United States Patent [19]

Hasselbring et al.

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[45] **Apr. 17, 1973**

[54] INCINERATOR

[75] Inventors: **Robert Joel Hasselbring**, Shelbyville; **Robert L. Shields**, Rushville, both of Ind.

[73] Assignee: **General Electric Company**, New York, N.Y.

[22] Filed: **July 2, 1971**

[21] Appl. No.: **159,251**

[52] **U.S. Cl.** ..... **110/8 R**, 110/28 F

[51] **Int. Cl.** **F23g 5/06**

[58] **Field of Search** ..... 110/7 R, 8 R, 10, 110/18 R, 28 F; 431/173

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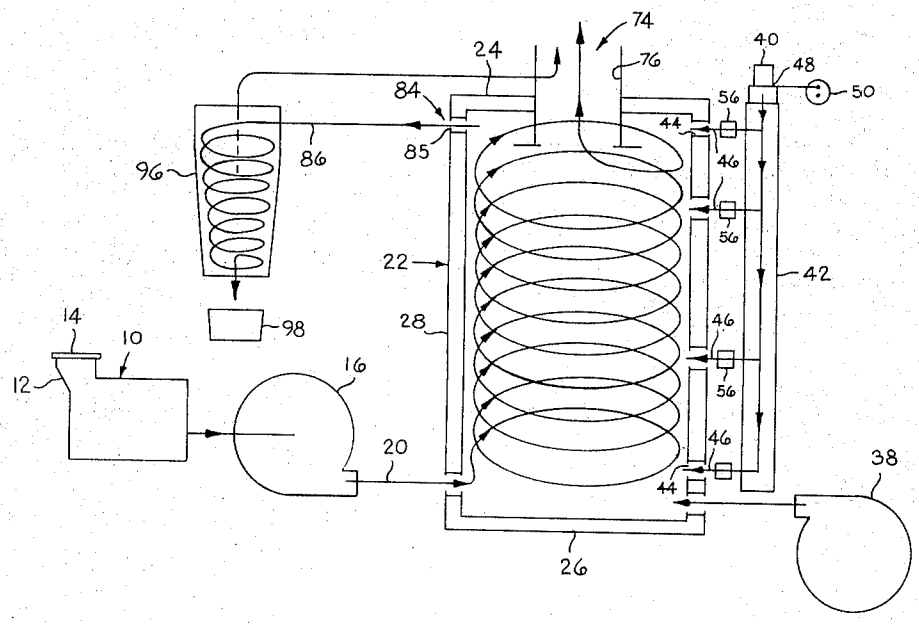
Primary Examiner—Kenneth W. Sprague
Attorney—Philip L. Schlamp et al.

[57] **ABSTRACT**

An incinerator for burning waste material includes a horizontally extending combustion chamber having spaced end walls and a side wall through which a mixture of waste material and air is introduced under pressure tangentially for establishing a vortical movement of the waste material toward one of the end walls. The waste material is ignited during its vortical movement and the chamber includes a discharge flue port near the one end wall which is concentric with the longitudinal axis of the chamber and which has an open end in the chamber spaced axially of the one end wall. A second discharge port extends tangentially through the chamber side wall adjacent the bottom of the chamber at one side thereof for discharging from the chamber non-combustible material entrained in the outer region of the vortex. The discharged material is conveyed through a conduit to a separator which separates the discharged gases and solid material. A baffle is mounted on the flue adjacent its open end for deflecting outwardly toward the side wall solid material which moves from adjacent the one end wall toward the open end of the flue. Means are provided for introducing secondary air into the chamber tangentially to the chamber side wall at a plurality of spaced regions which are aligned horizontally and which are located adjacent the bottom of the chamber at the other side thereof such that one of said regions is substantially opposite the second discharge port. Control means including dampers are provided for independently adjustably controlling the amount of secondary air flowing into the chamber at each spaced region. Also, automatic control means are provided for controlling generally the secondary air in accordance with variations of temperature within the chamber.

28 Claims, 8 Drawing Figures



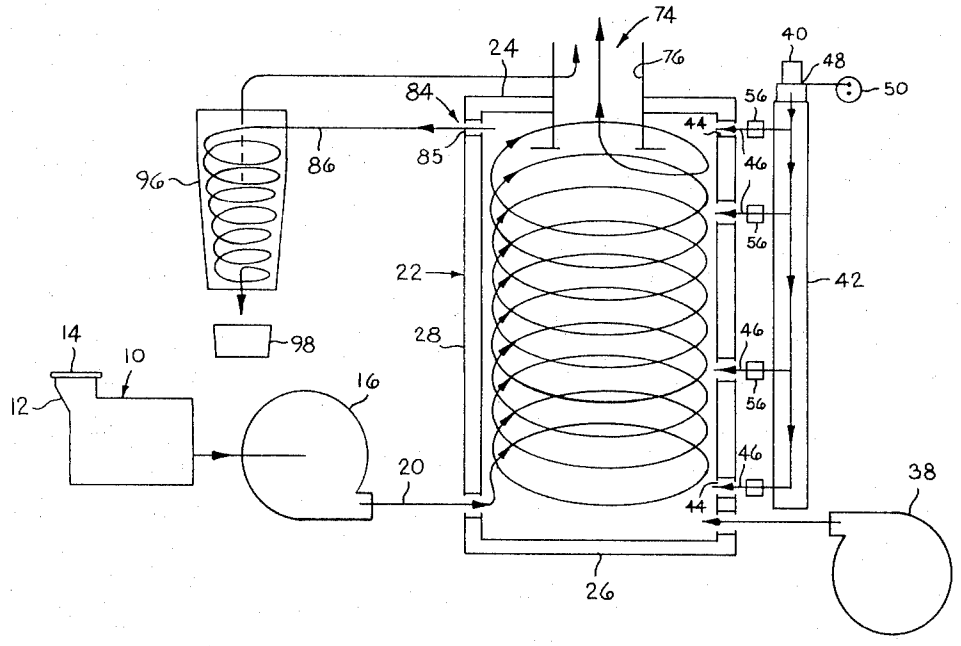


FIG 1

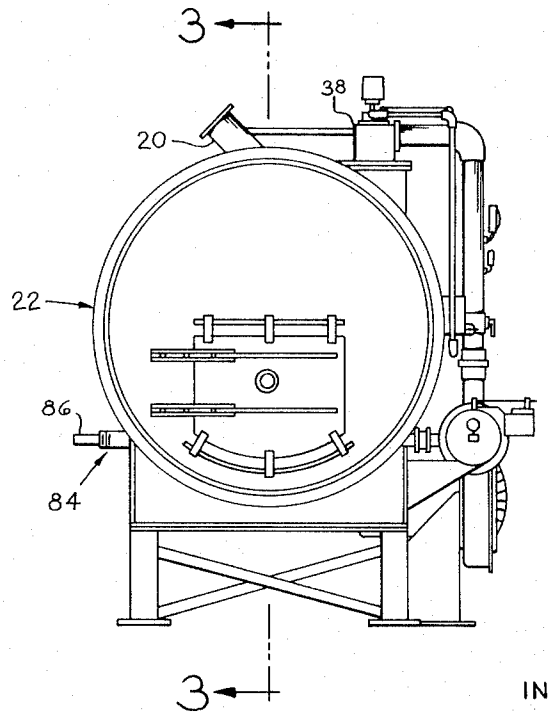


FIG 2

INVENTORS
ROBERT J. HASSELBRING
ROBERT L. SHIELDS

BY Philip J. Feldman
ATTORNEY

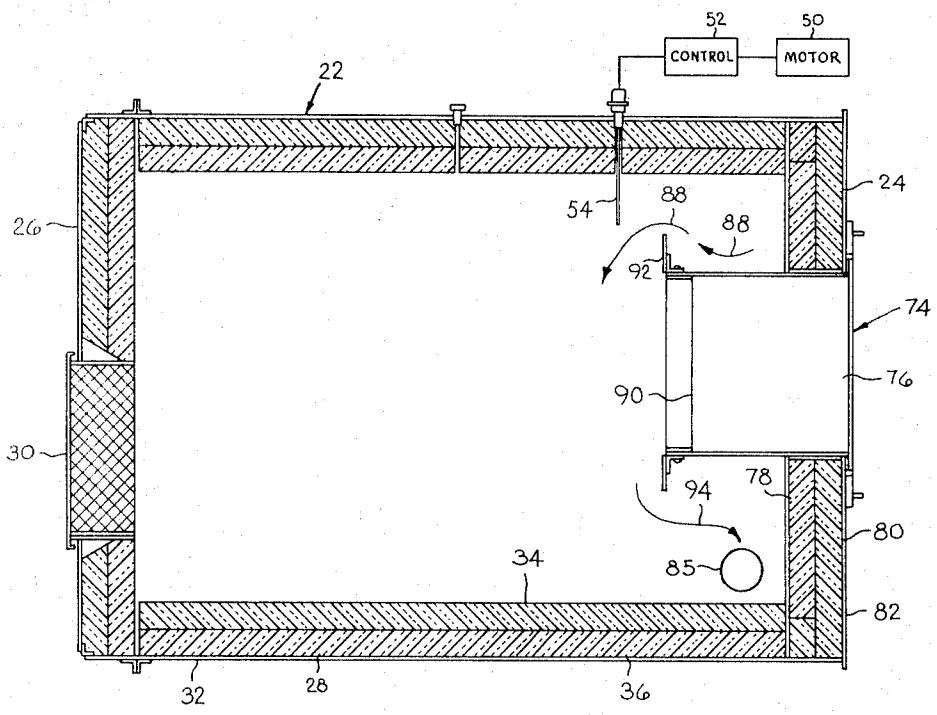


FIG 3

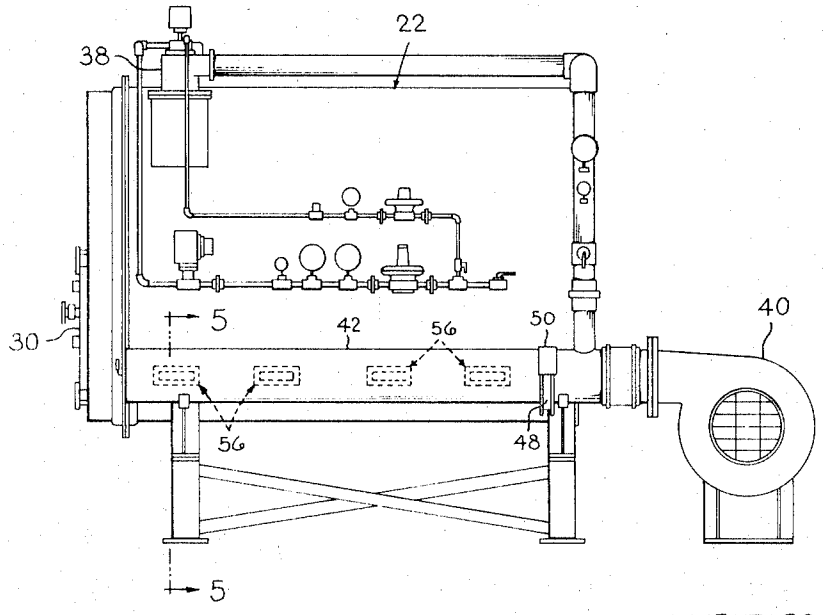


FIG 4

INVENTORS
ROBERT J. HASSELBRING
ROBERT L. SHIELDS

BY Philip J. Schlamp
ATTORNEY

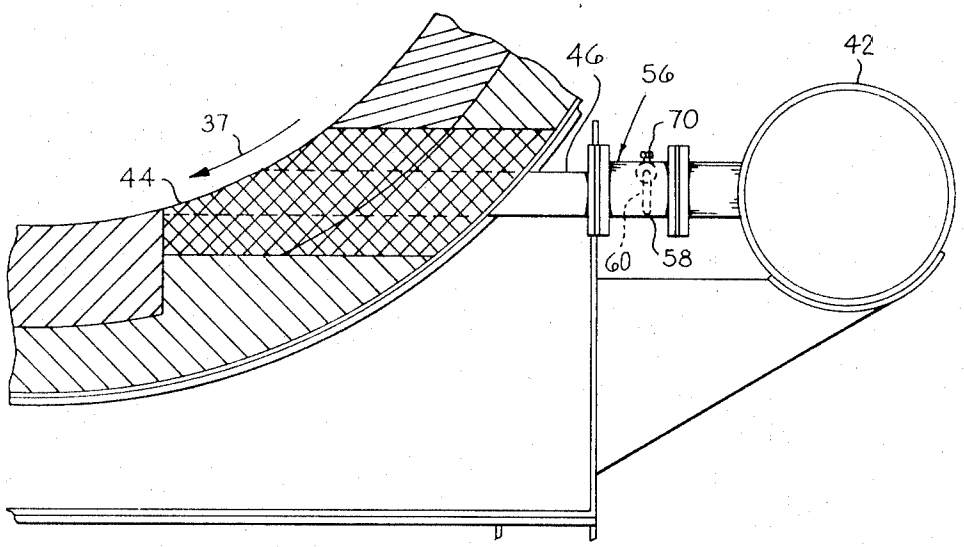


FIG 5

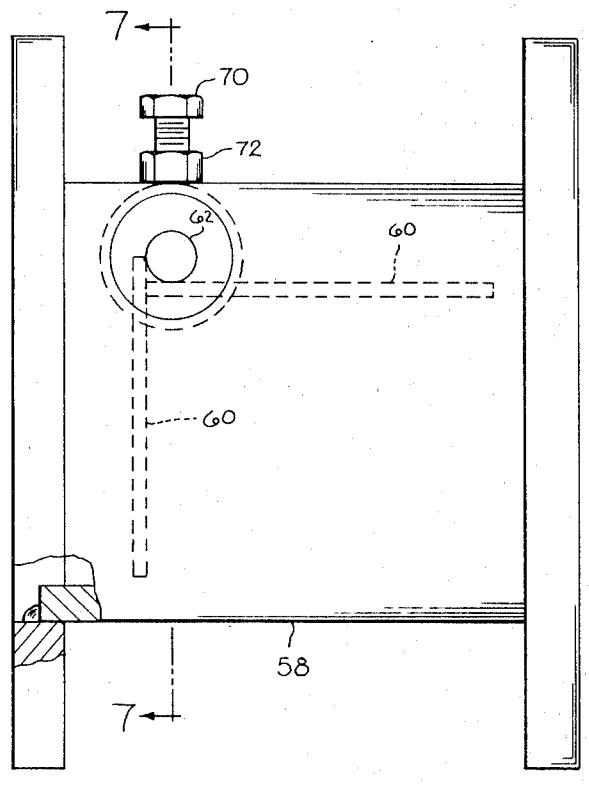


FIG 6

INVENTORS
ROBERT J. HASSELBRING
ROBERT L. SHIELDS

BY Philip L. Schlamp
ATTORNEY

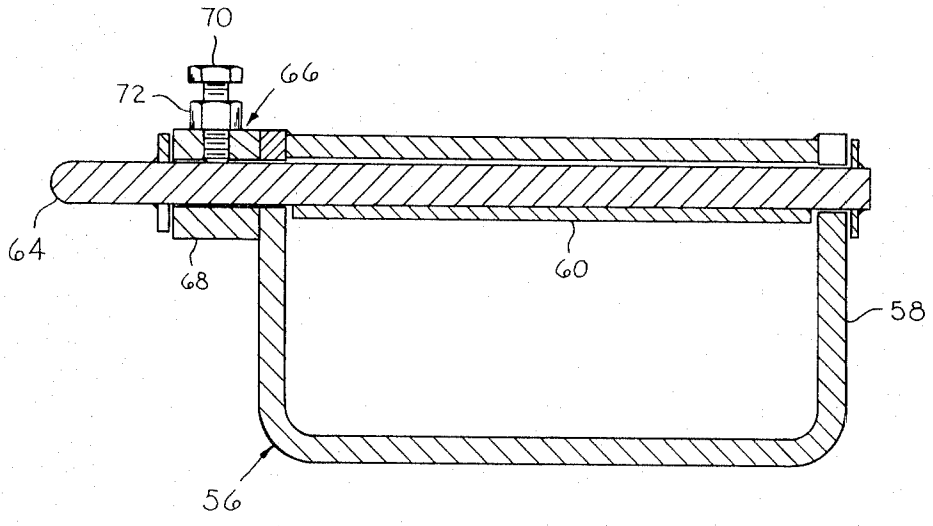


FIG 7

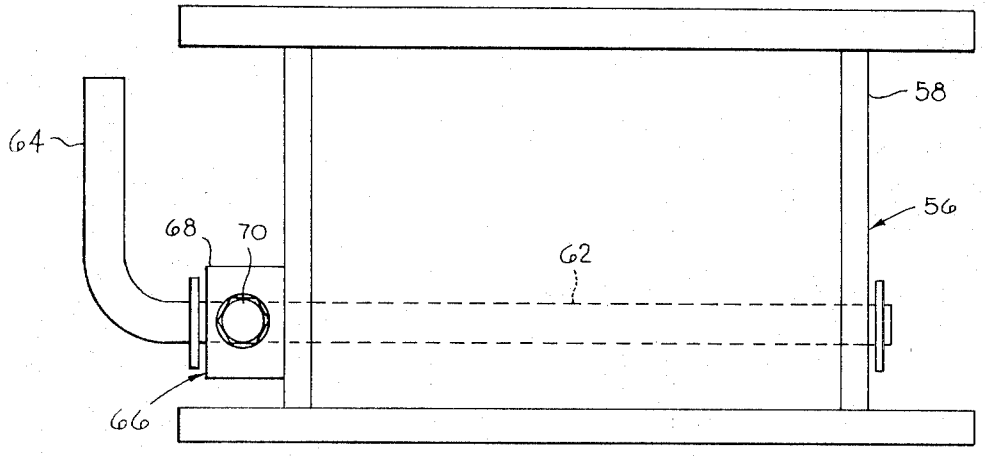


FIG 8

INVENTORS
ROBERT J. HASSELBRING
ROBERT L. SHIELDS
BY Philip L. Schlamp
ATTORNEY

INCINERATOR

CROSS-REFERENCE TO RELATED APPLICATIONS

Certain features disclosed in this application are disclosed and claimed in U.S. Pat. No. 3,577,940, issued on May 11, 1971 to Robert J. Hasselbring and Robert L. Shields and application Ser. No. 103,536, filed on Jan. 4, 1971 by Norman R. Dibelius and William L. Zabriskie, now U.S. Pat. No. 3,568,017, issued Apr. 25, 1972, said patents both being assigned to the assignee of this application.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to incinerators and has particular relation to industrial and municipal type incinerators for burning waste material.

2. Description of the Prior Art

Conventional industrial and municipal type incinerators ordinarily include one or more combustion chambers having drying grates with a flue for discharging to atmosphere the gaseous products of combustion of waste material in the chambers. Depending upon the efficiency of a particular incinerator design varying amounts of noxious gases and ash are discharged through the flue to atmosphere. Prior incinerator designs in general have been incapable of effecting good combustion of waste material such that the products of the resulting incomplete combustion consist of a large quantity of noxious gases and ash which are discharged to the surrounding atmosphere in the form of dense acrid smoke.

In an effort to comply with regulatory air pollution codes, more recent incinerator designs have provided for cleaning the gaseous products of combustion prior to their discharge to atmosphere. Such flue gas cleaning apparatus is usually of costly and bulky construction and in some cases has not operated to clean the flue gases sufficiently to comply with the regulatory codes. One known flue gas cleaning apparatus includes means for conducting the gaseous products of combustion through water sprays so that the suspended ashes and other particulate matter are entrained in the water which is then collected and conveyed to a suitable clarification system. This type of flue gas cleaning apparatus is expensive and complex and contributes not only to the high cost and massive structure of prior art incinerators but also to water pollution. Further, the very high temperatures within the chambers necessary to effect good combustion result in very hot flue gases which may result in inefficient operation of the flue gas cleaning apparatus and resulting undesirable pollution of the surrounding atmosphere. The provision of flue gas cleaning apparatus thus imposes a limitation upon the temperature within the combustion chambers which contributes to the poor combustion realized by certain prior art designs.

It is necessary of course that provision be made for collecting and disposing of non-combustible material. One known apparatus for accomplishing this function comprises a conveyor disposed beneath the combustion chambers for receiving such material and for conveying the same from the combustion chambers to a suitable disposition area. Such conveying apparatus is also very costly and in addition occupies considerable space which further contributes to the high cost and massive structure of prior art incinerators.

OBJECTS OF THE INVENTION

It is therefore a primary object of the invention to provide a novel and improved incinerator capable of effecting substantially complete combustion of waste material and wherein essentially solid-free flue gases are discharged to the atmosphere to minimize air and water pollution.

It is another object of the invention to provide a novel and improved incinerator of such character which avoids the use of costly and complex flue gas cleaning apparatus.

It is a further object of the invention to provide a novel and improved vortex incinerator of the foregoing character wherein non-combustible material is discharged from the combustion chamber during the burning process by action of the vortex without the use of costly and bulky material handling and conveying apparatus.

It is a still further object of the invention to provide a novel and improved vortex incinerator of the foregoing character wherein the burning process is more efficiently carried on and the removal of fly ash as well as the discharge of non-combustible material are facilitated.

SUMMARY OF THE INVENTION

In carrying out the invention in one preferred form, an incinerator is provided which includes a combustion chamber having spaced end walls and a side wall with its central longitudinal axis extending between the end walls. The chamber is preferably disposed in operative position with its central longitudinal axis extending horizontally or substantially horizontally. Means are provided for introducing waste material and primary air into the chamber for establishing a vortical movement of the waste material toward one of the end walls and provision is made for igniting the waste material during its vortical movement. Secondary air is introduced into the chamber substantially tangentially to the side wall at a plurality of regions which are spaced substantially throughout the entire length of the chamber and which are aligned along a horizontal axis. These regions are located adjacent the bottom of the chamber at one side thereof such that secondary air is introduced in directions to maintain the vortical movement of waste material. The secondary air entering the chamber at each of the mentioned spaced regions is controlled by an independently controllable damper which can be adjusted manually to control the amount of air entering the chamber and contributing to the vortex energy at each region. The secondary air is supplied through a blower-feed manifold and an automatically controllable damper controls generally the secondary air distributed through the manifold. The automatic damper is controlled adjustably and operates automatically in response to temperature variations in the chamber.

A discharge flue port has an open end opening in the chamber near the one end wall and substantially concentric with the central longitudinal axis of the chamber. A second discharge port includes an open end opening in the chamber adjacent the inner surface

of the side wall for discharging from the chamber during the burning process non-combustible material entrained in the outer region of the vortex. The open end of the second discharge port is located adjacent the bottom of the chamber at the side thereof substantially opposite one of the regions of introduction of the secondary air.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic diagram of an incinerator embodying the invention showing in particular the path of vertical movement of the waste material within the combustion chamber and the distribution paths of secondary air;

FIG. 2 is a view in end elevation of the combustion chamber and the secondary air manifold associated therewith;

FIG. 3 is a view in section taken along the line 3—3 of FIG. 2 and including a schematic illustration of the automatic secondary air control means;

FIG. 4 is a view in side elevation of the combustion chamber and the secondary air manifold associated therewith;

FIG. 5 is a view in section taken along the line 5—5 of FIG. 4;

FIG. 6 is a view in side elevation of a damper mechanism associated with the manifold;

FIG. 7 is a view in section taken along the line 7—7 of FIG. 6; and

FIG. 8 is a view in top plan of the mechanism of FIG. 6.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring now to the drawing there is illustrated in FIGS. 1–4 an incinerator embodying the invention and comprising in general a size reduction unit for chopping up the waste material, means for introducing the waste material and primary air into a combustion chamber for establishing a vortical movement of the waste material, means for igniting the waste material during its vortical movement, means for introducing secondary air into the chamber, discharge means for discharging gaseous products of combustion, and non-combustible material from the combustion chamber, and a separator for separating the gaseous and solid material discharged by the discharge means. The incinerator of the present invention is particularly suited for disposing of solid industrial and municipal waste material such as for example, paper, peanut hulls, cardboard cartons, wood scrap, garbage, foliage, bottles, cans and combustible floor sweepings. However, the incinerator is also capable of disposing of liquid waste material such as oils, paint sludges and plating tank residue.

More specifically, the incinerator as schematically shown in FIG. 1 includes a size reduction unit **10** designed to shred and chop the waste material into pieces small enough to be efficiently conveyed to and burned in the combustion chamber. If the waste material to be disposed of is already of an acceptable size, such as sawdust, then the size reduction unit **10** is not required. The size reduction unit **10** may be of any suitable construction and includes a hopper **12** having an open end **14** into which the waste material is fed for size reduction by a shredding and chopping mechanism (not shown) operated by a motor (not shown). After being reduced in size the waste material is drawn into a pneumatic conveying system including a blower **16** operated by a motor (not shown) which entrains the size reduced material in a primary air stream and transports it through a pipe **20** which opens into a combustion chamber **22**.

The combustion chamber **22** may be of any suitable configuration and is preferably cylindrical including a pair of spaced end walls **24** and **26** connected by an annular side wall **28**. The chamber **22** is preferably disposed when in operative position so that its central longitudinal axis which extends between the end walls **24** and **26** is horizontal or substantially horizontal as shown in FIGS. **3** and **4**. If desired, the end wall **26** of the chamber **22** may include an access door **30** to permit access to the interior of the chamber **22**. In the specific embodiment of the invention illustrated, the side wall **28** of the chamber **22** comprises an outer casing **32** (FIG. 3) formed of suitable material such as a low carbon steel and the casing **32** is lined with one or more inner layers **34** and **36** of suitable material such as fire brick. The innermost layer **34** is designed to exhibit good resistance to abrasion whereas the layer **36** may be designed to have good heat insulating qualities or to transfer the heat to a remote location. The end walls **24** and **26** of the chamber **22** may be similarly formed of an outer layer of low carbon steel with inner layers of fire brick. In the embodiment illustrated, the pipe **20** enters the chamber **22** tangentially of the side wall **28** near the top of the chamber **22** adjacent the end wall **26** and at the left side of the chamber as viewed in FIG. **2**. In certain installations it may be desirable to have the pipe **20** enter the chamber **22** at a region which is substantially midway between the end walls **24** and **26**.

Continuous injection of a mixture of waste material and air into the chamber **22** from the pipe **20** tangentially to the side wall **28** establishes a vortical flow of the waste material which travels from adjacent the end wall **26** toward the end wall **24** in a clockwise direction as viewed from the end wall **26** in FIG. **1** or in the direction of the arrow **37** in FIG. **5**. It is understood of course that the pipe **20** may be disposed to enter the chamber **22** at the upper right hand side thereof instead of at the upper left hand side in which event the direction of the vortex would be reversed from the clockwise direction illustrated to a counterclockwise direction.

The total pressure of the air exiting from the pipe **20** can be as high as 20 inches H_2O and is preferably about 12 inches H_2O. However, such pressure can be as low as 4 inches H_2O when burning finely divided, highly combustible material at a lower heat release rate. Therefore, pressures of air exiting from the pipe **20** are generally within the range of 4 inches H_2O to 20 inches H_2O.

In order to ignite the waste material entering the chamber **22**, a suitable gas burner **38** is disposed near the end wall **26** of the chamber **22** to fire tangentially into the chamber adjacent the top and at the right side thereof as viewed in FIG. **2**. Under conditions wherein a mixture of waste material and air is continuously fed into the chamber **22**, it has been observed that the burner **38** may oridinarily be turned off after ignition of the waste material is accomplished. The location of the

burner 38 shown in FIG. 2 is not our invention but is the sole invention of Robert L. Shields and is also assigned to the assignee of this application.

In order to enhance combustion of the waste material and to maintain the energy of its vortical flow in a predetermined and controlled manner through the entire length of the combustion chamber provision is made for introducing controlled quantities of high velocity secondary air into the chamber 22 during the burning process and at spaced regions throughout the length of the chamber. To this end a motor-driven fan or blower 40 is disposed to introduce secondary air into an elongated manifold 42 suitably supported externally of the chamber and extending along an axis substantially parallel to the longitudinal axis of the chamber. Also the manifold 42 is located preferably near the bottom and at the right side of the chamber as viewed in FIG. 2. The secondary air is injected substantially tangentially into the chamber through a plurality of substantially equally spaced openings 44 in the side wall 28 and at regions located downstream of the region of introduction of the mixture of primary air and waste material. In a preferred embodiment the openings are provided along the entire length of the chamber and are four in number. Additionally, and as illustrated in FIG. 5, the tangential injection of the secondary air into the chamber is provided by means of conduits 46 extending between the manifold 42 and the bottom portion of the chamber. If desired, means (not shown) may be provided for preheating the secondary air which is introduced into the chamber 22 through the openings 44 by means of the fan 40, manifold 42 and conduits 46. With the described arrangement the combustible waste material is substantially completely burned in suspension in a free vortex with the heavier solid waste fragments and non-combustible material traveling in a vortical path along the inner surface of the layer 34 and migrating toward the end wall 24. The solid material is forced toward the inner surface of the layer 34 by the tangential component of velocity of the vortex whereas the radially inward component of velocity creates high relative velocity between the air and burning material which greatly accelerates the combustion rate.

Additionally, in the described arrangement the tangential injection of the secondary air through the openings 44 and at spaced points along the length of the chamber, has the beneficial effect of periodically contributing to the vortex energy in the chamber. Thus, compensation is provided for losses in vortex energy or for effectively sustaining the vortex as the waste material progresses vortically along the length of the chamber.

The periodic or spaced tangential injection of secondary air and the resultant sustenance of the vortex along the entire length of the chamber enhances the efficiency of the waste burning process. Also, it reduces any tendency of combustion material particles, such as fly ash, to drop out of the vortex and settle on the bottom of the chamber which, if permitted to occur, can present substantial difficulties in effecting removal of such particles from the chamber and can require longer shut down times for chamber cleaning purposes. Also, it can adversely affect exhaust emissions.

For the purpose of predeterminedly controlling the secondary air generally and individually at each of the particular regions of injection into the chamber, adjustable control means are provided between the blower 40 and the manifold 42 and in each of the conduits 46 extending between the manifold 42 and the chamber. More specifically, a damper comprising, for example a butterfly valve 48 is provided in the manifold 42 between the fan and the main portion of the manifold to which the several conduits 46 are connected. The operation of the butterfly valve 48 is determined by the operation of a suitable proportional motor 50 adapted for positioning the valve between open and closed positions in accordance with the degree of energization of the motor. The motor energization is, in turn, determined by a suitable control means generally indicated and designated 52 in FIG. 3. The control means 52 is operatively connected to a thermocouple or other suitable thermally responsive device 54 which extends into the chamber 22 to sense the temperature therein and provide an appropriate control signal. Specifically, the control means 52 is adapted for automatically operating the damper or valve 48 in response to temperature variations within the chamber and such that the valve is moved toward its most open position in response to increases in temperature thereby to increase the flow of secondary air into the system, and toward its closed position in response to decreases in temperature thereby to decrease the flow of air into the system. The control means 52 is adjustably presettable so that the temperature range over which the valve automatically opens and closes is predeterminable by the operator.

The secondary air entering the chamber 22 through the openings 44 is further and individually controllable by means of separate and independently adjustable dampers 56 interposed one in each of the conduits 46. Each damper 56 is adapted for further controlling the secondary air as it enters the chamber at its respective region along the vortical path of the waste material. Thus, the dampers 56 are effective for enabling the operator to control separately and individually the energy added to the vortex at each of the regions, permitting more or less energy to be introduced as required to maintain a desired vortical profile and in accordance with experience as to regions where more or less energy is needed to compensate for energy losses in the vortex.

The construction of the dampers 56 is best seen in FIGS. 5–8, and each such damper comprises a housing 58 of generally rectangular cross section and having suitable flanges for mounting in the respective conduits 46. Also, each damper includes an appropriate flapper element 60 which is pivotally movable about one end thereof between fully open horizontal and fully closed vertical positions illustrated in dash lines in FIG. 6. The pivoting of the element 60 is specifically accomplished by mounting it on a rod 62 suitably rotatably mounted between the side walls of the housing 58. Externally of the housing 58, the rod 60 is bent to provide an operating arm or lever 64. Cooperating with the external portion of the rod 62 is a locking device 66 which can comprise a collar 68 fitted over the rod and fixed to the housing and a set screw 70 threadedly mounted in the collar and carrying a lock nut 72. This arrangement permits the operator of the system to presettably position and lock each of the flapper elements 60 in a

desired adjusted position in its respective damper housing for thereby controlling the air entering the chamber at its respective region and for the purpose discussed above. This arrangement is particularly adapted for manual individual adjustment of the dampers **56**. However, it will be seen from the foregoing that, if desired, each of the dampers **56** could be controlled automatically in a manner similar to the butterfly valve and also that the dampers **56** could be automatically controlled individually or in a cooperating coordinated manner in response to various predetermined parameters such, for example, as secondary air temperature or temperature at different regions in the chamber.

In order to discharge gaseous products of combustion from the chamber **22** to atmosphere first discharge means is provided including a first discharge port or flue **74** having an open end opening in the chamber in the region of the end wall **24** and substantially concentric with the central longitudinal axis of the chamber **22**. As best shown in FIG. **3** the flue **74** includes a hollow cylinder or flue pipe **76** of any suitable material extending through and suitably mounted in an opening in the end wall **24**. In the particular embodiment of the invention shown the end wall **24** includes adjacent layers **78** and **80** formed of suitable material such as fire brick, and an outer annular plate **82** secured together by suitable fasteners (not shown). The cylinder **76** is releasably attached to a flue section (not shown) which terminates in an open end opening to atmosphere.

Second discharge means is provided for discharging from the chamber **22** during the burning process of non-combustible material. For this purpose the preferred embodiment provides a second discharge port **84** having an open end **85** opening in the chamber **22** at a region downstream from the point of introduction of the waste material in the region adjacent the inner surface of the end wall **24** and adjacent the inner surface of the layer **34** for receiving and discharging from the chamber non-combustible material which is entrained in the outer region of the vortex. In the illustrated embodiment the port **84** comprises a conduit **86** extending through the side wall **28** substantially tangentially thereto and substantially horizontally at the bottom of the chamber as viewed in FIGS. **2** and **3** with its open end **85** opening at the inner surface of the layer **34**. The conduit **86** leads to suitable separator and disposal means described hereinafter. With the described arrangement the opening **85** is in the path of the non-combustible material which during operation of the incinerator is at the outer region of the vortex and which has migrated to adjacent the end wall **24**, and the action of the vortex causes such material to enter the opening **85** for discharge from the chamber **22**. As shown in FIGS. **2** and **3** the conduit **86** extends horizontally adjacent the bottom of the chamber **22**. Also, and as seen from FIGS. **1** and **2**, the discharge opening **85** provided by the conduit **86** is located substantially opposite and in substantially the same horizontal plane as one of the secondary air openings **44**. This relative positioning of the second discharge port **85** and one of the secondary air openings **44** results in the injected secondary air from that opening being effective in assisting in the direction of fly ash and other waste materials through the second discharge port **85**. Also, it serves effectively to prevent waste material from accumulating in front of, and obstructing passage through, the discharge port **85**. It is to be understood that although a single conduit **86** is illustrated, a plurality of such conduits can be provided if desired. Moreover, the conduit **86** can be replaced by a scoop positioned to receive material in the outer region of the vortex and connected to a conduit extending through the chamber wall. Also, each such conduit or scoop can be arranged to cooperate with an oppositely disposed secondary air inlet to obtain the resultant benefits described above.

Most if not all of any non-combustible material will enter the conduit **86** as it initially reaches the end wall **24**. However, in the event that such material does not enter the conduit **86** when it initially reaches the end wall **24**, this material becomes entrained in the stream of hot gases which normally flows in the direction of the arrows **88** along the inner surface of the end wall **24** toward the open end **90** of the flue pipe **76** where a low pressure area exists. If the open end of the flue pipe **76** were flush with the end wall, a considerable portion of this material would enter the flue pipe **76** thus necessitating provision of flue gas cleaning apparatus to avoid pollution of the surrounding atmosphere. In order to reduce the amount of such solid material which exits from the chamber **22** through the flue pipe **76**, the flue pipe **76** is extended into the chamber **22** so that the inner open end of the flue pipe **76** is spaced axially inwardly from the end wall **24** as shown in FIG. **3**. With this arrangement the solid material which does not enter the conduit **86** tends to move from adjacent the end wall **24** along the outside diameter of the flue pipe **76** toward its open inner end. Such movement increases the time of residence of the material in the chamber **22** thus resulting in more complete combustion and a reduction in the amount of this material which enters the flue pipe as compared to the amount entering the flue pipe if its open end were flush with the end wall **24**.

In order to still further reduce the amount of solid material entering the flue pipe **76** a baffle **92** is positioned adjacent the open inner end of the flue pipe **76** to divert outwardly toward the inner layer **34** of the chamber **22** any non-combustible material which moves from adjacent the end wall **24** toward the open end of the flue pipe **76**. The arrangement is such that solid material moving in the direction of the arrows **88** engages the baffle **92** and is thereby deflected in the direction of the arrow **94** so that the material so diverted once again becomes entrained in the vortex for further burning and movement toward the end wall **24** for discharge through the conduit **86**. As shown in FIG. **3**, the baffle **92** preferably comprises a plate of any suitable material in the form of a ring suitably releasably secured to the pipe **76** adjacent its open end. Additionally, this arrangement disposes the inner end of the flue pipe **76** and the baffle **92** adjacent the region of the vortex which can be influenced by the secondary air injected through the opening disposed for cooperation with the discharge port **85**. This arrangement together with the adjustability of the secondary air provided by the respective damper **56** affords the operator the opportunity to adjust the secondary air injected at this region in a manner to predeterminedly influence

the energy condition of the vortex in the region of the flue pipe opening. Thus, one can adjust to a degree the pressure conditions in the region of the baffle **92** for thereby influencing the flow paths indicated by the arrows **88** and **94**.

A separator **96** is provided for separating the gases and the solid material discharged through the conduit **86** and for dropping the solid material into a suitable container **98**. The separator **96** is preferably a commercially available cyclone or vortex type separator wherein material discharged through the conduit **86** is introduced tangentially into the separator **96** with the result that the solid material drops out the open end of the separator into the container **98**. Such solid material constitutes ashes and other particulate matter formed in the combustion process and also non-combustible material which can be disposed of in any suitable manner. The hot gases separated out by the separator **96** are introduced into the flue pipe **76**. While most of the non-combustible material is delivered to the separator **96**, a small portion of such material tends to settle to the bottom of the chamber **22**. This settled material is minimized in the manner described above by the effects of the injection of secondary air at multiple regions spaced along the waste flow path. However, to the extent any such settlement of material occurs in the chamber, it can periodically be removed from the chamber in any suitable manner through the access door **30**.

By means of the invention a very efficient incinerator is provided characterized by the exhaust of gases to the atmosphere which are substantially free of particulate matter so as to minimize air and water pollution. In addition, non-combustible material is discharged from the combustion chamber during the burning process by action of the vortex so as to avoid the provision of costly and complex material handling apparatus for conveying such material away from the combustion chamber. Further, the provision of costly and complex flue gas cleaning apparatus is avoided by the invention which allows operation of the incinerator at temperatures which are higher than that which would be allowable in the event flue gas cleaning apparatus were utilized. Moreover, the incinerator effects substantially complete combustion of combustible waste material resulting in an extremely high percentage reduction in the original volume of waste material.

A typical design of the incinerator of the present invention includes a combustion chamber having an internal length of 8 feet and an inner diameter D of 4½ feet. The flue pipe **76** has an inner diameter of 2 feet and extends into the chamber a distance of about 16 inches from the inner surface of the end wall **24**. The baffle plate **92** has a diameter of approximately 35 inches. Also, the conduit **86** has an inner diameter of 4 inches. An incinerator of such design presently appears capable of disposing of solid waste having up to 20 percent moisture content and normally 10 percent ash content with a heat value of 5,000 BTU per pound at a rate of 3,000 pounds per hour to effect close to 98 percent destruction of combustible material. It presently appears that such an incinerator design emits particulate matter to the atmosphere of not more than 0.2 grains per standard dry cubic foot of flue gas. The foregoing results seem to be obtainable with chamber temperatures between 1,200°F and 2,200°F.

Although the invention has been described with reference to certain specific embodiments thereof, numerous modifications are possible and it is desired to cover all modifications falling within the spirit and scope of the invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. An incinerator for burning waste material comprising in combination;

a. a combustion chamber having spaced end walls and a side wall with its central longitudinal axis extending between said end walls, said chamber being disposed such that its central axis extends substantially horizontally,

b. means for introducing waste material and primary air into said chamber for establishing a vortical movement of said waste material and primary air toward one of said end walls,

c. means for igniting said waste material during its vortical movement,

d. a discharge flue port having an open end opening in said chamber near said one end wall and substantially concentric with said central longitudinal axis,

e. means for introducing secondary air directly into said combustion chamber substantially tangentially to said side wall at a plurality of regions which are spaced substantially throughout the entire length of said combustion chamber side wall and which are aligned along an axis substantially parallel to the longitudinal axis of said chamber, said regions being located adjacent the bottom of said combustion chamber side wall at one side thereof such that secondary air is directly introduced in directions to maintain the vortical movement of waste material, and

f. control means for independently controlling the introduction of secondary air into said chamber at each of said plurality of regions.

2. An incinerator as defined in claim **1** including a second discharge port having an open end opening in said chamber adjacent the inner surface of said side wall for discharging from said chamber during the burning process non-combustible material which is entrained in the outer region of the vortex.

3. An incinerator as defined in claim **2** wherein said second discharge port extends through said side wall substantially tangentially thereto with its open end located adjacent the bottom of said chamber at the other side thereof substantially opposite one of the regions of introduction of said secondary air.

4. An incinerator as defined in claim **1** wherein the open end of said discharge flue port is spaced axially of said one end wall.

5. An incinerator as defined in claim **4** including a baffle adjacent the open end of said discharge flue port to divert outwardly toward said side wall solid non-combustible material which moves from adjacent said one end wall toward the open end of said discharge flue port.

6. An incinerator as defined in claim **5** including a second discharge port having an open end opening in said chamber adjacent the inner surface of said side wall for discharging from said chamber during the burning process non-combustible material which is entrained in the outer region of the vortex.

7. An incinerator as defined in claim 6 wherein said second discharge port extends through said side wall substantially tangentially thereto with its open end located adjacent the bottom of said chamber at the other side thereof substantially opposite one of the regions of introduction of said secondary air.

8. An incinerator for burning waste material comprising in combination;

a. a combustion chamber having spaced end walls and a side wall with its central longitudinal axis extending between said end walls, said chamber being disposed such that its central axis extends substantially horizontally,

b. means for introducing a mixture of waste material and primary air under pressure into said chamber tangentially to said side wall for establishing a vortical movement of said waste material toward one of said end walls,

c. means for igniting said waste material during its vortical movement,

d. means for introducing secondary air into said chamber substantially tangentially to said side wall at a plurality of spaced regions which are aligned along an axis substantially parallel to the longitudinal axis of said chamber and which are located adjacent the bottom of said chamber at one side thereof, said secondary air being introduced into said chamber in directions to maintain the vortical movement of waste material,

e. a first discharge flue port having an open end opening in said chamber near said one end wall and substantially concentric with said central axis,

f. a second discharge port having an open end opening in said chamber adjacent the inner surface of said side wall for discharging from said chamber during the burning process non-combustible material which is entrained in the outer region of the vortex, and

g. the open end of said second discharge port and one of the regions of introduction of said secondary air being located relative to each other such that they both are intersected by a plane which is substantially perpendicular to the longitudinal axis of said chamber.

9. An incinerator as defined in claim 8 wherein said means for introducing secondary air includes control means for automatically adjusting the flow of secondary air in response to variations of temperature within said chamber such that the flow of secondary air is increased in response to an increase in temperature, and is decreased in response to a decrease in temperature.

10. An incinerator as defined in claim 8 wherein the open end of said first discharge flue port is spaced axially of said one end wall.

11. An incinerator as defined in claim 10 including a baffle adjacent the open end of said first discharge flue port to divert outwardly toward said side wall solid non-combustible material which moves from adjacent said one end wall toward the open end of said discharge flue port.

12. An incinerator as defined in claim 9 wherein the open end of said first discharge flue port is spaced axially of said one end wall.

13. An incinerator as defined in claim 12 including a baffle adjacent the open end of said first discharge flue port to divert outwardly toward said side wall solid non-combustible material which moves from adjacent said one end wall toward the open end of said first discharge flue port.

14. An incinerator for burning waste material comprising in combination;

a. a combustion chamber having spaced end walls and a side wall with its central longitudinal axis extending between said end walls, said chamber being disposed such that its central axis extends substantially horizontally,

b. means for introducing waste material and primary air to said chamber for establishing a vortical movement of said waste material toward one of said end walls,

c. means for igniting said waste material during its vortical movement,

d. a discharge flue port having an open end opening in said chamber near said one end wall and substantially concentric with said central longitudinal axis,

e. the side wall of said chamber having a plurality of spaced first openings extending tangentially therethrough which are aligned along an axis substantially parallel to the longitudinal axis of said chamber and which are located adjacent the bottom of said chamber at one side thereof,

f. means for introducing secondary air into said chamber through each of said first openings in directions to maintain the vortical movement of waste material, said means for introducing including a manifold supported externally of said chamber to extend along an axis substantially parallel to the longitudinal axis of said chamber, and a blower connected to said manifold to supply secondary air thereto,

g. first control means for independently adjustably controlling the flow of secondary air supplied from said manifold to each of said first openings, and

h. second control means for adjustably controlling the flow of secondary air supplied from said blower to said manifold.

15. An incinerator as defined in claim 14 wherein said first control means includes a plurality of first dampers each disposed for manual adjustment for effectively varying the size of a separate one of said first openings.

16. An incinerator as defined in claim 14 wherein said second control means includes a damper movable between open and closed positions, and means for automatically moving said second damper in response to variations of temperature within said chamber such that said second damper is moved toward open position in response to an increased in temperature to increase the flow of secondary air, and is moved toward closed position in response to a decrease in temperature to decrease the flow of secondary air.

17. An incinerator as defined in claim 14 including a second discharge port having an open end opening in said chamber adjacent the inner surface of said side wall for discharging from said chamber during the burning process non-combustible material which is entrained in the outer region of the vortex.

18. An incinerator as defined in claim 17 wherein said second discharge port extends through said side

wall substantially tangentially thereto with its open end located adjacent the bottom of said chamber at the other side thereof substantially opposite one of said first openings.

19. An incinerator as defined in claim **14** wherein the open end of said discharge flue port is spaced axially of said one end wall.

20. An incinerator as defined in claim **19** including a baffle adjacent the open end of said discharge flue port to divert outwardly toward said side wall solid non-combustible material which moves from adjacent said one end wall toward the open end of said discharge flue port.

21. An incinerator as defined in claim **20** including a second discharge port having an open end opening in said chamber adjacent the inner surface of said side wall for discharging from said chamber during the burning process non-combustible material which is entrained in the outer region of the vortex.

22. An incinerator as defined in claim **21** wherein said second discharge port extends through said side wall substantially tangentially thereto with its open end located adjacent the bottom of said chamber at the other side thereof substantially opposite one of said first openings.

23. An incinerator for burning waste material comprising in combination;

a. size reducing means for receiving waste material and reducing it in size.

b. blower means for drawing the size reduced material from the size reducing means and entraining it in a primary air stream,

c. a generally cylindrical combustion chamber having spaced end walls and an annular side wall with its central longitudinal axis extending between said end walls, said chamber being disposed such that its central axis extends substantially horizontally,

d. a conduit extending between said blower means and said chamber for delivering the primary air stream and the entrained size reduced material to said chamber and introducing it into said chamber tangentially to said side wall for establishing a vortical movement of said waste material toward one of said end walls,

e. means for igniting said waste material during its vortical movement,

f. a discharge flue port having an open end opening in said chamber near said one end wall and substantially concentric with said central longitudinal axis,

g. the side wall of said chamber having a plurality of spaced first openings extending tangentially therethrough which are aligned along an axis substantially parallel to the longitudinal axis of said chamber and which are located adjacent the bottom of said chamber at one side thereof,

h. means for introducing secondary air into said chamber through each of said first openings in directions to maintain the vortical movement of waste material, said means for introducing including a manifold supported externally of said chamber to extend along an axis substantially parallel to the longitudinal axis of said chamber, and a blower connected to said manifold to supply secondary air thereto,

i. first control means for independently adjustably controlling secondary air supplied from said manifold to each of said first openings,

j. second control means for adjustably controlling secondary air supplied from said blower to said manifold,

k. said first control means including a plurality of first dampers each adapted for manual adjustment for effectively varying the size of a separate one of said openings, and

l. said second control means including a second damper movable between open and closed positions, and means for automatically moving said second damper in response to variations of temperature within said chamber such that said second damper is moved toward open position in response to an increase in temperature to increase the flow of secondary air, and is moved toward closed position in response to a decrease in temperature to decrease the flow of secondary air.

24. An incinerator as defined in claim **23** including a second discharge port having an open end opening in said chamber adjacent the inner surface of said side wall for discharging from said chamber during the burning process non-combustible material which is entrained in the outer region of the vortex.

25. An incinerator as defined in claim **24** wherein said second discharge port extends through said side wall substantially tangentially thereto with its open end located adjacent the bottom of said chamber at the other side thereof substantially opposite one of said first openings.

26. An incinerator as defined in claim **23** wherein the open end of said discharge flue port is spaced axially of said one end wall.

27. An incinerator as defined in claim **26** including a baffle adjacent the open end of said discharge flue port to divert outwardly toward said side wall solid non-combustible material which moves from adjacent said one end wall the open end of said discharge flue port.

28. An incinerator as defined in claim **23** wherein said plurality of first openings comprises four openings spaced equally substantially throughout the entire length of said chamber.

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