United States Patent

Dibelius et al.

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[45] **Apr. 25, 1972**

[54] INCINERATOR

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[73] Assignee: **General Electric Company**

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[21] Appl. No.: **103,536**

[52] **U.S. Cl.** ..... **110/8 R,** 110/18 R, 110/119, 110/120

[51] **Int. Cl.** **F23g 5/12**

[58] **Field of Search** ..... 110/7 R, 8 R, 18 R, 119, 120, 110/28 F

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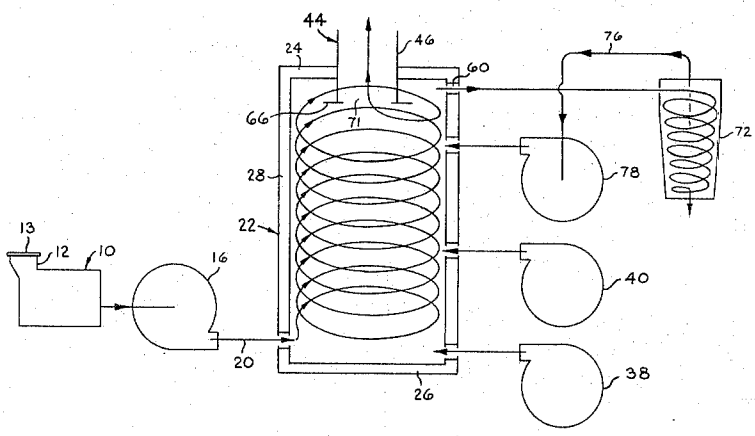
[57] **ABSTRACT**

An incinerator for burning waste material includes a 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 adjacent the one end wall extends tangentially through the side wall for discharging from the chamber residual combustible material and 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. The separated gases and any solid particles suspended therein are introduced back into the chamber. 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. The ratio of the area of the open end of the discharge flue port to the area of a cross-section of the chamber taken perpendicular to its longitudinal axis is selected to be within the range of one-sixteenth to four twenty-fifth and is preferably one-ninth.

42 Claims, 4 Drawing Figures



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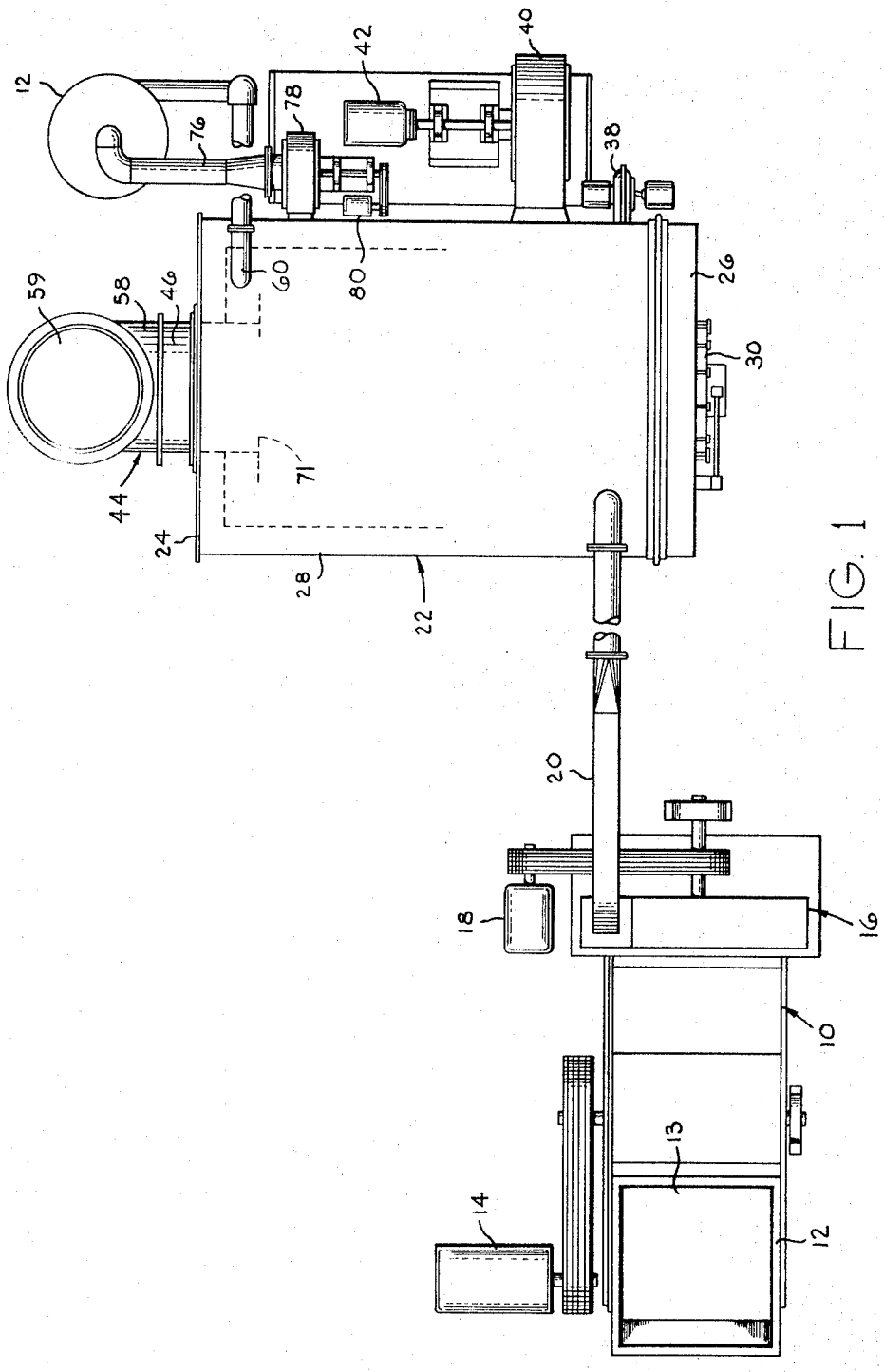

FIG. 1

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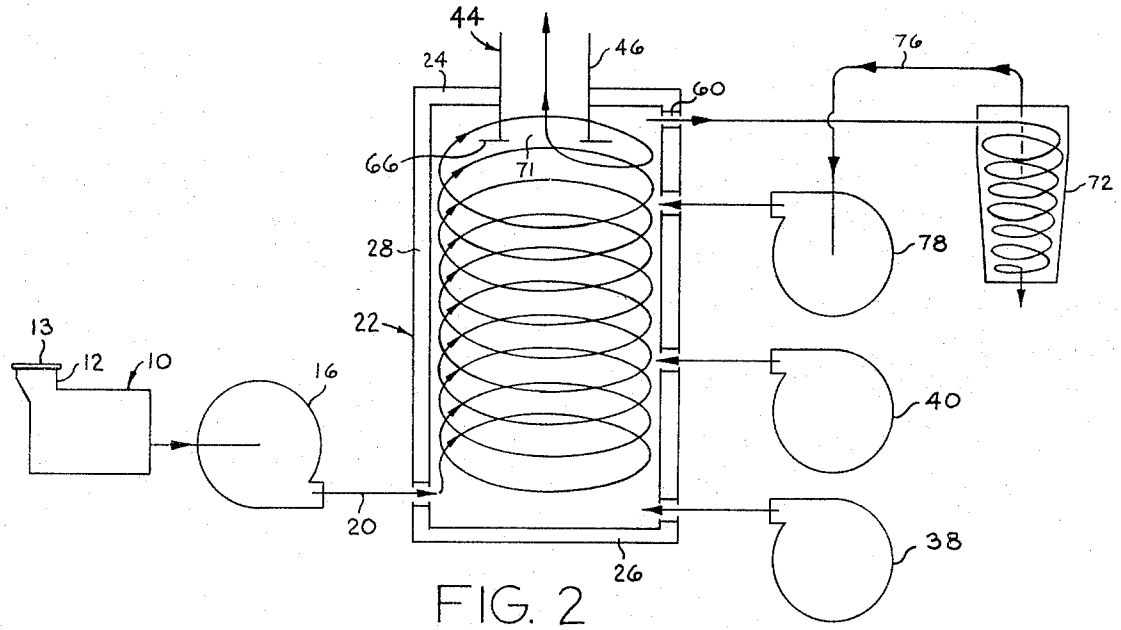

FIG. 2

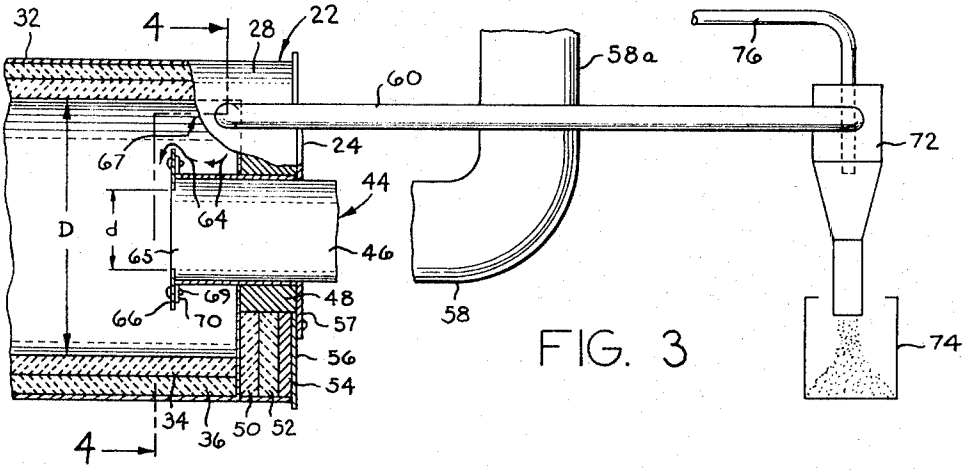

FIG. 3

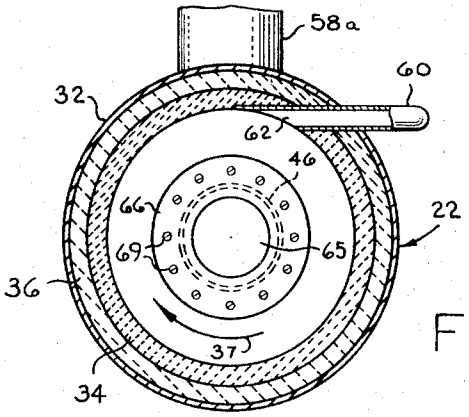

FIG. 4

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INCINERATOR

CROSS-REFERENCE TO RELATED APPLICATION

Certain features disclosed in this application are disclosed and claimed in application Ser. No. 869,823, now U.S. Pat. No. 3,577,940, filed on Oct. 27, 1969 by Robert J. Hasselbring and Robert L. Shields and 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 any residual combustible material and 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 any residual combustible material and non-combustible material are 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.

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. The pressure of the primary air is selected to be within the range of 4 inches H_2O to 20 inches H_2O, and is preferably about 12 inches H_2O. Also, secondary air is introduced into the chamber at an area downstream from the area of introduction of the waste material, and the pressure of the secondary air is preferably about 12 inches H_2O.

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 at an area downstream from the area of introduction of the waste material and adjacent the inner surface of the side wall for discharging from the chamber during the burning process residual combustible material and non-combustible material entrained in the outer region of the vortex. The ratio of the area of the open end of the discharge flue port to the area of a cross-section of the chamber taken perpendicular to its longitudinal axis is selected to be within the range of 1/16 to 4/25 and is preferably 1/9.

The combustion chamber is preferably of generally cylindrical configuration and the open end of the discharge flue port is preferably of generally circular configuration. For such configurations the above referred to area ratios can be translated to corresponding diameter ratios with the result that the ratio of the diameter of the open end of the discharge flue port to the inner diameter of the chamber is selected to be within the range of 1/4 to 2/5 and is preferably 1/3.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a view in top plan of an incinerator embodying the invention;

FIG. 2 is a schematic diagram of the incinerator of FIG. 1 showing in particular the path of vortical movement of the waste material within the combustion chamber;

FIG. 3 is a view in side elevation of the combustion chamber and the separator associated therewith with parts of the combustion chamber broken away and shown in section; and

FIG. 4 is a view in section taken along the line 4—4 of FIG. 3.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring now to the drawing there is illustrated in FIGS. 1 and 2 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, discharge means for discharging gaseous products of combustion, residual combustible material 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 dispos-

ing of liquid waste material such as oils, paint sludges and plating tank residue.

More specifically, the incinerator as 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 **13** into which the waste material is fed for size reduction by a shredding and chopping mechanism (not shown) operated by a motor **14**. After being reduced in size the waste material is drawn into a pneumatic conveying system including a blower **16** operated by a motor **18** 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 FIG. **3**. 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** (FIGS. **3** and **4**) 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. **1**. In certain installations it may be desirable to have the pipe **20** enter the chamber **22** at an area 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. **4**. 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.

In accord with the present invention, 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, the present invention contemplates pressures of air exiting from the pipe **20** within the range of 4 inches H_2O to 2 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 bottom and at the right side thereof as viewed in FIG. **1**. 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 ordinarily be turned off after ignition of the waste material is accomplished.

In order to enhance combustion of the waste material and to maintain its vortical flow provision is made for introducing a controlled quantity of secondary air into the chamber **22** continuously during the burning process. To this end a fan **40** driven by a motor **42** is disposed to introduce secondary air into the chamber **22** preferably near the bottom and at the right side thereof as viewed in FIG. **1**. The secondary air is injected tangentially to the side wall **28** at an area downstream of the area of introduction of the mixture of primary air and waste material and according to the present invention, the pressure of the secondary air is preferably about 12 inches H_2O. If desired, means (not shown) may be provided for preheating the secondary air which is introduced into the chamber **22** by the fan **40**. 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. The temperatures are such as to be below the ash fusion temperature so that there is no slagging.

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 **44** 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 **44** includes a hollow cylinder **46** of any suitable material extending through an opening of a casting **48** which forms part of the end wall **24**. In the particular embodiment of the invention shown the end wall **24** includes adjacent layers **50** and **52** formed of suitable material such as fire brick, a casting **54**, and an outer annular plate **56** all secured together by suitable fasteners (not shown) and all surrounding the casting **48**. An annular plate **57** surrounds the cylinder **46** and is joined to its outer periphery. The plate **57** is secured to the casting **48** at its outer surface by suitable fasteners (not shown) and overlaps a portion of the plate **56**. The plates **56** and **57** are detachably secured together in any suitable manner at their overlapping portions in order to detachably connect the flue **44** and the casting **48** to the end wall **24**. The cylinder **46** is releasably attached to a flue section **58** shown in FIGS. **1** and **3** which includes a vertically extending portion **58***a* outside the chamber **22** which terminates in an open end **59** (FIG. **1**) opening to atmosphere.

Second discharge means is provided for discharging from the chamber **22** during the burning process residual combustible material and non-combustible material. For this purpose the preferred embodiment provides a second discharge port **60** having an open end **62** opening in the chamber **22** at an area downstream from the area of introduction of the waste material in the region of the end wall **24** and adjacent the inner surface of the layer **34** for receiving and discharging from the chamber residual combustible material and non-combustible material which are entrained in the outer region of the vortex. In the illustrated embodiment the port **60** comprises a conduit extending through the side wall **28** tangentially thereto and substantially horizontally at the top of the chamber as viewed in FIG. **4** with its open end **62** opening at the inner surface of the layer **34**. The conduit **60** leads to suitable separator and disposal means described hereinafter. With the described arrangement the open end **62** of the conduit **60** is in the path of the residual combustible material and the non-combustible material which are at the outer region of the vortex and which have migrated to adjacent the end wall **24**, and the action of the vortex causes such material to enter the open end **62** for discharge from the chamber **22**. While the conduit **60** is shown in FIG. **4** as extending horizontally at the top of the chamber **22**, it is understood that the conduit **60** may be disposed in any angular position about the axis of the chamber **22**. For example, in certain installations it may be desirable to position the conduit **60** so that it extends vertically and downwardly. It is also understood that although a single con-

duit **60** is illustrated, a plurality of such conduits may be provided if desired spaced angularly about the axis of the chamber. Moreover, the conduit **60** may be replaced by a scoop positioned to receive material in the outer region of the vortex and connected to a conduit extending through the end wall **24**.

Most if not all of any residual combustible material and non-combustible material will enter the conduit **60** as they initially reach the end wall **26**. However, in the event that such material does not enter the conduit **60** 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 **64** along the inner surface of the end wall **24** toward the open end **65** of the flue pipe **46** where a low pressure area exists. If the open end of the flue pipe **46** were flush with the end wall, a considerable portion of this material would enter the flue pipe **46** 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 **46**, the flue pipe **46** is extended into the chamber **22** so that the open end of the flue pipe **46** is spaced axially from the end wall **24** as shown in FIG. **3**. With this arrangement the solid material which does not enter the conduit **60** tends to move from adjacent the end wall **24** along the outside diameter of the flue pipe **46** toward its open 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 **46** a baffle **66** is positioned adjacent the open end of the flue pipe **46** to divert outwardly toward the inner layer **34** of the chamber **22** any residual solid combustible fragments and non-combustible material which move from adjacent the end wall **24** toward the open end of the flue pipe **46**. The arrangement is such that solid material moving in the direction of the arrows **64** engages the baffle **66** and is thereby deflected in the direction of the arrow **67** 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 **60**. As shown in FIG. **3**, the baffle **66** preferably comprises a plate of any suitable material in the form of a ring releasably attached as by bolts **69** to another ring-shaped plate **70** which is welded or otherwise secured to the pipe **46** adjacent its open end. The baffle **66** preferably overlies the open end of the flue pipe **46** and includes a central circular orifice **71** having a diameter *d* (FIG. **3**) which is less than the inner diameter of the flue pipe **46**. The orifice **71** of the baffle **66** thus constitutes the open end of the discharge flue port. The outside diameter of the baffle **66** and the diameter *d* of its orifice **71** are selected to provide optimum performance for the conditions involved. Under certain conditions the baffle **66** may surround the pipe **46** adjacent its open end in which event the open end of the pipe **46** constitutes the open end of the discharge flue port. The detachable mounting of the flue **44** to the end wall **26** as previously described permits detachment of the flue pipe **46** and the baffle **66** from the chamber **22** so as to permit replacement or repair of pipe **46** and baffle **66** as desired.

A separator **72** is provided for separating the gases and the solid material discharged through the conduit **60** and for dropping the solid material into a suitable container **74**. The separator **72** is preferably a commercially available cyclone or vortex type separator wherein material discharged through the conduit **60** is introduced tangentially into the separator **72** with the result that the solid material drops out the open end of the separator **72** into the container **74**. 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. While most of the residual combustible fragments and the non-combustible material are delivered to the separator **72**, a small portion of such material settles to the bottom of the chamber **22**. This settled material may periodically be removed from the chamber in any suitable manner.

The hot gases separated out by the separator **72** are introduced back into the chamber **22**. This is very advantageous in that it maintains the vortex within the chamber **22**, further cleans such gases by removing residual fly ash, and drys out wet waste material within the chamber **22**. For this purpose a conduit **76** extends coaxially into the separator **72** at the top thereof so that the hot gases separated by action of the separator **72** are drawn into the conduit **76** through the central low pressure area and are conveyed through the conduit **76** to a fan **7** operated by a motor **80** to withdraw the separated hot gases from the conduit **76** and to introduce such into the chamber **22**. These gases are preferably introduced into the chamber **22** at an area downstream from the area of introduction of the secondary air. However, under certain conditions the secondary air fan **40** may be employed instead of the fan **78** to introduce the separated gases back into the chamber **22**.

The total pressure available from the primary and secondary air entering the chamber is utilized both to introduce energy into the vortex for obtaining high combustion rates and also to accelerate material out through the conduit **60** and the flue pipe **46**. It has been observed that if the area of the orifice **71**, which constitutes the open end of the discharge flue port, is too small relative to an optimum area, then combustion rates will be lower than optimum because too much of the available pressure will be used to accelerate the flow of material out of the combustion chamber. On the other hand, if the area of the open end of the discharge flue port is too large relative to the optimum area, it is impossible to establish the vortex flow field required for effecting centrifugal separation of the fly ash and for obtaining substantially complete combustion of larger particles. Tests have demonstrated that the optimum area of the open end of the discharge flue port bears a specific relationship to the area of a cross-section of the combustion chamber **22** taken perpendicular to its longitudinal axis.

In accord with the present invention the ratio of the area of the open end of the discharge flue port to the area of a cross-section of the combustion chamber taken perpendicular to its longitudinal axis is selected to be within the range of 1/16 to 4/25 and is preferably about 1/9. In the illustrated embodiment of the invention these area ratios can be translated to corresponding diameter ratios with the result that the ratio of the diameter *d* of the open end of the circular discharge flue port to the diameter D of the cylindrical chamber **22** is selected to be within the range of 1/4 to 2/5. This range of diameter ratios has been found to be effective over a range of diameters of the chamber from 1½ feet to 15 feet.

In the preferred embodiment of the invention the ratio of the diameter *d* to the diameter D is selected to be approximately 1/3 or in other words, the inner diameter D of the chamber **22** is selected to be about three times as great as the diameter *d* of the open end of the discharge flue port. It is understood of course that the invention is not limited to the particular cylindrical chamber configuration and circular discharge flue configuration illustrated and is applicable in its broader aspects to other configurations of the chamber and discharge flue which are non cylindrical and non circular.

The nature of the free vortex flow field is influenced strongly by the ratio of the diameter *d* to the diameter D. With proper dimensions of these diameters selected in accord with the invention, the strong free vortex flow field provides an increasing tangential velocity with decreasing radius. Thus, the tendency of the particles to be drawn to the center of the chamber **22** by the drag forces imparted from the radially inward flow are counterbalanced by a stronger centrigugal force field. Therefore, the particles are maintained in suspension until complete combustion has occurred or until they are withdrawn from the chamber **22** through the conduit **60**.

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, residual combustible fragments and non-combustible material are 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 **46** 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 **66** has a diameter of approximately 35 inches and its orifice **71** has a diameter *d* of about 1½ feet. Also, the conduit **60** 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 6,000 BTU per pound at a rate of 4,000 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,

b. means for introducing waste material and primary air into 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 first 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. 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 residual combustible material and non-combustible material which are entrained in the outer region of the vortex, and

f. the ratio of the area of the open end of said first discharge flue port to the area of a cross-section of said chamber taken perpendicular to it longitudinal axis being within the range of 1/16 to 4/25.

2. An incinerator as defined in claim **1** including means for introducing secondary air into said chamber tangentially to said side wall at an area downstream from the area of introduction of said waste material.

3. An incinerator as defined in claim **2** wherein the pressure of said secondary air is approximately 12 inches H_2O.

4. An incinerator as defined in claim **1** wherein said ratio is approximately 1/9.

5. An incinerator as defined in claim **1** wherein the pressure of said primary air is within the range of 4 inches H_2O to 20 inches H_2O.

6. An incinerator as defined in claim **1** wherein the pressure of said primary air is approximately 12 inches H_2O.

7. An incinerator as defined in claim **1** wherein said chamber is disposed such that its central longitudinal axis extends substantially horizontally.

8. An incinerator as defined in claim **1** wherein said chamber is of generally cylindrical configuration and the open end of said first port is of generally circular configuration, the ratio of the diameter of the open end of said first port to the inner diameter of said chamber being approximately 1/3.

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

10. An incinerator as defined in claim **9** including a baffle adjacent the open end of said first port to divert outwardly toward said side wall residual combustible material and non-combustible material which move from adjacent said one end wall toward the open end of said first port.

11. 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 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 tangentially to said side wall at an area downstream from the area of introduction of said 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, the open end of said first discharge flue port being spaced axially of said one end wall,

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

g. the ratio of the area of the open end of said first discharge flue port to the area of a cross-section of said chamber taken perpendicular to its longitudinal axis being within the range of 1/16 to 4/25.

12. An incinerator as defined in claim **11** wherein said ratio is approximately 1/9.

13. An incinerator as defined in claim **11** wherein the second discharge port extends through said side wall tangentially thereto.

14. An incinerator as defined in claim **11** including a baffle adjacent the open end of said first port to divert outwardly toward said side wall residual combustible material and non-combustible material which move from adjacent said one end wall toward the open end of said first port.

15. An incinerator as defined in claim **11** wherein said chamber is of generally cylindrical configuration and the open end of said first port is of generally circular configuration, the ratio of the diameter of the open end of said first port to the inner diameter of said chamber being approximately 1/3.

16. An incinerator as defined in claim **11** wherein the pressure of said primary air is within the range of 4 inches H_2O to 20 inches H_2O.

17. An incinerator as defined in claim **11** wherein the pressure of said primary air is approximately 12 inches H_2O.

18. An incinerator as defined in claim **11** wherein the pressure of said secondary air is approximately 12 inches H_2O.

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

a. a generally cylindrical combustion chamber having spaced end walls and a side wall with its central longitu-

dinal axis extending between said end walls, said chamber being disposed such that its central axis extends substantially horizontally,

b. means including a conduit opening in said chamber 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. the pressure of said primary air being within the range of 4 inches H_2O to 20 inches H_2O,

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

e. means for introducing secondary air into said chamber tangentially to said side wall at an area downstream from the area of introduction of said waste material,

f. a first discharge flue port having a generally circular open end opening in said chamber near said one end wall and substantially concentric with said central axis, the open end of said first discharge flue port being spaced axially of said one end wall,

g. a baffle adjacent the open end of said first port to divert outwardly toward said side wall residual combustible material and non-combustible material which move from adjacent said one end wall toward said open end of said first port,

h. a second discharge port having an open end opening in said chamber at an area downstream from the area of introduction of said waste material and adjacent the inner surface of said side wall for discharging from said chamber during the burning process residual combustible material and non-combustible material which are entrained in the outer region of the vortex, and

i. the ratio of the diameter of the open end of said first discharge flue port to the inner diameter of said combustion chamber being within the range of 1/4 to 2/5.

20. An incinerator as defined in claim **19** wherein said second discharge port is in the vicinity of said one end wall and extends tangentially through said side wall.

21. An incinerator as defined in claim **19** wherein said ratio is approximately 1/3.

22. An incinerator as defined in claim **19** wherein the pressure of said secondary air is approximately 12 inches H_2O.

23. An incinerator as defined in claim **19** wherein the pressure of said primary air is approximately 12 inches H_2O.

24. An incinerator as defined in claim **21** wherein the pressure of said primary air is approximately 12 inches H_2O.

25. 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,

b. means for introducing waste material and primary air into 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 axis, the open end of said discharge flue port being spaced axially of said one end wall,

e. a baffle adjacent the open end of said discharge flue port to divert outwardly toward said side wall residual combustible material and non-combustible material which move from adjacent said one end wall toward said open end of said discharge flue port, and

f. the ratio of the area of the open end of said discharge flue port to the area of a cross-section of said chamber taken perpendicular to its longitudinal axis being within the range of 1/16 to 4/25.

26. An incinerator as defined in claim **25** including means for introducing secondary air into said chamber tangentially to said side wall at an area downstream from the area of introduction of said waste material.

27. An incinerator as defined in claim **26** wherein the pressure of said secondary air is approximately 12 inches H_2O.

28. An incinerator as defined in claim **25** wherein said ratio is approximately 1/9.

29. An incinerator as defined in claim **25** wherein said chamber is disposed such that its central longitudinal axis extends substantially horizontally.

30. An incinerator as defined in claim **25** wherein the pressure of said primary air is within the range of 4 inches H_2O to 20 inches H_2O.

31. An incinerator as defined in claim **25** wherein the pressure of said primary air is approximately 12 inches H_2O.

32. An incinerator as defined in claim **28** wherein the pressure of said primary air is within the range of 4 inches H_2O to 20 inches H_2O.

33. An incinerator as defined in claim **28** wherein the pressure of said primary air is approximately 12 inches H_2O.

34. 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, 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. the pressure of said primary air stream being within the range of 4 inches H_2O to 20 inches H_2O,

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

g. means for introducing secondary air into said chamber tangentially to said side wall at an area downstream from the area of introduction of said waste material,

h. a discharge flue port extending substantially coaxially of said central axis through said one end wall and having a generally circular open end opening in said chamber, and

i. the ratio of the diameter of the open end of said discharge flue port to the inner diameter of said chamber being within the range of 1/4 to 2/5.

35. An incinerator as defined in claim **34** including a second discharge port having an open end opening in said chamber at an area downstream from the area of introduction of said waste material and at the extremity of the inside diameter of said side wall for discharging from said chamber during the burning process residual combustible material and non-combustible material which are entrained in the outer region of the vortex.

36. An incinerator as defined in claim **34** wherein the open end of said discharge flue port is spaced axially of said one end wall, and a baffle plate mounted on said discharge flue port adjacent the open end thereof to divert outwardly toward said side wall residual combustible material and non-combustible material which move from adjacent said one end wall toward the open end of said discharge flue port.

37. An incinerator as defined in claim **34** wherein said ratio is approximately 1/3.

38. An incinerator as defined in claim **34** wherein the pressure of said secondary air is approximately 12 inches H_2O.

39. An incinerator as defined in claim **34** wherein the pressure of said primary air stream is approximately 12 inches H_2O.

40. An incinerator as defined in claim **35** wherein said ratio is approximately 1/3.

41. An incinerator as defined in claim **40** wherein the pressure of said primary air stream is approximately 12 inches H_2O.

42. An incinerator as defined in claim 41 wherein the pressure of said secondary air is approximately 12 inches H_2O.

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