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(54) **ARRANGEMENT AND METHOD FOR BURNING FUEL**

ANORDNUNG UND VERFAHREN ZUR VERBRENNUNG VON BRENNSTOFF

SYSTÈME ET PROCÉDE POUR BRÛLER DES COMBUSTIBLES

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DE-A1- 3 217 030 US-A- 4 211 669

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Description

Background

[0001] The invention relates to an arrangement for fuel burning, the arrangement comprising gasification equipment for converting fuel into a product gas by gasification and a combustion plant for burning the product gas.

[0002] The invention also relates to a method for fuel burning, in which method the fuel is converted into product gas by gasification in gasification equipment and the product gas is burned in a combustion plant.

[0003] A growing tendency is to replace conventional fuels by renewable fuels, such as agro fuels, waste, or the like, as a replacing energy source.

[0004] However, burning of such replacement fuels causes problems. With agro fuels, for example, problems may arise due to sintering of the fluidized bed, soiling of the walls and other thermal surfaces of the burner, and superheater corrosion, the problems being caused by an attempt to achieve complete combustion and low CO emissions. In EP1136542 A1, an arrangement for burning fuel is disclosed, having a gasifier, a separator and a combustion plant.

Brief description

[0005] The arrangement and method of the invention are characterized by what is disclosed in the characterizing parts of the independent claims. Other embodiments of the invention are characterized by what is disclosed in the other claims.

[0006] Inventive embodiments are also disclosed in the specification and drawings of this application. The inventive contents of the application may also be defined in ways other than those described in the following claims. The inventive contents may also consist of several separate inventions, particularly if the invention is examined in the light of expressed or implicit sub-tasks or in view of obtained benefits or benefit groups. In such a case, some of the definitions contained in the following claims may be unnecessary in view of the separate inventive ideas. Features of the different embodiments of the invention may be applied to other embodiments within the scope of the basic inventive idea.

[0007] The idea of the invention is that fuel is gasified at a lower temperature so that alkali metals contained in the fuel remain in a solid state and in that the gasified fuel is conveyed to a separator comprising means for purifying the product gas of solids and thus enabling to remove the alkali metals from the product gas to be conveyed into combustion equipment.

Brief description of the drawings

[0008] Some embodiments of the invention are explained in more detail in the accompanying drawings, in which

Figure 1 is a schematic side view of an arrangement and method according to the invention,

Figure 2 is a schematic side view of a second arrangement and method according to the invention,

Figure 3 is a schematic side view of a third arrangement and method according to the invention, and

Figure 4 is a schematic view of a combustion plant arrangement comprising an arrangement of the invention.

[0009] For the sake of clarity, the figures show some embodiments of the invention in a simplified manner. In the figures, like reference numerals identify like elements.

Detailed description

[0010] Figure 1 is a schematic sectional side view of an arrangement and method of the invention. The arrangement 1 may be intended for burning poor-grade fuels, such as wet biomasses, sludges, recycled fuels, and waste coals; naturally other fuels can also be used. According to an idea, a boiler is used for burning what are known as agro fuels. Agro fuel refers to straw, straw pellets, palm oil waste or any other waste produced in agricultural production, for example. Agro fuels typically originate from fast-growing plants and, thus, contain lots of alkali metals, chlorine and phosphor.

[0011] The arrangement comprises gasification equipment 3 for converting the fuel to a product gas by gasification and a separator 4 comprising means for purifying the product gas of solids.

[0012] The gasification equipment 3 may be any gasification equipment known per se, such as a circulating fluidized bed gasifier, i.e. a CFB gasifier. The gasification of the fuel F takes place in a reactor 7 of the gasification equipment.

[0013] Fuel gas P generated in the gasification equipment 3 is conveyed to the separator 4, where solids are separated from it. Product gas G thus produced is conveyed into the combustion plant. Substantially all, most preferably 100%, of the gasified fuel flows from the gasification equipment 3 through the separator 4 into the combustion plant.

[0014] The arrangement 1 comprises adjustment means 10 for maintaining the gasification temperature in the reactor 7 under 800 °C, preferably within a temperature range of 600 to 750 °C, i.e. below the prior art CFB gasification temperature. According to an idea, the adjustment means 10 adjust the ratio of air to fuel to be conveyed into the reactor 7.

[0015] In the conditions prevailing in the reactor 7, i.e. within said temperature range and in the sub-stoichiometric conditions, the alkali metals contained in the fuel remain in a solid state. Alkali metals in solid state flow with the fuel gas P into the separator 4, where they are removed from the product gas G. The alkali metals content of the product gas to be conveyed into the combustion

plant is very low, even to the extent that the product gas G is in practice preferably free of alkali. The low alkali metals content of the product gas G essentially reduces, or, in practice, even abolishes altogether the corrosion risk of the combustion plant. This allows e.g. corrosion of superheaters possibly provided in the combustion plant to be reduced.

[0016] A particularly high amount of alkali metals is found in agro fuels. Agro fuels show a good reactivity in gasification, which is partly due to the catalysing effect of alkali metals which provides a good carbon conversion in the low temperature range mentioned above.

[0017] If the temperature exceeds 800°C, alkali metals begin to gasify and become essentially more difficult to remove from the product gas. On the other hand, carbon conversion may decrease significantly if the temperature is below 600°C.

[0018] In addition to alkali metals, other harmful substances or compounds, such as chlorine and phosphor, can be removed.

[0019] A further advantage of the low temperature to be mentioned is that it is below the typical sintering temperature of alkali metals, so alkali metals are unlikely to sinter on the surfaces of the reactor 7. This allows the cleaning interval of the reactor 7 to be extended.

[0020] If the reactor 7 walls are made of masonry material, their temperature is rather high. Hence the reactor 7 does not have cold surfaces to which ash, or the like, would attach.

[0021] The product gas G may have a fairly high CO content, but this is not a problem because the fuel burns to extinction in a combustion plant following the separator 4.

[0022] According to an idea, a heat exchanger 14a, 14b may be arranged between the gasification equipment 3 and the separator 4 and/or between the separator 4 and the combustion plant. The heat exchanger 14a arranged between the gasification equipment 3 and the separator 4 reduces the temperature of the fuel gas P before the separation step. This allows the temperature prevailing in the separator 4 to be reduced, which makes it possible to manufacture the separator 4 using affordable materials. The heat exchanger 14b arranged between the separator 4 and combustion plant reduces the temperature of the product gas G to be conveyed into the combustion plant, which in turn decreases the combustion temperature and reduces the melting of the ash in the combustion plant. Naturally, the same advantage may be gained with the heat exchanger 14a arranged between the gasification equipment 3 and the separator 4. In addition, the heat exchangers 14a, 14b allow heat energy to be recovered for utilization in the arrangement 1 or outside it.

[0023] The separator 4 may be an apparatus based on a cyclone, multi-cyclone, separator, ceramic filter, electric filter, or a similar device in which solid particles contained in the fuel gas and the alkali metals they carry can be removed or at least the amount of them substantially

reduced so that the product gas G to be supplied into the combustion plant contains substantially less alkali metals than the fuel gas P.

[0024] Figure 2 is a schematic side view of a second and Figure 3 of a third arrangement and method of the invention. In both figures the gasification equipment is a CFB-type gasifier.

[0025] Fuel F is conveyed through one or more fuel supply channels 8 into the reactor 7 of the CFB gasifier. The walls of the reactor 7 are most preferably of a masonry material, although they may also be composed of a membrane wall comprising cooling pipes that are typically arranged side by side and parallel with one another and interconnected by fins, or as a plate structure or as a combination of these wall structures.

[0026] The operation of the CFB gasifier is based on recycling of the bed material. This kind of situation is achieved by increasing the flow rate of the fluidization gas to be higher than the terminal rate of the particles. As a result, the bed becomes turbulent and the particles are carried in the fluidization gas to the top part of the gasifier 7 and from there into the cyclone 6 of the gasifier.

[0027] The CFB gasifier naturally comprises components and structures not shown in the figures for simplicity of presentation. These include nozzles for supplying primary air and/or circulation gas into the reactor 7, channels for supplying reagents and other additives possibly needed in the gasification, etc.

[0028] In the cyclone 6 the bed material is separated from the gas flow, whereby fuel gas P is produced. The operation of the cyclone 6 is based on a strong rotating motion in which what is known as centrifugal force separates the bed material outward onto the cyclone walls from where it accumulates onto the bottom of the cyclone 6. The bed material is returned through a return channel 9 back into the bottom part of the reactor 7. The fuel gas P is conveyed from the cyclone 6 into the separator 4.

[0029] The separator 4 may comprise a cyclone, or one of the other separators mentioned above, which separates solids S from the fuel gas. The product gas G produced as a result of the separation is conveyed into the combustion plant.

[0030] The solids separated in the separator 4 may contain inert ash, nutrients usable for plants, incombustible coal, and the like. The solids may be utilized e.g. as such or further processed into products for use or returned into the nature.

[0031] The embodiments shown in Figures 2 and 3 differ from one another in the placement of the channel conveying the fuel gas P into the separator 4. In Figure 2 the channel begins at the top part of the cyclone, whereas in Figure 3 the channel begins at the bottom of the cyclone. Both solutions, as any other structural solution of a CFB gasifier, may be applied to the equipment and method of the invention.

[0032] Because of the low gasification temperature in the reactor 7, the bottom ash on the bottom of the reactor 7 may contain coal. It may be removed by means of a

bottom ash oxidizer 11, such as a wind sieve known per se. The oxidizer blows air and, with it, the light coal upward for gasification in the reactor 7.

[0033] The bottom ash that accumulates on the bottom of the reactor 7 may be removed by bottom ash removal means 12 known per se and not disclosed here for simplification of the disclosure.

[0034] Figure 4 is a schematic view of a combustion plant arrangement in which the arrangement and method of the invention is applied. The combustion plant arrangement comprises the separator 4 already disclosed above and the combustion plant 5 arranged after it. The product gas G is burned in the combustion plant 5 and the thermal energy generated by the combustion is recovered.

[0035] The combustion plant 5 may be a boiler, known per se, in which the product gas G may be burned and the generated thermal energy is recovered into water and/or steam by means of different thermal surfaces, such as the boiler walls, superheaters, boiling surfaces and economizers. According to another idea, the combustion plant 5 may be a furnace, such as cement kiln, in which the energy obtained by burning the product gas is used for carrying out a chemical or physical process.

[0036] The combustion plant arrangement may comprise fuel pre-processing means 2, which may include drying means for reducing the moisture content of the wet fuel. The drying means may comprise a belt drier, for example.

[0037] In some cases, features disclosed in this application may be used as such, regardless of other features. On the other hand, when necessary, features disclosed in this application may be combined in order to provide different combinations.

[0038] In summary, the arrangement of the invention is characterized in that: the gasification equipment comprises means for gasifying fuel to produce a product gas at a low temperature and in that the arrangement further comprises a separator arranged between the gasification equipment and the combustion plant so that substantially all the product gas flows through it from the gasification equipment into the combustion plant, the separator comprising means for purifying the product gas of solids.

[0039] In addition, the method of the invention is characterized by adjusting the temperature of the gasification equipment so that it is at most 800°C, conveying the fuel gas generated in the gasification from the gasification equipment into the separator, purifying the fuel of solids, whereby product gas is produced, and conveying the product gas into the combustion plant for combustion.

[0040] The drawings and the related description are only intended to illustrate the idea of the invention. A person skilled in the art will find it obvious that the invention is not restricted to the above embodiments, which disclose the invention by means of some embodiments, but various modifications and different applications of the invention are possible within the inventive idea defined in the accompanying claims.

Reference numbers

[0041]

5	1	arrangement
	2	fuel pre-processing means
	3	gasification equipment
	4	separator
	5	combustion plant
10	6	cyclone
	7	reactor
	8	fuel supply channel
	9	return channel
	10	adjustment means
15	11	bottom ash oxidizer
	12	bottom ash discharge means
	13	solids discharge channel
	14a, b	heat exchanger
20	F	fuel
	G	product gas
	P	fuel gas
	S	solids

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Claims

1. An arrangement for burning fuel, the arrangement (1) comprising gasification equipment (3) for converting fuel (F) into product gas (G) by gasification and a combustion plant (5) for burning the product gas (G), wherein the gasification equipment (3) comprises means for gasifying fuel at a low temperature, the arrangement (1) further comprising a separator (4) arranged between the gasification equipment (3) and the combustion plant (5) so that substantially all product gas (G) conveyed into the combustion plant (5) flows from the gasification equipment (3) through the separator into the combustion plant (5); the separator (4) comprising means for purifying the product gas (G) of solids, between the gasification equipment (3) and the separator (4) and/or between the separator (4) and the combustion plant (5) there is arranged a heat exchanger (14a, 14b), **characterized in that** the combustion plant (5) for burning the product gas (G) is arranged to receive the product gas (G) produced in the gasification equipment (3) and cooled in the heat exchanger (14a, 14b).
2. An arrangement as claimed in claim 1, **characterized in that** the gasification equipment (3) is a CFB gasifier.
3. An arrangement as claimed in claim 1 or 2, **characterized in that** said low temperature is below 800°C, preferably within a temperature range of 600 to

750°C.

4. An arrangement as claimed in any one of the preceding claims, **characterized in that** the bottom part of the gasification equipment (3) is provided with means (11) for oxidizing bottom ash.
5. An arrangement as claimed in any one of the preceding claims, **characterized in that** the gasification equipment (3) comprises masonry walls.
6. An arrangement as claimed in any one of the preceding claims, **characterized in that** the combustion plant (5) is a boiler.
7. An arrangement as claimed in any one of claims 1 to 6, **characterized in that** the combustion plant (5) is a furnace.
8. An arrangement as claimed in any one of the preceding claims, **characterized in that** the separator (4) comprises a cyclone or a multi-cyclone.
9. An arrangement as claimed in any one of claims 1 to 7, **characterized in that** the separator (4) comprises a separating tank.
10. An arrangement as claimed in any one of claims 1 to 7, **characterized in that** the separator (4) comprises a ceramic filter or an electric filter.
11. A method for burning fuel, in which method the fuel (F) is converted into product gas (G) by gasification in gasification equipment (3) and the product gas (G) is burned in a combustion plant (5), by adjusting the temperature of the gasification equipment (3) so that it is at most 800°C; conveying the fuel gas (P) produced in the gasification from the gasification equipment (3) into the separator (4); purifying the fuel gas (P) of solids, whereby product gas (G) is produced; and conveying the product gas (G) into the combustion plant (5) for combustion, reducing the temperature of the fuel gas (P) and/or the product gas (G) by a heat exchanger (14a, 14b) arranged between the gasification equipment (3) and the separator (4) and/or between the separator (4) and the combustion plant (5), **characterized by** burning the product gas (G) produced in the gasification equipment (3) and cooled in the heat exchanger (14a, 14b) in the combustion plant (5).
12. A method as claimed in claim 11, **characterized in that** fuel (F) comprising agro fuel is supplied into the gasification equipment (3).

13. A method as claimed in claim 11 or 12, **characterized by** gasifying the fuel in a CFB gasifier.

14. A method as claimed in any one of claims 11 to 13 **characterized by** adjusting the temperature of the gasification equipment (3) to be within a range of 600 to 750°C.

15. A method as claimed in any of claims 11 to 14, **characterized by** purifying the fuel gas (P) of solids in a cyclone (6), multi-cyclone, separating tank, ceramic filter or electric filter.

15 Patentansprüche

1. Vorrichtung zum Verbrennen von Treibstoff, wobei die Vorrichtung (1) eine Vergasungsanlage (3) zur Konvertierung von Treibstoff (F) in Produktgas (G) mittels Vergasung umfasst und eine Feuerungsanlage (5) zur Verbrennung des Produktgases (G), wobei die Vergasungsanlage (3) Mittel zur Vergasung von Treibstoff bei einer niedrigen Temperatur umfasst, wobei die Vorrichtung (1) weiterhin umfasst:

einen Abscheider (4) angeordnet zwischen der Vergasungsanlage (3) und der Feuerungsanlage (5), so dass im Wesentlichen alles Produktgas (G), das in die Feuerungsanlage (5) befördert wurde, von der Vergasungsanlage (3) durch den Abscheider in die Feuerungsanlage (5) fließt;

wobei der Abscheider (4) Mittel zur Reinigung des Produktgases (G) von Feststoffen umfasst, wobei zwischen der Vergasungsanlage (3) und dem Abscheider (4) und/oder zwischen dem Abscheider (4) und der Feuerungsanlage (5) ein Wärmetauscher (14a, 14b) angeordnet ist, **dadurch gekennzeichnet, dass** die Feuerungsanlage (5) zur Verbrennung von Produktgas (G) eingerichtet ist, um das Produktgas (G) aufzunehmen, das in der Vergasungsanlage (3) produziert und in dem Wärmetauscher (14a, 14b) gekühlt wurde.

2. Vorrichtung nach Anspruch 1, **dadurch gekennzeichnet, dass** die Vergasungsanlage (3) ein CFB Vergaser ist.

3. Vorrichtung nach einem der Ansprüche 1 oder 2, **dadurch gekennzeichnet, dass** die niedrige Temperatur unter 800 °C, vorzugsweise innerhalb eines Temperaturbereiches von 600 bis 750 °C ist.

4. Vorrichtung nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der Unterteil der Vergasungsanlage (3) mit Mitteln (11) zur Oxidation von Schlacke ausgestattet ist.

5. Vorrichtung nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Vergasungsanlage (3) Mauerwerk umfasst.
6. Vorrichtung nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** sich in der Feuerungsanlage (5) ein Heizkessel befindet.
7. Vorrichtung nach einem der Ansprüche 1 bis 6, **dadurch gekennzeichnet, dass** sich in der Feuerungsanlage (5) ein Hochofen befindet.
8. Vorrichtung nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der Abscheider (4) einen Fliehkraftabscheider oder einen Multi-Fliehkraftabscheider umfasst.
9. Vorrichtung nach einem der Ansprüche 1 bis 7, **dadurch gekennzeichnet, dass** der Abscheider (4) ein Trennbecken umfasst.
10. Vorrichtung nach einem der Ansprüche 1 bis 7, **dadurch gekennzeichnet, dass** der Abscheider (4) einen Keramikfilter oder einen Elektrofilter umfasst.
11. Verfahren zur Verbrennung von Treibstoff, wobei in dem Verfahren der Treibstoff (F) in Produktgas (G) konvertiert wird mittels Vergasung in einer Vergasungsanlage (3) und das Produktgas (G) in einer Feuerungsanlage (5) verbrannt wird mittels
- einstellen der Temperatur der Vergasungsanlage (3), so dass sie höchstens 800 °C ist;
transportieren des Treibstoffgases (P) produziert in der Vergasung von der Vergasungsanlage (3) in den Abscheider (4);
reinigen des Treibstoffgases (P) von Feststoffen, wobei das Produktgas (G) produziert wird;
und
transportieren des Produktgases (G) in die Feuerungsanlage (5) zur Verbrennung,
reduzieren der Temperatur des Treibstoffgases (P) und/oder des Produktgases (G) mittels eines Wärmetauschers (14a, 14b) angeordnet zwischen der Vergasungsanlage (3) und dem Abscheider (4) und/oder zwischen dem Abscheider (4) und der Feuerungsanlage (5),
dadurch gekennzeichnet, dass
das Produktgas (G) produziert in der Vergasungsanlage (3) und gekühlt in dem Wärmetauscher (14a, 14b) in der Feuerungsanlage (5) verbrannt wird.
12. Verfahren nach Anspruch 11, **dadurch gekennzeichnet, dass** der Treibstoff (F), der Agrotreibstoff enthält, in die Vergasungsanlage (3) eingeleitet wird.
13. Verfahren nach Anspruch 11 oder 12, **dadurch ge-**

kennzeichnet, dass der Treibstoff in einem CFB Vergaser vergast wird.

14. Verfahren nach einem der Ansprüche 11 bis 13, **dadurch gekennzeichnet, dass** die Temperatur der Vergasungsanlage (3) so eingestellt wird, dass sie in einem Bereich von 600 bis 750 °C liegt.
15. Verfahren nach einem der Ansprüche 11 bis 14, **gekennzeichnet durch** das Reinigen des Treibstoffgases (P) von Feststoffen in einem Fliehkraftabscheider (6), Multi-Fliehkraftabscheider, Trennbecken, Keramikfilter oder Elektrofilter.

Revendications

1. Système pour la combustion de combustible, le système (1) comprenant un équipement de gazéification (3) pour la conversion du combustible (F) en produit gazeux (G) par gazéification et une installation de combustion (5) pour la combustion du produit gazeux (G), dans lequel l'équipement de gazéification (3) comprend des moyens pour gazéifier le combustible à faible température, le système (1) comprenant en outre un séparateur (4) disposé entre l'équipement de gazéification (3) et l'installation de combustion (5) de sorte que pratiquement tout le produit gazeux (G), transporté à l'intérieur de l'installation de combustion (5), circule depuis l'équipement de gazéification (3) à travers le séparateur et à l'intérieur de l'installation de combustion (5);
le séparateur (4) comprenant des moyens pour la purification du produit gazeux (G) de solides, un échangeur de chaleur (14a, 14b) disposé entre l'équipement de gazéification (3) et le séparateur (4) et/ou entre le séparateur (4) et l'installation de combustion (5), **caractérisé en ce que** l'installation de combustion (5) pour la combustion du produit gazeux (G) est disposée pour la réception du produit gazeux (G) produit dans l'équipement de gazéification (3) et refroidi dans l'échangeur de chaleur (14a, 14b).
2. Système selon la revendication 1, **caractérisé en ce que** l'équipement de gazéification (3) est un gazéificateur LFC.
3. Système selon la revendication 1 ou 2, **caractérisé en ce que** ladite basse température est inférieure à 800°C, de préférence dans une plage de température de 600 à 750°C.
4. Système selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la partie inférieure de l'équipement de gazéification (3) est pourvue de moyens (11) pour l'oxydation des mâchefers.

5. Système selon l'une quelconque des revendications précédentes, **caractérisé en ce que** l'équipement de gazéification (3) comprend des parois de maçonnerie.
6. Système selon l'une quelconque des revendications précédentes, **caractérisé en ce que** l'installation de combustion (5) est une chaudière.
7. Système selon l'une quelconque des revendications 1 à 6, **caractérisé en ce que** l'installation de combustion (5) est un four.
8. Système selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le séparateur (4) comprend un cyclone ou un multi-cyclone.
9. Système selon l'une quelconque des revendications 1 à 7, **caractérisé en ce que** le séparateur (4) comprend un réservoir de séparation.
10. Système selon l'une quelconque des revendications 1 à 7, **caractérisé en ce que** le séparateur (4) comprend un filtre en céramique ou un filtre électrique.
11. Procédé de combustion de combustible, procédé dans lequel le combustible (F) est converti en produit gazeux (G) par gazéification dans l'équipement de gazéification (3) et le produit gazeux (G) est brûlé dans une installation de combustion (5), par un ajustement de la température de l'équipement de gazéification (3) de sorte qu'elle soit au maximum à 800°C;
un transport du gaz combustible (P) produit lors de la gazéification depuis l'équipement de gazéification (3) dans le séparateur (4);
une purification du gaz combustible (P) de solides, grâce à quoi le produit gazeux (G) est produit; et un transport du produit gazeux (G) dans l'installation de combustion (5) pour la combustion,
une réduction de la température du gaz combustible (P) et/ou du produit gazeux (G) par un échangeur de chaleur (14a, 14b) agencé entre l'équipement de gazéification (3) et le séparateur (4) et/ou entre le séparateur (4) et l'installation de combustion (5),
caractérisé par
une combustion du produit gazeux (G) produit dans l'équipement de gazéification (3) et refroidi dans l'échangeur de chaleur (14a, 14b) dans l'installation de combustion (5).
12. Procédé selon la revendication 11, **caractérisé en ce que** le combustible (F) comprenant de l'agro-combustible est fourni dans l'équipement de gazéification (3).
13. Procédé selon la revendication 11 ou 12, **caractérisé par** une gazéification du combustible dans un gazéificateur LFC.
14. Procédé selon l'une quelconque des revendications 11 à 13, **caractérisé par** un réglage de la température de l'équipement de gazéification (3) situé dans une plage de 600 à 750°C.
15. Procédé selon l'une quelconque des revendications 11 à 14, **caractérisé par** une purification du gaz combustible (P) de solides dans un cyclone (6), un multi-cyclone, un réservoir de séparation, un filtre en céramique ou un filtre électrique.

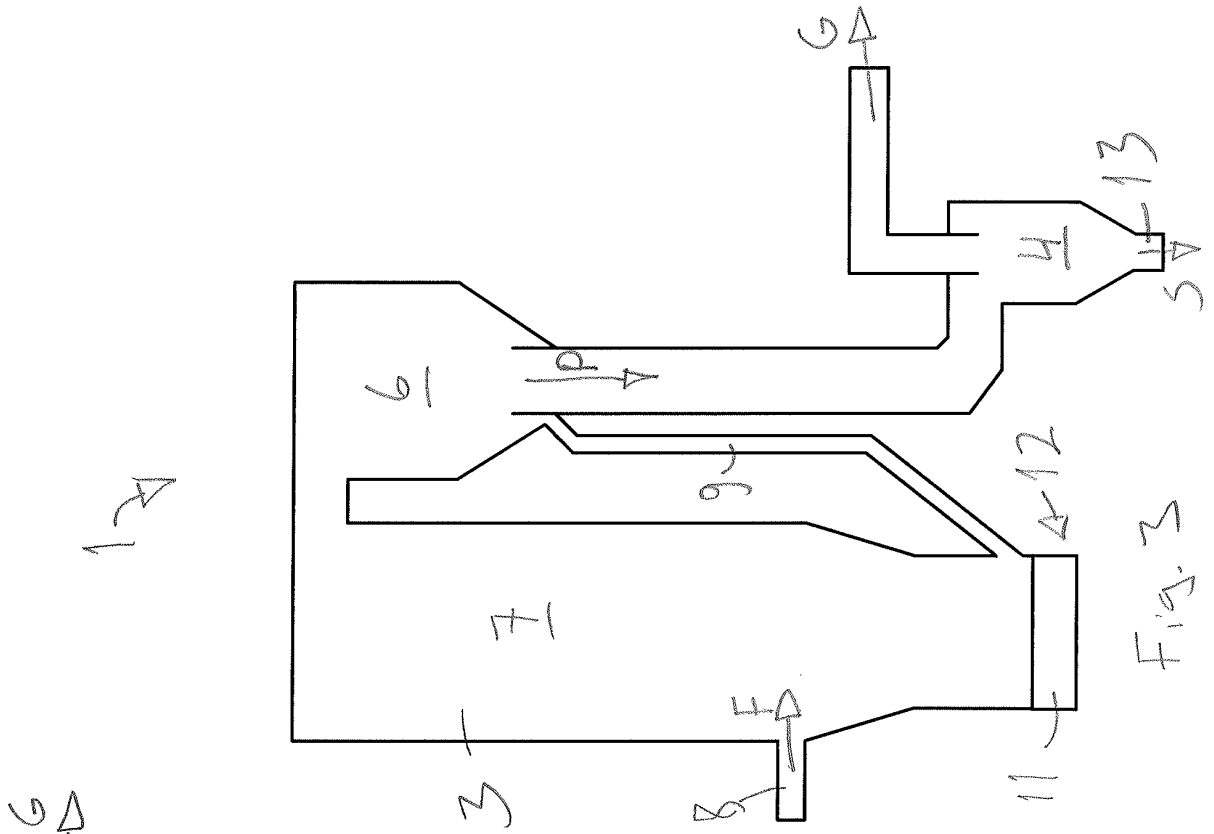


Fig. 2

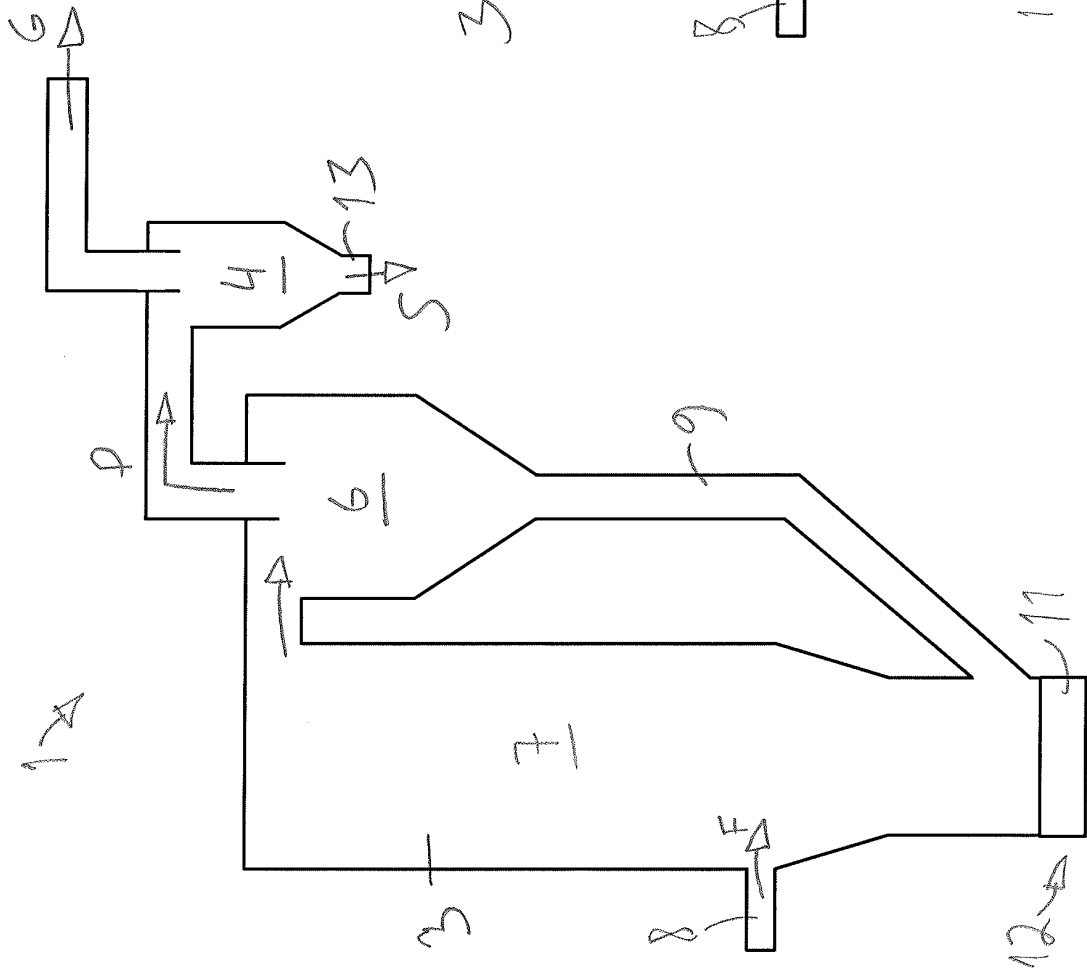


Fig. 3

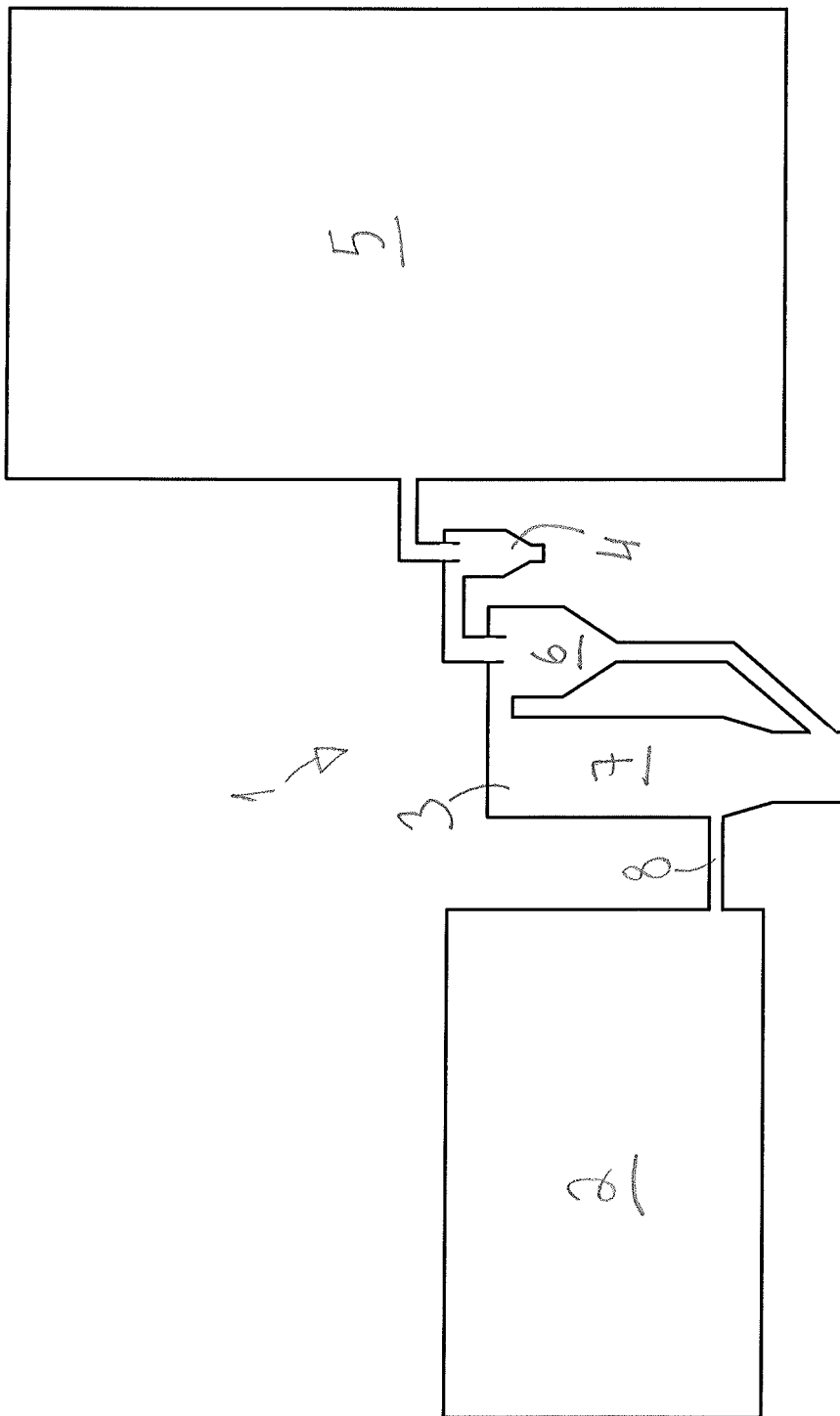


Fig. 4

REFERENCES CITED IN THE DESCRIPTION

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