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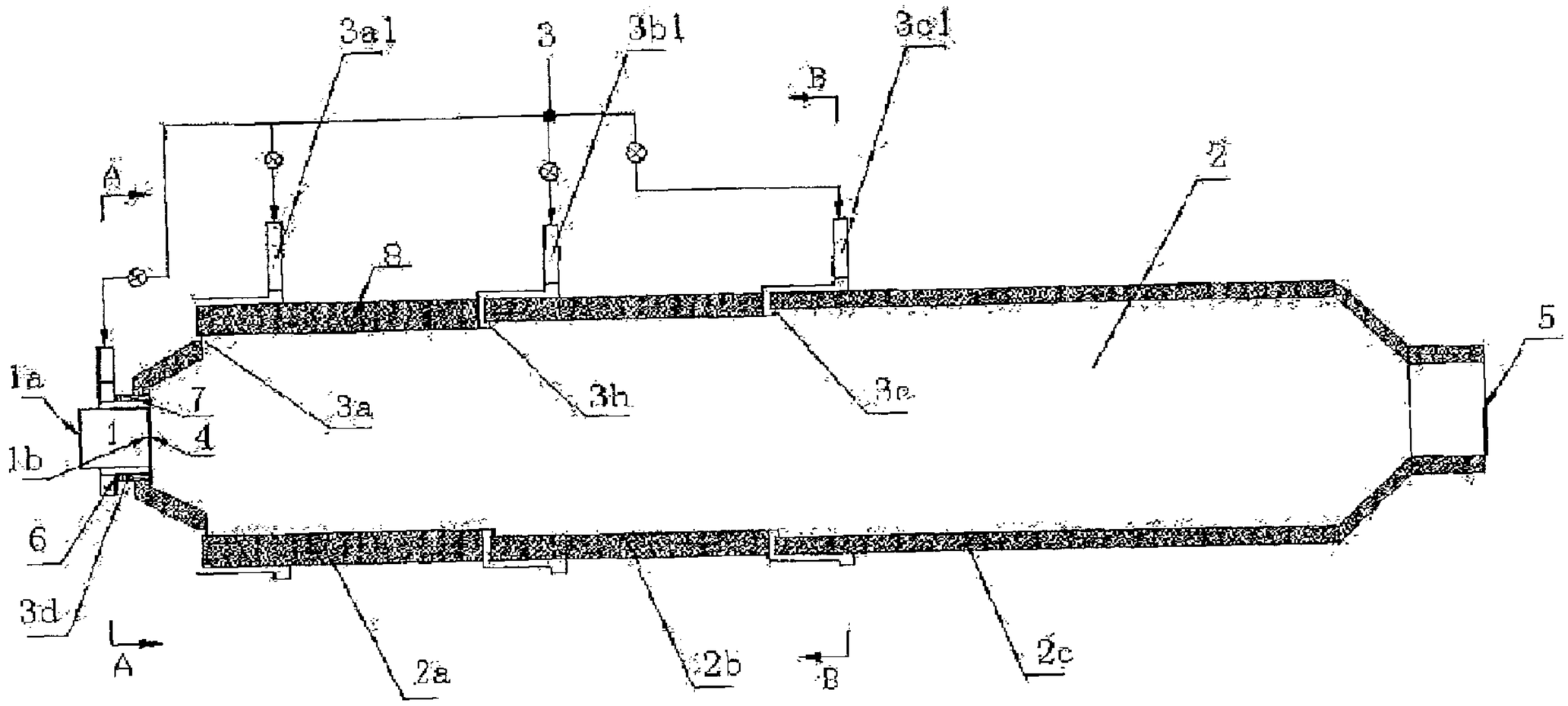
(54) **Titre : PROCEDE ET DISPOSITIF POUR LA PREPARATION DE VAPEUR D'EAU A HAUTE TEMPERATURE RICHE EN PARTICULES ACTIVES UTILISANT UN PLASMA**

(54) **Title: METHOD AND DEVICE FOR PREPARING HIGH TEMPERATURE WATER VAPOUR RICH IN ACTIVE PARTICLES USING PLASMA**



(57) **Abrégé/Abstract:**
Disclosed is a method and device for preparing a high temperature water vapour rich in active particles using plasma, the device comprising a plasma generator (1) and a high temperature vapour generator (2), wherein the middle of one end of the high temperature vapour generator (2) is provided with a high temperature plasma inlet (4) in communication with an outlet (1b) of the plasma generator (1); the plasma generator (1) has an inlet (1a) for non-oxidizing gases; the high temperature plasma inlet (4) is surrounded by an annular vapour inlet (3d), which annular vapour inlet (3d) has rotary guide blades (7) mounted therein. The casing of the high temperature vapour generator (2) has a shape of stepped increasing stages divided into 1-4 stage(s), and an annular narrow orifice (3a, 3b, 3c) for vapour entrance is provided between two adjacent casing parts at each stage, with the annular narrow orifice (3a, 3b, 3c) connected to a vapour pressure feeding device (3). The method comprises the steps of: spraying the prepared vapour and the high temperature plasma working materials ionized by the plasma generator (1) into the high temperature vapour generator (2) through their respective inlets, intensively mixing the high temperature vapour and the high temperature plasma, and heating and activating the vapour so as to form the vapour with active particles.

ABSTRACT

Disclosed is a method and device for preparing a high temperature water vapor enriched in active particles using plasma, the device comprising a plasma generator (1) and a high temperature vapor generator (2), wherein the middle of one end of the high temperature vapor generator (2) is provided with a high temperature plasma inlet (4) in communication with an outlet (1b) of the plasma generator (1); the plasma generator (1) has an inlet (1a) for non-oxidizing gases; the high temperature plasma inlet (4) is surrounded by an annular vapor inlet (3d), which annular vapor inlet (3d) has rotary guide blades (7) mounted therein. The casing of the high temperature vapor generator (2) has a shape of stepped increasing stages divided into 1-4 stage(s), and an annular narrow orifice (3a, 3b, 3c) for vapor entrance is provided between two adjacent casing parts at each stage, with the annular narrow orifice (3a, 3b, 3c) connected to a vapor pressure feeding device (3). The method comprises the steps of: spraying the prepared vapor and the high temperature plasma working materials ionized by the plasma generator (1) into the high temperature vapor generator (2) through their respective inlets, intensively mixing the high temperature vapor and the high temperature plasma, and heating and activating the vapor so as to form the vapor with active particle.

METHOD AND DEVICE FOR PREPARING HIGH TEMPERATURE WATER VAPOUR RICH IN ACTIVE PARTICLES USING PLASMA

FIELD OF THE INVENTION

[0001] The invention relates to a method and a device for preparing high-temperature and active particles-enriched steam by using plasma, and more particularly to a method for preparing high-temperature and high activity steam that is used for improving gasification intensity in the process of gasification and conversion of coal, biomass, and garbage.

BACKGROUND OF THE INVENTION

[0002] Steam thermal plasma, used in the gasification and conversion of coal, biomass, and garbage, can improve the gasification intensity and adjust the proportion of an effective gas of H_2 in a syngas, thereby enabling the syngas to meet different requirements in specific use. The technology of steam gasification based on the thermal plasma has been a focus in the research field in the world. A conventional method of steam gasification employs steam as a working gas of the plasma. However, the steam has oxidizing ability, which accelerates the electrode consumption to a certain degree, and the service life of the electrodes is shortened. Thus, the development of the plasma gasification is greatly restricted.

[0003] Patent Application No. 01129931.2 has disclosed a method for preparing a syngas by using plasma pyrolysis and gasification with hydrogen, CH_4, and steam as a working gas. However, the oxidizing steam accelerates the consumption of electrodes to a certain degree, thereby shortening the service life of the electrodes.

SUMMARY OF THE INVENTION

[0004] In view of the above-described problems, it is one objective of the invention to provide a method and a device for preparing high-temperature and active particles-enriched steam by using plasma. The method employs a non-oxidizing gas as a working gas to produce high-temperature plasma which heats vapor steam to yield high-temperature and active particles-enriched steam, thereby preventing the contact between the steam and the electrode and prolonging the service life of the electrode.

[0005] Technical scheme of the invention is as follows: a method for preparing high-temperature and active particles-enriched steam by using plasma, comprises the following steps:

[0006] 1) preparing a steam; selecting one or several non-oxidizing gases as a working gas; ionizing the working gas into a high-temperature plasma working medium by using a plasma generator; and

[0007] 2) injecting the high-temperature plasma working medium into a high-temperature steam generator to form high-temperature ionized environment while introducing steam through a rotary guide vane into the high-temperature steam generator at a high speed for allowing the steam to contact with the high-temperature plasma working medium so that the steam is heated and activated to form an active particles-enriched steam.

[0008] The working gas in step 1) is ionized into high-temperature plasma having a temperature of between 3,000 and 12,000 K by the plasma generator.

[0009] Preferably, the working gas is nitrogen.

[0010] The high-temperature plasma working medium in step 2) is injected into the high-temperature steam generator at a speed of between 30 and 100 m/s. The steam is injected into the high-temperature steam generator at a speed of between 5 and 30 m/s. A

mass flow ratio between the high-temperature plasma working medium and the steam in the high-temperature steam generator is adjusted for enabling the steam at an outlet of the high-temperature steam generator to have a temperature of between 1,000 and 4,000 K.

[0011] Between 1 and 4 annular gaps are arranged at intervals on a housing of the high-temperature steam generator; part of the steam is guided through the annular gaps into the high-temperature steam generator by a pressure conveyor and forms a low temperature water film on a wall of the high-temperature steam generator for protection.

[0012] Preferably, the steam input into the high-temperature steam generator is a saturated steam.

[0013] A device for preparing high-temperature and active particles-enriched steam by using plasma, comprises: a plasma generator; and a high-temperature steam generator. A high-temperature plasma inlet is arranged at a central part of one end of the high-temperature steam generator and communicates with an outlet of the plasma generator. The plasma generator is provided with a non-oxidizing gas inlet. An annular steam inlet is provided to surround the high-temperature plasma inlet. A rotary guide vane is disposed inside the annular steam inlet.

[0014] The high-temperature steam generator comprises a housing in a gradually enlarged step structure. The housing comprises between 1 and 4 steps. An annular gap is arranged between every two adjacent steps of the housing for allowing the steam to enter the high-temperature steam generator. The annular gaps are connected to a pressure conveyor.

[0015] Each of the gradually enlarged steps of the housing of the high-temperature steam generator has a length of between 300 and 800 mm.

[0016] The annular gap has a radial width of between 3 and 15 mm.

[0017] Advantages of the invention is as follows:

[0018] The method employs a non-oxidizing gas as the working gas, which has no corrosion on the plasma generator. Besides, the steam is introduced through an individual inlet, thus, the steam does not contact with the electrode, thereby prolonging the service life of the electrode.

[0019] The steam is introduced into the high-temperature ionized environment in the high-temperature steam generator through the rotary guide vane disposed inside the annular steam inlet at a high speed, so that the steam is instantly mixed and contacts with the high-temperature plasma and is heated and activated to form the active particles-enriched steam. The mass flow ratio between the high-temperature plasma working medium and the steam in the high-temperature steam generator is adjusted for enabling the steam at the outlet of the high-temperature steam generator to have a temperature of between 1,000 and 4,000 K, thereby meeting the requirement for gasification. Part of the steam is guided through the annular gaps into the high-temperature steam generator and forms a low temperature water film on the wall of the high-temperature steam generator for protection.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] FIG. **1** is a structure diagram of a device for preparing high-temperature and active particles-enriched steam by using plasma;

[0021] FIG. **2** is a cross-sectional view taken from line A-A of FIG. **1**; and

[0022] FIG. **3** is a cross-sectional view taken from line B-B of FIG. **1**.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0023] As shown in FIGS. **1-3**, a device for preparing high-temperature and active

particles-enriched steam by using plasma, comprises: a plasma generator **1**, and a high-temperature steam generator **2**. A high-temperature plasma inlet **4** is arranged at a central part of one end of the high-temperature steam generator **2** and communicates with an outlet **1b** of the plasma generator **1**. The plasma generator **1** is provided with a non-oxidizing gas inlet **1a**. An annular steam inlet **3d** is provided to surround the high-temperature plasma inlet **4**. A rotary guide vane **7** is disposed inside the annular steam inlet **3d**. The annular steam inlet **3d** communicates with a pressure conveyor **3** via an annular cavity and a nozzle **3d1**. **6** represents a perforated plate of the annular steam inlet **3d**. **5** represents an outlet of the high-temperature steam generator for outputting the high-temperature and active particles-enriched steam.

[0024] The high-temperature steam generator **2** comprises a housing **8** in a gradually enlarged step structure. The housing **8** comprises between 1 and 4 steps. Take a 3 steps housing **8** of the high-temperature steam generator **2** as an example, the housing **8** of the high-temperature steam generator **2** comprises sections of **2a, 2b,** and **2c**. Annular gaps **3a, 3b,** and **3c** are arranged between every two adjacent steps of the housing **8** for allowing the steam to enter the high-temperature steam generator. The annular gaps **3a, 3b,** and **3c** are connected to the pressure conveyor **3** through nozzles **3a1, 3b1,** and **3c1** provided with annular cavities, respectively.

[0025] Each of the gradually enlarged steps of the housing of the high-temperature steam generator has a length of between 300 and 800 mm. The housing is made of a fire-proof material.

[0026] The annular gap has a radial width of between 3 and 15 mm.

[0027] A method for preparing high-temperature and active particles-enriched steam by using plasma, comprises the following steps:

[0028] 1) preparing a steam; selecting one or several non-oxidizing gases as a working gas; ionizing the working gas into a high-temperature plasma working

medium by using a plasma generator; and

[0029] 2) injecting the high-temperature plasma working medium into a high-temperature steam generator to form high-temperature ionized environment while introducing one part of the steam through a rotary guide vane into the high-temperature steam generator at a high speed for allowing the steam to contact with the high-temperature plasma working medium so that the steam is heated and activated to form an active particles-enriched steam.

[0030] The working gas in step 1) is ionized into high-temperature plasma having a temperature of between 3,000 and 12,000 K by the plasma generator.

[0031] The steam comprises: an unsaturated steam, a saturated steam, a superheated steam, and a mixture of a steam and the air or/and oxygen. Preferably, the steam is the saturated steam.

[0032] Common non-oxidizing gas comprises: Ar, N_2, H_2, CO_2, and CH_4. Preferably, the non-oxidizing gas is nitrogen.

[0033] The high-temperature plasma working medium in step 2) is injected into the high-temperature steam generator at a speed of between 30 and 100 m/s. The steam is injected into the high-temperature steam generator at a speed of between 5 and 30 m/s. A mass flow ratio between the high-temperature plasma working medium and the steam in the high-temperature steam generator is adjusted for enabling the steam at an outlet of the high-temperature steam generator to have a temperature of between 1,000 and 4,000 K.

[0034] Between 1 and 4 annular gaps are arranged at intervals on the housing of the high-temperature steam generator. Part of the steam is guided through the annular gaps into the high-temperature steam generator by a pressure conveyor and forms a low temperature water film on the wall of the high-temperature steam generator for protection.

[0035] Each of the gradually enlarged steps of the housing of the high-temperature steam generator has a length of between 300 and 800 mm. The annular gap has a radial width of between 3 and 15 mm.

Example 1

[0036] A working gas N_2 is ionized into high-temperature plasma having the temperature of 3,000 K by a plasma generator **1** and is injected into a high-temperature steam generator **2** at a speed of 30 m/s, so that a 3,000 K of high-temperature ionized environment is formed. One part of saturated steam is introduced through an annular steam inlet **3d** provided with a rotary guide vane into the high-temperature steam generator **2** in the form of a rotary flow at a speed of 10 m/s, and the steam contacts with the high-temperature plasma. The other part of the steam is guided through annular gaps **3a**, **3b**, and **3c** and into the high-temperature steam generator **2** at a speed of 5 m/s and forms a low temperature water film on a wall of the high-temperature steam generator **2** for protection. As the high-temperature plasma is abundant in ionized active particles, when the saturated steam is mixed and contacts with the high-temperature plasma, the steam is heated and ionized to be high-temperature steam enriched in active particles (active H_2O, active H, active O and HO^-, and H^-, O^{+2}). The steam after the reaction at an outlet **5** of the high-temperature steam generator **2** has the temperature of 1,500 K, and can be directly transferred into a gasification device for gasification.

Example 2

[0037] A working gas CO_2 is ionized into high-temperature plasma having the temperature of 5,000 K by a plasma generator **1** and is injected into a high-temperature steam generator **2** at a speed of 70 m/s, so that a 5,000 K of high-temperature ionized

environment is formed. One part of saturated steam is introduced through an annular steam inlet **3d** provided with a rotary guide vane into the high-temperature steam generator **2** in the form of a rotary flow at a speed of 15 m/s, and the steam contacts with the high-temperature plasma. The other part of the steam is guided through annular gaps **3a**, **3b**, and **3c** and into the high-temperature steam generator **2** at a speed of 7 m/s and forms a low temperature water film on the wall of the high-temperature steam generator **2** for protection. As the high-temperature plasma is abundant in ionized active particles, when the saturated steam is mixed and contacts with the high-temperature plasma, the steam is heated and ionized to be high-temperature steam enriched in active particles (active H_2O, active H, active O and HO^-, and H^-, O^{+2}). The steam after the reaction at an outlet **5** of the high-temperature steam generator **2** has the temperature of 2,400 K, and can be directly transferred into a gasification device for gasification.

Example 3

[0038] A working gas Ar is ionized into high-temperature plasma having the temperature of 12,000 K by a plasma generator **1** and is injected into a high-temperature steam generator **2** at a speed of 100 m/s, so that a 10,000 K of high-temperature ionized environment is formed. One part of saturated steam is introduced through an annular steam inlet **3d** provided with a rotary guide vane into the high-temperature steam generator **2** in the form of a rotary flow at a speed of 30 m/s, and the steam contacts with the high-temperature plasma. The other part of the steam is guided through annular gaps **3a**, **3b**, and **3c** having a width of 10 mm and into the high-temperature steam generator **2** at a speed of 10 m/s and forms a low temperature water film on the wall of the high-temperature steam generator **2** for protection. As the high-temperature plasma is abundant in ionized active particles, when the saturated steam is mixed and contacts with the high-temperature plasma, the steam is heated and ionized to be high-temperature

steam enriched in active particles (active H_2O, active H, active O and HO^-, and H^-, O^{+2}). The steam after the reaction at an outlet **5** of the high-temperature steam generator **2** has the temperature of 3,000 K, and can be directly transferred into a gasification device for gasification.

[0039] Steam inlets of the high-temperature steam generator of the invention are individually designed for preventing the steam from contacting with the electrodes. Therefore, those technical schemes that employ non-oxygen gases as an ionizing medium and adopt individual inlets to allow the steam to enter the high-temperature steam generator will fall within the protection scope of the invention.

CLAIMS

1. A method for preparing steam by using plasma, comprising the following steps:

1) preparing a first steam; selecting one or several non-oxidizing gases as a working gas; ionizing the working gas into a plasma working medium by using a plasma generator; and

2) injecting the plasma working medium into a steam generator to form ionized environment while introducing the first steam through a guide blade into the steam generator for allowing the first steam to contact with the plasma working medium so that the first steam is heated and activated to form a second steam;

characterized in that

between 1 and 4 annular gaps are arranged at intervals on a housing of the steam generator; and

part of the first steam is guided through the annular gaps into the steam generator by a pressure conveyor and forms a water film on a wall of the steam generator for protection.

2. The method of claim 1, **characterized in that** the working gas in step 1) is ionized into plasma having a temperature of between 3,000 and 12,000 K by the plasma generator.

3. The method of claim 1 or 2, **characterized in that** the working gas is nitrogen.

4. The method of claim 1 or 2, **characterized in that**

the plasma working medium in step 2) is injected into the steam generator at a speed of between 30 and 100 m/s;

the first steam is injected into the steam generator at a speed of between 5 and 30 m/s; and

a mass flow ratio between the plasma working medium and the first steam into the steam generator is adjusted for enabling the first steam at an outlet of the steam generator to have a temperature of between 1,000 and 4,000 K.

5. The method of claim 1 or 2, **characterized in that** the first steam is a saturated steam.

6. A device for preparing steam by using plasma, comprising:

a plasma generator (1); and

a steam generator (2);

characterized in that

a plasma inlet (4) is arranged at a central part of one end of the steam generator (2) and communicates with an outlet (1b) of the plasma generator (1);

the plasma generator (1) is provided with a non-oxidizing gas inlet (1a);

an annular steam inlet (3d) is provided to surround the plasma inlet (4); and

a guide blade (7) is disposed inside the annular steam inlet (3d).

7. The device of claim 6, **characterized in that**

the steam generator (2) comprises a housing in a gradually enlarged step structure;

the housing comprises between 1 and 4 steps;

an annular gap is arranged between every two adjacent steps of the housing for allowing a steam to enter the steam generator; and

the annular gaps are connected to a pressure conveyor.

8. The device of claim 7, **characterized in that** each of the gradually enlarged steps of the housing of the steam generator has a length of between 300 and 800 mm.

9. The device of claim 8, **characterized in that** the annular gap has a radial width of between 3 and 15 mm.

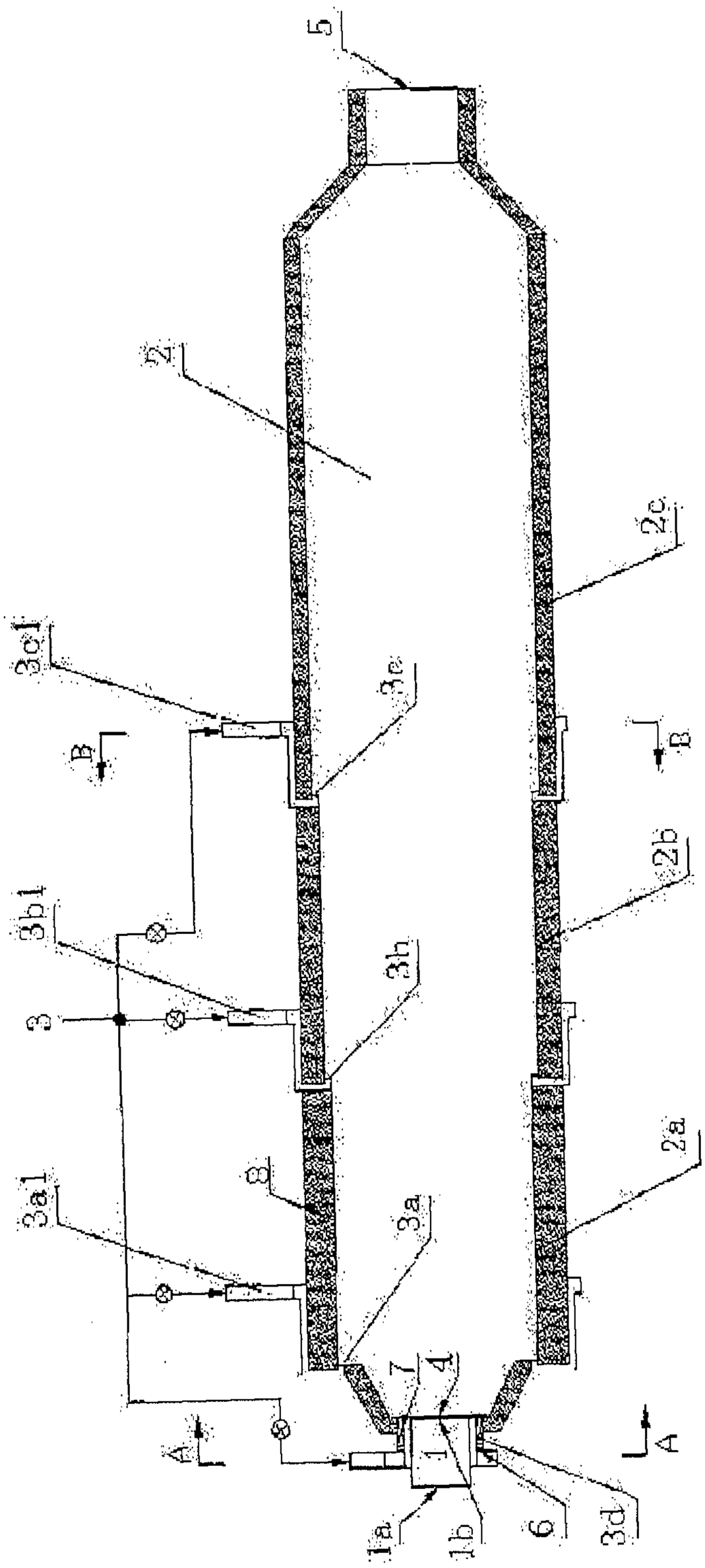


FIG. 1

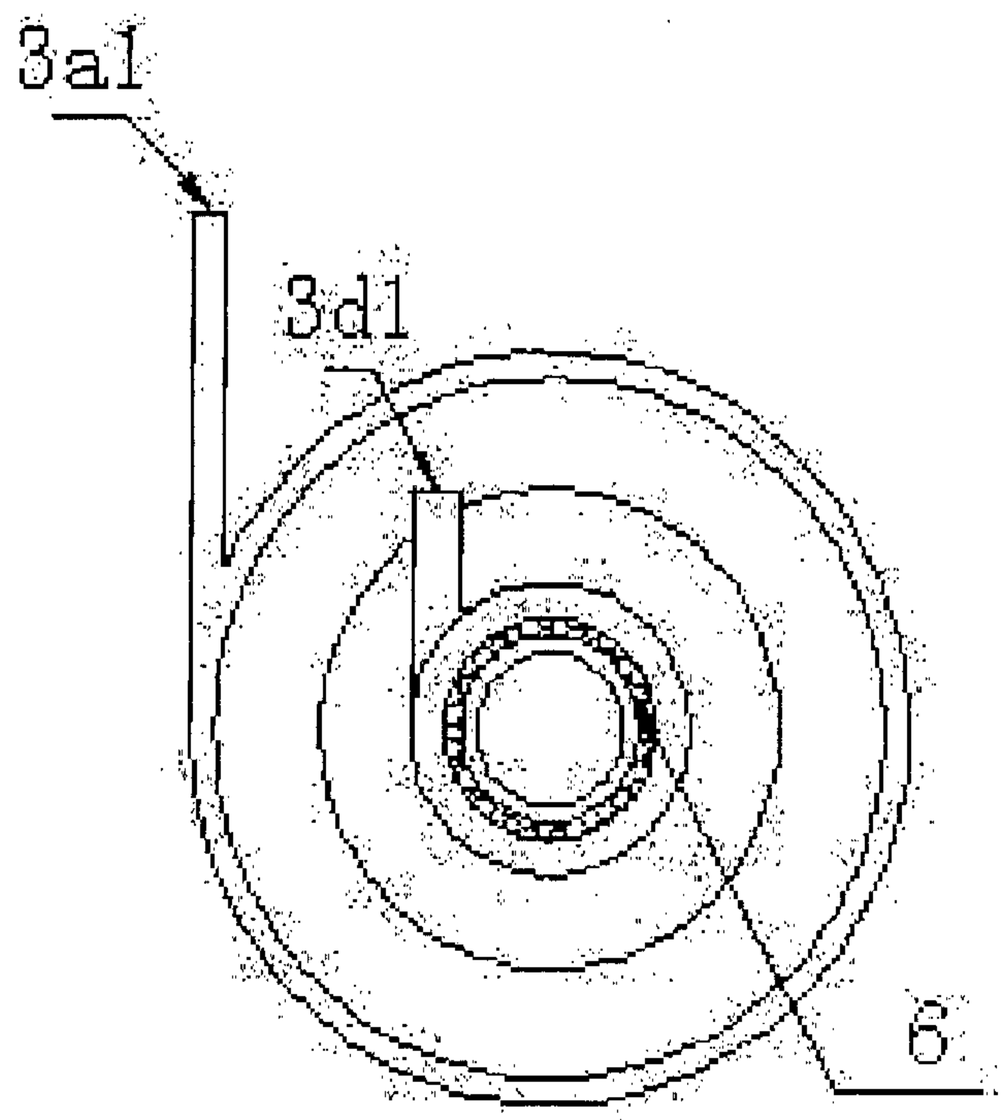


FIG. 2

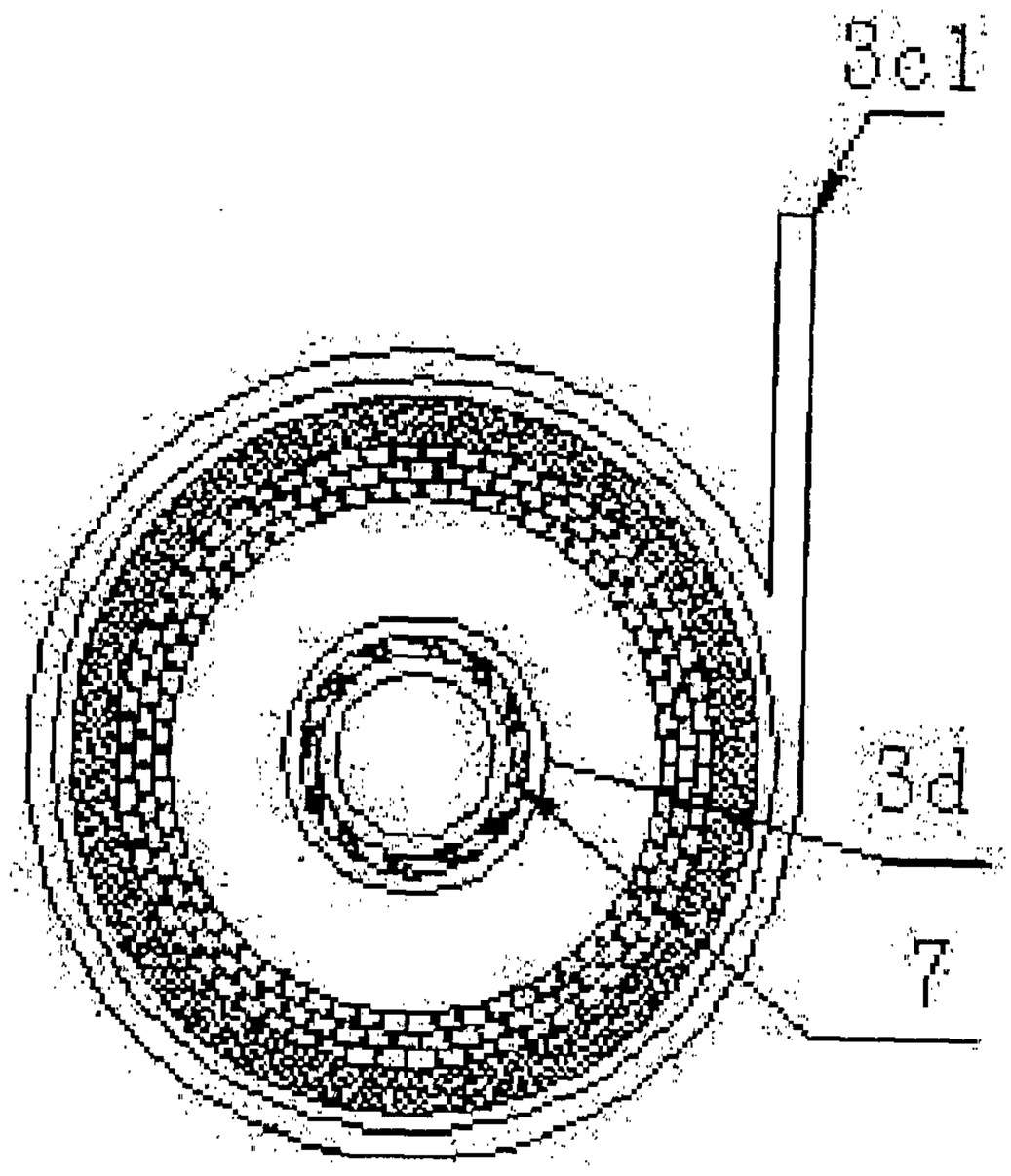
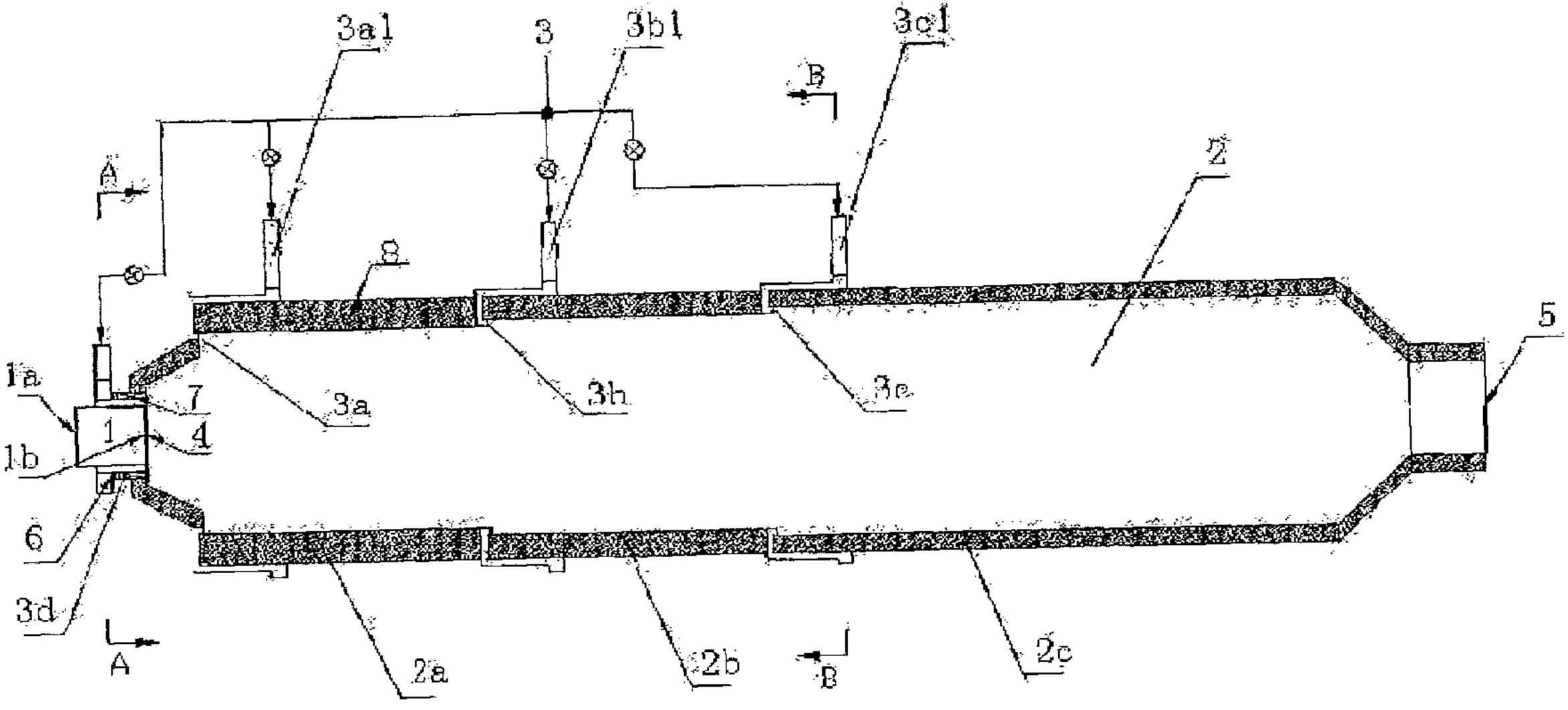


FIG. 3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