

- [54] **PORTABLE COMBUSTION APPARATUS**
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 [51] Int. Cl. **F23g 5/12**
 [58] Field of Search **110/8 R, 8 C, 18 R, 18 C, 110/7 R, 19, 119**

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Primary Examiner—Kenneth W. Sprague

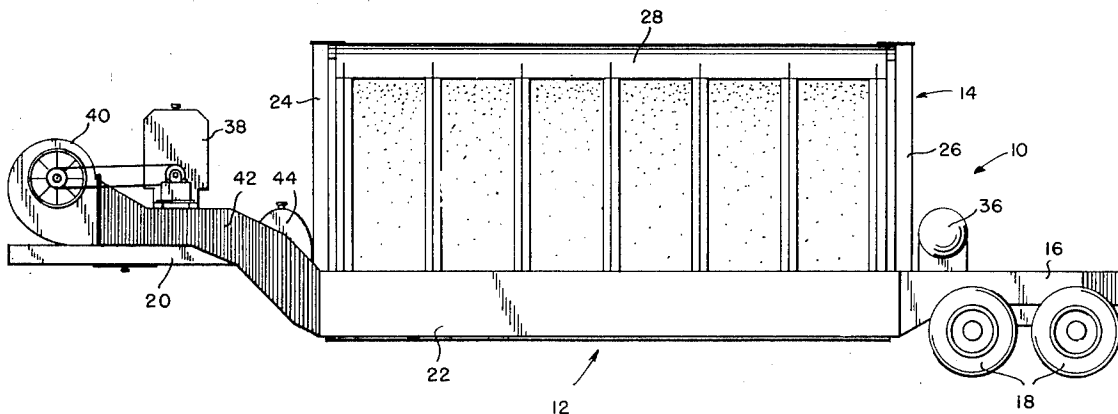
Attorney, Agent, or Firm—Graybeal, Barnard, Uhlir & Hughes

[57] **ABSTRACT**

A portable combustion unit especially adapted to burn

low ash, moderately high heat content materials characterized by wood waste. This unit comprises a mobile equipment frame to which is mounted an open top hopper shaped housing, providing a lower combustion zone and an upper combustion zone. At the forward end of the unit is a fan unit which supplies pressurized air to plenum chambers located about the entire lower periphery of the housing. Pressurized air from the plenum chambers flows upwardly through cooling ducts in the side walls of the housing and out through elongate lateral slot-like nozzles extending the entire length of the upper edge of each of the side walls of the housing. These nozzles direct opposing curtains of high velocity air horizontally toward the center of the open top of the housing to provide lateral air barriers and intermixing of the air at the second combustion zone to accomplish substantially complete combustion of volatiles and other particulate matter rising from the matter being burned. Air from the lower plenum chambers is directed through passages in a lower grate to dissipate heat from the burning material and from the ash material that drops through the grate. The air directed into the grate serves to cool the grate system and then passes upwardly through the combustion chamber to enhance burning in the combustion chamber.

21 Claims, 12 Drawing Figures



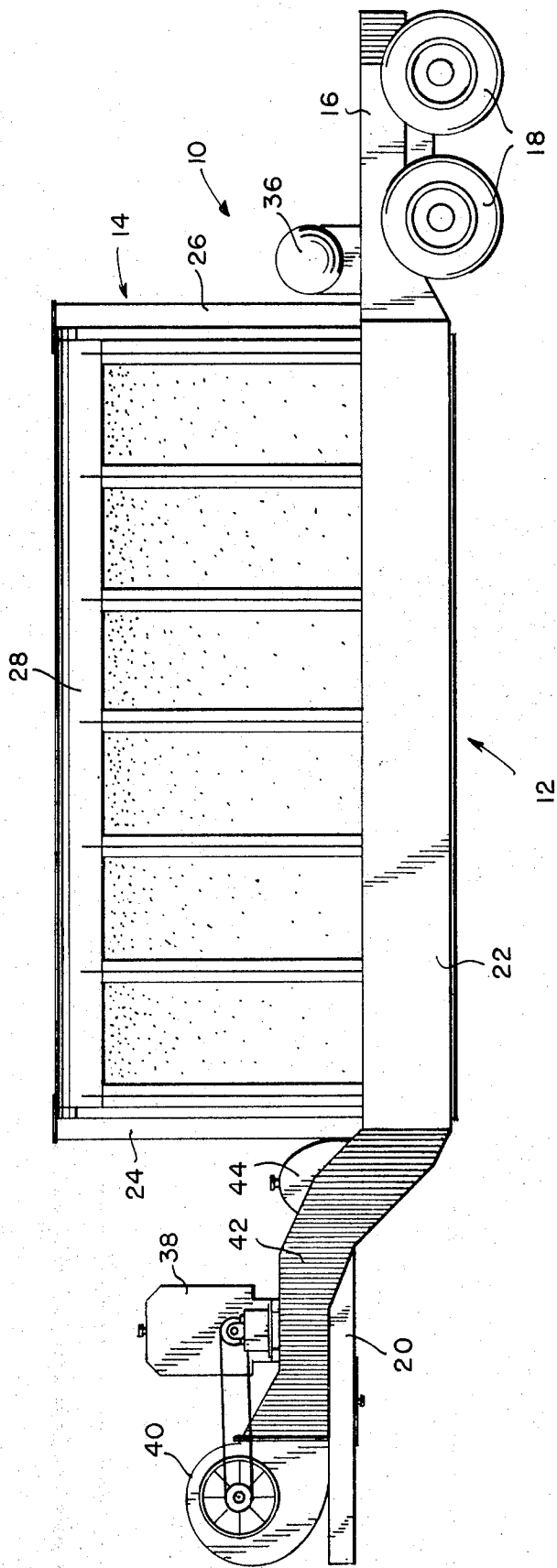


FIG. 1

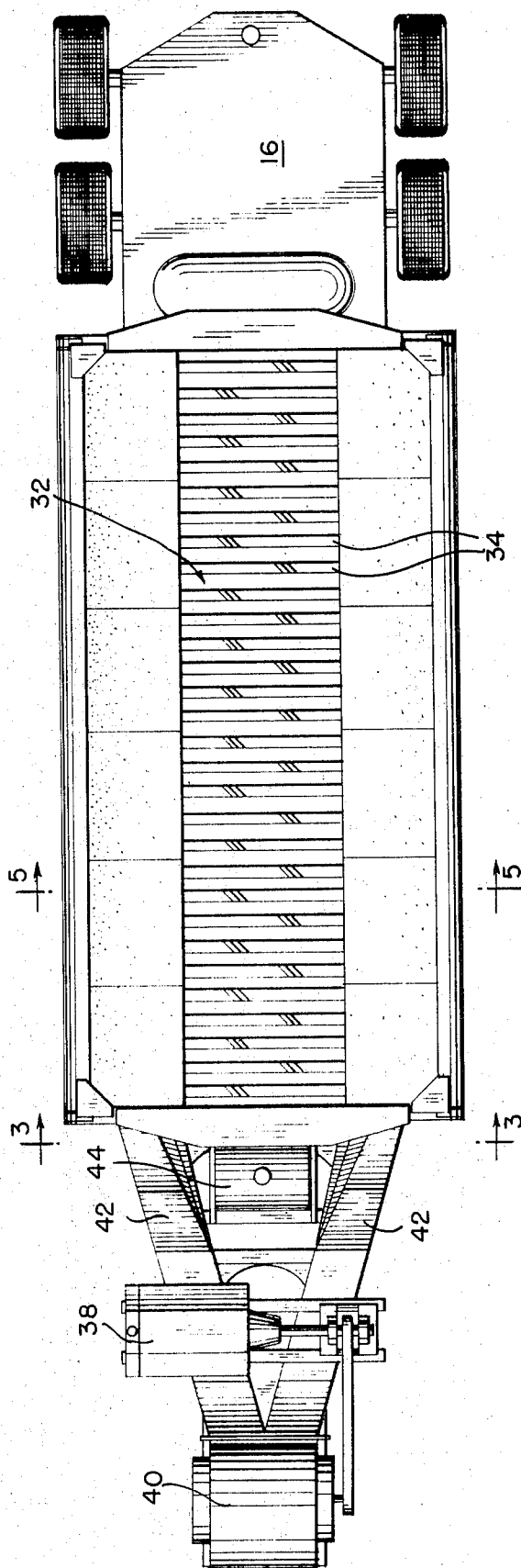


FIG. 2

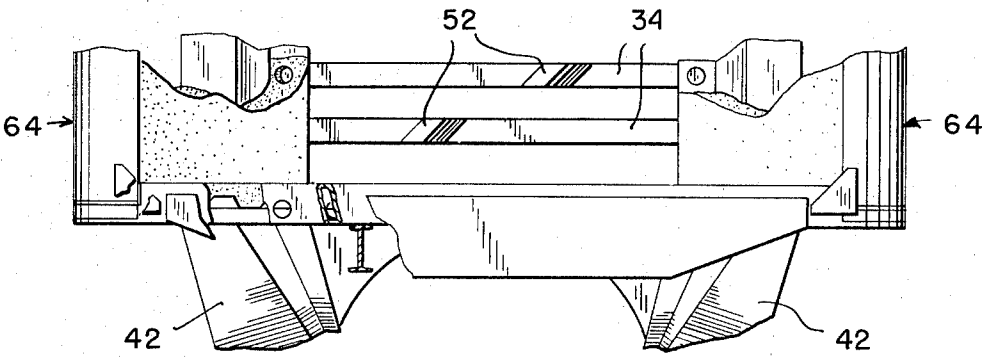


FIG. 4

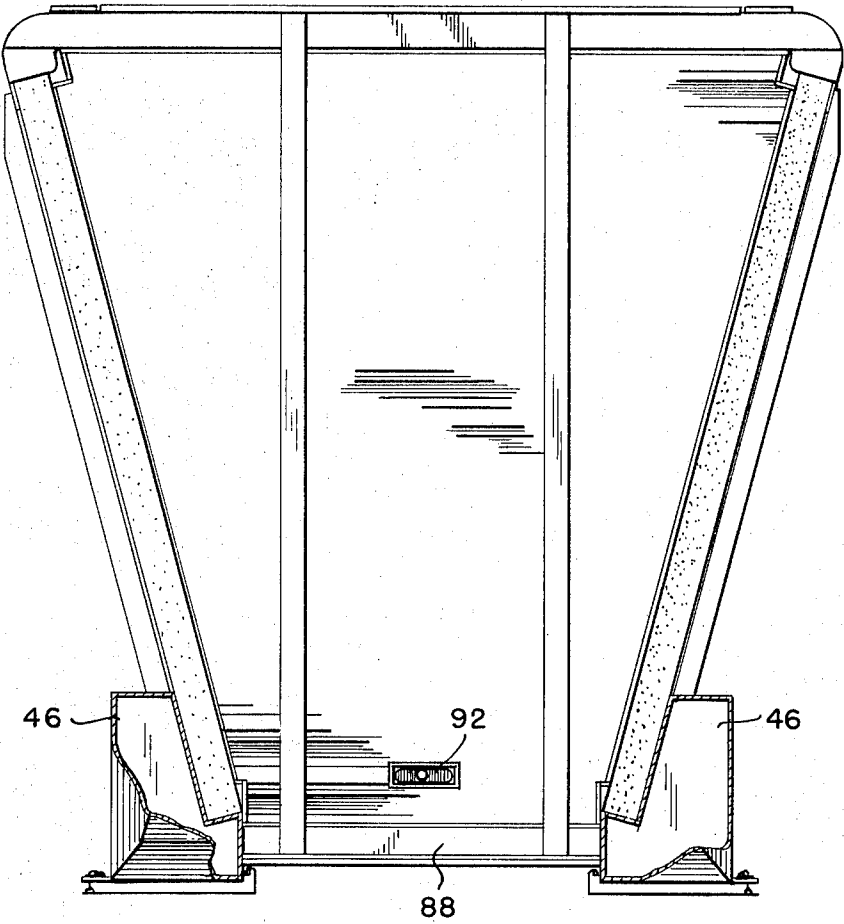
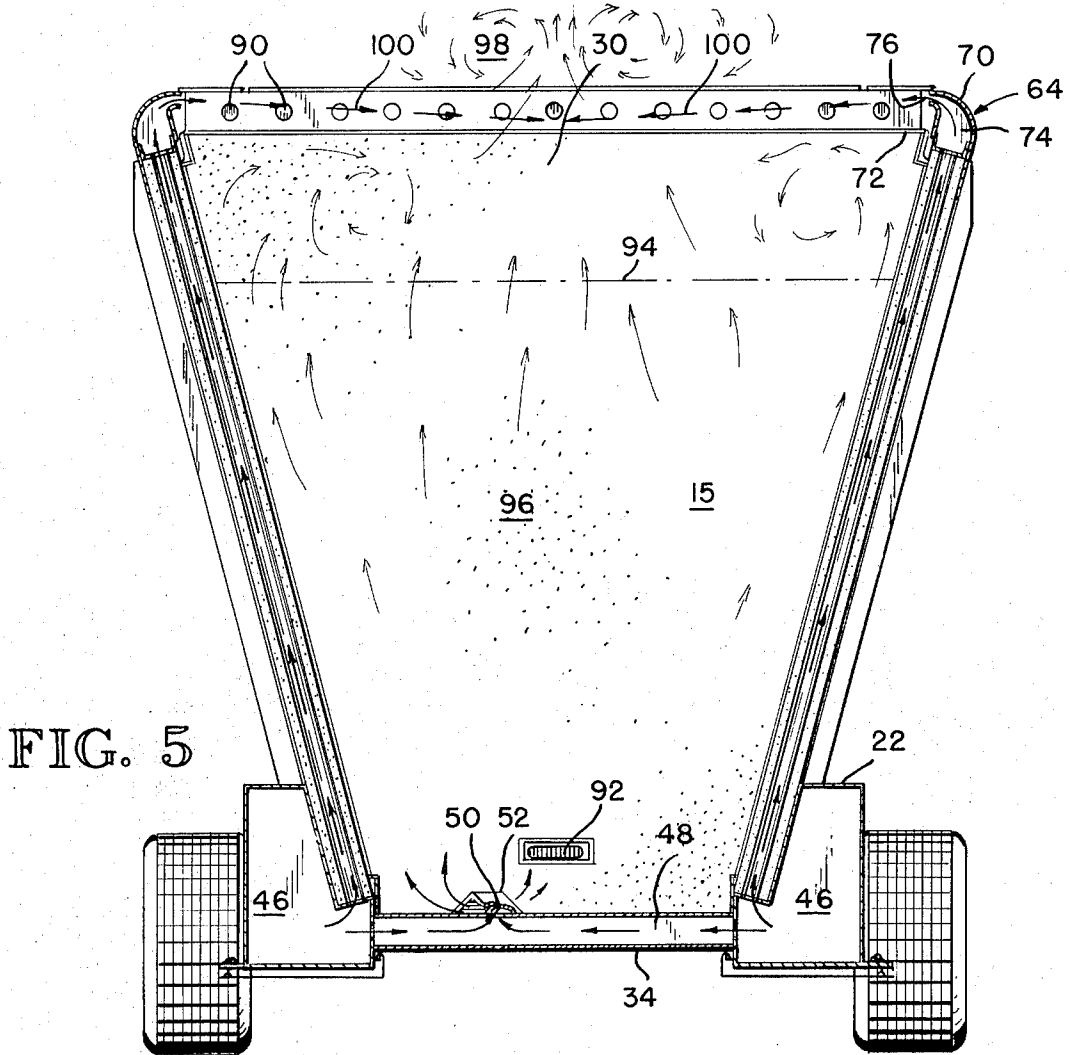
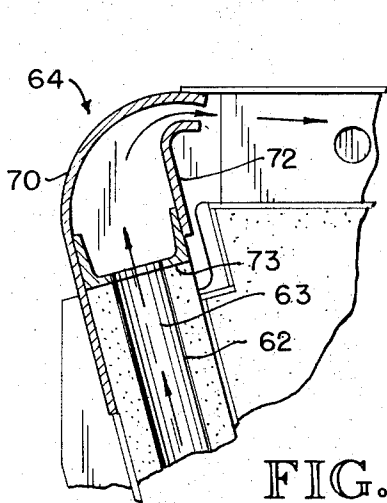
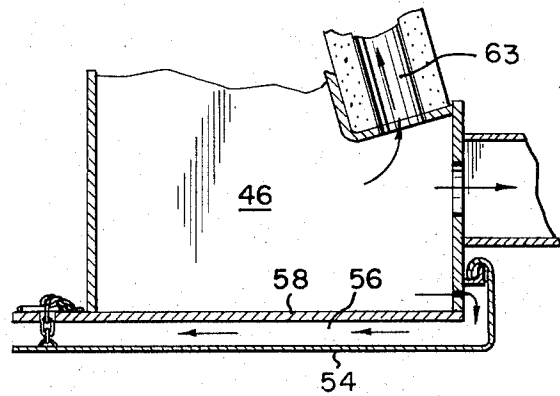


FIG. 3



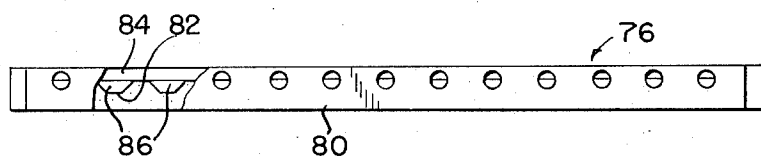


FIG. 8

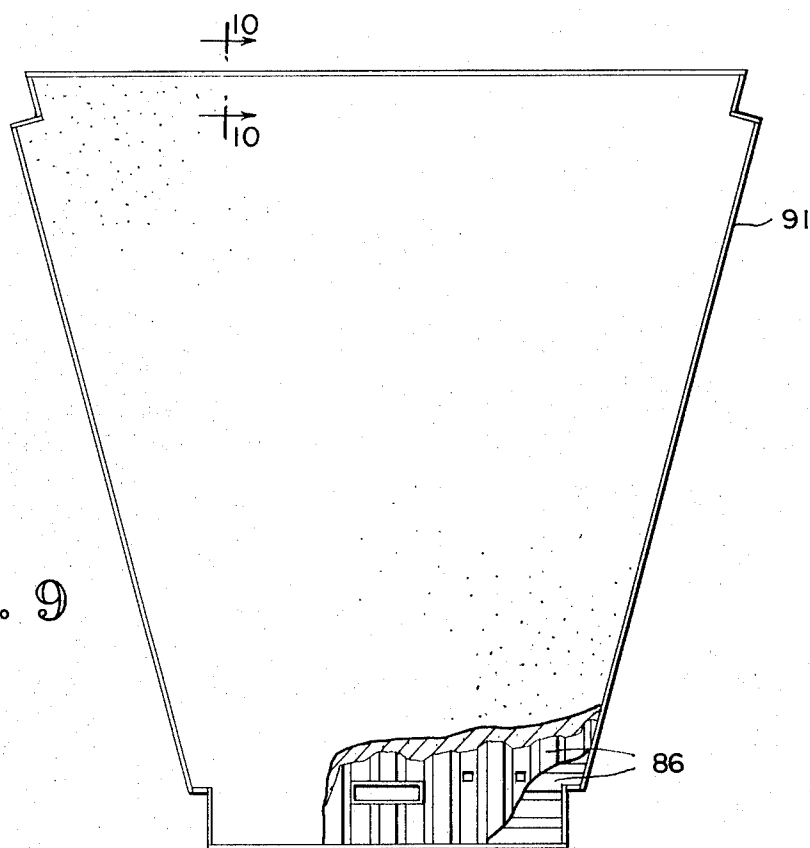


FIG. 9

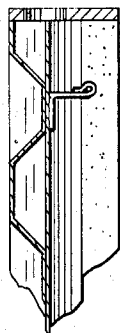


FIG. 10

SHEET 6 OF 6

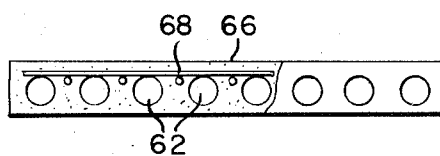


FIG. 11

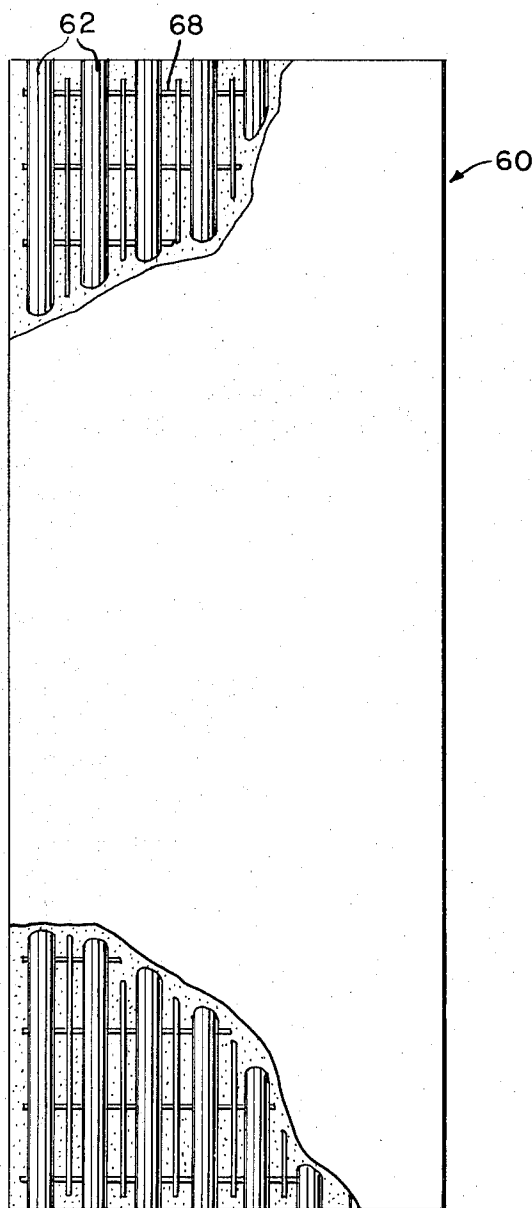


FIG. 12

PORTABLE COMBUSTION APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a portable combustion apparatus especially adapted for disposal of commercial land clearing debris, clean building demolition materials and other wood wastes, such as stumps, cull logs, tree branches, mill wood waste, etc.

2. Description of the Prior Art

Logging operations and clearance of wooded land for highways and other forms of construction cause the accumulation of waste wood in the form of stumps, timber, tree branches, and other such products generally known as slash. Also various types of construction projects generate large amounts of combustible wastes. Although an effective way to dispose of this material is by burning, this is quite difficult to accomplish in a manner to comply with current air pollution regulations that prohibit or severely limit the making of smoke and the discharge of particulate matter into the air. There are various devices in the prior art for burning a variety of waste material. Typical of such devices are those shown in the following patents: Toepel, U.S. Pat. No. 2,592,491; Toepel, U.S. Pat. No. 2,754,779; McGinnis, U.S. Pat. No. 3,295,477; Lager et al., U.S. Pat. No. 3,372,656; Mandelbaum et al., U.S. Pat. No. 3,392,690; Amundsen, U.S. Pat. No. 3,465,696; Trott, U.S. Pat. No. 3,498,240; Gatewood, U.S. Pat. No. 3,508,505; Doner, U.S. Pat. No. 3,543,701; Mattenley, U.S. Pat. No. 3,552,332; Erman, U.S. Pat. No. 3,557,722; Amundsen, U.S. Pat. No. 3,561,377; Muirhead, U.S. Pat. No. 3,577,938; Anderson, U.S. Pat. No. 3,595,181; and Wahler, U.S. Pat. No. 3,602,163.

It is an object of the present invention to provide an effective combustion apparatus especially adapted for field use as a portable unit in the burning of wood wastes.

SUMMARY OF THE INVENTION

The present invention comprises a housing having side walls and a substantially open top, and providing a first lower combustion zone and a second upper combustion zone. At upper side portions of the housing, there are oppositely positioned first and second air discharge means arranged to direct opposing curtains of air generally laterally and inwardly to an intermediate location generally at said second combustion zone, with the curtains of air interengaging to form counter rotating intermixing air currents to accomplish substantially complete combustion of incompletely burned products emanating from the material being burned in the first combustion zone.

In the preferred embodiment, there are two lower plenum beam members which form plenum chambers from which air is fed upwardly through cooling passageways in the side walls of the housing, with this air being discharged through longitudinally extending slot-like nozzles of the air discharge means to form the two air curtains. Also, there is a lower open grate below the first combustion zone, through which air is directed from the plenum chambers through passageways in the grate bars, with the air being emitted from the grate bars to pass upwardly through the first combustion zone to enhance the burning of the material. The grate system allows for passage of ash and other residues to

the ground surface below without restricting the combustion process. Other features of the invention will become apparent from the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of the apparatus of the present invention;

FIG. 2 is a top plan view thereof;

FIG. 3 is a transverse sectional view taken along line 3—3 of FIG. 2;

FIG. 4 is a top view of that portion of the apparatus shown in FIG. 3, with portions broken away;

FIG. 5 is a transverse view taken along line 5—5 of FIG. 2;

FIG. 6 is an enlarged view of the upper left hand portion of the apparatus shown in FIG. 5;

FIG. 7 is an enlarged view of the lower left hand portion of the apparatus shown in FIG. 5;

FIG. 8 is a top plan view of one of the end panels of the housing of the apparatus of the present invention;

FIG. 9 is a view looking at the face of the panel shown in FIG. 8;

FIG. 10 is a sectional view taken along line 10—10 of FIG. 9;

FIG. 11 is a top plan view of one of the side panels making up the housing of the apparatus, with portions thereof broken away, and

FIG. 12 is a view looking into the face of the panel of FIG. 11, with portions thereof broken away.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The apparatus of the present invention, generally designated 10, comprises a wheeled equipment frame section 12 and a housing 14 mounted thereon. The equipment frame section 12 comprises a rear platform section 16 resting on dual tandem rear axles and wheels 18, a forward fifth wheel and equipment platform 20 by which the apparatus 10 is towed, and an intermediate section comprising two laterally spaced elongate beam members 22. Each beam member 22 serves not only as a structural load carrying member interconnecting the front and rear platforms 16 and 20 and supporting the combustion housing 14, but also provides a related plenum chamber to carry pressurized air, the functions of which will be disclosed more fully hereinafter. Thus the members 22 are referred to hereinafter as "plenum beam members".

Mounted to and extending upwardly from the two plenum beam members 22 is the aforementioned housing 14 comprising front and rear walls 24 and 26, respectively, and two downwardly and laterally inwardly sloping side walls 28. Thus, the housing 14 has a hopper like construction (i.e., has the general configuration of a trapezoidal right angle prism with the smaller base of the trapezoid positioned at the bottom of the housing. The relatively wide top area 30 of the housing 14 is open, while the narrower bottom of the housing 14 comprises a grate 32 made up of a plurality of horizontal tubes or bars 34 extending laterally between the bottom edges of the side walls 28. The lateral spacing of the wheels 18 is greater than the width of the grate 32, so that the ash material dropping through the grate 32 does not burn the wheels 18.

Mounted to the rear platform 16 of the housing 14 is a propane tank 36 which supplies fuel to enhance combustion during the start-up portion of the burning oper-

ation. Mounted to the forward platform 20 an engine 38 which powers a fan 40, which in turn supplies pressurized air through conduits 42, each of which leads into a respective one of the two plenum beam members 22. A fuel tank 44 mounted just forward of the housing 14 supplies fuel to the motor 38.

Each of the plenum beam members 22 has in transverse section a general rectangular or box-like configuration and defines a respective lower plenum chamber 46 of a relatively large cross sectional area. In normal operation, each plenum chamber 46 is pressurized from the fan 40 to pressure level of about ten inches of water. The pressurized air in the plenum chambers 46 performs five functions; namely to, (1) supply cooling air through the front, rear and side walls 24, 26 and 28 of the housing 14, (2) provide cooling air for the grate bars 34, (3) provide cooling air for the bottom surface of each plenum beam 22, (4) supply air into the lower portion of the housing 14 to enhance combustion therein, and (5) provide a dual air curtain across the open top area 30 of the combustion housing 14 (the function of this dual air curtain to be described more particularly hereinafter).

With reference to FIG. 5, it can be seen that each of the grate bars 34 is an elongate tubular member having a through passage 48. Each bar 34 has an upper air outlet opening 50, over which is mounted a guard 52 in the shape of an angle iron section which permits the flow of pressurized air from the plenum chamber 46 through the passageway 48, through the opening 50 and out the open ends of the guard 52 to pass upwardly through the housing 14. Thus the air passing through the passages 48 of the grate bars 34 function not only to cool the grate bars 34 but to enhance combustion of material burning in the housing 14.

With reference to FIG. 7, it will be seen that there is mounted just a short distance below the bottom of each of the plenum beams 22 a heat shield 54. Pressurized air passes from each plenum chamber 46 into a related cooling passageway 56 defined by the heat shield 54 of the lower wall 58 of the plenum beam 22 to shield the bottom beam wall 58 from the heat of the ash material that falls through the grate bars 34.

The side walls 28 of the housing 14 are made up of a plurality of individual wall sections or panels 60. These wall panels 60 are precast and are composed of expanded shale or similar heat resistant aggregate and calcium aluminate or similar heat resistant binder, the composition of which depends upon the temperature requirements of the particular combustion unit. Each panel 60 contains a plurality of vertically oriented, laterally spaced steel ducts 62 which are open at both their upper and lower ends to provide vertical cooling passages 63 for the panel 60. The lower open ends of the ducts 62 of each panel 60 communicate with their respective plenum chamber 46, and the open upper ends of the ducts 62 of each panel 60 communicate with a combination nozzle plenum member 64, each nozzle plenum member 64 extending the entire length of its related side wall 28.

With reference to FIGS. 11 and 12, each panel 60 has adjacent the outer face 66 thereof a matrix of steel reinforcing bars 68. The passage of air upwardly from the plenum chamber 46 through the conduits 62 provides a heat shield for the reinforcing steel 68 to maintain the structural integrity of the panels 60. Within the broader scope of the invention, it is also possible to make the

walls 24, 26 and 28 from other material such as steel. However, this is less desirable since the structure tends to warp, this resulting not only in deterioration of the structure, but also in possible malfunctioning of the nozzles that provide the dual air curtain (the function of these nozzles to be described more particularly immediately below).

Of particular significance in the present invention is the manner in which the two nozzle-plenum members 64 provide a double air curtain over the combustion chamber 15. Each nozzle plenum member 64 comprises an outer elongate curved metal piece 70, an inner elongate piece 72, and an interconnecting base piece 73, the pieces 70, 72 and 73 collectively defining an upper plenum chamber 74 which receives the pressurized air from the conduits 60 in its related side wall 28. The design of the upper plenum is such that it also serves as a structural member to interconnect front and back structure and to support the top ends of the side walls 28. The upper ends of the members 70 and 72 of each of the plenum-nozzle member 64 curve inwardly and are spaced a short distance apart to define an inwardly directed elongate slot-like nozzle 76 which extends the entire length of its related side wall 28. The two opposed elongate slot-like nozzles 76 each direct a sheet or curtain of air laterally across the open upper area 30 of the housing 14 with the opposed streams of air meeting at approximately the center portion of the open top area 30 of the housing 14. The manner in which this enhances the operation of the apparatus is described later herein in the discussion of the operation of the apparatus.

The front and rear housing walls 24 and 26 are substantially identical, with the rear wall 26 being shown in FIGS. 8, 9 and 10. The inner or hot face 80 of the panel 26 is of a material and construction similar to the side panels 60. The outer face of the panel 26 is made up of two layers of corrugated metal, the innermost layer 82 having its corrugations vertically oriented, and the outer exposed corrugated layer 84 having its corrugations horizontally oriented. Thus the two corrugated layers 82 and 84 define a plurality of interconnecting vertical and horizontal passageways 86, which serve a cooling function similar to the aforementioned conduits 61. At the lower edge of each of the front and rear walls 24 and 26 of the housing 14, there is a plenum chamber 88 which receives air from the main plenum chambers 46 and directs this air upwardly through the vertical and horizontal passageways 86 in the front and rear panels 24 and 26 to provide cooling for these panels. The air passing from the vertical passageways 86 passes outwardly through inwardly directed openings 90 into the top open area at approximately the same horizontal level as the aforementioned nozzles 76. For structural integrity each panel 24 or 26 has a respective metal perimeter frame 91.

At the lower central portion of both the front and rear panels 24 and 26, there is a respective one of two fuel nozzles 92, which receive fuel from the aforementioned propane tank 36. During start up of the combustion unit 10, fuel is directed through these nozzles 92 into the lower portion of the combustion chamber 15 to enhance initiation of proper combustion of the material to be burned.

The operation of the present invention is described herein with reference to the burning of waste material in the form of stumps, timber, tree branches, etc., the

preferred embodiment shown herein being especially adapted for that purpose. However, it is to be understood that the scope of operation is not necessarily so limited.

An apparatus was constructed substantially as shown in the accompanying drawings, with the lengthwise dimension of the housing 14 being 24 feet, the width across the upper top opening 30 being 12 feet, and the width of the grate 32 being 6 feet. With the wheels 18 resting on a substantially planar ground surface, the grate 32 is positioned about 2 feet above the ground surface, and the upper edge of the housing 14 is about 14 feet above the ground surface, with the over all depth of the housing from the upper top opening 30 to the grate 32 being about 12 feet.

In operation, the burning unit 12 is towed by its fifth wheel platform 20 by means of a suitable towing vehicle to the location at which the wood material to be burned is located. The stumps, logs and other wood material are loaded, desirably by suitable power equipment, down through the top open area 30 into the housing 14. Initially, the housing 14 is loaded with wood waste to a level between the top of the housing 14 and about 3 feet below the top edge of the housing 14, with this lower level being shown by means of a dotted line indicated at 94 in FIG. 5. As the material burns down, additional material is loaded into the housing 14 through the top opening 30 to maintain the burning material at about the desired level. It is to be understood that of course some of the wood waste will extend above the level 94 and possibly even above the level of the top edge of the housing 14, due to the varying shape of the stumps, branches, etc., and that the level indicated at 94 represents a general average height of the lower level to which the housing 14 is loaded.

This general burning area of the housing 14 that is occupied by the wood material functions as a first combustion zone where the primary burning of the wood waste takes place. This zone is indicated at 96 in FIG. 5. The area at the upper open end of the housing 30 functions as a second combustion zone, this being indicated in FIG. 5 at 98.

To initiate operation of the apparatus, propane fuel is fed through the two fuel nozzles 92 into the wood waste, and the fuel is ignited by suitable means. The motor 38 is started up to power the fan 40 which in turn supplies pressurized air at about ten inches of water to the lateral plenum chambers 46 and the end plenum chambers 88. The pressurized air in the plenum chambers 46 pass through the passageways 48 in the grate bars 34 to pass out the grate bar openings 50 and upwardly through the first combustion zone 96. Also, pressurized air passes through the lower passageways 56 to cool the lower wall 58 of each of the plenum beams 22. A substantial portion of the pressurized air from the two plenum chambers 46 passes upwardly through the many conduits 62 into the two upper plenum chambers 74 of the two nozzle plenum chambers 64.

The air passes from the two nozzle plenum chambers 64 through the slot-like nozzles 76 at each upper edge portion of the housing 14 to provide the aforementioned two curtains of air, these air curtains being indicated by the solid arrows designated 100 in FIG. 5. In the unit 10 that was actually constructed, the discharge velocity of the air at the discharge plane of the nozzles 76 is approximately 10,000 feet per minute, which

worked satisfactorily. Depending upon such factors as intensity of burning, size of the unit, etc., this velocity normally would be at least 5,000 feet per minute.

The manner in which the two air curtains 100 interact to provide the secondary combustion at the second combustion zone 98 is described with reference to the broken-line arrows of FIG. 5, which represent the general flow pattern of the combusted material and non-combusted volatiles and particulate matter from the burning wood waste and also the flow of air from the two air curtains 100 intermixing with the same. It is to be understood of course that the general flow patterns indicated by these arrows will vary, depending upon the rate and pattern of burning of the material in the housing 14, the level to which the housing 14 is filled, surrounding wind conditions, the fluctuations due to the turbulent action of the burning, etc. However, the pattern indicated by the arrows in FIG. 5 is representative of the over all flow pattern that generally prevails in the operation of the present invention.

First, it can be observed that the two air curtains 100 that are discharged from the two nozzles 76 proceed laterally and inwardly toward each other in generally opposing directions. The side portions of the air curtains 100 provide substantial barriers to the combustion products rising from the side portions of the wood waste. The two air curtains 100 interengage with one another at an intermediate area generally within the second combustion zone 98. The combustion products emanating from the burning wood waste 96 comprise carbon dioxide, water vapor, and other combusted material, and also comprise partially combusted volatiles and unburned or partially burned particulate matter. The combustion products tend to flow upwardly and laterally toward the longitudinal center line of the housing 14 and into the second combustion zone 98.

At the two areas below the air curtains 100 and spaced laterally of the center of the second combustion zone 98, there is a tendency to form a swirling vortex of particulate matter. Much of the particulate matter rising from the side portions of the burning waste travels in this vortex pattern to be redirected toward the burning wood waste to be burned or to be burned by longer exposure to the elevated temperatures that exist nearer the wood waste.

The combustion products entering the second combustion zone 98 intermix with the air from the two air curtains 100 in an upward swirling intermixing action approximately along the longitudinal center line of the housing 14. This action causes substantially complete combustion of the partially burned combustion products so as to provide substantially clean burning of the wood waste. Also, since the air that forms the two air curtains 100 is preheated by its passage through the side wall conduit 62, this further enhances combustion of the partially burned combustion products in the second combustion zone. Also as wood material is loaded into the top area 30 of the housing 14, there is greater tendency to generate particulate material into the combustion gases. The air curtains 100 serve to encapsulate the material being charged and returns this burning particulate material into the secondary combustion zone 98 to insure substantially complete combustion.

In the normal operation of burning wood wastes, such as stumps, logs, branches, etc., of average moisture content, the temperature in the first combustion zone is between approximately 1,600°F. to 1,800°F.

Because of the cooling action of the air passing upwardly through the housing walls 24, 26 and 28, the outside temperature of these walls is usually not greater than approximately 90°F. to 120°F. While no accurate measurement is available for the gases in the second combustion zone 98, it is estimated that this temperature is between about 1,200°F. to 1,500°F.

Of the total amount of air fed into the plenum chambers 46 and 88, approximately 30 percent of the air passes through the grate bars 34 and into the first combustion zone to enhance burning in the first combustion zone. The remaining approximate 70 percent of the air acts as the cooling air for the walls of the housing and forms the two air curtains 100 to provide air for completing combustion in the second combustion zone 98, with a small portion of this air passing through the lower cooling passages 56.

The open top and hopper shaped construction of the housing 14 permits substantial radiation of heat from the first burning zone 96 to aid in dissipating the heat from the combustion of the burning products, thus minimizing wall hot face temperatures.

What is claimed is:

1. A combustion apparatus especially adapted to burn low ash, moderately high heat content material such as wood waste products, said apparatus comprising:

- a. a housing having a longitudinal axis and comprising a front portion, a back portion and at least two upwardly reaching side walls,
- b. said housing having a substantially open top area and providing a first lower combustion zone and a second combustion zone positioned above said first combustion zone in said open top area,
- c. a first longitudinally extending air discharge means located proximate an upper side portion of one of said side walls and arranged to direct a curtain of air laterally and inwardly in a first direction having a substantial horizontal component across said top area into said second combustion zone,
- d. a second longitudinally extending air discharge means located proximate a second upper side portion of said housing and arranged to direct a second curtain of air generally laterally and inwardly across said top area into said second combustion zone in a second direction having a substantial horizontal component generally opposing said first direction, and
- e. said first and second curtains of air having a velocity sufficient that the curtains interengage at said second combustion zone to form counter rotating intermixing air currents to accomplish substantially complete combustion of said combustion products.

2. The apparatus as recited in claim 1, wherein said first and second air discharge means each extends along at least a substantial length of its related side wall to provide substantially complete air barriers across said open top area on opposite sides of said second combustion zone.

3. The apparatus as recited in claim 1, wherein said side walls have upwardly extending wall cooling air passage means interconnecting with said first and second air discharge means, whereby cooling air passing upwardly through said side wall air passages is discharged through said air discharge means to provide said air curtains.

4. The apparatus as recited in claim 3, wherein there is for each side wall a structure defining a plenum chamber extending substantially the length of its related side wall at a lower portion thereof and interconnecting with said wall cooling air passages to provide air thereto.

5. The apparatus as recited in claim 4, wherein said housing comprises a lower grate connecting to said side walls and positioned below said first combustion zone, said grate having air passages therein interconnecting with at least one of said plenum chamber so that air is supplied from said plenum chamber to said grate passages.

6. The apparatus as recited in claim 5, wherein said grate has air opening means to direct air from said grate passages upwardly through said first combustion zone to enhance burning of said material.

7. The apparatus as recited in claim 1, wherein there is at the lower portion of said housing a grate having bottom through openings to permit an updraft of air through said first combustion zone and to allow passage of ash and other inert residues to the ground surface below, said grate having air passages therein for the flow of cooling air therethrough, and exit openings to discharge the air from said air passages upwardly through said first combustion zone to enhance burning of said material.

8. The apparatus as recited in claim 7, wherein there is at the lower portion of said housing structure defining a plenum chamber interconnecting with said grate passages to supply air thereto.

9. The apparatus as recited in claim 1, wherein said side wall means comprises a plurality of connected side wall panels, each of which is made up of a refractory material having an inner face directed to said combustion chamber and an outer face, each of said panels having upwardly extending air passages therein connecting with said first and second nozzle means to supply air thereto, said side panels each having reinforcing means located outwardly of said air passage means so as to maintain said reinforcing means at a temperature substantially below that in said combustion chamber.

10. A mobile combustion apparatus especially adapted for on-site burning of low ash, moderately high heat content material such as wood waste products, said apparatus comprising:

- a. a mobile frame having laterally spaced wheel means for travel;
- b. a generally hopper shaped housing having a longitudinal axis and comprising a front portion, a back portion and at least two upwardly reaching side walls;
- c. said housing having a relatively wide substantially open top area, with said side walls slanting downwardly and inwardly to a relatively narrow bottom section, said housing providing a first lower combustion zone and a second combustion zone positioned above said first combustion zone at said open top area;
- d. a first longitudinally extending air discharge means located proximate an upper portion of one of said side walls and arranged to direct a curtain of air laterally and inwardly in a first direction having a substantial horizontal component across said top area into said second combustion zone;
- e. a second longitudinally extending air discharge means located proximate a second upper side por-

tion of the other of said side walls and arranged to direct a second curtain of air generally laterally and inwardly across said top area into said second combustion zone in a second direction having a substantial horizontal component generally opposing said first direction, and

- f. said first and second curtains of air having a velocity sufficient that the curtains interengage at said second combustion zone to form counter rotating intermixing air currents to accomplish substantially complete combustion of said combustion products.

11. The apparatus as recited in claim 10, wherein there is at the lower portion of said housing a grate having bottom through openings to permit an updraft of air through said first combustion zone and to allow passage of ash and other inert residues to the ground surface below, said grate being positioned inwardly of and between said wheel means, whereby ash material falling through said grate does not damage said wheel means, said grate having air passages therein for the flow of cooling air therethrough and exit openings to discharge the air from said air passages upwardly through said first combustion zone to enhance burning of said material.

12. The apparatus as recited in claim 11, wherein there is at a lower portion of said housing structure defining a plenum chamber interconnecting with said grate passages to supply air thereto, said plenum chamber structure being spaced laterally of said grate means.

13. The apparatus as recited in claim 10, wherein said first and second air discharge means each extends along at least a substantial length of its related side wall to provide substantially complete air barriers across said open top area on opposite sides of said second combustion zone.

14. The apparatus as recited in claim 10, wherein said side walls have upwardly extending wall cooling air passage means interconnecting with said first and second air discharge means, whereby cooling air passing upwardly through said side wall air passages is discharged through said air discharge means to provide said air curtains.

15. The apparatus as recited in claim 14, said apparatus defining two lower laterally spaced plenum chambers extending substantially the length of said apparatus, and interconnecting with said wall cooling air passages to provide air thereto.

16. The apparatus as recited in claim 15, wherein said housing comprises a lower grate extending between said side walls and positioned below said first combustion zone, said grate having air passages therein interconnecting with at least one of said plenum cham-

bers so that air is supplied from said plenum chamber to said grate passages.

17. The apparatus as recited in claim 16, wherein said grate has air opening means to direct air from said grate passages upwardly through said first combustion zone to enhance burning of said material.

18. The apparatus as recited in claim 10, wherein said side wall means comprises a plurality of connected side wall panels, each of which is made up of a refractory material having an inner face directed to said combustion chamber and an outer face, each of said panels having upwardly extending air passages therein connecting with said first and second nozzle means to supply air thereto, said side panels each having reinforcing means located outwardly of said air passage means so as to maintain said reinforcing means at a temperature substantially below that in said combustion chamber.

19. A method to accomplish substantially complete combustion of low ash, moderately high heat content material such as wood waste products, said method comprising:

- loading said material into a substantially open top housing having substantially closed side walls;
- burning said material in a first combustion zone in said housing, and
- directing first and second curtains of air from opposed upper side portions of said housing laterally and inwardly across the open top area of said housing with said first and second air curtains interengaging above said first combustion zone to provide a second combustion zone above said first combustion zone,

whereby said first and second curtains of air interengage at said second combustion zone to form counter rotating intermixing air currents to cause substantially complete combustion of volatile and particulate matter emanating from said material, thus causing substantially complete combustion of said material,

said method further comprising directing cooling air upwardly through side walls of said housing and then laterally across the open top of said housing to form said air curtains.

20. The method as recited in claim 19, further comprising directing pressurized air into lower plenum chambers and then upwardly through said wall cooling passage means.

21. The method as recited in claim 20, further comprising directing pressurized air upwardly through a bottom portion of said first combustion zone to enhance combustion therein.

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