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[54] METHOD FOR COMBUSTING REFUSE AND OTHER ORGANIC MATERIAL
7 Claims, 5 Drawing Figs.

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[50] Field of Search 110/7, 8, 8c, 15, 18, 18c; 299/3; 166/11, 38

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ABSTRACT: A method for combusting refuse or other combustible material comprising the passing of air through the combustible material while burning to thereby force combustion gases through the combustible material so that the combustible material filters, cools and removes particulate matter and toxic gaseous air pollutants from the combustion gases before the latter pass into the atmosphere. The combustion gases, after flowing through the combustible material, may be flowed through a porous media prior to being emitted into the atmosphere to thereby further clean and deodorize the gases. The method of this invention may be conducted in pits in field operations or in assembled units on a commercial level or in households.

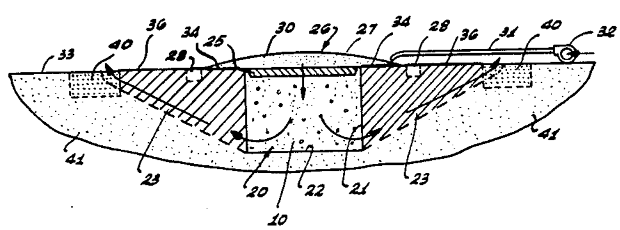

Fig. 1a

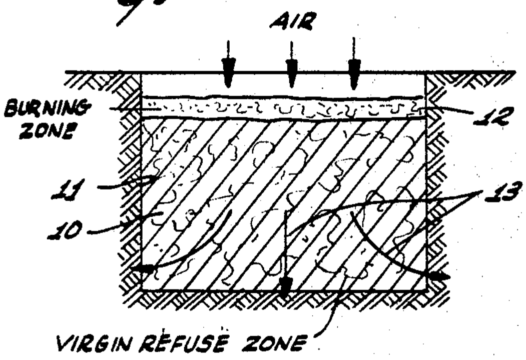

Fig. 1b

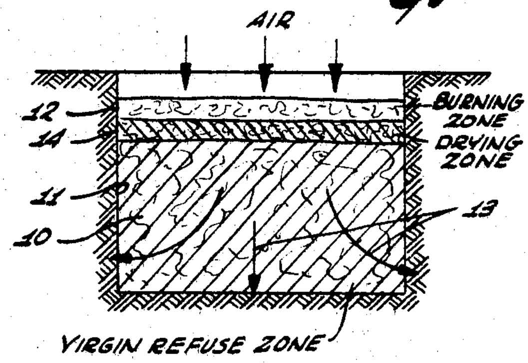

Fig. 1c

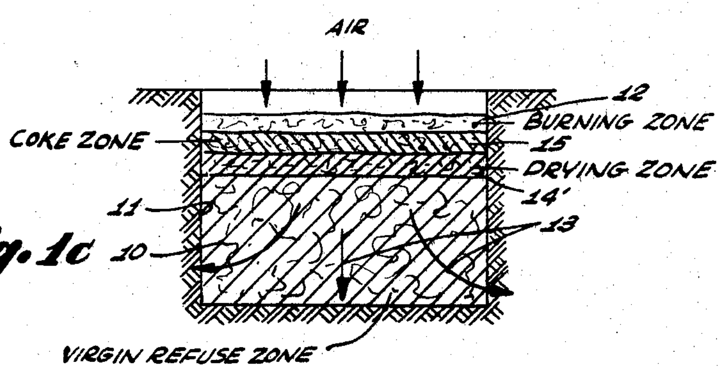

Fig. 2

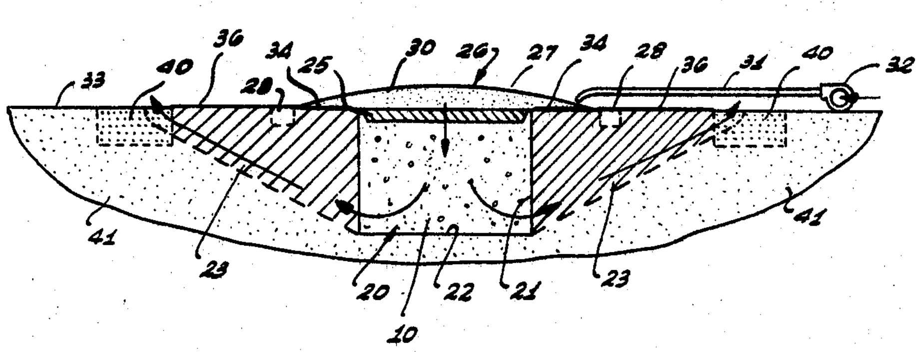

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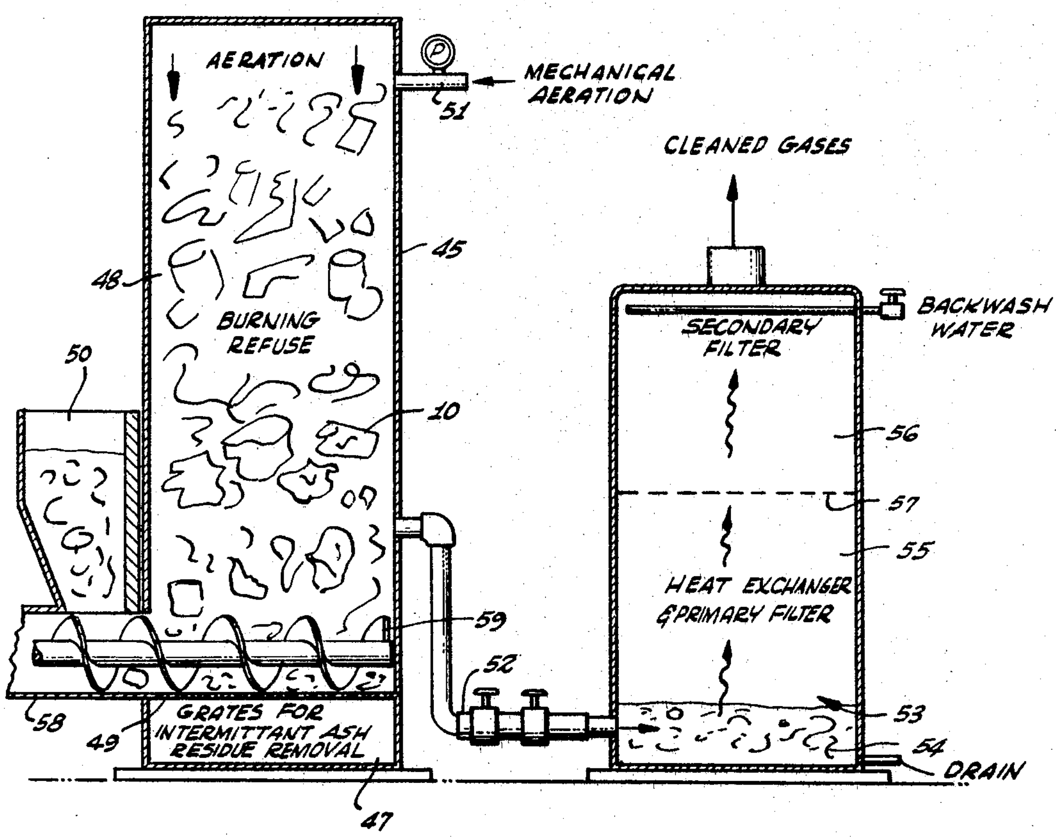
Fig. 3



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METHOD FOR COMBUSTING REFUSE AND OTHER ORGANIC MATERIAL

BACKGROUND OF THE INVENTION

This invention relates to the burning of combustibles such as refuse.

With increasing population, the elimination of combustible material becomes more important because the amount of combustible materials produced increases and because the land fill areas required to dispose of the combustible materials or residue therefrom becomes less available. Additionally, land fill burial of raw combustible materials is generally undesirable. Therefore, methods have been developed to burn refuse to thereby attempt to reduce it to inerts which are stable and to reduce its weight and volume so that burial of the oxidized residue will require less final land fill space while permitting normal ultimate land use.

Methods of burning combustible materials range from the use of small household incinerators to large commercial and municipal incinerators, including open pit burning. The presently-employed methods for burning combustibles have several disadvantages. In general, they are relatively inefficient with the result that complete or substantially complete burning of the combustibles is not realized. This incomplete combustion results in the production of toxic gases, e.g., sulfur dioxide and nitrogen oxides, particulate matter, and odoriferous compounds, e.g., mercaptans, all of which are sometimes called "smog".

As is well known, smog is detrimental to the general health and safety. Additionally, due to the incomplete combustion, a relatively large percent of the initial refuse volume remains after combustion with the result that substantial space is still required to bury the burned combustible material. Even after burial, the land fill may settle and generate undesirable gases. Large commercial and municipal incinerators commonly exhibit the foregoing disadvantages. Moreover, these large incinerators have a further disadvantage of being extremely expensive to construct and they are often expensive to maintain because of intrinsic difficulties associated with the burning method used therein. To obtain more efficient combustion, more complicated units have been developed with better combustion and reduced air pollution capabilities. However, these units are costly and only partially satisfactory in solving the solid accumulations, and air pollution problems.

A particular disadvantage of presently-used, open field burning methods, such as those used by communities, in addition to producing smoke and smog, is that the residue settles substantially when used as fill material. This is because the residue is not completely burned, which means that further organic decomposition takes place over a period of time, and because the residue has a relatively low density which means that natural compaction and differential settlement occurs over a long period of time. Combustible methane and noxious gases are produced in landfills; also organic leachate may pollute the ground water.

In view of the foregoing and in view of the increasing emphasis being placed on clean air and the related problems of ground and water pollution, by governmental bodies, the more efficient burning of refuse, both to reduce the amount of residue and to substantially eliminate contamination of the surrounding air, ground and water is greatly needed.

SUMMARY OF THE INVENTION

In general, the method of this invention employes a closed environment in which combustible material is placed so as to provide an air permeable mass. The mass is fired by electrical resistance electrodes or gas/air methods. While the combustible material burns, air under pressure is forced through the mass, thereby aerating the mass and carrying the burning process and products of combustion through the mass. In this way, the combustible material is used to filter and cool the products of combustion. Burning of the refuse may be postponed until the air passing through the combustible material has reduced the moisture content of the material to a desired level.

More particularly, in large commercial and municipal units or cells, a removable, non-combustible top is placed over the unit opening and is sealed about its periphery to form a substantially airtight cover. Air is continuously blown into the space between the cover and the combustible material until the air pressure above the combustible material is sufficient to force the air supported fire and combustion gases downwardly through the combustible material. Where the combustion unit is an underground or open pit cell, the combustion gases are forced outwardly from adjacent the bottom of the combustible mass and through the surrounding earth which acts first as a heat exchanger to reduce the temperatures of the combustion gases and secondly as a combined bio-mechanical-chemical filter to remove gaseous components and particulate matter which would pollute the surrounding atmosphere. Where required, a portion of the surrounding earth is treated to improve the aforementioned filtration (by the soil) of the combustion products.

The above-described method can be used in combination with assembled combustion units on either a commercial scale or in the home to effect more efficient combustion. In such combustion units, the combustion gases are generally withdrawn from the bottom of the combustion chamber and are then preferably passed first through porous media functioning as both a filter and a heat exchanger and thereafter through organically-treated media before being exhausted to the atmosphere.

Because the combustion gases are forced to pass through the aerated combustible mass prior to entering the atmosphere, several advantages over presently-used burning methods are realized. First, the passage of the combustion gases through the combustible mass further oxidizes the combustion products thereby making the combustion process more complete. Some undersirable components, such as carbon monoxide, are oxidized to a more desirable form, for example, carbon dioxide, before entering the atmosphere.

Secondly, the unburnt portion of the refuse is pre-dryed by the combustion gases by the burning portion. Such drying removes moisture from the combustible material prior to burning thereby permitting carbonization and hotter burning temperatures which produce substantially complete oxidation of the combustible material. Thus, a relatively dense, slag-like residue can be produced by the method of this invention. Because of its high density, this residue can be compacted so that substantially no settlement occurs even after extended periods of time so that it makes good landfill material. Additionally, because the residue contains substantially little unburned material, toxic decomposition gases, which cause ground and air pollution, are substantially eliminated thereby adding to the usefulness of the residue for land fill.

Thirdly, the forcing of combustion gases through the combustible mass, enables the exiting gases to be filtered by the soil adjacent to the combustion pits in field operations without the need for costly apparatus. The soil is an inexpensive and effective filter. Use of adjacent soil in field operations to further filter the combustion gases, produces a gaseous product which has substantially no odor and substantially no air pollutants.

The method of this invention has equal utility when applied to the burning of either large or small volumes of combustible material and permits the use of a relatively simple and inexpensive combustion unit construction.

DESCRIPTION OF THE DRAWINGS

FIGURES 1a, 1b and 1c are cross-sectional views of a combustion unit containing a combustible mass showing the burning process of this invention at different times.

FIGURE 2 is a cross-sectional view showing field operation burning by the method of this invention including the use of soil adjacent the combustion chamber as a filter medium for the combustion gases.

FIGURE 3 is a cross-sectional view of a fabricated unit for burning combustible material continuously by the method of this invention

DESCRIPTION OF THE PREFERRED EMBODIMENT

The combustion method of this invention basically comprises forcing air through combustible material which is to be incinerated while simultaneously burning the combustible material. The flow of air is sufficient to force substantially all of the gases and particulate matter produced from the combustion of the material through the combustible material. The unused portion of the combustible material acts as a mechanical, chemical and biological filter with respect to the combustion gases and particulate matter with the result that substantially no toxic gases, e.g., sulfur dioxide and nitrogen oxides, or particulate matter escape from the combustible material and with the result that the combustion gases are substantialy "cleaner", that is, they contain substantially smaller amounts of matter which is harmful to health as compared with the combustion gases produced by the standard up-draft type of burning.

To further prevent undesirable elements from entering the atmosphere and particularly to substantially deodorize the gases exhausted to the atmosphere, the combustion gases exiting from the combustible material are further filtered and/or treated by flowing the gases through a porous media. When the combustible material is being burned in pits or cells dug into the earth, the combustion gases are forced out of the refuse and into and through the adjacent soil. Some of the soil through which the combustion gases travel may be treated to enhance filtration of the gases by the soil. In assembled or fabricated units, e.g., commercial or household units, the gases are passed from the combustible material through auxiliary filters which may contain soil or other porous filtering material. The gases which are further filtered in this manner have substantially no odor and add little or no pollutants to the atmosphere.

Carbon monoxide which is produced from the combustion of the combustible material and which is a health hazard is substantially reduced by oxidation to carbon dioxide. In ordinary burning, such carbon monoxide would escape directly into the atmosphere as essentially carbon monoxide. By comparison, the carbon monoxide produced as a result of combusting material by this invention is substantially oxidized to carbon dioxide because oxygen has sufficient time to react with the carbon monoxide while the latter flows through the unburned combustible material.

As used herein, the term "combustion gases" includes both gases which are produced as a result of the burning of the refuse, for example, carbon monoxide, carbon dioxide, methane and hydrogen, and gases which may pass unreacted through the refuse, for example, nitrogen and inert gases. Also, as used herein, the term "filtration" refers to either mechanical, chemical or biological reactions in which the combustion gases are "cleaned" of air pollutants or deodorized and it refers to any combination of such reactions.

Hereafter, for simplification, the method of this invention will be described in connection with the burning of refuse which includes, for example, paper, rags, grass and leaves. However, it is to be understood that the method of this invention is useful for the combustion of, for example, tires, logs, coal, automobile combustibles and plastic materials.

To simplify the description, this invention will be described for a burning process in which the combustion layer is located at the top of a combustible mass and in which air is forced downwardly through the combustible material to cause the combustion gases to pass downwardly through the combustible material. It will be understood, however, that the advantages of the method of this invention are also realized by burning combustible material upwardly starting from the bottom of the material and by passing air upwardly through the combustible material.

This invention will now be particularly described with reference to the drawings. First, the combustion method of this invention will be generally described together with the presumed burning mechanism with reference to **FIGURE** 1. Refuse **10** is dumped into a combustion cell, pit or incinerator **11** as shown in **FIGURE** 1a. Initial compaction of the refuse may vary over a wide range. It is only necessary that the refuse have sufficient permeability to allow air to flow downwardly through it at moderate air pressures on the order of about **0.05** psig.-**20** psig. Refuse having a friction factor of about **3** has given satisfactory results.

The air pressure above the refuse **10** is raised to a pressure sufficient to flow downwardly through the refuse and sufficient to carry the combustion gases produced upon combustion of the refuse downwardly through the refuse. The air pressure over the refuse may be varied depending upon whether the air is used for drying the refuse before combustion or whether it is flowed through the refuse during combustion of the refuse. The flow rate of air through the refuse after combustion has been initiated should be sufficient to oxidize substantially all of the carbon monoxide produced upon combustion but should be less than a flow rate which may blow out the refuse fire and/or which may reduce the effectiveness of subsequent filtration. Gas analyses of combustion gases indicate that an air flow rate between about **0.5** and about **30.0** cu. ft./min./sq.ft. (cross-sectional area of flow path) of refuse produces satisfactory results.

Air may be passed downwardly through the refuse until the moisture content of the refuse, which may initially have a substantial water content, for example, **50%** and higher (dry basis), has preferably been reduced below about **30-40%** (dry basis). Below this moisture content, combustion of the refuse is more readily supported and substantially less energy is absorbed from the combustion by the vaporization of water in the refuse, thereby permitting higher combustion temperatures.

With the moisture content of the refuse **10** at a desired level (with or without pre-combustion drying) the refuse is fired by any appropriate means to cause an upper volume **12** of refuse in the combustion cell **11** to burn. As burning continues, substantially all of the combustion gases **13** are forced downwardly from the burning zone **12** by the downwardly moving air. These hot combustion gases **13** further dry the refuse in a zone **14** immediately below the burning zone **12** as shown in **FIGURE** 1b. As burning continues, the temperature of the refuse in the drying zone **14** increases and distillation and carbonizing of the organic matter commences. The refuse in the drying zone **14** (**FIGURE** 1b) then turns to a coke thereby producing a coke zone **15** as shown in **FIGURE** 1c. The refuse immediately below the coke zone **15** is further dried to produce a drying zone **14'** as shown in **FIGURE** 1c. Continued burning causes the burning, coke and drying zones **12, 14** and **15** to move progressively downwardly through the cell **11** as the refuse is burned.

The initial burning temperature may be as low as about **350°F.** and as high as about **600°F.** to **1000°F.** depending upon the heat equivalent of the burning refuse components and upon the rate of heat loss from the combustion zone. It will also be understood that the combustion temperature may be increased by increasing the air flow into the refuse. The coke usually burns or flashes off at temperatures between about **2000°F.** to **4000°F.** The ash residue and coke layers act as a refractory to retain and reflect heat into the lower refuse layers. As the coke layer approaches the bottom of the cell, it is common for the temperatures of the residue coke to rise substantially. This is borne out by the fact that the residue remaining after burning is concluded is a very dense, slag-like material.

Burning by the method of this invention is substantially slower (and more thorough) than the burning rates of presently-employed methods. For example, for a particular amount and type of refuse, burning a load by this invention may range from 6 hours to 30 days whereas burning by conventional means may take only ½to 2 hours.

The result of the described burning mechanism is that a significantly higher volume reduction of the refuse is achieved by the method of this invention as compared to other commonly-employed methods. For example, organic volume reductions of 99% and higher can be obtained using the method of this invention as compared to organic volume reductions of 85-90% and 50-60% by normal burning where the combustion gases flow upwards and by sanitary land-fill decomposition methods, respectively. In addition to obtaining less residue by the method of this invention, the residue is more suitable for land-fill where structures are to be built over the filled areas since it provides better support because of its higher density and because substantially no settling or noxious gas production occurs after combustion since combustion of the refuse is substantially complete.

In addition to the foregoing advantages over commonly-employed methods, the combustion gases are cleaned and filtered by the coke and virgin refuse layers. The refuse removes substantially all of the particulate matter and toxic gases (95% reduction in SO_2) from the combustion gases leaving the latter with substantially only a burning refuse odor. This odor may be substantially removed by flowing the combustion gases through a porous media as will be described hereafter. The gases introduced into the atmosphere from the combustible material are therefore substantially cleaner than gases emitted from normally-used methods. Because of the generally higher temperatures produced by this invention and because burning rates are significantly less than prior art methods, bulky items such as tree trunks, tires, food slop, industrial or sewage sludges, dead animals, nuclear residue, abandoned vehicles, and cans can be readily burned whereas such items in the past have been regarded as very difficult to burn.

The method of this invention, together with means for using same, will be further described with reference to **FIGURE** 2 which illustrates the use of this invention for burning refuse in a field combustion unit such as are used by communities. In **FIGURE** 2, the numberal **20** designates a combustion pit having sidewalls **21** and a bottom or floor **22** and surrounded by natural earth or soil **23**. The soil **23** (hereafter referred to as "-natural soil") preferably has the permeability of loam, that is, a friction factor of about **7** or less, but may be as impermeable as clay. It has been found that, although clay may be substantially impermeable to combustion gases, it can be treated to increase permeability and that the heat generated by combustion of the refuse is sufficient to crack the clay and allow the gases to flow outwardly away from the refuse.

In some applications, it may be desirable to position a vapor-impermeable liner (not shown) along the walls **21** of the pit **20** to prevent leakage of combustion gases into the natural soil **23** from the refuse **10** adjacent the burning zone of the refuse. Although leakage of combustion gases in this manner is generally not significant, this ensures maximum flow of combustion gases downwardly through the refuse **10**.

Refuse **10** is dumped into the lined or unlined pit **20** to any desired height. The initial refuse density is not critical except that it must be air permeable; however, less dense refuse, for example, about **400-1200** lb/cu.yd. is desirable to increase the burning rate. A layer of earth **25** is spread over the refuse **10**. The depth of the earth layer **25** may vary from **3** to **6** inches and more but must be air permeable. The function of the earth layer **25** is to provide a sanitation layer over the refuse **10** to eliminate temporary open storage odors and to act as a heat shield or refractory to reduce heating of any structure placed over the pit **20**. In its latter capacity, the soil layer **25** augments the refractory action of the ashes residue from the combustion process as previously desribed.

To ensure efficient passage of air into the refuse **10**, a cover is placed over the pit **20** in sealing relation therewith to prevent pressurized air from escaping into the atmosphere. The cover may comprise a relatively permanent and inflexible roof mounted on wheels moving along tracks adjacent the pit (not shown) so that the cover can be rolled into sealing position over the pit during burning and rolled away for refuse fill.

A flexible cover **26** which is inexpensive and readily replaced and easily moved into position over the pit **20** is shown in **FIGURE** 2. The cover **26** comprises a flexible roof section **27** which is affixed at its outer edges to a footing **28**, for example, of concrete, circumventing the pit **20**, by any suitable means to form a substantially air-tight seal about the pit. The roof **27** may be made from fireproof or fire resistant air-tight fabrics, e.g., asbestos canvas or polyethylene-coated canvas. However, because of the heat-shield action of the earth layer **25**, a roof material which is not fireproof or fire resistant may be employed in some applications.

Air is pumped into the space **30** above the pit **20**, which is enclosed by the cover **26**, through an air supply pipe **31**. The supply pipe **31** is connected at one end to an adjustable blower **32** which supplies pressurized air to the pipe and is connected at the other end to the roof section **27**.

The walls **21** of the pit **20** may extend up to the earth surface **33** at the footing **28** (not shown) or they may intersect the surface at some distance within the boundary defined by the footing (**FIGURE** 2). In the latter situation, an annular surface area **34** exists between the pit **20** and the footing **28**. Gases escaping from the refuse **10** through the pit walls **21** may pass upwardly through the annular surface **34** and into the air space **30**. This is undesirable because mixing the incoming air with the combustion gases decreases the oxygen content of the mixture thereby decreasing the ability of the incoming air to support combustion.

Although the air pressure within the air space **30** is generally sufficient to prevent the escape of combustion gases into the air space, any such escaping gases may be prevented from entering the air space by placing a gas-impermeable membrane **36** over the annular surface area **34**. Such membrane **36** may be made from polyethylene or other impervious material. The membrane **36** preferably of a fire resistant material may be extended outwardly beyond the footing **28** or employed only beyond the footing as will hereafter be described.

In operation, and with the roof **27** folded back or removed from the pit **20**, refuse **10** is dumped into the pit to a desired depth, for example seven feet, and is covered with a layer of earth **25**, for example, one foot deep. The roof **27** is next moved into position over the pit **20** and sealingly secured to the footing **28**. Air is then forced by the blower **32** through the air supply pipe **31** into the air space **30**. When the air pressure within the air space **30** reaches a level sufficient to overcome the resistance of the earth layer **25** and refuse **10**, the air flows downwardly through the refuse. The air pressure in the air space **30** is adjusted to provide a desired air flow rate through the refuse and through the adjacent soil **23**. The flow of air downwardly through the refuse is continued until the moisture level in the refuse has been lowered to below about **30% - 40%** (dry weight basis). The refuse **10** is then ignited near the top of the refuse and burning of the refuse commences as previously described.

The combustion gases are forced downwardly by the positive air pressure in the air space **30**. After passing through part or all of the depth of refuse **10**, the combustion gases flow outwardly from the pit **20** through the adjacent soil **23**, wherein the gases are cooled and filtered. The filtered gases thereafter pass into the atmosphere with relatively little odor and contain substantially no air pollutants.

Further improvement in the odor and quality of the combustion gases exiting into the atmosphere may be obtained by placing an organically-treated soil **40** adjacent the natural or untreated soil **23** so that the combustion gases pass first through the natural soil and then through the treated soil. The treated soil may comprise, for example, a manure (25%) - loam soil admixture. To ensure that the combustion gases pass through both types of soil, the membrane **36** is extended over the surface above the natural soil **23** but not over the surface above the treated soil **40**. To further channel the combustion gases, a highly compacted soil **41**, for example, clay, may be placed under both the natural and treated soils **23**, **40**. The combustion gases then flow outwardly from the pit as shown in **FIGURE** 2.

To optimize the filtering action of the soils, the amount of natural soil **23** is adjusted so that the flow path of the combustion gases through the soil is sufficiently long to cool the combustion gases to a temperature below the minimum pasteurization temperature, about **170**°F. of the treated organic soil **40** before entering the treated soil. The minimum pasteurization temperature is about **170**°F. but will vary somewhat depending upon the organisms present in the treated soil. Preferably, the temperature of the combustion gases is also lowered to below the dew point of the gases before they pass into the organically treated soil **40**. Lowering the combustion gas temperature below the gas dew point produces moisture which is required by the organisms in the organically-treated soil **40**. Although this water can be supplied by a sprinkling system, a more economical method is provided by allowing the natural soil **23** to cool the gases below their dew point in addition to filtering them. In this manner, part or all of the preferred amount of moisture in the treated and untreated soils **40**, **23** can be supplied by the gases. Thus, moisture is removed from the refuse **10** to improve burning and this moisture is transferred to the soils to improve bio-chemical filtration. Preferably, the moisture content of the filter soils is substantially equal to but less than saturation. Less moisture tends to decrease the efficiency of soil treatment and more moisture hinders the flow of air.

The method of this invention, as previously described, may also be used in combination with assembled units such as commercial and household incinerators as will now be described with reference to **FIGURE** 3. As shown in **FIGURE** 3, the numeral **45** designates an assembled combustion unit for continuously combusting refuse having a residue cleanout bin **47** at its lower end. Above the cleanout bin **47** is a combustion chamber **48** in which burning of the refuse **10** takes place and which is separated from the cleanout bin by a grate **49**. A hopper **50** containing refuse communicates with a feeder pipe **58** which communicates with the lower end of the combustion chamber **48**. A rotating feeder screw **59** is carried within the feeder pipe **58** for continuously conveying refuse into the combustion chamber **48**. An air inlet line **51** communicates with the upper section of the chamber **48** and is connected at its other end to an air supply source (not shown). An outlet line **52** for carrying off combustion gases communicates at one end with the cleanout bin **47** and communicates at its other end with a primary filter **53** (which doubles as a heat exchanger or gas cooler as described in connection with the natural soil **23** of **FIGURE** 2).

The primary filter **53** contains a lower layer of, for example, gravel **54**, for dispersing the incoming combustion gases throughout the filter and an upper layer of permeable soil **55** or other porous media. The primary filter **53** communicates with a secondary filter **56** through a grate **57**. The secondary filter contains organically treated soil. The function, amounts and path lengths through the primary and secondary filters **53**, **56** are the same as previously described in connection with the natural and treated soils **23**, **40** of **FIGURE** 2.

Operation of the assembled combustion unit is substantially the same as has previously been described in connection with the field or pit combustion unit of **FIGURE** 2. Although an assembled combustion unit with bottom feeding for continuously burning refuse has been shown and described, assembled combustion units for continuous feeding through the top, or batch combusting of refuse may also be used.

The method of this invention will be further described by the following example.

EXAMPLE I

A combustion chamber substantially as shown in **FIGURE 3** but without the hopper and feeder screw shown therein was filled from the top with refuse to a height of about **4.0** feet. The refuse had the following composition (%) by volume and by wet weight (lb.): paper - **68**%, **128** lb.; yard trimmings - **28**%, **35** lb.; inerts (glass and metals) - **4**%, **13** lb.). The moisture content was about **27.0**% (dry basis) initially. A layer of loam soil about **10**" - **12**" deep was placed on top of the refuse.

Air at a pressure of **0.11** psig. (**80**°F) was flowed at a rate of **5** cfm downwardly through the refuse and the refuse was ignited near the top of the refuse mass. The average burning temperature was about **550**°F. - **900**°F. but ranged up to about **1150**°F. At intervals during the burning process, the combustion gases exiting from adjacent the bottom of the combustion chamber were sampled and analyzed.

The average values (% by volume) for the components of the combustion gas were found to be: CO_2 - **8.2**%; O_2 - **13.0**%; N_2 - **77.4**%; CH_4 - **0.2**%; CO - **1.2**%. The exhausting combustion gases had a strong smoky odor but a filter paper placed at the exhaust collected substantially no particulate matter indicating that the refuse had absorbed and/or absorbed substantially all of the particulate matter. This was verified by the observation that the exhaust gases were very lightly colored, i.e., barely visible. The smoky odor was substantially eliminated by passing the exhausting combustion gases through a pair of filters in series (Filter #**1** (Heat exchanger - **3** parts by weight soil, **1** part peat moss, **3.5** ft. flow path; Filter **02** - domestic refuse, **3.5** ft. flow path).

The residue remaining after combustion was completed after about **7** days, was a slag-like material.

EXAMPLE 2

A combustion unit identical to that used in Example **1** was filled with about 4 ft. of refuse having the following composition (%) by volume and by weight wet basis - (lb.): paper - **76**%, **102** lb.; yard trimmings - **20**%, **28** lb.; inerts - **4**%, **6** lb. The moisture content was about **52**% (dry basis). A layer of soil **10**" - **12**" deep was placed over the refuse.

In this example, the fire was started at the bottom of the refuse mass and air at a pressure of **0.11** psig (**75**°F.) was flowed at **3.0** cfm downwardly through the refuse as in Example **1**. The combustion gases (which did not pass through the refuse) exiting from the combustion unit were sampled and analyzed.

The average values (% by volume) for the components of the combustion gases were found to be as follows: CO_2 - **6.6**%, O_2 - **13.0**%; N_2 - **78.5**%; CO - **1.9**%. The exhaust gases had a strong, smoky odor. A piece of filter paper placed over the exhaust became highly discolored indicating a high particulate concentration in the combustion. This was verified by the observation that the exhausting combustion gases were a very dark, i.e., highly visible, color.

The residue remaining after combustion was completed was ashes.

A comparison of the results of Examples **1** and **2** show that the combustion gases produced by the method of this invention have a lower carbon monoxide content and contained substantially less particulate matter than a commonly-used method represented by Example **2**. Additionally, the residue from this invention is substantially completely combustible and is relatively hard and incompressible. In contrast, the residue of ordinary burning is a partially-combusted, compressible ash.

EXAMPLE 3

The same combustion unit as used in Example **1** was filled to a height of about **4.0** feet with coal (**490** lbs.) having a moisture content of about **2.6**% (dry basis). A **10**" - **12**" layer of earth was placed over the coal and air at a pressure of **0.5** psig (68°F.) was passed downwardly through the coal at a rate of 5 cfm. The coal was thereafter fired at the top of the coal mass.

The combustion gases exiting from the bottom of the combustion chamber were sampled and analyzed. The average gas composition (% by volume) was: CO_2 - 4.2%; O_2 - 14.5%; N_2 - 79.7%; CH_4 - 0.4%; CO - 1.2%. The exhausting gases had a strong smoky odor which was removed by passing the gases through a first filter (3 parts by weight peat moss, 1 part soil, flow path length 3.5 ft.) and then through a second filter of domestic refuse (flow path length 3.5 ft.).

The residue consisted of clinkers or slag.

EXAMPLE 4

The effectiveness of refuse as a filtering medium for sulphur dioxide and nitrogen dioxide is shown by this Example.

The exhaust of a 1963 Chevrolet was sampled and analyzed both without first passing the exhaust gases through a filter and after the gases had been passed through various types of filters. Each of the filters used had substantially the same cross-section and flow path length.

The results for sulphur dioxide were as follows:

Filter	SO_2 (p.p.m.)
(1) None	19.64
(2) Fiberglass	1.68
(3) Domestic refuse (96% by volume organics, 4% inerts)	0.953
(4) 3 parts by weight soil and 1 part by weight peat moss	1.41
(5) (3) and (4) in series	0.785

The results for nitrogen dioxide were as follows:

Filter	NO_2 (p.p.m.)
(1) None	27.0
(2) 3 parts by weight soil and 1 part by weight peat moss	0.62
(3) Domestic refuse (96% organics, 4% inerts)	0.83
(4) (2) and (3) in series	0.62

From the foregoing, it will be apparent that the process of this invention is capable of burning substantially all of the burnable material in an incinerator, while producing an effluent gas which is substantially non-polluting and a residue which is compact and stable for building upon. Additionally, the concept of what is burnable in commonly-used incinerators is expanded. Such materials as sludge and sewage which have an extremely high moisture content can be burned following preliminary drying in a combustion unit before ignition. Additionally, burning can be maintained more readily when burning relatively wet materials, as opposed to presently-employed combustion methods, because of the additional drying during burning resulting from the downward flow of hot air and combustion gases. Materials which create high burning temperatures, such as tires, logs, plastic materials and cans, can also be burned without significantly polluting the atmosphere because the oxidation and filtration processes are superior to the burning environment of commonly-used incineration methods. All of these advantages are produced using relatively inexpensive facilities which can, in one embodiment, be easily moved from one location to another.

Modifications of this invention may be made by those skilled in the art without departing from the spirit of the invention. Therefore, the invention is limited only by the scope of the appended claims.

I claim:

1. A method for burning a mass of refuse comprising:
   burning a first zone of said mass;
   flowing air under pressure through said first zone and into and through a second, non-burning zone of said mass, to thereby force the combustion gases from said first zone through said second zone of unburned refuse to filter said combustion gases; and
   passing said combustion gases through earth a distance sufficient to substantially completely clean said combustion gases.

2. The method of Claim 1 wherein said flow rate of said air lies between about 0.5 cu.ft./min./sq.ft. of refuse and about 30.0 cu.ft./min./sq.ft. of refuse.

3. The method of Claim 1 wherein a portion of said earth is organically treated and said combustion gases pass through said organically-treated portion after passing through the non-organically treated portion, whereby the odors of said combustion gases are substantially eliminated.

4. The method of Claim 3 wherein the path traversed by said combustion gases through said non-organically treated earth acts as a heat exchanger to sufficiently cool said combustion gases to a temperature below the pasteurization temperature of said organically-treated soil.

5. The method of Claim 3 wherein said combustion gases are cooled to a temperature below the dew point of said combustion gases before entering said organically-treated soil.

6. The method of Claim 4 wherein said pasteurization temperature is about 170°F.

7. The method of Claim 1 wherein said layer is earth.