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# (54) Process for the treatment of materials, in particular waste materials

(57) In a process for the treatment of materials, in particular waste materials (13), inside a pressure-tight chamber (2) by combustion under a high pressure oxygen medium, the materials are advantageously held suspended during the combustion process.

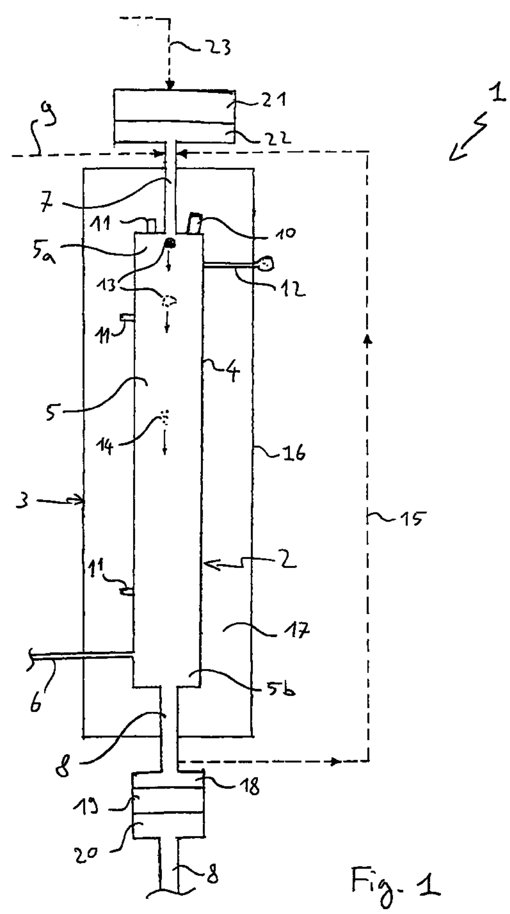


Fig. 1

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## Description

### Field of the Invention

**[0001]** This invention relates to a process for the treatment of materials, in particular waste materials, in a pressure-tight chamber by combustion under a high pressure oxygen medium.

**[0002]** In the description given below and in the following claims, the term: "materials", is understood to mean materials substantially of any types as issuing from a variety of activities. Examples of such materials include: organic and inorganic town solid waste; particular materials such as asbestos (also in compositions such as Eternit(TM)); wheel tires from road vehicles; incombustible materials such as cement (e.g., cement impregnated with toxic substances like arsenic and chrome); harmful combustible materials impregnated with toxic substances (parasiticides), such as telephone poles and railway sleepers; particular organic waste such as solid or near-solid residues from tanneries, dairy plants and crushers; and radioactive materials.

**[0003]** Suitable materials to be treated with this invention are in particular those of the solid and near-solid types, although liquid or flowable substances such as burned mineral oils also are eligible.

**[0004]** The invention further relates to a pressure-tight chamber as well as an apparatus for implementing the inventive process.

**[0005]** As is known, in consequence of the ever stricter standards and norms applied by industrialized countries to the collection, storage and disposal of waste materials in general, there is increasingly felt the need of setting up processes, which allow to treat such materials in a simple and environmentally friendly manner, at low investment and operating costs and with a low energy consumption.

**[0006]** In particular, the environmental and energy concerns are becoming prominent in setting up processes for the treatment of waste materials.

### Prior Art

**[0007]** In order to meet the above requirement, processes for the treatment of waste materials which are based on burning, in a more or less selective manner, such materials in incinerators usually operated at temperatures in the range of 300° to 800°C, have found a wide application in the field.

**[0008]** While being simple to implement, these processes are beset with drawbacks due primarily to the fact that conventional combustion releases significant amounts of harmful substances in the forms of slag or gaseous emissions (fumes), requiring complicated and expensive arrangements for their neutralization.

**[0009]** And even where such neutralizing arrangements are provided, environmental pollution often cannot be held within the limiting values of current standards.

**[0010]** Moreover, the production of large amounts of slag, even when partially killed, still implies the need to arrange for its delivery and disposal to a dumping site or repository, thereby adding further costs and environmental problems.

**[0011]** In all cases, prior art processes tend to be expensive to apply, both in terms of investment and operating costs, and especially so in the respect of energy consumption.

**[0012]** Finally, it should not be overlooked that such processes are unsuited to treat materials of just any types. For example, they cannot be applied effectively to the treatment of radioactive substances and incombustible materials like cement, due to their excessively low operating temperatures.

**[0013]** To reduce these drawbacks, it has recently been proposed of burning the waste materials inside a hyperbaric chamber, under oxygen at a high pressure.

**[0014]** While from a theoretical standpoint the recourse to hyperbaric chamber technology (a technology that has been widely employed in the medical field for years) in order to burn waste materials may seem to hold promises, no processes have yet been proposed in the field which can provide a safe and efficient type of hyperbaric combustion at both laboratory and commercial levels.

**[0015]** In fact, due to the very high temperatures (for instance in the range of 1000° to 3000°C) generated inside a hyperbaric chamber by the combustion of the waste materials, it is highly difficult to control such a treatment process, and especially the exothermic reactions implied, in any long-term safe fashion without the risk of the hyperbaric chamber catching fire or exploding.

**[0016]** A further serious problem connected with the use of this technology is posed by the materials generally used for the construction of conventional hyperbaric chambers. These materials are in the long run unable to accommodate the very high stresses to which they are subjected without suffering irreversible deterioration, which makes the hyperbaric chambers only suitable for a single use.

**[0017]** Accordingly, the prior art processes for treating waste materials are still rather deficient, despite the increasingly felt need in the field and the presence of laws and regulations that push towards non-polluting technologies and low energy consumption.

### Summary of the Invention

**[0018]** The problem underlying the present invention is that of providing a process for treating materials, in particular waste materials, which is simple to implement, effective and non-polluting, and neither involves high investment and operating costs nor a high energy consumption.

**[0019]** This problem is solved, according to the invention, by a process as indicated above which is characterized in that the materials to be treated are held in suspension during said combustion.

**[0020]** In the description given below and in the following claims, the term: "suspension", is understood to mean a state whereby the materials being treated are dispersed through a gaseous phase (oxygen) with no chance of coming into contact with any of the pressure-tight chamber members.

**[0021]** Advantageously, the process of this invention can treat materials, in particular waste materials, in a safe and efficient way by burning them under high pressure oxygen within a pressure-tight chamber.

**[0022]** This is made possible by the fact that, during the combustion, the materials to be treated are held suspended inside the pressure-tight chamber, without ever contacting the chamber and, in particular, the inner walls thereof.

**[0023]** Contrary to any conclusions that might be drawn from the prior art teachings, it has only been after the research work carried out by the Applicant that it has unexpectedly come forth that, notwithstanding the extreme operating conditions established within the pressure-tight chamber - which conditions would be unacceptable for commercially available construction materials - by preventing all contacts of these materials with the material to be treated during combustion, it is possible to overcome in a most simple and efficient manner a major technical drawback, which had led to regard the technology based on combustion under high pressure oxygen impracticable for the purpose of treating waste materials.

**[0024]** In other words, it has been found that the absence of contact between the pressure-tight chamber and the materials to be treated, advantageously causes the large amount of heat released by the combustion under high pressure oxygen to remain confined within a predetermined portion of the chamber, and to expand gradually through the chamber interior without triggering any undesired phenomena of spontaneous combustion or sublimation of the chamber members, in particular of the chamber walls.

**[0025]** Thus, the explosion and fire hazard connected with the difficulty of controlling the exothermic reactions initiated by the combustion can be drastically reduced, and the problem of the deteriorating of the pressure-tight chamber construction materials effectively obviated.

**[0026]** The advantages to be derived from the present invention are manifold and reflect most favourably on the environmental and energy aspects.

**[0027]** In fact, by carrying out the combustion under high pressure oxygen, the very high temperatures attained with this combustion can be utilized to treat materials of almost any types, in particular waste materials and, advantageously, incombustible materials as well, such as cement and radioactive materials.

**[0028]** In the last-mentioned instance, the process of this invention - although affording no reduction in the material radioactivity - advantageously allows their volume to be significantly reduced, thereby making their ultimate disposal easier, and possibly allowing them to be converted into suitable compounds for subsequent treatment by other processes.

**[0029]** It should be noted that the exothermic reactions, initiated by the high pressure combustion, advantageously cause the temperature to spurt to very high values resulting in quick sublimation and/or vaporization of the materials to be treated.

**[0030]** This leaves a solid combustion residue which is a mere fraction of the original mass of material loaded for burning, thus greatly alleviating the environmental problem as well as the expense for removing and disposing of such residue.

**[0031]** As an example, consider that with this process the solid combustion residue can be abated, to a mere 0.1% to 0.5% for organic waste, and 1% to 15% for inorganic waste, of the starting mass.

**[0032]** As regards the gaseous effluent resulting from the process according to this invention, it should be noted that by carrying out the waste materials combustion under controlled atmosphere, i.e. virtually under oxygen alone, it is possible to advantageously eliminate the release to the environment of nitrogen compounds ($NO_X$), with nitrogen accounting for approximately 80% of atmospheric air, and other gaseous pollutants and fumes, by virtue of the high combustion temperature. It can be said that, in practice, the one gaseous substance released to the environment will be carbon dioxide.

**[0033]** Furthermore, since the combustion-supporting gas for burning the waste materials to be treated under a high pressure is mainly formed of oxygen, the costs for implementing the process of this invention can be kept quite low.

**[0034]** As brought out in greater detail by the ensuing description, this process also allows thermal and mechanical energy to be advantageously recovered by exploiting the large amounts of heat and the high pressures generated inside the pressure-tight chamber.

**[0035]** To implement this process, the invention advantageously provides a pressure-tight chamber for the treatment of materials, in particular waste materials, by combustion under a high pressure oxygen medium, which comprises:

- an upright shell substantially cylindrical in shape;
- a combustion zone defined on the interior of said shell;
- means for supplying a gaseous stream, essentially comprised of oxygen gas, to said combustion zone;
- suitable means for feeding a predetermined amount of materials to be treated into a top end of said

combustion zone;

- means for extracting a flue gas stream, resulting from the combustion of said materials to be treated and eventually comprising dispersed solid particles, from a bottom end of said combustion zone.

**[0036]** The features and advantages of this invention will become apparent from the following description of an embodiment thereof, given by way of non-limitative example with reference to the accompanying drawing.

Brief Description of the Drawing

**[0037]**

Figure 1 is a longitudinal section view of an apparatus for the treatment of materials, in particular waste materials, by combustion under a high pressure oxygen medium inside a pressure-tight chamber, for implementing the process according to the present invention.

Detailed Description of a Preferred Embodiment

**[0038]** Referring to Figure 1, generally shown at 1 is an apparatus for the treatment of materials by combustion under a high pressure oxygen medium, according to this invention.

**[0039]** Advantageously, the apparatus 1 comprises at least one pressure-tight chamber 2 for implementing the inventive process, and suitable means 3 for indirect heat exchange between the chamber 2 and a cooling fluid (not shown) caused to swept the chamber exterior.

**[0040]** The pressure-tight chamber 2 according to this invention advantageously comprises: an upright shell 4 substantially cylindrical in shape; a combustion zone 5 defined on the interior of the shell 4; means 6 for supplying a gaseous stream, essentially comprised of oxygen gas, to the combustion zone 5; suitable means 7 for feed a predetermined amount of materials 13 (such as waste materials) to be treated into a top end 5a of the combustion zone 5; and means 8 for extracting a flue gas stream, resulting from the burning of the materials to be treated and comprising eventually any dispersed solid particles 14, from a bottom end 5b of the combustion zone 5.

**[0041]** The means 6, 7 and 8 for respectively supplying the combustion zone 5 with the stream of oxygen gas and feeding it with materials 13 to be treated, and for extracting the flue gas stream from that zone, preferably comprise a conventional piping or ducting, as well as valves (not shown) for opening and closing such lines.

**[0042]** In this chamber 2, the process for the treatment of materials, such as waste materials, according to the invention can be advantageously implemented, which process is characterized in that the materials 13 are held in suspension during combustion under high pressure oxygen inside the chamber 2.

**[0043]** In this way, the materials 13 to be treated are prevented from contacting the inner wall surfaces of the shell 4 during the combustion process, thereby avoiding the risk of explosion, fire, or inflicting serious damages on the pressure-tight chamber 2.

**[0044]** As previously mentioned, the process of this invention unexpectedly allows the materials 13 to be treated by combustion under high pressure oxygen in a simple, effective and safe manner.

**[0045]** The operational conditions of pressure and temperature inside the pressure-tight chamber 2 may vary with the type and amount of materials 13 to be treated. For example, pressure may vary between 8-10 atm and several hundreds atmospheres, while the combustion temperature may swing between 1100°C and over 3000°C.

**[0046]** To ensure a most efficient combustion, free of polluting gas emissions, it is preferable to carry out the process in a controlled atmosphere, that is under a gaseous flow - as combustion-supporting medium - comprising essentially oxygen, with a concentration of nitrogen or other components to be found in the air limited to a few ppm.

**[0047]** Preferably, the means 6 for supplying the oxygen-containing gas stream discharge to a location in the combustion zone 5 close to its bottom end 5b, so as to ensure a fast, uniform and thorough saturation of the whole combustion zone 5 and to prevent gradients in the oxygen concentration within the chamber 2, which might result in uneven and uncontrolled combustion.

**[0048]** Particularly satisfactory results of the process according to this invention have been obtained by causing the materials 13 to be treated to flow in a free falling manner within the chamber 2. In other words, these materials are burned during their gravity fall from above toward the bottom of the combustion zone 5, as shown schematically in Figure 1 at 13 and 14.

**[0049]** In this way, the risk of the materials 13 incidentally touching the inner walls of the shell 4 during their combustion can be minimized.

**[0050]** For the purpose, the shell 4 of the pressure-tight chamber 2 is designed to have a high width-to-diameter ratio, preferably within the range of 1 to 10.

**[0051]** Advantageously, a narrow, elongate cylindrical shell 4 can successfully accommodate the high pressures under which the chamber 2 is operated (thereby allowing the thickness of the shell walls, and its associated cost, to be minimized), while affording a sufficiently long fall time for the materials 13, to ensure that they will be thoroughly burned before reaching the bottom end 5b of the combustion chamber 5.

**[0052]** Preferably, the walls of the shell 4 are formed from stainless steel of a suitable thickness to withstand the operational pressures of the chamber 2.

**[0053]** In this invention, the materials 13 which can be treated by the above process may be disparate, ranging from combustible to incombustible or radioactive materials, having any toxic content, composition and state.

**[0054]** In this respect, it matters to observe that particularly satisfactory results have been obtained by feeding said chamber 2 with the materials in small amounts, regardless of the material type. Preferably, such amounts are on the order of a few grams.

**[0055]** In this way, the energy released from the combustion can be limited, or at least controlled, and the risk of damaging the chamber 2 further reduced.

**[0056]** According to a particularly preferred embodiment of this invention, the pressure-tight chamber 2 may be advantageously fed with materials 13 of either the solid (or near-solid) or liquid type.

**[0057]** For example, as indicated by a dash arrow 9 in Figure 1, toxic or otherwise harmful materials, such as burned oils, can advantageously be fed to the combustion zone 5 through the means 7, as additional fuels to materials of the solid type to be treated.

**[0058]** Thus, a blend of liquid/solid materials will be formed, with the former burning for example at lower temperatures than the latter, so as to allow to obtain a controlled combustion within the zone 5.

**[0059]** In other words, the heat generated by the combustion of a given material can be utilized to activate the combustion of another material having a higher combustion temperature, and so on. In practice, it will be sufficient for an activating temperature to be relatively low (and hence produce a smaller energy consumption) to trigger a chain of exothermic reactions effective to even sublimate such incombustible materials as cement.

**[0060]** It should be noted that the exothermic reactions taking place inside the chamber 2 are extremely fast, and allow the materials to be treated to be burned within infinitesimal times.

**[0061]** Preferably, the treatment of the materials 13 is carried out by controlled spontaneous combustion of the same inside the pressure-tight chamber 2.

**[0062]** Advantageously, according to this process, the chamber 2 can thus be fed with a mixture (solid/solid or liquid/solid) of materials 13, preferably waste materials, which burn at different temperatures.

**[0063]** In addition, the mixture of materials 13 fed into the chamber 2 may advantageously comprise combustible as well as incombustible materials.

**[0064]** As said before, it thus becomes possible to control the combustion progress inside the pressure-tight chamber in a simple and effective way, obtaining a gradual, albeit rapid, temperature increase. Furthermore, by exploiting the different combustion temperatures of the materials fed into the pressure-tight chamber, it is possible to carry out the combustion of materials that sublimate at very high temperatures with a relatively low activating energy.

**[0065]** To avoid all contacts of the inner walls of the shell 4 with the materials 13 or any external elements, which would result in the chamber 2 being damaged irreparably, the process of this invention further provides for the step of feeding the materials 13 to be treated into the chamber under the urge of mechanical means or of a gaseous or liquid fluid medium.

**[0066]** To achieve this, the means 7 for feeding materials to be treated to the combustion zone 5 may comprise suitable spring means (not shown), or are of the pneumatic or the hydraulic type.

**[0067]** Preferably, the materials 13 are fed into the combustion zone 5 by means of a gaseous flow comprising oxygen which flows together with the materials to be treated within the means 7, which are of the pneumatic type.

**[0068]** The reference numerals 10, 11 and 12 indicate combustion activating means which are located preferably near the top end 5a of the combustion zone 5, conventional pressure switches and/or sensors for controlling the pressure and temperature inside the combustion zone 5, and a relief valve, respectively.

**[0069]** The combustion activating means 10 are preferably used to just get the chamber 2 started, that is when the latter is still cold, for example at a temperature below 700°C, and energy must be supplied from outside to initiate combustion under a high pressure of the materials to be treated.

**[0070]** Once the chamber 2 is brought up to normal operation, the means 10 are no longer required to activate combustion each time that materials 13 are being fed to it, because according to the process of this invention, at least some of the combustion activating heat is advantageously provided by residual heat from a previous combustion.

**[0071]** Thus, the energy still present within the chamber 2 - in form of heat - as a consequence of a combustion is utilized to initiate the next combustion, and so on. This affords outstanding savings in energy compared to prior art processes requiring a continued supply of energy from outside.

**[0072]** The combustion activating means 10 may comprise, for instance: a resistance heater (not shown) for raising a confined portion of the combustion zone 5 preferably located near the top end 5a to a threshold temperature; and suitable means to inject a predetermined amount of a liquid or gaseous fuel, preferably gas oil or burned oils, into the suitably heated portion of the combustion zone 5.

**[0073]** The temperature attained in said portion of the zone 5 upon combustion should be adequate to ensure that the liquid or gaseous fuel injected into the pressure-tight chamber will ignite instantaneously by spontaneous combustion (blaze), thereby allowing to reach the desired temperature to activate the combustion under a high pressure of a predetermined material to be treated.

**[0074]** Advantageously, the starting of the pressure-tight chamber by the means 10 is controlled such that, by the time of the combustion and consequent blaze, the materials to be treated are presented ready at the top end 5a of the combustion zone 5.

**[0075]** The relief valve 12, which is preferably of the mechanical type, has the function to prevent the internal pressure of the chamber 2 from attaining too high a level for the chamber own safety, in the event of something going amiss.

**[0076]** Upon the sensors and pressure switches 11 detect a temperature or pressure above pre-set limiting values, an emergency procedure is initiated whereby the conduits for feeding the combustion-supporting medium (means 6) and the combustible material (means 7) are shut off simultaneously as the conduit to extract the flue gas (means 8) is opened. This effectively produces a quick drop in pressure and temperature within the chamber 2 and results in the latter being emptied of its contents.

**[0077]** In relation to the chamber 2 of Figure 1, the process of this invention is characterized in that it advantageously comprises the following steps: supplying a gas stream, essentially comprised of oxygen gas, to the pressure-tight chamber 2 until a pressure of at least 5 atm is attained; feeding a predetermined amount of materials 13 to be treated into the chamber 2, and subjecting them to combustion with the oxygen at a temperature of at least 1100°C, with the materials 13 being held in suspension during the combustion process; and extracting a flue gas stream issuing from the combustion of the materials 13, which stream may include dispersed solid particles 14, from the chamber 2.

**[0078]** As previously mentioned, the above process steps allow a simple, effective and environmentally friendly treatment of materials of any types, with low energy consumption and low investment and operating costs.

**[0079]** These steps can advantageously be repeated for a number of times in the same chamber 2 to allow large volumes of materials 13 to be treated in continuous, which materials would be introduced however in small amounts at each operational cycle of the pressure-tight chamber 2. Operational cycle means here the complete sequence of the above process steps.

**[0080]** In this way, large amounts of materials can be treated in a very safe manner, using one or more pressure-tight chambers 2 of comparatively small size and, hence, cost efficient.

**[0081]** Since the high pressure combustion proceeds at a very fast rate, the operational cycles can be completed quite rapidly, within a few second time or even in less than one second, such that relatively large amounts of materials can be treated and then disposed of, even if limited amounts of such materials are treated per cycle.

**[0082]** For example, a pressure-tight chamber measuring only two meters in height, and 0.2 meter in diameter, can treat over eight hundred kilograms of waste materials daily (which is approximately one half of the daily waste from a hospital of average size), when operated in cycles of one second and with material unit charges of a few grams.

**[0083]** According to a particularly advantageous aspect of this invention, the process further comprises the step of circulating at least a part of said flue gas stream back to said pressure-tight chamber.

**[0084]** For this purpose, the chamber 2 advantageously comprises suitable means (indicated by a dash line 15 in Figure 1) for circulating at least a part of the flue gas stream back to the combustion zone 5.

**[0085]** For instance, the means 15 comprise a duct in fluid communication with the means 8 for extracting the flue gas stream from the chamber 2, and with the means 7 for feeding to the same the materials to be treated.

**[0086]** In other words, the gas and eventually any solid residue 14 resulting from the combustion of the materials 13, once extracted from the chamber 2 by the means 8, can advantageously be reintroduced (at least in part) into the chamber 2, instead of being dispersed in the environment.

**[0087]** In this way, a non-polluting closed loop system is provided which affords a drastic reduction, if not the suppression, of gas emissions to the atmosphere, even though such emissions substantially comprise carbon dioxide only.

**[0088]** A further feature of the process according to the invention is that the materials 13 can be advantageously fed to a plurality of chambers 2 operated in parallel and/or series.

**[0089]** The simultaneous feeding of the materials 13 to a number of chambers 2 in parallel enables the treatment process to be applied in a highly flexible manner, with the materials to be treated being distributed, if desired, to the various pressure-tight chambers in different amounts and compositions.

**[0090]** In addition, the parallel arrangement of the chambers can accommodate maintenance or emergency downtime for one or more chambers without the whole process having to be shut down.

**[0091]** Feeding the materials 13 to several chambers 2 arranged in series is a convenient choice where the combustion within a first chamber is carried out only partially. In this case, the partially burned materials 13 would be fed into a second or a third or a fourth, etc., pressure-tight chambers 2 for completion of the combustion process.

**[0092]** Advantageously, this allows the combustion of the materials to be carried out in a more gradual and controlled manner through a number of chambers, so as to minimize the risk of accidents or damage for the chambers.

**[0093]** It should be understood that the process of this invention can be applied to the treatment of materials 12 fed to a plurality of chambers 2 in either a parallel and/or a series arrangement.

**[0094]** Although in the example of figure 1, it is shown a single chamber 2, the apparatus 1 according the present invention can advantageously comprise a plurality of chambers 2 arranged in parallel and in series

**[0095]** Preferably, in this apparatus 1, the means 3 for indirect heat exchange comprise a safety shroud 16 provided around the chamber(s) 2. A single safety shroud can be adequate to protect a plurality of chambers 2.

**[0096]** The safety shroud 16 is designed to protect the environment in the event of a pressure-tight chamber 2 bursting or otherwise failing, and is made of shockproof materials resistant to high temperatures and sharp pressure changes.

**[0097]** As shown in Figure 1, a free space 17 is advantageously created between the safety shroud 16 and the chamber(s) 2 to contain the aforementioned cooling fluid (not shown).

**[0098]** The cooling fluid inlet and outlet conduits to/from the free space 17 have not been shown because conventional and known to the skilled one.

**[0099]** The cooling fluid preferably consists of a liquid, such as water, being circulated externally the chamber 2 to advantageously remove heat therefrom and to keep the temperature of the walls of the shell 4 below a predetermined value, thereby ensuring that they are cooled constantly and continually.

**[0100]** At the same time, the heated cooling fluid allows a significant amount of energy to be recovered in a simple and effective way, which energy can be advantageously used for a variety of purposes, such as heating or to produce steam at high thermal level.

**[0101]** It should be noted in this respect that a large amount of heat is produced inside the chamber 2 from high exothermic chemical-physical reactions activated by the combustion, which heat can advantageously be recovered, at least in part, thanks to the present invention.

**[0102]** Energy can be additionally recovered according to the process of this invention by utilizing to advantage the high temperature and pressure of the flue gas stream leaving the combustion zone 5.

**[0103]** The flue gas produced in the chamber 2 is of a significant amount, because the combustion process results in substantially all the matter being sublimated or vaporized, passing from the solid or near-solid respectively liquid state directly to the gaseous state, thereby enabling considerable amounts of thermal or mechanical energy to be recovered.

**[0104]** To this aim, the apparatus 1 further includes means for producing thermal and/or mechanical energy arranged in fluid communication with the means 8 for extracting the flue gas stream from the combustion zone 5 of the chamber(s) 2.

**[0105]** This energy recovering means may be provided in a chamber 18, schematically shown in Figure 1, directly downstream of the safety shroud 16. This means are not shown in further detail because it would comprise apparatuses known per se, such as turbines, generators or heat exchangers, suitable to produce mechanical or electric energy or to exploit the heat thermally.

**[0106]** Downstream of the chamber 18 and in fluid communication with the means 8 for extracting the flue gas stream are, as shown schematically, a zone 19 for filtering out any solid particles 14 eventually dispersed in the flue gas stream, and a zone 20 for separating any fluorine and chlorine also eventually present in the flue gases.

**[0107]** Accordingly, the zones 19 and 20 would include conventional filters or scrubbing apparatuses, no further described herein.

**[0108]** The reference numerals 21, 22 and 23 respectively indicate a grinding and/or mixing zone for the materials 13 to be treated, an agglomerating and/or encapsulating and/or metering zone for the materials 13 to be treated, and means - shown in dash lines - for conveying the materials to be treated from a collecting zone (not shown) to the zones 21 and/or 22.

**[0109]** The zone 21 advantageously comprises means for suitably grinding the materials 13, which means are connected to the feeding means 7 for feeding the materials 13 to be treated to the combustion zone 5 of the chamber(s) 2.

**[0110]** Mills or other known apparatuses may be used as the grinding means, according to the nature of the material being handled.

**[0111]** In this connection, according to a further aspect of this invention, this process advantageously comprises the step of feeding the materials 13 into the chamber in a suitably ground form, in order to have them rapidly and effectively burned, with an extremely reduced energy consumption.

**[0112]** In fact, this additional process step - concerning, of course, solid or near-solid materials - allows the combustion zone 5 to be fed with relatively homogeneous small-size fragments whose total surface area is significantly larger than the surface area of the same material before grinding, which can substantially favour and speed up the combustion process.

**[0113]** Furthermore, the zone 21 may advantageously comprise means for mixing materials 13 to be treated which burn at different temperatures, which means would be connected to the means 7 for feeding the materials 13 to the combustion zone 5 of the chamber(s) 2.

**[0114]** Screw or auger type mixers, or other known apparatuses, may be used as the mixing means, according to the type of material to be treated.

**[0115]** The advantages that accrue from the step of mixing together materials 13 having different combustion temperatures have been previously outlined.

**[0116]** Specially satisfactory results have been obtained with the process according to the invention by feeding the materials 13 to be treated in a suitably granulated form into the chamber 2.

**[0117]** In this way, the materials to be treated which have been ground to facilitate their combustion are compacted together, thereby preventing them from being undesirably scattered radially against the walls of the shell 4 upon introduction into the combustion zone 5.

**[0118]** Preferably, the granules fed into the chamber 2 would be contained in respective vacuum envelopes (not shown) to facilitate the introduction of the materials 13 into the chamber, either under the urge of mechanical means or of a liquid or gaseous fluid medium, and to prevent undesired contacting.

**[0119]** To this aim, means are provided in the zone 22 for agglomerating in granule form the materials 13 after grinding, and if required, encapsulating the granules in respective vacuum envelopes. This means are disposed between said grinding means and the means 7 for feeding the materials 13 to be treated to the combustion zone 5.

**[0120]** The zone 22, moreover, advantageously comprises a metering device for feeding the materials 13 in a controlled manner, which device is in direct communication with the means 7 for feeding the materials 13 to the combustion zone 5.

**[0121]** The metering device allows the feeding of the materials 13 to be treated to occur in a controlled manner and in phase with the operational cycles of the chamber 2, which materials being delivered directly from the collecting zone, from zone 21, or from the agglomerating and/or encapsulating means of the zone 22.

**[0122]** For simplicity, the grinding, mixing, agglomerating, and encapsulating means have been omitted from Figure 1 because known per se.

**[0123]** From the foregoing description emerge clearly the numerous advantages achieved by the present invention; in particular, it is obtained a simple, effective and nonpolluting treatment of any type of material, at low energy consumption and with low investment and operating costs.

**[0124]** In particular, an analysis of the products released from the combustion of the above cited materials according to the process of this invention has shown:

- absence of nitrogen oxides (NO, $NO_2$, $NO_X$);
- absence of sulphur dioxide and/or trioxide ($SO_2$, $SO_3$);
- absence of straight chlorides, polychlorinated compounds (dioxins), and cyanides;
- a reduced solid residue of down to 0.1%-0.5% for organic waste, and 1%-15% for inorganic waste, relative to the initial mass;
- presence among the gaseous compounds essentially of only carbon dioxide, virtually of no environmental consequence if released to the atmosphere.

## Claims

1. Process for the treatment of materials, in particular waste materials, in a pressure-tight chamber by combustion under a high pressure oxygen medium, characterized in that said materials are held in suspension during said combustion.

2. Process according to Claim 1, characterized in that the materials to be treated flows into said pressure-tight chamber in a free falling manner.

3. Process according to Claim 1, characterized in that the materials to be treated are fed into said pressure-tight chamber in a suitable ground form.

4. Process according to Claim 3, characterized in that the materials to be treated, suitably ground, are fed into said pressure-tight chamber in a granulated form, preferably contained in respective vacuum envelopes.

5. Process according to Claim 1, characterized in that said pressure-tight chamber is fed with a blend of materials to be treated having different combustion temperatures.

6. Process according to Claim 1, characterized in that said pressure-tight chamber is fed with a blend of combustible and incombustible materials to be treated.

7. Process according to Claim 1, characterized in that said pressure-tight chamber is fed with materials to be treated in small amounts of the order of a few grams.

8. Process according to Claim 1, characterized in that the materials to be treated are fed into said pressure-tight chamber under the urge of mechanical means or of a gaseous or liquid fluid medium, preferably a gaseous fluid medium comprising oxygen.

9. Process according to Claim 1, characterized in that said materials to be treated are fed into a plurality of pressure-tight chambers operated in parallel and/or in series with one another.

10. Process according to Claim 1, characterized in that at least a part of the combustion activating heat comprises residual heat from a previous combustion.

11. Process according to Claim 1, characterized in that the materials are treated by controlled spontaneous combustion thereof within said pressure-tight chamber.

**12.** Process according to Claim 1, characterized in that it comprises the following steps:

- supplying a gas stream essentially comprised of oxygen gas to said pressure-tight chamber until a pressure of no less than 5 atm is attained;

- feeding a predetermined amount of materials to be treated into said pressure-tight chamber;

- subjecting said materials to be treated to combustion under oxygen at a temperature of at least 1100°C, said materials to be being held in suspension during said combustion;

- extracting a flue gas stream, released from the combustion of said materials to be treated and eventually comprising dispersed solid particles, out of said pressuretight chamber.

**13.** Process according to Claim 12, characterized in that it further comprises the step of:

- circulating at least a part of said flue gas stream back to said pressure-tight chamber.

**14.** Pressure-tight chamber for the treatment of materials, in particular waste materials, by combustion under a high pressure oxygen medium, comprising:

- an upright shell (4) substantially cylindrical in shape;

- a combustion zone (5) defined on the interior of said shell (4);

- means (6) for supplying a gaseous stream, essentially comprised of oxygen gas, to said combustion zone (5);

- suitable means (7) for feeding a predetermined amount of materials to be treated into a top end (5a) of said combustion zone (5);

- means (8) for extracting a flue gas stream, resulting from the combustion of said materials to be treated and eventually comprising dispersed solid particles, from a bottom end (5b) of said combustion zone (5).

**15.** Chamber according to Claim 14, characterized in that said shell (4) has a high height-to-diameter ratio, preferably within the range of 1 to 10.

**16.** Chamber according to Claim 14, characterized in that said means (6) for supplying said gaseous stream essentially comprised of oxygen gas discharges to said combustion zone (5) in the proximity of the bottom end (5b) thereof.

**17.** Chamber according to Claim 14, characterized in that it further comprises means (10) for activating said combustion, located in the proximity of said top end (5a) of the combustion zone (5).

**18.** Chamber according to Claim 14, characterized in that said means (7) for feeding the materials to be treated to said combustion zone (5) comprise suitable spring means or are of the pneumatic or the hydraulic type.

**19.** Chamber according to Claim 14, characterized in that it further comprises means (15) for circulating at least a part of said flue gas stream back to said combustion zone (5).

**20.** Apparatus for the treatment of materials, in particular waste materials, by combustion under a high pressure oxygen medium, comprising:

- at least one pressure-tight chamber (2) according to any of Claims 14 to 19;

- means (3) for indirect heat exchange between said at least one pressure-tight chamber (2) and a cooling fluid flowing the chamber exterior.

**21.** Apparatus according to Claim 20, characterized in that it further comprises:

- means for suitably grinding said materials to be treated, connected to said means (7) for feeding the materials to be treated to the combustion zone (5) of said at least one pressure-tight chamber (2)

**22.** Apparatus according to either Claim 20 or 21, characterized in that it further comprises:

- means for mixing materials to be treated having different combustion temperatures, connected to said means (7) for feeding the materials to be treated to the combustion zone (5) of said at least one pressure-tight chamber (2).

**23.** Apparatus according to Claim 21, characterized in that it further comprises:

- means for agglomerating to a granulated form said materials to be treated, suitably ground, and optionally encapsulating such granules within respective vacuum envelopes, disposed between said grinding means and said means

(7) for feeding the materials to be treated.

**24.** Apparatus according to any one of claims 21 to 23, characterized in that it further comprises:

- a metering device for controlled feeding of the materials to be treated, disposed in direct communication with said means (7) for feeding the materials to be treated.

**25.** Apparatus according to Claim 20, characterized in that it further comprises:

- means for producing thermal and/or mechanical energy disposed in fluid communication with said means (8) for extracting said flue gas stream from the combustion zone (5) of said at least one pressure-tight chamber (2).

**26.** Apparatus according to Claim 20, characterized in that it comprises a plurality of pressure-tight chambers (2) arranged in parallel and/or series with one another.

**27.** Apparatus according to Claim 20, characterized in that said means (3) for indirect heat exchange comprise a safety shroud (16) extending around said at least one pressuretight chamber (2).

**28.** Apparatus according to Claim 27, characterized in that a free space (17) containing a cooling fluid, preferably a liquid, is defined between said safety shroud (16) and said at least one pressure-tight chamber (2).

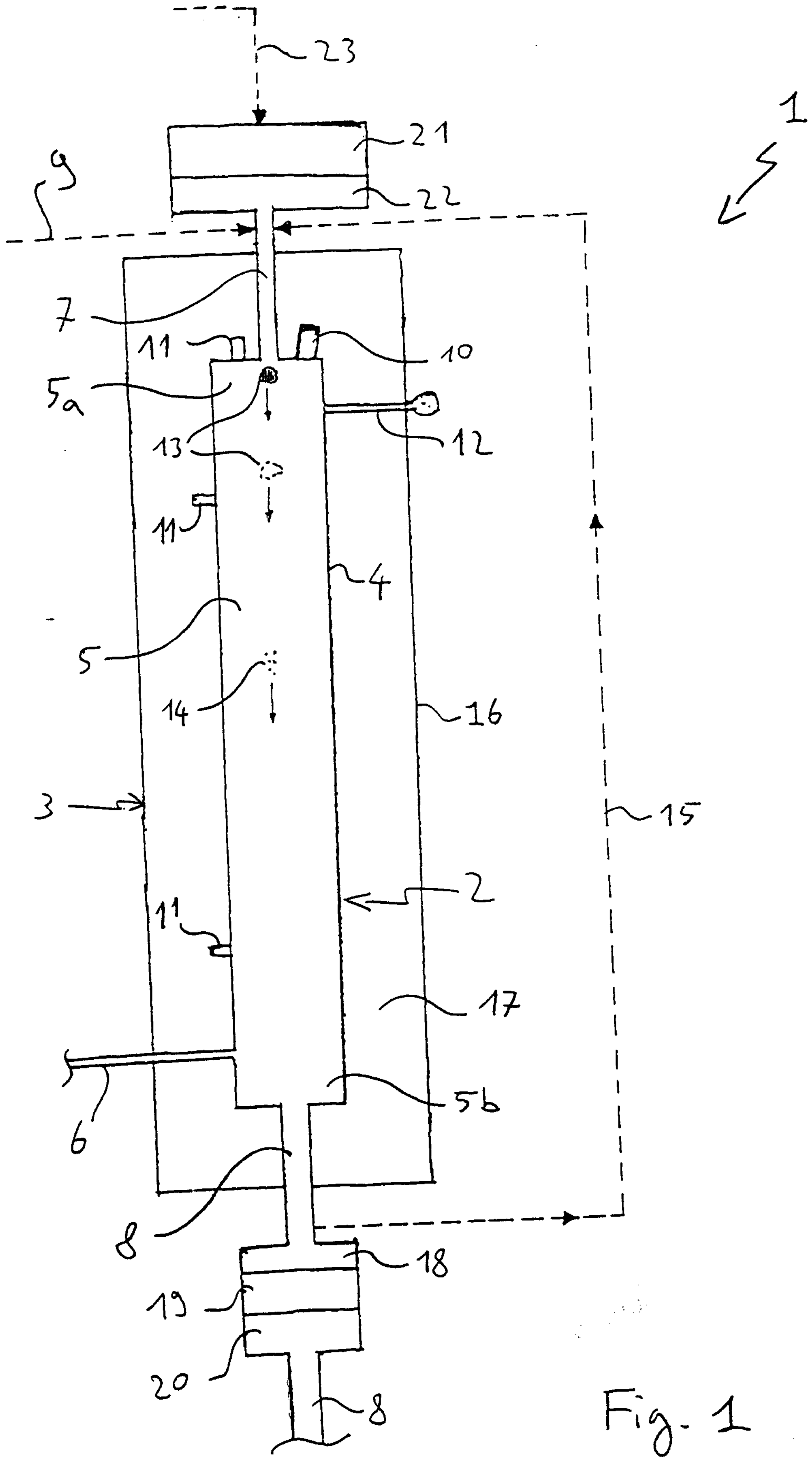


Fig. 1

European Patent Office

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Application Number
EP 98 83 0106

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