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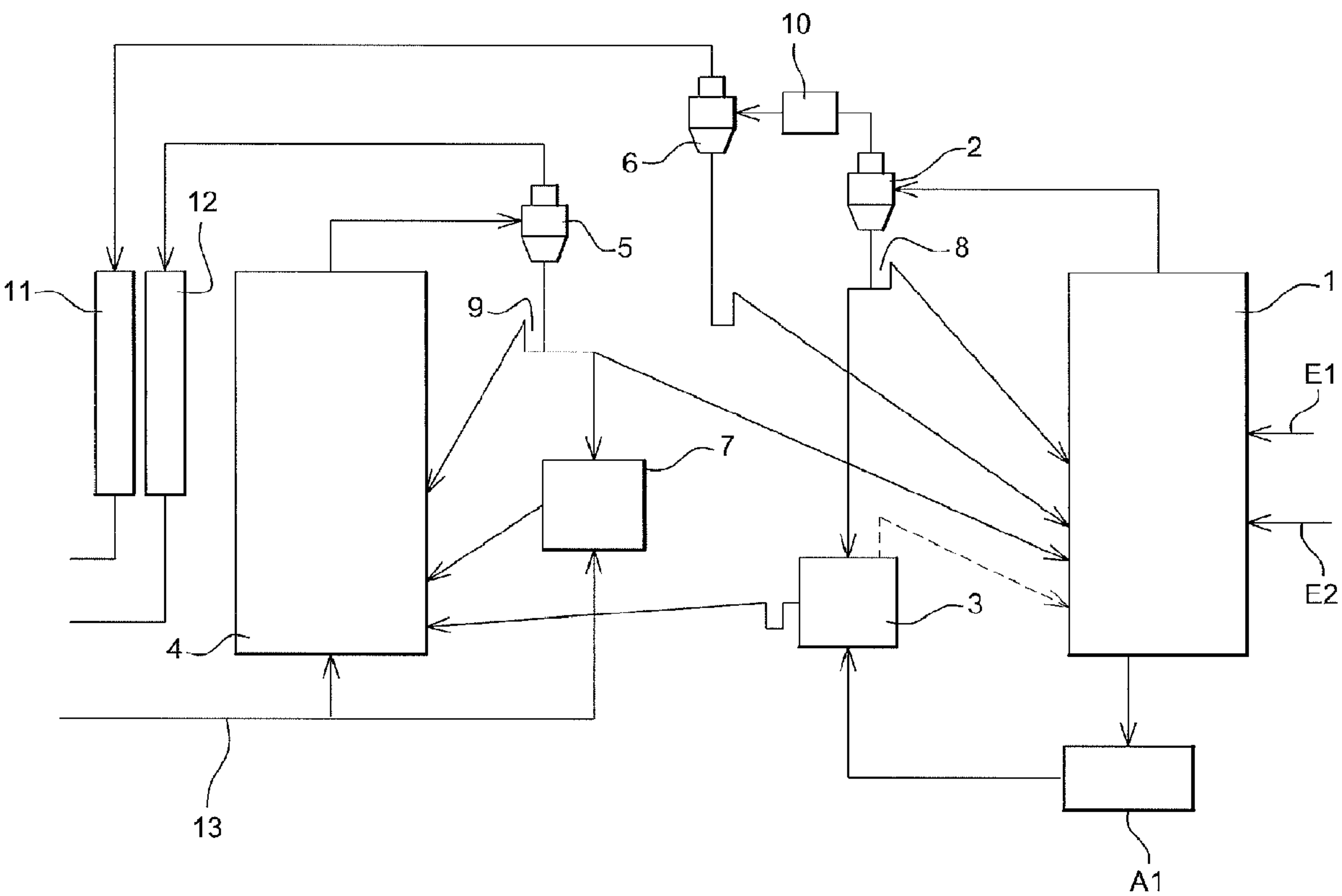
(54) **Titre : PROCEDE D'UTILISATION D'UNE INSTALLATION POUR LA COMBUSTION DE MATERIAUX CARBONES ET INSTALLATION ASSOCIEE**
(54) **Title: PROCESS FOR USING A FACILITY FOR COMBUSTING CARBONACEOUS MATERIALS AND RELATING FACILITY**



(57) **Abrégé/Abstract:**
The invention concerns a process for using a facility in which circulates at least one oxide which is reduced and then oxidized in each of both reactors (1, 4) and including a reactor (1) for reducing oxide in which enter a grounded solid fuel material (E1) and oxide (E2), a lower efficiency separation device (2) receiving entrained solids from the reactor (1) for reducing oxide, the upper stream of the solids of the lower efficiency separation device (2) being circulated into a higher efficiency separation device (6), in order to separate the solids from the gases and to re-introduce the solids into the reactor (1) for reducing oxides, a carbon

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

separator (3) installed at the outlet of the lower efficiency separation device (2) in order to send the carbonaceous particles into the reactor (1) for reducing oxide and the oxide into a reactor (4) for oxidizing oxide and a separation device (5) receiving entrained solids from the reactor (4) for oxidizing oxide. According to the invention, the average particle diameter of the enter-ing solid fuel material (E1) is controlled to be at least twice smaller than the average particle diameter of the entering oxide (E2).

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(54) **Title**: PROCESS FOR USING A FACILITY FOR COMBUSTING CARBONACEOUS MATERIALS AND RELATING FACILITY

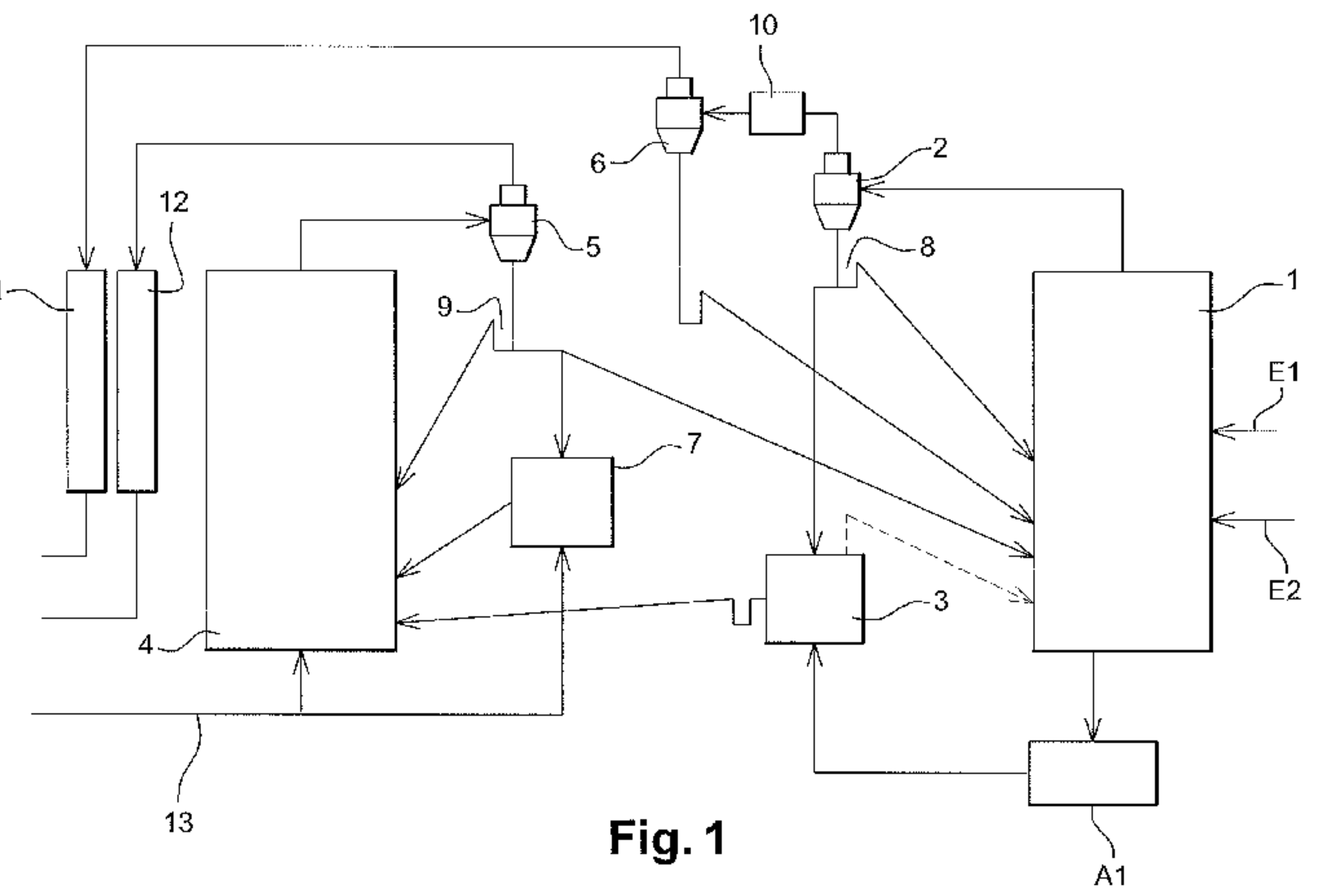

Fig. 1

(57) **Abstract**: The invention concerns a process for using a facility in which circulates at least one oxide which is reduced and then oxidized in each of both reactors (1, 4) and including a reactor (1) for reducing oxide in which enter a grounded solid fuel material (E1) and oxide (E2), a lower efficiency separation device (2) receiving entrained solids from the reactor (1) for reducing oxide, the upper stream of the solids of the lower efficiency separation device (2) being circulated into a higher efficiency separation device (6), in order to separate the solids from the gases and to re-introduce the solids into the reactor (1) for reducing oxides, a carbon separator (3) installed at the outlet of the lower efficiency separation device (2) in order to send the carbonaceous particles into the reactor (1) for reducing oxide and the oxide into a reactor (4) for oxidizing oxide and a separation device (5) receiving entrained solids from the reactor (4) for oxidizing oxide. According to the invention, the average particle diameter of the entering solid fuel material (E1) is controlled to be at least twice smaller than the average particle diameter of the entering oxide (E2).

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PROCESS FOR USING A FACILITY FOR COMBUSTING CARBONACEOUS MATERIALS AND RELATING FACILITY

The invention relates to a process for using a facility for burning carbonaceous solid materials and relating facility, in order to produce electricity and/or steam. The solid materials can be fossil fuels such as coal, for example, waste or biomass, and they are injected into a combustion chamber, for example a fluidized bed combustion chamber.

Such a facility for burning carbonaceous materials is described in patent document FR 2 850 156. This facility includes a reactor for reducing oxides, a first cyclone, a reactor for oxidizing oxides, a second cyclone, exchangers for controlling temperature of the circulating oxides and exchangers for flue gas heat recovery. In the facility circulate oxides which are reduced and then oxidized in the two reactors. According to this prior art, the solid fuel material is grounded before entering the oxide reduction reactor, and in the case of coal the average particle diameter is less than 500 μm. The oxides are reduced by having them in contact with the fuel which reacts with the oxygen released by the oxides and then oxidized by contact with air which regenerates the oxides. The oxides have a particle size range from 50 to 500 μm and a density from 2000 to 7000 kg/m^3.

In fact, for crushing process and hydrodynamic reasons, the average diameter of particles of entering coal is about 300 μm in conventional fluidized bed combustion chambers. This leads to circulating particle diameter of about 150 μm.

This type of facility for combustion of carbonaceous solid materials operating at atmospheric pressure with integrated capture of carbon dioxide does not require any prior air separation. Because of the simplicity and the compactness of this system, the costs of capturing carbon dioxide may be reduced while providing production of steam for generating electricity.

The solid particles at the outlet of the first cyclone associated with the reduction reactor, consisting of oxides particles and of carbonaceous residues, pass through a seal pot and are then directed towards a device for removing the carbonaceous residues. This removal device is fluidized by steam. With this fluidization, the fine and light particles such as the carbonaceous residues may be separated and re-introduced into the reduction reactor, while the denser and larger oxide particles are transferred towards the oxidation reactor.

This removal device which is a separator contains an internal baffle formed with a wall integral with the roof of the separator and leaving a flow space in the bottom of the latter and which forms two compartments on the passage of fluidized solids with a pressure seal provided by the height of the fluidized solids, between the two compartments. The fluidization of each compartment is independently controlled by two steam inlets, in order to obtain the desired velocity field for separating the oxides and the carbonaceous residues in the first compartment as well as the transfer of the oxides into the second compartment. Above the first compartment, a vent brings the carbonaceous residues carried off by steam back towards the reduction reactor.

This separator is a carbon barrier in the facility, essential for capturing carbon dioxide which is a greenhouse gas which should be subject to emission restrictions.

The object of patent document WO 2007/113016 is to increase the yield of this barrier by improving such a separator. By means of the solid separator described in this document, the segregation phenomenon is enhanced, while increasing the time for treating the solid materials in the first compartment and keeping a separator of limited size.

The object of the invention is to improve such facility in order that an easier separation of carbonaceous residues and oxides is obtained, and in order to assure that no carbonaceous residues will be sent to the reactor for oxidizing oxides. This is obtained by using non conventional coal particle size in order to lead to a lower efficiency requirement on the carbon separator and then to achieve the carbon dioxide capture.

To do this, the invention relates to a process for using a facility in which circulates at least one oxide which is reduced and then oxidized in each of both reactors and including a first reactor for reducing oxide in which enter a grounded solid fuel material and oxide, a lower efficiency separation device receiving entrained solids from the reactor for reducing oxide, the upper stream of the solids of the lower efficiency separation device being circulated into a higher efficiency separation device, in order to separate the solids from the gases and to re-introduce the solids into the reactor for reducing oxide, a carbon separator installed at the outlet of the lower efficiency separation device in order to send the carbonaceous particles into the reactor for reducing oxide and the oxide into a reactor for oxidizing oxide and a separation device receiving entrained solids from the reactor for oxidizing oxide, process characterized in that the average particle diameter of the entering solid fuel material is controlled to be at least twice smaller than the average particle diameter of the entering oxide.

Solid fuel material is preferably coal.

Said oxide can be metal oxide. It can be limestone too.

The metal oxide can be based on iron, nickel, alumina or a mixture thereof.

The reduced size of the solid fuel particles allows more complete and faster combustion. The reactor for reducing oxide can be consequently of smaller size.

Advantageously, the average particle diameter of the entering solid fuel material is equal to about 50 μm.

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 invention relates too to a facility for implementing the process according to the invention, characterized in that it comprises a reactor for reducing oxide in which enter a grounded solid fuel material and oxide, a lower efficiency separation device receiving entrained solids from the reactor for reducing oxide, the upper stream of the solids (i.e. the finest particles outlet) of the lower efficiency separation device being circulated into a higher efficiency separation device, in order to separate the solids from the gases and to re-introduce the solids into the reactor for reducing oxides, a carbon separator installed at the outlet of the lower efficiency separation device in order to send the carbonaceous particles into the reactor for reducing oxide and the oxide into a reactor for oxidizing oxide and a separation device receiving entrained solids from the reactor for oxidizing oxide.

According to a preferred embodiment, the lower efficiency separation device has such efficiency that the average particle diameter of the finest particles fraction escaping from the lower efficiency separation device is about equal to said average particle diameter of the entering solid fuel material.

Preferably, the higher efficiency separation device is a separation cyclone.

Preferably, the lower efficiency separation device is a separation cyclone. It can be a mechanical separator by impact too.

The facility can comprise a solid cooling device implemented in between the lower efficiency separation device and the higher efficiency separation device.

According to still another aspect of the present invention, there is provided process for using a facility in which circulates at least one oxide and in which the at least one oxide is reduced in a first reactor and then oxidized in a second reactor, the facility including the first reactor for reducing oxide in which enters a grounded solid fuel material and an oxide, a lower efficiency cyclone device receiving entrained carbon solids from the first reactor, an upper fraction of the carbon solids at a finest particles outlet of the lower efficiency cyclone device beingcirculated into a higher efficiency cyclone device in order to separate the carbon solids from the gases and to re-introduce the carbon solids into the first reactor, a carbon separator installed at an outlet of the lower efficiency cyclone device in order to send carbonaceous particles into the first reactor and to send oxides into the second reactor for oxidizing oxide, and a separation device receiving entrained solids from the second reactor, wherein the process comprises controlling the average particle diameter of the solid fuel material entering the first reactor to be at least twice smaller than the average particle diameter of the oxide entering the first reactor.

According to yet another aspect of the present invention, there is provided facility for implementing the process as described herein, which comprises a first reactor for reducing oxide in which enters a grounded solid fuel material and an oxide, the facility comprising a lower efficiency cyclone device receiving entrained carbon solids from the first reactor, an upper fraction of the carbon solids at a finest particles outlet of the lower efficiency cyclone device being circulated into a higher efficiency cyclone device in order to separate the carbon solids from the gases and to re-introduce the carbon solids into the first reactor, a carbon separator installed at the outlet of an lower efficiency cyclone device in order to send carbonaceous particles into the first reactor and to send oxides into a second reactor for oxidizing oxide, and a separation device receiving entrained solids from the second reactor.

The invention is described hereafter in more details with the figure which only illustrates a preferred embodiment of the invention.

The figure 1 is a schematic view of a facility according to the invention.

As shown on figure 1, a facility for combusting carbonaceous solid materials, in order to produce electricity and/or steam, according to the invention, in which circulates at least one oxide, preferably a mixture of oxides, advantageously metal oxides, which is reduced and then oxidized, includes a reactor 1 for reducing oxides in which enter a grounded solid fuel material E1 and oxides E2, a low efficiency separation cyclone 2 feeding with entrained solids from the reactor 1 for reducing oxides, a carbon separator 3 installed at the outlet of this first cyclone 2 in order to send the carbonaceous particles into the reactor for reducing oxides 1 and the oxides into a reactor 4 for oxidizing oxides fluidized by air 13 and a separation cyclone 5 receiving entrained solids from the reactor 4 for oxidizing oxides.

The facility comprises two back pass 11, 12, containing recovery exchangers for the flue gases and for the air, each dedicated to one of the reactors.

According to the invention, the average particle diameter of the entering solid fuel material E1 is controlled to be smaller than the average particle diameter of the entering oxides E2, and more precisely the average particle diameter of the entering solid fuel material E1 is at least twice smaller than the average particle diameter of the entering oxides E2.

Advantageously, the average particle diameter of the entering solid fuel material E1 is equal to about 50 μm and the solid fuel material is preferably coal.

The reactor 1 for reducing oxides is fluidized by a mixture A1 of steam and recycled flue gas. After reduction in the reactor 1 for reducing oxides, the oxides enter the first cyclone 2 in which the solid oxides particles are separated from the carbonaceous residues and the combustion gases, consisting of CO_2, SO_2 and steam.

According to the invention, the first separation cyclone 2 is a low efficiency cyclone and the facility comprises other separation apparatus 6 of high efficiency connected at the upper outlet of this first cyclone 2 and which is preferably a separation cyclone too.

The low efficiency separation cyclone 2 has such efficiency that the average particle diameter of the upper stream escaping from this first separation cyclone 2 is about equal to said average particle diameter of the entering solid fuel material E1 i.e. equal to about 50 μm.

A solid cooling device 10 is implemented in between the first separation cyclone 2 and the other separation cyclone 6.

The fly ash and the combustion gases then enter the heat exchangers contained into back pass 11, downstream cyclones 2 and 6.

The solids leaving the low efficiency cyclone 2, consisting mainly of oxides, enter a seal pot 8 from which a first portion is fed to the reactor 1 for reducing oxides and a second portion is fed to the separator 3 for separating of the carbon-containing residue. The seal pot 8 can be fluidized by steam and/or recycled flue gas.

The separator 3 is fluidized by steam and/or recycled flue gas, which separates out the fine and light particles, such as the carbon-containing residue, which is fed to the reactor 1 for reducing oxides, while the denser and larger oxides particles are fed to the reactor 4 for oxidation. Preferably the solid separator 3 is of the type of separator described in patent document WO 2007/113016.

After oxidation in the reactor 4 for oxidizing oxides, the oxides and the depleted air enter the cyclone 5, in which the solid oxides particles are separated from the gases, consisting essentially of N2 and O2.

The solid oxides particles extracted from the bottom of the cyclone 5 enter a seal pot 9 from which a first portion is transferred to the bottom of the reactor 4 for oxidizing oxides, a second portion is re-circulated to the bottom of the reactor 1 for reducing oxides and a third portion is sent to an external bed 7 fluidized by air where heat exchangers are implemented, and finally fed to the reactor 4 for oxidizing oxides. The seal pot 9 can be fluidized with compressed air. The complete cycle of the various reactions is described next.

The solid grounded fuel E1 is injected into the reactor 1 for reducing oxides, which contains a circulating bed of oxides at a high temperature of 700°C to 1 150°C. According to the invention, it is preferably grounded coal with an average particle diameter equal to about 50 µm. The particle size range of the fuel avoids the accumulation of coarse ash at the bottom of the first reactor

1 for reducing oxides, that has to be extracted, and produces almost 100% fly ash. Therefore ash does not accumulate in the circulating bed of coarser oxides, which is collected by the first cyclone 2.

Metal oxides E2 are injected into the reactor 1 for reducing oxides too. According to the invention, it is preferably metal oxides with an average particle diameter equal to or greater than 100 μm.

The volatile materials are released very quickly following heating of the fuel and react with the oxygen given off by the oxides to achieve partial combustion that continues with the combustion of the fixed carbon.

The solids are circulated after in the first separation cyclone 2 which has such efficiency that the average particle diameter of the solids escaping from this first separation cyclone 2 is about equal 50 μm. These solids are mainly composed of carbonaceous residues.

This upper fraction of the solids which is constituted by carbon, is circulated into the other separation cyclone 6 installed in series with the first one 2, in order to separate the solids from the gases and to re-introduce the carbonaceous materials into the reactor 1 for reducing oxides.

A first separation of the carbonaceous residues from the metal oxides is obtained by means of the series of the first cyclone 2 of low efficiency and the other separation cyclone 6.

The lower fraction of solids at the outlet of first cyclone 2 is extracted at the bottom of the seal pot 8 to be cleaned of the carbon-containing residues in the solid separator 3, and is then fed to the reactor 4 for oxidizing oxides in order to be oxidized by the oxygen in the air atmosphere.

The oxides enter the reactor 4 for oxidizing oxides, and are regenerated and partly fed to the reactor 1 for reducing oxides to start a new cycle of transport of oxygen from the reactor 4 for oxidizing oxides to the reactor 1 for reducing oxides. The quantity of oxides fed to the reactor 1 for reducing oxides is controlled by a solids flow rate control valve (not shown).

The device can also be pressurized.

The oxygen depleted air is cooled in exchangers and de-dusted by a bag filter before it is discharged to the atmosphere.

The separation of the carbonaceous residues from the metal oxides is obtained conventionally by the arrangement of cyclone 2, seal pot 8 and finally solid separator 3, which receives a little rate of solid fuel and leading to a lower separation efficiency requirement.

By means of the invention, no carbon-containing residue is transferred into the second reactor 4 for oxidizing oxides. It is very important because such transfer would lead to the exothermic production of CO2, which would then be discharged to the atmosphere.

CLAIMS:

1. Process for using a facility in which circulates at least one oxide and in which the at least one oxide is reduced in a first reactor and then oxidized in a second reactor, the facility including the first reactor for reducing oxide in which enters a grounded solid fuel material and an oxide, a lower efficiency cyclone device receiving entrained carbon solids from the first reactor, an upper fraction of the carbon solids at a finest particles outlet of the lower efficiency cyclone device being circulated into a higher efficiency cyclone device in order to separate the carbon solids from the gases and to re-introduce the carbon solids into the first reactor, a carbon separator installed at an outlet of the lower efficiency cyclone device in order to send carbonaceous particles into the first reactor and to send oxides into the second reactor for oxidizing oxide, and a separation device receiving entrained solids from the second reactor, wherein the process comprises controlling the average particle diameter of the solid fuel material entering the first reactor to be at least twice smaller than the average particle diameter of the oxide entering the first reactor.

2. Process according to claim 1, wherein the solid fuel material is coal.

3. Process according to claim 1 or 2 wherein the oxide is metal oxide.

4. Process according to any one of claims 1 to 3, wherein the average particle diameter of the entering solid fuel material is about 50 μm.

5. Process according to claim 1, wherein the lower efficiency cyclone device has such efficiency that the average particle diameter of the finest particles fraction escaping from the lower efficiency cyclone device is about equal to the average particle diameter of the entering solid fuel material.

6. Facility for implementing the process according to any one of claims 1 to 5, which comprises a first reactor for reducing oxide in which enters a grounded solid fuel material and an oxide, the facility comprising a lower efficiency cyclone device receiving entrained carbon solids from the first reactor, an upper fraction of the

carbon solids at a finest particles outlet of the lower efficiency cyclone device being circulated into a higher efficiency cyclone device in order to separate the carbon solids from the gases and to re-introduce the carbon solids into the first reactor, a carbon separator installed at the outlet of an lower efficiency cyclone device in order to send carbonaceous particles into the first reactor and to send oxides into a second reactor for oxidizing oxide, and a separation device receiving entrained solids from the second reactor.

7. Facility according to claim 6, wherein the lower efficiency cyclone device has such efficiency that the average particle diameter of the finest particles fraction escaping from the lower efficiency cyclone device is about equal to the average particle diameter of the entering solid fuel material.

8. Facility according to claim 6 or 7, which comprises a solid cooling device implemented between the lower efficiency cyclone device and the higher efficiency cyclone device.

9. Facility according to any one of claims 6 to 8, wherein the average particle diameter of the entering solid fuel material is controlled to be at least twice smaller than the average particle diameter of the entering oxide.

10. Facility according to any one of claims 6 to 9, wherein the solid fuel material is coal.

11. Facility according to any one of claims 6 or 10 wherein the oxide is metal oxide.

12. Facility according to any one of claims 6 to 11, wherein the average particle diameter of the entering solid fuel material is about 50 μm.

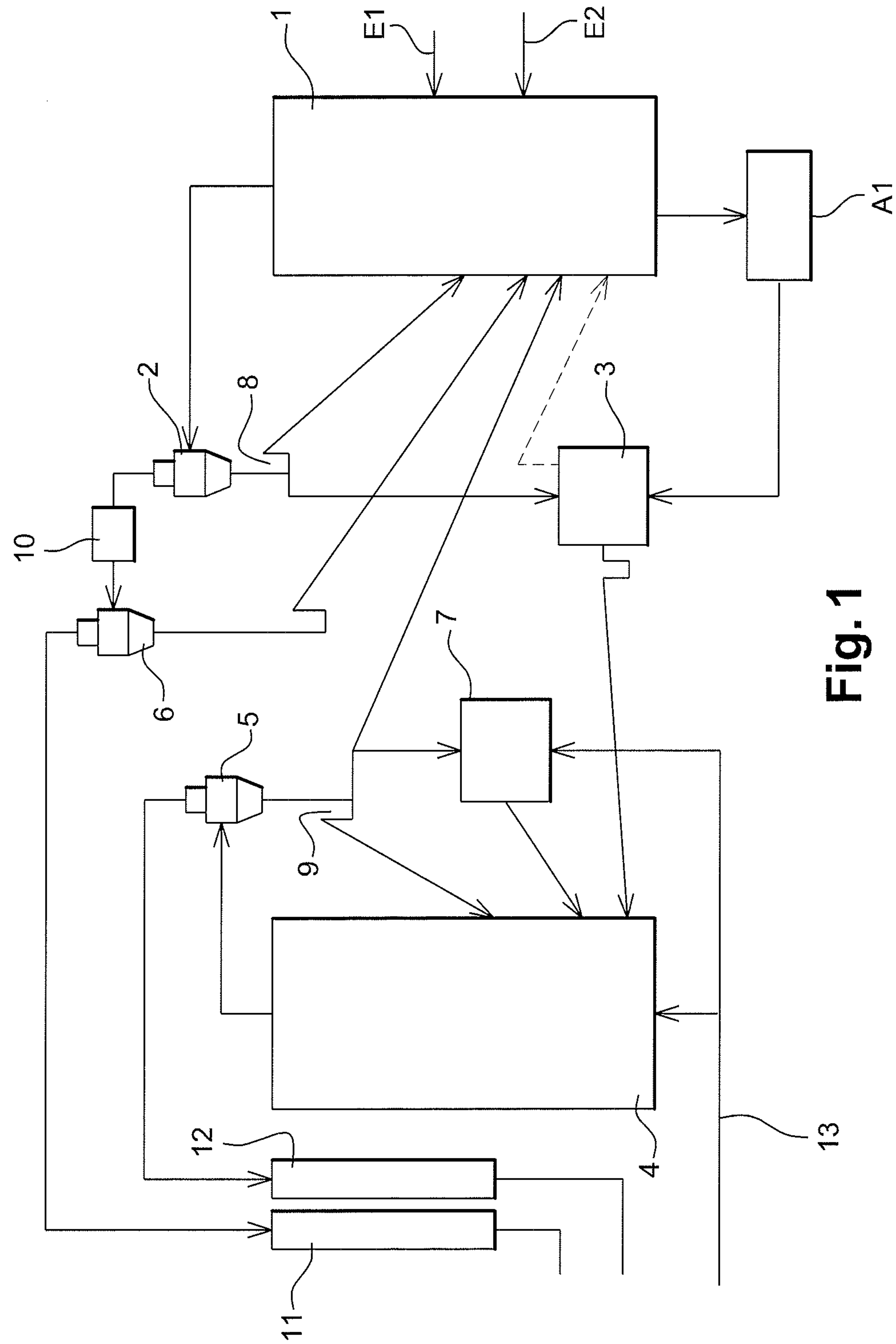
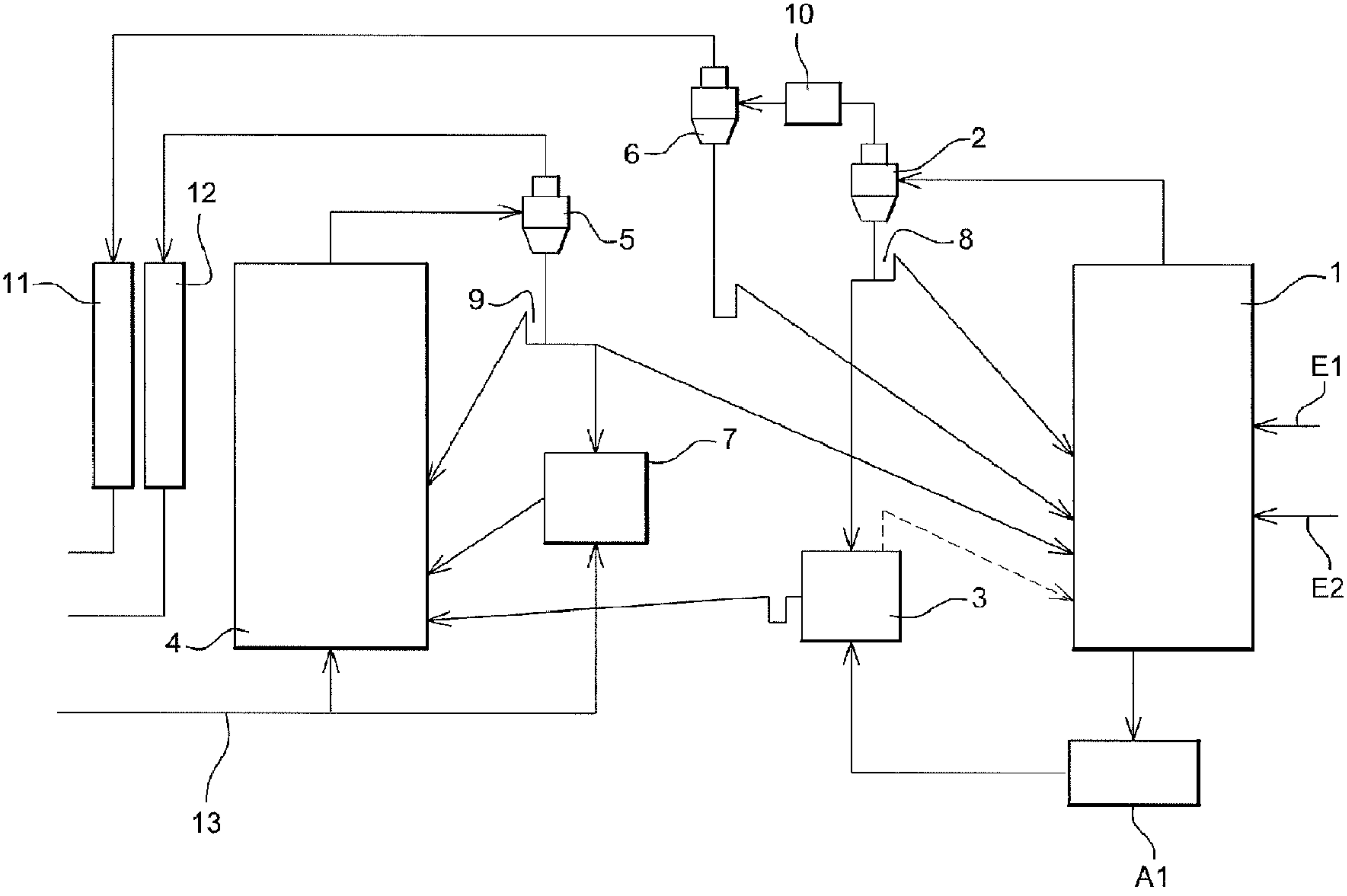


Fig. 1



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