unless otherwise expressly indicated; Standard Cubic Feet per Minute (SCFM) and Standard Cubic Feet per Hour (SCFH) are referred to 30 inches of mercury total pressure and 70°F. as standards.

EXAMPLE

Fumes from various kettles and reactors of a paint plant were brought into collection header **6** by means of ducts f_1, f_2 f_3, f_4 and f_5. The fume load for incineration entering the several ducts was variable and peaked in volume at various times. Each duct was designed to handle as much as 350 SCFM of vapors containing about 24,000 ppm of combustible organic materials such as hydrocarbons. As such, this incineration system was designed to handle as much as about a 400 percent overload.

Also fed into collection header **6** was a throttled flow of as much as 2,750 SCFM of fresh air entering through suction inlet **7** and control valve **8**, an automatic butterfly-type throttling valve. The fumes and this diluent air are drawn by fan suction into the body of safety vent valve **9**. In the normal incineration operation valve **9** is open, directing the fumes and diluent air into duct **11** (which is necked down in section **12** to give a high velocity flow and thus help suppress flashbacks) and into incinerator **14**.

Incinerator **14** is provided with a flow of natural gas primary fuel at 5 psig, a maximum of 1,450 SCFM. It enters line **18,** passes through automatic throttle valve **19,** and flows into primary fuel burner **15** through feed line **21.** Also entering the primary fuel burner is a constant flow of air for burning the primary natural gas fuel, this air flow being set at 300 SCFM entering feed line **22.** Te hot combustion products from burning the primary fuel flow from burner **15** through incineration zone **16,** along with the feed from header **6.** The temperature of incineration in zone **16** is sensed by thermocouple **17** in a thermowell probing into said zone. The hot, incinerated products leave the incineration zone through fan suction line **23.** Also drawn into this suction line is a flow of stack dilution fresh air, **24,** max. 12,000 SCFM. The stack is designed to handle as much as about 19,600 actual CFM.

Recording temperature controller **27** operates to give pneumatic pressure throttle control impulse to automatic valves **8, 9** and **19.** The controller is supplied by instrument air entering instrument line **28.** Thermocouple **17** is connected to controller **27** by means of conventional leads indicated as item **29.** Such controlled throttling impulse from the controller passes through line **31** and branch lines **32, 33** and **34** leading, respectively, to automatic pneumatic throttle valve **19,** automatic throttle valve **8,** and automatic throttling diverter valve **9.** Valve **9** is of the dumbbell type, that is having a dumbbell-shaped element, one end of which is adapted to seating for throttling the fume load to the incinerator through line **11,** and the other end of which is adapted to seating for throttling the fume load to a vent fan (not shown) which pulls suction on line **13.** Valve **9,** alternatively, can be of a double butterfly type acting to throttle down flow to line **11** while opening up to line **13,** and vice versa.

In a normal steady operation, temperature of about 1,200°F. is maintained in the incineration zone **16.** Temperature of the zone is sensed by thermocouple **17,** and is maintained about the set point by controller **27** in such normal operation as follows: (*a*) delivering controller air output pressure through lines **31** and **32** to valve **19;** and (*b*) delivering controller air output pressure through lines **31** and **33** to valve **8.**

The normal control sequence is preset as follows: valve **19** is set to open widest at 15 psig of control air, and is set to diminish to its lowest controlled flow at **11** psig while still leaving enough flow of primary gas fuel to maintain such fuel combustion in burner **15** with the constant air supply that enters line **22;** valve **8** is set to open widest at control air pressure of 7 psig and to close shut at 11 pisg; Temperature fluctuations in zone **16,** sensed by thermocouple **17,** thus raise the controller air output pressure upwards to 15 psig maximum and downwards to 3 psig with attendant throttling adjustments on the automatic valves which correspond to the controller air output pressure being delivered at any time.

In such normal steady operation throttling diverter valve **9** remains closed, and the operating temperature in zone **16** is sustained by the burning of the natural gas and the incineration of the fume load. However, when an adventitious, transient fume overload occurs and the temperature of zone **16** can no longer be maintained at about 1,200°F. by the further throttling down of the natural gas feed and the further increasing of the diluent air bearing the fumes, then valve **9** is set to begin throttling back on the fumes being drawn into line **11** by fan **25;** at the same time valve **9** also begins to divert these fumes into safety vent line **13** away from incinerator **14.** Pneumatic valve **9** is preset to vent fumes and diluent completely through line **13** at controller air output pressure from line **34** of 3 psig, and is set to send all fumes and diluent air completely to the incinerator at 7 psig. From 7 to 3 psig of declining controller air output pressure on valve **9,** this valve is directed towards a fuller diversion of the fumes and diluent air to safety vent line **13** as the controller impulse decreases responsive to rising incineration temperature towards or beyond the set point temperature (1,200°F.) of controller **27.** From 3 to 7 psig of increasing controller air output pressure, this valve **9** is directed to a fuller feeding of the fumes and diluent air to line **11.**

Pneumatic temperature controller **27** is a reverse-acting, 3–15 psig output recording controller, that is, one wherein increase above the temperature of its adjustable set point tends to decrease the controller air output pressure. If the temperature sensed by thermocouple **17** continues to rise when controller air output pressure goes below 3 psig, or if there is a failure of controller air output pressure, all the fume load and diluent air therefor are bypassed through safety vent line **11** automatically, and gas valve **19** shuts off completely, thus discontinuing effective incineration until such upset condition can be corrected and the normal incineration operation is restarted by hand. In summation, the automatically-controlled throttling sequence responsive to a rise in temperature in said incineration zone tending to exceed 1,200°F. is staged as follows:

first the flow of primary fuel is increasingly throttled down by valve **19** to the stated minimum; secondly, the flow of diluent air for the fumes is increasingly "unthrottled" by valve **8;** and, finally, the flow of fumes mixed with the diluent vapor are bypassed at an increasing rate away from the incineration zone, the maximum diversion being reached at 3 psig of controller air output pressure on valve **9** at which time the flow of primary fuel is at its minimum and the flow of fume diluent air is at its maximum. While this flow control throttling sequence is preferred without substantial overlapping as to these sequential flow operations, in some installations such overlapping can be tolerated where necessary or desirable. Thus, diluent air can be increased before primary fuel flow is fully throttled down, and fume diversion can take place before diluent air flow is at its maximum. This instrumentation and general facility are, and clearly should be, fast-acting for sudden, extreme emergency so that the sequence can be made to take place extremely rapidly if necessary, while at the same time accommodating lesser transient and ordinary conditions smoothly without disruption.

Obviously many variations and combinations of the foregoing can be made without departing from the invention, and it should be limited only by the scope of the appended claims.

I claim:

1. In a process for incineration of combustible fumes capable of exothermic reaction in an enclosed incineration zone at preselected, elevated incinerating temperatures wherein hot combustion products from the burning of a flow of primary fuel are supplied to the zone

together with a flow of the fumes for incineration and the supply of primary fuel is to be stopped when the temperature in the zone reaches a preselected maximum level as a result of fume overload and fumes are to be diverted from said zone, the improvement of relieving a transient fume overload comprising the steps of diverting at least a portion of the fumes on the occurrence of a fume overload when the temperature in the zone reaches a predetermined level which is below said maximum level at which all flow of primary fuel is to cease, and operating the flow of primary fuel at a minimum level during the transient fume overload to continue to supply some hot combustion products to said zone at a low level which is sufficient to maintain combustion in said zone while fumes are being diverted to relieve the transient overload to thereby maintain the process operative to incinerate fumes upon the relieving of the overload without a restarting operation.

2. A process as defined in claim **1** wherein said flow of primary fuel is at a minimum level close to extinction for combustion of the fuel while fumes are being diverted during a transient overload.

3. A process as defined in claim **1** wherein the portion of fumes being diverted is varied as a function of the transient overload.

4. A process as defined in claim **3** wherein said flow of primary fuel is at a level close to extinction for combustion of the fuel while fumes are being diverted during a transient overload.

5. A process as defined in claim **3** wherein the flow of primary fuel is stopped after the diversion of said fumes reaches a predetermined maximum.

6. A process as defined in claim **5** wherein said flow of primary fuel is at a level close to extinction for combustion of the fuel while fumes are being diverted and before the diversion reaches the said predetermined maximum.

7. A process as defined in claim **1** wherein the fumes are diluted with a diluent vapor and the flow of vapor is increased when a fume overload occurs and the temperature in said zone is at substantially said predetermined level.

8. A process as defined in claim **7** wherein said flow of primary fuel is at a level close to extinction for combustion of the fuel while the fumes are being diverted during a transient fuel overload.

9. A process of claim **7** wherein said diluent vapor comprises molecular oxygen, and the process is automatically controlled in response to a rise in temperature in the incineration zone tending to exceed said predetermined level to effect the following:

a. the maintaining of the flow of primary fuel at its said minimum level,

b. the increasing of the flow of the diluent vapor, and

c. the diverting of fumes from said zone at a variable rate dependent on overload the flow of fumes mixed with said diluent vapor.

10. The process of claim **9** wherein said predetermined temperature level is between about 800° and 2,500° Fahrenheit.

11. The process of claim **9** wherein the diversion temperature is between about 1,100° and 1,400° Fahrenheit.

12. The process as defined in claim **1** wherein said predetermined level is between about 1,100° and 1,400° Fahrenheit.

* * * * *

Dedication

3,789,104.—*Albert P. McCauley,* Chagrin Falls, Ohio. CONTROL METHOD FOR FUME INCINERATORS. Patent dated Jan. 29, 1974. Dedication filed Mar. 1, 1982, by the assignee, *SCM Corp.*

Hereby dedicates to the Public the remaining term of said patent.

[*Official Gazette August 10, 1982.*]