

[54] TRANSPORTABLE INCINERATION
SYSTEM

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Related U.S. Application Data

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1969, abandoned.

[52] U.S. Cl. **110/8 A, 110/18 R, 110/119**

[51] Int. Cl. **F23g 7/00**

[58] Field of Search **110/7, 8, 18, 119**

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[57] **ABSTRACT**

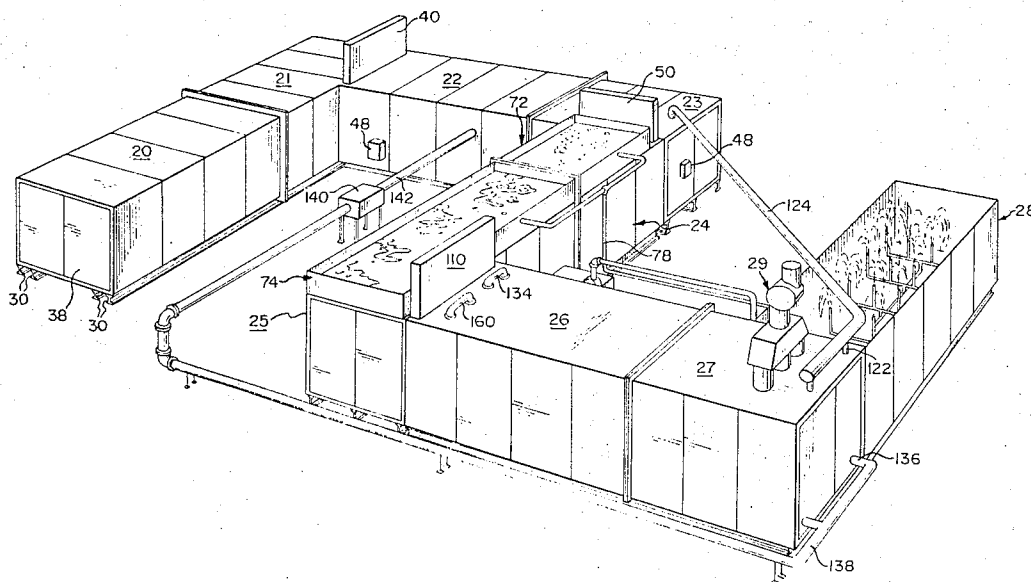
A portable incineration system is provided in which transportable modular units are interconnected to provide a large scale incineration system. The fly ash and other undesired particles are removed from the hot gases without developing a steam plume by reheating and drying these gases prior to exhaust.

The hot water produced during fly ash removal is circulated through a suitable cooler, or used as a constant heat source, and the cooled water is recirculated. Cleaning action is improved by injecting chemical sprays into the final drying chamber which solidify certain vapors in the exhaust stream.

In the primary burning chamber the formation of large clinkers between the sides of the stoker and the refractory walls is avoided by providing a relatively wide, deep ledge of refractory material adjacent the moving edges of the stoker.

In another embodiment a series of hollow perforated cylinders, arranged in a gradually sloping or vertically stepped array, may also be used as a stoker grate in the primary burning chamber to transport the material being burned through this chamber. The exhaust hot gases may be mixed with oxygen and supplied to the interior of these cylinders to prevent clogging and to assist in combustion of the material on the primary chamber.

16 Claims, 15 Drawing Figures



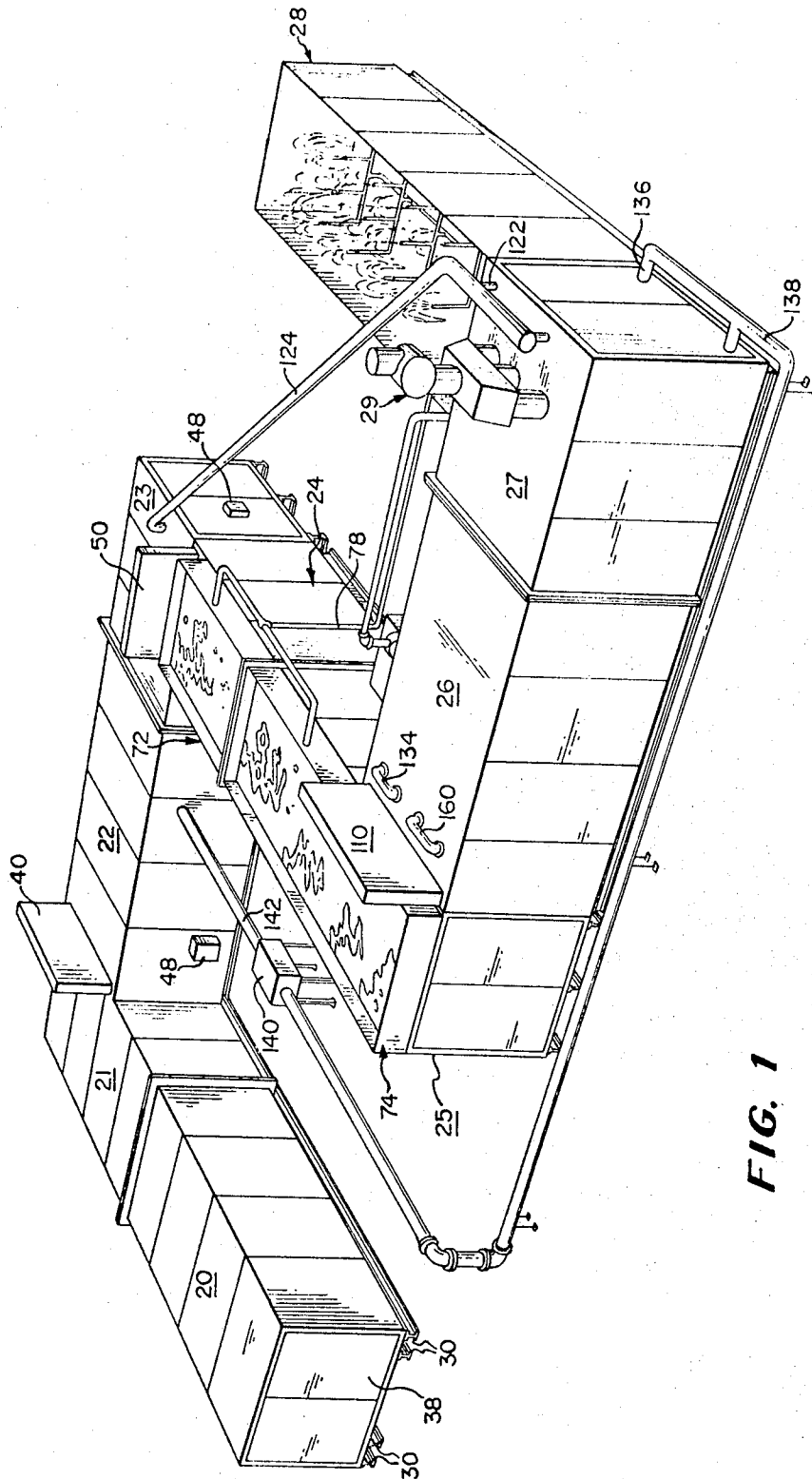


FIG. 1

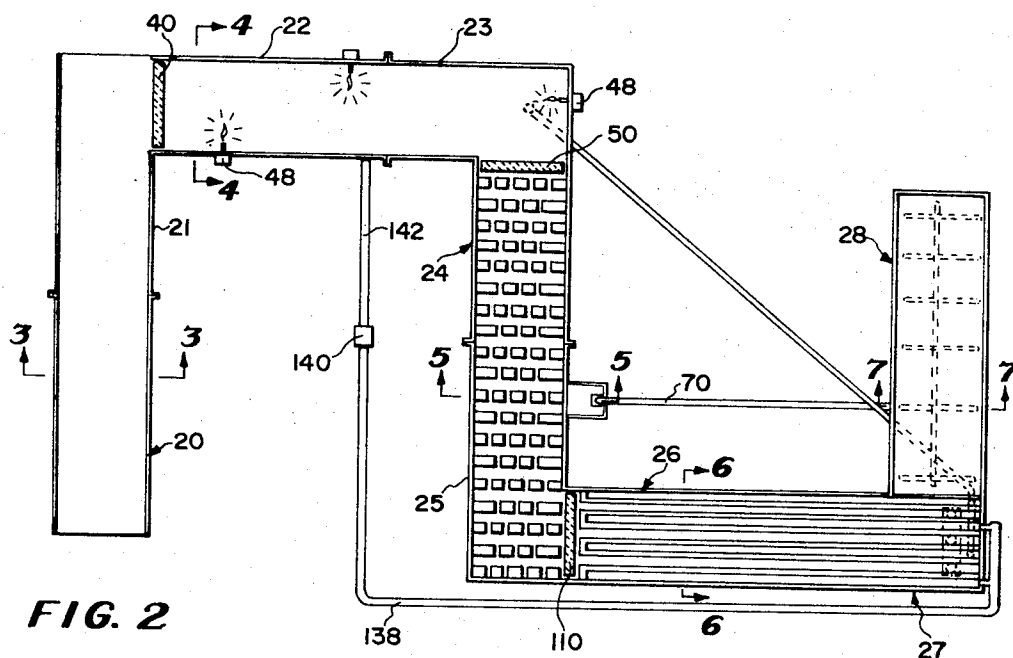


FIG. 2

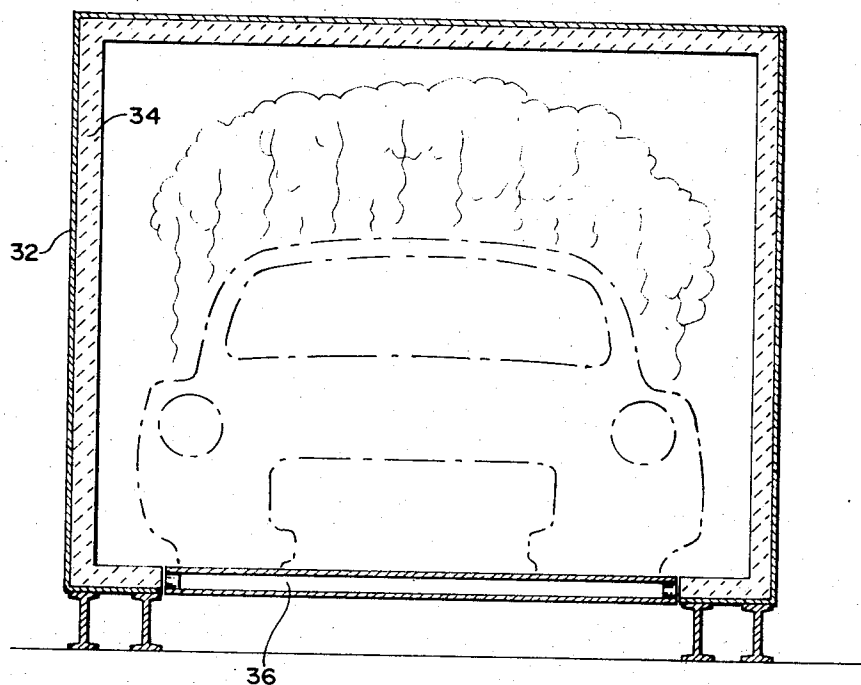
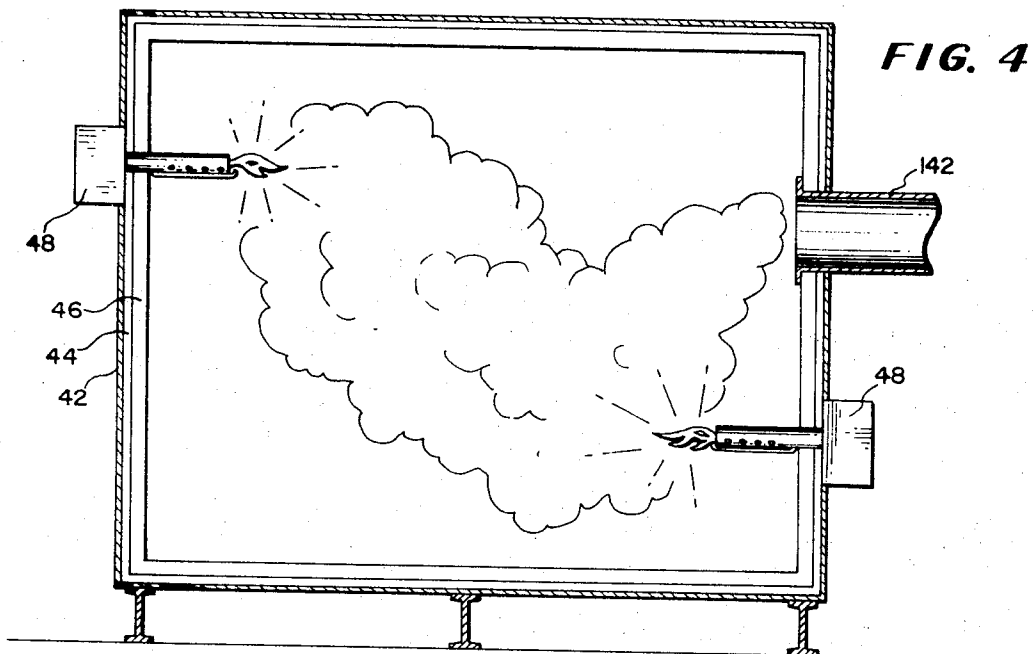
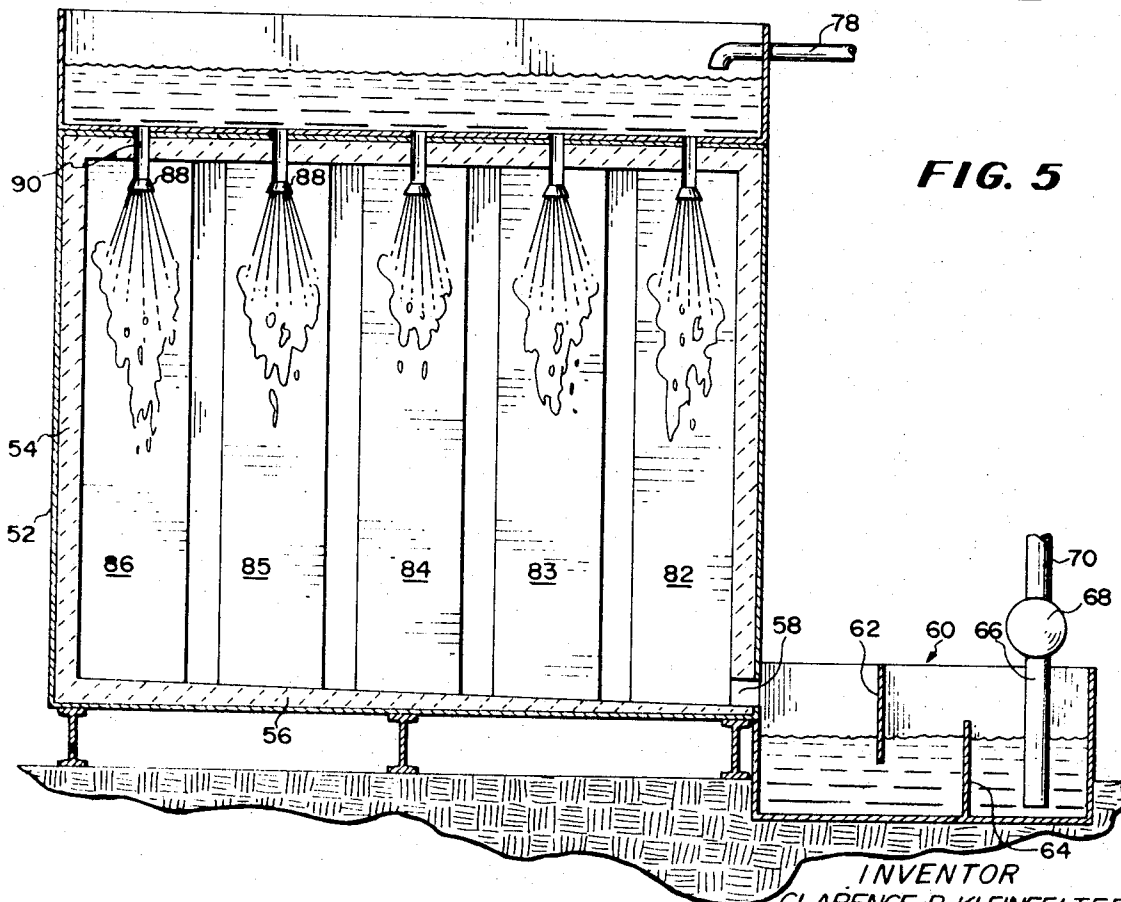


FIG. 3

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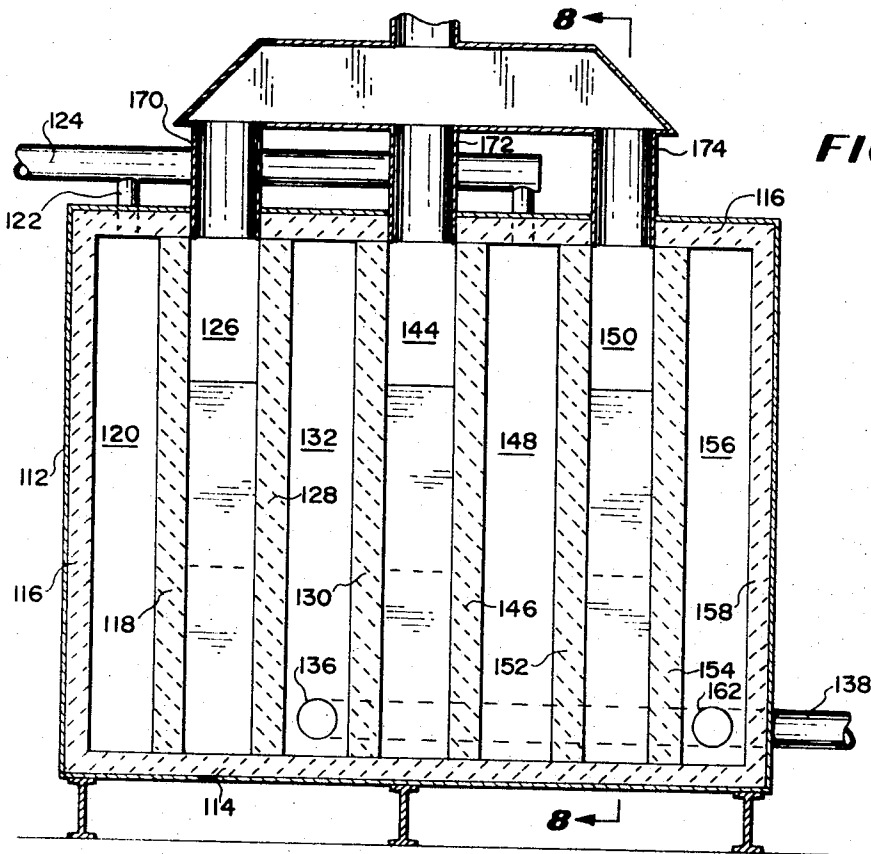


FIG. 6

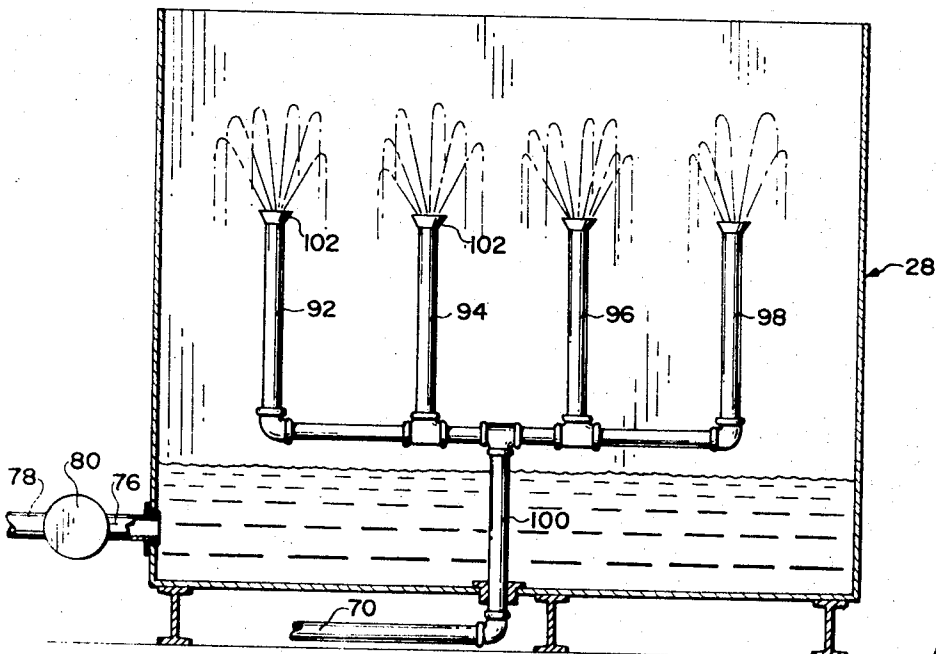


FIG. 7

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FIG. 8

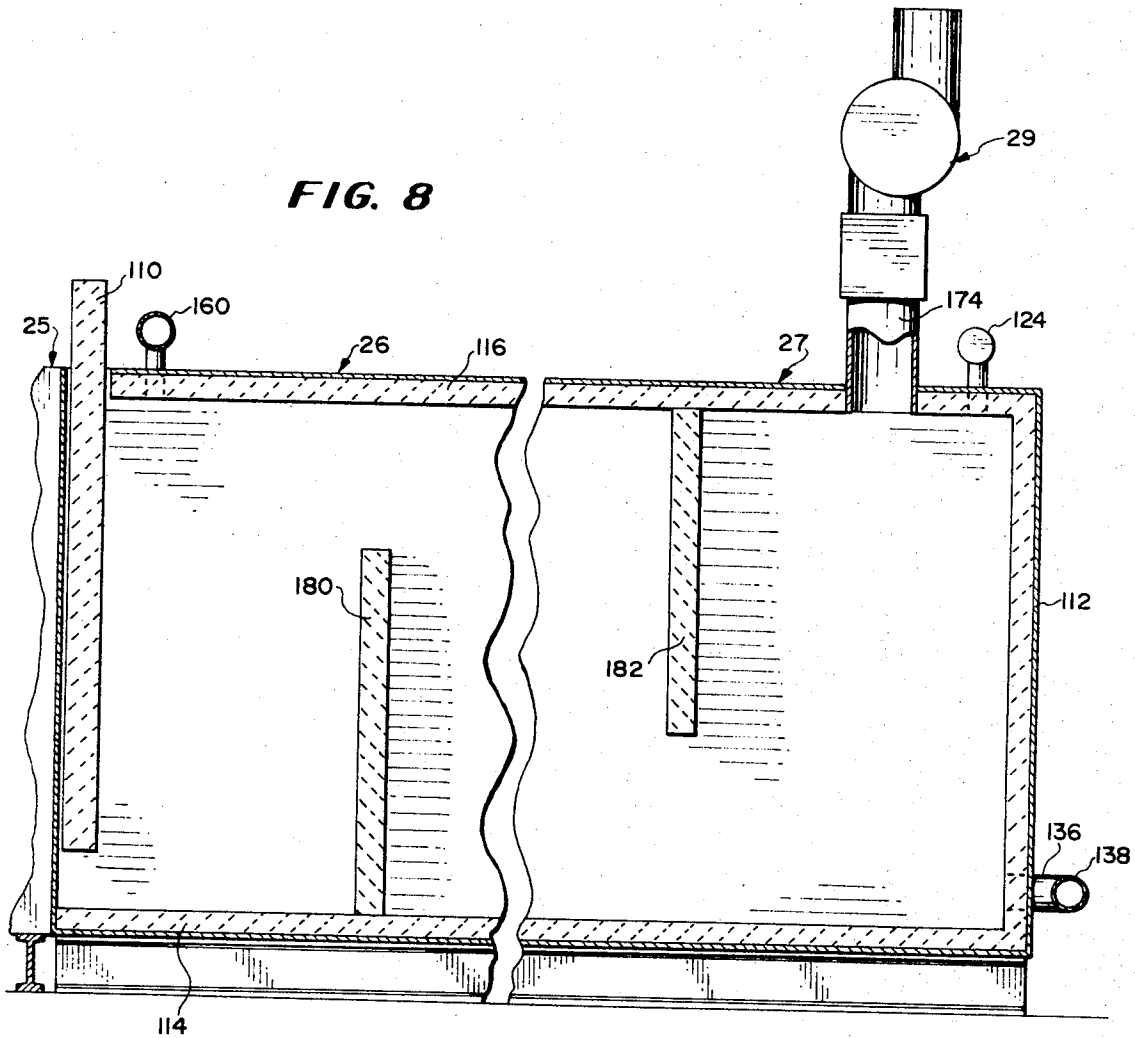
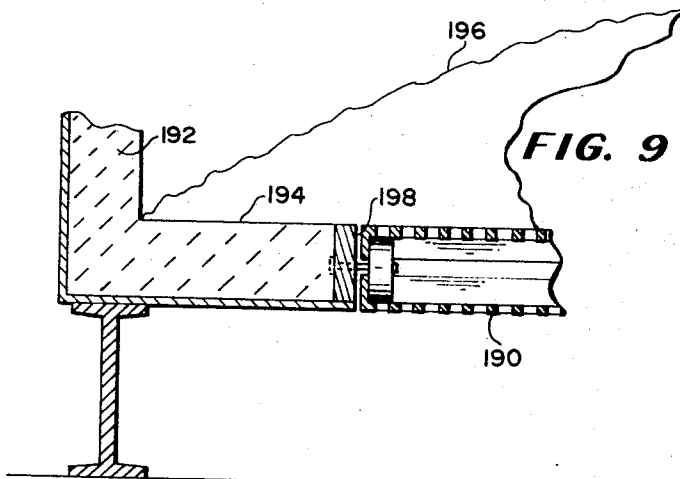


FIG. 9



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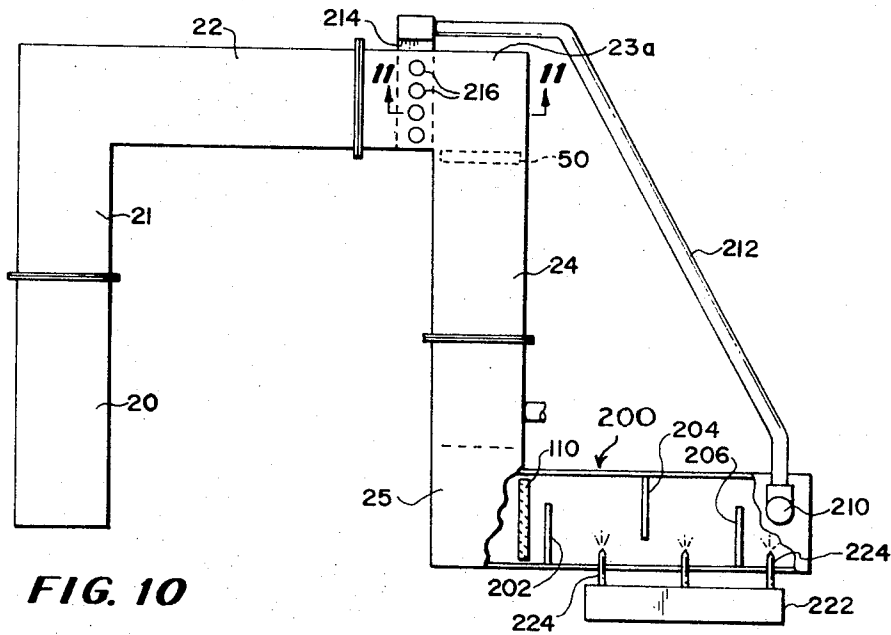


FIG. 10

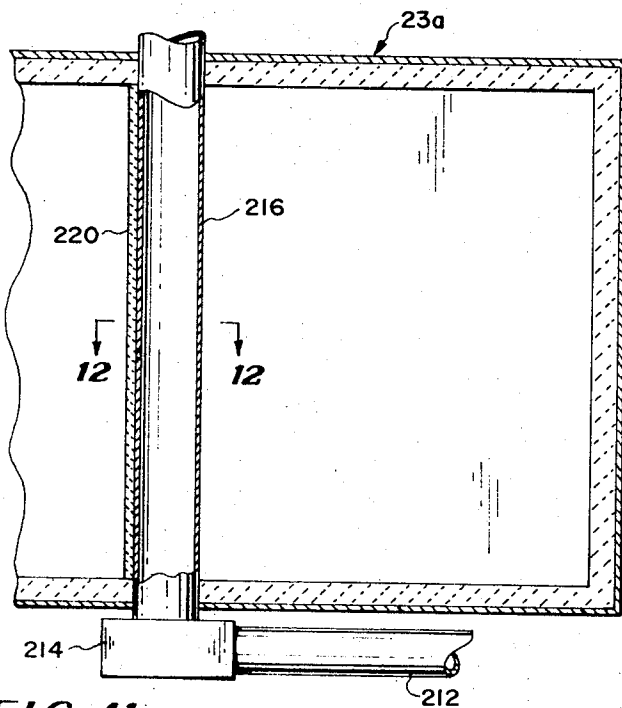


FIG. 11

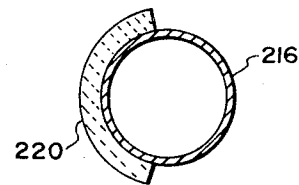


FIG. 12

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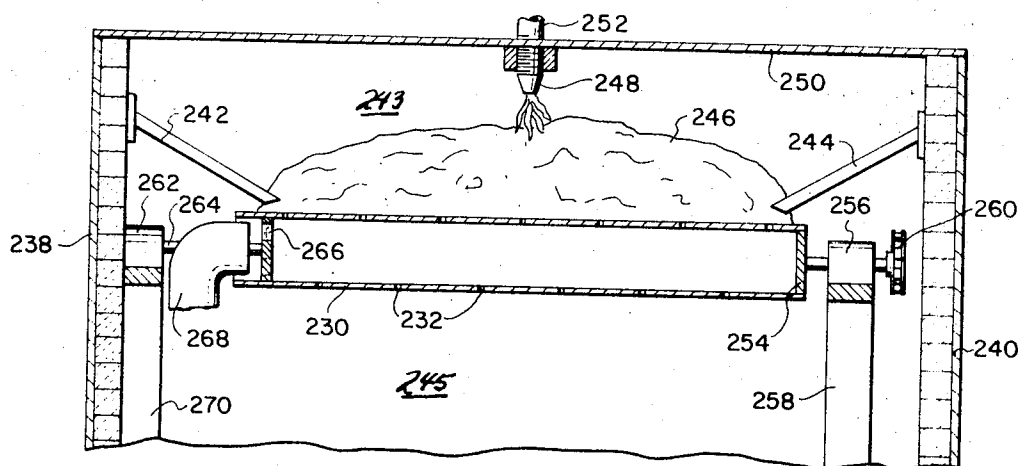


FIG 14

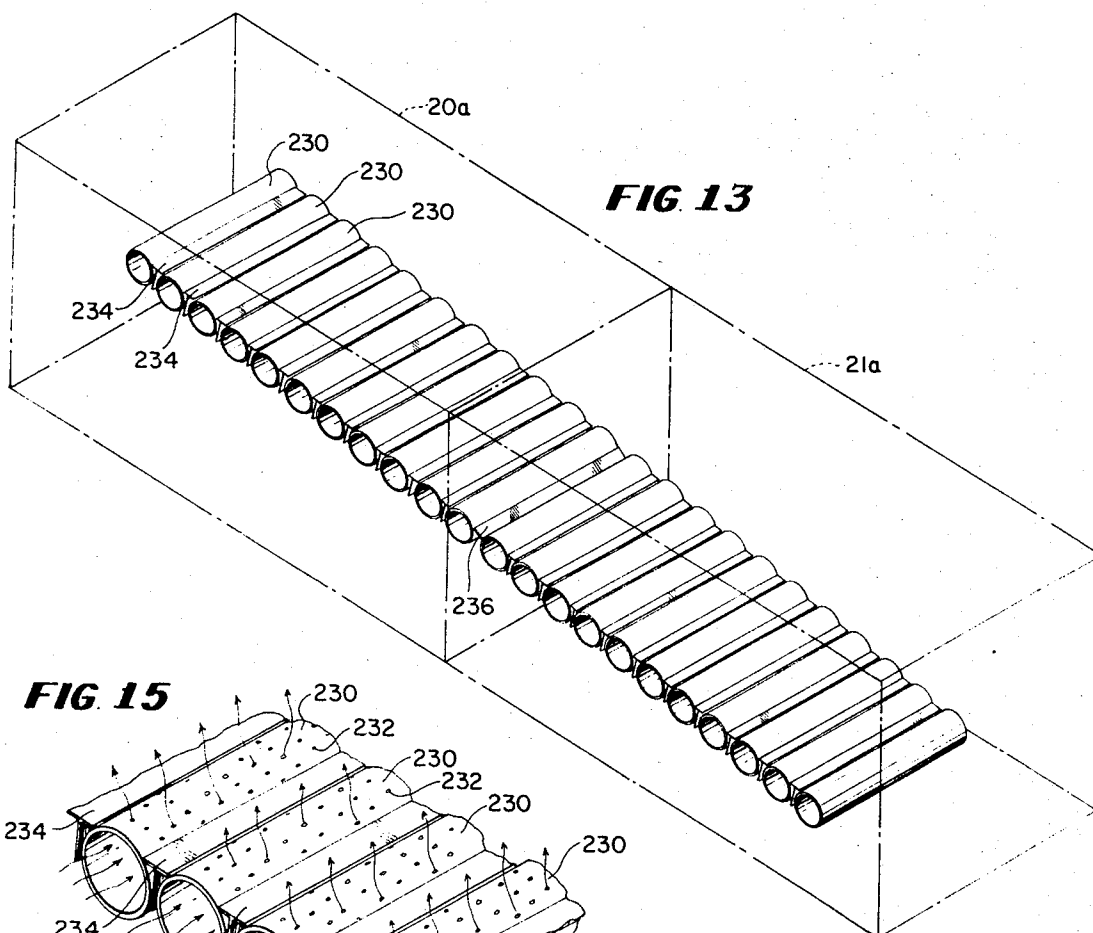


FIG 13

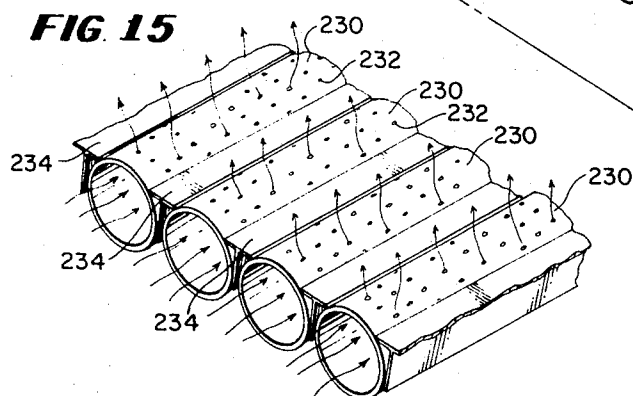


FIG 15

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TRANSPORTABLE INCINERATION SYSTEM

The present invention is a continuation-in-part of application Serial No. 873,966 filed November 4, 1969, now abandoned.

The present invention relates to incineration systems, and, more particularly, to incineration systems which are transportable so that they may be used in temporary or permanent incineration applications.

While various portable incinerators have been proposed in the past, their arrangements have been of limited application due to the small volume of combustibles which could be incinerated therein. Also, these portable arrangements have not been acceptable for large scale incineration applications because they do not meet the strict air pollution codes of many states. Furthermore, those arrangements which have attempted to remove the fly ash and other undesired particles from the hot gases characteristically emit what is known as a steam plume which is also objectionable.

In prior art systems employing moving stokers of certain types a problem also arises due to the fact that large clinkers tend to form adjacent the moving edges of the stoker. These clinkers may become so large that they will stop the stoker or cause severe damage thereto. Furthermore, the removal of such clinkers is a laborious and time consuming task.

It is, therefore, an object of the present invention to provide a new and improved transportable incineration system wherein one or more of the above-discussed disadvantages of the prior art arrangements is eliminated.

It is another object of the present invention to provide a new and improved transportable incineration system wherein a plurality of separably interconnectable modules which can be readily transported over standard width highways and assembled to provide temporary or permanent large volume incineration for a wide variety of combustibles.

It is a further object of the present invention to provide a new and improved transportable incineration system wherein a plurality of separably interconnectable modules are assembled to provide a large volume incineration system and facilities are provided in said modules to minimize the steam plume effect of the exhaust gases.

It is a still further object of the invention to provide a new and improved transportable incineration system consisting of a group of separably interconnectable modules which can readily be assembled into a complete large scale incineration system which meets the strict requirements of all air pollution codes of the various states today.

It is another object of the present invention to provide a new and improved transportable incineration system wherein fly ash and other suspended particles in the exhaust gases of the system are minimized so as to meet air pollution code requirements.

It is a further object of the present invention to provide a new and improved transportable incineration system wherein the exhaust gases are thoroughly dried and cooled before being exhausted from the system so as to eliminate a steam plume at the exhaust.

It is a still further object of the present invention to provide a new and improved incineration system wherein clinkering at the moving edges of the stoker is substantially eliminated.

It is another object of the present invention to provide a new and improved incineration system wherein a chemical spray is employed to solidify certain vapors in the exhaust stream, thereby providing improved cleaning action.

It is a further object of the present invention to provide a new and improved transportable incineration system wherein the exhaust gases are mixed with oxygen and reused in the primary burning chamber to assist in the combustion of the material in said chamber.

The invention, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following specification taken in connection with the accompanying drawings, in which:

FIG. 1 is a perspective view of a transportable incineration system embodying the features of the present invention;

FIG. 2 is a plan view, partly in section and taken on a smaller scale, of the system of FIG. 1;

FIG. 3 is a sectional view, taken along the line 3—3 of FIG. 2 but on a somewhat larger scale;

FIG. 4 is a sectional view, taken along the line 4—4 of FIG. 2 but on a somewhat larger scale;

FIG. 5 is a sectional view, taken along the line 5—5 of FIG. 2 but on a somewhat larger scale;

FIG. 6 is a sectional view, taken along the line 6—6 of FIG. 2 but on a somewhat larger scale;

FIG. 7 is a sectional view, taken along the line 7—7 of FIG. 2 but on a somewhat larger scale;

FIG. 8 is a sectional view taken along the line 8—8 of FIG. 6;

FIG. 9 is a fragmentary sectional view similar to FIG. 3 but illustrating the manner in which clinkering is avoided when burning garbage;

FIG. 10 is a plan view of an alternative embodiment of the invention;

FIG. 11 is a sectional view taken along the line 11—11 of FIG. 10 but on a somewhat larger scale;

FIG. 12 is a fragmentary sectional view taken along the line 12—12 of FIG. 11;

FIG. 13 is a diagrammatic perspective view of a further alternative embodiment of the invention wherein an improved stoker grate arrangement is employed to transport material through the primary burning chamber;

FIG. 14 is a cross-sectional view taken through the first cylinder grate of the arrangement of FIG. 13; and

FIG. 15 is a fragmentary perspective view of the perforated cylinders employed in the arrangement of FIG. 13.

Referring now to the drawings, and more particularly to FIGS. 1 to 8, inclusive, thereof, the present invention is therein illustrated as comprising a plurality of separably interconnectable modular units 20 to 28, inclusive. The modules 20 to 28, inclusive, are arranged to be transmitted to the job site on flat bed trucks and are of a width which may conveniently be carried on standard highways. These modules are arranged to be bolted or otherwise secured together in the form shown in FIG. 1 so as to comprise a complete incineration system capable of capacities up to 125 tons per day while at the same time these module units may be transported to different job sites to perform different incineration applications. While the incineration system of the present invention is capable of general application, it is particularly suitable for use with and will be described in con-

nection with an arrangement for removing combustibles from car bodies. The incineration system of the present invention may thus be leased to junk yards, moved in and set up to clean up the combustibles from car bodies so that the owners can get a higher price for bare metal units. The present incineration system permits the controlled burning of combustibles and would eliminate the burning of cars at night which is the present procedure under uncontrolled conditions.

In the arrangement of FIG. 1, the first two modular units 20 and 21 are arranged to be bolted together end to end so as to provide a primary burning chamber through which the car bodies may be moved to remove all combustibles therefrom. While this primary burning chamber may obviously be of any suitable dimensions, for certain applications this primary burning chamber 20, 21 may have a height of 8 feet, a width of 10 feet and a length of approximately 50 feet for the two sections 20 and 21. The modular units 20 and 21 are arranged to be lifted off of flat bed transports and rest upon suitable eye beams 30, or any suitable foundation arrangement, as will be readily understood by those skilled in the art.

Each of the modular units 20, 21 includes an outer housing 32 of sheet steel and a refractory lining 34 which may be approximately $4\frac{1}{2}$ inches thick to provide a suitable refractory lining for the primary burning chamber. Preferably only the lower portions of the side walls of the unit are made of refractory brick or other heavy material which will withstand abrasion due to wear. The upper portions of these side walls and the top walls of the modular units are preferably lined with an asbestos type refractory lining which is of substantially less thickness and weight than conventional fire brick.

A conveyor 36 (FIG. 2) extends through the length of the two modular units 20 and 21 and beyond both the electrically operated entrance door 38 of the modular unit 20 and a similar exit door at the end of the unit 21, so that car bodies may be placed upon the conveyor 36 exteriorly of the unit 20 and may be removed therefrom at the exit of unit 21 after all combustibles have been burned off of the car bodies.

The temperature in the primary burning chamber is preferably controlled so that high grade metals of the car bodies will not melt. Accordingly, the temperature in the primary burning chamber is maintained at from 1,200° to 1,400°F. A secondary burning chamber is then provided which operates at a higher temperature so as to eliminate smoke and odors. More particularly, the modular units 22 and 23 are connected end to end to provide a secondary burning chamber one end of which communicates with the side of the modular unit 21 through a vertically moving damping member 40. The damper 40 is preferably of 6 inch thick refractory material and is motor driven so as to control the volume of gases, draft and temperature. Preferably the secondary burning chamber within the modular units 22 and 23 is operated at a temperature from 1,800° to 2,000°F.

The modular units 22 and 23 are preferably each provided with an outer sheet steel housing 42, a first layer of block insulation 44 approximately $2\frac{1}{2}$ inches thick, and an inner layer of refractory material 46 which may be approximately $2\frac{1}{2}$ inches in thickness if an asbestos type lining is employed. Such a lining is again preferably employed to reduce the weight of the transportable units 22 and 23. A plurality of burner units 48 are

mounted in the sides and end wall of the units 22, 23 so as to insure burning of the solids in the smoke and gases within the chamber 22, 23. Also, suitable baffles (not shown) may be provided within the modular units 22, 23 to insure that the hot gases pass through the secondary burning chamber with sufficient distance of travel to eliminate smoke and insure the complete combustion of the gases.

Considering now the manner in which the primary and secondary burning chambers are preferably operated, the front and rear doors 38 of the primary burning chamber 20, 21 are electrically timed for proper entrance and exit of the car bodies. Approximately 20 minutes is required in the primary burning chamber during which about 300 pounds of combustible material will be removed from the metal car body.

After the combustibles have been removed from the car body, the discharge door at the rear end of the modular unit 21 is opened, the car body is removed, and this door is then closed. During this period of time the damper 40 is positioned so as to maintain the proper draft so that the gases will continue to go to the secondary burning chamber, and air keeps coming in the open exit door of the unit 21.

After the burned car body is removed, the entrance door 38 is opened, a new body is moved into the unit 20 and this door is then closed. As the temperature and volume of gases increases, the damper 40 is raised so as to maintain the proper draft and combustion. A pressure of approximately 0.2 inch of water is thus maintained in each of the primary and secondary burning chambers, by means of the exhaust fan 29 at the end of the unit 27.

The modular units 24, 25 are connected end to end to provide a spray chamber which is interconnected with the adjacent side of the chamber 23. A vertically movable baffle 50 is provided in the end of the unit 24 which communicates with the unit 23, the baffle 50 being driven by a suitable electric motor so as to cooperate in controlling the volume of gases, draft, etc. Each of the units 24, 25 is preferably provided with an outer housing 52 of sheet steel, and a refractory lining 54 on the sides, top and bottom of these units. The bottom portion 56 of the refractory lining is preferably sloped to one side to communicate with a water outlet 58 which empties into a sump or well 60 (FIG. 5). The sump 60 is provided with vertically extending baffles 62 and 64 which promote settling of the fly ash material to the bottom of the sump 60 before the water is drawn off through an outlet pipe 66 by means of a pump 68. The pump supplies the heated outlet water from the spray chamber 24, 25 through the pipe 70 to the cooler unit 28.

The units 24 and 25 are each provided with an open-topped water supply tank 72, 74. The tanks 72, 74 are supplied with water which has been cooled by the cooler 28, by means of the supply line 76, 78 and the pump 80, indicated diagrammatically in FIG. 7. Referring to FIG. 5, the spray chamber comprising the units 24, 25 consist of a number of flat piers 82, 83, 84, 85 and 86, extending from top to bottom of the units 24, 25. A nozzle 88 is provided at the upper end of each pier and communicates with the tanks 72, 73 through the inlet pipes 90. The nozzles 88 may simply comprise a flared end of the pipe 90 so that a stream or sheet of water continuously runs down each of the piers 82-86, inclusive. The piers provided in the units 24, 25 are

each of relatively small thickness as compared to their width and are arranged in rows which are staggered with respect to each other. Accordingly, as the hot gases from the secondary burning chamber are admitted to the spray chamber, they are washed to eliminate the fly ash still present in the gases to an amount which is acceptable for all air pollution code requirements.

More specifically, the hot gases containing fly ash are made to travel over a tortuous path whereby they are made to hit the staggered piers 82-86 in each row. When the gases hit these piers, the fly ash contained therein becomes trapped and water-logged so that it adheres to the walls of the piers, and is washed down these walls to the floor of the spray chamber. In this connection, it is pointed out that the sprays provided by the nozzles 88 are not in the form of a fine mist or spray but instead produce curtains or sheets of water which run down the surfaces of the piers 82-86. The fly ash thus becomes trapped in these curtains or sheets of water and is washed down the piers and into the sump 60 where the fly ash collects in the bottom thereof.

Since the water in the tanks 72 and 74 becomes quite hot, when exposed to the gases from the secondary burning chamber, it is necessary to cool it so that it can be used continuously. In this connection it will be understood that a cold water supply can be provided for the nozzles 88 but such an arrangement would require a much larger water supply when the incineration system is used over any prolonged period of time.

After the fly ash has settled to the bottom of the sump 60, water is removed therefrom through the pipe 66, the pump 68 and the outlet pipe 70 to the cooler 28. The cooler 28 is preferably an open-topped unit having a plurality of rows of vertically extending stand pipes 92, 94, 96 and 98 which are connected to the pipe 70 coming from the pump 68 through an intermediate line 100. Each of the pipes 92-98 terminated in a fine mist spray nozzle 102 so that the hot water coming from the pipe 70 is sprayed upwardly within the cooler 28 and is mixed with air so as to lower its temperature to approximately 150°F. As it is cooled, the water from the nozzles 102 falls to the bottom portion of the unit 28 and is drained off through the pipe 76, the pump 80 and return line 78 to the tanks 72 and 74 on the top of the units 24 and 25 respectively.

While a separate cooler 28 has been described for the purpose of cooling the water in the tanks 72 and 74, it is pointed out that the hot water produced in these tanks can, in the alternative, be used to do useful work and the cooler 28 eliminated. For example, the hot water from the tanks 72 and 74 may in accordance with the present invention, be used to heat a building. Furthermore, the constant temperature of this water makes it particularly suitable for heating structures, such as greenhouses, which must be held at a constant temperature over long periods of time.

After the hot gases in the secondary burning chambers 22, 23 have been washed to eliminate fly ash in the spray chamber 24, 25, they are then cooled and dried so that when exhausted from the stack 29 they will not produce a so-called steam plume which is objectionable. More particularly, after the fly ash has been removed from the hot gases in the spray chamber 24, 25, they are passed into a cooling chamber comprising the modular units 26, 27 which are connected end to end. The end of the modular unit 26 is interconnected with the adjacent side of the unit 25 and a damper 110 is

provided in the end of the unit 26 adjacent the unit 25, the damper 110 being motor controlled so as to provide the correct opening for proper draft, combustion, etc. through the units 22-27, inclusive. Also, in accordance with a further feature of the invention, the hot gases from the secondary chamber 22, 23 are employed to heat the wet gases emerging from the spray chamber 24, 25 so that the above-described steam plume is eliminated without requiring additional energy for drying of the gases in the chambers 26, 27.

The drying chamber 26, 27 includes an outer housing 112 (FIG. 6) and a floor 114 and roof 116 of refractory material. In addition, a number of walls of refractory material are provided to define channels for the wet gases which flow past walls heated by the hot gases from the chamber 22, 23. Thus, a first pair of walls 116, 118, is provided to define a channel 120 within which hot gases from the unit 23 are introduced through the pipe 122 which communicates with the pipe 124 connected to the unit 23. Wet gases from the spray chamber 25 are introduced in the adjacent channel 126. The next pair of walls 128 and 130 of refractory material define a second hot gas channel 132 which is connected to the channel 120 through an overhead pipe 134 (FIG. 1). The hot gases are exhausted from the end of the unit 27 through a pipe 136 which is connected to a pipe 138 which feeds the hot gases back to the secondary burning chamber 22 through an induced draft fan 140 and the pipe 142.

The wet gases from the chamber 25 are also admitted through a channel 144 where they strike the wall 130 and a wall 146 which is heated by hot gases within the channel 148 also connected to the pipe 124. In a similar manner wet gases introduced through the channel 150 are dried by exposure to the walls 152 and 154 which are heated respectively by the hot gases within the channel 148 and the channel 156. An outer wall 158 of refractory material is also provided. The hot gases from the channel 148 are supplied to one end of the channel 156 by means of the overhead pipe 160, and are exhausted through the pipe 162 at the other end of the channel 156.

The exhaust fan 129 is provided with a plurality of openings 170, 172 and 174 communicating respectively with the channels 126, 144 and 150 at the far end of the unit 27 so that the gases which have been cooled and dried during transmission through the units 26 and 27 may now be exhausted to the atmosphere without producing a steam plume. In order to prolong travel of the wet gases through the units 26, 27 a number of vertically extending baffles 180, 182, are provided in the channels 126, 144 and 150 so as to prolong the exposure of the wet gases to the heated walls in the drying chamber.

While the incineration system of FIGS. 1 to 8, inclusive, has been described in connection with a car body incineration operation, it will be appreciated that the features of this invention may be employed when burning any type of combustible material in large quantities. For example, the incineration system of FIGS. 1 to 8, inclusive, may be readily employed to burn garbage for city and municipality operations. In the event that garbage is to be burned, the primary combustion chamber 20, 21 is capable of providing the additional feature of preventing the formation of clinkers at the edges of the moving conveyor, as shown in FIG. 9. Thus, referring to FIG. 9, the stoker or moving grate 190 is positioned

inwardly of the side walls 192 of refractory material so as to provide a ledge 194 of refractory material which is preferably approximately 1 foot in width. In accordance with the invention, the garbage to be burned is distributed by suitable means so that it is piled onto the conveyor 190 in such manner that it extends beyond the moving portion of the conveyor 190 and onto the ledge 194, as indicated by the pile of material 196. If the side wall of the primary burning chamber is positioned adjacent the moving edge of the conveyor, and no ledge 194 is provided, the air, which must be forced upwardly through the holes in the stoker 190 to promote combustion, is also forced up along the edges 198 of the moving stoker at a point where the thickness of the material to be burned is relatively small. Accordingly, a blast effect is produced when the ledge 194 is not provided which induces the formation of large clinkers which ultimately jam the stoker and cause it to stop, or, in some instances, cause breakage of the drive mechanism therefor.

When the ledge 194 is provided, a relatively thick pile of material accumulates over the opening 198 between the moving stoker 190 and the inner edge of the ledge 194 so that the air cannot rush through this material and cause the production of clinkers. However, the portion of the material 196 which is positioned on the ledge 194 burns clear out to the side wall 192 when proper operating temperatures in the order of 1,800°F. are employed. The opening 198 is thus covered by a moving mass of material a portion of which is being pushed over onto the stationary ledge 194. By this arrangement a blast furnace effect is eliminated at the edges of the moving conveyor 190 and clinkering is substantially reduced or in some instances completely eliminated.

In FIGS. 10 to 12, inclusive, of the drawings, there is illustrated an alternative embodiment of the invention wherein a different arrangement is employed to eliminate the conventional steam plume at the exhaust of the incineration system. Referring to these figures, the units 20, 21, 22, 24 and 25 of the incineration system of FIGS. 10 to 12, inclusive, are substantially identical to the embodiment shown and described heretofore in connection with FIG. 1. However, the wet gases from the output of the spray chamber unit 25 are supplied through an adjustable baffle 110 to a single modular collecting chamber indicated generally at 200 which is provided with a plurality of oppositely directed partitions 202, 204 and 206.

The modular unit 200 is lined with a wall of approximately 2-inch thickness of refractory material which has the effect of keeping the wet gases from rusting out the metal walls of the unit 200. An exhaust fan 210 is mounted in the top wall of the unit 200 and the outlet of the exhaust fan 210 is supplied by way of a relatively large conduit 212 to a plenum chamber 214 positioned beneath the secondary heating chamber 23a, the plenum 214 extending transversely across the width of the chamber 23a. The chamber 23a is substantially identical to the chamber 23 described heretofore, except for the addition of the plenum 214 and a plurality of stainless steel pipes 216 which extend vertically through the secondary heating chamber 23a and are connected at the bottom end thereof to the plenum 214 beneath the floor of the unit 23a. Thus, as shown in FIG. 11, the pipes 216 are connected to the plenum 214 and extend through the bottom and top walls of the unit 23a.

With the arrangement of FIGS. 10 to 12, the wet gases exhausted by the fan 210 are diverted back through the secondary combustion chamber 23a where they are reheated an amount sufficient to dry the gases so that a steam plume is not produced when they are exhausted to the atmosphere through the open upper ends of the pipes 216. However, the clean gases which are diverted back through the chamber 23a do not come into contact with the dirty combustion gases in the chamber 23a since they are within the stainless steel tubes 216.

In order to prevent the stainless steel pipes 216 from wearing out quickly under the abrasive force of the fly ash and other particles contained in the gases moving through the secondary combustion chamber 23a, a shield 220 of abrasion resistant refractory material is provided around the upstream portion of each of the pipes 216 so as to prevent the sides of these pipes which are exposed to the rapidly flowing gases from direct contact with particles carried by these gases. The diameter and number of the pipes 216 is chosen so that the wet exhaust gases supplied to the plenum 214 are dried out sufficiently in traversing the length of the pipes 216 that a steam plume is substantially eliminated as these dried gases are emitted to the atmosphere.

It is also pointed out that an arrangement for eliminating steam plume similar to that shown in FIGS. 10 to 12 may be employed, in accordance with the present invention, in existing non-portable incineration systems. Thus, the output of the exhaust fan of such systems may be diverted back through the secondary combustion chamber of the system by employing an arrangement similar to the plenum 214 and pipes 216 so that the wet exhaust gases are dried sufficiently to eliminate the plume.

In accordance with a further aspect of the present invention, a chemical is injected into the wet gases present in the chamber 200 so as to solidify particular vapors present in the exhaust stream. To this end, a pressurized spray unit, indicated generally at 222, is provided outside the modular unit 200 and a series of vertically extending rows of nozzles 224 are arranged to inject chemical sprays into the wet gases which are pulled around the partitions 202, 204 and 206 in the chamber 200. These sprays contain suitable chemicals such as alkali which react with certain components of vapors present in the exhaust stream to form solids and thereby provide improved cleaning action so that the gases exhausted by the fan 210 are essentially free from the solidified components.

Referring now to the alternative embodiment shown in FIGS. 13 to 15, inclusive, a transportable primary burning chamber arrangement is shown therein which may be incorporated in either of the total incineration systems shown in FIG. 1 or FIG. 10. In the alternative embodiment of FIGS. 13 to 15, inclusive, an improved primary combustion arrangement is provided in the transportable modules 20a and 21a, which is particularly adapted for transmitting garbage and refuse through the primary burning chamber without clogging and includes the re-utilization of the dried gases, after addition of oxygen, to assist combustion in the primary burning chamber while providing increased efficiency of the overall system. More particularly, referring to this figures, a series of hollow rotatable cylinders 230 are rotatably mounted within the modules 20a and 21a, the cylinders 230 being arranged in a downwardly slop-

ing array with a series of anticlogging members 234, of generally tee-shaped cross section, interposed between the rollers 230. The tee-shaped stationary members 234 may be supported in any suitable manner from the bed of the module units 20a and 21a with a slight clearance between the edges of the members 234 and the adjacent rotating cylinders 230. While the cylinders 230 are illustrated in a gradually sloping array, they may also be arranged in a series of vertical steps so that the material to be burned is moved off of a step and drops downwardly into the next step and is carried forwardly on this step by the rotating rollers 230. The members 234 may be supported at any desired angle between the rollers in the vertical fall of each step to facilitate movement of the material down the array.

The cylinders 230 are provided with a large number of small openings 232 throughout the length thereof so that the dried exhaust gases of the system may be supplied to the interior of these cylinders, after additional oxygen is added, to assist in the combustion of the material within the primary burning chamber, as will be described in more detail hereinafter. At the juncture of the two modules 20a and 21a, a supporting plate 236 may be placed between the adjacent cylinders 230 after these two module units have been assembled at the site of the incineration system.

The side walls 238 and 240 of each module unit, which are lined with refractory lining, as described in detail heretofore, support a pair of inwardly extending aprons 242 and 244 which are inclined downwardly to a point somewhat inside of the ends of the cylinders 230 so as to contain the refuse 246 on top of the cylinders 230 as this material moves through the module units 20a and 21a. The aprons 242 and 244 thus divide the modules 20a and 21a into an upper chamber 243 and a lower chamber 245 (FIG. 14). The aprons 242 and 244 may either be of a metal which will withstand the flame temperature which will be produced at the edges of the pile of material 246 where much of the burning occurs, or preferably these aprons may comprise extensions of refractory brick built out from the walls 238 and 240 above the array of rotating rollers 230. Above the uppermost one of the rollers 230 and approximately midway of the top wall 250 of the module unit 20a, a burner 248 is mounted, this burner being connected to the conduit 252 from a suitable source of fuel so as to provide primary ignition of the refuse at the horizontal center of the stoker.

One end of each of the cylinders 230 is closed by means of a plate 254 and each cylinder is rotatably mounted in a bearing block 256, these blocks being supported from the floor of the module units 20a and 21a by means of the members 258. A chain driven gear 260 is mounted on the end of each of these supporting axles so that the rollers 230 may be rotated at any desired speed by means of a suitable driving motor (not shown). In the alternative, different groups of rollers 230 may be arranged to be driven from separate driving motors so that the refuse may be moved through the module units 20a and 21a at different speeds in different combustion areas thereof.

The other end of the cylinders 230 is supported by means of a spoked wheel 266 which is mounted on an axle 264 which extends through an inlet conduit 268 and is rotatably mounted in the bearing block 262 carried by the supporting member 270. This other end of the cylinders 230 is thus essentially open to receive air

supplied through the individual conduits 268 so that air may be forced outwardly through the holes 232 of the cylinders 230.

In accordance with an important aspect of the invention the upper chamber 243, which is separated from the lower chamber 245 by means of the aprons and the material 246 to be burned, is operated at a slightly negative pressure whereas the lower chamber 245 is operated at a positive pressure so that the exhaust gases and the air mixture which is supplied to the inside of the cylinders 230 is forced inwardly through the material 246 and assists in the combustion of this material as it moves along the cylinders 230. To this end the individual conduits 268 may be connected to a common header system which is connected to suitable forced draft fans which receive the exhaust gases from the induced draft exhaust fans 29 (FIG. 1) or 210 (FIG. 10) and mix these gases with air to reduce the temperature thereof and provide oxygen for combustion. More particularly, the exhaust gases from the induced draft fans 29 or 210, which are at minus 3 inches static pressure and 400°F., are converted to an exhaust gas and air mixture at plus 3 inches static pressure and 200°F. This mixture is supplied to the conduits 268. Also, the pressure in the bottom chamber 245 is maintained at plus three inches and 200°F., either by supplying this mixture to the chamber 245 or by suitable forced draft fans opening directly into the chamber 245. The induced draft fans 29 or 210, which establish a negative pressure throughout the entire incineration system, will provide a negative pressure of approximately minus 1 inch in the upper chamber 243 so that the hot gases supplied to the interior of the cylinders 230 is forced upwardly through the material 246 and assists combustion thereof, particularly at the edges adjacent the aprons 242 and 244 where the pile of material 246 is of minimum depth.

Considering now the operation of the arrangement shown in FIGS. 13 to 15, inclusive, the debris or refuse is initially loaded onto the upper end of the array of rollers 230 by means of any suitable feed conveyor arrangement such as an apron conveyor, or the like, so that the refuse is deposited through the intake area onto the first group of rollers 230 adjacent the burner 248. After sufficient material has been deposited to separate off the chambers 243 and 245 from each other, the supply of air necessary for combustion is furnished by means of one or more induced draft fans 29 or 210 which are located at the far end of the system, as described heretofore, these fans being controlled to start after the burner 248 has ignited the refuse at the horizontal center of the stoker. These induced draft fans will be controlled to start after sufficient combustion gases have been developed to provide the necessary draft requirements. After combustion has started and dried gases are developed in the drying chamber 27 (FIG. 1) these dried gases from the outlets of the induced draft fans 29 or 210 are mixed with air in forced draft fans provided with a Venturi type air intake so that the temperature of the mixture is reduced and pressure thereof is increased, as described in detail heretofore. This mixture is connected through a suitable header arrangement to each of the ducts 268 leading to the interior of the rotatable cylinders 230, this header being provided with a suitable controlled damper so that this mixture is supplied to the inside of the cylinders 230 after proper combustion has been

started. The motor, or motors, controlling the rotation of the cylinders 230 may again be energized so as to cause the refuse 246 to move down the gradually sloping array of rotating cylinders 230, these cylinders being self-cleaning by virtue of the tee fittings 234 provided between these cylinders so that clogging is positively prevented. The speed of rotation of the cylinders 230 is properly regulated to allow sufficient burning time within the various zones of the modules 20a and 21a. Since the nature of the refuse materials themselves will require different lengths of time for complete reduction, the speed of rotation of the cylinders 230 will obviously be modified to accommodate the required burning time within the primary burning chamber. A suitable conveyor system may be provided along the floor of the module units 20a and 21a to remove siftings which pass through the cylinders 230 and fines which pass through the spaces between the tee fittings 234 and the rotating cylinders 230, as will be readily understood by those skilled in the art. If desired, the modules 20a and 21a may be utilized ahead of other modules, such as the modules 20 and 21 (FIG. 1) to provide a more extended primary burning chamber for more complete combustion of the material to be burned. In either event, the material remaining at the exit of the module 21a is discharged in any suitable manner to a suitable refuse pit or to a succeeding primary burning chamber unit.

While there have been described what are at present considered to be the preferred embodiments of the invention, it will be understood that various modifications may be made therein which are within the true spirit and scope of the invention.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A portable incineration system comprising a transportable body, the body being provided with first and second combustion chambers, a charging door on the body for introducing combustible material into the first combustion chamber, means in the first combustion chamber for producing the primary incineration of combustible material, means in the second combustion chamber for producing the secondary incineration of combustible material incompletely incinerated in the first combustion chamber, means in the body for removing a substantial portion of particles suspended in the atmosphere of the body following primary and secondary incineration by entraining said suspended particles in a downwardly flowing film of water, a discharge means for discharging residue from the body, means for transporting combustible material and residue from the charging door to the discharge means, and means for drying the wet gases after they have traversed said downwardly flowing film of water, whereby said dried gases may be exhausted to the atmosphere without producing an objectionable steam plume.

2. The portable incineration system of claim 1 wherein means are connected to the body to maintain a negative pressure within the chambers of the body between the charging door and the discharging means to provide draft for the burning process.

3. The portable incineration system of claim 1 wherein the transportable body comprises a plurality of separably interconnectable and transportable modules.

4. The portable incineration system of claim 3 wherein the charging door and first combustion chamber comprise a first pair of transportable modules and

include means for connection in communication with another module, the secondary combustion chamber comprises a second pair of transportable modules and including means for connection in communication with one of said first pair of modules and with another module, and the means for removing a substantial portion of the suspended particles in the atmosphere of the system and the discharge means comprises a third pair of transportable modules for connection in communication with one of said second pair of modules.

5. The portable incineration system of claim 3 wherein the means for transporting combustible material and residue from the charging door of one of the modules to the discharge means of another of the modules comprises mechanical conveyor means.

6. A portable incineration system comprising a transportable body, the body being provided with first and second combustion chambers, a charging door on the body for introducing combustible material into the first combustion chamber, means in the first combustion chamber for producing the primary incineration of combustible material, means in the second combustion chamber for producing the secondary incineration of combustible material incompletely incinerated in the first combustion chamber, means in the body for removing a substantial portion of particles suspended in the atmosphere of the body following primary and secondary incineration, a plurality of vertically extending piers positioned in the path of hot gases laden with suspended particles, and means for producing a continuous downwardly flowing film of water on the surfaces of said piers exposed to said gases, whereby said suspended particles are entrained in said water film and washed downwardly to the bottom of said piers.

7. The portable incineration system of claim 6, wherein there is provided means for cooling the water which has been exposed to said hot gases and re-using the same in further entraining of particles suspended in said hot gases.

8. The portable incinerator system of claim 6, wherein the water at the bottom of said piers is employed as a source of substantially constant heat and is then re-used to produce said continuous film of water.

9. The portable incinerator system of claim 6, wherein means are provided for drying the wet gases after they have traversed said film covered piers, and exhausting said dried gases to the atmosphere without producing an objectionable steam plume.

10. The portable incinerator system of claim 9, wherein said wet gases are dried by heat derived from said second combustion chamber.

11. The portable incinerator system of claim 9, which includes a collection chamber connected to receive the wet gases which have traversed said piers, a plurality of exhaust tubes extending through said second combustion chamber, and means exhausting the wet gases in said collection chamber through said tubes to the atmosphere, said wet gases being dried by heat derived from said second combustion chamber as they traverse said tubes.

12. The portable incinerator system of claim 11, wherein means are provided for protecting said tubes against wear on the side thereof exposed to movement of gases through said second combustion chamber.

13. In a stoker fed incinerator system, the combination of, a combustion chamber lined with refractory material, a stoker for carrying combustible material

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through said chamber, said stoker being positioned in the floor of said chamber, means for forcing air upwardly in the space between the sides of said stoker and the adjacent edges of said floor, said floor having sufficient width to form relatively wide ledges extending away from and on substantially the same level as said stoker, and means for depositing material to be burned on said stoker so that it covers said space with a layer of material of substantial depth, thereby to avoid the formation of large clinkers between said stoker and said adjacent floor edges.

14. The portable incineration system of claim 1, wherein said wet gases are dried by heat derived from said second combustion chamber.

15. In a stoker fed incinerator system, the combination of, a combustion chamber lined with refractory material, a series of elongated hollow cylinders, positioned transversely of the path of movement of material through said chamber, and closely spaced one to another,

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means for rotating said cylinders so as to move material along said path at a desired rate, stationary means positioned between said cylinders near the upper edges thereof so as to form with said upper edges of said cylinders a downwardly sloping bed over which the material may be moved, means defining a plurality of openings in each of said cylinders, means for supplying combustible gas under pressure to the interior of said cylinders, and means enclosing the bottom portions of said cylinders, whereby said gas is forced upwardly through said openings and through the material thereon to assist in the combustion thereof.

16. The combination of claim 15, wherein said stationary means comprises a series of members of tee-shaped cross section positioned between said cylinders, the edges of said tee-shaped members being positioned close to said rotating cylinders to prevent clogging thereof.

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