Aug. 5, 1958 A. I. BRATTON 2,845,882

INCINERATION APPARATUS AND METHOD

Filed Feb. 23, 1955 3 Sheets-Sheet 1

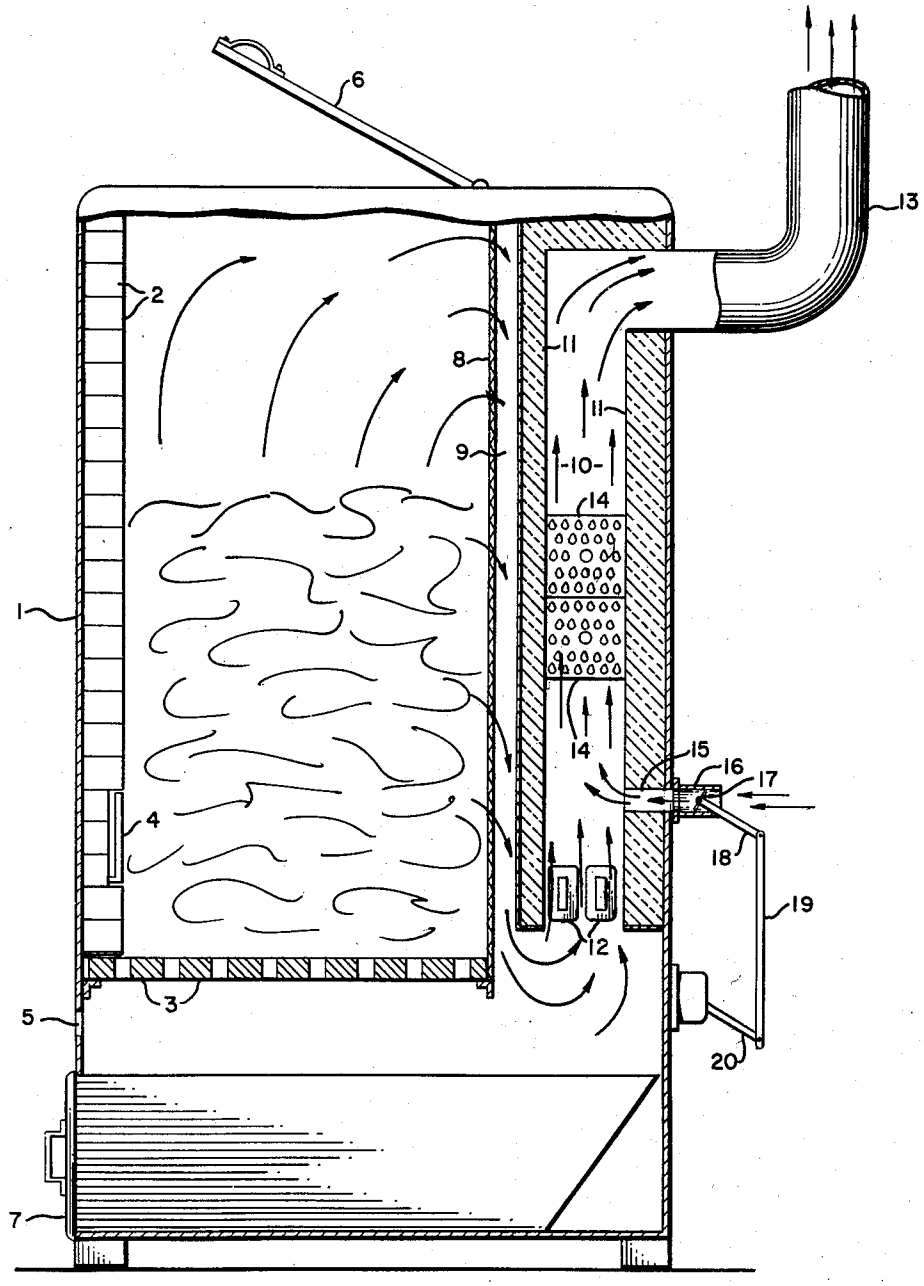


FIG. 1.

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INCINERATION APPARATUS AND METHOD

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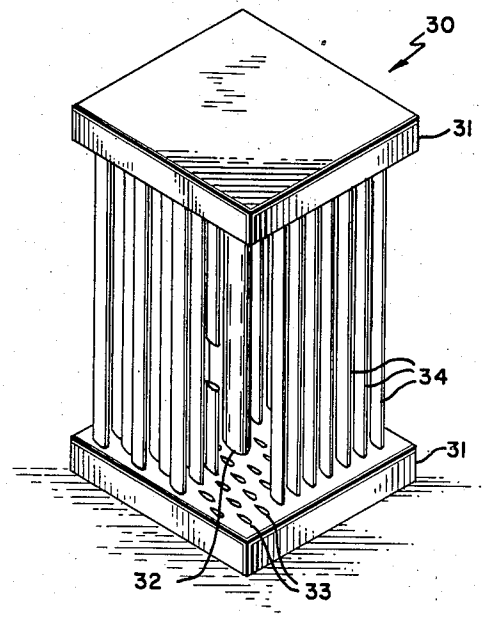
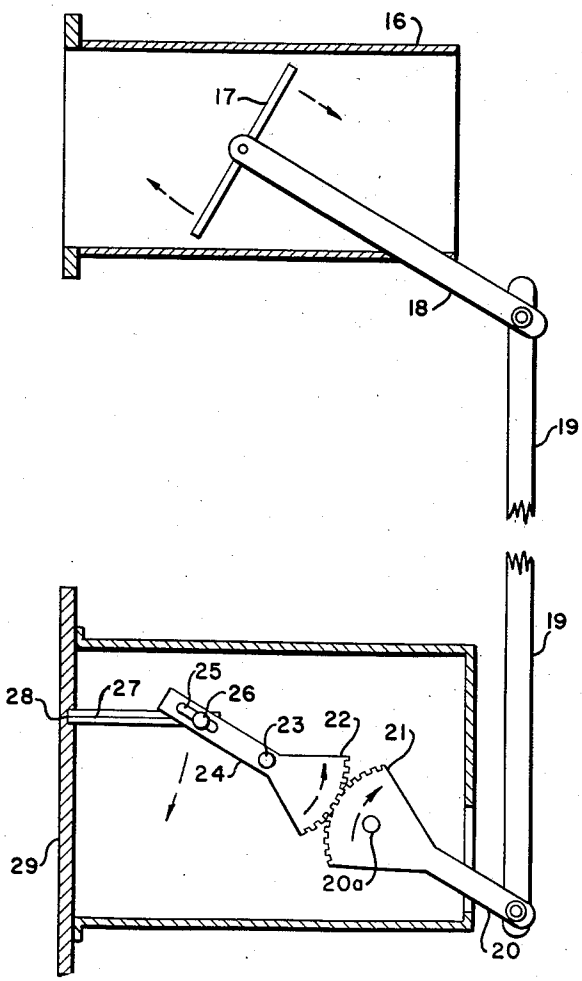


FIG. 5.

FIG. 2.



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INCINERATION APPARATUS AND METHOD

Filed Feb. 23, 1955 3 Sheets-Sheet 3

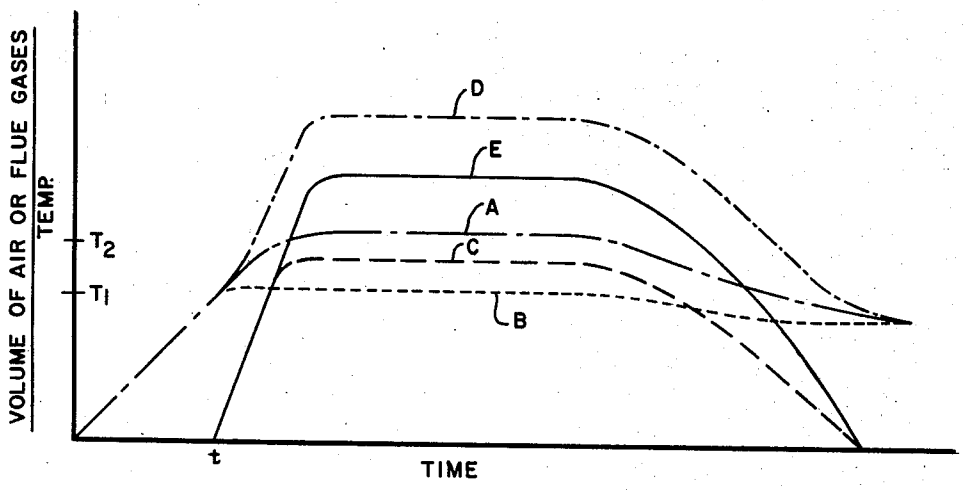


FIG. 4.

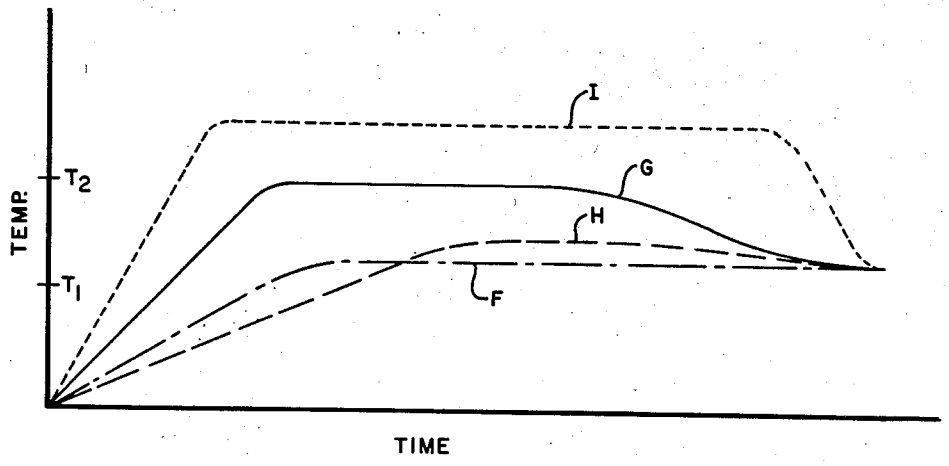


FIG. 3.

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INCINERATION APPARATUS AND METHOD

Alfred I. Bratton, Broomall, Pa., assignor to Oxy-Catalyst, Inc., a corporation of Pennsylvania

Application February 23, 1955, Serial No. 489,890

5 Claims. (Cl. 110—8)

This invention relates to incinerators and methods of incineration of the general class in which the charge is burned with only a limited amount of combustion air and the combustion products from the burning are subsequently passed over an oxidation catalyst to thereby eliminate the objectionable and obnoxious components therein. Incineration methods and incinerating apparatus of this general type are disclosed in the copending application of Eugene J. Houdry and Elvin L. Krieble, Serial Number 422,838, filed April 13, 1954 for "Incinerating Apparatus and Method," and assigned to the same assignee as the present application.

It is an object of the invention to provide an incinerating method and apparatus in which the effluent from the burning is substantially free of smoke and other objectionable components.

It is a further object of the invention to provide an incinerating method and apparatus in which the combustion products from the burning are intermixed with air from the atmosphere in order to provide sufficient oxygen for a subsequent catalytic oxidation process in which the smoke and other objectionable components of the combustion products are catalytically oxidized.

It is a further object of the invention to provide method and apparatus for regulating the amount of air supplied from the atmosphere to the combustion products in accordance with the varying requirements of the process.

It is a further object of the invention to provide an incinerating method and apparatus in which the operating costs will be minimized.

It is a further object of the invention to provide an incinerating method and apparatus which is operative under widely varying conditions of charge and combustibility of the charge to produce an effluent substantially free of smoke and other objectionable components.

Further objects of the invention will be apparent from the following description and from the annexed drawings in which:

Fig. 1 is a cross-sectional view of an incinerating apparatus constructed in accordance with the principles of the invention.

Fig. 2 is an enlarged view of an automatic damper which forms part of the invention.

Figs. 3 and 4 show a series of curves which depict some of the operating principles of the invention.

Fig. 5 is a perspective view of a catalytic unit of the type usable in the practice of the invention.

It is generally recognized that incinerators are an important contributor to the air pollution problems which beset many urban communities. The use of small incinerators of the type adapted for use in a single household or in a multiple dwelling housing unit has increased appreciably within the past several years and these small type incinerators contribute a relatively large portion of the nuisance engendered with incineration processes. It

is relatively difficult to operate an incinerator, particularly the household incinerator, in such manner as to efficiently and cleanly burn the charge because of the fact that the charge itself will contain a highly varying amount and types of material such as garbage, wood, paper, and floor sweepings. Some of the charge ordinarily burned in an incinerator will be of a comparatively highly combustible nature, such as the paper and the wood, while other components of the charge will be burnable only with relative difficulty, such as the garbage. Under conditions such as these, it is extremely difficult to effect a combustion process in which all of the material will be consumed without the production of comparatively large volumes of smoke and highly objectionable odors. This is particularly true in the case of a domestic type incinerator which must be capable of being operated by a householder relatively unskilled in matters of combustion and furthermore, such devices must be capable of being operated with little or no attention and adjustment. The growing importance of the air pollution problem in many cities is causing an increasing interest in the possibility of a solution for the air pollution problems created by incinerators, particularly of the household type.

A practical solution to the air pollution problems inherent in incineration operations is suggested in the above mentioned application Serial Number 422,838. According to the principles of the invention of the aforesaid application, the charge in the incinerator is burned with only a limited amount of combustion air to produce a stream of combustion products which is relatively low in free oxygen and relatively high in combustible components such as smoke and carbon monoxide. The stream of combustion products is then heated by passing it over a heating unit and/or intermixing it with heated secondary air from the atmosphere. Subsequently the stream of combustion products is passed over an oxidation catalyst which eliminates by catalytic oxidation substantially all of the objectionable components of the gases and produces an effluent which is comparatively innocuous and unobjectionable. The process explained and disclosed in the aforesaid application Serial No. 422,838 differs materially from ordinary incineration processes in which relatively large amounts of combustion air are supplied. As explained in the Houdry et al. application, reducing the amount of combustion air supplied for the burning of the charge results in a relatively slow consumption of the readily combustible components of the incinerator charge and the production of a stream of gases during all portions, or substantially all portions, of the burning cycle which is at a higher temperature than is the case with conventional incineration operations.

It is further explained in the above mentioned application that it is necessary to preheat the catalyst for the reason that practical, presently available oxidation catalysts are in general operative only at elevated temperatures and for an incineration process the catalyst should be heated to about 800° F. or higher. In order to preheat the catalyst an auxiliary heating unit disposed adjacent the catalyst is activated prior to the beginning of the burning of the charge so that the catalyst will be heated to its activation temperature when burning commences. During at least a substantial portion of the burning cycle it is necessary to intermix air from the atmosphere with the combustion products for the reason that the oxygen-deficient combustion products do not contain sufficient oxygen to effect catalytic oxidation of the oxidizable components thereof. In the disclosure of the previous Houdry application, air is admitted through an

inlet into the flue carrying the combustion products during all portions of the burning cycle.

It has been found that when secondary air is admitted through an air inlet during all portions of the burning cycle, the amount of heat which must be supplied for preheating the catalyst and for heating the gases is relatively high. While an incinerator constructed in such manner that secondary air is admitted during all portions of the burning cycle will effectively burn the charge without the production of objectionable components in the effluent, the operating costs are somewhat increased over those of a conventional incinerator.

The present invention provides a means and method for regulating the amount of secondary air admitted and intermixed with the combustion products from the burning in accordance with the varying needs of the process. In this manner, the amount of heat supplied for preheating the catalyst and heating the combustion products prior to catalytic oxidation is minimized with resulting economies of operation. The regulation of the amount of oxygen supplied is effected in response to temperature variations of the incinerator firebox which are indicative of the requirements of oxygen for the catalytic oxidation process. These principles of the invention will be apparent from the more detailed description which follows. It should be mentioned that while the invention is herein disclosed with reference to a household incinerator of the type in which the heat is supplied by electric heating elements, the principles of the invention are also applicable to a gas incinerator and of course to larger incinerators of the type which might be used for municipalities or for multiple dwelling units.

Referring to the drawing the reference numeral **1** denotes the shell or housing of the incinerator which is partially lined with suitable refractory **2** such as firebrick. A grate **3** is provided in the lower portion of the housing and an electric heating unit **4** is disposed adjacent to grate for the purpose of igniting and effecting combustion of the charge. An air inlet **5** is located beneath grate for the purpose of admitting combustion air into the immediate area in which combustion takes place. Preferably this air inlet is adjustable so that varying amounts of air might be provided for different conditions of burning. The top of the incinerator is provided with a suitable door **6** through which the material to be burned may be charged into the incinerator firebox. An ash drawer **7** is provided in the lower portion of the incinerator for collecting and permitting removal of the various noncombustible ashes which might be charged into the incinerator and after burning fall through the grate. It should be mentioned that the shell **1** of the incinerator should be comparatively air tight and sealed against all leakage of air so that all of the air provided for the burning will of necessity pass through the opening **5**. This permits control of the amount of air and provides for controlled burning of the charge in a manner to be described more fully hereinbelow.

A screen **8** of expanded metal or the like is disposed across the inside of the shell adjacent the rear end thereof. This screen functions to retain the charge as indicated in the drawing above the grate **3** and to provide a passage **9** for the products of combustion. A flue **10** is provided in the rear portion of the interior of the incinerator which as shown in the drawing is of substantially rectangular cross-section. The flue **10** is preferably lined with suitable insulation indicated by the reference numeral **11** and an electric heating means **12** is disposed within this flue adjacent the lower end thereof. Gases from the burning pass through this flue in the manner indicated by the arrows to the stack **13** which conducts them to the atmosphere.

Mounted within flue **10** are a plurality of catalytic units **14** of a type which will be explained and described more fully hereinbelow. An opening **15** is provided at a point upstream from the catalyst **14** which opening communicates with the atmosphere in order to permit the admission of secondary air as indicated by the arrows. In the disclosed embodiment, this opening is provided with a suitable sleeve **16** mounted exteriorally of the shell **1** as shown by the drawing. A damper **17** is pivotally mounted within this sleeve and a lever **18** rigidly secured to the axis of the damper. Lever **18** is in turn pivoted to a connecting rod **19** which in turn is pivoted to a member **20**. Member **20** as shown in Fig. 2 is pivoted intermediate its ends at **20***a* and is provided on one end with a segmental gear **21** which meshes with a second segmental gear **22** pivoted for rotation at **23**. Segment **22** is provided with an extension **24** having a slot **25** adjacent one end through which a pin **26** extends. This pin is secured to a bimetallic element **27** anchored at its opposite end **28** to a plate **29** secured in the casing **1** of the incinerator. Preferably the plate **29** should be within sight of the area of the incinerator firebox in which combustion takes place although exact location of this plate is a matter involving some empirical determination as will be explained more fully below. As shown by the arrows the bimetallic element **27** is adapted to assume a curved shape upon heating thereof. This causes rotation of the gear segment **22** in a counterclockwise direction as indicated and rotation of gear segment **21** in the clockwise direction indicated. As a result, the connecting rod **19** is displaced in a downward direction thereby rotating lever **18** in a clockwise direction and opening damper **17** as indicated. Obviously in any specific embodiment of the invention the relative sizes of the gear segments **21**, **22**, and the location of the pivot points **20***a*, **23** should be such that the damper **17** will be opened to the proper extent in response to a temperature increase in the firebox.

When a conventional charge consisting of a mixture of difficulty combustible material, such as garbage, and readily combustible material such as paper and wood is burned in accordance with the principles of the invention, the burning cycle can be roughly divided into three periods. During the first or initial burning period, which ordinarily will last about five minutes, the area of combustion spreads as the readily combustible materials disposed adjacent the heating unit are ignited. During this portion of the cycle some of the difficultly combustible portions of the charge also disposed adjacent the heating unit will be at least partially dehydrated which dehydration is a necessary prerequisite to burning. The temperature of the incinerator firebox will, of course, gradually increase as the combustion area spreads and the firebox grate and walls are heated. During at least the beginning of this initial burning period the amount of combustion air admitted through air inlet **5** will be sufficient for the combustion which is taking place since the actual amount of burning being carried out will be limited. The flow rate and temperature of the combustion products will gradually increase as the combustion area spreads and the concentration of unburned combustibles in the combustion products will, in general, increase somewhat. During at least the first few moments of this initial burning period the combustion products will contain sufficient free oxygen to effect substantially complete elimination of the oxidizable components thereof at the oxidation catalyst **14**.

After the combustion area has spread so that it covers substantially the entire grate area a second or intermediate burning period commences during which the charge is consumed by a process akin to a smouldering or retorting process. During this period the amount of air admitted through inlet **5** will be insufficient to permit complete combustion in the firebox and the effluent produced will, as a result, contain a relatively high concentration of combustible components such as smoke and CO. The rapid propagation of flames through the charge, by rapid consumption of the readily combustible materials thereof, is prevented by virtue of the fact that the

air admitted through inlet 5 is limited and any flame which might form is snuffed out as it tends to travel upwardly through the charge, in the oxygen deficient atmosphere of the upper portions of the firebox. As a result, the readily combustible portions of the charge will be slowly consumed along with those difficultly combustible portions which have been dehydrated during earlier times in the burning cycle. Also, further dehydration of the remaining difficultly combustible portions of the charge will be effected by the combustion products flowing thereover and by the heat generated in the combustion area.

As mentioned above, the combustion products produced during this intermediate portion of the burning cycle will contain relatively high concentrations of combustible components such as CO and smoke. The free oxygen content of the combustion products generated during this intermediate portion of the burning cycle is relatively low. For this reason it is necessary to intermix secondary air from the atmosphere with these combustion products in order to provide the necessary oxygen for substantially complete catalytic oxidation of the rather high concentrations of smoke, CO and other combustibles at the catalyst 14.

After the readily combustible portions of the charge have been entirely consumed during the intermediate burning period, there follows a final burning period during which the remainder of the difficultly combustible portions of the charge are burned. This burning period is characterized by a gradual diminution of the combustion area, the volume of effluent produced, the concentration of combustibles in the effluent and the temperature of the effluent as the final portions of the charge are burned. At the termination of this final burning period the temperature of the gases entering flue 10 at the lower end thereof will be merely the temperature of the air which enters the firebox through inlet 5 and is heated upon flowing over heating unit 4. Since the combustion area, the volume of effluent produced, and the concentration of combustibles in the effluent all decrease during this final burning period, it follows that the need for the addition of secondary air for catalytic combustion also decreases. In other words, the limited amount of air admitted through inlet 5 to the firebox once more becomes sufficient for both the combustion process of the firebox and the catalytic oxidation of the oxidizable components of the combustion products.

From the foregoing description it is apparent that secondary air for the catalytic combustion process need be supplied only during the final phases of the initial burning period, during the intermediate burning period and during the beginning portions of the final burning period. During these times the combustion products from the burning will not contain sufficient oxygen to permit catalytic elimination of the smoke, CO and other combustibles by the catalyst. At these times then damper 17 should be opened or at least partially opened to permit inspiration of air into the flue 10. At other times the damper 17 should be closed in order to conserve heat and prevent unnecessary cooling of the combustion products by the admixture of air at ambient temperature.

In an operating cycle of the apparatus shown, the damper 17 will of course be closed when the firebox is cold and the bimetallic element 27 is straight as shown in Fig. 2. The electric preheating element 12 is first energized for a suitable length of time, which is usually five minutes or less, in order to heat the catalyst 14 to its operating temperature. Since the damper 17 is closed while this preheating is being carried out, no large volumes of air will be induced to flow through opening 15 and thereby retard heating of the catalyst. This is particularly important in electric incinerators in which the costs of providing the heat are relatively high as compared to gas fired incinerators.

The damper 17 will remain closed during a substantial portion of the first burning period while the combustion area spreads. As the firebox temperature rises however, bimetallic element 27 will gradually assume a curved posture and thereby gradually open damper 17. The element 27 should, of course, be positioned and designed in such manner as to effect beginning of opening of damper 17 as soon as the free oxygen content of the combustion products falls below the level necessary for effecting cleanup at the catalyst 14.

Since the oxygen content of the combustion products, the volume of the combustion products and the firebox temperature are interrelated in the manner described above, this condition can be achieved by location and design of the bimetallic element and the linkage to the damper 17.

During the second portion of the burning cycle damper 17 will remain open since continuing, relatively high temperatures will exist in the firebox. During the final portions of the burning cycle, damper 17 will gradually be closed under the influence of decreasing firebox temperatures. During this period the need for secondary air for catalytic combustion gradually decreases as explained above.

The principles of the invention can readily be appreciated from a consideration of Figures 3 and 4 which show a family of curves depicting the various changes in the temperatures and flow rates of gases during a burning cycle of an incineration process conducted in accordance with the principles of the invention. Referring to Fig. 4, the curve labeled "A" shows the temperature changes which take place during a normal burning operation of the type described above, in which a mixed charge is consumed. It can be observed that this curve rises abruptly during the initial portion of the cycle as the combustion area spreads and as the temperature of the flue gases increases with the partial consumption of some of the more readily combustible portions of the charge. During the intermediate portion of the burning cycle this temperature remains relatively constant at a maximum uniform level during which time the remainder of the readily combustible portions of the charge are partially dehydrated and consumed. In the final portion of the burning cycle it can be seen that the temperature of the flue gases drop somewhat as the final portions of the charge are consumed and as the combustion area recedes and the smouldering action dies out. The temperature marked as "T–1" on the ordinate represents the point at which the damper 17 is set to begin to open. The temperature marked "T–2" represents the point at which the damper 17 is fully opened.

The curve labeled "B" in Fig. 4 represents the volume of combustion air drawn into the firebox through the inlet 5 for combustion of the charge. This curve, as clearly shown, rises along with curve A as the combustion area increases but reaches a maximum value when the combustion area attains its equilibrium. Obviously, the curve representing this variable is constant throughout the median portions of the cycle for the reason, as previously explained, that the inlet 5 is of limited area in order to preclude the possibility of the admission of excessive quantities of air.

The curve labeled "C" represents the volume of secondary air drawn through the inlet 15 adjacent the catalyst. As is apparent from the drawing, this curve rises at a time t which is somewhat in advance of the beginning of the burning cycle for the reason that the damper 17 is not opened immediately but is opened only after several minutes of burning have taken place. Curve C rises rapidly as the damper 17 is opened and reaches a maximum value at that point on the abscissa at which damper 17 is fully open. This curve also shows that the amount of air drawn into flue 10 through inlet 15 decreases during the final portions of the burning cycle as damper 17 is gradually closed when the firebox temperature decreases.

Curve D represents the total amount of air drawn into the incinerator by the accumulative effect of the inlet **5** in the firebox and the inlet **15**. This curve of course is a representation of the sums of curves B and C.

Curve E represents the concentration of combustibles in the gases produced by the incinerator or, stated alternatively the amount of combustibles which must be removed by catalytic oxidation at the catalyst **14**. As is apparent from the drawing, this curve starts at time *t* and rises to a maximum during the intermediate portions of the burning cycle. During the very beginning of the cycle, of course, no combustibles are present, as previously explained, for the reason that inlet **5** provides sufficient air during the period when the combustion area is relatively small, for complete combustion of the charge. It is only during the intermediate portions of the burning cycle that the air provided by inlet **5** is insufficient to permit complete combustion so that combustibles are present in the flue gases. It is also apparent that curve E falls to zero toward the end of the burning cycle when the combustion area recedes with the final consumption of the last portions of the charge.

Fig. 4 clearly illustrates that with the present invention the air admitted through inlet **15** will be admitted only during such times of the burning cycle as it is needed (i. e. during times of high combustible concentration and low oxygen concentration) for catalytic oxidation of the combustible components of the charge. Obviously, no air is needed during this portion of the burning cycle when the combustibles in the charge are not of such concentration as to require oxygen in amounts greater than the amounts present from the primary combustion. Furthermore, Fig. 4 illustrates that the amount of air provided through inlets **7**, **15** is reduced or increased during the burning cycle as required by the stream of combustion products produced.

The curves shown in Fig. 4 are predicated upon the assumption that the charge is relatively normal for a domestic type incinerator. That is to say, the charge consists of a heterogeneous mixture of readily combustible and difficultly combustible materials rather than the extreme conditions which might exist if the charge were composed entirely of wood or paper on the one hand or of wet garbage on the other. Fig. 3 illustrates the varying temperatures in the flue gases obtainable when other than ordinary conditions exist. In this figure curve F represents the temperature of the flue gases which is obtained when no charge at all is present (when the burner is merely activated without accompanying destruction and burning of wood, paper, etc.). As shown, this temperature rises to an equilibrium and will of course maintain this equilibrium temperature so long as the burner or heating unit is operated.

Curve G represents the temperature-time relationship which exists with a normal incinerator charge, that is a charge consisting of mixed paper and kitchen refuse, wood, etc. This curve is of course the same as the curve A of Fig. 4 and is re-plotted in Fig. 3 to provide a basis for comparison.

Curve H illustrates the condition which obtains with an extremly wet charge, for example a charge consisting primarily or exclusively of garbage. With such charges the maximum temperature is obtained only after a protracted period of dehydration as indicated by the rather gentle slope of this curve. Furthermore, the period of continuous burning is not so protracted, comparatively speaking, as with curve G. Such charges are relatively difficult to consume and comparatively vexatious as compared to the situation which exists when some readily combustible material is present.

Curve I represents the condition which exists where the charge is composed almost exclusively of easily combustible materials such as paper, wood, magazines, etc. With the burning of such charges the temperature will rise rather abruptly to a high maximum level and will maintain this maximum during most of the burning cycle as a rather intense burning process is carried out. When the charge has been entirely consumed the temperature will drop rather abruptly as indicated to the equilibrium level since such charges generally are not followed by a smoldering period when difficultly combustible portions are consumed. Charges of this nature are relatively easy to burn, although they produce larger flow rates of flue gases.

With burning of the abnormal types shown in Fig. 3 the family of curves representing the amount of combustible components in the flue gases, the amount of secondary air required for catalytic combustion of these combustibles and the other relationships shown in Fig. 4 would be considerably different than those of Fig. 4. Obviously, with different burning conditions, varying amounts of oxygen must be provided for the catalytic combustion process. With the instant invention, however, any of the abnormal charges shown in Fig. 3 can be charged into the incinerator and the damper **17** will be opened automatically at the proper time to effect the admission of sufficient secondary air for the catalytic combustion process. It is therefore evident that the invention permits use of the incinerator in widely varying conditions and under widely varying circumstances.

Fig. 5 discloses a catalytic unit of the type shown at **14** in Fig. 1, usable in the practice of the invention. Referring to Fig. 5 it can be seen that the unit indicated by the reference numeral **30** consists of a pair of end plates **31** maintained in spaced-apart parallel relationships by center post **32**. The opposing faces of the end plates are apertured as at **33** and accommodate a plurality of rod-like elements **34** of streamline cross-section, in staggered rows. The unit shown in Fig. 5 is preferably of high grade ceramic material such as porcelain of the type used in spark plug manufacture. It is desirable to anchor only one end of the rod-like elements **30** or to permit the elements **34** to slide freely within their apertures in order to permit thermal expansion without fracture and breakage.

Each of the rod-like elements **34** is provided with a thin film of catalytically active metal oxide such as alumina or beryllia. Preferably the film is of about 0.001" to 0.006" in thickness, the preferred thickness being about 0.003". This film is impregnated with a minor amount of catalytically active metal such as platinum or palladium in an amount corresponding to about 0.5% to 5% of the weight of the alumina or beryllia film. Film type catalysts of this type are described more in detail in the copending application Serial Number 312,152 filed September 29, 1952 by Eugene J. Houdry and in U. S. Patent 2,580,806.

It is understood of course that the invention can be practiced with catalysts other than the catalyst disclosed in Fig. 5. For example, it is contemplated that the invention might be practiced with a coated wire type catalyst consisting of resistance wire coated with catalytic material such as platinum-impregnated alumina. With coated wire type catalysts, the catalyst can be heated to its activation temperature by merely passing an electric current through the wire. However the problem of admitting the proper amounts of secondary air for catalytic combustion will be present regardless of the type catalyst employed.

As previously noted, the invention while disclosed herein with reference to an electric incinerator is equally applicable to incinerators in which the heat is supplied by combustion of fuel gas. Electric incinerators, of course, will generally cost more to operate than gas incinerators and for this reason it is essential to minimize the amount of heat expended on raising the temperature of the catalyst. The invention is also applicable to incinerators of the larger type such as might be used in large apartment houses or in municipal refuse disposal systems.

Obvious modifications of the invention within the spirit and scope of the appended claims will be apparent to those skilled in the art.

I claim:

1. In an incinerator for burning combustible material with concomitant destruction of smoke and fumes in the stream of combustion products, said incinerator comprising a firebox to receive the material to be burned, a catalyst chamber housing an oxidation catalyst and communicating with said firebox to receive the stream of combustion products therefrom before passage to the incinerator stack, a heating element disposed within said catalyst chamber at a point upstream from said catalyst to heat said stream of combustion products and to heat said oxidation catalyst, and an air inlet communicating with the interior of said catalyst chamber at a point upstream from said catalyst to supply oxygen for catalytic oxidation of said smoke and fumes, the improvement comprising air flow regulating means associated with said air inlet, temperature responsive control means for controlling said regulating means, said control means being responsive to the temperature of said firebox in such manner that during the burning cycle of a single charge with varying firebox temperatures and similarly varying flow rates and smoke and fume concentrations in the stream of combustion products, the amount of air admitted through said air inlet is at all times adequate to supply the oxygen necessary for said catalytic oxidation while the admission, during periods of low firebox temperature and low flow rates and smoke and fume concentrations in the stream of combustion products, of excessive quantities of air, such as would cool said catalyst to a level below its operating temperature, is prevented.

2. In an incinerator for burning combustible material with concomitant destruction of smoke and fumes in the stream of combustion products, said incinerator comprising a firebox to receive the material to be burned, a catalyst chamber housing an oxidation catalyst and communicating with said firebox to receive the stream of combustion products therefrom before passage to the incinerator stack, an electric heating element disposed within said catalyst chamber at a point upstream from said catalyst to heat said stream of combustion products and to heat said oxidation catalyst, and an air inlet communicating with the interior of said catalyst chamber at a point upstream from said catalyst to supply oxygen for catalytic oxidation of said smoke and fumes, the improvement comprising damper means within said air inlet, temperature responsive control means for controlling said damper means, said control means being responsive to the temperature of said firebox in such manner that during the burning cycle of a single charge with varying firebox temperatures and similarly varying flow rates and smoke and fume concentrations in the stream of combustion products, the amount of air admitted through said air inlet is at all times adequate to supply the oxygen necessary for said catalytic oxidation while the admission of excessive quantities of air is prevented thereby minimizing the amount of power required for said heating unit.

3. A method for batch incineration with concomitant destruction by catalytic oxidation of the fumes produced thereby comprising the steps of burning a charge of refuse in the presence of a limited amount of primary air thereby producing during portions of the burning cycle relatively high concentrations of combustible fumes and insufficient oxygen for combustion thereof in the incinerator flue gases, the concentration of combustible fumes and of oxygen in said flue gases varying over a relatively wide range during the burning cycle corresponding to relatively wide variations in the combustion rate, contacting the incinerator flue gases with an oxidation catalyst to catalytically oxidize the combustible fumes contained therein, introducing a stream of secondary air into said flue gases upstream from the catalyst to supply the oxygen required for oxidation of said combustibles, detecting variations in the firebox temperature and regulating the amount of secondary air in accordance with and responsive to the temperature variations detected such that the amount of secondary air is increased and decreased corresponding respectively to increasing and decreasing firebox temperatures accompanying varying combustion rates and varying concentrations of combustibles in said flue gases, and such that sufficient oxygen is supplied at all times for the oxidation of said combustibles while avoiding the introduction of secondary air in substantial excess of said oxygen requirements so as to thereby minimize the cooling effect of said secondary air stream on the oxidation catalyst.

4. A method for batch incineration of a heterogeneous charge of refuse containing easily combustible and difficultly combustible portions with concomitant destruction by catalytic oxidation of the fumes produced thereby comprising the steps of burning said charge in the presence of a limited amount of primary air thereby producing during the middle portion of the burning cycle relatively high concentrations of combustible fumes and insufficient oxygen for the combustion thereof in the incinerator flue gases, while during the initial and terminal portions of the burning cycle the incinerator flue gases contain relatively small concentrations of combustible fumes together with sufficient oxygen for combustion thereof, contacting the incinerator flue gases with an oxidation catalyst to catalytically oxidize the combustible fumes contained therein, introducing a stream of secondary air into said flue gases upstream from the catalyst to supply the oxygen required for oxidation of said combustibles, and controlling the flow of said stream of secondary air such that substantially no secondary air is admitted during the initial and terminal portions of the burning cycle when the concentration of oxygen in the incinerator flue gas is sufficient for the oxidation of the combustible constitutents thereof, while sufficient secondary air is admitted during the middle portion of said burning cycle to provide sufficient quantities of oxygen to effect catalytic oxidation of the combustible components of said flue gas at all times during the burning cycle while avoiding the introduction of secondary air in substantial excess of said oxygen requirements so as thereby to minimize the cooling effect of said secondary air stream on the oxidation catalyst.

5. A method for batch incineration of a heterogeneous charge of refuse containing easily combustible and difficultly combustible portions with concomitant destruction by catalytic oxidation of the fumes produced thereby comprising the steps of burning said charge in the presence of a limited amount of primary air thereby producing during the middle portion of the burning cycle relatively high concentrations of combustible fumes and insufficient oxygen for the combustion thereof in the incinerator flue gases, while during the initial and terminal portions of the burning cycle the incinerator flue gases contain relatively small concentrations of combustible fumes together with sufficient oxygen for combustion thereof, contacting the incinerator flue gases with an oxidation catalyst to catalytically oxidize the combustible fumes contained therein, introducing a stream of secondary air into said flue gases upstream from the catalyst to supply the oxygen required for oxidation of said combustibles, and controlling the flow of said stream of secondary air by detecting variations in the firebox temperature and regulating the amount of secondary air in accordance with and responsive to the temperature variations detected such that during the initial and terminal portions of the burning cycle when said firebox temperature is relatively low and the concentration of oxygen in the incinerator flue gas is sufficient for the oxidation of the combustible constitutents thereof substantially no secondary air is admitted, while during the middle portion of said burning cycle when said firebox tempera-

ture is relatively high and the incinerator flue gas contains insufficient oxygen for the oxidation of the combustible constituents thereof, sufficient secondary air is admitted to effect catalytic oxidation of the combustible components of said flue gas, such that at all times during the burning cycle the introduction of secondary air in substantial excess of the oxygen requirements for the oxidation of said combustible constituents is avoided so as thereby to minimize the cooling effect of said secondary air stream on the oxidation catalyst.

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