



(86) Date de dépôt PCT/PCT Filing Date: 1992/02/06

(87) Date publication PCT/PCT Publication Date: 1992/09/03

(45) Date de délivrance/Issue Date: 2003/09/16

(85) Entrée phase nationale/National Entry: 1993/07/26

(86) N° demande PCT/PCT Application No.: DK 1992/000039

(87) N° publication PCT/PCT Publication No.: 1992/014969

(30) Priorité/Priority: 1991/02/15 (272/91) DK

(51) Cl.Int.⁵/Int.Cl.⁵ F23C 6/04, F23G 5/32, F23G 5/04

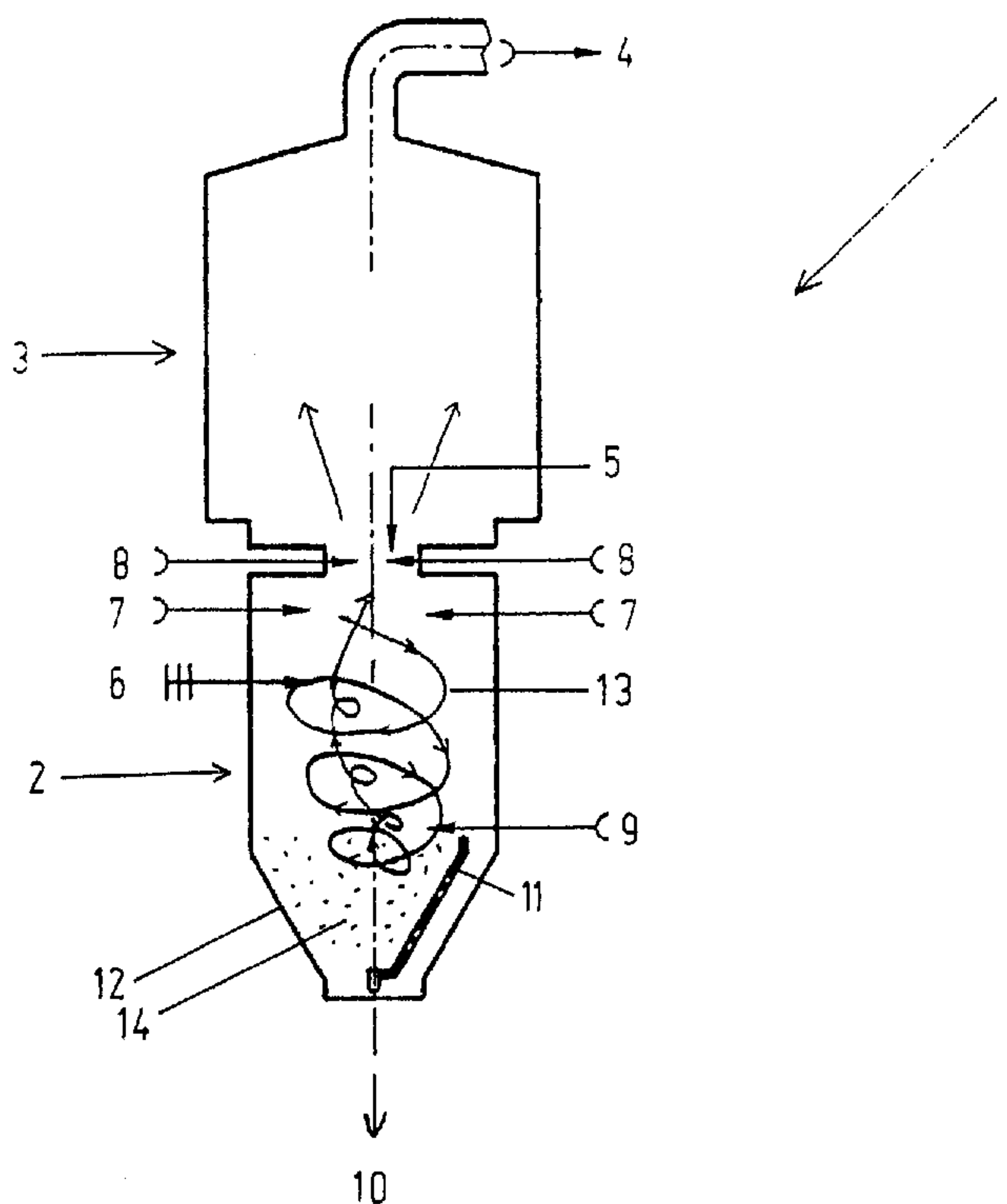
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(54) Titre : METHODE DE BRULAGE D'UN CARBURANT COMPOSE DE PARTICULES ET UTILISATION DE CETTE METHODE POUR BRULER DES BOUES

(54) Title: METHOD OF BURNING A PARTICULATE FUEL AND USE OF THE METHOD FOR BURNING SLUDGE



(57) Abrégé/Abstract:

Method for the production of hot drying gas by the burning of flowable, biological refuse in an incinerator (1) which comprises a vertical cyclone furnace (2), into which there is an injection of fuel (6) tangentially together with the primary combustion air, secondary combustion air (7) and tertiary combustion air (8) which is injected into a throat (5). In the bottom of the furnace there is provided a cooled, rotating ash scraper (11). The waste gas is conducted via a throat (5) to a secondary combustion chamber (3) in which an incineration of residuals takes place, and from which the drying gas (4) is removed. Combustion-retarding air (9) is injected into the hottest area of the cyclone furnace (2), so that sintering and the formation of slag is avoided.



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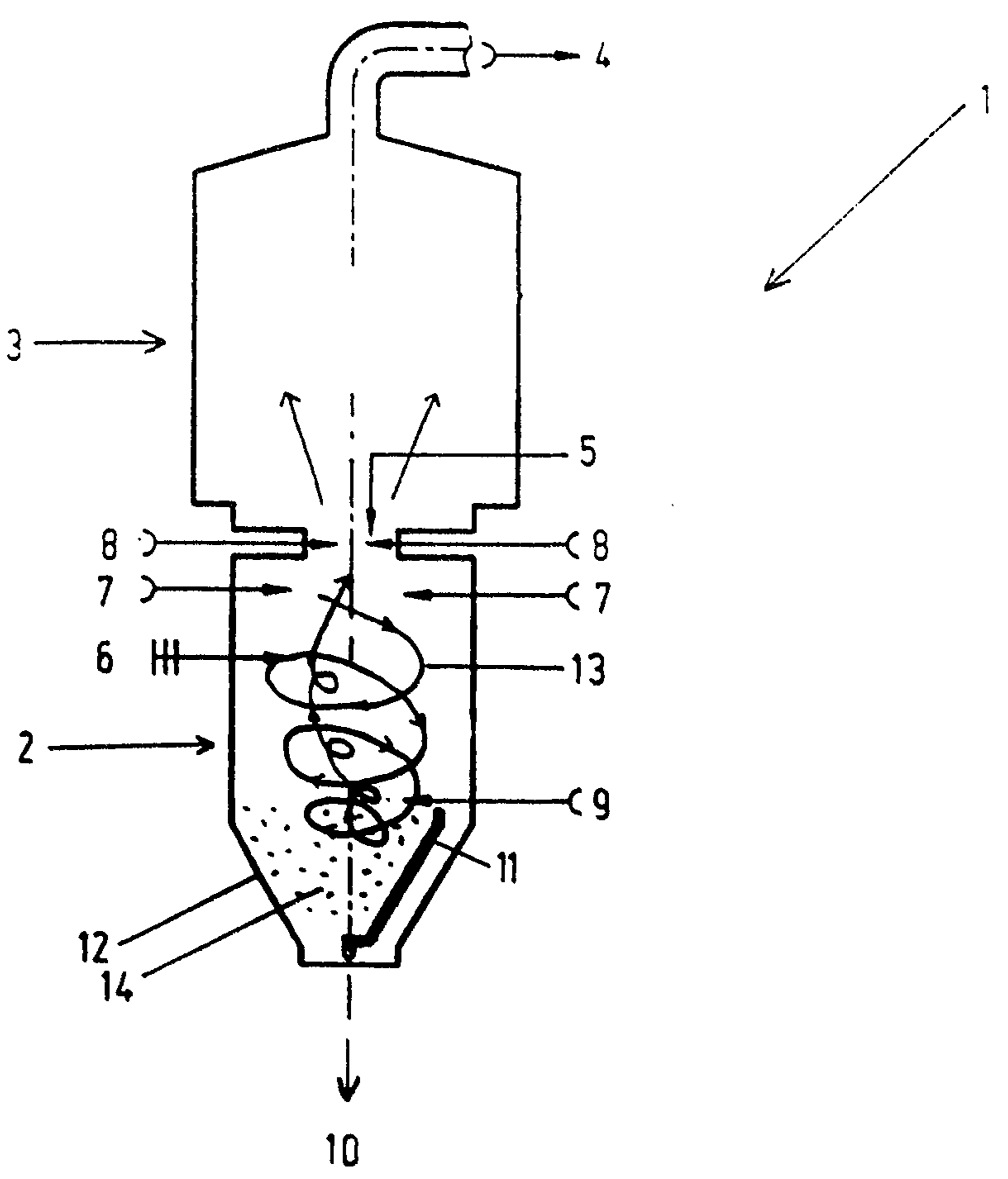
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(51) International Patent Classification 5 : F23C 6/04, F23G 5/04, 5/32 F23L 7/00</p>	<p>A1</p>	<p>(11) International Publication Number: WO 92/14969 (43) International Publication Date: 3 September 1992 (03.09.92) 2101318</p>
<p>(21) International Application Number: PCT/DK92/00039 (22) International Filing Date: 6 February 1992 (06.02.92) (30) Priority data: 272/91 15 February 1991 (15.02.91) DK (71) Applicant (for all designated States except US): ATLAS INDUSTRIES A/S [DK/DK]; Baltorpvej 160, DK-2750 Ballerup (DK). (72) Inventor; and (75) Inventor/Applicant (for US only): CHRISTENSEN, Jørgen, Steen [DK/DK]; Bøgebakken 32, DK-3520 Farum (DK). (74) Agent: LARSEN & BIRKEHOLM A/S; Skandinavisk Patentbureau, Skagensgade 64, Box 200, DK-2630 Taastrup (DK).</p>	<p>(81) Designated States: AT, AT (European patent), AU, BB, BE (European patent), BF (OAPI patent), BG, BJ (OAPI patent), BR, CA, CF (OAPI patent), CG (OAPI patent), CH, CH (European patent), CI (OAPI patent), CM (OAPI patent), CS, DE, DE (European patent), DK, DK (European patent), ES, ES (European patent), FI, FR (European patent), GA (OAPI patent), GB, GB (European patent), GN (OAPI patent), GR (European patent), HU, IT (European patent), JP, KP, KR, LK, LU, LU (European patent), MC (European patent), MG, ML (OAPI patent), MN, MR (OAPI patent), MW, NL, NL (European patent), NO, PL, RO, RU, SD, SE, SE (European patent), SN (OAPI patent), TD (OAPI patent), TG (OAPI patent), US.</p> <p>Published With international search report. In English translation (filed in Danish).</p>	

(54) Title: METHOD OF BURNING A PARTICULATE FUEL AND USE OF THE METHOD FOR BURNING SLUDGE

(57) Abstract

Method for the production of hot drying gas by the burning of flowable, biological refuse in an incinerator (1) which comprises a vertical cyclone furnace (2), into which there is an injection of fuel (6) tangentially together with the primary combustion air, secondary combustion air (7) and tertiary combustion air (8) which is injected into a throat (5). In the bottom of the furnace there is provided a cooled, rotating ash scraper (11). The waste gas is conducted via a throat (5) to a secondary combustion chamber (3) in which an incineration of residuals takes place, and from which the drying gas (4) is removed. Combustion-retarding air (9) is injected into the hottest area of the cyclone furnace (2), so that sintering and the formation of slag is avoided.



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METHOD OF BURNING A PARTICULATE FUEL AND USE OF THE METHOD
FOR BURNING SLUDGE

BACKGROUND OF THE INVENTION

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The invention relates to a method of the kind disclosed in
the preamble to claim 1.

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Such a method is known, for example from USA patent no.
4,398,477, where the two combustion chambers consist of two
cyclone furnaces arranged one above the other and connected
via an opening with a reduced clearance, a so-called
throat. The fuel, which consists of rice hulls, is blown
together with the primary air into the lower vertical cyc-
lone furnace, and the waste gas is then burned in the upper
cyclone furnace during the introduction of additional com-
bustion air through tangential nozzles. There is hereby
achieved an optimal incineration of the fuel, and the re-
sidual product in the form of ash can be removed from the
bottom lower cyclone furnace by means of a cooled, rotating
ash scraper.

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In order to achieve optimal incineration of the fuel, the
temperature in the lower furnace is in the order of 1200°C.
Such a high temperature is unfavourable, in that during the
combustion of biological fuels at this temperature there
are formed relatively large amounts of nitrogen oxides, so-
called NOx'es, which are poisonous.

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From the applicant's own previously-submitted international
application, published under no. W090/05272, there is known
a sludge drying apparatus in which, for example, sewage
sludge is dried down to less than 10% water content in a
rotating dryer, after which the dried sludge is used as
fuel in a furnace which delivers the thermal energy neces-
sary for the rotating dryer. However, it has proven to be

almost impossible to incinerate the dried sludge in a normal cyclone furnace, the reason being that the dried sludge and similar types of fuel vitrify to form a kind of slag filled with porous pores which have an insulating effect, while at the same time it is highly viscous, thus rendering the removal of the slag impossible. Therefore, use is made in practice of other types of furnaces, e.g. fluid-bed ovens, for the incineration of fuels which are aqueous or of low energy content, such as e.g. dried biological sludge. Furnaces of such a type are suitable only for large amounts of fuel and require a long start-up time, and thus furnaces of this type are not suitable if they cannot be used in continuous operation. Moreover, this type of furnace demands a comprehensive process regulation with specially-trained personnel.

Therefore, when it is required to dispose of refuse from smaller towns or urban areas, it is necessary either to use other methods for the disposal of the biological sludge or to transport this to larger communal plants for incineration.

ADVANTAGES OF THE INVENTION

By proceeding as disclosed and characterized in claim 1, it is possible to use a cyclone furnace for the incineration of dried, flowable biological refuse of the kind which cannot otherwise be burned in a cyclone furnace. The cyclone furnace has the great advantage that it is relatively cheap to produce, that it is compact and results in an intensive combustion and, what is very important, the cyclone furnace is quick and easy to start up. Consequently, a cyclone furnace for the incineration of biological refuse does not need to operate continuously.

By arranging and controlling a furnace as disclosed and

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characterized in claim 1, it is possible to burn bio-fuels of low calorific value without the fuel sintering, which gives rise to the formation of slag and sintering in the combustion zone. The combustion zone usually lies slightly below the middle of the furnace, the reason being that the fuel will not ignite until it has reached a good distance down towards the bottom and has achieved the ignition temperature. The introduction of combustion-retarding gas to the ash separation area, e.g. oxygen-deficient air in the form of wet flue gas, will retard combustion so that this is less intense, and the sintering formation is avoided. At the same time, there is hereby achieved a reduction in the formation of NOx because the surplus air is decreased and, providing that the temperature is around 850°C, the CO-formation can be held at an acceptably low level.

The waste gas formed by the controlled and retarded combustion is burned after the throat in a secondary combustion chamber which is merely a large, brick-lined chamber in which the post-combustion takes place. In order to burn out the flue gas from the retarded combustion, it is necessary for the secondary combustion chamber to be of sufficient size for a reduction of the CO-content in the waste gas, and to give the waste gas an adequate period of time in the chamber, i.e. in the order of 0.5 - 2 seconds.

By proceeding as disclosed and characterized in claim 2, sintering and the formation of slag at the throat is avoided, even during the use of dried biological sludge with low ash content. Moreover, a particularly good ash separation is achieved if the diameter of the throat is small in relation to the diameter of the cyclone combustion furnace, e.g. a diameter which is less than half of that of the cyclone furnace, and if the air velocity is around 60 - 100 m/sec.

By proceeding as disclosed and characterized in claim 3, it can be ensured that no sintering of the fuel with slag formation can occur at any place within the combustion area in the cyclone furnace. All ash/slag will fall to the bottom in the conical area of the furnace, where by means of a cooled, rotating ash scraper it can be removed from the furnace in the normal manner, e.g. by means of an ash sluice.

By proceeding as disclosed and characterized in claim 4, the operational reliability of the furnace is increased so that a uniform and complete incineration of the fuel is achieved. The fuel is measured and screened so that it has the desired particle distribution. The smallest particles are ignited quickly and ensure the combustion, while the large particles are held by the centrifugal force in the periphery of the primary chamber until combustion has taken place.

If a poor fuel is used, i.e. fuel with a high ash content or high water content, a subsidiary-firing must be established as disclosed and characterized in more detail in claim 5. The subsidiary-firing plant can also be used in connection with the start-up of the combustion furnace. However, by proceeding as disclosed in claims 1-4, when a fuel with a calorific value of around 1700 kcal/kg or higher is used, it is possible to maintain a constant combustion of the fuel without subsidiary-firing.

By proceeding as disclosed and characterized in claim 6, a complete combustion of the waste gas is achieved, so that the CO-content is burned to CO₂, and a suitably low CO-content is achieved without any significant formation of NO_x.

By proceeding as disclosed and characterized in claim 7, it

is ensured that sintering of the fuel can not take place at any point in the furnace during combustion, and at no point in the furnace is there any formation of viscous slag. The combustion throughout the whole of the primary combustion chamber is a so-called dry (non-slagging) combustion, the only waste products of which are ash and flue gas, and where the ash is of such a consistency that it can be removed without problems by means of a commonly-known, rotating ash scraper.

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Experiments have shown that in connection with the burning of fuel which consists solely of biological refuse in the form of dried sludge, the best incineration of the fuel is achieved by proceeding as disclosed and characterized in claim 8.

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The method according to the invention has been developed mainly for use in connection with refuse incineration plants as disclosed in more detail in claims 9 and 10, but can naturally also be used in connection with the burning of other forms of biological fuel.

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THE DRAWING

The method according to the invention will now be described in more detail with reference to the drawing, which shows the principle of an incinerator comprising a vertical cyclone furnace which is connected to a secondary combustion chamber via a throat.

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DESCRIPTION OF EMBODIMENT EXAMPLES

In the drawing is seen an incinerator 1 for bio-fuels, e.g. dried sludge, and comprising a primary combustion chamber in the form of a vertical cyclone furnace 2, a throat 5 and a secondary combustion chamber 3 for subsequent incinera-

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tion of the waste gas from the cyclone furnace.

5 In the bottom of the conical part 12 of the cyclone furnace there is provided a rotating ash scraper 11 which is air-cooled in the normal manner, and which scrapes the ash 14 out through a not-shown ash sluice 10 or an ash conveyor with product lock.

10 The top of the secondary chamber 3 is arranged for the removal of the hot waste gas 4, which for example can be used directly in a rotary drier as described in more detail in International Patent Application No. PCT/DK89/00246 (W090/05272), and to which reference is made to all extent in connection with the use of the hot drying gas 4.

15 The primary air 6 together with the fuel is blown in through tangential injection nozzles. The fuel is bio-fuel, e.g. dried sludge, as explained in more detail in the above-mentioned international application. The dried bio-fuel in the form of sludge is dried down to less than 15%, preferably 10%, water content, pulverised in a mill and
20 screened, e.g. through a 5 mm sieve. The main part of the fuel, i.e. at least 75%, has a particle size of less than 1 mm, and the maximum particle size due to the sieve is 5
25 mm.

30 At the same level, or possibly slightly higher up in the cyclone furnace than that at which the primary air is injected, the secondary air 7 is injected through a series of tangential nozzles, and tertiary air 8 is blown into the throat 5 itself, similarly through a number of tangential
35 nozzles. A modest amount of combustion air is also injected through the cooled ash scraper 11, in that cooling-air is introduced into the combustion chamber through openings in the ash scraper 11.

- At some distance down in the cyclone furnace, preferably at around the mid-point or immediately below, the injected fuel 6 will be ignited and will burn. In order to control and dampen the intensity of the combustion, so that the fuel does not sinter and give rise to the formation of slag in the combustion zone, combustion-retarding air 9 is injected directly into the combustion zone via tangential nozzles in the direction of rotation for the combustion.
- 10 The combustion-retarding air is air with reduced oxygen content and/or with high moisture content, so that the oxygen content of the air is reduced approx. 30-50% in relation to normal atmospheric air, and the air has a temperature in the order of 100-200°C, preferably 150°C. The air, for example, is recirculated drying air with a temperature of approx. 150°C from the rotary dryer in the above-mentioned international application. The amount of combustion-retarding air 9 can be set once and for all, depending on the capacity of the furnace. Primary air, secondary air and tertiary air is also set once and for all, similarly depending on the capacity of the furnace. The temperature of the furnace is controlled at approx. 850°C. If the temperature falls, the amount of injected fuel is increased. If the temperature rises, the amount of injected fuel is reduced. There is hereby achieved a very simple and reliable form of control, which at the same time ensures that the temperature does not exceed 950-1000°C at any point in the primary chamber.
- 30 With an incinerator of the kind described, and controlled as explained above, a cyclone combustion 13 is achieved whereby with the use of gravitation and the special form of injection for the combustion air, the combustion takes place in a downwardly-directed spiral movement as shown in the drawing, and where the waste gas, similarly sketched in the drawing, is transferred via the throat 5 to the post-

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combustion chamber 3 for incineration. The post-combustion chamber 3 is at least of the same size as the cyclone furnace, but will normally have a volume which ensures that the period of time for which the waste gases are in the chamber is at least 0.5 secs.

The following table shows a series of different values for incinerators controlled according to the invention and used in connection with recirculated waste gas (drying air) and biological fuel from a rotary dryer as disclosed in the above-mentioned international application.

Type	30 - 190
Evaporation kg/h	500 - 3,200
Person equivalents	30,000 - 190,000
Wet sludge t/week	63 - 400
Ash t/week	6 - 36
Furnace effect MW	0.5 - 2.8
Primary air %	30
Secondary air %	30
Tertiary air %	15
Scraper air %	10
Recirculated air % **)	15
Waste gas % *)	100

Prerequisites: 60 g solids per person equivalent per 24 hours; the dried sludge has 20% solids, of which 40% is ash. Operational time per week is 100 h.

*) This drying air, which for example is used in a rotary

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dryer as disclosed in the above-mentioned international application, has a temperature of approx. 850°C and a NOx content of less than 100 ppm.

- 5 **) The air has a temperature of 100-150°C, an oxygen content of 10 - 12% and a moisture content of 0.4 kg water per kg dry air.

10 At the start-up of the incinerator, oil or gas, e.g. N-gas, is introduced in the secondary air 7 by means of not-shown nozzles. These nozzles are also used for subsidiary firing if the fuel has a calorific value of less than 1700 kcal/kg.

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1. Method for the production of hot drying gas by the incineration of fuel consisting of flowable biological refuse in an incinerator comprising a primary combustion chamber in the form of a vertical cyclone furnace (2), the method comprising the steps of:

tangentially injecting the fuel in an upper half of the vertical cyclone furnace together with the primary combustion air;

tangentially injecting secondary combustion air in the same plane as that at which the primary combustion air is injected or higher in the primary combustion chamber;

removing ash from a bottom area of the furnace by a rotating cooled ash scraper;

transferring waste gas through a reduced aperture in a top of the vertical cylindrical furnace to a secondary combustion chamber; and

tangentially injecting combustion-retarding gas into an ash separation area of the vertical cyclone furnace.

2. Method according to claim 1, further comprising the step of injection tertiary combustion air tangentially and directly into the reduced aperture, and injecting the secondary combustion air immediately below the aperture, wherein said injections are effected with relatively high air velocity.

3. Method according to one of claims 1 or 2, wherein the fuel is a flowable fuel, and wherein the fuel is pulverized and screened so that at least 75% of the fuel has a particle size of less than 1 mm, and a maximum particle size of 5 mm.

4. Method according to claim 3, further comprising the step of effecting a subsidiary firing with oil or gas injection into the secondary combustion air if a calorific value of the fuel is less than 1700 kcal/kg.

5. Method according to claim 1, wherein the secondary combustion chamber has a volume at least sufficient for the waste gases to remain herein for at least 0.5 sec.

6. Method according to one of claims 1 or 2, wherein fuel is injected in an amount which is sufficient to ensure that the temperature does not exceed 950-1000°C at any point in the vertical cyclone furnace.

7. Method according to one of claims 1 or 2, wherein an amount of injected combustion-retarding gas is in the order of about one-half of an amount of primary combustion air, and wherein an amount of the secondary combustion air is of the same order as the amount of primary combustion air.

8. A method according to one of claims 1 or 2, wherein the vertical cyclone combustion furnace incinerates biological sludge with a water content of less than 25%, hot drying gas is used for a predrying the biological sludge in a drying plant, and wherein moist drying air from the drying plant is recirculated to the incinerator and is used as combustion-retarding gas in the vertical cyclone furnace.

9. Method according to one of claims 1 or 2, wherein the vertical cyclone furnace is arranged in a drying plant for aqueous masses.

10. Method according to claim 9, wherein the aqueous masses include biological sludge.

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