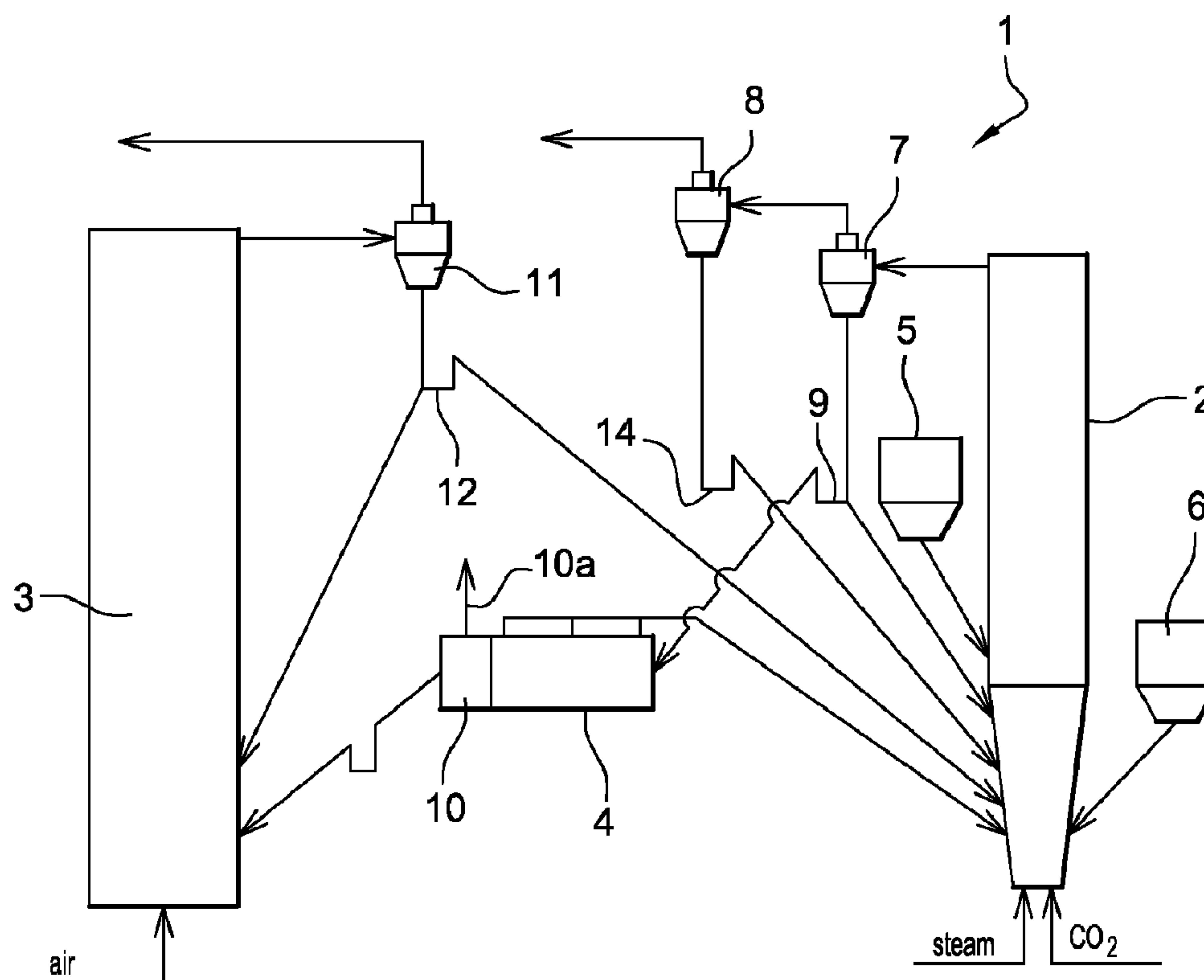




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(72) Inventeurs/Inventors:  
VANDYCKE, MICHEL, FR;  
MAGHDISSIAN, LAURENT, FR;  
BEAL, CORINNE, FR  
(73) Propriétaire/Owner:  
ALSTOM TECHNOLOGY LTD, CH  
(74) Agent: SMART & BIGGAR

(54) Titre : SYSTEME DE CONVERSION DE MATERIAU COMBUSTIBLE  
(54) Title: SYSTEM FOR CONVERTING FUEL MATERIAL



(57) Abrégé/Abstract:

The invention is related to a system (1) for converting fuel material comprising : a first reactor (2) in which a fuel material reacts with an oxide material for producing reaction products including fuel particles, ash and oxide particles, a second reactor (3) for oxidizing



(57) **Abrégé(suite)/Abstract(continued):**

the oxide particles produced in the first reactor (2), a carbon separator (4) that receives fuel particles, ash and oxide particles produced in the first reactor (2) and suitable for separating the oxide particles and ash from the fuel particles, the carbon separator (4) comprising an outlet path (4c) for the oxide particles and ash exhaust, characterized in that said outlet path (4c) of the carbon separator (4) is connected to an ash separator (10) for separating the ash from the oxide particles.

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**(57) Abstract:** The invention is related to a system (1) for converting fuel material comprising : a first reactor (2) in which a fuel material reacts with an oxide material for producing reaction products including fuel particles, ash and oxide particles, a second reactor (3) for oxidizing the oxide particles produced in the first reactor (2), a carbon separator (4) that receives fuel particles, ash and oxide particles produced in the first reactor (2) and suitable for separating the oxide particles and ash from the fuel particles, the carbon separator (4) comprising an outlet path (4c) for the oxide particles and ash exhaust, characterized in that said outlet path (4c) of the carbon separator (4) is connected to an ash separator (10) for separating the ash from the oxide particles.

## SYSTEM FOR CONVERTING FUEL MATERIAL

The present invention is related to a system for converting fuel  
5 material, such as a boiler, and is more particularly directed to an  
oxidation-reduction reactor system used in fuel conversion.

Chemical looping technology is a promising technology intended  
to achieve gasification or combustion of solid fuels replacing direct  
oxygen feed by using an oxygen carrier.

10 Chemical looping is a process by which combustion or  
gasification of a carbon-based fuel occurs in two steps. In a first step,  
the oxygen carrier delivers oxygen in a fuel reactor where the oxygen  
carrier is reduced by the solid fuel and is then transferred to an air  
reactor. Fuel particles, ash and reduced oxygen carrier are produced in  
15 the fuel reactor. In a second step, the reduced oxygen carrier is  
oxidized by air in the air reactor. In the chemical looping process, the  
gas resulting from the combustion or gasification of the fuel in the fuel  
reactor is then free or nearly free from nitrogen. The oxygen carrier can  
typically comprise a metal oxide or other oxygen rich compounds.

20 Most of chemical looping technologies use the fluidized beds  
technology for the fuel reactor to benefit from the high residence time  
as well as from the good mixing associated with fluidized beds. Fluidized  
beds can be bubbling fluidized beds or circulating fluidized beds.

Typical crushed coal that is introduced into conventional systems  
25 for converting fuel material has a mean diameter of 2 mm and the top  
size of the coal can reach 20 mm. The biggest particles that do not end  
as fly ash have hence to be removed as bottom ash.

The current ratio between fly ash and bottom ash is 60/40 and  
tends to go down to 40/60. A dedicated bottom ash extraction system

has to be designed to remove approximately half of the ash introduced via the fuel material into the system.

Thus, a major challenge is to separate the fuel particles and the ash from the oxygen carrier before sending the oxygen carrier to the air  
5 reactor for oxidation and regeneration.

The conventional chemical looping systems for converting fuel material comprise a carbon separator, as mentioned for instance in document FR 2 850 156. The carbon separator, which is also called "carbon stripper", is placed between the air reactor and the fuel reactor.

10 The conventional chemical looping systems also comprise an ash separator placed at the bottom of the fuel and/or air reactor in order to drain ash from the system. This extraction is typically located at the very bottom of the reactor. Several designs exist with different locations for the extraction hole. The hole can be located in the middle of the  
15 grate of the reactor by removing some nozzle which leads to a vertical extraction. The hole can be located on a side wall of the reactor with a lateral extraction with a flow that is controlled by a cone valve.

These systems suffer the shortcoming that the ash separator involves a heavy and complex separator system at the bottom or nearly  
20 the bottom of the fuel and/or air reactor.

Moreover, the solids mixture at the bottom of fuel and air reactors typically comprises about 10% ash. If 1kg/s ash is to be extracted, this would mean that 10 kg/s of the mixture containing 1kg/s ash will be extracted. Thus, the solid quantity that would be needed to  
25 treat is ten times higher than the really needed solid quantity.

Thus, an object of the present invention is to provide a system for converting fuel material in such a manner as to solve the above-described problems.

The object mentioned above is accomplished by a system for  
30 converting fuel material comprising :

- a first reactor in which a fuel material reacts with an oxide material for producing reaction products including fuel particles, ash and oxide particles,

- a second reactor for oxidizing the oxide particles produced in  
5 the first reactor,

- a carbon separator that receives fuel particles, ash and oxide particles produced in the first reactor and suitable for separating the oxide particles and ash from the fuel particles, the carbon separator comprising an outlet path for the oxide particles and ash exhaust.

10 According to the present invention, said outlet path of the carbon separator is connected to an ash separator for separating the ash from the oxide particles.

This specific arrangement provides that starting from a mixture of fuel particles, ash and oxide particles, it is possible to separate  
15 theses three compounds from each other in a simple way. The device made of the carbon separator and the ash separator is compact and economic to install.

Thus, oxide particles can be sent to the air reactor to be regenerated. The unburned carbon can be sent back to the fuel reactor  
20 for further oxidation and the ash is removed which avoids an ash enrichment in the system that could cause an agglomeration.

Last, this specific arrangement avoids a complex and expensive use of an ash separator at the bottom of the fuel and/or air reactor.

It is to be appreciated that both of the carbon separator and the  
25 ash separator are fluidized and that the system comprises means for controlling the fluidization velocity of each separator.

The ash density being higher than the fuel particles density, the fluidization velocity of the ash separator is preferably higher than the fluidization velocity of the carbon separator.

The carbon separator and the ash separator can be adjacent separators via a common side wall.

The carbon separator and the ash separator can be connected by a pipe. In this case, the ash separator can be placed below the carbon  
5 separator.

The fuel reactor is advantageously connected to a low efficiency cyclone separator comprising a lower outlet connected to the carbon separator and an upper outlet connected to a high efficiency cyclone separator.

10 The fuel material is typically coal.

The oxide material is typically metal oxide.

Other features and advantages of the invention will become apparent from the following description of embodiments of the invention given by way of non-limiting examples only, and with reference to the  
15 accompanying drawings, in which:

- Figure 1 is a schematic diagram of a system for converting fuel material according to the invention,

- Figure 2 is a schematic view of a part of the system according to a first embodiment, and

20 - Figure 3 a schematic view of a part of the system according to a second embodiment.

As illustrated in figure 1, a system 1 for converting fuel material according to the invention, which is intended to produce electricity and/or steam, comprises a fuel reactor 2, an air reactor 3 and a carbon  
25 separator 4.

A solid fuel material coming from a fuel silo 5 and a metal oxide coming from an oxide silo 6 enter the fuel reactor 2. The solid fuel material is preferably coal. The metal oxide can be based on iron, nickel, alumina or a mixture thereof.

The fuel reactor 2 is fluidized by steam and/or recycled flue gas and/or carbon dioxide. A first separation device, preferably a low efficiency separation cyclone 7, is fed with combustion gases, ash, fuel particles and oxide particles coming from the fuel reactor 2. The  
5 combustion gases comprise mainly CO<sub>2</sub> and steam.

The efficiency of a separation device is the ratio of the quantity of particles collected by the device to the quantity of solids at the inlet of the device.

The upper stream of the solids of the low efficiency separation  
10 cyclone 7 is circulated into a high separation device, preferably a high efficiency separation cyclone 8. Thus, the solids comprising mainly fine carbon particles are separated from the fly ash and are re-introduced in the fuel reactor 2 via a seal pot 14.

The solids leaving the low efficiency cyclone 7 enter a seal pot 9  
15 from which a first portion is routed into the fuel reactor 2 and from which a second portion is routed into the carbon separator 4. The seal pot 9 can be fluidized by steam and/or recycled flue gas.

The carbon separator 4 separates out the fine and light particles, such as the carbon-containing residue, which are sent to the fuel  
20 reactor 2, from the denser and larger oxide particles and ash which are sent to the air reactor 3. According to the invention, the carbon separator 4 is connected to an ash separator 10 that includes a specific vent 10a to allow the ash to escape. The average particle diameter of the fuel material entering the fuel reactor 2 is preferably less than the  
25 average particle diameter of the oxide material. More preferably, the average particle diameter of the fuel material is controlled to be at least twice smaller than the average particle diameter of the oxide material. The average particle diameter of the fuel material can be equal to about 50 µm. It can be comprised between 50 and 60 µm.

In this case, the density of the oxide particles is higher than the density of the fuel particles, the density of the ash being comprised between the density of the fuel particles and the density of the oxide particles.

5           The oxide particles coming from the carbon and ash separator 4,10 are oxidized by air in the air reactor 3. The oxides and the depleted air leaving the air reactor 3 enter a separation device 11, typically a cyclone separator, in which the oxide particles are separated from the gases comprising  $N_2$  and  $O_2$ .

10           The solid oxide particles extracted from the bottom of the cyclone 11 enter a seal pot 12 from which a first portion is transferred to the bottom of the air reactor 3 and from which a second portion is routed to the bottom of the fuel reactor 2. The seal pot 12 can be fluidized with air.

15           A detailed view of the association of the carbon separator 4 and the ash separator 10 is shown in figures 2 and 3. Figures 2 and 3 schematically illustrate two embodiments of an assembly of a carbon separator and an ash separator used in the system for converting fuel material according to the invention.

20           The carbon separator 4 comprises an inlet 4a through which the fuel particles FP, the oxide particles OP and the ash A enter the carbon separator 4. The oxide particles OP are oxide particles that have been at least partially reduced in the fuel reactor. The carbon separator 4 is fluidized by fluidization means F. The fluidization means F can be steam  
25 and/or recycled flue gas and/or  $CO_2$  inlets placed at the bottom of the carbon separator 4.

          The fine and light fuel particles FP having a density of about 1.2 are directed toward the fuel reactor via outlets 4b of the carbon separator 4 while the denser and larger oxide particles OP and ash A  
30 are routed towards the ash separator 10.

The ash separator 10 is fluidized by fluidization means F. The fluidization means F can be steam and/or recycled flue gas and/or CO<sub>2</sub> inlets placed at the bottom of the carbon separator 4. The light ash A flows out the vent 10a towards a gas treatment system while the denser oxide particles OP pass through an outlet 10b of the ash separator 10 towards the air reactor.

The fluidizing velocity of the carbon separator 4 and of the ash separator 10 can be controlled in order to control the ash concentration in the system. The fluidizing velocity can be based on the respective density of ash A and oxide particles OP (about 2.5 and 4.5 respectively). Thus, the ash separator 10 can be fluidized at a velocity comprised between 0.3 and 0.8 m/s and the carbon separator 4 can be fluidized at a velocity comprised between 0.1 and 0.6 m/s.

According to a first embodiment, as shown in figure 2, the carbon separator 4 and the ash separator 10 are adjacent via a common side wall 13. The carbon separator 4 and the ash separator 10 are connected by an opening 4c of the side wall 13.

According to a second embodiment, as shown in figure 3, the carbon separator 4 and the ash separator 10 are connected by a pipe 4c. Moreover, the ash separator 10 can be placed below the carbon separator 4 in order to facilitate the passage of the oxide particles OP and the ash A from the carbon separator 4 to the ash separator 10.

**CLAIMS**

1. A system (1) for converting fuel material comprising :

- a first reactor (2) in which a fuel material reacts with an oxide material for producing reaction products including fuel particles, ash and oxide particles,

- a second reactor (3) for oxidizing the oxide particles produced in the first reactor (2),

- a carbon separator (4) that receives fuel particles, ash and oxide particles produced in the first reactor (2) and suitable for separating the oxide particles and ash from the fuel particles, the carbon separator (4) comprising an outlet path (4c) for the oxide particles and ash exhaust,

characterized in that said outlet path (4c) of the carbon separator (4) is connected to an ash separator (10) for separating the ash from the oxide particles.

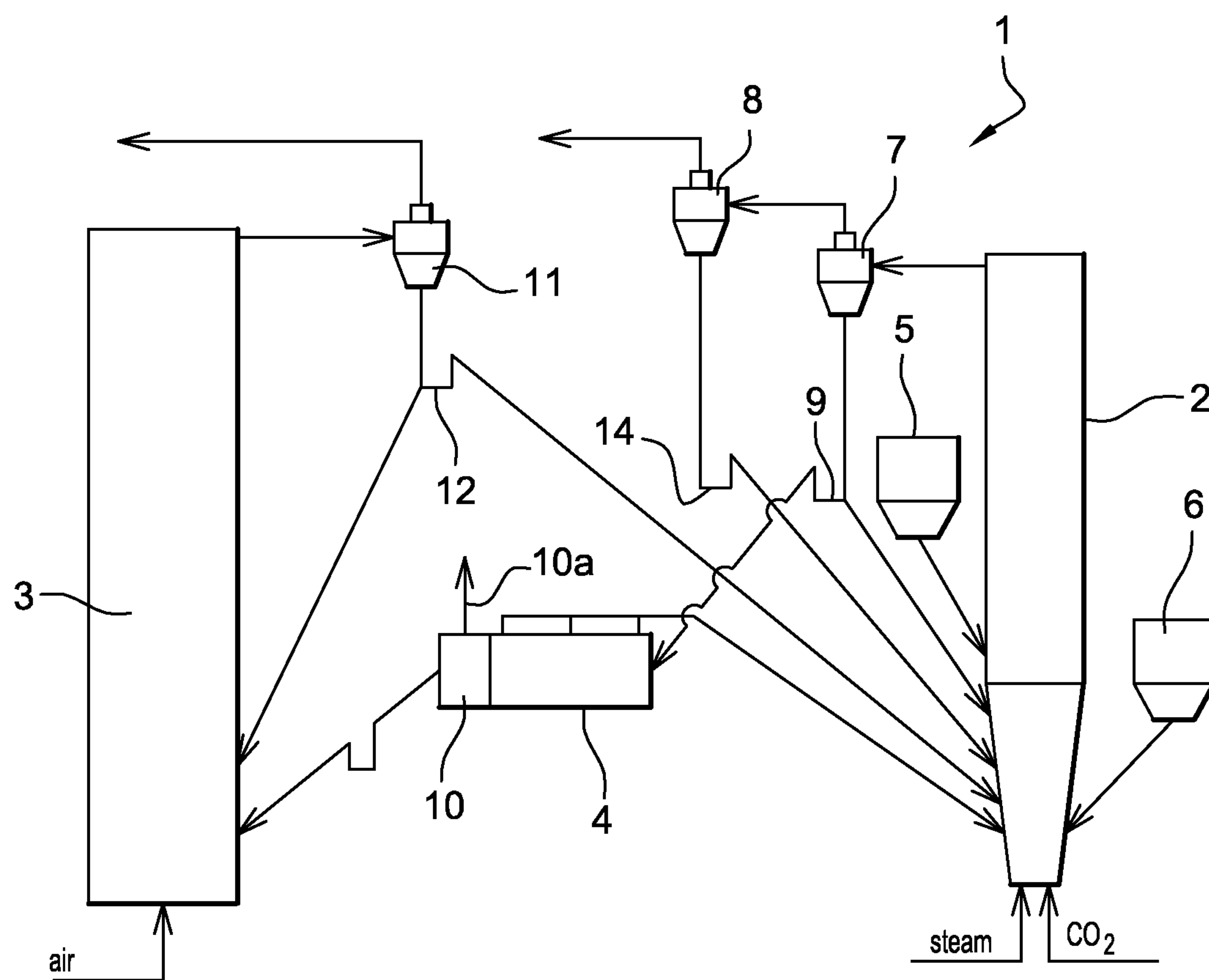
2. A system (1) according to claim 1, characterized in that both of the carbon separator (4) and the ash separator (10) are fluidized and in that the system (1) comprises means for controlling the fluidization velocity of each separator (4,10).

3. A system (1) according to claim 2, characterized in that the fluidization velocity of the ash separator (10) is higher than the fluidization velocity of the carbon separator (4).

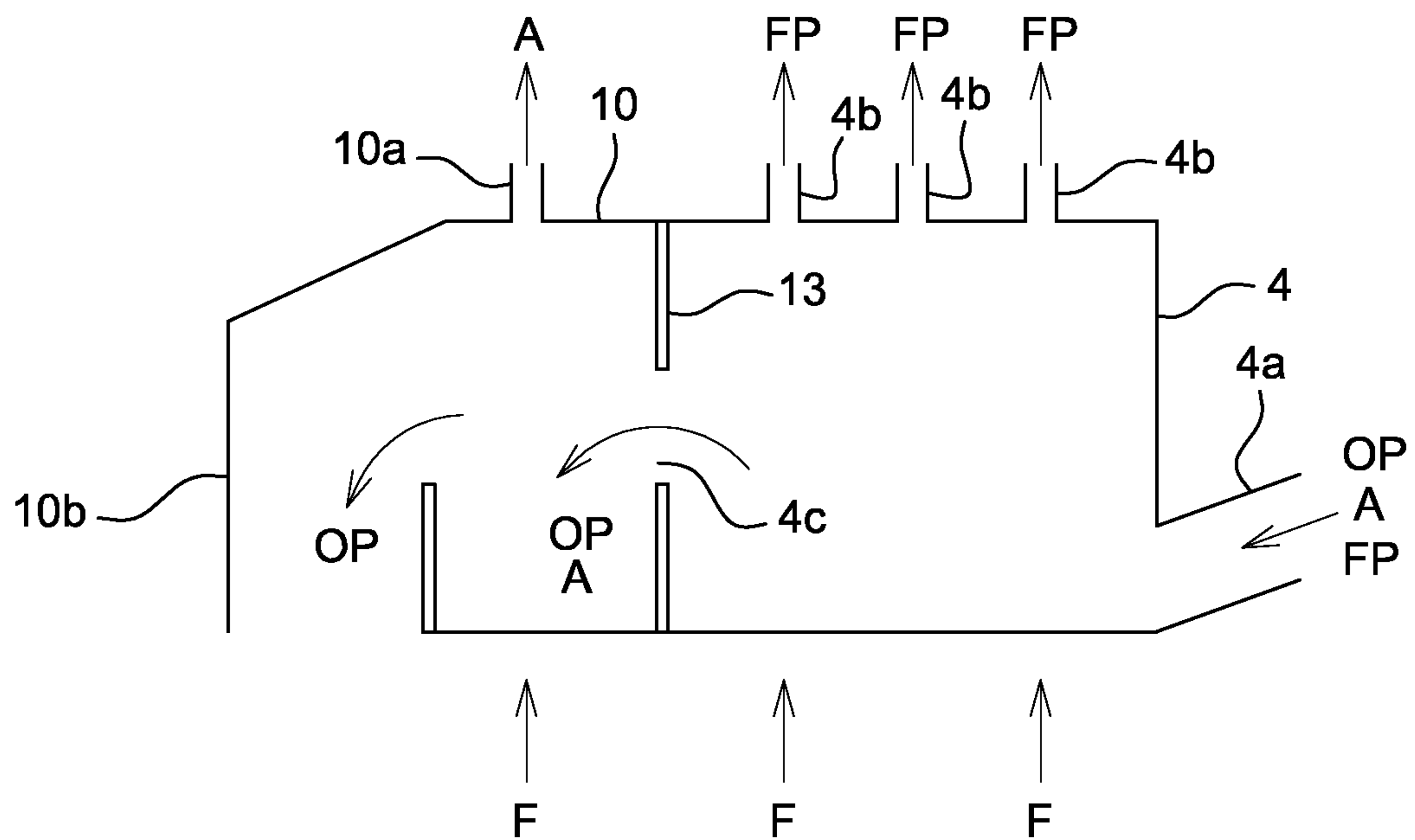
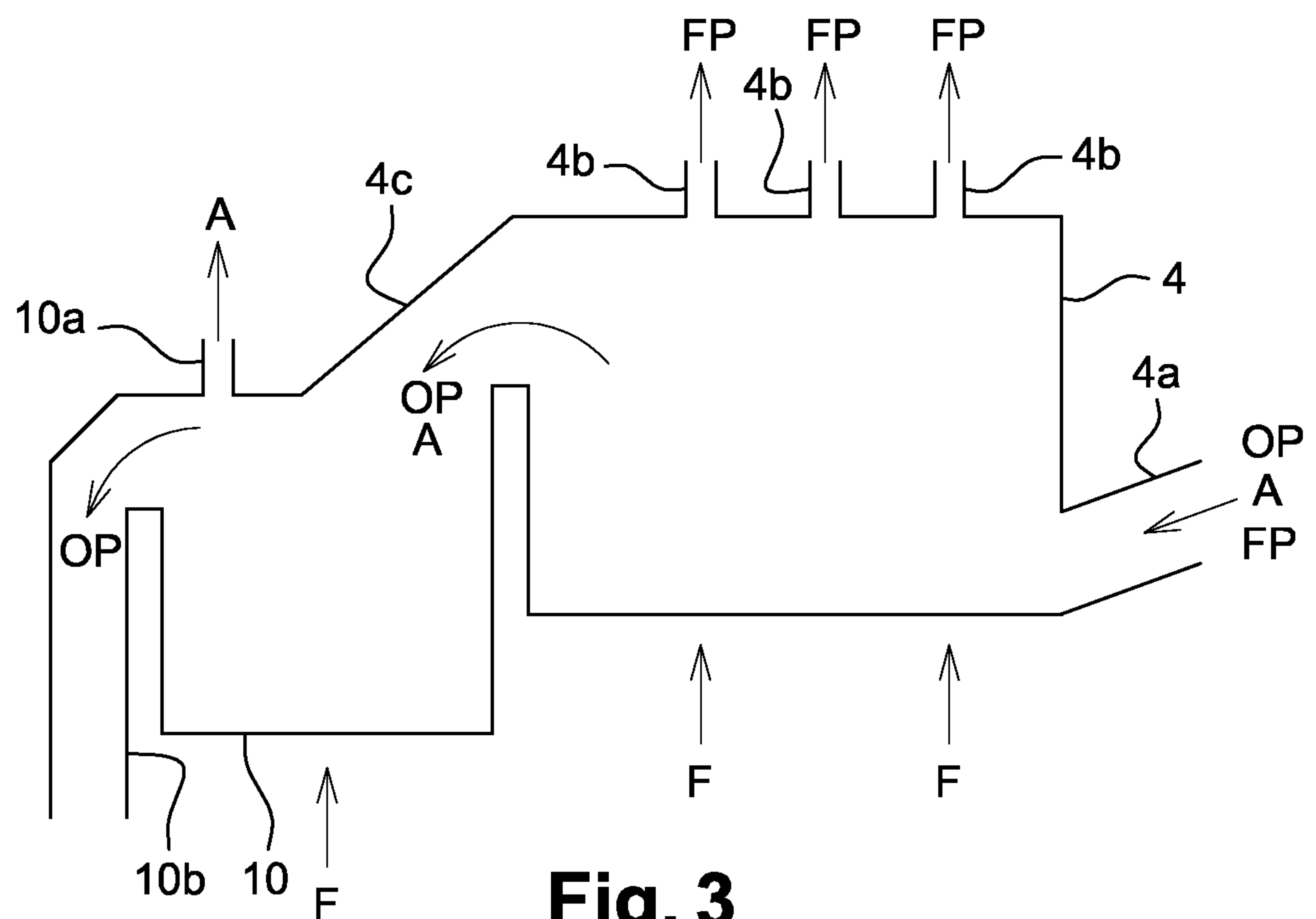
4. A system (1) according to any one of claims 1 to 3, characterized in that the carbon separator (4) and the ash separator (10) are adjacent separators (4,10) via a common side wall (13).

5. A system (1) according to any one of claims 1 to 3, characterized in that the carbon separator (4) and the ash separator (10) are connected by a pipe (4c).
- 5 6. A system (1) according to claim 5, characterized in that the ash separator (10) is placed below the carbon separator (4).
- 10 7. A system (1) according to any one of claims 1 to 6, characterized in that the fuel reactor (2) is connected to a low efficiency cyclone separator (7) comprising a lower outlet connected to the carbon separator (4) and an upper outlet connected to a high efficiency cyclone separator (8).
8. A system (1) according to any one of claims 1 to 7, characterized in that the fuel material is coal.
9. A system (1) according to any one of claims 1 to 8, characterized in that the oxide material is metal oxide.

1/2

**Fig. 1**

2 / 2

**Fig. 2****Fig. 3**

