United States Patent [19]

Kramer

[11] **3,722,433**

[45] **Mar. 27, 1973**

[54] **METHOD AND APPARATUS FOR WASTE INCINERATION**

[76] Inventor: **Ralph J. Kramer,** 6180 Olentangy River Rd., Delaware, Ohio 43015

[22] Filed: **May 18, 1971**

[21] Appl. No.: **144,432**

[52] **U.S. Cl.**.....**110/8 R,** 110/7 R, 110/8 C, 110/14, 110/119

[51] **Int. Cl.**.....**F23g 3/00**

[58] **Field of Search**.....110/8 R, 8 C, 8 A, 10, 119, 110/7 R, 14, 15

[56] **References Cited**

UNITED STATES PATENTS

3,587,488	6/1971	Mutka	110/10
3,556,025	1/1971	Holley	110/8 R
2,701,536	2/1955	Miller	110/8 R
3,601,070	8/1971	Lambiris	110/10
3,068,812	12/1962	Hemeon	110/8 A
3,031,982	5/1962	Gordon et al.	110/8 R
2,292,571	8/1942	Komline	110/8 C
3,060,869	10/1962	Reilly	110/8 R
3,322,079	5/1967	Komline et al.	110/8 R
3,592,149	7/1971	Mutke	110/15

FOREIGN PATENTS OR APPLICATIONS

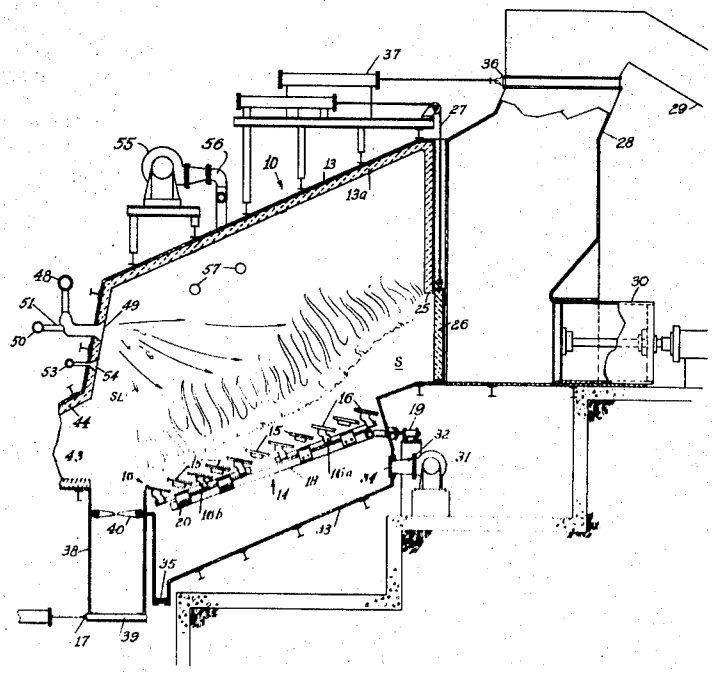
1,165,349	9/1969	Great Britain	110/8 R

Primary Examiner—Kenneth W. Sprague
Assistant Examiner—James C. Yeung
Attorney—Mahoney, Miller & Stebens

[57] **ABSTRACT**

Waste incineration apparatus and method are provided having two serially connected combustion chambers for incineration of solid, semi-solid and liquid waste material, each of which comprises combustible components. The combustion chambers are relatively positioned so that heated gaseous fluids produced by combustion of substantially only solid and semi-solid waste introduced into the first chamber are discharged into the second chamber for enhancement of combustion of liquid waste introduced into the second chamber. These gaseous fluids which are at a relatively high temperature include those that enable or support combustion of liquid waste and may also include those that are combustible when combined with additional combustion air with these gaseous fluids intermixing with liquid waste entering the second chamber thereby enhancing the combustion characteristics of the liquid waste. Preferably, combustion in the first chamber is carried out in the presence of a substantial amount of excess air resulting in complete combustion and preheating of the remaining combustion air prior to its entry into the second combustion chamber. Alternatively, combustion in the first chamber is controlled by limiting the amount of combustion air admitted to that necessary to effect burning of the solids or semi-solids but not sufficient for combustion of the gaseous fluids evolved as a result of that combustion process thereby forming a combustible gaseous fluid.

23 Claims, 7 Drawing Figures



PATENTED MAR 27 1973

3,722,433

SHEET 1 OF 4

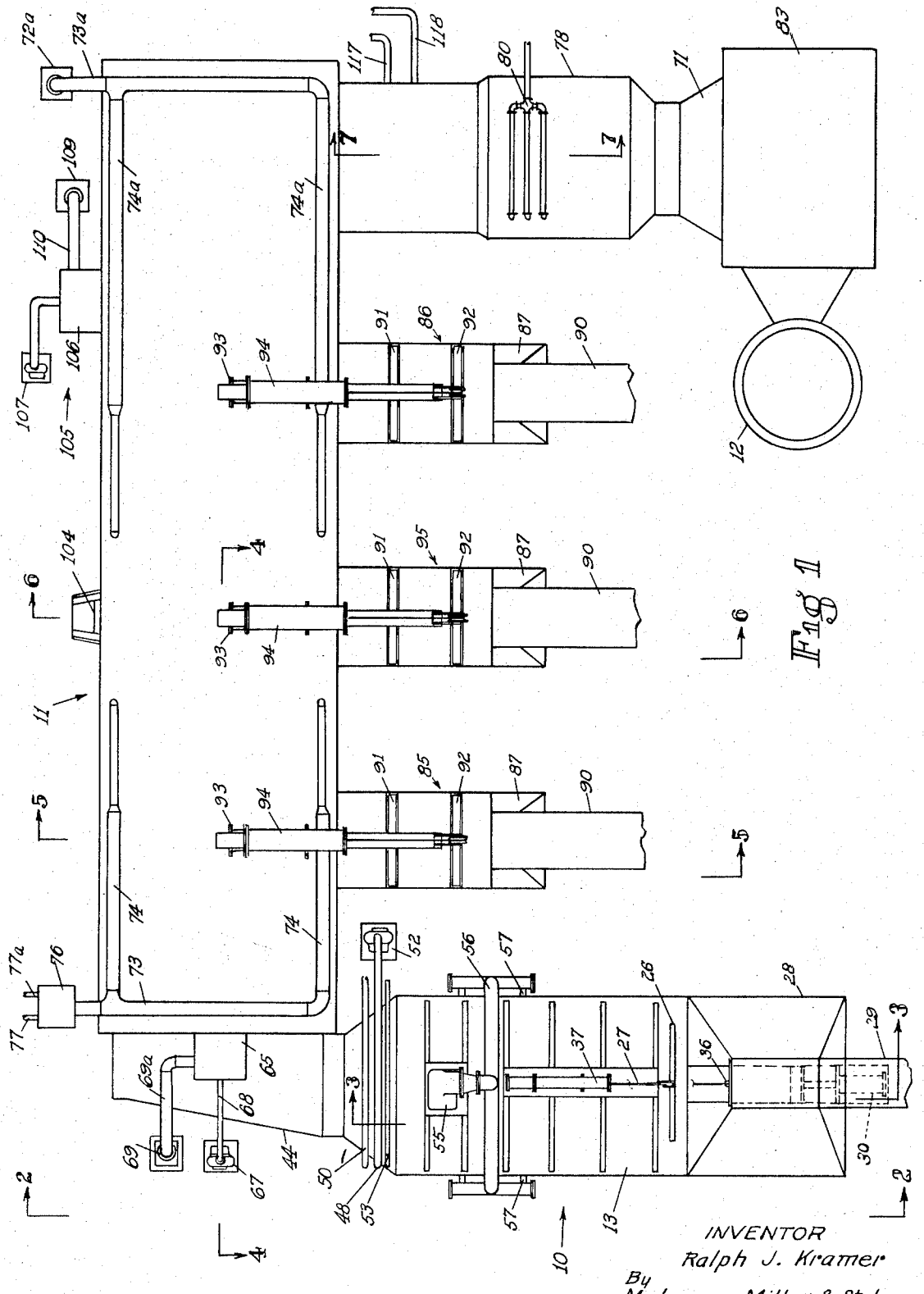


Fig 1

INVENTOR
Ralph J. Kramer
By
Mahoney, Miller & Stebens
By
Robert E Stebens

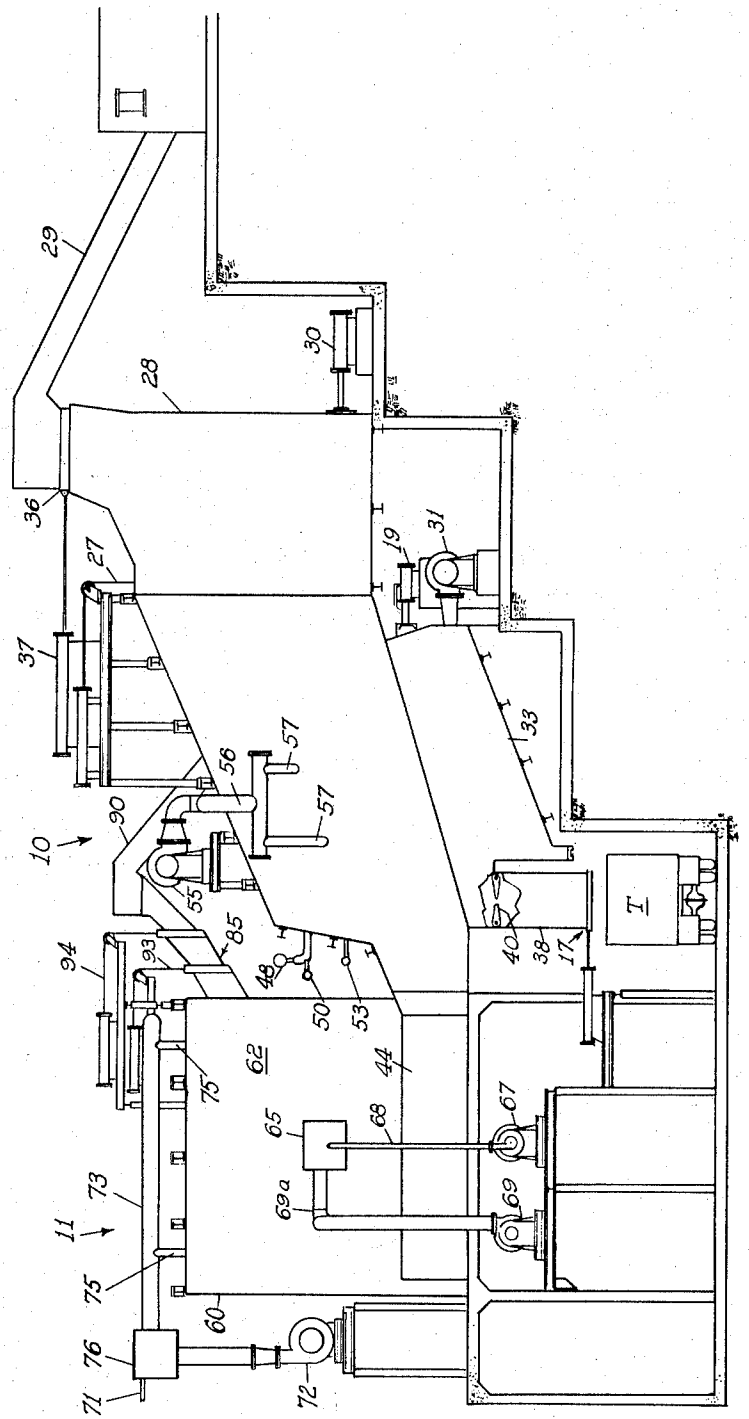


Fig. 2

INVENTOR
Ralph J. Kramer
By
Mahoney, Miller & Stebens
By Robert E. Stebens

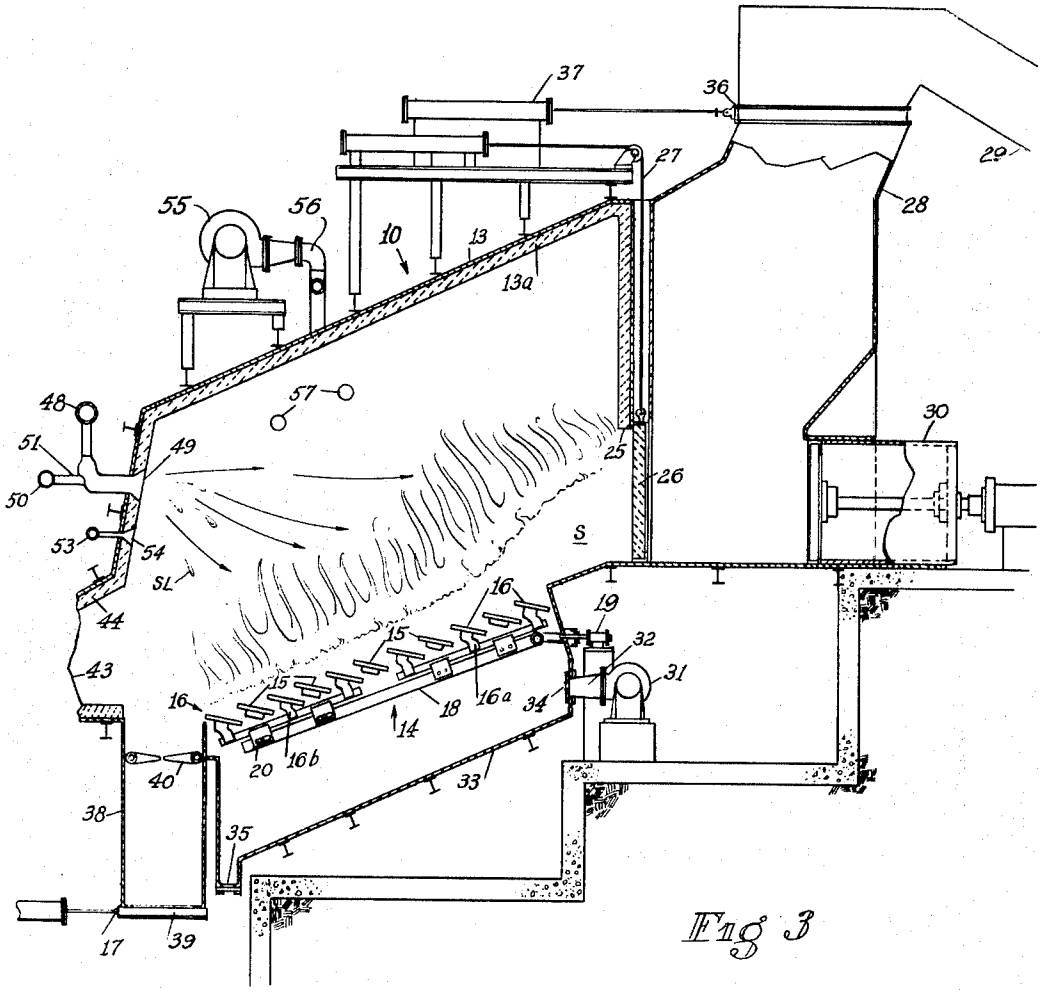


Fig 3

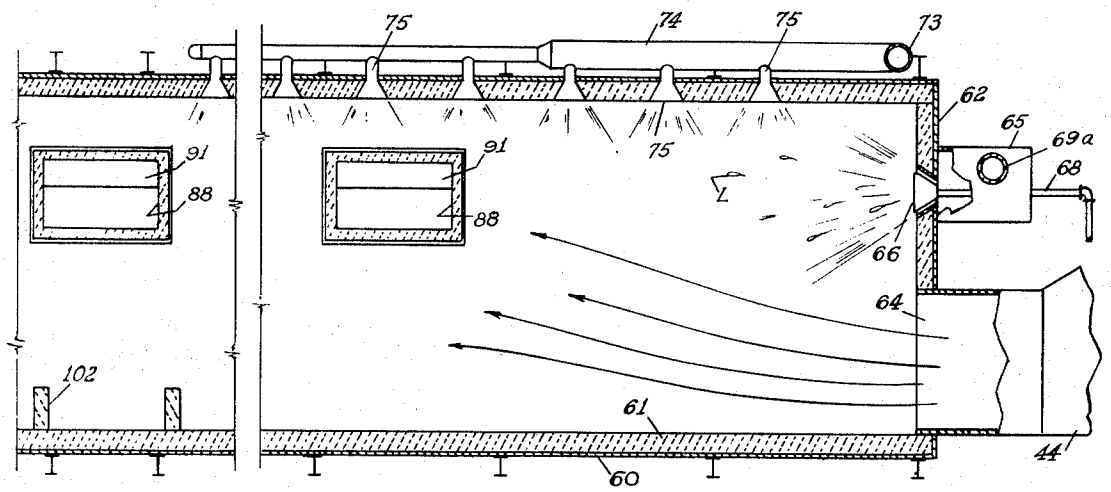


Fig 4

INVENTOR
Ralph J. Kramer
By
Mahoney, Miller & Stebens
By
Robert E. Stebens

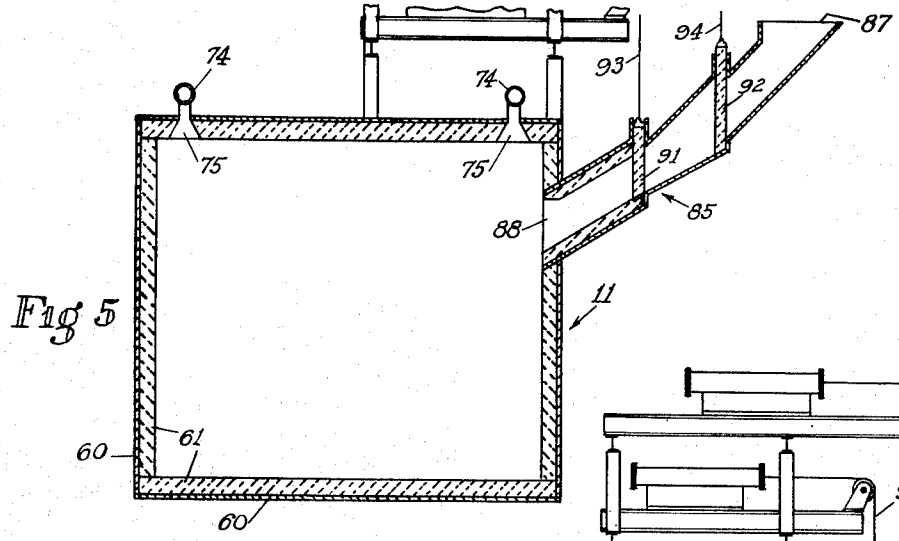


Fig 5

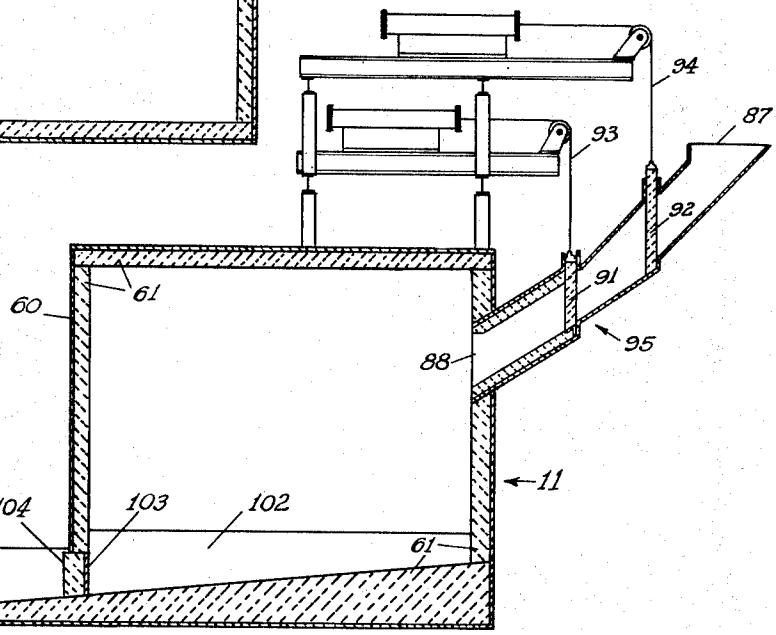


Fig 6

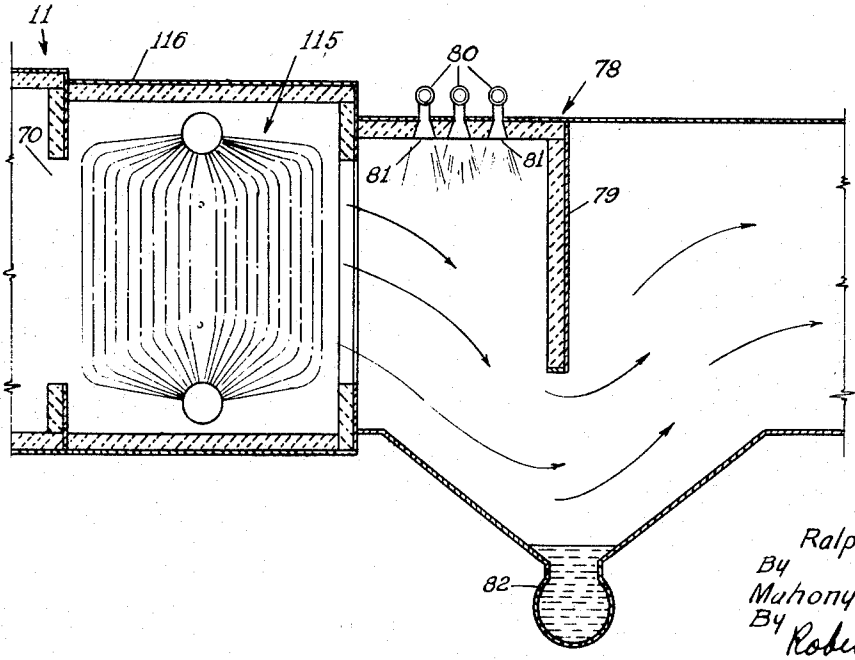


Fig 7

INVENTOR
Ralph J. Kramer
By
Mahony, Miller & Stebens
By
Robert E. Stebens

METHOD AND APPARATUS FOR WASTE INCINERATION

BACKGROUND OF THE INVENTION

Heretofore, incineration-type waste disposal systems and apparatus were designed for and capable only of independently incinerating specific portions of the respectively separated solids, semi-solids and liquids. Each form of waste has its own particular combustion characteristic which is variable within a specific range and dependent on the characteristics of the combustible component or components included in the waste. In view of this difference in waste combustion characteristics, it is a common practice to separate or segregate waste types as to solids, semi-solids or liquids and to then independently process each type waste by respective incineration apparatus that is specifically designed for and capable of handling only a single type waste. This prior practice has resulted in relatively uneconomic incineration apparatus and techniques that favored other waste disposal systems that are less desirable.

BRIEF DESCRIPTION OF THE INVENTION

The apparatus and method for waste incineration of this invention enables incineration of both solids and liquid wastes with economic feasibility. The apparatus of this invention comprises two combustion chambers which are specifically designed for combustion of solid waste and liquid waste, respectively, but are serially intercoupled so that gaseous-fluid products of combustion from incineration of solid waste in the one combustion chamber along with heated excess combustion air is introduced into the second combustion chamber and intermixed with the liquid waste. The heated combustion products and combustion air which are at a relatively high temperature and, when intermixed with the liquid waste, result in raising of the temperature of the liquid waste and consequently improved combustion.

Alternatively, combustion of the solid waste may be controlled by limiting the combustion atmosphere so that gaseous fluids evolved or generated as products of combustion retain a substantial combustible component and combustion thereof is completed in the second combustion chamber along with the liquid waste. In addition to supplying combustible components to aid and enable combustion of the liquid waste, these combustible components are at a relatively elevated temperature and further enhance incineration through elevation of the temperature of liquid waste intermixed therewith for more complete combustion of the liquid waste without necessity of adding support fuel as is the case with prior art apparatus where liquid wastes have a relatively low combustible component of the order of 30 percent.

These and other objectives and advantages will be readily apparent from the following detailed description of an embodiment of this invention and the accompanying drawings:

IN THE DRAWINGS

FIG. 1 is a top plan of a diagrammatically illustrative embodiment of an incineration apparatus of this invention along with axuiliary supportive equipment.

FIG. 2 is an end elevational view of the apparatus taken along line 2—2 of FIG. 1.

FIG. 3 is a vertical sectional view of the first combustion chamber taken along line 3—3 of FIG. 1.

FIG. 4 is a fragmentary vertical sectional view taken along line 4—4 of FIG. 1.

FIG. 5 is a vertical sectional view taken along line 5—5 of FIG. 1.

FIG. 6 is a vertical sectional view taken along line 6—6 of FIG. 1.

FIG. 7 is a vertical sectional view taken along line 7—7 of FIG. 1.

Having specific reference to the several FIGURES of drawings, waste incineration apparatus embodying this invention is illustrated and clearly demonstrates the method for more effectively and efficiently incinerating waste that includes both solids and liquids although segregated for separate injection into the apparatus. This apparatus comprises the basic components of first and second combustion chambers that are designed and specifically adapted for incineration of solid waste and liquid waste, respectively. These two combustion chambers designated generally by the numerals **10** and **11** are serially connected such that the gaseous-fluid products of combustion generated in the first chamber are routed through the second combustion chamber to assist in the combustion of the liquid waste introduced into the second chamber. In the illustrated embodiment, these two chambers are of an elongated configuration having respective longitudinal axes and are relatively oriented with the longitudinal axis at right angles. Solid wastes introduced into the first combustion chamber **10** generate gaseous-fluid products of combustion that are at a relatively high temperature which then flow into the second combustion chamber **11** adjacent one end thereof and then flow longitudinally through the second chamber intermixing with the liquid waste to raise the temperature thereof and may undergo further combustion. Excess combustion air in the first chamber is also heated and transferred to the second chamber along with the products of combustion and assists in elevating the temperature of the liquid waste as well as enabling combustion thereof. The products of combustion resulting in the second chamber are exhausted through an opening at the end opposite the first combustion chamber and the extremely hot gases are treated to lower their temperature and remove solid ash particles as well as prevent escape of excessive quantities of undesirable gasses to the atmosphere through a smoke stack **12**.

Referring specifically to FIG. **3**, a preferred type of first combustion chamber **10** is shown in vertical section for better illustration of the several components and their general operation. This chamber which may be generally rectangular in transverse section comprises a steel plate outer shell **13** mounted on a supporting structure with the interior surfaces of the vertical walls and the top preferably lined with a refractory **13***a*. Included in this chamber is a reciprocating grate assembly **14** having fixed elements **15** and relatively movable elements **16** disposed in the lower portion of the chamber and forming a surface on which the solid wastes are supported during combustion. Reciprocating grate assemblies are well known in the art and it will suffice for the purpose of describing this invention to

indicate that the grate is preferably downwardly inclined from the charging end toward an ash gate **17** thereby providing gravitational assistance in movement of solid waste and resultant ash toward the ash gate. Also, the movable grate elements **16** may be divided into at least two groups (**16***a* and **16***b*) that are mechanically coupled with an actuating mechanism **18**. This mechanism **18** comprises an elongated actuating bar supported for axial reciprocating movement and an operator **19** such as a fluid cylinder and piston unit connectable with a suitable fluid control system (not shown). A "lost motion" connection **20** is utilized between the mechanism **18** and the grate elements in one group **16***b* to provide a difference in rate of movement of waste over the grate with the waste being moved relatively more rapidly by the group **16***a* grate elements.

Charging of solid waste into the first combustion chamber is effected at the upper end of the inclined grate assembly **14** through an inlet aperture **25** formed in an end of the chamber and provided with a movable gate **26**. This gate **26** is movable vertically from the illustrated closed position by means of a selectively operable mechanism **27** that may be of a fluid actuated type. A A suitable hopper **28** is constructed exteriorly of the chamber **10** for receiving a quantity of solid waste S as from a waste conveyor **29**. A fluid actuated charging mechanism **30** may also be provided with this mechanism selectively operable to displace the charge of solid waste S in the hopper **28** through the inlet aperature **25** and onto the grate assembly **14** when the gate **26** is vertically displaced to an open position. The upper end of the hopper **28** is also perferably provided with an air lock gate **36** which seals the first combustion chamber **10** against introduction of air during a charging operation. This air lock gate **36** is coupled with a selectively operable actuating mechanism **37**.

Combustion of the solid waste is supported by underfire combustion air supplied by means of a forced-draft fan **31** having an atmospheric air inlet and a discharge **32** exiting into a distribution chamber **33** formed beneath the grate assembly **14**. The distribution chamber **33** is of a configuration to prevent combustion air other than that supplied by the fan **31** from reaching the solid waste supported by the grate assembly **14**. A flow control valve **34** may be provided in the fan discharge **32** to permit selective adjustment of the combustion air available to support combustion of the solid waste in accordance with the method of incineration of this invention. An access opening **35** with a closure may also be provided in the distribution chamber **33** at a lowermost point to facilitate removal of ash or other debris that may accumulate within the distribution chamber.

Incorporated with the first combustion chamber **10** is the ash gate **17** formed as the bottom of a receptacle **38** for ash or other solid debris resulting from the combustion process or solids included in the waste that are not combustible. The ash receptacle **38** and ash gate **17** are disposed in following relationship to the material traversing the grate assembly and includes a removable closure member **39** permitting periodic removal of the ash and other debris collected as into a transporting apparatus T for removal to a remote disposal point. A swinging ash grate **40** is positioned in the upper part of the ash receptacle **38** to collect non-combustible solid waste or debris while permitting the normal ash leaving the reciprocating grate assembly **14** to enter the ash receptacle. The swinging ash grate **40** may comprise a pair of opposed grate elements normally projecting across the receptacle but selectively movable to a position for removal of solid materials and debris through the ash gate **17** but not necessarily into the same transporting apparatus T for the ash residue. Other means of disposal may be more appropriate for these solid materials.

Also formed as products of combustion from incineration of solid waste in the first combustion chamber **10** are gaseous fluids comprising several elements or compounds including the following: CO_2, CO, O_2, N_2, HCl, SO_2, SO_3, NO_2, NO. Some of these elements or compounds are either capable of supporting combustion of other materials or may be combustible themselves with the relative quantity of each, including whether existing in any amount, is dependent on the composition of the specific solid waste entering the first combustion chamber and the degree of combustion as controllable through the quantity of combustion air provided. In accordance with this invention, these gaseous fluids, along with entrained fly-ash are routed into the second combustion chamber **11** for utilization in a subsequent combustion process. A discharge outlet **43** is formed in the first combustion chamber **10** to permit outflow of these gaseous-fluids with this outlet preferably formed in the end of the chamber opposite the inlet aperature and at a location for optimum fluid flow. A suitable duct **44** interconnects the discharge outlet **43** with the second combustion chamber **11** to introduce the gaseous-fluids at a desired point.

While the first combustion chamber **10** has been described as only receiving solid waste, it will be understood that some semi-solid waste may also be advantageously incinerated in this chamber. Such semi-solid waste may be introduced along with the solid waste, but specific auxiliary apparatus may be provided for introducing semi-solid waste. For example, this apparatus may comprise a distributor or header tube **48** extending transversely across the first combustion chamber **10** in relatively elevated relationship to the grate assembly **14**. A plurality of nozzles or discharge orifices **49** are provided in spaced relationship along the header tube and are designed and oriented to direct semi-solid waste onto the solid waste and ash or residue carried by the grate assembly **14**. Assistance in distribution of the semi-solid waste, designated generally by the letters SL, is provided by an air jet produced by escape of air under substantial pressure from a supply conduit **50** through a plurality of nozzles **51** with one nozzle being associated with each of the discharge orifices. A fluid pump **52** connected with the header tube **48** forces semi-solid waste SL accumulated in a suitable reservoir (not shown) through the header tube **48** and out of the orifices **49**. The air supply conduit **50** is connected to a source of pressurized air (not shown).

At times, it is desirable to control the temperature of the gaseous-fluids exiting the first combustion chamber to the extent of decreasing their temperature which may readily exceed 2000° F. Such temperature control may be accomplished through addition of water by means of a header tube **53** extending transversely

across the top of the combustion chamber **10** in preceding relationship to the discharge outlet **43**. A plurality of horizontally directed spray heads **54** are provided along the header tube **53** to properly disperse the water and the header tube is connected to a source of pressurized water (not shown).

Temperature control in addition to modification of the chemical composition of the gaseous-fluid products of combustion exiting the first combustion chamber **10** may be effected by the addition of overfire air. Overfire air, may be provided by an auxiliary forced draft fan **55** having a discharge connected through appropriate duct work **56** to distributor nozzles **57** mounted in the walls of the chamber. These discharge nozzles are disposed to generally limit overfire air to region above the solid waste undergoing combustion so as not to affect the combustion process controlled by the underfire air. Addition of overfire air will not only tend to reduce the temperature of the products of combustion but will enable more complete combustion of some of these products. While only two distribution nozzles **57** are shown in FIG. **3** of the drawing, it will be seen in FIG. **2** that additional nozzles are located at the opposite side of the combustion chamber.

The second combustion chamber **11** comprises an elongated steel shell **60** lined with a refractory **61** and preferably horizontally disposed on a suitable support structure. This chamber may be of rectangular cross-section with the opposed ends closed by respective end walls **62** and **63** also lined with the refractory **61**. An inlet opening **64** is formed in the end wall **62** and connected with the duct **44** for introducing the gaseous-fluid products of combustion discharged from the first combustion chamber **10** into the second. A liquid inlet **65** is also provided in the end wall **62** for introducing liquid waste interiorly of the second combustion chamber and may advantageously comprise a rotary burner **66** of known construction and oriented to disperse the liquid waste in droplet form (generally designated by the letter L) in a predetermined pattern projecting axially through the second combustion chamber **10** toward the closed end wall **63**. A liquid waste pump **67** connected with a liquid waste reservoir (not shown) supplies the liquid waste at a predetermined pressure to the rotary burner **66** through an interconnecting conduit **68** for effecting the desired dispersion of the droplets of liquid waste L. A rotary burner of this type is also provided with aspirating air with the source thereof comprising a forced draft fan **69** connected to the burner housing by a conduit **69a**.

As can be best seen in FIG. **4**, the rotary burner **66** is disposed vertically above the inlet opening **64** whereby the gaseous-fluid products of combustion and heated excess combustion air from the first combustion chamber **10** are better enabled to intermix with the liquid waste L. These gaseous fluids are at a relatively high temperature and will tend to flow upwardly as well as being induced to flow longitudinally of the second combustion chamber. The heat contained by the gaseous fluids will be at least partially utilized in increasing the temperature of the liquid waste with the result being that the liquid droplets L will tend to be vaporized with the mixture of vaporized liquid waste, products of combustion, aspirating air and excess combustion air forming a highly combustible mixture. This intermixing occurs in a region immediately following the rotary burner **66** and this region may be designated as a gasification zone. The extent of the gasification zone is dependent on factors such as the specific composition of the liquid waste and temperature as well as composition and temperature of the gaseous fluids received from the first combustion chamber. Consequently, the relative arrangement of the rotary burner **66** and gaseous-fluid inlet opening **64** for a particular incineration apparatus will be partially dependent on the specific wastes to be incinerated and the construction may be modified to provide optimum intermixing and gasification.

Following the gasification zone is a combustion zone where the intermixed gaseous fluids and vaporized liquid wastes are burned. Again, the specific location and extent of the combustion zone in a particular incineration apparatus will be dependent on characteristics peculiar to the waste being incinerated. Once ignited, combustion of the vaporized liquid waste with intermixed gaseous fluid will be sustained within the combustion zone. Additional or secondary combustion air may be supplied to the second combustion chamber to assure complete combustion resulting in substantially only gaseous fluids with only a minimal amount of solids such as fly ash.

Gas flow is axially through the second combustion chamber **11** with the ultimate products of combustion exiting through an exhaust opening **70** to the smoke stack **12**. The exhaust opening **70** is preferably formed in a vertical side wall of the second combustion chamber adjacent the end wall **63** to avoid direct radiation of flame heat through the exhaust opening. Enhancement of this gas flow is effected by an induced draft fan **71** interposed between the exhaust opening **70** and the smoke stack **12**. The induced draft fan **71** produces a negative pressure in the second combustion chamber and which may also be effective in inducing gas flow from the first combustion chamber **10**.

As previously indicated, secondary combustion air may be required to attain the desired complete combustion. For this purpose, a first overfire air fan **72** is provided having a discharge conduit **73** which is coupled with a pair of header ducts **74** extending longitudinally along the top of the second combustion chamber **11**. Several feeder ducts connecting with the header ducts **74** and longitudinally spaced therealong connect with the combustion chamber to direct secondary combustion air into the intermixed gaseous-fluids from the first combustion chamber and the liquid waste. The number of and location of feeder ducts **75** as well as the quantity of secondary combustion air required is dependent on specific characteristics of the waste, solid, semi-solid and liquid, as well as the combustion process in the first combustion chamber and the necessity of secondary combustion air, or the amount thereof, must be determined for each incineration apparatus.

To further increase the versatility and adaptability of the incineration apparatus to a wide range of waste compositions, a second source of overfire combustion air may be provided as in the illustrative embodiment. This second source includes a forced draft fan **72*a*** with discharge conduit **73*a*** and similar interconnecting ductwork. This ductwork includes a pair of header

ducts 74*a* extending longitudinally of the second combustion chamber and a plurality of feeder ducts (not seen in the drawings) interconnecting the header ducts with the combustion chamber. As can be best seen in FIG. 1, the two overfire air systems generally supply respective halves of the second combustion chamber with the first normally always operated and the second operated as dictated by the specific waste composition.

It may also be advantageous to preheat the secondary combustion air prior to its entry into the second combustion chamber. Preheating is readily accomplished through inclusion of a heat exchanger **76** of an appropriate type in the discharge conduit **73** of the first overfire air fan **72**. The heat exchanger **76** may either be steam or hot water operated as determined by degree of heat deemed adviseable and is provided with inlet and outlet conduits **77** for the heating medium. Optionally, a similar heat exchanger may be included in the second overfire air system but is not shown in this illustrative embodiment.

In some instances, the combustion apparatus and combustion process of this invention may result in an ultimate gas discharge containing quantities of solid particles or gasses deemed objectionable and their discharge directly into the atmosphere may be a violation of antipollutant regulations. Accordingly, appropriate auxiliary gas treatment apparatus may be interposed between the smokestack **12** and the exhaust opening **70** in the second combustion chamber **11**. One such auxiliary treatment apparatus may be a gas tempering chamber **78** wherein the extremely high gas temperature of the order of 2000° F is substantially reduced to the range of 600°–700° F and the solid particles entrained in the gas and carried out of the combustion chamber such as fly ash are separated for disposal. A typical gas tempering chamber **78** having an inlet or upstream end receiving the gasses and particles discharged from the exhaust opening **70** and an outlet or downstream end, may comprise a baffle **79** disposed in the chamber to cause the gas to flow in a downward direction during traversal of the chamber and a water spray system **80**. The water spray system **80** includes a plurality of spray heads **81** connected to a source of pressurized water (not shown) and adapted to direct water uniformly through a first section of the chamber. This water spray not only cools the gas but carries the solid particles (such as fly ash) downwardly toward the bottom of the chamber which may have inclined walls thereby forming a collection zone for the water which now carries fly ash. A waste outlet **82** is incorporated at the lowermost point for either periodic or continuous withdrawal of the water and solids.

The induced draft fan **71** is connected with the gas tempering chamber at the downstream end and forces the now solid-free gas either directly into the smokestack **12** or into another gas treatment apparatus as in FIGS. **1** and **2** illustrative of a preferred embodiment. This gas treatment apparatus is a gas scrubber **83** designed to remove or chemically neutralize those gasses that may be harmful or otherwise undesirable if exhausted into the atmosphere. Since gas scrubbing apparatus is well known to those skilled in this art, further description or illustration is omitted as the necessary details are readily obtainable from previous publications.

The second combustion chamber **11** is primarily designed for incineration of liquid waste which has a characteristically low ash content. It is for this reason that this chamber is not provided with ash or debris removal means as is the first combustion chamber **10**. However, solid waste or semi-solid waste also having a relatively low ash characteristic may, in some instances, also be directly introduced into the second combustion chamber. Introduction of solid and semi-solid waste is illustrated as being accomplished at two longitudinally separated points along the axis of the chamber with FIG. **5** being an exemplary illustration of the waste feeding apparatus **85** and **86**. Each comprises a substantially closed hopper structure inclined downwardly in the direction of the chamber with the structure projecting into an opening **88** formed in the chamber wall thereby aiding gravitational flow of the waste into the chamber and provided with a charging opening **87** at the opposite or upper end. Waste may be transported to the hopper structure **85** or **86** from a respective collection hopper (not shown) by an associated conveyor **90** discharging into the charging opening **87**. An air lock including selectively movable gates **91** and **92** is also preferably installed in the hopper structure of each waste feeding apparatus **85** and **86** to effectively seal the combustion chamber against entrance of atmospheric air during a charging operation. The air lock gates **91** and **92** are provided with respective actuating mechanisms **93** and **94** that are operated in conjunction with each other and are shown more completely in FIG. **6**.

Location of the waste feeding apparatus **85** and **86** is dependent on the heat characteristics of the specific waste. Waste having a relatively high heat value would be advantageously supplied by the apparatus **85** disposed at the beginning of the combustion zone while waste having a relatively low heat value is better supplied by the apparatus **86** further downstream in the combustion zone.

The relatively high temperatures developed in the combustion zone, temperatures of the order of 2600° F, result from the advantageous coupling of the two combustion chambers **10** and **11** in series relationship and this high temperature gas is useful in facilitating disposal of glass waste with a possible recovery for recycling. Glass waste which may also include combustible waste residue may be introduced into the second combustion chamber **11** in the high-temperature combustion zone where the glass will melt and can be collected. An auxiliary glass waste feeding apparatus is indicated generally at **95** in FIG. **1** with the feeding and glass collection structure shown in greater detail in FIG. **6** and comprising the same structure as feeding apparatus **85** and **86**. As in the auxiliary waste feeding apparatus **85** and **86**, this apparatus **95** includes a substantially closed hopper structure inclined downwardly in the direction of the combustion chamber **11** with the structure projecting into an opening **88** formed in the vertical wall of the chamber and provided with a charging opening **87** at the opposite or upper end. An air lock including selectively movable gates **91** and **92** is also preferably installed in the hopper structure to seal the combustion chamber during a charging operation with the gates operated by respective actuating mechanisms **93** and **94**. Glass waste may be transported

from an associated collection hopper **89** by a conveyor **90** discharging into the charging opening **87**.

A collector **102** for molten glass is formed of a refractory in the lower part of the combustion chamber with a discharge orifice **103** formed in the chamber wall and provided with a removable plug **104** for periodic removal of the molten glass. Other systems for recycling of glass may also be devised.

The liquid waste inlet **65** is designed and located for introducing into the second combustion chamber **11**, liquid waste having a preferred combustible component of at least 30–40 percent. Where the liquid waste as initially received may have a substantially lower combustible component, it may be necessary or at least desirable from an operational standpoint to increase the relative combustible component of the liquid waste entering the inlet **65** by separating the liquid waste into at least two parts to bring the combustible percentage of the one part up to this preferred range. The other part then having an extremely low combustible component may be separately introduced as liquid waste near the exhaust opening **70** where combustion will occur and be utilized in cooling the extremely hot gasses resulting from the combustion process with any included combustible components also being burned. In general, the liquid wastes introduced at this point contained such a low combustible component as to be unable to sustain combustion and are preferably introduced at this point in the combustion process.

The inlet **105** for this portion of separated liquid wastes comprises a rotary burner **106** similar to that previously described and illustrated and mounted in the side wall of the second combustion chamber as can be best seen in FIG. **1**. A liquid waste pump **107** is connected to the burner by a conduit **108** with the pump having an inlet communicating with a supply of the separated liquid waste with this supply not being shown. A source of aspirating air is also provided for this rotary burner **106** and includes a forced draft fan **109** having a discharge outlet coupled with the burner by a conduit **110**.

Economy of operation is enhanced by incorporation of a waste heat boiler into the system with the heat energy utilized to operate auxiliary apparatus associated with incineration apparatus. Auxiliary apparatus of this type may include the heat exchanger **76** included in the first overfire air source but is not limited to this apparatus. A boiler **115** for this purpose is shown in FIGS. **1** and **7** of the illustrative embodiment and is positioned in immediately following relationship to the exhaust opening **70** of the second combustion chamber **11**. A housing **116** is provided for the boiler with gaseous fluids discharged from the second combustion chamber **11** passing through the housing and into the gas tempering chamber **78**. The specific boiler construction is determined by the auxiliary power requirements and as in the illustrated embodiment, may be of the type having upper and lower headers interconnected by a multiplicity of tubes. Inlet and outlet conduits **117** and **118** are provided for supply of feed water and for discharge of either hot water or steam. For example, conduits **117** and **118** may be coupled with the inlet and outlet connections **77** and **77***a* of the heat exchanger **76** to form a closed system. It will be noted that the boiler may be either a hot water or steam type as determined most desirable in a specific installation. The boiler **115**, in addition to providing waste heat recovery, also reduces the temperature of the gaseous fluids thereby reducing the operational requirements of the gas tempering chamber **78**.

As previously described in conjunction with the structural explanation of the incineration apparatus of this invention, the basic method involved in attaining the advantageous incineration of solid and liquid waste is utilization of two separate combustion chambers that are serially interconnected in a manner whereby combustion of solid waste in a first combustion chamber materially enhances combustion of liquid waste in a second combustion chamber. Products of combustion from the solid waste comprises gaseous fluids that may include elements or chemical compounds that are useful in support of combustion of liquid waste as well as some compounds that are capable of further combustion.

In accordance with the preferred method of this invention, overfire air is supplied for combustion in the first combustion chamber **10** so that there is 200–300 percent excess combustion air. This results in substantially complete combustion in the first chamber with no carbon monoxide or other hydrocarbons in the gaseous fluids transferred to the second combustion chamber. Where the underfire air is insufficient for complete combustion of the solid waste in the first combustion chamber and results in products of combustion that are combustible, the presence of overfire air in the indicated proportion will result in further combustion of these components with the excess air being heated and therefore aiding in the combustion process in the second combustion chamber **11**. In addition to enabling complete combustion in the first combustion chamber and providing combustion air for the second combustion chamber, the overfire air supplied to the first combustion chamber is effective in reducing the temperature of the gaseous fluids exiting the first chamber and results in a consequently lower temperature in the second combustion chamber. Lower temperatures prolong the life of the apparatus and are desirable whenever permitted by the specific combustion process. For example, temperatures of the order of 3000° F. are possible in the second combustion chamber when omitting cooling of the gaseous fluids discharging from the first combustion chamber. Additional cooling of gaseous fluids discharged from the first combustion chamber may be effected by subjecting these fluids to a water spray as they exit the first chamber.

The combustion air that has been preheated in the first combustion chamber is discharged into the second combustion chamber along with other gaseous fluid products of combustion and transferred to the second combustion chamber. Liquid waste is introduced concurrently into the second combustion chamber and intermixed with the combustion air and gaseous-fluid products of combustion resulting in better vaporization of the liquid waste and substantial increase in the temperature thereof thereby enhancing the combustion process. Intermixing of liquid waste that is normally at a low ambient temperature of the order of 50° F with

gaseous fluids at a relatively high temperature, easily within the range of 2000°–3000° F, greatly aids vaporization of the liquid waste for better combustion as well as increasing the temperature of the liquid waste to enhance ignition.

In accordance with the alternate method of this invention, combustion of the solid waste in the first combustion chamber is controlled to provide gaseous-fluid products of combustion that also aid combustion of liquid waste in the second combustion chamber. This control is accomplished through limiting the amount of underfire combustion air supplied to the solid waste to that necessary for combustion of the solid waste in burning of the carbon and driving off combustible gasses where this is necessary to attain optimum combustion of the liquid waste. In addition to producing gaseous fluid products of combustion that may include combustible components, these products of combustion are heated to a relatively high temperature.

The gaseous-fluid products of combustion at an elevated temperature are transferred to the second combustion chamber and liquid waste is introduced and intermixed with the gaseous fluids. This enables combustion of liquid waste that may only have a combustible component of 30–40 percent and would not otherwise be capable of disposal by incineration without the addition of support fuel which is not economically feasible.

Combustion in the second chamber may also be controlled through the addition of combustion air for either sustaining combustion of the liquid waste or limiting the temperature rise. Also, solid waste having a low ash characteristic may be introduced into the second combustion chamber for incineration concurrently with the liquid waste.

It is readily apparent from the foregoing detailed specification that novel waste incineration apparatus and method are provided and which are capable of more efficient incineration of a wide range of waste. This method and apparatus enables incineration of both solid and liquid waste in a single apparatus.

Having thus described this invention, what is claimed is:

1. A waste incineration apparatus comprising

A. a first combustion chamber having a charging aperture for receiving therethrough solid waste containing combustible material and including primary air inlet means providing an inflow of combustion air to said chamber for combustion of the solid wastes thereby producing gaseous-fluid products of combustion at elevated temperatures and a discharge outlet for removal of the products of combustion from said chamber; and

B. a second relatively elongated combustion chamber having a liquid inlet disposed in one end thereof for introducing liquid waste comprising combustible components interiorly of said second chamber, and directing the liquid waste longitudinally thereof, a gaseous-fluid inlet connected in fluid communicating relationship with the discharge outlet of said first combustion chamber and positioned relative to said liquid inlet for intermixing of the gaseous-fluid products of combustion with the liquid waste for combustion thereof, (and) an exhaust opening formed in said second combustion chamber relatively remote to said liquid inlet and toward which the liquid waste is directed to permit removal of combustion products, and at least one solid waste inlet disposed intermediate said liquid inlet and said exhaust opening.

2. Waste incineration apparatus according to claim 1 wherein said first combustion chamber includes secondary combustion air inlet means relatively disposed therein to admit combustion air for intermixing with the gaseous fluid products of combustion for heating thereof and further combustion of the combustible components in the gaseous fluid products of combustion.

3. Waste incineration apparatus according to claim 1 wherein said primary air inlet means is selectively controllable to limit inflow of combustion air to that producing gaseous-fluid products of combustion having combustible components.

4. Waste incineration apparatus according to claim 1 including means controlling the temperature of the gaseous fluid products of combustion through a water spray device disposed in said first combustion chamber adjacent the discharge outlet thereof.

5. Waste incineration apparatus according to claim 1 wherein said first combustion chamber includes a grate for support of the solid waste during the combustion thereof and said primary air inlet means supplying combustion air to solid waste from beneath said grate.

6. Waste incineration apparatus according to claim 5 wherein said primary air inlet means supplying combustion air includes a closed chamber beneath said grate, a forced draft fan coupled with said closed chamber for forcing air into said closed chamber and valve means selectively operable to control air flow into said closed chamber.

7. Waste incineration apparatus according to claim 5 wherein said first combustion chamber includes an ash removal gate disposed at a discharge end of said grate and wherein said grate is operable to advance solid waste therealong toward said ash gate.

8. Waste incineration apparatus according to claim 5 wherein said first combustion chamber includes charging means for solid waste disposed at a charging end of said grate opposite said ash gate and charging means for semi-solid waste disposed in said combustion chamber to introduce semi-solid waste onto an upper surface of said grate and solid waste carried by said grate.

9. Waste incineration apparatus according to claim 1 wherein said liquid inlet is a rotary burner introducing the liquid waste in droplet-form that vaporizes as it intermixes with the gaseous-fluid products of combustion from said first combustion chamber.

10. Waste incineration apparatus according to claim 1 wherein said second combustion chamber includes secondary combustion air inlet means disposed to admit combustion air for intermixing with the liquid waste and gaseous-fluid products of combustion.

11. Waste incineration apparatus according to claim 10 wherein said secondary combustion air inlet means includes a forced draft fan for forcibly introducing secondary combustion air interiorly of said second combustion chamber.

12. Waste incineration apparatus according to claim 11 wherein said secondary combustion air inlet means includes a plurality of inlet orifices disposed in relatively spaced relationship longitudinally of said second combustion chamber.

13. Waste incineration apparatus according to claim 10 wherein said secondary combustion air inlet means includes a preheater for elevating the temperature of such secondary air prior to introduction into said second combustion chamber.

14. Waste incineration apparatus according to claim 1 wherein said exhaust opening is disposed at right angles to the longitudinal axis of said second combustion chamber thereby preventing direct radiation of flame heat through said exhaust opening.

15. Waste incineration apparatus according to claim 1 including a fan coupled with said second combustion chamber in communicating relationship with said exhaust opening for inducing fluid flow through said first and second combustion.

16. Waste incineration apparatus according to claim 1 including means removing solids from a gaseous fluid stream coupled with said second combustion chamber at said exhaust opening.

17. Waste incineration apparatus according to claim 1 including waste heat recovery means coupled with said second combustion chamber at said exhaust opening and interposed heat exchanging relationship in the gaseous fluid stream exiting through said exhaust opening.

18. A method of incinerating segregated solid and liquid wastes comprising the steps of

A. incineration in a first combustion chamber of solid wastes producing gaseous-fluid products of combustion at an elevated temperature,

B. transfer of the gaseous-fluid products of combustion from the first combustion chamber to a second combustion chamber,

C. introduction of liquid waste in droplet form into the second combustion chamber and intermixture with the gaseous-fluid products of combustion, (and)

D. combustion of the intermixed liquid waste and gaseous-fluid products of combustion in a combustion atmosphere permitting substantially complete combustion(.),and

E. introducing solid waste into the second combustion chamber at a point within a zone of combustion for the liquid waste and gaseous-fluid products of combustion.

19. The method of claim 18 which includes the step of introducing secondary combustion air into the first combustion chamber for intermixture with the gaseous-fluid products of combustion for complete combustion thereof and for providing combustion air at a temperature for the second combustion chamber.

20. The method of claim 18 which includes the step of cooling the gaseous-fluid products of combustion prior to transfer thereof from the first combustion chamber.

21. The method of claim 18 which includes the step of introducing additional combustion air into the second combustion chamber.

22. The method of claim 18 including the step of controlling the combustion air supplied to the first combustion chamber to prevent complete combustion of the gaseous-fluid products of combustion.

23. A waste incineration apparatus comprising

A. a first combustion chamber having a charging aperture for receiving therethrough solid waste containing combustible material and including primary air inlet means providing an inflow of combustion air to said chamber for combustion of the solid wastes thereby producing gaseous-fluid products of combustionat elevated temperatures and a discharge outlet for removal of the products of combustion from said chamber; and

B. a second relatively elongated combustion chamber having a liquid inlet disposed in one end thereof for introducing liquid waste comprising components interiorly of said second chamber and directing the liquid waste longitudinally thereof, a gaseous-fluid inlet connected in fluid communicating relationship with the discharge outlet of said first combustion chamber and positioned relative to said liquid inlet for intermixing of the gaseous-fluid products of combustion with the liquid waste for combustion thereof, an exhaust opening formed in said second combustion chamber relatively remote to said liquid inlet and toward which the liquid waste is directed to permit removal of combustion products, and a second liquid inlet disposed downstream from said first mentioned liquid inlet.

* * * * *