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Giles

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[54] **CYCLONE INCINERATOR**

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[52] **U.S. Cl.** ..... **110/8 R,** 110/13, 110/28 F

[51] **Int. Cl.** **F23g 5/00**

[58] **Field of Search** ..... 110/8 R, 8 C, 13, 18 R, 110/28 F

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[57] **ABSTRACT**

A continuously operable cyclone incinerator for miscellaneous waste includes a vertically oriented cyclone separator substantially enclosed at the lower end by a slowly rotating or vibrated cone-shaped kiln device. Tangentially admitted gas-borne solid waste is burned and separated, and combustibles are supported on the kiln device for additional residence time while noncombustibles slide by gravity into a residue chamber. A recirculation line connected between the residue chamber and inlet duct recirculates unburned combustible particulates.

11 Claims, 5 Drawing Figures

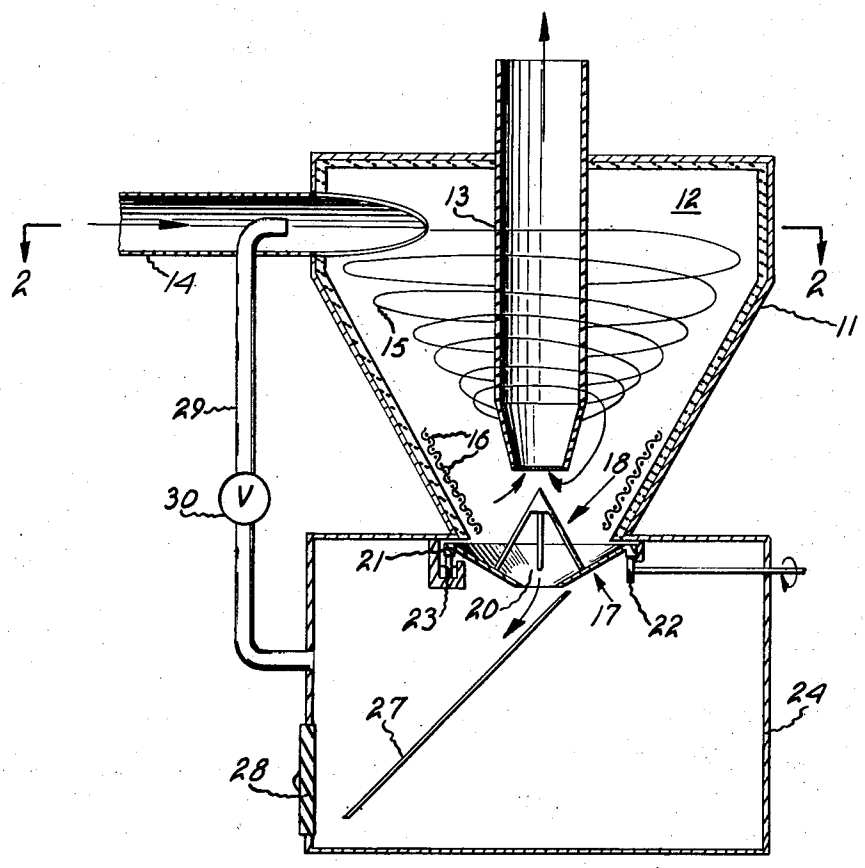


Fig.1

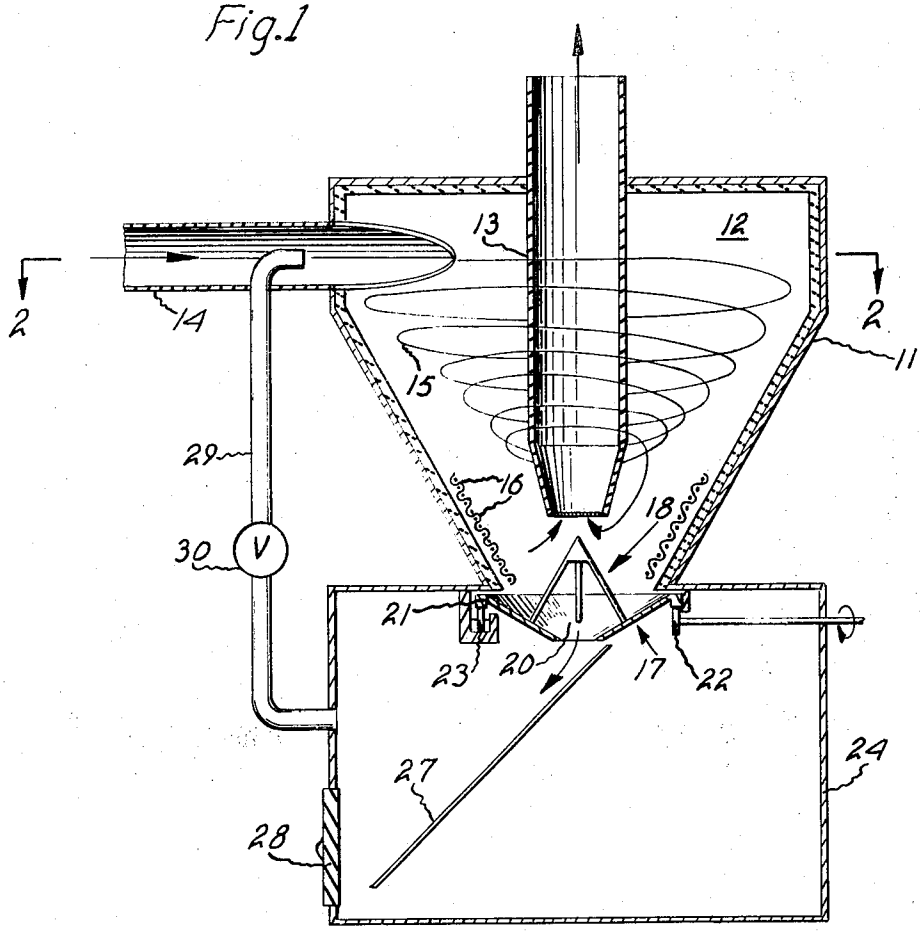


Fig.2

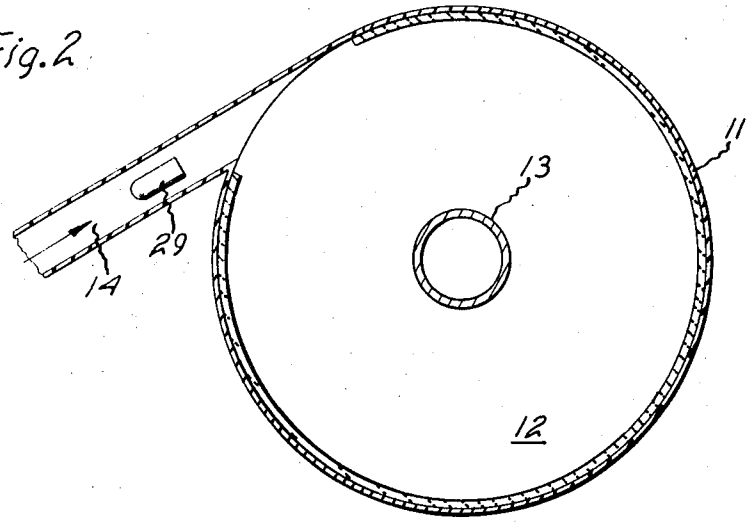
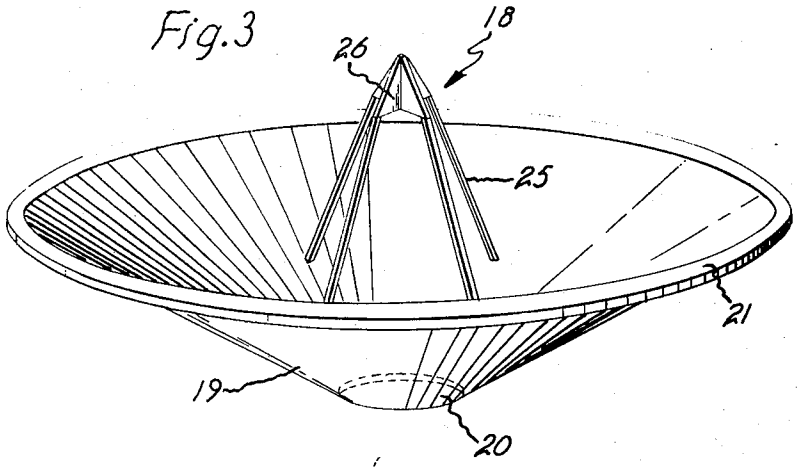


Fig.3



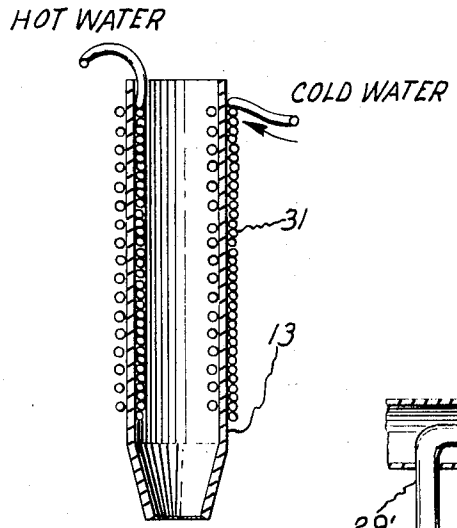
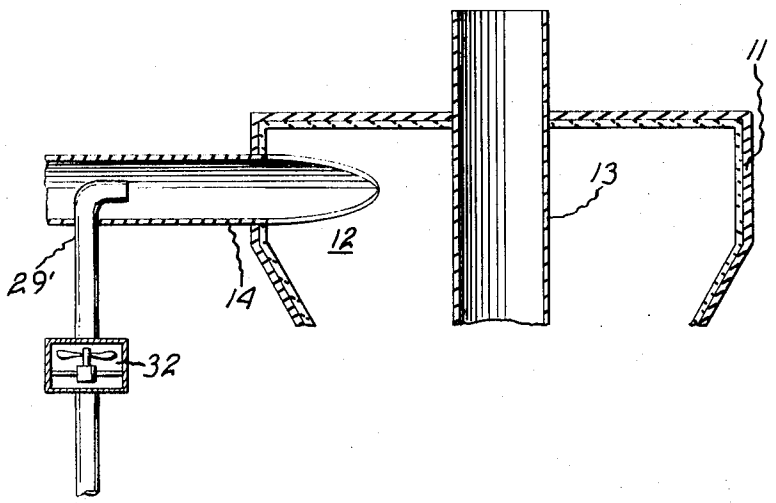


Fig.4

Fig.5



CYCLONE INCINERATOR

BACKGROUND OF THE INVENTION

This invention relates to solid waste incinerators, and more particularly to a vertically oriented cyclone incinerator capable of continuous operation with miscellaneous solid waste.

A variety of different types of incinerators are used to dispose of the combustible components of trash and solid waste by burning. One such incinerator known as a vortex incinerator includes a large horizontal cylindrical combustion chamber lined with refractory bricks. Shredded miscellaneous waste is conveyed pneumatically and introduced tangentially at the front end of the cylinder, while gaseous products of combustion exit axially from the center of the back end, and are exhausted through a stack. Flyash is extracted through a tangential duct at the rear of the cylinder, using a blower-driven cyclone separation technique. Because of the high content of non-combustibles in unsorted waste there is a residue problem. The rapid, asymmetric buildup of slag, comprised mostly of metal and glass, in the bottom of the cylinder limits continuous operation since periodic shutdown is required for removal of the slag. The accumulation is objectionable because it reduces the space available for combustion, and also alters the proportions of the chamber to such a degree that the original vortex air flow pattern is impaired and combustion and centrifugal particulate separation becomes unsatisfactory. For these reasons, separation of metal and glass before incineration may be mandatory. The present invention is directed to an improved cyclone incinerator which overcomes these deficiencies.

SUMMARY OF THE INVENTION

In accordance with the invention, the improved cyclone incinerator combines a vertically oriented cyclone separator and combustion chamber with an inclined or conical kiln device and a recirculation flow line for greater combustion and particulate removal efficiency. Miscellaneous, relatively unsorted waste is pneumatically propelled through a tangential inlet duct into the cyclone separator, which has a closed upper end and an open lower end with a centrally located exhaust duct extending vertically through the cyclone chamber and out the upper end. Centrifugal and gravitational forces separate the waste as it burns. The inclined kiln device, preferably comprised by a rotating or vibrating conical collector plate with a central exit opening, substantially encloses the lower end of the cyclone chamber and supports combustible waste components for further burning while separating non-combustibles and other ash and unburned particulates to drop by gravity into a residue chamber. Larger particles of non-combustibles such as metal and glass are sterilized without melting. The recirculation or ejector line is connected between the residue chamber and inlet duct for recirculating unburned combustible particulates.

Desirably, there is a flow deflector structure carried by the kiln device for weakening vortex flow in the vicinity of the entrance to the exhaust duct to reduce particulate emission. Also, a coarse screening attached adjacent to the cyclone chamber wall near the lower end augments the separation and burning of small particulates. Additional optional features are heat recovery by means of piping wound about the exhaust duct for circulation of water, and predrying of the admitted trash by connecting the recirculation line in the vicinity of the inlet duct blower. This improved cyclone incinerator is capable of continuous operation with miscellaneous solid waste and does not require a separate system for flyash and residue removal.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an elevational cross-sectional view of a cyclone incinerator for miscellaneous solid waste constructed in accordance with the teaching of the invention;

FIG. **2** is a cross section taken on the line **2—2** of FIG. **1** showing the tangential input duct for pneumatically propelled trash;

FIG. **3** is an enlarged perspective view of the conical kiln collector plate and attached flow deflectors;

FIG. **4** illustrates a modification of the exhaust duct for heat recovery by incorporating cylindrically wound piping for water circulation; and

FIG. **5** is a partial elevational cross-sectional view similar to FIG. **1** showing a modified connection of the recirculation line in which a blower is incorporated in the recirculation line to accommodate the higher losses attendant to its use (and long length) for pre-drying the solid waste.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The cyclone incinerator for solid waste shown in FIG. **1** is suitable for a wide variety of miscellaneous household and commercial solid waste and some industrial solid waste. Although a degree of pre-treatment of the admitted solid waste is usually required, such as passage through a shredder and the sorting out of unusually large or totally unsuitable objects, the admitted solid waste can be said to be relatively unsorted and contain miscellaneous combustible and non-combustible trash components made of many materials. These include paper, cardboard, wood, cloth, and a variety of objects made of metal, glass, plastic, and so on, depending upon the source of the trash. In general, the improved cyclone incinerator substantially burns all of the combustible components, while the non-combustible components made of metal, glass, etc., are sterilized without being melted or with minimal melting and deposited in a residue chamber for subsequent removal. Thus, the need for pre-conditioning the trash after the shredder is minimized, since this system is less sensitive to metal, glass, and other non-combustible content and particulate size.

The upper part of the cylcone incinerator is essentially a vertically oriented cyclone separator which also functions as a combustion chamber. The furnace wall **11** enclosing the cyclone chamber **12** is preferably lined with firebrick, and is closed at the upper end except for the passage of a vertically extending, centrally located exhaust duct **13** which provides an exit for the hot combustion gases to the exterior. As best seen in FIG. **2**, a tangential inlet duct **14** is provided at or near the upper end of the cyclone chamber **12** for admitting the pneumatically propelled miscellaneous solid waste. The inlet duct **14** preferably contains a blower or fan for impelling the air-borne trash tangentially into the upper end of the cyclone chamber **12** and establishing

a vortex flow field. The path of the vortex or swirl flow pattern is shown at **15** (FIG. **1**), proceeding from the upper end spirally toward the lower end of the cyclone chamber and exiting through the vertical exhaust duct **13.** Below the inlet duct **14** the wall **11** of the cyclone chamber is desirably shaped as an inverted truncated cone to accelerate the peripheral velocity of the flow field for enhanced separation capability.

In the cyclone chamber **12,** which as previously mentioned is a cyclone separator and combustion chamber, the action of the centrifugal force moves the heavier trash components including, for example, paper and cloth, to the periphery, while the heaviest components such as metal and glass drop to the bottom of the chamber, and the cleanest and hottest air and combustion gases move toward the center and then up the exhaust duct **13.** Combustion is initiated in an appropriate manner (not illustrated), and may be sustained by an additional fuel supply line depending on the moisture content of the trash. Much of the combustible solid waste content is burned in the cyclone chamber **12,** however the intermediate combustible components made of wood, cardboard, paper, and cloth, for example, require additional residence time in order to obtain complete or nearly complete combustion. Near the reduced diameter lower end of the cyclone chamber **12** there is desirably provided a coarse screening **16** that is mounted near the wall to provide a narrow passage for flyash and other small combustible particulates. Separation of these particulates for the additional burning time made possible by the slower boundary layer flow is augmented by this coarse screening, which serves to disengage the boundary layer flow with these separated small particulates from the main swirl flow and thus minimize re-entrainment.

At the open end of the cyclone chamber or furnace wall **11** is an inclined rotating kiln device **17,** which substantially encloses the bottom of the cyclone chamber **12** with the exception of a central exit opening for non-combustibles, ash, and other furnace residue. The kiln device **17** also supports or carries a centrally located flow deflector structure **18** for improving the flow pattern in the vicinity of the entrance to the exhaust duct **13.** Referring also to FIG. **3,** kiln device **17** is preferably comprised by an inverted, frusto-conical kiln collector plate **19** defining at its lower surfaces a circular exit opening **20** for the residue. At the upper end of the collector plate **19** is an attached horizontal flange **21** for supporting the kiln device for rotary motion. By way of illustration, the conical collector plate **19** is supported by a drive roller or gear **22** and a plurality of idler rollers **23** (FIG. **1**) which engage the flange **21.** The motive force for rotating or vibrating the conical kiln device can be mechanical. In operation, unburned or partially burned solid waste components, particularly the intermediate type previously mentioned that require additional residence time, fall by gravity onto the kiln collector plate **19** and are supported there for a period of time before sliding toward the center of the plate and out th exit opening **20.** Noncombustible objects of metal and glass, for example, are sterilized but do not remain on the kiln for a long enough time to cause melting. That is, the conical angle is empirically selected to meet specific incinerator requirements. It is recognized that under some conditions the longer reisdence time may not be required, or with steeper conical angles the vibration due to rotation may not be mandatory to spill or pour the residue into the residue box **24.**

The flow deflector or vane structure **18** is supported axially above the exit opening **20** by means of a plurality of wires or struts **25** connected to the lower surfaces of the collector plate **19.** The flow deflector structure can include a pair of vertically oriented triangular vanes **26** mounted at right angles to one another (FIG. **3**), or can include a single vertical vane or a horizontally mounted vane. The vertical deflector structure over the kiln device **17** serves to weaken the suction of the exiting vortex core, thereby minimizing the amount of flyash and other small particulates going up the exhaust duct **13.** The lower end of the exhaust duct is preferably inclined inwardly to a lesser diameter as illustrated. When a planar vane structure is provided, it serves to isolate the suction pressures above and below. It will also be noted that the cone-shaped kiln collector plate **19** tends to suppress the vortex core passing out the exhaust and weaken its ability to such out flyash and other particles.

The residue box **24** supports the cyclone chamber wall **11** and is suitably also lined with firebrick. Within the residue chamber, an inclined residue chute **27** receives the non-combustibles, ash, and other residue exiting from the kiln device **17.** The accumulating residue is removed periodically through an access door **28** or can be automatically and continuously removed as by using a conveyor mechanism. Some of the particulates dropping through the exit opening **20** in the kiln device, however, are unburned combustible particulates. To obtain improved operation, the cyclone incinerator includes a recirculation line or duct **29** connected between the residue chamber and the inlet duct **14** for recirculating these unburned particulates. Recirculation line **29** includes a valve or damper **30** for adjustment, and the upper end of the duct extends into the middle of the inlet duct **14** and is bent in the direction of the inlet air flow. Operating as an ejector, the high velocity inlet line scavenges the residue, drawing some unburned combustible particulates and combustion gases off from beneath the kiln device to provide recirculation for further combustion and separation. Regulation of this recirculation loop provides adjustment of the temperature of the residue box **24** and particulate emission. Instead of being connected as an ejector system, it is understood that the recirculation line can include a fan for sucking unburned particulates from the residue box into the recirculation loop.

FIGS. **4** and **5** illustrate two modifications of the basic cyclone incinerator to obtain additional functions. FIG. **4** illustrates the added capability of heat recovery by fabricating the exhaust duct **13** with spirally wound piping **31** for the circulation of water. The pipe **31** is continuous and is wound down the outside surface of the duct **13** and then up the inside surface. Cold water admitted at one end of the piping is heated as it passes through the cyclone chamber, and the emerging hot water or steam has many possible uses. In FIG. **5,** pre-drying of the admitted trash is obtained by locating the recirculation line **29'** further upstream in the inlet duct **14,** to allow direct heat transfer between the hot recirculated gas and the incoming air-borne trash, or a longer recirculation line with blower **32** may be used for indirect heat transfer.

By way of summary, the operation of the preferred embodiment of FIGS. **1–3** will be reviewed briefly. The

improved cyclone incinerator is capable of continuous operation on miscellaneous, relatively unsorted solid waste made up of a variety of sizes and types of solid waste components, both combustible and non-combustible. The pneumatically propelled miscellaneous trash in the inlet duct **14** is blown tangentially into the upper end of the cyclone chamber **12**, where a vortex or swirl flow pattern ensues with the flow exiting through the vertical exhaust duct **13**. Combustion is initiated in the cyclone chamber **12** and normally sustained without the addition of fuel. The centrifugal forces tend to spin out the burning heavier solid waste components toward the outer wall, separating them from the exhaust gases. The heaviest non-combustible components drop onto the rotating cone-shaped kiln device **17**. Intermediate components of wood, paper, cloth, etc., which do not burn completely fall and migrate in the outer boundary layer flow into the rotating kiln device **17** where more residence time is provided for complete combustion. The separation of flyash and other small unburned combustible particulates is augmented by the coarse screening **16** on the cyclone chamber wall which serves to disengage the slower boundary layer flow from the vortex flow and thereby minimize re-entrainment while allowing more time for burning. The buildup of material in the rotating kiln device **17** is relatively symmetrical with respect to the flow field and allows the non-combustible components, ash, unburned combustible particulates, and other furnace residue to slide by gravity through exit opening **20** onto the chute **27** for removal via the access door **28** in the residue box **24**. The flow deflector stucture **18** over the rotating kiln device **17** weakens the suction of the exiting vortex core to lessen particulate emission through the exhaust duct. The ejector or recirculation line **29** connected between the residue chamber and the inlet duct **14** recirculates some of the unburned combustible particulates for further combustion. The flow created thereby scavenges the boundary layer flow over the kiln to minimize emission of flyash and other particulates. Among the possible modifications are the modified exhaust duct for recovery of heat as shown in FIG. **4** and the pre-drying of the admitted trash using the relocated recirculation line as shown in FIG. **5**.

While the invention has been particularly shown and described with reference to several preferred embodiments thereof, it will be understood by those skilled in the art that the foregoing and other changes in form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A cyclone incinerator for solid waste comprising

a vertically oriented cyclone separator having a closed upper end and an open lower end, a tangential inlet duct adjacent the upper end for admitting pneumatically propelled miscellaneous solid waste, and a centrally located exhaust duct extending vertically through said separator and out the upper end,

inclined kiln means substantially enclosing the lower end of said cyclone separator for supporting combustible components of the solid waste for further burning and for separating non-combustible and other components to drop by gravity into a residue chamber, and

a recirculation line connected between said residue chamber and inlet duct for recirculating unburned combustible particulates.

2. A cyclone incinerator according to claim **1** wherein said inclined kiln means is comprised by a conical kiln collector plate having a central exit opening.

3. A cyclone incinerator according to claim **2** further including a flow deflector structure carried by said kiln collector plate for weakening the flow in the vicinity of the entrance to said exhaust duct and reducing undesired particulate emission.

4. A cyclone incinerator according to claim **1** wherein said inclined kiln means is comprised by a rotatable conical kiln collector plate having a central exit opening.

5. A cyclone incinerator according to claim **1** further including a coarse screening adjacent to the wall of said cyclone separator to augment separation and burning of small particulates.

6. A cyclone incinerator according to claim **1** wherein said exhaust duct has wound piping for circulating fluid for recovery of heat.

7. A cyclone incinerator according to claim **1** wherein said recirculation line is connected to said inlet duct sufficiently upstream to obtain pre-drying of the admitted solid waste.

8. A cyclone incinerator for solid waste comprising

a vertically oriented cyclone separator including at least an inverted truncated conical chamber having a closed upper end and an open lower end, a tangential inlet duct adjacent the upper end for admitting pneumatically propelled miscellaneous solid waste, and an exhaust duct extending axially through said separator and out the upper end,

kiln means substantially enclosing the lower end of said cyclone separator and including a rotatable, inverted conical collector plate for supporting combustible components of the solid waste for further burning and for separating non-combustible and other components by gravity to drop through a central exit opening into a residue chamber,

a flow deflector structure attached to said conical collector plate for weakening the flow in the vicinity of the entrance to said exhaust duct and reducing particulate emission, and

a recirculation line connected between said residue chamber and inlet duct for recirculating unburned combustible particulates.

9. A cyclone incinerator according to claim **8** further including a coarse screening adjacent to the wall of said cyclone separator near the lower end thereof for augmenting separation and burning of small particulates.

10. A cyclone incinerator according to claim **8** wherein said exhaust duct has wound piping for circulating water for recovery of heat.

11. A cyclone incinerator according to claim **8** wherein said recirculation line is connected to said inlet duct sufficiently upstream to obtain pre-drying of the admitted solid waste.

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