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(54) **MOBILE SOLID WASTE GASIFICATION UNIT**

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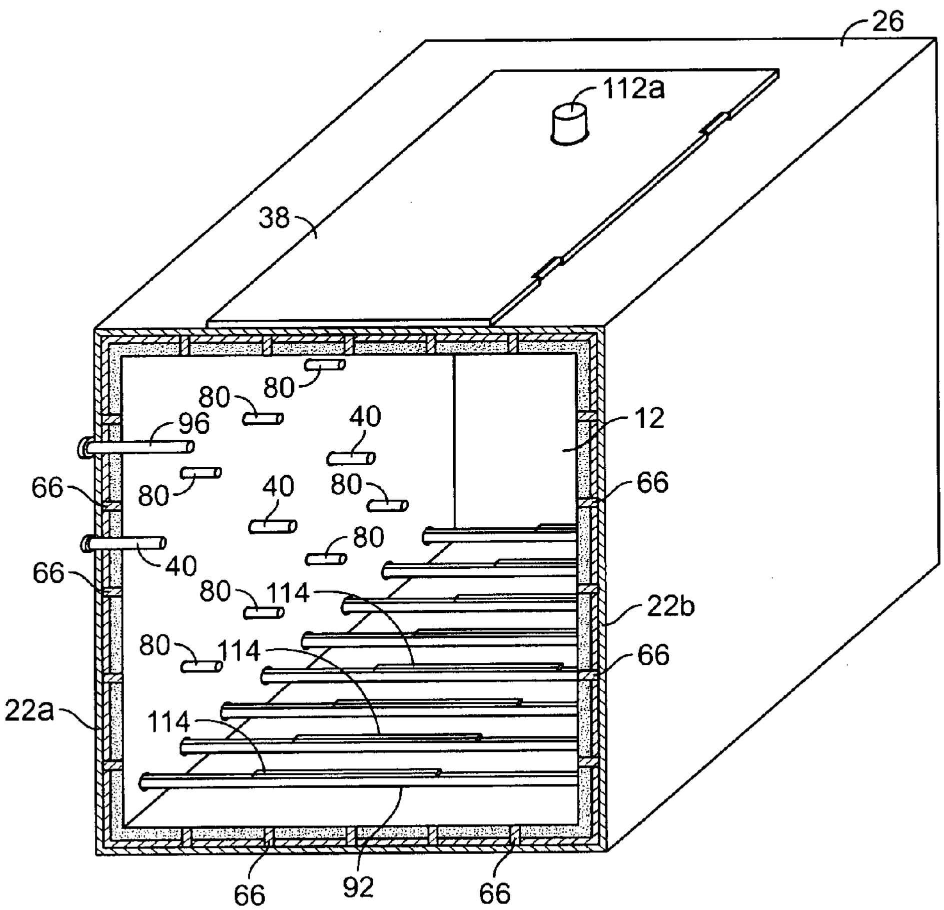
(57) **ABSTRACT**

A mobile waste gasification system comprised of a container, at least one gasification chamber, and a produced fuel gas combustion chamber, and may include a control room. Waste material is loaded into a suspended mesh liner that is offset away from the walls of the gasification chamber, thereby increasing the surface area of waste materials that are exposed to gasification conditions, and thus decreasing gasification temperature, time, and cooling period between subsequent gasification procedures. Process gas and supplemental flaring gases are preferably comprised of an oxygen or hydrogen rich gas. Produced fuel gases are withdrawn from the gasification chamber and into the produced fuel gas combustion chamber. The produced fuel gas combustion chamber may be comprised of a maze ignition chamber for the flaring of said fuel gases. Alternatively, the fuel chamber may be comprised of a gas accumulation tank that stores the produced fuel gas.



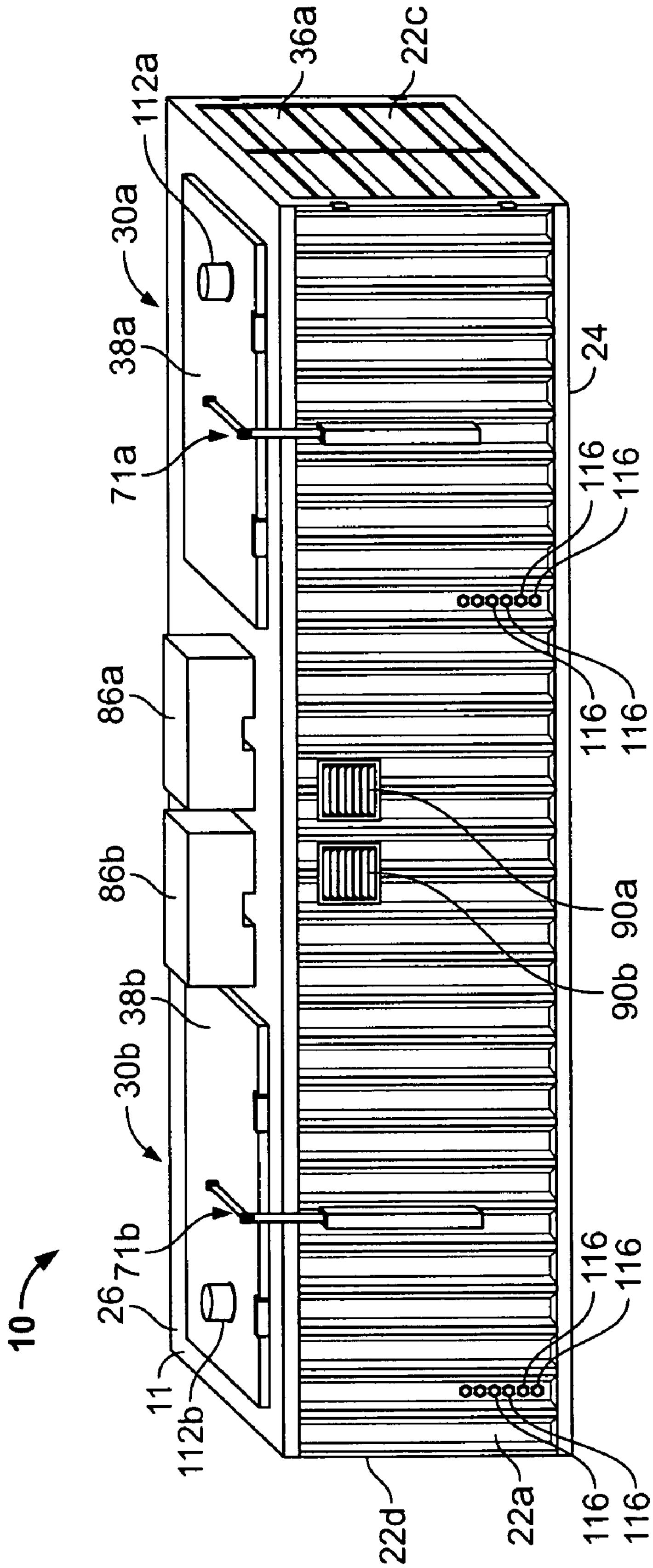

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FIG. 1

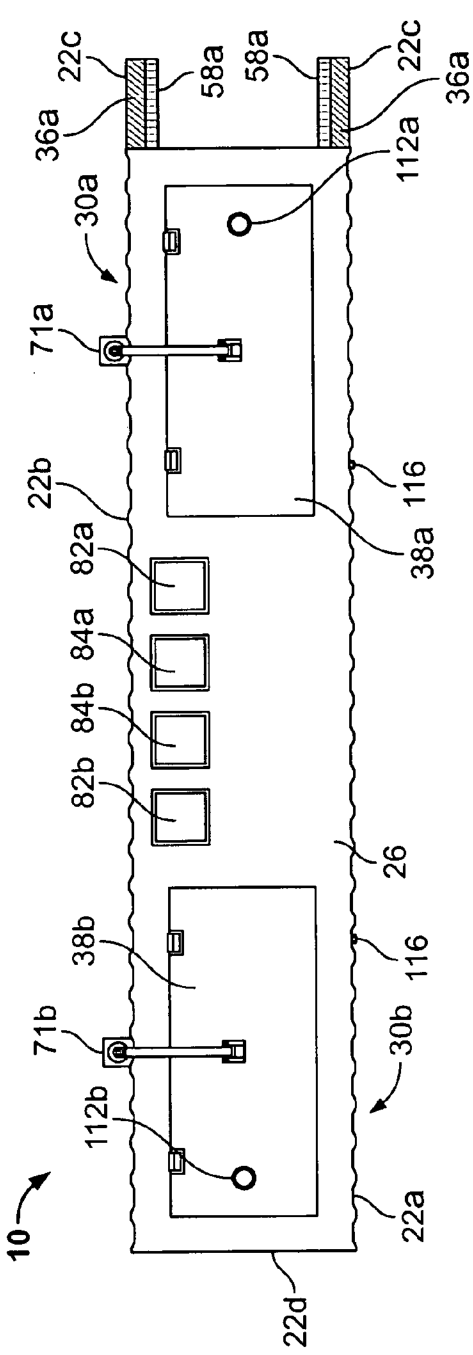
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FIG. 2

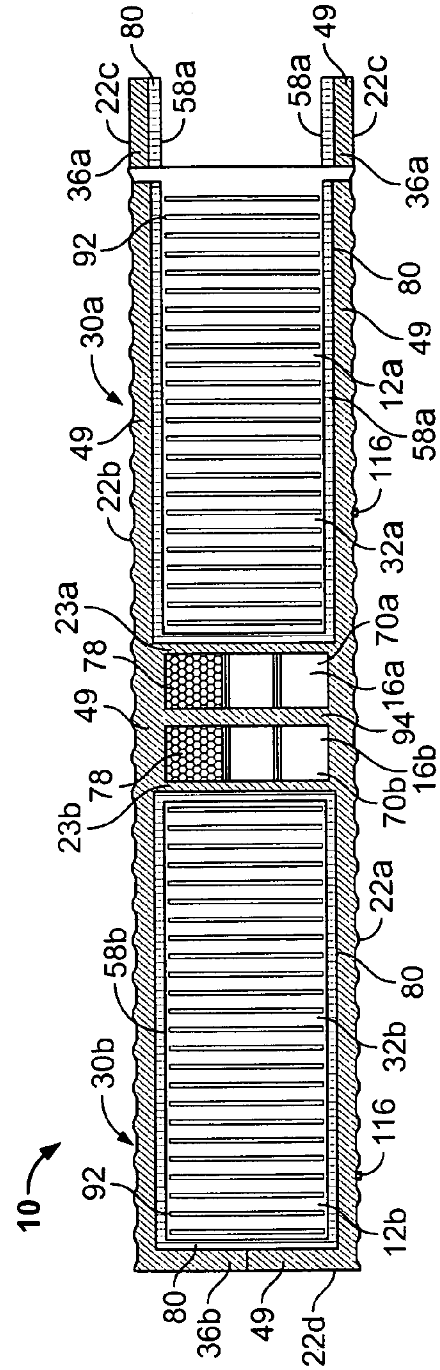
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FIG. 3

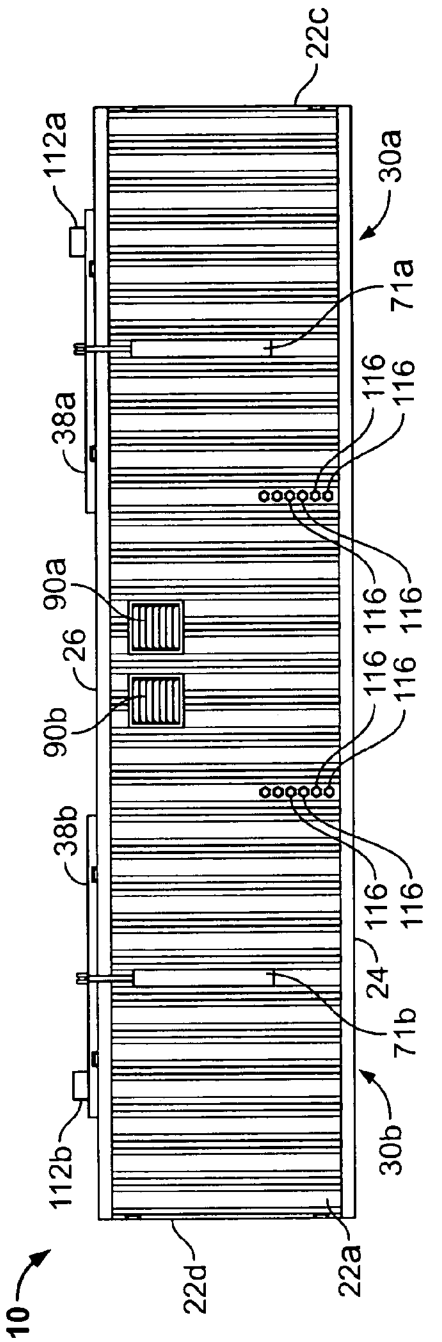
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FIG. 4

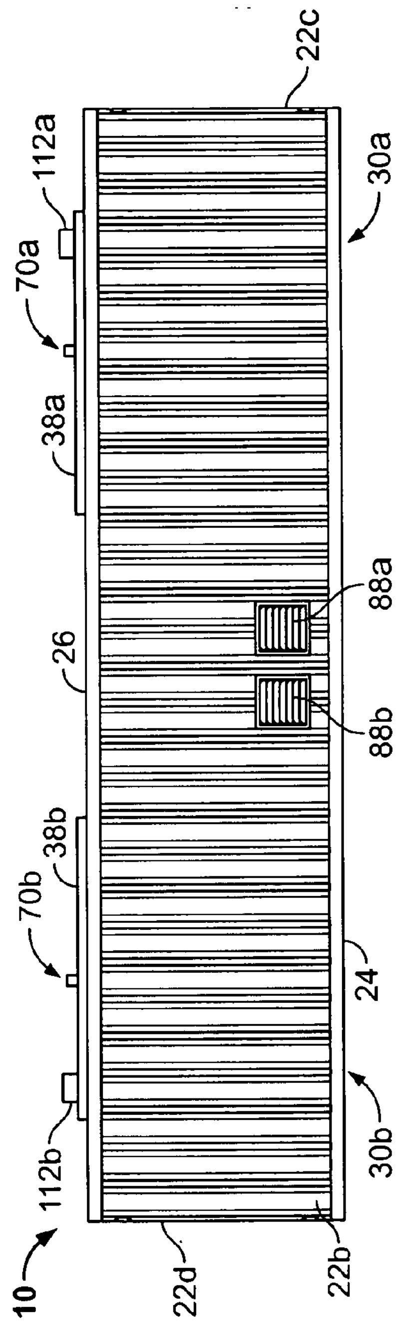
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FIG. 5

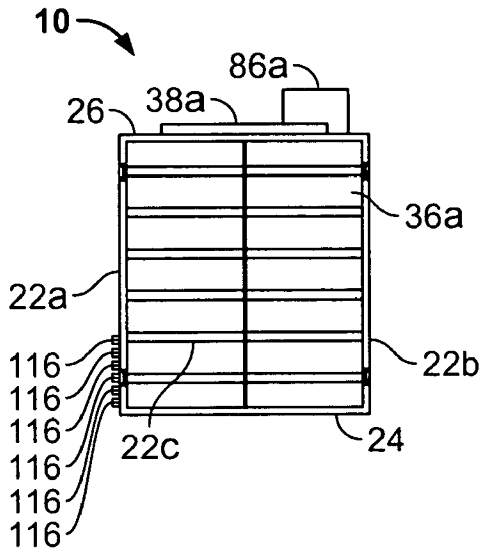

FIG. 6

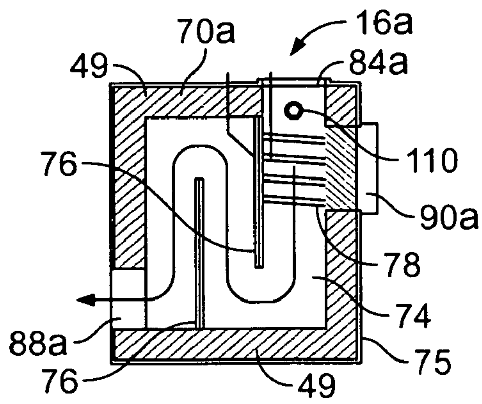

FIG. 10

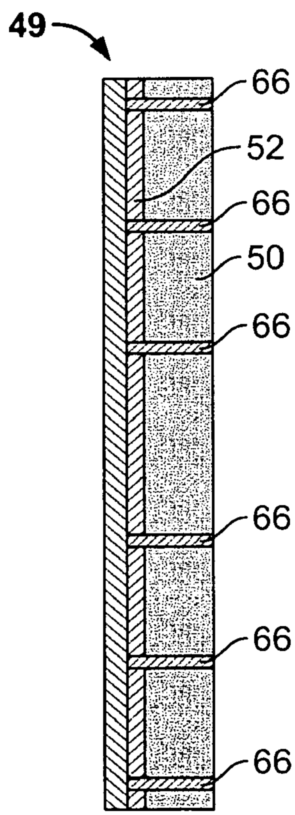

FIG. 11

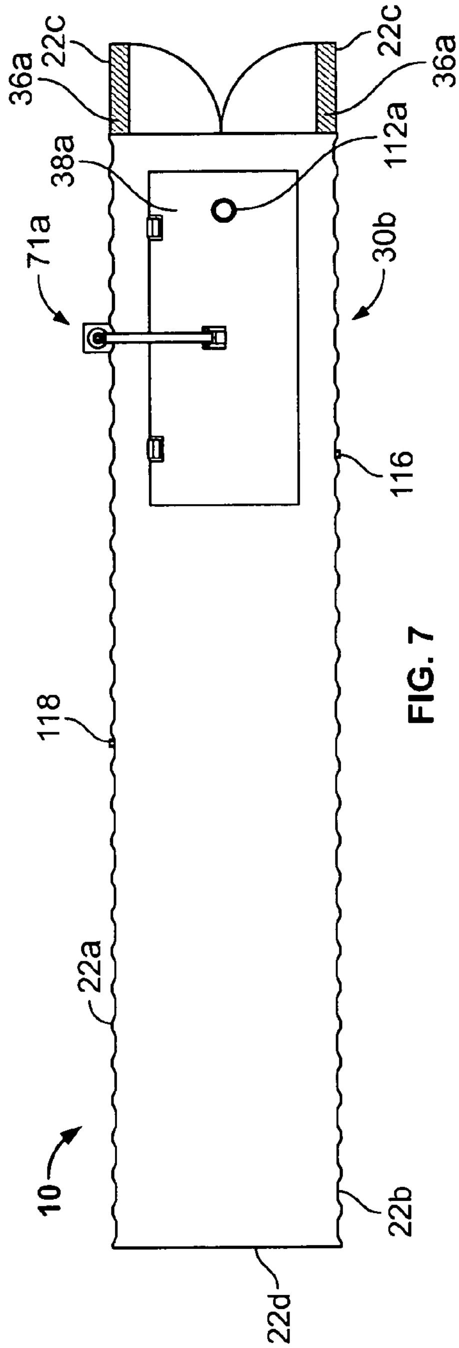
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FIG. 7

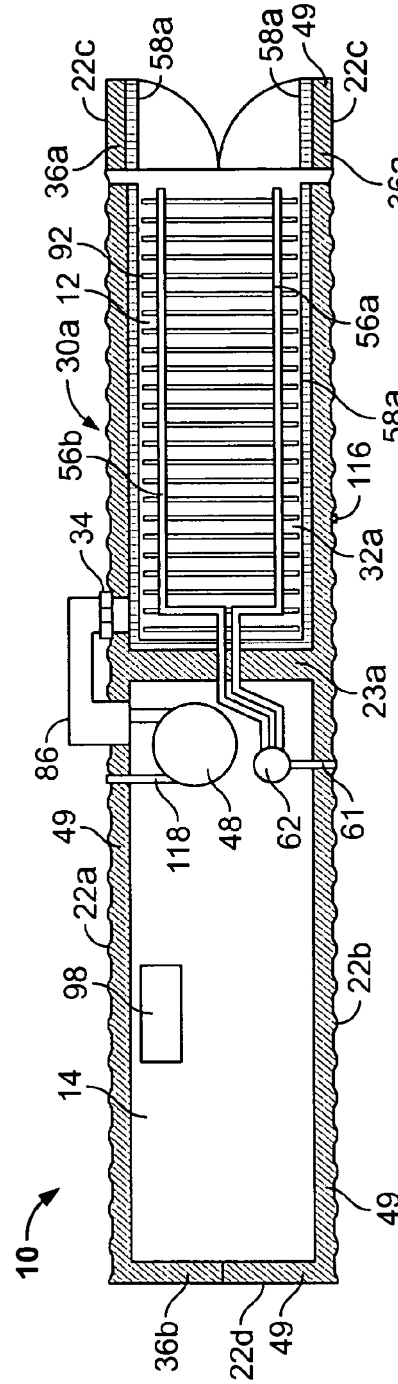
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FIG. 8

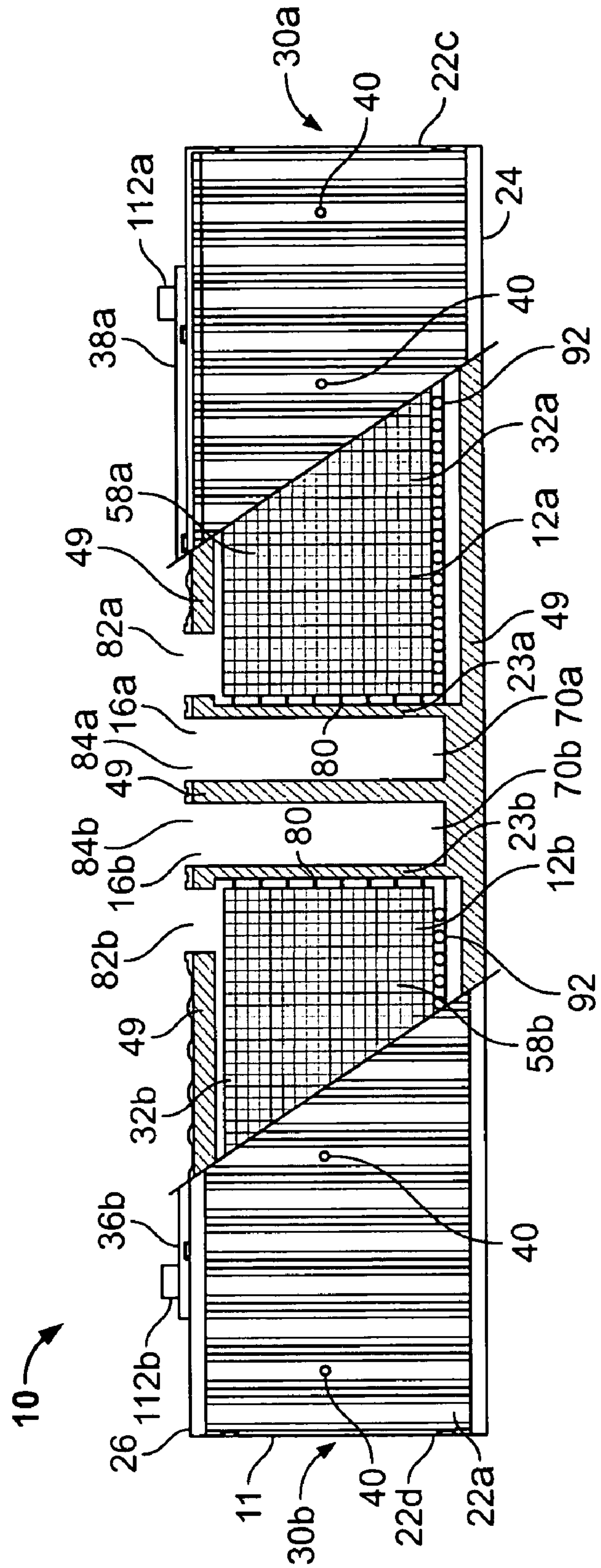
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FIG. 9

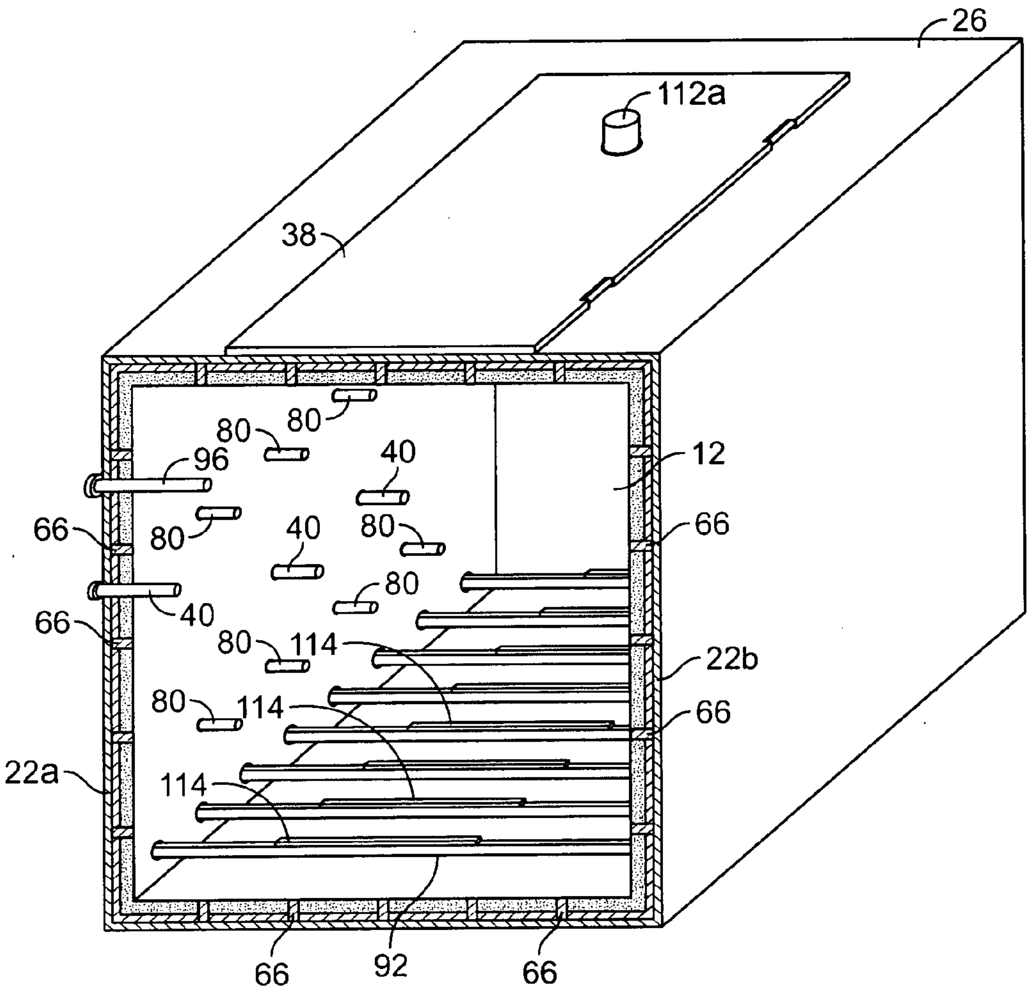
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FIG. 12

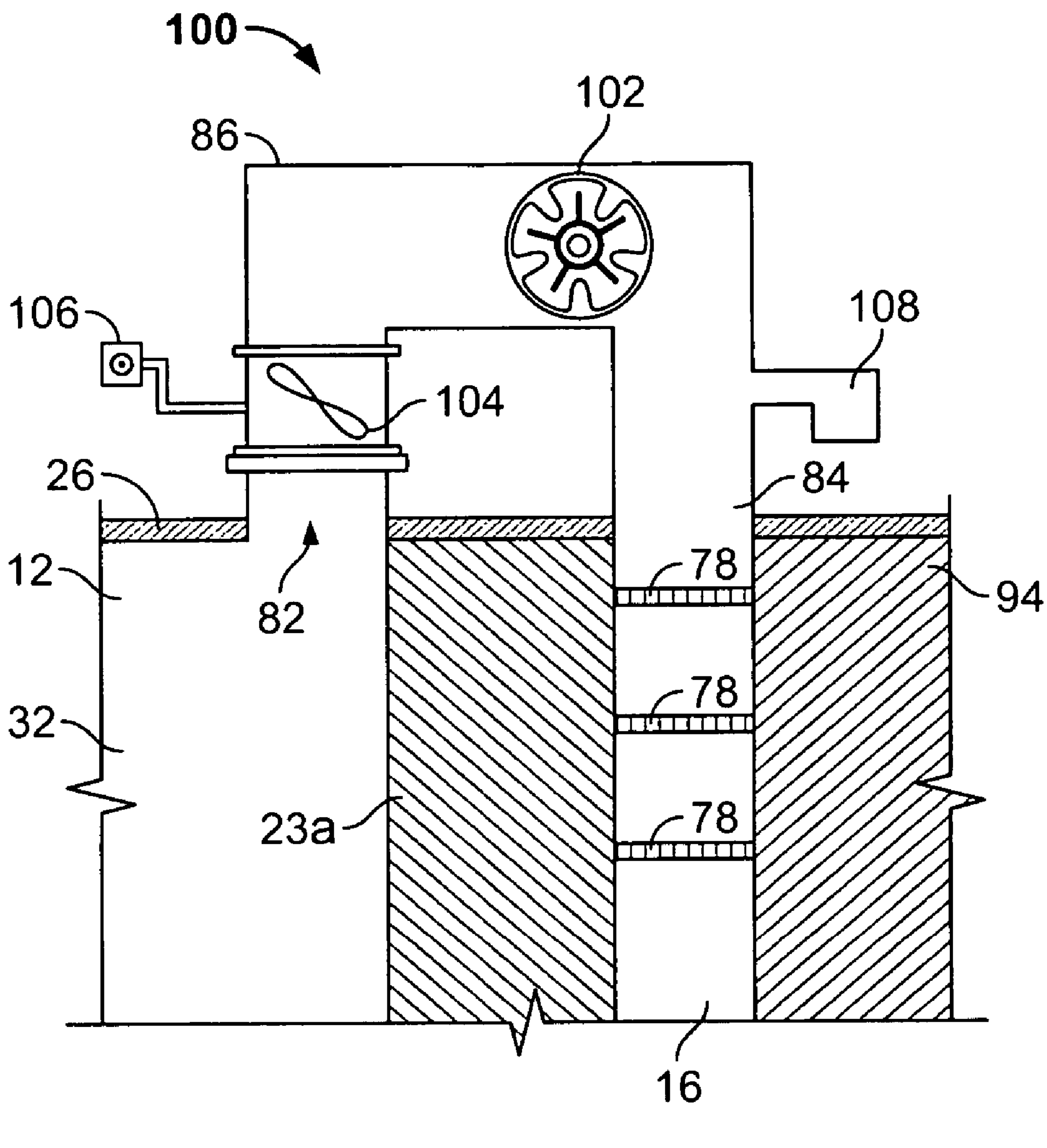

FIG. 13

MOBILE SOLID WASTE GASIFICATION UNIT

RELATED APPLICATIONS

[0001] This application is a continuation of U.S. application Ser. No. 10/882,133, filed on Jun. 29, 2004, which claims the benefit of U.S. Provisional Application No. 60/518,245, filed Nov. 7, 2003, and U.S. Provisional Application No. 60/561,936, filed Apr. 14, 2004, both of are all incorporated herein by reference in their entirety. This application also claims the benefit of U.S. application Ser. No. 10/632,043, filed on Jul. 31, 2003, which in turn is a continuation of U.S. application Ser. No. 10/439,398, filed on May 16, 2003, which in turn claims the benefit of U.S. Provisional Application 60/381,958, filed on May 17, 2002, all of which are incorporated herein by reference in their entirety.

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] [Not Applicable]

MICROFICHE/COPYRIGHT REFERENCE

[0003] [Not Applicable]

BACKGROUND OF THE INVENTION

[0004] Many attempts have been made at creating waste disposal systems that eliminate or reduce the need to landfill municipal solid waste. Traditional approaches have included incineration and pyrolisis. Conventional incineration however is objectionable because the high burn temperatures result in the formation of complex pollutants that are difficult and expensive to control. Furthermore, the vast majority of incinerated organic material is converted into undesirable carbon dioxide and nitrous oxides, which are implicated in global warming, ozone layer depletion, and the formation of volatile organic compounds which contribute to smog problems in urban areas. The pyrolisis procedure involves the conversion of various materials into a Carbon-rich residue in an oxygen depleted, high temperature environment. However, the high temperature, depleted oxygen environment of pyrolisis creates some extremely toxic compounds. Furthermore, pyrolisis is an inefficient method for disposing large volumes of waste materials due to the requirement that pyrolisis feed stocks must be pre-sorted and processed.

[0005] Many of the disadvantages of incineration and pyrolisis are overcome by waste gasification. Waste gasification involves supplying the minimum amount of oxygen necessary to cause a thermo-chemical reaction that releases combustible gases at a controlled temperature, without supplying enough oxygen to cause combustion. When feed stock waste materials that are rich in energy, as measured by British thermal units, are loaded into gasification reactor chambers, and are exposed to a controlled temperature, oxygen depleted environment, such solid, sludge, or liquid feed stock materials are converted into a produced fuel gas. Materials that are rich in energy include, but are not limited to, coal, wood, cardboard, paper, industrial scrap, plastics, tires, organic wastes, sewage cake, animal waste, and crop residue, or combinations thereof. The released produced fuel gas is then mixed with oxygen and combusted as an alternative to the use of natural gas, diesel fuel, or propane. Examples of prior gasification systems are shown in U.S. Pat. Nos. 4,941,415 and 5,941,184, the disclosures of which are incorporated by reference herein.

[0006] The material remaining after the completion of the gasification process cycle is composed of incombustible materials, including metals, glass, and ceramics, along with a fine inert salt and mineral power residue of low carbon content, and has a greatly reduced volume that is suitable for remanufacturing into concrete material or land filling. Furthermore, recyclable materials that do not undergo phase transition, such as all glass, aluminum, metals, and other non-combustible residuals, are recoverable after the gasification process, thereby eliminating the need for pre-sorting or processing the in-bound feed stock material.

[0007] Conventional prior art gasification systems are multi-step processes that generally utilize four open-looped process steps. These four steps typically involve: one or more primary gasifiers; a central air mixing chamber; a secondary processor for combusting the produced fuel gas; and final air cleaning systems. However, conventional gasification systems have proved to be somewhat difficult to cost-effectively construct. Therefore, a need exists for a simplified gasification apparatus that is inexpensive to build, simple to operate, and yet achieves the benefits of producing a gas fuel from solid waste feed stock materials.

[0008] Furthermore, prior art gasification systems have been designed for permanent installment at a particular location. These systems have high capital costs. The permanency of such systems prohibits the ability to move the waste disposal systems to a areas of need as job demands change or vary over time. Therefore, there exists a need to provide a simplified gasification system that is both mobile and cost efficient in the disposal of waste materials while at the same time being able to meet the air emission standards set by federal and state environmental protection agencies. A low cost, small scale system that efficiently disposes of waste meets the needs of smaller waste generators and allows for waste disposal at the same location where it is generated, avoiding expensive cartage, sorting, and "tip" sees.

[0009] Current research indicates that increasing the surface area of the feed stock material that is exposed to gasification process gas significantly improves the production rate of produced fuel gas from waste materials which translates into faster batch cycle times, further reducing operating costs. Yet, some prior art gasification systems, such as those illustrated in U.S. Pat. Nos. 6,439,135 and 5,619,938, utilize gasification reactor chamber configurations that expose only limited waste material surface area to gasification process gas. Such prior art systems typically incorporate gasification reactor chamber configurations where only the bottom of the feed stock at grate level, known as the primary reaction zone, and the uppermost surface of the feed stock, known as the secondary reaction zone, are exposed to optimum gasification conditions.

[0010] As a result, gasification of waste material that is not located at either the primary or secondary zones, such as that on the sides and center of the gasification chamber, requires that the temperature and/or duration of the gasification cycle be increased. Yet, higher gasification temperatures tend to reduce the Btu content of the resulting produced fuel gas. High operating temperatures also increase the time required for cooling the gasification reactor chamber to a temperature suitable for the loading and disposal of subsequent loads of waste materials. Longer cycle durations also greatly reduce the overall capacity of the system.

[0011] Furthermore, the costs associated with obtaining and maintaining higher gasification temperatures, along with the cost of fabricating a complex gasification reactor chamber that can withstand prolonged exposure to high temperatures, also increase. Some prior art gasification reactor chambers are lined with various clay-based insulative/refractory materials. These refractory materials maintain gasification reactor temperatures while also preventing structural damage to the gasification reactor chamber's steel superstructure and surface paint associated with prolonged exposure to excessive heat. Refractory material is usually applied to the gasification reactor chamber as pre-cast panels, bricks, or sprayed on as a gunnite-like application. Such refractory material is affixed to the exterior steel jacket of the gasification reactor chamber by refractory hangers, which are heavy metal dowels in the form of hooks. With typical prior art systems, a two to four inch layer of ceramic fiber blanket is usually inserted between the refractory material and the steel jacket before the refractory layer is installed to offer additional thermal protection for the exterior steel surfaces of the gasification reactor chamber.

[0012] Application of refractory material is thus labor intensive, time consuming, and a significantly expensive step. Additionally, the weight of the refractory liner necessitates a expensive, high strength gasification chamber construction, such as a steel vessel constructed from at least ¼ inch thick hot rolled A36 steel plate and heavy structurals. This additional weight of the superstructure further increases the overall cost of manufacturing, shipping, and installation.

[0013] An additional problem with the use of refractory material is the length of time required for cooling the gasification reactor chamber before it can be re-used to gasify a subsequent load of solid waste material. More specifically, a subsequent gasification process typically cannot begin until the gasification reactor chamber has cooled to approximately 150 degrees Fahrenheit. Yet, at the end of a process cycle, the clay refractory material tends to retain heat for a long period of time. Depending on the particular chemistry of the refractory material, this retention of heat may require that the gasification reactor chamber be inoperative for several hours as the temperature of the chamber, and associated refractory material, cools down.

[0014] The limited waste load capacity of prior art gasification systems often required the construction of multiple gasification reactor chambers to meet demand requirements. In previous designs, gasification reactor chambers typically have a rectangular configuration. As the length of the rectangular sidewalls is increased to satisfy larger feed stock capacity requirements, the size of the gasification reactor chamber creates problems associated with load density in various feed stocks in the gasification reactor chamber. This problem typically limits gasification reactor chambers to configurations that are approximately 20 feet high, 20 feet wide, and 20 feet long, accommodating approximately 50 tons of municipal solid waste. Larger configurations develop problems with the side load waste dump arrangement. More specifically, as the gasification chamber width extends beyond 20 feet, the angle of repose of the trash spilling out of the garbage truck and into the gasification chamber typically only fills a small portion of the gasification reactor chamber's near sidewall, necessitating the addition of another load door in the roof of the gasification chamber.

[0015] Because the resulting produced fuel gas from the gasification of waste material has been produced in an environment that typically contains no more than 8% oxygen, waste gasification systems must also increase the level of ambient oxygen in the gas produced in the gasification reactor chamber to make it fully flammable. This often requires increasing the oxygen content of the produced fuel gas to approximately 15% to 20%.

[0016] Prior art gasification systems have typically increased the oxygen content of the produced fuel gas by directing the produced fuel gas through air mixing chambers. These mixing chambers are typically large, cylindrical vessels, with a variety of air induction tubes attached to multiple blower fans that flood the air mixing chambers with outside ambient air using air compressors or high velocity fans. Because of the large size of these chambers, they require substantial fabrication and installation time, and as a result are expensive. The use of fans and/or air compressors also increases the initial cost of the system and operating and maintenance expenses.

[0017] Conventional gasification systems also use cumbersome techniques for moving the produced fuel gas to the point of combustion. Such systems often vent, or breech, the fuel gas from the top or at least one side of the gasification reactor chamber, and direct the vented fuel gas from the gasification reactor chamber into a secondary gas processor, which is usually driven by a natural draft current that is created by hot air in the system rising through an exhaust stack. The fuel gas' exit from the gasification reactor chamber is controlled by a motor driven damper assembly that regulates the varying flow of produced fuel gas from this first process step into ducting that connects the gasification reactor chamber to the secondary air mixing chamber. Such systems typically require large diameter piping to draw the gas off from the gasification reactor chamber. This large piping, and associated ductwork, increases not only equipment cost, but also installation expenses.

[0018] A further disadvantage of traditional air draft systems is that produced fuel gases have a tendency to linger in the gasification reactor chamber, and become subject to accidental combustion, which ultimately lowers the Btu content of the extracted produced fuel gas. This problem is exacerbated by the inconsistency of up-draft air movement in a natural draft system. Humidity, wind, barometric pressure and outside temperature all affect the rate of flow through a natural draft system. This inconsistent flow causes the evacuation of gases from the gasification reactor chambers to frequently stall, produces negative results in the process, and adversely effects the total cycle time for the gasification of the feed stock material.

[0019] Additionally, the ability to withdraw and vent gases produced during the gasification process out from the gasification chamber affects the overall gasification process cycle time. More specifically, if the venting of produced gases from the gasification chamber is slower than the production rate of the gas, then the gasification chamber becomes back pressured, and the subsequent rate of gasification of the waste load becomes suppressed. For instance, it has been determined that the gasification of roughly 2 tons of solid waste material over a ten to twelve hour period can produce approximately 140 cfm of produced fuel gas. However, because some prior art designs are only capable of moving approximately 9 to 15 cfm, the complete gasification of 2 tons of waste material could require more than 48 hours.

[0020] In instances in which oxygen levels have dipped below desired levels, prior art systems have introduced additional ambient air into the gasification chamber in order to raise oxygen levels. Yet, ambient air is comprised of approximately 78% nitrogen and 21% oxygen. Therefore, the use of ambient air as a process gas to obtain desired oxygen levels in the gasification chamber, results in the unavoidable inclusion of a large volume of nitrogen. Unfortunately, this additional volume of nitrogen to the gasification process contributes substantially to the formation and ultimate system air emission of nitrous oxides, which is an air emission contaminant that is currently regulated by the Environmental Protection Agency. Replacing ambient air as a process gas with a high oxygen content gas, such as, but not limited to raw oxygen, would virtually eliminate the presence of nitrous oxides in the produced exhaust stream as long as the combustion temperature the produced fuel gas is maintained below 2,100 degrees F.

[0021] Furthermore, in order to improve the combustibility of produced fuel gases that are produced by the gasification process, prior art systems have mixed produced fuel gases with ambient air. Such mixing has usually required that four parts of ambient air be mixed with one part of the produced fuel gas to sufficiently bring the produced fuel gas from its starved oxygen state (+/−9%) to one of maximum combustibility (17-20%) Yet, as previously mentioned, thermal processes, such as flaring the mixture of produced fuel gas with ambient air, may result in the presence of regulated nitrous oxides in the gas exhaust stream. Therefore, it is desirable to create a gasification system that may combust produced fuel gases without the formation of nitrous oxides.

[0022] Gasification system components that transport or contain this additional volume of ambient air must also be oversized to handle the accompanying large volumes of nitrogen. The presence of large volumes of nitrogen in ambient air also increases the size, associated fabrication costs, and weight of gasification systems. For instance, the replacement of ambient air with raw oxygen could result in up to a 78% decrease in the amount of process gas that is required to enter into the gasification system. This signification reduction in volume may allow for a reduction in the size of the gasification chamber, which thereby would allow for a savings in material and fabrication costs and overall weight. Therefore, it would be desirable to have gasification system that may be constructed from smaller system components while still being capable of gasifying large quantities of waste materials.

[0023] It is therefore an object of the present invention to provide a gasification unit capable of gasifying waste materials at a reduced temperature and time.

[0024] It is a further object of the present invention to provide a gasification system that produces a high Btu content produced fuel gas from the gasification of a wide variety of un-processed and unsorted waste materials.

[0025] It is another object of the present invention to provide an inexpensive to build, simple to operate, mobile gasification unit that provides the benefits of producing a non-fossil fuel gas from these waste materials.

[0026] It is another object of the present invention to provide a mobile gasification unit in which a gasification control room and produced fuel gas combustion chamber may both be substantially located in a self contained unit.

[0027] It is a further object of the present invention to provide a mobile gasification unit that contains at least one gasification chamber equipped with a mesh liner for the purpose of substantially increasing the surface area of the primary thermo-chemical reaction zone, resulting in reduced system cycle times and a higher volume fuel gas production per unit of time.

[0028] It is a further object of the present invention to provide an improved gasification apparatus that is capable of venting produced fuel gases out of the primary gasification chamber at a sufficient rate so as to prevent the development of back pressure in that primary gasification chamber.

[0029] It is another object of the present invention to create a gasification system that may combust produced fuel gases with minimal formation of nitrous oxides.

[0030] It is a further object of the present invention to provide a gasification system that may be constructed from smaller system components while still being capable of gasifying similar or larger quantities of waste materials.

[0031] These and other desirable characteristics of the present invention will become apparent in view of the present specification, including the claims and drawings.

BRIEF SUMMARY OF THE INVENTION

[0032] The present invention is directed to an apparatus that converts combustible solids, sludges, and liquids into a usable non-fossil fuel gas. More particularly, the present invention relates to a self-contained mobile gasification unit that includes at least one gasification chamber and a produced fuel gas combustion chamber. Additionally, the present invention may be adapted to also include a control room, wherein the gasification chamber, produced fuel gas combustion chamber, and a control room are all substantially located within the same self contained mobile gasification unit. The mobile gasification unit is preferably a container that has a standard configuration, such as that of a standardized sea cargo shipping container, so that the container may be easily transported from one location to another via a variety of intermodal modes of transportation, including, but not limited to, truck, train, or container ship.

[0033] A portion of the container is enclosed so as to form the at least one gasification chamber within the interior of the container. The size and number of gasification chambers within the container is dictated by the total waste processing volume desired and the overall size and configuration of the container. Each of the at least one gasification chambers are preferably comprised of an exterior vessel and an inner portion.

[0034] The exterior vessel is preferably, in part, comprised of at least a portion of the walls, base, and top portion of the container. Alternatively, the exterior vessel is comprised of walls within the container that are dedicated for the at least one gasification chamber. Additionally, the exterior vessel preferably includes a side partitioning wall that is positioned within the container. The partitioning wall preferably provides a common wall for the at least one gasification chamber and a produced fuel gas combustion chamber. Alternatively, the partitioning wall divides the portion of the container that is used for the gasification chamber from that which may be used for other aspects of the mobile gasification unit, such as both a control room and a produced fuel gas combustion chamber.

[0035] The exterior vessel also preferably includes doors, access ports, and/or load hatches that are configured for the loading of waste material into, or the removal of non combustible materials and ash from, the gasification chamber, and which may provide access to the inner portion for service and maintenance purposes. Additionally, the exterior vessel includes structural components, such as metal hangers, from which insulation materials may be operably attached to the inner surfaces of the exterior vessel walls. Insulation materials are preferably configured to assist in maintaining operating temperatures within the gasification chamber during the gasification process, while also protecting the walls of the exterior vessel from prolonged exposure to excessive heat.

[0036] The insulation materials are preferably comprised of multiple layers of spun ceramic fiber and hard ceramic board. The use of ceramic fiber and board allows the gasification chamber to cool down faster than prior designs that rely on refractory brick style materials. This faster cool down period decreases the lapse in time between the gasification of subsequent loads of waste materials. Such ceramic insulation material is preferably designed to contain the heat of the process within the inner portion of the gasification chamber, and to prevent the exterior vessel wall surface temperature from rising above 150 degrees F. Furthermore, because ceramic insulation materials are considerably lighter than refractory brick style materials, the supporting hangers and exterior vessel walls may be constructed from lighter materials, thereby decreasing material and fabrication costs. In the illustrated embodiment of the present invention, the inner surfaces of the exterior vessel walls and attached insulation materials, preferably define the area of the inner portion.

[0037] Inside the inner portion of the gasification chamber is a mesh liner. The liner is preferably constructed from stainless steel mesh screen that is oriented to create a basket configuration around the sides of the loaded waste material. The liner is preferably supported approximately three inches away from the side walls and the floor by an additional set of hangers, or pins, the hangers preferably being welded to the walls of the exterior vessel and protrude through the ceramic insulation material. Supporting the liner away from the sidewalls and floor of the exterior vessel, and thus preventing the direct physical contact of said waste material with the walls of exterior vessel, allows the gasification chamber walls to be fabricated from substantially thinner material, thereby reducing the weight and associated expenses of fabricating and transporting the mobile gasification unit. The base of the loaded waste material is preferably supported by a pipe bridge floor assembly or other such means that prevent said loaded waste from being positioned directly on the floor of the gasification chamber.

[0038] Supporting the loaded waste material away from the walls and floor of the gasification chamber allows process gas to freely flow around the top, sides, and bottom of said loaded waste material. Furthermore, the plurality of openings in the mesh screen of the liner and the spacing of the supporting bridge floor assembly allows the process gas to flow into the sides and bottom of the basket, thereby increasing the surface area of waste materials that are exposed to process gas, and thus creates primary reaction zones along said sides, bottom, and top of the loaded waste material. Because gasification cycle time is a function of waste material surface area that is exposed to process gases, these elements of the design allow for a significant reduction in the process cycle time and temperatures. Reduced gasification temperatures and time also decrease the lapse in time before a subsequent load of waste material may undergo the gasification procedure.

[0039] At least one heating device is operably connected the gasification chamber. The at least one heating device is configured to provide a source for initiating the gasification procedure and may assist in maintaining gasification operation temperatures within the gasification chamber. In the illustrated embodiment of the present invention, the at least one heating device may include, but is not limited to, a fuel-fired burner or an electric thermal radiant heat assembly, and may also be configured to provide an ignition source for the combustion of produced fuel gas in the produced fuel gas combustion chamber. In one embodiment of the illustrated invention, the at least one heating device is comprised of electric heating elements that are operably connected to the chamber via two penetrations that are positioned along at least one wall of the gasification chamber.

[0040] At least one process gas inlet is operably positioned and configured to allow process gas to enter the inner portion of the gasification chamber. The process gas may be comprised of, but is not limited to, ambient air, a high oxygen content gas such as raw oxygen, or some combination thereof. The at least one process gas inlet is preferably fitted with a valve or damper so that process gas enters into the gasification chamber at a controlled rate. A controller, such as, but not limited to, a process logic controller, preferably located in a control room or on a control board, may be used to monitor the environment in the gasification chamber, including oxygen and temperature levels, and use such information in determining whether the valve for the at least one process gas inlet should be opened or closed.

[0041] While the process gas may be comprised of ambient air, in the illustrated embodiment of the present invention, any supplemental process gas that is vented into the inner portion is preferably a high oxygen content gas, such as, but not limited to raw oxygen or a raw oxygen-ambient air mixture. Because nitrogen comprises approximately 78% of ambient air, the use of a high content oxygen gas in lieu of ambient air typically translates into the need to transport, and the presence of, a smaller volume of process gas in order to obtain desired oxygen levels than would be required if ambient air were used. The reduction in the volume of process gas that must be transported to, and present in, the gasification chamber, allows for a reduction in size of the duct work that transports the process gas. This reduction in size may reduce both material and fabrication costs while also decreasing the weight of the system. Furthermore, the use of high oxygen content gases, such as, but not limited to, raw oxygen, rather than ambient air also preferably decrease the formation and release of regulated pollutants, such as nitrous oxides.

[0042] At least one temperature sensor is positioned within the inner chamber to monitor temperature before, during, and after the gasification process. Temperature information detected by the at least one temperature sensor is preferably relayed to the control room. During the gasification process, such information obtained by the at least one temperature sensor may be used by the controller to determine whether the at least one heating device should be activated or deactivated, and whether the at least one process gas inlet should be opened or closed. In the illustrated embodiment of the present invention the temperature sensors are six Type-K thermocouples that are positioned along the mid-line of the chamber, with three on each side of two parallel walls.

[0043] The present invention also includes at least one outlet orifice that is positioned along a portion of an exterior vessel wall and at least one inlet orifice positioned along at least a portion of the produced fuel gas combustion chamber. The at least one outlet orifice preferably provides a passageway for produced gases to be removed from the gasification chamber, while the at least one inlet orifice preferably provides a passageway for said gases to pass into the produced fuel gas combustion chamber. Both the at least one outlet and inlet orifice are preferably configured for operable attachment to an induced draft fan. Through the opening of the at least one inlet orifice, the fan preferably provides pressurization to the produced fuel gas combustion chamber so that produced fuel gases that are produced during the gasification process are withdrawn out from the gasification chamber, through the opened at least one outlet, and into the produced fuel gas combustion chamber. The at least one outlet orifice may be fitted with a gate valve that can be employed to regulate the exit of produced fuel gas from the gasification chamber.

[0044] In one embodiment of the present invention, the produced fuel gas combustion chamber is a maze ignition chamber that is comprised of an insulated enclosure, the enclosure having an exhaust port, an outer surface, and an inner chamber. Although the present invention is capable of operating with only one maze ignition chamber, in accordance with the illustrated embodiment of the present invention, each of the at least one gasification chambers has a dedicated maze ignition chamber. Within the inner chamber of the enclosure is preferably at least one baffle and at least one produced gas igniter, the at least one baffle being oriented to create a winding passageway in the inner chamber. In accordance with the illustrated embodiment of the present invention, the at least one inlet orifice is operably positioned so that produced fuel gases that are withdrawn and/or vent from the gasification chamber may flow into the inner chamber of the enclosure. Furthermore, in the illustrated embodiment of the present invention, at least a portion of the container top and base preferably form at least a portion of the walls of the enclosure. Additionally, the maze ignition chamber may be positioned so that at least a portion of one sidewall of the enclosure is also at least a portion of an exterior vessel sidewall.

[0045] After passing through the at least one inlet orifice and into the inner chamber of the maze ignition chamber, supplemental flare gas is preferably added to the produced fuel gas via a supply nipple so as to improve the combustibility of the produced fuel gas. Alternatively, supplemental flare gas may be added to the produced fuel gas after being withdrawn from the gasification chamber but prior to passage into the produced fuel gas combustion chamber. Although the supplemental flare gas may be comprised of ambient air, in the illustrated embodiment of the present invention, the supplemental flare gas is a high oxygen content gas, a high hydrogen content gas, or some combination thereof. The produced fuel gas and supplemental flare gas then preferably proceed onto the at least one produced gas igniter, whereupon the gases are combusted. Once combusted, the gases proceed through the winding passageway.

[0046] The at least one baffle within the inner chamber is oriented so as to create a winding passageway through which the combusting produced fuel gases may flow. In the illustrated embodiment of the present invention, the at least one baffle is preferably oriented so as to subject the flowing gases to square turns. This winding passageway creates additional turbulence that enhances the mixing of the combusted gases. Each turn in the winding passageway that is created by the at least one baffle also allows for additional retention time of the combusting gases in the hot environment of the maze. In the illustrated embodiment of the present invention, the additional retention time allows the combusted gases to continue to be exposed to an environment of approximately 1550-1750 degrees F. Combusted gases exiting the maze chamber via the exhaust port are preferably used to provide heat to a primary end use device, such as, but not limited to, a boiler, so as to provide energy for steam or hot water production in lieu of natural gas.

[0047] In an alternative embodiment of the present invention, the produced fuel gas combustion chamber is a gas accumulation tank that is preferably located adjacent to the partitioning wall. In such an embodiment, uncombusted produced fuel gases are stored in the gas accumulation tank before being delivered to a primary end use device. In an effort to retain the high temperatures of the accumulated produced fuel gas, the gas accumulation tank is preferably encapsulated in a blanket of insulation material, such as a ceramic material. The gas accumulation tank also preferably includes at least one pipe flange that pierces through the exterior of the container. The at least one flange serves as a gas delivery port from which the produced fuel gas product to one or more end use devices. In the illustrated embodiment of the present invention, the combustion of the produced fuel gases preferably occurs at some point after the produced fuel gases have passed through the gas accumulation tank and have been delivered to the primary end use device.

[0048] The present invention may also include at least one water line. Such a water line may be configured to provide an emergency quench for the process as well as dust control during the clean-out process. In one embodiment of the present invention, the at least one water line is comprised of two water lines that pierce the partitioning wall that divides the gasification chamber from the remainder of the interior of the mobile gasification unit, the two water lines connecting a water supply pump and pressure unit located in the control room to the spray nozzles located in the ceiling of the gasification chamber. In another embodiment, the water supply pump and pressure unit are located outside of the mobile gasification unit.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

[0049] For a more complete understanding of this invention, reference should now be made to the embodiment illustrated in greater detail in the accompanying drawings and described below by way of example of the invention.

[0050] **FIG. 1** illustrates a perspective view of a mobile gasification unit with fan housings in accordance with the illustrated embodiment of the present invention.

[0051] **FIG. 2** illustrates a top view of a mobile gasification unit in accordance with the illustrated embodiment of the present invention.

[0052] **FIG. 3** illustrates a top interior cross sectional view of a mobile gasification unit in accordance with the illustrated embodiment of the present invention.

[0053] **FIG. 4** illustrates a rear side view of a mobile gasification unit in accordance with the illustrated embodiment of the present invention.

[0054] **FIG. 5** illustrates a front side view of a mobile gasification unit in accordance with the illustrated embodiment of the present invention.

[0055] **FIG. 6** illustrates a side view of a mobile gasification unit in accordance with the illustrated embodiment of the present invention.

[0056] **FIG. 7** illustrates a top view of a mobile gasification unit in accordance with an alternative embodiment of the present invention.

[0057] **FIG. 8** illustrates a top interior cross sectional view of a mobile gasification unit in accordance with an alternative embodiment of the present invention.

[0058] **FIG. 9** illustrates a side partial cross sectional view of a mobile gasification unit in accordance with one embodiment of the present invention.

[0059] **FIG. 10** illustrates a maze ignition chamber in accordance with the illustrated embodiment of the present invention.

[0060] **FIG. 11** illustrates a cross sectional side view of insulation material used in accordance with the illustrated embodiment of the present invention.

[0061] **FIG. 12** illustrates a partial cross sectional view of a gasification chamber in accordance with the illustrated embodiment of the present invention.

[0062] **FIG. 13** illustrates a cross sectional view of a fuel gas extraction assembly in accordance with the illustrated embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0063] **FIGS. 1 and 9** illustrate a mobile gasification unit **10** in accordance with one embodiment of the present invention. The gasification unit **10** is comprised of a container **11**, at least one gasification chamber **12**_a_, **12**_b_, and at least one produced fuel gas combustion chamber **16**_a_, **16**_b_. Furthermore, as illustrated in **FIG. 8**, the mobile gasification unit **10** may also be configured to include a control room **14**. The container **11** is preferably comprised of a plurality of side walls **22**_a_, **22**_b_, **22**_c_, **22**_d_, a base **24**, and a top portion **26**. In the illustrated embodiment of the present invention, the container **11** is, or is of similar construction to, a standard sea cargo shipping container, which is approximately eight feet in width, nine feet in height, and twenty, forty, or forty-two feet in length. These dimensions however may change to satisfy waste capacity and/or gasification requirements.

[0064] Furthermore, the size and number of the at least one gasification chamber **12**_a_, **12**_b_ may be impacted by the choice of process gas. For instance, the use of process gases that has large amounts of undesirable gases accompanying the desired oxygen, such as the high content of nitrogen present in ambient air, requires that the at least one gasification chamber **12**_a_, **12**_b_ be sized to accommodate the inclusion of the undesired gases. However, in the illustrated embodiment of the present invention, the process gas is preferably comprised of a high oxygen content gas, such as, but not limited to, raw oxygen. While the present invention will operate using ambient air, which includes a large volume of undesirable nitrogen, the use of a high oxygen content gas, such as raw oxygen, which reduces or eliminates the inclusion of undesirable gases, may allow for a decrease in the required size of the at least one gasification chamber **12**_a_, **12**_b_.

[0065] Each of the at least one gasification chambers **12**_a_, **12**_b_ have an exterior vessel **30**_a_, **30**_b_ and an inner portion **32**_a_, **32**_b_. The exterior vessel **30**_a_, **30**_b_ is preferably configured so that at least a substantial portion of the at least one gasification chamber **12**_a_ fits into the interior of the container **11**. The exterior vessel **30**_a_, **30**_b_ for the at least one gasification chamber **12**_a_, **12**_b_ is comprised of a plurality of side walls, a top portion, and a base. In the illustrated embodiment of the present invention, at least a portion of the sidewalls **22**_a_, **22**_b_, **22**_c_, **22**_d_, base **24**, and top portion **26** of the container **11** that are adjacent to the gasification chamber **12**_a_, **12**_b_ are used as at least a portion of the plurality of walls of the exterior vessel **30**_a_, **30**_b_, as illustrated in **FIGS. 2, 3, 8**, and **9**. Alternatively, the exterior vessel **30**_a_, **30**_b_ for each of the at least one gasification chamber **12**_a_, **12**_b_ may be comprised of walls that are substantially dedicated for that individual chamber **12**_a_, **12**_b_.

[0066] In the illustrated embodiment of the present invention, each exterior vessel **30**_a_, **30**_b_, also includes a partitioning wall **23**_a_, **23**_b_ within the container **11** that substantially separates the at least one gasification chamber **12**_a_, **12**_b_ from the remainder of the inner portion of the container **11**, as illustrated in **FIGS. 3, 8**, and **9**. The location of the partitioning wall **23**_a_, **23**_b_ within the container **11** is preferably determined by the total waste processing volume desired. For example, if need dictates a two ton (15 cubic yard) waste capacity, then preferably one half of a container **11** having the equivalent size of a conventional twenty foot sea cargo container is used for a gasification chamber **12**_a_.

[0067] The remainder of the container **11** that is separated from the at least one gasification chamber **12**_a_ by the partitioning wall **23**_a_ is designed to house at least one produced fuel gas combustion chamber **16** and either an additional gasification chamber **12**_b_ or, alternatively, a control room **14**, as illustrated in **FIGS. 3, 8**, and **9**. In an embodiment in which the container **11** includes a control room **14**, the control room **14** may be configured to include various controls, such as, but not limited to, a process logic controller **98**, which is used to control gasification conditions, including the gas content and temperature inside the at least one gasification chamber, a primary access loading door **38***a*, a recovery removal door, a hydraulic assembly **71***a*, water pump and pressure unit **62** and associated spray systems, temperature and gas sensing equipment, and control devices. Access to the control room may be obtained via an access door **36***b*. In the illustrated embodiment of the present invention, the access door **36***b* is comprised of two adjacent hinged doors that are both sections of a container **11** sidewall **22***d*, as illustrated in **FIG. 8**.

[0068] The exterior vessel **30***a*, **30***b* of the at least one gasification chamber **12***a*, **12***b* also includes a primary access loading door **38***a*, **38***b* that is configured to cover at least one opening along the top portion **26** of the container **11**, and when in an opened position, allows for the insertion of waste material into the inner portion **32***a*, **32***b* of the at least one gasification chamber **12***a*, **12***b*. In the illustrated embodiment of the present invention, the opening and closing of the primary access loading door **38***a*, **38***b* is accomplished by the use of a hydraulic assembly **71***a*, **71***b* that is operably connected to the primary access loading door **38***a*, **38***b*. In one embodiment of the present invention, a seal is operably position between the base of the primary access loading door **38***a*, **38***b* and the container **11**, which is configured to create an air-tight fit between the primary access loading door **38** and the exterior vessel **30**. The primary access loading door **38***a*, **38***b* may also include a safety pressure relief vent **112***a*, **112***b* that is designed to dislodge or "burp" in the event that the pressure within the at least one gasification chamber **12***a*, **12***b* reaches undesirable levels (usually 4 to 6 psi).

[0069] The exterior vessel **30***a*, **30***b* in the illustrated embodiment of the present invention also preferably includes at least one access door **36***a*, **36***b* for the removal of noncombustible material, as illustrated in **FIGS. 2, 3**, **7**, and **8**. The at least one access door **36***a*, **36***b* is also preferably configured to provide access to the inner portion **32***a*, **32***b* for maintenance and service purposes. In the illustrated embodiment of the present invention, the access door **36***a*, **36***b* is comprised of two adjacent hinged doors that are both preferably sections of the container sidewall **22***c*, **22***d*, as shown in **FIG. 6**. A seal is preferably used to insure an air-tight fit between the at least one access door **36***a*, **36***b* and the container **11** when the at least one access door is in a closed position.

[0070] In the illustrated embodiment, the exterior vessel **30***a*, **30***b* also includes at least one disposal opening positioned along the base **24** of the container **11** to aid in the removal of post-process residual materials from the at least one gasification chamber **12***a*, **12***b*. In the illustrated embodiment of the present invention, the disposal opening is preferably a rectangular slot, measuring approximately 12 inches wide by 14 inches long, and is configured to allow for residual ash and small pieces of residual material to be flushed out of the chamber during a clean-out process.

[0071] **FIGS. 2, 8**, and **9** illustrate the inner portion **32***a*, **32***b* of the at least one gasification chamber **12***a*, **12***b* in accordance with one embodiment of the present invention. At least a portion of the surrounding inner surfaces of exterior vessel **30***a*, **30***b* walls **22***a*, **22***b*, **22***c*, **22***d*, **23***a*, **23***b*, base **24**, and top portion **26** are lined with insulation material **49** to assist in maintaining the temperature of the inner portion **32** during the gasification procedure and/or to protect the structure of the at least one gasification chamber **12***a*, **12***b* from prolonged exposure to excessive heat. As illustrated by **FIGS. 11 and 12**, metal hangers **66** that are operably attached to the inner portion of the walls **22***a*, **22***b*, **22***c*, **22***d*, **23***a*, **23***b* of the exterior vessel **30***a*, **30***b* are used to line at least a portion of said walls **22***a*, **22***b*, **22***c*, **22***d*, **23***a*, **23***b* with an approximately eight inch thick layer of insulation material **49**. In accordance with one embodiment of the present invention, the insulation material **49** is preferably comprised of three layers of spun ceramic fiber **50** and hard ceramic board **52**. Such insulation material is preferably designed to contain the heat of the gasification process, while preferably also limiting the temperature of the outer surfaces of the container **11** walls **22***a*, **22***b*, **22***c*, **22***d*, **23***a*, **23***b*, **24**, **26** to a temperature of no greater than 150 degrees F. Furthermore, such insulation material **49** preferably has the ability to cool down relatively quickly so as to assist in allowing a faster cool down period of the inner portion **32***a*, **32***b* following the completion of a gasification procedure. In the preferred embodiment of the present invention, the hangers **66** are welded to the interior of the exterior vessel walls **30** sidewalls **22***a*, **22***b*, **22***c*, **22***d*, **23***a*, **23***b* and are approximately 6 inches in length. Once in place, the insulated materials **49** are preferably pushed over the welded hangers **66**.

[0072] The present invention also preferably includes at least one temperature sensor **40**, such as a thermocouple, and at least one oxygen sensor **96** to monitor the temperature and oxygen levels within the inner portion **32***a*, **32***b*, as illustrated in **FIG. 12**. Information regarding temperature and oxygen levels inside the inner portion **32***a*, **32***b*, as detected by a the sensors **40**, **96**, are preferably sent to the controller **98**. Such information may then indicate to the controller **98** whether an action is needed, such as whether the heating device **114** should be activated or deactivated. In the illustrated embodiment of the present invention, six Type K thermocouples are used to detect whether the average ambient temperature in the inner portion **32***a*, **32***b* has reached, or is within, a predetermined range of operating temperatures. These thermocouples may be positioned in a variety of locations, including, but not limited to, the placement of three thermocouples **40** along the mid line of opposing gasification chamber **12***a*, **12***b* sidewalls **22***a*, **22***b*.

[0073] At least one process gas inlet **116** is configured to release process gas into the inner portion **32***a*, **32***b* of the at least one gasification chamber **12***a*, **12***b*. While process gas that passes through the at least one process gas inlet **116** may take the form of ambient air, the at least one process gas inlet **116** is preferably operably connected to a source for high oxygen content gas, such as, but not limit to, raw oxygen. In one embodiment of the present invention, the high oxygen content gas is supplied by an oxygen generator. However, oxygen may also be provided from other sources, such as a pre-bottled cylinder of oxygen. In the illustrated embodiment of the present invention, the at least one process gas inlet **116** is comprised of six four inch diameter pipe nipples that are positioned along the lower quadrant of one side of the at least one gasification chamber **12***a*, **12***b*. The at least one process gas inlet **116** is also preferably operably connected to a valve, the valve being used to control the rate at which process gas enters into the at least one gasification chamber **12***a*, **12***b*. The valve is preferably connected to a motor, the motor being operably connected to the controller **98**, so that, as the controller **98** monitors and regulates oxygen and temperature levels within the inner portion **32** of the at least one gasification chamber **12***a*, **12***b*, the controller **98** may send signals to the motor as to whether the valve should be in an opened or closed position depending on the temperatures and oxygen levels within the gasification chamber **12***a*.

[0074] As shown in **FIGS. 9 and 12**, the present invention also includes a mesh liner **58** and supporting bridge floor assembly, including, but not limited to, support rails **92**, that are configured to hold waste material within the inner portion **32***a*, **32***b* of the at least one gasification chamber **12***a*, **12***b* and away from the sidewalls and floor of the exterior vessel **30***a*, **30***b*, as illustrated in **FIGS. 3, 8, 9**, and **12**. The rails **92** are preferably configured with a sufficient space between adjacent rails **92** so as to allow process gas to flow, and residual ash and remaining non-combusted materials to fall, between the rails while also preventing loaded waste material from falling to the base of exterior vessel **30**. Although the liner **58** may be configured to create a number of different orientations, such as, but not limited to, a basket or bowl type orientation, in the preferred embodiment of the present invention, the liner **58** has a generally rectangular configuration.

[0075] The mesh liner **58** is preferably supported by a plurality of pins **80** that are operably connected to a portion of the adjacent exterior vessel **30** walls **22***a*, **22***b*, **22***c*, **22***d*, **23***a*, **23***b*, as illustrated in **FIG. 12**. In the illustrated embodiment of the present invention, the mesh liner **58** is constructed from panels of 316 stainless steel mesh, the mesh having a wire diameter of ¼ inch and hole diameter of two inches. Furthermore, in the illustrated embodiment of the present invention, the pins **80** are preferably about 12 inch long, ¾ inch diameter stainless steel bolts, with the heads of said bolts being welded to the interior of the exterior vessel **30** sidewalls **22***b*, **22***c*, **22***d*, **23***a*, **23***b*. In such an embodiment, about 9 bolts are preferably present per 3 foot×10 foot mesh panel. The mesh liner **58** is preferably secured to the threaded ends of the bolts via a set of double nuts and fender washers. The support rails **92** are preferably comprised of two inch diameter pipes laid in rows with adequate spacing so as to allow process gas to flow into the bottom of loaded waste material, and are approximately ten inches above the floor of the exterior vessel **30***a*, **30***b* so as to provide sufficient clearance for the gasification environment.

[0076] The mesh liner **58** is preferably offset away from the insulation material **49** that is attached to the inner portion of the adjacent exterior vessel **30** walls **22***a*, **22***b*, **22***c*, **22***d*, **23***a*, **23***b*. In the illustrated embodiment of the present invention, the mesh liner **58** is positioned approximately 3 inches away from said insulation material **49**. By offsetting the mesh liner **58** away from the adjacent walls **22***a*, **22***b*, **22***c*, **22***d*, **23***a*, **23***b*, process gas may circulate around the liner **58** and through the mesh openings on the bottom and sides of said liner **58**, thereby directly exposing a substantial portion of the waste material that is located in proximity to the bottom, sides, and top of the liner **58** to process gas. This increase in surface area of said collected waste material that is exposed to process gases results in an increase in the size of the primary reaction zone, and thereby allows for both a significant reduction in both gasification process cycle time and required gasification temperatures.

[0077] Additionally, because waste material is placed within the constraints of the mesh liner **58**, and is not against the walls adjacent walls **22***a*, **22***b*, **22***c*, **22***d*, **23***a*, **23***b* of the exterior vessel **30**, the walls of the at least one gasification chamber **12***a*, **12***b* preferably do not come into direct physical contact with said waste material. By preventing the direct physical contact of said waste material with the walls **22***a*, **22***b*, **22***c*, **22***d*, **23***a*, **23***b* of the at least one gasification chamber **12***a*, **12***b*, the exterior vessel **30** walls **22***a*, **22***b*, **22***c*, **22***d*, **23***a*, **23***b*, **24**, **26** may be fabricated from substantially thinner material, thereby reducing the weight and associated expenses of fabricating the at least one gasification chamber **12***a*, **12***b*. Furthermore, offsetting the liner **58** away from the exterior vessel **30***a*, **30***b* walls **22***a*, **22***b*, **22***c*, **22***d*, **23***a*, **23***b*, **24** prevents waste material from covering the at least one process gas inlet **116** and blocking the flow of process gas into the inner portion **32***a*, **32***b*.

[0078] At least one heating device **114** is operably connected to the inner portion **32***a*, **32***b* of the at least one gasification chamber **12***a*, **12***b*. The at least one heating device **114** is preferably configured to provide heat to the inner portion **32***a*, **32***b* for initiation of the gasification process and any additional heat that may be required during the gasification process so that the temperature within the inner portion **32***a*, **32***b* remains within a desired operating range. The at least one heating device **114** may be comprised of, but is not limit to, a fuel-fired burner or an electric thermal radiant heat assembly. Furthermore, in one embodiment of the present invention, a hydrogen generator may provide a combustible hydrogen gas to the at least one heating device **114** that may be used to provide a live flame in the gasification chamber or in the produced fuel gas combustion chamber. In the illustrated embodiment of the present invention, the at least one heating device **114** is comprised of a plurality of electric radiant heat elements that lay on top of the supporting rails **92**, as illustrated in **FIG. 12**. With such an embodiment, an additional heating element may be added between the support rails **92** and the floor so as to ensure the complete oxidation of any combustible waste material that may have fallen between the spacing of the rails **92**. In an alternative embodiment of the present invention, two penetrations in the exterior vessel **30** partitioning wall **23***a*, **23***b* provides attachment and access for electric heating elements which maintain temperature with the inner portion **32***a*, **32***b* at desired levels. In another embodiment of the present invention, the at least one heating device **114** is a comprised of a plurality of electric heating elements that located in the fuel chamber **16** and which also provide ignition for the combustion of produced heavy fuel gases in said fuel chamber **16**.

[0079] The illustrated embodiment of the present invention may also include at least one emergency water line **56***a*, **56***b*, as shown in **FIG. 8**. The at least one emergency water line **56***a*, **56***b* is preferably comprised of two one inch diameter water lines that pierce the portioning wall **23***a*, **23***b* of an exterior vessel **30***a*, **30***b*, and are configured to provide emergency quench for the gasification process and dust control during the clean-out process. In one embodiment of the present invention, the at least one emergency water line

56*a*, **56***b* operably connects a water supply pump and pressure unit **62** located in the control room **14** to the spray nozzles located in the ceiling of the gasification chamber **12**, the inlet **61** of said pump and pressure unit **62** being operably connected to a water source, such as, but not limited to, a hydrant or water supply line.

[**0080**] **FIG. 13** illustrates a fuel gas extraction assembly **100** in accordance with the illustrated embodiment of the present invention. An induced draft fan **102** is operably connected to the inner portion **32** of the at least one gasification chamber **12** and the produced fuel gas combustion chamber **16**. In the illustrated embodiment, the at least one outlet orifice **82** provides a passageway in which produced fuel gases may be vented or withdrawn from the inner portion **32** of the at least one gasification chamber **12**, while the at least one inlet orifice **84** provides an inlet for the vented produced fuel gases to enter into the produced fuel gas combustion chamber **16**. The fan **102** is preferably configured to create a pressure in the produced fuel gas combustion chamber **16** that assists in withdrawing the produced fuel gas out from the at least one gasification chamber **12** and into produced fuel gas combustion chamber **16**. In the illustrated embodiment of the present invention, the inlet and outlet orifices **82**, **84** are 24 inch square flanged openings that penetrate the top portion **26** of the container **11**. Furthermore, the at least one outlet orifice **82** is operably connected to a gate valve **104** that is configured to regulate the removal of produced fuel gases out of the at least one gasification chamber **12**. In the illustrated embodiment, the gate valve **104** is a damper that is operably connected to an electric motor **106** that controls the movement of the damper. Furthermore, in the illustrated embodiment, the fan **102** is preferably a squirrel cage blower fan constructed from stainless steel that is powered by a five horsepower variable speed motor and has a housing **86** that is constructed from ¼ inch thick **316** stainless steel that is configured to resist the high temperatures of incoming produced fuel gases. As shown in **FIG. 13**, the housing **86** may be operably connected to a fan **108** that may provide a supplemental flare gas, including, but not limited to, ambient air, a high oxygen content gas such as raw oxygen, a high content hydrogen gas, or a combination thereof, to the stream of withdrawn produced fuel gas prior to arrival into the produced fuel gas combustion chamber **16**. However, in an alternative embodiment, the produced fuel gas combustion chamber **16** is configured to supply the supplemental flare gas may be into the stream of produced fuel gas after said produced fuel gas passes through the inlet orifice **84**, as discussed below.

[**0081**] Although **FIG. 13** illustrates the fuel extraction assembly **100** in conjunction with a maze ignition chamber **70**, the illustrated fuel extraction assembly **100** may also be configured for use in conjunction with a gas accumulation tank **48**, as illustrated in **FIG. 8**. In such embodiments, because produced fuel gases are preferably not combusted until after leaving the gas accumulation tank **48**, the fuel extraction assembly **100**, when used with said tank **48**, does not have to be operably connected to a fan **108** that introduces a oxygen or hydrogen containing gas into the passing stream of withdrawn produced fuel gases in the fuel extraction assembly **100**.

[**0082**] As shown in **FIG. 8**, in an alternative embodiment, the outlet orifice **82***a* is operably connected to a flange **34** that is preferably eight inches in diameter and is configured to be operably connected to the induced draft fan **102** and housing **86***a*, and which is preferably fitted with a gate valve **104**. The gate valve **104** allows for the regulated removal of produced fuel gases from the at least one gasification chamber **12***a*, **12***b* and into an intake portion of the produced fuel gas combustion chamber **16**. In such an embodiment, the flange **34** is preferably positioned along a sidewall **22***a* of the exterior vessel **30***a*. However, the flange may also be positioned along the top portion **26** of the container **11**.

[**0083**] In accordance with one embodiment of the present invention, the produced fuel gas combustion chamber **16** receives withdrawn or vented produced fuel gases from the gasification chamber **12** for combustion and/or storage before delivery to a primary end use device, such as, but not limited to a boiler. In the preferred embodiment of the illustrated invention, the produced fuel gas combustion chamber **16** is a maze ignition chamber **70** as illustrated in **FIGS. 3, 9,** and **10**. Although a single maze ignition chamber **70** may, in some situations be sufficient to support multiple gasification chambers **12***a*, **12***b*, in accordance with the illustrated embodiment of the present invention, each gasification chamber **12***a*, **12***b* has its own dedicated maze ignition chamber **70***a*, **70***b*, each dedicated maze **70***a*, **70***b* preferably mutually sharing at least one common wall with the associated gasification chamber **12***a*, **12***b*, as illustrated in **FIGS. 3 and 9**.

[**0084**] The maze ignition chamber **70***a* is capable of being used when the unit **10** includes more than one gasification chamber **12***a*, **12***b* or with embodiments that include a control room **14**. For example, in the illustrated embodiment, when a section of the container **11** includes a control room **14**, one maze **70** sidewall is preferably used to separate the maze **70***a* and gasification chamber **12***a* from the control room. For configurations in which an additional gasification chamber **12***b* replaces the control room, the dedicated maze chambers **70***a*, **70***b* are preferably spaced approximately 12 inches from one another by an insulated divider **94**. In the illustrated embodiment, the divider **94** preferably serves as a common wall for both maze chambers **70***a*, **70***b*.

[**0085**] **FIG. 10** illustrates a cross sectional side view of the maze chamber **70***a* in accordance with the illustrated embodiment of the present invention. The maze chamber **70***a* is preferably comprised of insulation **49**, an enclosure **75**, an inner chamber **74**, at least one inlet orifice **84***a*, **84***b*, at least one baffle **76**, at least one secondary igniter **78**, and at least one exhaust port **88**. At least a portion of the base **24** and top portion **26** of the container **11** are used as a portion of the walls for the enclosure. The at least one baffle **76** is oriented to so as to create a winding passageway in the inner chamber **74** of the chamber **16** through which produced fuel gas may flow along while passing from the inlet orifice **84***a* and out through the exhaust port **88***a*. Each turn in the winding passageway that is created by positioning of the at least one baffle **76** not only creates turbulence so as to aid in mixing the passing gases, but also allows for additional retention time of those gases in the hot environment of the maze **70***a* enclosure **75**. In the illustrated embodiment of the present invention, the additional retention time in the enclosure **75** allows the gases to continued to be exposed to an environment of approximately 1550-1750 degrees F.

[**0086**] In accordance with the illustrated embodiment of the present invention, once within the inner chamber **74**, the produced fuel gases are preferably mixed with a supplemental flare gas, such as, but not limited to, ambient air, a high oxygen content gas or a high hydrogen content gas, so as to improve the combustibility of said produced fuel gases In the illustrated embodiment of the present invention, the supplemental flare gas enters into the winding passageway via a ¾ inch nipple **110** located above the first of the at least one produced gas igniter **78** and beneath the at least one inlet orifice **84***a*. In one embodiment of the present invention, hydrogen may be supplied via a hydrogen generator or a hydrogen supply tank. Supplemental flare gas is preferably added to the produced fuel gas at a controlled rate, as determined by the process controller **98**. However, as previously discussed, the mixing of the supplemental flare gas with the produced fuel gas may occur prior to passage through the inlet orifice **84***a*.

[**0087**] The mixing of supplemental flare gases in the form of high oxygen or hydrogen content gases with the produced fuel gas may reduce the potential for the formation of regulated pollutants. Furthermore, because high oxygen content gas, such as, but not limited to raw oxygen, or high hydrogen content gases, or a combination thereof, preferably contain less undesirable gas volume than ambient air, the duct work required for transporting the high oxygen or hydrogen content gases to the maze chamber **70**, and the maze chamber **70** itself, may have a smaller overall size then if the less desirable gas, such as ambient air, were used. The use of such relatively clean burning gases as the supplemental flare gas may also increase the size of the "fireball" that is created during combustion, which thereby further improves the mixing of the produced fuel gas with the supplemental flare gas.

[**0088**] As the mixed supplemental flare gas and produced fuel gas proceed along the maze **70***a*, the gases encounter the first of the at least one produced gas igniter **78**, the at least one produced gas igniter **78** being configured to provide a source for the combustion of the produced fuel gas and supplemental flare gas. The at least one produced gas igniter **78** may be comprised of, but is not limit to, a fuel-fired igniter or an electric thermal radiant heat assembly. In the illustrated embodiment of the present invention, the at least one produced gas igniter **78** is comprised of three to four sets of electric radiant heat panels that have a generally "W" shaped configuration and which are approximately 24 inches high by 24 inches long, as illustrated in **FIG. 3**. In an alternative embodiment, the at least one produced gas igniter **78** may be comprised of four electric heat elements that are enclosed in stainless pipe and covered with a piece of titanium expanded metal with ⅛ inch openings and which are preferably heated by the passing of a 220 volt current through said electric heat element.

[**0089**] The maze chamber **70***a* may also include at least one access door **90***a*. In the preferred embodiment of the present invention, the access door **90***a* provides a point of entry for maintenance of the maze chamber **70***a* and/or service of the at least one produced gas igniter **78**. In the illustrated embodiment of the present invention, the at least one access door **90***a* is preferably located on one sidewall of both the maze chamber **70***a* and container **22***a*.

[**0090**] In an alternative embodiment, the produced fuel gas combustion chamber **16** is comprised of a gas accumulation tank **48**. In such an embodiment, the gas accumulation tank **48** preferably includes at least one inlet orifice **84***a* that is operably connected to the at least one gasification chamber **12***a* via at least one exhaust manifold **62**, the at least one exhaust manifold **62** being operably connected to the induced draft fan **102** and flange **34**, as illustrated in **FIG. 8**. The induced draft fan **102** preferably provides pressurization to the gas accumulation tank **48**, thereby assisting in venting and/or withdrawing the produced fuel gas through the at least one outlet orifice **82***a*. Produced fuel gases are stored and eventually delivered from the gas accumulation tank **48** to the appropriate primary end use device, such as, but not limited to, water heaters, boilers, chillers, kiln dryers, et al for subsequent combustion.

[**0091**] In accordance with this illustrated embodiment of the present invention, the size and configuration of the gas accumulation tank **48** is preferably determined based on the size and capacity requirements of the at least one gasification chamber **12***a*, **12***b* and the available space in the container **11**. The gas accumulation tank **48** is preferably a round, square, or rectangular tank that is approximately four feet in diameter and approximately eight feet six inches in height, and which is wrapped in twelve inches of a ceramic isolative blanket. The gas accumulation tank **48** is also preferably located adjacent to the flange **34**, inside the control room **14**.

[**0092**] In the illustrated embodiment of the present invention, at least one pipe flange **118** is welded into the side of the gas accumulation tank **48**, the opposite end of the at least one flange **118** preferably piercing the exterior of the container **11**. The at least one pipe flange **118** serves as gas delivery port through which the produced fuel gas fuel product produced in the at least one gasification chamber **12***a*, **12***b* is distributed to the primary end use devices.

[**0093**] Operation of the mobile gasification unit **10** begins with transporting the unit **10** to a desired location. For ease of mobility, the unit **10** is preferably constructed to have a standard container **11** configuration, such as a sea cargo container configuration, so that the unit **10** may be transported via standard modes of transportation, including, but not limited ship, truck, or train. Once at the desired location, the gasification unit **10** may remain on the transportation device, such as a truck bed, or may be set down upon a stable surface, such as, but not limited to, concrete or a prepared bed of gravel.

[**0094**] Operation of the gasification unit **10** in accordance with the illustrated embodiment of the present invention typically begins with waste material entering though the opened primary access door **38***a* and into the inner portion **32** of the at least one gasification chamber **12***a*, **12***b*. The waste material is then placed onto the support rails **92** and into the mesh liner **58** that is supported by metal pins **80** and which extends away from a portion of the inner surfaces of the adjacent exterior vessel **30***a*, **30***b* walls **22***a*, **22***b*, **22***c*, **22***d*, **23***a*, **23***b*. Once the waste material is loaded into the mesh liner **58**, the primary access door **38** and any other additional exterior vessel **30***a*, **30***b* removal ports or doors **36***a*, **36***b* are subsequently closed.

[**0095**] An air purge is then employed in which ambient air is vented out from the inner portion **32** so as to reduce the volume of oxygen in the at least one gasification chamber **12***a*, **12***b*. During the air purge process, the valve for the at least one process gas inlet **116** is shut closed so as to prevent additional ambient air from entering into the at least one gasification chamber **12***a*, **12***b*. The closing of the at least one process gas inlet **116** may be initiated by a signal that is sent from a controller **98** in the control room **14** or on the control board, to the motor that opens and closes said valve. Preferably, an induced draft, such as the fan **102** that is operably connected to the outlet orifice **86***a*, **86***b* is then activated to withdraw ambient air out from the chamber **12***a*, **12***b* until oxygen levels and air volume within the at least one gasification chamber **12***a*, **12***b* have been reduced to desired levels for the initiation of the gasification process.

[0096] Once oxygen levels and air volume within the inner portion **32** of the at least one gasification chamber **12***a*, **12***b* are reduced to desired levels, the at least one heating device **114** is activated, and remains activated until the temperature within the inner portion **32** reaches a desired gasification temperature, as detected by the at least one temperature sensor **40**. The at least one heating device **114** may also provide the heat required to sustain an optimal gasification environment.

[0097] As the temperature within the inner portion **32** reaches desired gasification levels, the valve for the at least one process gas inlet **116** may be opened. The opening of the at least one process gas inlet **116** occurs in a controlled manner, as determined by the controller **98**, so that the desired gasification temperatures and oxygen levels are maintained, while also preventing the possibility that combustion will occur. Typically, the gasification of solid, sludge, and liquid wastes happens in a controlled atmosphere of restricted oxygen, preferably 4 to 12% of ambient, and at temperatures of about 675-850 degrees F. As previously mentioned, although ambient air may be used as process gas, in accordance with the preferred embodiment of the present invention, the process gas is comprised of a high oxygen content gas, such as, but not limited to, raw oxygen. The use of such oxygen rich gases not only prevents the formation of regulated pollutants, such as nitrous oxides, but also allows for structural components, such as the at least one gasification chamber **12***a*, **12***b*, vents, and associated ducting, of the unit **10** to be smaller then would be required if an abundance of undesirable gases accompanied the desired oxygen.

[0098] As process temperatures and oxygen levels reach desired ranges, the gasification of the waste material commences. As previously mentioned, the combination of offsetting the mesh liner **58** and support rails **92** away from the adjacent walls **22***a*, **22***b*, **22***c*, **22***d*, **24**, **2623***a*, **23***b* of the exterior vessel **30***a*, **30***b* and the gaps in the said liner **58** and rails **92** allow process gases to flow around, and into the top, bottom, and side surfaces of the loaded waste material. Exposing all sides of the loaded waste material to process gas increases the surface area of waste material that is exposed to process gas, and thus increases the size of the primary reaction zone. Because gasification cycle time is a function of surface area exposure to process gas, an increase in exposed surface area improves the substochiometric combustion conditions that will produce produced fuel gas at a lower temperature. Furthermore, the decrease in required gasification temperatures assists in preventing reformation reactions similar to those that typically occur in mass burn incinerators.

[0099] In the accordance with the illustrated embodiment of the present invention that includes at least one maze ignition chamber **70***a*, the at least one produced gas igniter **78** is preferably activated prior to the gasification procedure to a temperature of approximately 1000 degrees F. Such early activation prevents the possibility that uncombusted gases may pass through the maze chamber **70***a*, thereby insuring the cleanliness of any emissions released to the atmosphere.

[0100] The gasification of the loaded waste material is a function of time, temperature, and oxygen concentration in the gasification chamber. Once the ambient temperature within the at least one gasification chamber **12***a* reaches approximately 350 degrees F., the oxygen content in the at least one gasification chamber **12***a* will be significantly depleted. At this point, there will likely be a volume of produced gas hanging in the upper quarter of the at least one gasification chamber **12***a*, at which point the induced draft fan **102** may be turned on to withdraw or vent the produced fuel gases out of the at least one gasification chamber **12***a* and into the produced fuel gas combustion chamber **16***a*. The at least one gasification chamber **12***a* also preferably includes an oxygen sensor that indicates to the controller **98** whether the at least one process gas inlet **116** should be opened so as to allow additional process gas to enter into the at least one gasification chamber **12***a*.

[0101] The controller **98** preferably determines when to activate the induced draft fan **102** of the fuel extraction assembly **100**. As previously mentioned, The fan **102** is preferably configured to create a pressure in the produced fuel gas combustion chamber **16** that assists in withdrawing produced fuel gases out of the gasification chamber **12***a*. The controller **98** also preferably determines when to send a signal to the motor **105** that controls the opening and closing of the gate valve **104**, so that the process of removing produced fuel gases from the gasification chamber **12***a* may commence.

[0102] In accordance with the illustrated embodiment of the present invention in which the produced fuel gas combustion chamber **16** is a maze ignition chamber **70**, a supplemental flare gas, preferably in the form of a high oxygen content gas or hydrogen gas, or some combination thereof, is added to the produced fuel gases in the inner chamber **74** of the maze **70** prior to combustion. However, as previously mentioned, the addition of supplemental flare gas to the produced fuel gas may occur prior to passage of the produced fuel gas into the produced fuel gas combustion chamber **16**.

[0103] Produced fuel gases typically enters the produced fuel gas combustion chamber **16** at the same temperature as the gasification chamber **12***a* itself, i.e. approximately 800 degrees F. In the embodiment of the present invention in which the produced fuel gas combustion chamber **16** is a maze **70***a*, the combustion of the produced fuel gases by the at least one produced gas igniter **78** preferably raises the temperature of the inner chamber **74** to an approximate range of 1600 degrees F. The maintenance of an optimal 1,600 degrees F. for 2 seconds retention time or greater, is controlled by the size of the combustion maze and the interface of the process logic controller **98**.

[0104] Following combustion of the gases, the gases flow through the winding passageway of the inner chamber **74** of the maze **70***a*, the winding passageway preferably being configured to create turbulence in the passing gases. The winding pattern of the inner chamber **74** also increases the retention time of the gasses passing through the maze **70**, thereby increasing the time the combusted gases are exposed to a hot environment. In the illustrated embodiment of the present invention, the retention time is approximately 2.7 seconds. The combusted gases then pass through the at least one exhaust port **88***a*, whereupon the hot air effluent is preferably directed into the enclosure of a primary end use device, such as, but not limited to, the base of a boiler so as to provide the energy for steam/hot water production in lieu of natural gas.

[0105] While the present invention has been illustrated in some detail according to the preferred embodiment shown in the foregoing drawings and descriptions, it will be understood that the invention is not limited thereto, since modifications may be made by those skilled in the art, particularly in light of the foregoing teaching. It is therefore contemplated by the appended claims to cover such modifications that incorporate those features that come within the spirit and scope of the invention.

1. A mobile gasification unit for the gasification of solid waste material and production of a produced fuel gas comprising:

a. a container having an interior, a plurality of sidewalls, a top portion, a base, and at least one primary access loading door;

b. at least one gasification chamber positioned in the interior of the container, the at least one gasification chamber being comprised of an inner portion, an exterior vessel, and at least one outlet orifice, the exterior vessel being comprised of a partitioning wall and at least a portion of the plurality of sidewalls;

c. at least one heating device operably connected to the gasification chamber, the at least one heating device configured to provide heat to the inner portion of the at least one gasification chamber;

d. at least one process gas inlet configured to release a process gas into the at least one gasification chamber, the at least one process gas inlet operably connected to a valve, the valve being used to control the rate at which process gas enters into the at least one gasification chamber;

e. a mesh liner operably connected to at least a portion of the exterior vessel, the mesh liner being offset away from the partitioning wall and at least a portion of the plurality of sidewalls, the mesh liner configured to receive the insertion of a plurality of solid waste material;

f. a maze ignition chamber positioned in the interior of the container, the maze ignition chamber having at least one inlet orifice, the maze ignition chamber being operably connected to the inner portion of the at least one gasification chamber and configured to receive a plurality of produced fuel gas, the maze ignition chamber having an insulated enclosure, an inner chamber, at least one baffle, at least one produced gas igniter, and an exhaust port, the at least one baffle configured to create a winding passageway in the inner chamber, at least a portion of the plurality of produced fuel gas proceeding to the at least one produced gas igniter for combustion before proceeding through the winding passageway;

g. an induced draft fan, the induced draft fan operably connected to the at least one outlet orifice and the at least one inlet orifice, the induced draft fan configured to withdraw the produced fuel gas out from the at least one gasification chamber and vent the produced fuel gas into the maze ignition chamber.

2. The system of claim 1, wherein the maze chamber includes a supply nipple, the supply nipple being configured to deliver a high oxygen content supplemental flare gas to the inner chamber for combustion with the produced fuel gas.

3. The system of claim 1, wherein the maze chamber includes a supply nipple, the supply nipple being configured to deliver a high hydrogen content supplemental flare gas to the inner chamber for combustion with the produced fuel gas.

4. The system of claim 1, including a control room, the control room being located in the interior of the container, at least a portion of the control room being separated from the gasification chamber by the partitioning wall.

5. The system of claim 1, wherein the at least one gasification chamber is comprised of two gasification chambers.

6. The system of claim 1, wherein the process gas is comprised of a high oxygen content gas.

7. The invention of claim 1 wherein the at least one heating device is a produced gas igniter located in the produced fuel gas combustion chamber, the produced gas igniter being operably connected to the inner portion of the at least one gasification chamber.

8. A mobile gasification unit for the gasification of solid waste material and production of a produced fuel gas comprising:

a. a container, the container having an interior, a plurality of sidewalls, a top portion, a base, and at least one primary access loading door;

b. a seal operably position between the base of the at least one primary access loading door and the container, the seal configured to create an air-tight fit between the at least one primary access loading door and the container;

c. at least one gasification chamber positioned in the interior of the container, the at least one gasification chamber being comprised of an inner portion, an exterior vessel, and at least one outlet orifice, the exterior vessel being comprised of a partitioning wall and at least a portion of the plurality of sidewalls, the interior of the plurality of sidewalls being insulated so as to limit the temperature of the outer surfaces of the plurality of walls;

d. at least one process gas inlet configured to release a process gas into the at least one gasification chamber, the at least one process gas inlet operably connected to a valve, the valve being used to control the rate at which process gas enters into the at least one gasification chamber, the valve being connected to a motor, the motor being operably connected to a controller, the controller being configured to monitor and regulate the oxygen and temperature levels within the at least one gasification chamber, the controller sending signals to the motor as to whether the valve should be in a opened or a closed position based on the temperature and oxygen levels within the gasification chamber;

e. at least one heating device operably connected to the gasification chamber, the at least one heating device configured to provide heat to the inner portion of the at least one gasification chamber;

f. a mesh liner operably supported by a plurality of pins that are operably connected to a portion of the adjacent plurality of sidewalls, the mesh liner being offset away from the partitioning wall and at least a portion of the plurality of sidewalls, the mesh liner configured to receive the insertion of a plurality of solid waste material;

g. a maze ignition chamber positioned in the interior of the container, the maze ignition chamber having at least one inlet orifice, the maze ignition chamber being operably connected to the inner portion of the at least one gasification chamber and configured to receive a plurality of produced fuel gas, the maze ignition chamber having an insulated enclosure, an inner chamber, at least one baffle, at least one produced gas igniter, an exhaust port, and a supply nipple, the supply nipple being configured to deliver a supplemental flare gas to the inner chamber for combustion with the produced fuel gas, the at least one baffle configured to create a winding passageway in the inner chamber, at least a portion of the plurality of produced fuel gas proceeding to the at least one produced gas igniter for combustion before the proceeding through the winding passageway; and

h. an induced draft fan, the induced draft fan operably connected to the at least one outlet orifice and the at least one inlet orifice, the induced draft fan configured to withdraw the plurality of produced fuel gas out from the at least one gasification chamber and vent the plurality of produced fuel gas into the maze ignition chamber.

9. The system of claim 8, wherein the supply nipple is configured to deliver a high hydrogen content supplemental flare gas to the inner chamber for combustion with the plurality of produced fuel gas.

10. The system of claim 8, including a control room, the control room being located in the interior of the container, at least a portion of the control room being separated from the gasification chamber by the partitioning wall.

11. The system of claim 8, wherein the at least one gasification chamber is comprised of two gasification chambers.

12. The system of claim 8, wherein the process gas is comprised of a high oxygen content gas.

13. The invention of claim 8 wherein the at least one heating device is a produced gas igniter located in the produced fuel gas combustion chamber, the produced gas igniter being operably connected to the inner portion of the at least one gasification chamber.

14. A mobile gasification unit for the gasification of waste material and production of a produced fuel gas comprising:

a. a container, the container having an interior, a plurality of sidewalls, a top portion, a base, and at least one primary access loading door, a portion of the plurality of sidewalls being configured to provide access to the interior;

b. a seal operably position between the base of the at least one primary access loading door and the container, the seal configured to create an air-tight fit between the at least one primary access loading door and the container;

c. at least one gasification chamber positioned in the interior of the container, the at least one gasification chamber being comprised of an inner portion, an exterior vessel, and at least one outlet orifice, the exterior vessel being comprised of a partitioning wall and at least a portion of the plurality of sidewalls, the interior of the plurality of sidewalls being insulated so as to limit the temperature of the outer surfaces of the plurality of walls to less than approximately 150 degrees Fahrenheit;

d. at least one process gas inlet configured to release a process gas into the at least one gasification chamber, the at least one process gas inlet operably connected to a valve, the valve being used to control the rate at which process gas enters into the at least one gasification chamber, the valve being connected to a motor, the motor being operably connected to a controller, the controller being configured to monitor and regulate the oxygen and temperature levels within the at least one gasification chamber, the controller sending signals to the motor as to whether the valve should be in a opened or a closed position based on the temperature and oxygen levels within the gasification chamber;

e. a mesh liner positioned in the inner portion of the at least one gasification chamber, the mesh liner being operably connected to at least a portion of the exterior vessel, the mesh liner being offset away from the partitioning wall and at least a portion of the exterior vessel;

f. a plurality of support rails configured to support a plurality of loaded waste material, at least a portion of the plurality of support rails being spaced apart from an adjacent support rail.

g. at least one heating device operably connected to at least a portion of the plurality of support rails, the at least one heating device configured to provide heat to the inner portion of the at least one gasification chamber;

h. a maze ignition chamber positioned in the interior of the container, the maze ignition chamber having at least one inlet orifice, the maze ignition chamber being operably connected to the inner portion of the at least one gasification chamber and configured to receive a plurality of produced fuel gas, the maze ignition chamber having an insulated enclosure, an inner chamber, at least one baffle, at least one produced gas igniter, and an exhaust port, the at least one baffle configured to create a winding passageway in the inner chamber, at least a portion of the plurality of produced fuel gas proceeding to the at least one produced gas igniter for combustion before the proceeding through the winding passageway; and

i. a fuel extraction assembly, the fuel extraction assembly comprised of an induced draft fan and a gate valve, the induced draft fan operably connected to the at least one outlet orifice and the at least one inlet orifice, the induced draft fan configured to withdraw at least a portion of the plurality of produced fuel gas out from the at least one gasification chamber and vent the plurality of produced fuel gas into the maze ignition chamber.

15. The system of claim 14, including a control room, the control room being located in the interior of the container, at least a portion of the control room being separated from the gasification chamber by the partitioning wall.

16. The invention of claim 14, wherein the maze chamber includes a supply nipple, the supply nipple being configured to deliver a high oxygen content supplemental flare gas to the inner chamber for combustion with the produced fuel gases.

17. The invention of claim 14, wherein the maze chamber includes a supply nipple, the supply nipple being configured to deliver a high hydrogen content supplemental flare gas to the inner chamber for combustion with the produced fuel gases.

18. The system of claim 14, wherein the at least one gasification chamber is comprised of two gasification chambers.

19. The system of claim 14, wherein the at least one process gas inlet is configured to deliver a process gas to the at least one gasification chamber, the process gas being comprised of a high oxygen content gas.

20. The invention of claim 14 wherein the at least one heating device is a produced gas igniter located in the produced fuel gas combustion chamber, the produced gas igniter being operably connected to the inner portion of the at least one gasification chamber.

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