Jan. 16, 1962 H. A. MARKLE, JR., ET AL 3,016,849

INCINERATOR FOR WASTE MATERIAL

Filed Aug. 18, 1959 2 Sheets-Sheet 1

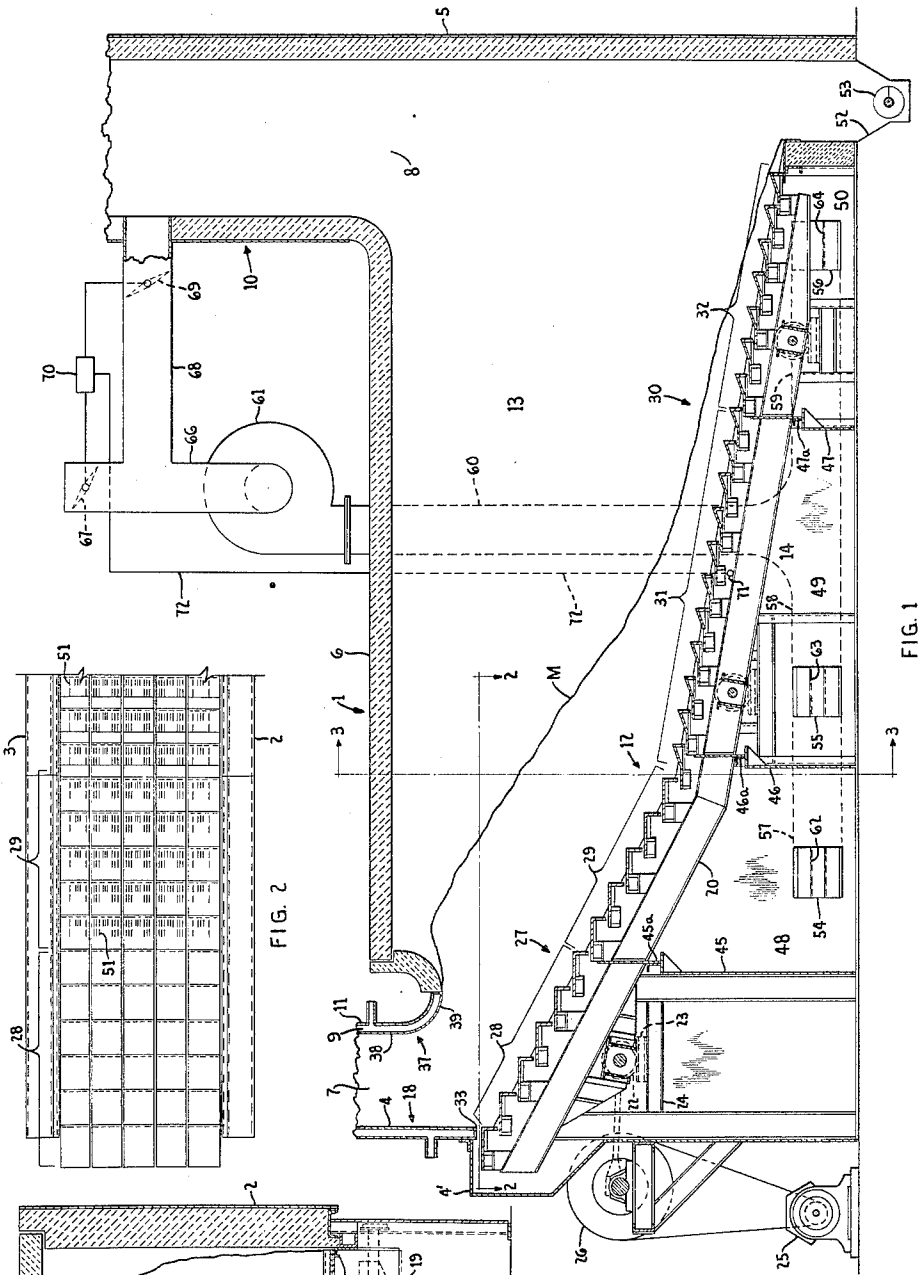


FIG. 1

FIG. 2

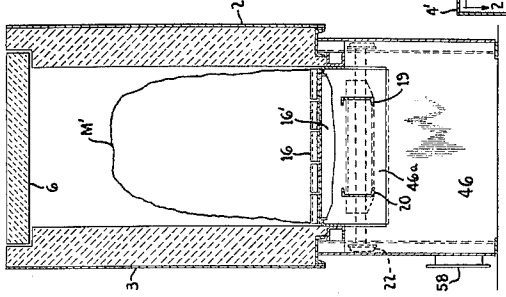


FIG. 3

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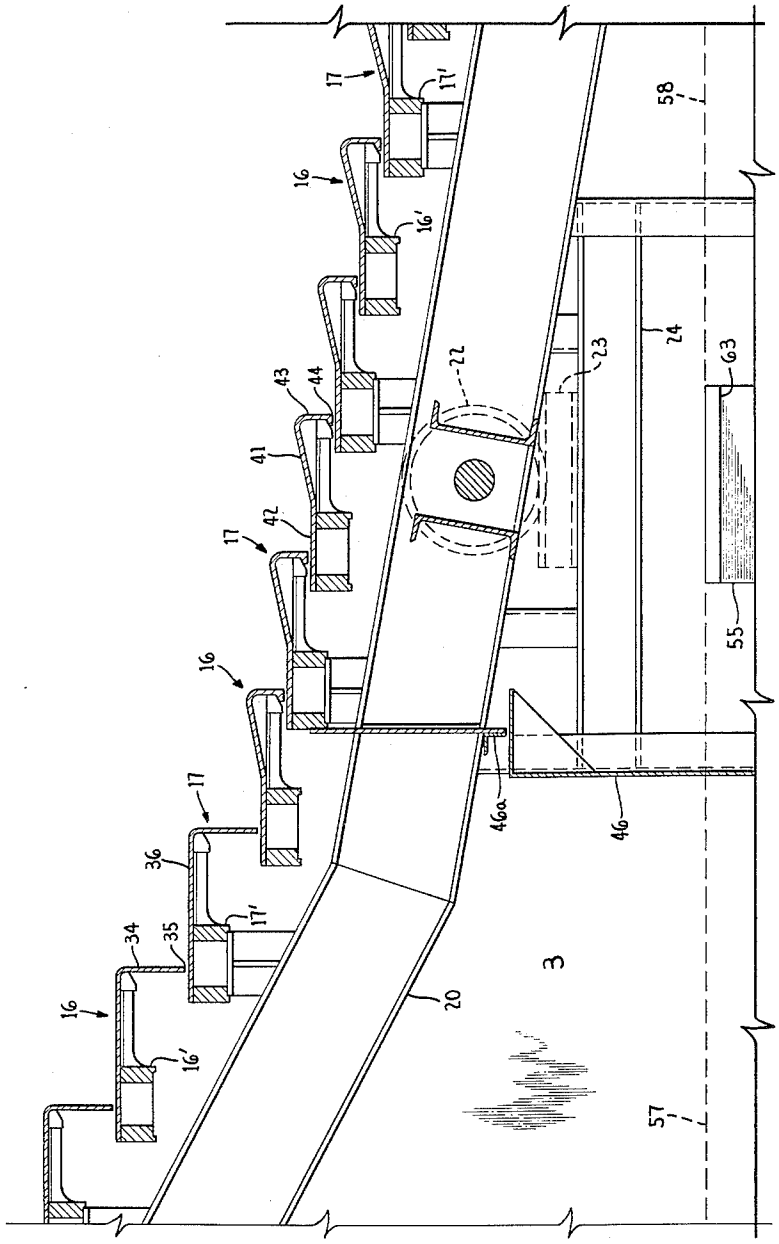


FIG. 4

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INCINERATOR FOR WASTE MATERIAL

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2 Claims. (Cl. 110—18)

The present invention relates to the treating and conveying of solid materials, and is more particularly concerned with the conveying of materials which exhibit changing characteristics during such treatment.

In the case of the incineration of garbage and refuse, the material to be incinerated is fed to an incineration zone in a random state, and during the combustion operation, progressively diminishes in bulk and volume due to the burning of the combustibles therein, thereby creating a progressively changing conveying problem.

The expedients employed heretofore to accommodate the changing characteristics of materials undergoing treatment in a conveying or transferring zone have included complex feeding, conveying, and discharge systems requiring multiple drives, compartmentation of the treatment zone or zones, and other arrangements, none of which has been found to be entirely satisfactory.

In general, the preferred form of apparatus of the present invention, when embodied, for example, in a refuse and garbage incinerator, comprises a generally horizontal treating and conveying chamber having a material inlet and a gas outlet at opposite ends thereof, an air or gas inlet in its lower region and an incinerated material discharge at the end thereof remote from the material inlet.

The chamber is divided into an upper subchamber and a lower subchamber by a grate assembly comprising a plurality of transversely-extending grates, or rows of grates, arranged as first and second sections, with each section comprising a plurality of zones, with alternating rows of movable grates arranged to reciprocate between rows of stationary grates. The grates of the first section, which are below and adjacent the material inlet, are arranged in a relatively steep decline from adjacent the inlet toward the discharge end of the chamber. The second section of grates is contiguous with the first section and extends therefrom toward the discharge end of the chamber on a lesser angle of decline intersecting the plane of the first section and, in some cases, in a substantially horizontal plane. The first series of grates incline downwardly in relatively high steps from a first movable grate, which alternately protrudes beyond and recedes from the outer edge of the material inlet adjacent the inlet end of the chamber.

The reciprocation of the movable grates over the stationary grates causes the overlying material to be advanced over the grates and to cascade downwardly over the grates of both grate sections to a discharge hopper.

The grates of the first zone of the first, steeply-declining section, underlie the material inlet, and are imperforate to prevent the passage of gas upwardly therethrough and through the material inlet, while the remaining grates of the first section are perforate and form a second grate zone. The grates of the second or less steeply inclined section of grates are perforate and form third and fourth grate zones. The perforations in the grates permit the passage of an oxygen-containing gas, generally air, upwardly therethrough for supporting combustion of the material overlying the grates. The lower subchamber is divided into separate air-supply compartments beneath the respective zones of the grate assembly, and further serve to divide the grates of the second section into the third and fourth grate zones.

Air or other oxygen-containing gas is supplied to the

air-supply compartments of the lower subchamber to pass upwardly through the grates of the second, third and fourth zones and into the overlying material to supply the necessary oxygen to support combustion of the material as it is moved downwardly along the conveying grates.

The invention will be further described in connection with the accompanying drawings wherein it is shown as embodied in an incinerator.

In the drawings:

FIG. 1 is a longitudinal, vertical sectional view of an incinerator embodying the invention;

FIG. 2 is a partial plan view of the conveying grates taken along the lines 2—2 of FIG. 1;

FIG. 3 is a transverse, vertical sectional view taken along the lines 3—3 of FIG. 1, and

FIG. 4 is an enlarged sectional view of a portion of the conveying grate structure shown in FIG. 1.

As shown in the drawings, the incinerator includes a generally horizontally disposed chamber 1 having side walls 2 and 3, end walls 4 and 5, and a top wall 6. The top wall 6 has a material inlet 7 and a gas outlet 8 at opposite ends thereof. The walls are constructed of, or internally lined with a suitable temperature-resistant refractory material. The material inlet communicates with the lower end of a material feed conduit 9, while the gas outlet 8 communicates with a gas exhaust stack 10. The lower portion of the material feed conduit 9 is provided with a suitable water jacket 11, through which water is circulated to protect it from the heat within the chamber resulting from the burning of the material therein.

A converging grate assembly 12 is arranged within the chamber and divides it into an upper subchamber 13 and a lower subchamber 14. The grate assembly comprises a plurality of transversely-extending rows of fixed grates 16 alternating with rows of movable grates 17. The fixed grates are mounted on fixed frames 16' while the movable grates are carried by movable frames 17'.

The fixed frames 16' are supported at their ends on the side walls 2 and 3 by suitable means, such as bolts. The movable frames 17', carrying the alternate rows of movable grates, beginning with the uppermost row of grates adjacent the outer edge 18 of the material inlet 7, are mounted by suitable means on a reciprocating framework comprising a pair of transversely spaced side rails 19 and 20. These side rails are, in turn, mounted by a plurality of wheels 22 on a corresponding plurality of horizontal track rails 23 mounted on supports 24. The side rails 19 and 20 and the associated movable frames 17' and movable grates 17 are reciprocated in a direction parallel to the horizontal plane of the track rails 23 by driving means such as a variable speed gear-motor 25 and a crank drive 26.

The grates of the assembly are arranged as a first section 27, comprising a first zone 28 and a second zone 29, underlying and adjacent the material inlet 7, and a contiguous second section 30 extending forwardly from the first section and including a third zone 31 and a fourth zone 32 toward the end of the chamber adjacent the gas outlet 8. The grates of the first section 27 are arranged on a plane sloping downwardly from the outer edge 18 of the material inlet at an angle of between 25° and 35° from the horizontal, and preferably at an angle of about 28°, which has been found particularly advantageous. The uppermost grate of the first zone 28 is arranged to protrude and recede on its successive forward and rearward strokes with respect to the lower edge 33 of the inlet 7, thereby providing a completely open material passage beneath the inlet during the rearward grate stroke, and a positive engagement of material by the grate on its forward stroke, thereby precluding a build-up or jamming of material in that zone.

To permit the uppermost grate of the first zone to recede back from the lower edge 33 of the inlet, an extension 4' of the chamber is formed on the rear wall 4 into which the upper end of the grate structure extends.

The grates of the first series 27 are provided with substantially vertical forward faces 34 which are six to eight inches or more in height and which terminate at their lower edges 35 in slightly spaced relationship with the upper surfaces 36 of the adjacent downstream, or next lower grate. The upper surfaces 36 of the grates of the first section are substantially flat and arranged generally horizontally, thereby permitting horizontally reciprocating, relative motion between their forward lower edges 35 and the upper surfaces 36 of the next lower grates.

The second grate section 30 extends at a lesser slope from the horizontal, which preferably is between about 0° and 15°, and is shown as about 11°, on a plane intersected by the plane of the first section. The forward portions of the upper surfaces of both the stationary and movable grates of the second section are upwardly inclined from the horizontal so that the upper surfaces comprising two contiguous intersecting planes 41 and 42 with the rearward plane 42 lying substantially horizontally and parallel to the direction of the horizontal reciprocation of the movable grates and the forward plane 41 inclined upwardly therefrom at an angle of about 10°. Each grate of the second section has a forward face 43 about four inches in height which extends downwardly from the front edge of the upper forward surface 41 toward and terminating in an edge 44 a slight distance above the rearward surface of the next lower grate to provide a running clearance therebetween.

The lower subchamber 14 beneath the second zone of the first grate section and beneath the second grate section is subdivided by a plurality of transverse partitions 45, 46 and 47, into three compartments 48, 49 and 50, respectively. The rails 19 and 20 in these compartments carry transverse, auxiliary, movable partition members 45*a*, 46*a* and 47*a* which cooperate with the partitions 45, 46 and 47, respectively, to seal the compartments. The grates of the second, third and fourth zones 29, 31 and 32, above compartments 48, 49 and 50, respectively, are provided with elongated perforations or slots 51 in their upper surface, so that air or other oxygen-containing gas forced into those compartments may pass upwardly through the grates into the overlying material. The grates of the first zone 28 are not provided with such perforations or slots. The grates of each row adjacent the side walls 2 and 3 preferably are provided with fewer slots than those in the central grates to offset the tendency of the air to short-circuit upwardly along the walls 2 and 3.

The end of the second grate section 30 discharges to a hopper 52 having suitable ash removal means, such as a screw conveyor 53.

The side wall 3 is provided with air inlets 54, 55 and 56 communicating individually with the compartments 48, 49 and 50, respectively. The air inlets 54, 55 and 56 communicate by way of individual branch ducts 57, 58 and 59, respectively, with an air supply duct 60 which receives air under pressure from a fan 61. The branch ducts 57, 58 and 59 are provided with dampers 62, 63 and 64, respectively, to permit control of the amount of air supplied to the compartments 48, 49 and 50. The fan 61 has an intake connected to an intake duct 66 having a valve 67 therein and communicating with the atmosphere. A recycle duct 68 having a valve 69 therein communicates at one end with the intake duct 66, in the region between the fan intake and the valve 67, and at its other end with the exhaust conduit 10 leading from the gas outlet 8.

A temperature-responsive control 70 is arranged to regulate the valves 67 and 69 to adjust the relative volumes of air and gas drawn to the fan from the atmosphere and from the exhaust conduit for recycling, and, as shown, includes a thermocouple 71 located just beneath a grate of the third grate zone 31 and connected thereto by a line 72. The thermocouple 71 and control 70 maintain the valves 67 and 69 in positions in which the fan 61 draws a portion of the hot gases from the stack 10 through the recycle duct 68 to preheat the air supply to the compartments. The control 70 preferably is adjustable, to permit optional variation of the degree of air preheating. If for any reason the temperature of the air supplied to the compartments becomes too high or too low, the thermocouple actuates the control 70 to adjust the valves 67 and 69 and to re-establish the desired gas temperature which may be, for example, about 600° F., thereby providing for substantial preheating of the air while retaining a safe degree of cooling of the grates.

At the inner edge 37 of the material inlet 7, an arch or throat member 38 extends downwardly from the material feed conduit, generally vertically toward the first grate section 27. The lower region of the throat member 38 is formed as a curved section 39, with the curvature proceeding on a uniform radius from the plane of the inner edge of the material feed conduit downwardly and inwardly toward the adjacent chamber wall to provide a clearance space between its curving surface and the plane of the first grate section for the flow of material from the material feed conduit onto the first grate section. The clearance space preferably is at least equal to, but not more than six inches greater than the distance between the outer and inner edges, 18 and 37 respectively, of the material inlet, thereby providing an adequate passage for the material without permitting loosening of the material before it enters the combustion zone, which might permit leakage of air through the loosened material and into the feed conduit 9 with resultant combustion of the material therein.

The compaction of the material is substantially maintained over the first zone 28 by the opposed forces of the pushing effect of the movable grates in the upper portion of that zone, and by the restraining effect of the throat member 37. The material compaction and the absence of air supply through the grates of the first zone 28 are effective in preventing the escape of air or combustion gases or progression of the combustion zone upwardly through the throat and into the feed conduit 9 to the dumping floor or area.

Upon emerging from beneath the throat member 38, the refuse is free to expand upwardly toward the top wall 6, and is also subjected to the expanding effect of air or gas forced upwardly through the perforations 51 of the grates of the second zone 29 and into the overlying refuse in that zone.

In operation, the motor 26 and fan 61 are started, thereby reciprocating the movable portion of the grate assembly and delivering a supply of air to the compartments 48, 49 and 50 to pass upwardly through the slots 51 of the grates. Refuse is dumped into the feed conduit 9 by any suitable means and, upon continued dumping, collects in the conduit and throat area in a relatively compact state.

The reciprocation of the movable grates of the first zone 28 causes the refuse thereabove to cascade downwardly over the grates of that zone away from the inlet region and onto the grates of the second zone 29. This is caused by the uppermost movable grate of the first zone 28 receding behind the lower edge 33 of the end wall 4, allowing the material to fall down onto the upper surfaces 36 of the adjacent fixed grates. On the forward stroke, the forward faces of the uppermost movable grates positively engage the material on the subjacent stationary grates and move it forwardly toward the combustion zone until it is forced over the forward edges or noses of the subjacent stationary grates onto the upper surfaces of the next lower movable grates which also are moving forwardly. As the movable grates move backwardly, the noses of the next upper stationary grates

act as abutments preventing backward movement of the material on the backward moving grates and cause the material on each of the backward moving grates to be pushed off of those grates, over their noses, onto the next subjacent stationary grates. In this manner the material is caused to cascade downwardly over the grates. The uppermost grates then recede again behind the edge 33 to allow further material to fall.

The complete withdrawal of the uppermost grate of the first zone 28 from beneath the inlet 7 is especially advantageous in that any tendency of the refuse toward jamming in the throat is opposed by the repeated positive displacement of different portions of the material in the inlet 7 by the forward movement of the uppermost grate of that zone.

As the first of the material cascading downwardly over the grates of the first grate section reaches the junction of the second and third zones 29 and 31, the leading edge thereof is ignited by any suitable means. Upon ignition, the material is progressively reduced in solid volume by the combustion, until only the ash and the non-combustible residual content thereof remain to be discharged into the hopper 52 to be carried away by the screw conveyor 53. The line M of FIG. 1 describes a typical upper surface line of the material in the incinerator during continued operation.

As refuse from the imperforate grate zone 28 passes onto the slotted grates of the second zone 29 over compartment 48, the compaction of the material established in the throat zone tends to resist air flow or substantial penetration of air into the inner regions of the material. Therefore, the air supplied to compartment 48 tends to by-pass the slots of the middle grates and to short-circuit upwardly between the walls 2 and 3 and the material mass, although at a rate limited by the lesser number of slots in the grates adjacent those walls. This short-circuiting air favors combustion of the material adjacent the walls, forming an upwardly-widening channel in the material adjacent each wall, as indicated by the material outline M' of FIG. 3. Under the agitation caused by the movable grates, material from the upper portions of the longitudinal central zone of the material mass is loosened and a portion thereof falls into the channels adjacent the walls, utilimately causing a loosening of the material which permits air passage through and combustion of the inner zone of the material.

The flame or combustion zone tends to progress backwardly toward the inlet area but is limited in such travel by the relatively compact, unaerated material being moved over the imperforate grates in the inlet zone toward the combustion zone, as well as the absence of a positiev air supply to the first zone and by the constant forward advancement of the moving head of burning material.

When combustion has been established, the dampers 62, 63 and 64 are adjusted to regulate the air flow to the respective compartments 48, 49 and 50 and through the grate zones 29, 31 and 32, respectively. It has been found particularly advantageous to deliver air through the second grate zone 29 at a rate per unit area substantially in excess of the combustion requirements of the overlying material, while delivering a lesser flow of air through third or main combustion zone 31 at a rate meeting the combustion requirements of the lesser amount of the overlying combustible material, and supplying an even lesser air flow through fourth zone 32 at a rate per unit area sufficient only to complete combustion of the combustible component of the overlying residue.

The relatively cooler air passing upwardly through the grates serves to protect the grates from the extreme temperatures thereabove.

The excessive air flow through the grates of the second zone 29 has an agitating and loosening effect on the relatively compact material received in that zone from the first zone 28. It also causes a drying of the material and supports the preliminary combustion thereof.

The reduced number of slots 51 in the grates adjacent the side walls 2 and 3 not only reduces the tendency of the air to short-circuit through those grates and along the side walls, but results in a greater amount of the air being forced into the longitudinal-central portion of the mass of material with greater agitation and air penetration of the material in the inner regions thereof.

The air flow through the grates of the third zone 31, in which the greatest part of the combustion and reduction in bulk volume of the material occurs, is at least equal to, but not substantially in excess of the combustion requirements of the material. These requirements will vary with different materials, different material feed rates, and with differences in the degree of drying and burning which are effected in the material as it passes through the preceding second zone. The air flow through the fourth zone 32 is also subject to the same variations, as well as to the extent of combustion of the material as it passes through the third zone. In the fourth zone the air flow is reduced below the rate at which substantial entrainment of the overlying burning residue and ashes would occur.

The gases are drawn off the upper subchamber 13 through the outlet 8 and exhaust stack 10.

The relatively steep slope of the first section 27 facilitates the conveying of the difficult, relatively compactable material from the throat toward the combustion zone. As it passes over the second zone 29, the inner material is dried and preheated by heat radiating from the material burning along the side walls, and also by the preheated air passing upwardly therethrough from the compartment 48.

As the bulky components such as paper boxes are burned, the material becomes more uniform in density and responds more readily to the conveying action of the reciprocating grates.

The lesser slope of the terminal or second grate section 30, although still providing for positive conveying of the material, also provides for an extended retention time of the more easily conveyed material on the grate assembllly, to permit completion of the combustion of the material.

Various changes may be made in the details of construction of the invention without departing from the spirit thereof or the scope of the appended claims.

We claim:

1. An incinerator for the burning of waste material comprising a burning chamber, a grate assembly in said chamber having alternate fixed grates and movable grates, said grate assembly comprising at least first and second sections inclined with respect to one another, means forming an inlet in said chamber located vertically above and adjacent the receiving end of said grate assembly for supplying material vertically to the upper end of the first grate section, the first grate section being inclined at an angle of between about 25° to 35° to the horizontal, said angle being substantially greater than the angle which the second grate section makes with the horizontal, said fixed and movable grates each having an upper surface and a forward face, the lower edge of the forward face of each grate overlying and terminating adjacent the upper surface of the subjacent grate, means for reciprocating the movable grates over at least a portion of the upper surfaces of the fixed grates to force, on their forward strokes, material on the subjacent fixed grates over the forward edges thereof and onto the forwardly-moving movable grates subjacent the respective fixed grates, the forward faces of the fixed grtaes, on the backward strokes of the movable grates, acting as abutments to force material on the movable grates over the forward edges thereof and onto the fixed grates subjacent the respective movable grates, whereby the material is caused to advance along the grates, an abutment adjacent the

rearward edge portion of the incinerator inlet, an upper movable grate of the first section being adjacent and underlying said abutment, the forward face of said upper movable grate successively protruding beyond and receding back of a forward portion of said abutment upon reciprocation, whereby on the backward stroke of said upper grate the abutment causes material on said upper grate to be forced over the forward edge thereof, a plurality of the fixed and movable grates at the upper end of the first section being substantially imperforate, the fixed and movable grates of the second section and the fixed and movable grates of the lower end of the first section being perforate, and means for passing a combustion-supporting gas upwardly through the fixed and movable perforated grates.

2. An incinerator for the burning of waste material comprising a burning chamber, a grate assembly in said chamber having alternate fixed grates and movable grates forming a grate section lying in a plane inclined at an angle of between about 25° to 35° to the horizontal, said chamber having an upper wall, means forming an inlet in said chamber located vertically above and adjacent the receiving end of said grate assembly for supplying material vertically to the upper end of said grate section, said inlet having rearward and forward edge portions, several of the fixed and movable grates underlying said inlet, said fixed and movable grates each having an upper surface and a forward face, the lower edge of the forward face of each grate overlying and terminating adjacent the upper surface of the subjacent grate, means for reciprocating the movable grates over at least a portion of the upper surfaces of the fixed grates to force, on their forward strokes, material on the subjacent fixed grates over the forward edges thereof and onto the forwardly moving movable grates subjacent the respective fixed grates, the forward faces of the fixed grates, on the backward strokes of the movable grates, acting as abutments to

force material on the movable grates over the forward edges thereof and onto the fixed grates subjacent the respective movable grates, whereby the material is caused to advance along the grates, a throat member adjacent the forward edge portion of the incinerator inlet and extending downwardly from the upper wall of the chamber to provide a clearance space between the extending throat member and the grate section plane substantially equal to the distance between the rearward and forward edge portions of the material inlet, an abutment adjacent the rearward edge portion of the incinerator inlet, an upper movable grate of the grate section being adjacent and underlying said abutment, the forward face of said upper movable grate successively protruding beyond and receding back of the forward portion of said abutment upon reciprocation, whereby on the backward stroke of said upper grate the abutment causes material on said upper grate to be forced over the forward edge thereof, a plurality of the fixed and movable grates at the upper end of the grate section being substantially imperforate, the fixed and movable grates of the lower end of the grate section being perforate, and means for passing a combustion-supporting gas upwardly through the fixed and movable perforate grates.

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