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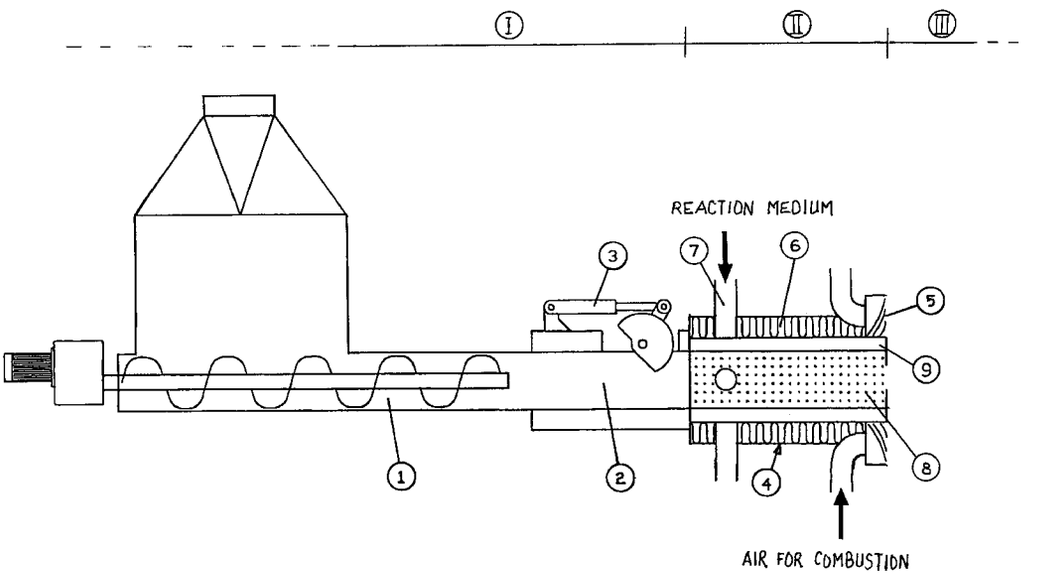
## (54) Method and plant for production and combustion of a combustible product

(57) In a method for the production and combustion of a combustible composite product being converted from a combustible organic material in a plant comprising an infeed zone (I), a reaction zone (II) and a combustion zone (III), said plant being capable e.g. of being connected to a conventional boiler plant,
the main novel features are

a) that the combustible organic material is advanced continuously through the infeed zone (I) and fed into the reaction zone (II), in which, in a reaction chamber (4) adapted for the purpose, it is converted while using a gaseous reaction medium being supplied via through openings (8) in a controlled condition with regard to quantity, speed and temperature, so as to cause the formation of a combustible composite product comprising gas, especially pyrolysis gas, tar and powder-like charcoal and having an internal temperature above the ignition temperature, but without molten slag being formed, and

b) that the combustible composite product formed is made to enter the combustion zone (III), in which the air for combustion is preferably supplied in a manner to prevent or minimize the formation of nitrogen oxides, in order to avoid high combustion temperatures.

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## Description

### TECHNICAL FIELD

The present invention relates to a method of the kind set forth in the preamble of claim 1.

### BACKGROUND ART

The combustion of combustible organic material, such as e.g. bio-mass comprising i.a. straw, hay, grass and wood, occurs normally by means of combustion systems, such as e.g. plants with combustion grates, fluid-bed plants or plants with cyclone combustion. In special cases, individually adapted systems like powder-fired plants or systems for the combustion of whole bales of straw are used.

The use of plants with combustion grates is limited by the fact that in high-capacity plants, it is difficult to adapt the size of the grates to the requisite boiler equipment, also because it is difficult to control an even layer of fuel and a good distribution of air, this being a necessary prerequisite for achieving good combustion. For this reason, plants comprising combustion grates are normally limited to a maximum fuel input corresponding to approximately 200 MW.

Fluid-bed plants can be used for types of fuel having a low reactivity, i.e. slow-burning fuels, and also for greater inputs of fuel, but with types of fuel with a high reactivity, i.e. fast-burning fuels like e.g. straw and other annual crops, it is necessary to use a supplementary fuel like e.g. coal for stabilizing the process of combustion.

Plants with cyclone combustion are used in those cases, in which a high turnover rate is desired in combination with small physical dimensions. The disadvantage with these plants is that cyclone combustion produces high combustion temperatures, and for the majority of organic material types this means that the slag is produced in liquid form. This causes the fertilizer value of the slag to be "encapsulated", for which reason it can no longer be utilized. This means that the slag product will have to be deposited, this being undesired, partly because of the increased costs, partly because the fertilizer value is lost as just mentioned.

Powder combustion is especially known from its use in large coal-fired power-station boilers, as coal can be ground into powder with few problems beyond those caused by the formation of dust. The use of organic materials as fuels is problematic, since the comminution of bio-mass crops is difficult and requires great amounts of energy, because these crops contain tough material or material comprising long fibres. In addition to this, the water content in this type of crops is usually high, for which reason it is necessary to subject the material to a drying process before comminuting it.

Combustion plants for burning whole bales of straw are known in a number of types, in some plants, whole bales of straw are burned "in one go", whilst in other plants, the bale of straw burns from one end and is gradually pushed forward during the combustion process. In these types of plants, problems can arise with regard to maintaining the continuous and uniform combustion process, because it is difficult to provide bales of straw that are uniform and homogeneous with regard to the calorific value.

It is a common feature for the combustion plants referred to above that they all use air for combustion that is cold or preheated to a maximum of 350°C. In the mechanical plants, this is due to the necessity of cooling the structural parts of the plants, while in the fluid-bed plants it is primarily a question of maintaining the combustion temperature sufficiently low to avoid sand and ash with low melting points coalescing or fusing.

Thus, the use of each of these previously known combustion systems is associated with both advantages and disadvantages depending on the combustible organic material being used, but these systems have that in common, that they are difficult to use for burning great quantities of organic material.

### DISCLOSURE OF THE INVENTION

It is the object of the present invention to provide a method of the kind referred to above for use in the continuous production and combustion of great quantities of combustible organic materials, with which it is possible to achieve very high conversion rates with difficult materials, e.g. such having a high water content, and according to the present invention, this object is achieved by proceeding in the manner set forth in the characterizing clause of claim 1.

In this manner, it is possible to convert a combustible organic material into a combustible composite product consisting of gas, tar and powder-like charcoal and having a very high calorific value and a very high reactivity, and which will burn with a strongly radiating flame, thus being well suited for use in association with a conventional boiler plant.

The invention also relates to a plant for carrying out the method according to the invention. This plant is of the kind set forth in the preamble of claim 7, and according to the invention, it also exhibits the features set forth in the characterizing clause of this claim 7.

Advantageous embodiments of the method and the plant, the effect of which - beyond what is obvious - will be evident from the following detailed part of the present description, are set forth in claims 2-6 and 8-11, respectively.

### BRIEF DESCRIPTION OF THE DRAWING

In the following detailed part of the present description, the invention will be explained in more detail with reference to the drawing, showing diagrammatically an embodiment of a plant that can be used for carrying out the method according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The plant for conversion and combustion of the combustible organic material comprises various zones placed immediately in sequence in the direction of advancement of the material, and the plant comprises mainly an infeed zone I, a reaction zone II and a combustion zone III. Thus, the combustion device may e.g. be connected to a conventional boiler plant so as to replace or supplement the conventional furnace equipment.

The infeed zone I comprises an infeed system 1 adapted to convey the combustible organic material continuously to the reaction zone II. The infeed system as such may e.g. consist of one or a number of worms or hydraulic systems with reciprocating pistons. Thus, the material is advanced by the infeed system 1 via an infeed channel 2 that may have various cross-sectional shapes. An adjustable obstruction 3 is placed in the infeed channel 2 so as to make it possible to achieve a suitable compacting and partial retaining of the material having been introduced, thus making it possible to establish and maintain a counter-pressure making the material sufficiently impervious to prevent gas and product of combustion from penetrating back into the infeed system 1.

The reaction zone II may be constructed with a reaction chamber 4 consisting of an inner part with through openings 8, preferably in the form of small air nozzles, i.e. having a small cross-sectional area. The through openings 8 are connected to supply ducts 7, e.g. via an air-distribution jacket 9, and accordingly, the gaseous reaction medium enters the reaction chamber 4 via the supply duct 7, the air-distribution jacket 9 and the through openings 8. The supply of reaction medium may be achieved by using commonly known air supply devices, for which reason these devices will not be described here. In addition, the reaction chamber 4 consists of an outer part, e.g. comprising an insulating layer 6. The reaction chamber 4 may have any imaginable cross-sectional shape, such as square or oval, but it is preferred that the reaction chamber 4 is a substantially cylindrical device with a length/diameter ratio of at least 1, preferably at least 3-4, to provide sufficient space for an optimum number of through openings 8 for the gaseous reaction mediums.

In this connection it may be mentioned that the gaseous reaction medium being used may e.g. comprise atmospheric air, oxygen, flue gases as well as mixtures thereof, and that the medium must be preheated to a temperature of more than 500°C, preferably between 650 and 900°C. And at the same time - in order to provide a composite product with maximum reactivity - the gaseous reaction medium contains oxygen in a proportion corresponding to a maximum of 25% of the stoichiometric quantity used in connection with a complete combustion, preferably in a proportion of between 15 and 25%.

In order to achieve that the air and the heat are distributed as evenly and and as uniformly as possible, it is preferred that the gaseous reaction medium is supplied to the inside of the reaction chamber through the highest possible number of openings. Thus, it is the combination of a small quantity of oxygen, a high velocity and high temperature for the reaction medium, as well as a relatively great length and small diameter of the reaction chamber, that makes it possible to convert large quantities of combustible organic material. At the same time, the small proportion of oxygen contained in the reaction medium enables the reaction temperature to be controlled in such a manner that the formation of molten slag is avoided, thus making it possible to use the slag as a fertilizer.

The converted combustible composite product contains approximately 50% gas and tar as well as approximately 50% powder-like charcoal when leaving the reaction zone II and entering the combustion zone III. The conversion per se is achieved without the use of mechanical means. The internal temperature of the product lies above the ignition temperature, but it is sufficiently low to avoid the formation of molten slag, and the combustible composite product being formed enters the combustion zone, in which the air for combustion is supplied in a controlled manner in order to avoid high combustion temperatures and to prevent or minimize the formation of nitrogen oxides ($NO_x$).

The combustion zone III comprises an air processor 5 through which the necessary air for combustion may be supplied. The air processor 5 must be of a type that is able to supply the air for combustion in steps, so as to prevent or minimize the formation of nitrogen oxides.

In this embodiment of the combustion zone III, it constitutes a final part of the reaction zone II, but it might just as well be an independent unit downstream of the reaction zone II.

LIST OF PARTS

| | |
|---|---|
| I | infeed zone |
| II | reaction zone |
| III | combustion zone |
| 1 | infeed system |
| 2 | infeed channel |
| 3 | adjustable obstruction |
| 4 | reaction chamber |
| 5 | air processor |
| 6 | insulating layer |
| 7 | supply ducts |
| 8 | through openings |
| 9 | air-distribution jacket |

**Claims**

1. Method for the production and combustion of a combustible composite product being converted from a combustible organic material in a plant comprising an infeed zone (I), a reaction zone (II) and a

combustion zone (III), said plant being capable e.g. of being connected to a conventional boiler plant, **characterized in**

a) that the combustible organic material is advanced continuously through the infeed zone (I) and fed into the reaction zone (II), in which, in a reaction chamber (4) adapted for the purpose, it is converted while using a gaseous reaction medium being supplied via through openings (8) in a controlled condition with regard to quantity, speed and temperature, so as to cause the formation of a combustible composite product comprising gas, especially pyrolysis gas, tar and powder-like charcoal and having an internal temperature above the ignition temperature, but without molten slag being formed, and
b) that the combustible composite product formed is made to enter the combustion zone (III), in which the air for combustion is preferably supplied in a manner to prevent or minimize the formation of nitrogen oxides, in order to avoid high combustion temperatures.

2. Method according to claim 1, **characterized in** that the converted combustible composite product contains approximately 50% gas, especially pyrolysis gas, and tar as well as approx. 50% powder-like charcoal, and that the conversion takes place without the use of mechanical means.

3. Method according to claims 1-2, **characterized in** that the gaseous reaction medium being used may e.g. comprise atmospheric air, oxygen, flue gases as well as mixtures thereof.

4. Method according to claims 1-3, **characterized in** that the gaseous reaction media being used contain oxygen in a proportion corresponding to a maximum of 25% of the stoichiometric proportion used in connection with a complete combustion, preferably in a proportion of between 15 and 25%.

5. Method according to claims 1-4, **characterized in** that the gaseous reaction medium being used is preheated to a temperature of more than 500°C, preferably between 650 and 900°C.

6. Method according to claims 1-5, **characterized in** that the gaseous reaction medium being used is supplied to the internal part of the reaction chamber (4) through a large number of openings (8) in order to achieve that the air is distributed as evenly as possible.

7. Plant for use in the production and combustion of a combustible composite product being converted from a combustible organic material in a combustion device comprising an infeed zone (I), a reaction zone (II) and a combustion zone (III), said plant e.g. being capable of being connected to a conventional boiler plant, and in which the various zones are placed in immediate succession in the direction of advancement of the material, **characterized in**

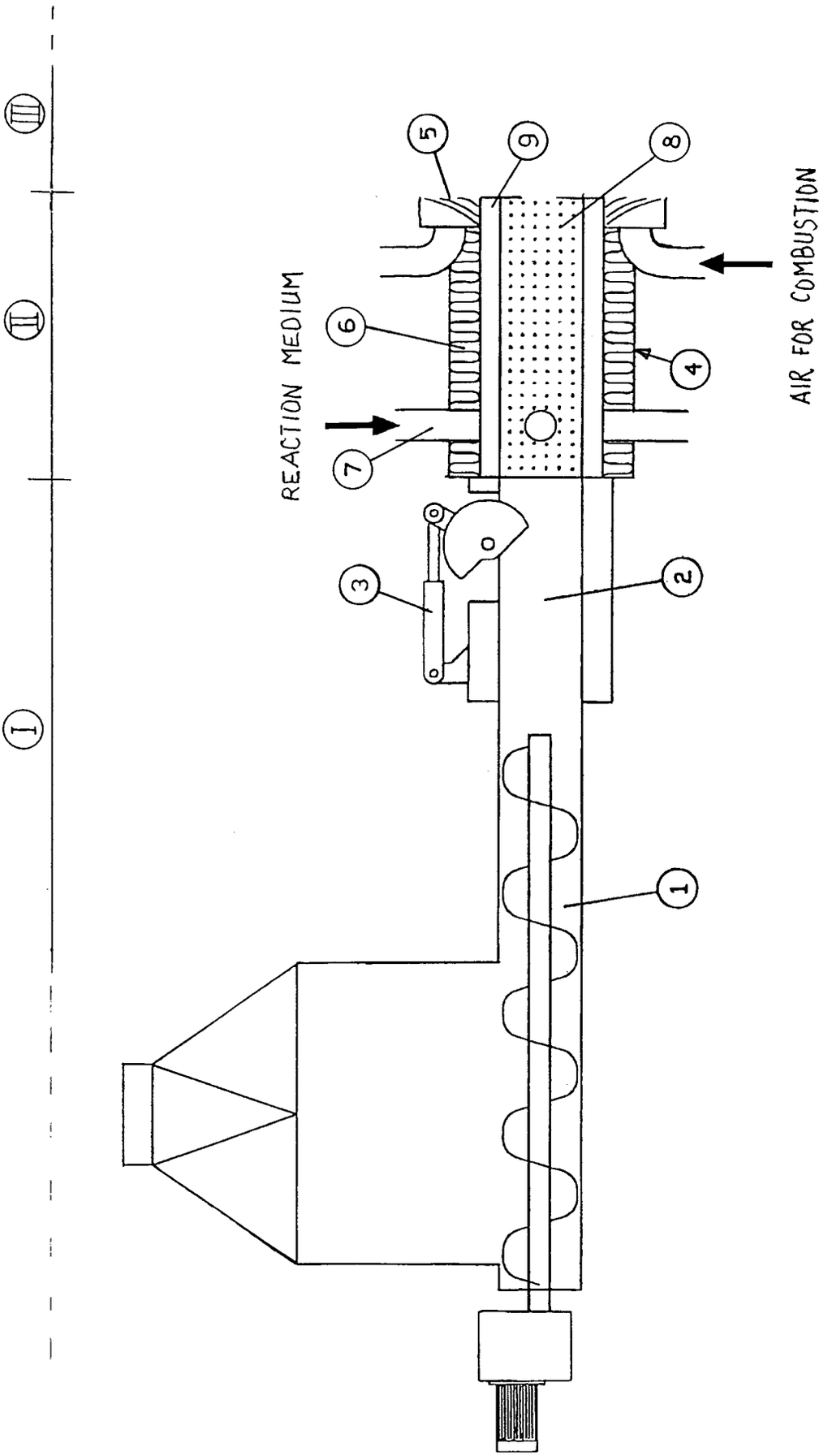
a) that the infeed zone (I) comprises an infeed system (1) adapted to convey the material continuously to the reaction zone (II) via an infeed channel (2),
b) that the reaction zone (II) comprises a reaction chamber (4) comprising an inner part with through openings (8), the latter being connected to supply ducts (7) for the gaseous reaction medium, e.g. via an air distribution jacket (9), and an inner part e.g. containing an insulating layer (6), and
c) that the combustion zone (III) comprises an air processor (5) through which the necessary air for combustion may be supplied, preferably in order to prevent or minimize the formation of nitrogen oxides.

8. Plant according to claim 7, **characterized in** that the air processor (5) is adapted to supply the air for combustion in steps, so as to prevent or minimize the formation of nitrogen oxides.

9. Plant according to claims 7-8, **characterized by** an adjustable obstruction (3) being placed in the infeed channel (2) making it possible to make the material more compact and hence maintain a counter-pressure making the material more dense and preventing gas and products of combustion to penetrate back into the infeed system (1).

10. Plant according to claims 7-9, **characterized in** that the reaction chamber (4) is a substantially cylindrical device with a length/diameter ratio of at least 1, preferably at least 3-4, so as to accomodate an optimum number of through openings (8) for the gaseous reaction medium.

11. Plant according to claims 7-10, **characterized in** that the combustion zone (III) constitutes a final part of the reaction zone (II).


III
II
I
REACTION MEDIUM
AIR FOR COMBUSTION
1
2
3
4
5
6
7
8
9

European Patent Office

# EUROPEAN SEARCH REPORT

Application Number EP 96109716.9

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl. 6) |
|---|---|---|---|
| A | US - A - 5 279 234 (BENDER et al.) * Claims 1,4,19; fig. 1 * -- | 1,2-5, 11 | F 23 G 5/027 F 23 G 5/50 |
| A | EP - A - 0 312 818 (KÜPAT A.G.) * Claim 3 * -- | 1,8 | |
| A | AT - B - 383 204 (HARGASSNER) * Page 3, last chapter; page 4, chapter 1; fig. 1-5 * -- | 1,3,4, 6,7,9, 10 | |
| A | EP - A - 0 033 753 (BIEDER) * Claim 19; page 5, penultimate chapter; fig. 1,3 * ---- | 9 | |

TECHNICAL FIELDS SEARCHED (Int. Cl. 6)

F 23 G

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| VIENNA | 01-10-1996 | BISTRICH |

CATEGORY OF CITED DOCUMENTS

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