# United States Patent [19]

**Bowen**

[11] **3,848,550**

[45] **Nov. 19, 1974**


[54] **DEVICE FOR SEPARATING SOLID OR LIQUID PARTICLES FROM A GASEOUS MEDIUM**


[75] Inventor: **Mack D. Bowen,** Smyrna, Ga.

[73] Assignee: **Georgia Tech Research Institute,** Atlanta, Ga.



[22] Filed: **Feb. 1, 1974**

[21] Appl. No.: **438,721**

**Related U.S. Application Data**

[62] Division of Ser. No. 136,099, April 21, 1971, Pat. No. 3,802,164.

[52] **U.S. Cl.** ..... **110/18 R,** 110/28 J, 55/338, 55/419, 55/459

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

[58] **Field of Search** ..... 110/8 R, 8 A, 18 R, 28 J; 55/447, 419, 459, 399, 338



[56] **References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 1,906,432 | 5/1933 | Summers | 55/457 |
| 2,911,926 | 11/1959 | Kocee | 110/18 |
| 2,981,369 | 4/1961 | Yellott et al. | 55/399 |
| 3,125,043 | 3/1964 | Gravel | 110/28 |
| 3,358,844 | 12/1967 | Klein et al. | 209/211 |
| 3,577,711 | 5/1971 | Bernardo | 55/459 |
| 3,590,558 | 7/1971 | Fernandes | 55/457 |
| 3,597,141 | 8/1971 | Fracke et al. | 110/28 |



*Primary Examiner*—Kenneth W. Sprague
*Attorney, Agent, or Firm*—Newton, Hopkins & Ormsby



[57] **ABSTRACT**

A device is disclosed for decomposing particulate agricultural waste products such as peanut hulls. The device comprises an elongate cylinder having first end wall means at one end thereof and second end wall means at the opposite end thereof whereby to define a chamber. Inlet means are provided for forcibly introducing the particulate waste product and combustion supporting gas tangentially into the chamber adjacent the first end wall means and axially toward the second end wall means to form an outer helical flow layer adjacent the inner surface of the cylinder which reacts with the second end wall means to reverse axial direction and form a second helical flow layer within the confines of the outer layer. Exhaust conduit means extend through the first end wall means and present a discharge mouth disposed concentrically within the chamber and positioned beyond the inlet means toward the second end wall means. Means are further provided for heating the chamber sufficiently to at least partially decompose the waste products. Flow control means are disposed adjacent the second wall of the chamber to trap partially decomposed waste products adjacent the second end while constraining the gas to reverse its flow and form a compressible vortex from the flow control means to the discharge mouth of the exhaust conduit.


**14 Claims, 7 Drawing Figures**

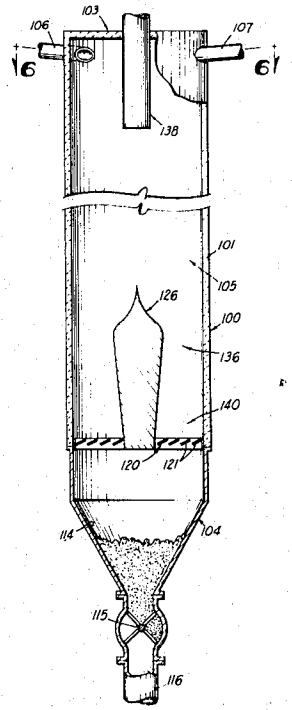


FIG.1

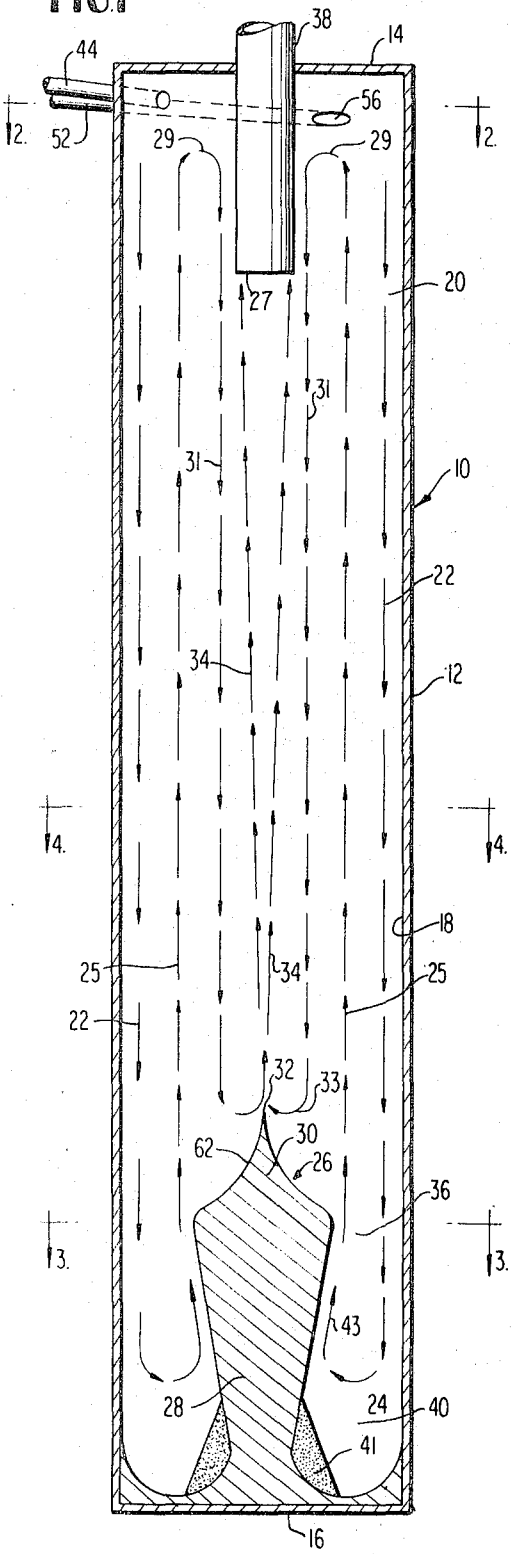



FIG.2

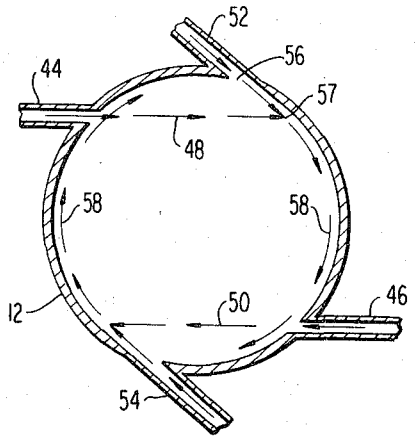
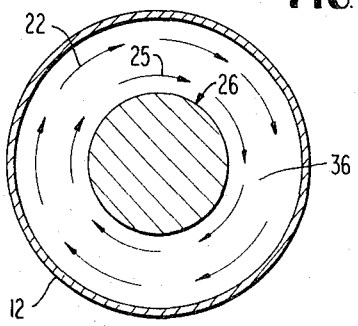



FIG.3



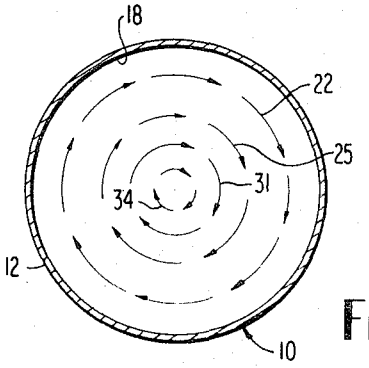




FIG.4

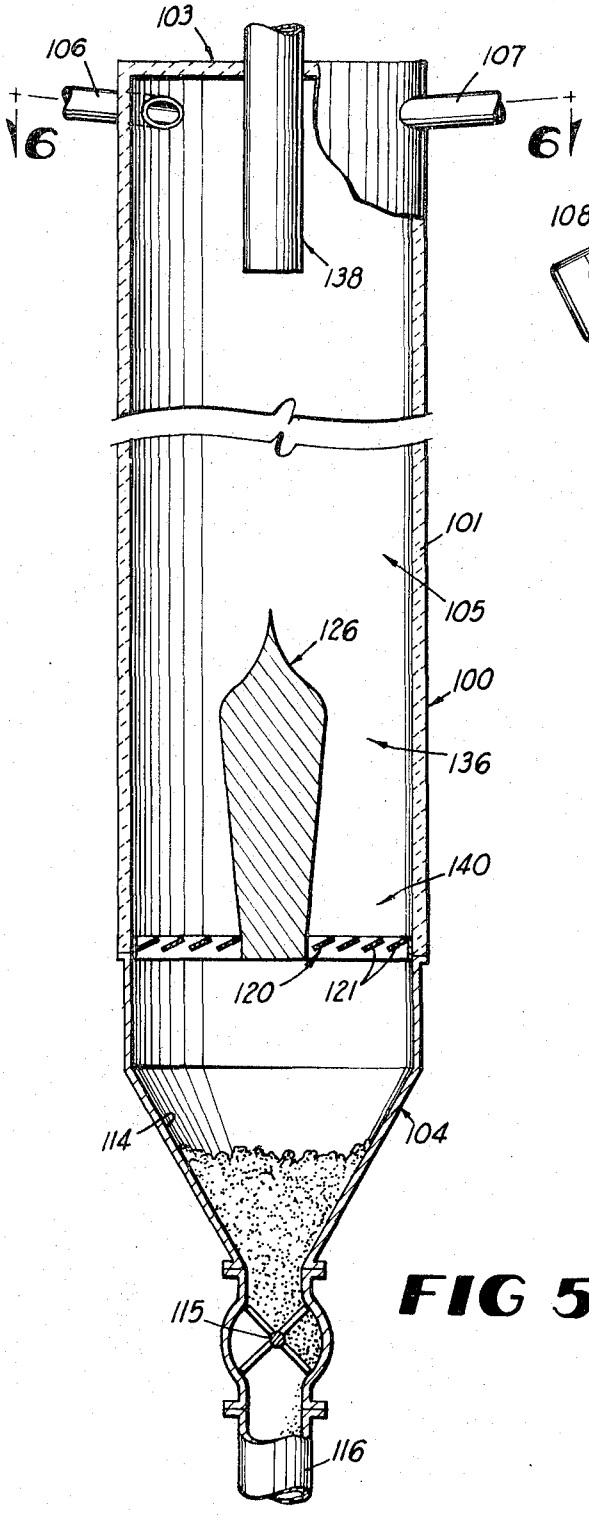



FIG 5

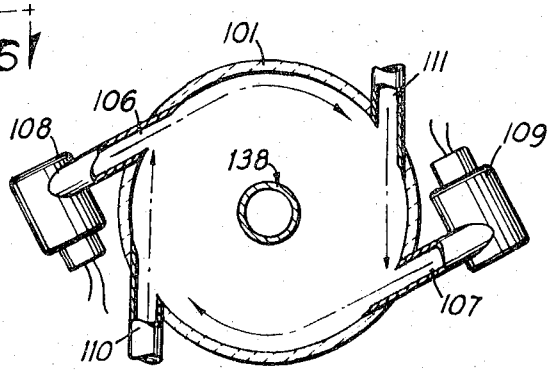



FIG 6

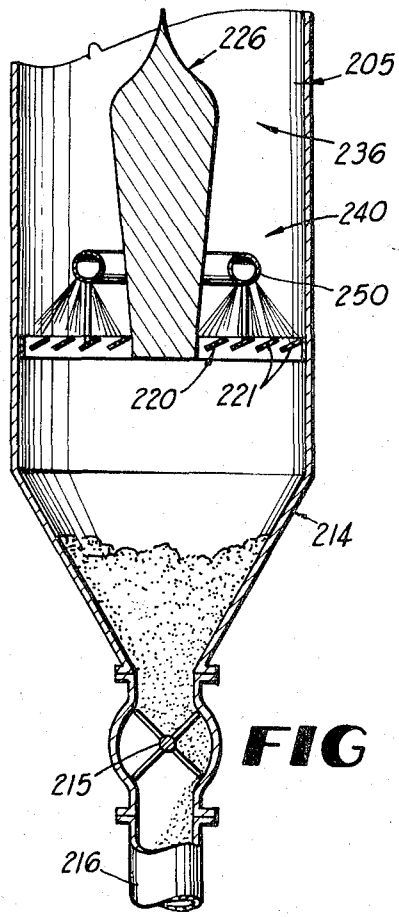



FIG 7

# DEVICE FOR SEPARATING SOLID OR LIQUID PARTICLES FROM A GASEOUS MEDIUM

## BACKGROUND OF THE INVENTION

This application is a division of my copending U.S. Pat. application serial No. 136,099 filed Apr. 21, 1971, now U.S. Pat. No. 3,802,164.

There is presently a great need for a compact, efficient and economical device for separating particles such as solids or liquid droplets from gaseous mediums. A number of complex and expensive procedures are employed for effecting this result to separate and remove particles down to very small sizes. Cyclone-type separators which have been utilized to separate solids or liquids from gaseous mediums are known to be restricted in the size of the particles so separated. Many of the prior art separators develop a pulsating effect within the separating chamber when the flow velocity changes thereby reducing the efficiency of a separating operation. Various types of wet scrubbing devices have also been used for removing contaminants from gaseous mediums but they are bulky and expensive.

There is also a great demand for an incinerator which is effective in disposing of our increasing quantities of waste material. One type of waste material which presents a disposal problem is the by-products of the peanut industry, such as peanut hulls.

Peanut hulls are produced in our southeastern states in extremely large quantities, and for peanut processors, they represent an agricultural waste product which is difficult and expensive of disposal. The most common form of disposal is incineration, but the emissions from the incinerators are extremely high, and it is moreover expensive due to the frequent need for replacement of the refractory insulation of the incinerators. Contemporarily, the disposal problem associated with peanut hulls is difficult, but in the near future will become acute with the enforcement of federal regulations governing air pollution.

Other means of disposal such as burial and use as a livestock feed filler have been tried but have been proven unsatisfactory primarily for the reason that tremendous quantities are involved, the hulls are of low bulk density and, moreover, contain a residual pesticide content. Burial results in a return of the pesticide to the soil which is undesirable, and the bulk density makes transportation costs high. Other uses such as chicken feed additives and as a mulch have also been considered, but again, the pesticide content and the quantities involved make these impractical.

## SUMMARY OF THE INVENTION

In one form of the invention a device is provided for decomposing particulate agricultural waste products such as peanut hulls. The device comprises an elongate cylinder having first end wall means at one end thereof and second end wall means at the opposite end thereof whereby to define a chamber. Inlet means are provided for forcibly introducing the particulate waste product and combustion supporting gas tangentially into the chamber adjacent the first end wall means and axially toward the second end wall means to form an outer helical flow layer adjacent the inner surface of the cylinder which reacts with the second end wall means to reverse axial direction and form a second helical flow layer within the confines of the outer layer. Exhaust conduit means extend through the first end wall means and present a discharge mouth disposed concentrically within the chamber and positioned beyond the inlet means toward the second end wall means. Means are further provided for heating the chamber sufficiently to at least partially decompose the waste products. Flow control means are disposed adjacent the second wall of the chamber to trap partially decomposed waste products adjacent the second end while constraining the gas to reverse its flow and form a compressible vortex from the flow control means to the discharge mouth of the exhaust conduit.

In another form of the invention, an incinerator is provided for use in disposing of particulate agricultural waste products. The incinerator comprises a housing defining an elongated cylindrical chamber and means for introducing the particulate waste product and combustion supporting gas to sweep helically from one end of the chamber to the other end thereof in close adjacency to the chamber wall. An exhaust conduit extends into the chamber with an inlet opening between the ends of the chamber, facing the other end thereof and disposed substantially on the axis of the chamber. Means for heating the housing sufficiently to incinerate the waste product are also provided. A contoured plug is disposed at the other end of the chamber to trap the ash by-products of combustion at said other end while constraining the gas to reverse its flow and form a compressible vortex from the plug to the inlet opening of the exhaust conduit.

## BRIEF DESCRIPTION OF THE FIGURES OF DRAWING

FIG. **1** is a longitudinal section taken through a material separating device which may be used in conjunction with the present invention which illustrates the axial flow directions of the helical flow layers obtained within the device;

FIG. **2** is a transverse section taken substantially along the plane of section line **2—2** in FIG. **1** and illustrating the inlet means which is particularly adapted to reduce erosion due to impingement of solid particles against the inner wall of the container;

FIG. **3** is a transverse section taken substantially along the plane of section line **3—3** of FIG. **1** and illustrating the constructed entrance mouth for the particle residence chamber;

FIG. **4** is a transverse section taken substantially along the plane of section line **4—4** in FIG. **1** and illustrating the flow patterns of the various helical flow layers;

FIG. **5** is a longitudinal section taken through an incinerator embodying principles of the present invention in one form and which shows means for removing ash by-products of combustion;

FIG. **6** is a transverse section taken substantially along the plane of section line **6—6** in FIG. **5** and illustrating the manner of end-feeding the combustion supporting gas and particulate waste material; and

FIG. **7** is a fragmentary longitudinal section taken through a modified embodiment showing means for removing particulate material, by scrubbing with a liquid spray in the base region.

## DESCRIPTION OF THE ILLUSTRATIVE EMBODIMENTS

Referring now to the drawings, the illustrative em-

bodiments embodying the principles of the present invention will be described with reference to a material separating device, as shown in FIGS. 1 – 4; a material incinerator, as shown in FIGS. 5 and 6; and a modified separating device having means for removing particulate material, as shown in FIG. 7.

## MATERIAL SEPARATING DEVICE

With reference to FIG. 1, a housing is indicated generally by the reference character 10 which will be seen to include a cylindrical wall portion 12 having opposite end closures 14 and 16. The inner wall surface 18 of the housing or body 10 forms a cylindrical chamber 20 into which, at the upper end thereof in FIG. 1, particulate material such as solids or liquid droplets and a stream of gas entraining such particles are introduced to flow helically downward within the chamber 20 toward the lower end thereof. The inlet means may be a single inlet duct or a plurality of inlet ducts as will be hereafter described; but, in any event, the inlet means causes gaseous medium with particulate material entrained therein to swirl helically downward in a layer closely adjacent the inner surface 18 and which has a net axial direction as indicated by the arrows 22 in FIG. 1. A contoured flow control plug 26 is provided in the lower end of the chamber and defines, with the inner wall of the chamber, a residence chamber 40 having a constricted annular inlet mouth 36. The outer helical flow layer 22 reverses direction as indicated by the reference character 24 within the confines of the residence chamber 40 and creates an upwardly flowing, swirling helical flow layer 25 within the confines of the outer layer 22. As will hereinafter be described in more detail, the contour of the flow control plug 26 is such as to cause the second flow layer 25 to be positioned toward the outer layer 22 in the region of the annular inlet mouth 36 and also causes the second layer 25 to extend substantially to the region slightly above the discharge mouth 27 of the gaseous medium withdrawal means 38, whereat the flow again reverses axial direction as indicated by the reference character 29 and forms a third helical, swirling flow layer 31 within the confines of the second layer 25. The tip portion 30 of the flow control plug is contoured to cause the third flow layer ro reverse direction as indicated by the arrow 33 and create the stable vortex extending from the tip 32 of the tip portion 30 of the flow control plug, which vortex extends upwardly to the discharge mouth 27 as indicated by the arrows 34.

FIG. 4 illustrates the helical flow patterns of the various helical flow layers 22, 25, 31 and of the vortex core 34.

The first low layer 22 entering the residence chamber 40 creates a high pressure within this region; and the material, indicated by the reference character 41, is separated in this region of highest pressure and collects around the base of the flow control member 28. This base is formed of inverted, frusto-conical section so as to cause a positioning of the flow as indicated by the reference character 43 of the second layer toward the outer layer 22 which tends to retain the high pressure condition within the chamber 40 and also to assure that particles down to very small sizes are separated into and retained by the residence chamber 40. This positioning effect also causes the establishment of the second helical flow layer 25 and prevents the gaseous medium from channelling directly to the vortex core 34, thereby assuring a long residence time of the gas within the separating chamber.

The above described flow control plug 26 is operable to maintain a stable vortex at wide ranges of flow velocity and the separating efficiency increases continuously as the total flow ratio increases. The sharper the point on plug 26, the sturdier the vortex remains. The vortex core attaches itself to needle tip portion of the plug and if the plug tip is shifted laterally, the vortex core will follow.

In FIG. 2 a preferred embodiment of inlet means is shown and will be seen to consist of a tangentially directed tube 52 having a discharge port 56 directing flow tangentially and in slightly axially inclined relationship into the chamber 20; and, additionally, an inlet tube 44 is directed to cause flow chordwise of the chamber, as indicated by the reference character 48, so that the flow emanating from the tube 52 and the chordwise flow emanating from the tube 44 intersect at 57 and join to provide the tangential inlet flow 58 as indicated. If desired, further inlet tubes 46 and 54 may be provided, the former having a chordwise flow inlet as indicated by the reference character 50. A preferred axial inclination of the inlet means is in the order of 6°.

The arrangement of FIG. 2 is intended to minimize erosion of the inner wall 18 of the cylinder 10; and, for this purpose, the tangentially directed tubes 52 and 54 are intended to contain a flow of gaseous material having little, if any, solids or liquids entrained therein, whereas the flow through the tubes 44 and 46 are heavily laden with the particulate material desired to be removed. This configuration primarily lends itself to adaptation for incinerator use wherein a gas inlet would be effected at the tubes 52 and 54 and particulate material to be incinerated would be inducted through tubes 44 and 46. In this manner, the interior of the chamber 20 would be supporting combustion and decomposing the particulate material; while, at the same time, retaining the residue within the residence chamber 40 so that the exhaust emanating from the outlet means 38 would be substantially free from entrained particles.

FIG. 3 is intended to show the annular arrangement of the constricted entrance mouth 36 for the residence chamber 40. It will be seen that the bulbous contoured plug 26 forms the constriction 36, and for this purpose it is preferred that the width of the entrance mouth 36 be in the order of 0.34 times the diameter of the cylinder 12.

It has been found that to best control the flow characteristics of the device as indicated in FIG. 1, the height of the base portion of the plug 28 should be in the order of 0.58 times the diameter of the cylinder 12, the diameter of the discharge mouth 27 should be in the order of 0.2 times the inner diameter of the cylinder 12 and the surface 62 of the tip portion 30 of the flow control plug 26 should be radiused on an arc about 0.375 times the diameter of the inner surface of the cylinder 12. Additionally, as mentioned hereinbefore, the length of the vortex core 34 should be in the order of 40 times its diameter.

## MATERIAL INCINERATOR

As shown in FIGS. 5, 6 and 7, the present invention is here constructed in the form of an incinerator capable of disposing of waste material, such as peanut hulls.

The incinerator is indicated generally by the reference character **100** which will be seen to include a cylindrical wall portion **101** having opposite end closure means **103, 104.** The cylindrical wall **101** and end closure **103** are constructed of conventional refractory material for defining a combustion chamber **105** into which, at the upper end thereof in FIG. **5,** particulate waste product material, such as peanut hulls, and a stream or streams of combustion supporting gas are introduced to flow helically downward within chamber **105** toward the lower end thereof. The flow pattern of the particulate material and gaseous medium will be the same as described hereinabove and as illustrated by arrows in FIGS. **1 – 4.**

The combustion supporting gas, such as air, is introduced into chamber **105** through conduits **106, 107.** Conventional blower and heat producing means **108, 190** are operatively associated with conduits **106, 107,** respectively. The heat producing means produce a sufficient elevation of temperature to cause the waste products to be ignited and burned in the incinerator chamber **100.** As shown in FIG. **6,** entrained waste products in air are introduced by conduits **110, 111** which as shown, are directed chordwise with respect to cylindrical wall **101,** in slightly downward inclined relationship. The combustion supporting gas introduced by the conduits **106** and **107** is substantially tangentially of the cylindrical wall **101,** the openings, **106a, 107a** of these conduits being located substantially at the points at which flows of material from the conduits **110** and **111** would otherwise impinge the inner wall surface of the chamber wall **101,** thereby minimizing erosion due to the inflow of material.

The net effect of this manner of introduction of the material and the air is such as to create a helical flow of waste product entrained in the air substantially as it is indicated hereinabove. This flow of material and air of course closely hugs the inner wall surface **101** of the chamber and continues this helical downward flow of gas, still helical, reverses itself as previously described in conjunction with the arrows **24** in FIG. **1** of the drawings.

As shown in FIG. **5,** end closure means **104** is formed as a hopper **114** having a rotary control valve means **115** communicating with a discharge conduit **116.** Hopper **114** will provide a collection reservoir for containing a predetermined amount of ash by-products of combustion while valve **115** will provide a controlled means for discharging ash from hopper **114** through discharge conduit **116.**

Located above hopper **114** is a grate structure **120** constructed of a plurality of spaced deflector vanes **121** detailed to permit the ash by-products of combustion to pass therethrough into hopper **114.** Vanes **121** may be adjustable to vary the size of the openings between vanes and/or to vary the angle of the vanes.

As shown in FIG. **5,** a contoured flow control plug **126** is supported above grate **120** and defines, with chamber wall **101,** a residence chamber **140** having a constricted annular inlet mouth **136.** Flow control plug **126,** residence chamber **140** and annular inlet mouth **136** are substantially the same as the control plug **26,** chamber **40** and mouth **36,** respectively, described hereinabove and as shown in FIGS. **1 – 4,** and reference is made to the above indicated description for the details of the material flow pattern within combustion chamber **105.**

The air and gas by-products of combustion are exhausted from combustion chamber **105** by a flue means **138** located within end closure means **103.** Flue means **138** is detailed in location, relative to flow control plug **126,** in the same manner as the location of conduit **38** relative to plug **26** described above.

## MODIFIED MATERIAL SEPARATING DEVICE

Referring now to FIG. **7,** a modified embodiment is described which includes means for purging the separation chamber of separated material. The device of FIG. **7** includes a separation chamber **205** having a collection hopper and grate means. Collection hopper is indicated generally by reference character **214** and includes a controlled discharger valve means **215** operable for discharging material from hopper **214** outwardly through a discharge conduit **216.** Grate means **220** having a plurality of spaced vane means **221** is supported above hopper **214** to allow separated material to pass from a residence chamber **240** to collection hopper **214.**

As shown in FIG. **7,** separation chamber **205** includes a flow control plug **226** supported above grate means **220.** Plug **226** is supported relative to chamber wall to define the residence chamber **240** and an inlet mouth **236.** Plug **226** is identical to plug **26** and will control the flow pattern within chamber **205** in the same manner as described above relative to FIGS. **1 – 4.**

An annular perforated dispensing manifold **250** is concentrically supported around plug **226** above grate **220.** Dispensing manifold **250** is connected by suitable means to conventional fluid supply means (not shown) for spraying a quantity of fluid into the particle separation region and down through grate **220,** hopper **214,** valve **215** and out through conduit **216** for purging the residence chamber **240** and hopper **214** of separated material contained therein.

It now becomes apparent that the illustrative embodiments described herein are capable of obtaining the above stated objects and advantages. It is obvious that those skilled in the art may make modifications in the details of construction without departing from the spirit of the invention which is to be limited only by the scope of the appended claims.

What is claimed is:

**1.** A device for decomposing particulate agricultural waste products such as peanut hulls, which comprises:

a. an elongate cylinder having first end wall means at one end thereof and second end wall means at the opposite end thereof whereby to define a chamber;

b. inlet means for forcibly introducing the particulate waste product and combustion supporting gas tangentially into said chamber adjacent said first end wall means and axially toward said second end wall means, whereby to form an outer helical flow layer adjacent the inner surface of said cylinder which reacts with said second end wall means to reverse axial direction and form a second helical flow layer within the confines of said outer layer;

c. exhaust conduit means extending through said first end wall means and presenting a discharge mouth disposed concentrically within said chamber and positioned beyond said inlet means toward said second end wall means;

d. means for heating said chamber sufficiently to at least partially decompose the waste products; and

e. flow control means disposed adjacent said second wall of said chamber to trap partially decomposed waste products adjacent said second end while constraining the gas to reverse its flow and form a compressible vortex from said flow control means to said discharge mouth of the exhaust conduit.

**2.** A device according to claim **1,** wherein said flow control means defines an annular residence pocket for said entrained material adjacent said second end wall means and within which pocket said axial flow reversal takes place, said flow control means providing a constricted annular entrance mouth which positions said second flow layer toward said outer flow layer and causes said second layer to extend to the region of said discharge mouth whereat it reverses axial direction to form a third helical flow layer within the confines of said second layer, said flow control means including a tip portion spaced from said discharge mouth and contoured to reverse the axial direction of said third flow layer and create a stable vortex extending therefrom to said discharge mouth.

**3.** The device according to claim **2** wherein said flow control means includes an inverted frusto-conical base extending from said second end wall means to said tip portion whereat said entrance mouth is defined.

**4.** The device according to claim **3** wherein said tip portion is in the form of a concave cone.

**5.** The device according to claim **1** wherein said tip portion is in the form of a concave cone.

**6.** The device according to claim **1** wherein said elongate cylinder second end wall means defines a hopper located below said flow control means for retaining said separated material and wherein means is provided in said hopper for removing material therefrom.

**7.** The device according to claim **6** wherein said elongate cylinder includes means for purging said cylinder and said hopper of separated material contained therein.

**8.** An incinerator for use in disposing of particulate agricultural waste products such as peanut hulls, which comprises:

a. a housing defining an elongated cylindrical chamber;

b. means for introducing the particulate waste product and combustion supporting gas to sweep helically from one end of said chamber to the other end thereof in close adjacency to the chamber wall;

c. an exhaust conduit extending into said chamber and having an inlet opening between the ends of said chamber, facing said other end thereof and disposed substantially on the axis of said chamber;

d. means for heating said housing sufficiently to incinerate the waste product; and

e. a contoured plug disposed at said other end of the chamber to trap the ash by-products of combustion at said other end while constraining the gas to reverse its flow and form a compressible vortex from said plug to said inlet opening of the exhaust conduit.

**9.** The device according to claim **8** wherein said plug is based at said other end of the chamber and projects axially therefrom toward said one end of the chamber.

**10.** The device according to claim **9** wherein said plug includes an inverted frusto-conical base surmounted by a concave cone.

**11.** The device according to claim **8** wherein said elongate cylinder includes a hopper located below said contoured plug for retaining said ash material and wherein means is provided in said hopper for removing ash therefrom.

**12.** The device according to claim **11** wherein said elongate cylinder includes means for purging said cylinder and said hopper of separated ash material contained therein.

**13.** A device for separating and removing entrained material from a gaseous medium, comprising:

a. an elongate cylinder having first end wall means at one end thereof and second end wall means at the opposite end thereof whereby to define a chamber;

b. inlet means for forcibly introducing the gaseous medium and entrained material tangentially into chamber adjacent said first end wall means to flow axially toward said second end wall means, whereby to form an outer helical flow layer adjacent the inner surface of said cylinder which reacts with said second end wall means to reverse axial direction and form a second helical flow layer within the confines of said outer layer;

c. outlet passage means extending through said first end wall means and presenting a discharge mouth disposed concentrically within said chamber and positioned beyond said inlet means toward said second end wall means;

d. flow control means defining an annular residence pocket for said entrained material adjacent said second end wall means and within which pocket said axial flow reversal takes place, said flow control means providing a constricted annular entrance mouth which positions said second flow layer toward said outer flow layer and causes said second layer to extend to the region of said discharge mouth whereat it reverses axial direction to form a third helical flow layer within the confines of said second layer, said flow control means including a tip portion spaced from said discharge mouth and contoured to reverse the axial direction of said third flow layer and create a stable vortex extending therefrom to said discharge mouth;

e. a hopper located below said flow control means for retaining said separated material; and

f. means in said hopper for removing material therefrom.

**14.** The device according to claim **13** wherein said elongate cylinder includes means for purging said cylinder and said hopper of separated material contained therein.

* * * * *