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(54) **Apparatus for the purification of a synthesis gas flow obtained from the gasification of refuses and/or biomasses**

(57) An apparatus (10) for the purification of a synthesis gas flow obtained from the gasification of refuses and/or biomasses, by means of physical removal of solid particles (particulate) and liquid particles (for example, drops of water) therein contained, comprising:
a substantially cylindrical shell (12), closed at the opposite ends by respective upper (16) and lower (18) bottoms,
a first (20) and a second chamber (22), coaxial, defined in said shell (12) and arranged in substantial mutual alignment, said first chamber (12) having an upper end (20a) closed by said upper bottom (16) and the other lower end (20b) open in the upper open end (22a) of said second chamber (22), the other lower end (22b) of said second chamber (22) being closed by said lower bottom (18),
an inlet duct (24) of a synthesis gas flow to be purified, open in said first chamber (20) in a direction substantially tangent to the inner wall (26) thereof,
a discharge duct (28) of purified synthesis gas, open in said first chamber (20) through said upper bottom (16),
a plate device of particulate-sedimentation (30), supported in said second chamber (22), axially extended therein and having an upper end (32) being in predetermined spaced relationship from the open lower end (20b) of said first chamber (20).

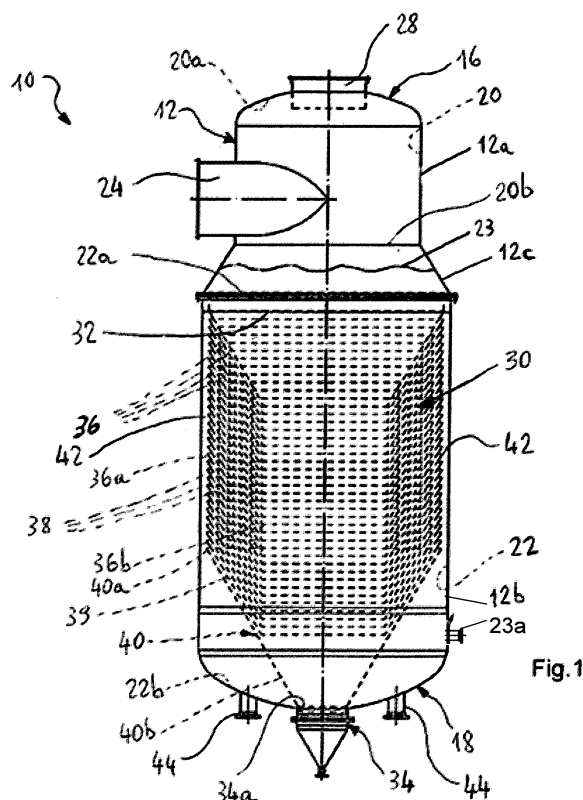


Fig.1

Description

Field of application

[0001] The present invention, in its most general aspect, refers to the purification of synthesis gas obtained from the gasification of refuses and/or biomasses.

[0002] In particular this invention concerns the purification of a continuous flow of such synthesis gas, by means of physical removal of solid particles (so-called particulate) and liquid particles (for example, drops of water) therein contained.

[0003] Still more in particular, the present invention refers to an apparatus for the aforesaid physical removal of solid particles (particulate) and liquid particles (for example, drops of water) therein contained from a continuous flow of synthesis gas obtained from the gasification of refuses and/or biomasses.

[0004] In the following description, exemplifying and non-limiting reference will be made to the sector of the technique related to the energy valorization plants of refuses and/or biomasses, i.e. the so-called RDF (Refuse Derived Fuel) comprising a gasification reactor in which said RDF is subjected to gasification, for the obtainment of a continuous flow of synthesis gas.

[0005] It should be specified that, in the present invention, with the English acronym RDF (Refuse Derived Fuel), it is intended to identify that particular dry, ground solid fuel obtained from the treatment of the solid urban refuses.

[0006] It is also specified that by refuses it is intended to identify all those substances or objects which are discards or residues of the most widely varying human activities, and that by biomasses it is intended to identify the substances of animal or vegetal origin, not fossil.

Prior Art

[0007] It is known that the synthesis gas obtained in the gasification reactor of the aforesaid RDF energy valorization plants, must be adequately purified before it can be effectively used in high-efficiency energy cycles, such as endothermic engines with recovery boiler and steam cycle with turboalternator, gas turbine with recovery boiler and steam cycle with turboalternator, fuel cells.

[0008] In fact it is known that, above all due to the "nature" of the fuel from which it is obtained, the synthesis gas coming from the gasification reactor generally comprises considerable quantities of polluting substances, globally defined as solid particulate, which must be removed in the most complete manner possible, so that said gas can be efficiently used precisely in the aforesaid high-efficiency energy cycles.

[0009] Adding to this is also the need to separate from said synthesis gas, the water which is used in great quantities for a cooling thereof to the predetermined temperatures compatible with the provided use. In particular, the flow of hot synthesis gas coming from the gasification

reactor is cooled with a "washing" of water through its passage in a duct equipped with nozzles which just inject cooling water. In order to limit its consumption within economically acceptable limits, the prior art may also provide for a substantial recovery of the cooling water, after its separation from the purified gas and with the subsequent recycling in the cooling stage of said gas.

[0010] The purification techniques of a synthesis gas of the type considered up to now from the solid particles (particulate) and from the liquid particles (in particular drops of water) therein contained, are generally based on the use of an apparatus essentially comprising a cyclone separator and a settler, associated in line. A flow of said synthesis gas, with related load of solid particulate and cooling water, is continuously introduced in a cyclone separator, tangentially to the inner wall thereof; water and particulate are collected on the bottom of the cyclone (also called cyclone basin), where a bath of so-called sludges is formed, while the purified synthesis gas is discharged from the top of the cyclone itself.

[0011] By means of appropriately sized and controlled pumping groups, the sludges are introduced in a settler of the so-called "plate" type where, due to the ascent of the sludges into the interspaces between a plurality of plates, arranged parallel to each other and tilted with respect to the settler axis, most of the particulate (which is deposited on the plates and tends to "slide" on the lower bottom of the settler, provided with a discharge opening of said particulate) is separated from the water, which is generally reused in the plant as process water (for example, such water can be recycled as such to the cooling stage of the synthesis gas).

[0012] While advantageous and widely used, an apparatus for the purification of synthesis gas of the above schematically described type, has recognized drawbacks, including the transfer of the sludges from the cyclone to the settler which always requires an accurate, continuous monitoring of their thickening level, so to be able to manage its treatment in the settler in an economically efficient manner, and to avoid that an excessive thickening of the sludges compromises the functionality of the cyclone separator itself, of the pumping groups and of the connection ducts between cyclone separator and settler. A further drawback is the need to appropriately manage, with dedicated devices of control and safety, the pumping groups and the aforesaid connection ducts between the cyclone separator and settler, in addition to the need for a considerable space availability, given that - in addition to the actual size of the aforesaid apparatus - it is necessary to provide for the access spaces for the apparatus maintenance.

Summary of the invention

[0013] The technical problem underlying the present invention is that of devising and providing an apparatus for the purification of synthesis gas obtained from the gasification of refuses and/or biomasses, having struc-

tural and functional characteristics capable of overcoming, in a simple and economical manner, the drawbacks mentioned with reference to the prior art, i.e. so that the need for monitoring the thickening level of the sludges is unusually limited and the size of the apparatus itself is reduced.

[0014] This problem is solved, according to the present invention, by an apparatus for the purification of a synthesis gas flow obtained from the gasification of refuses and/or biomasses, by means of physical removal of solid particles (particulate) and liquid particles (for example, drops of water) therein contained, characterized in that it comprises:

a substantially cylindrical shell, closed at the opposite ends by respective upper and lower bottoms,

a first and a second chamber, coaxial, defined in said shell and arranged in substantial mutual alignment, said first chamber having an upper end closed by said upper bottom and the other lower end open in the open upper end of said second chamber, the other lower end of said second chamber being closed by said lower bottom,

an inlet duct of a synthesis gas flow to be purified, open in said first chamber in a direction substantially tangent to the inner wall thereof,

a discharge duct of purified synthesis gas, open in said first chamber through said upper bottom,

a plate device of particulate-sedimentation, supported in said second chamber, axially extended therein and having an upper end being in a predetermined spaced relationship from the open lower end of said first chamber.

[0015] Advantageously, the apparatus comprises at least one discharge duct of the sedimented particulate, open in said second chamber, preferably through said lower bottom.

[0016] In accordance with one aspect of the present invention, said substantially cylindrical shell comprises an upper portion having lower diameter and axial length than the diameter and axial length, respectively, of the remaining portion or lower portion, for which it substantially constitutes a dome, said first chamber being defined in said upper dome portion, said second chamber being defined in said remaining portion or lower portion of said shell.

[0017] In the first chamber or dome chamber of the apparatus of the present invention, the purification of the synthesis gas takes place, by means of cyclonic separation of the particulate, and possibly of the cooling water, in the shape of drops, present therein; this chamber has the same functionality of a cyclone separator but, unlike the latter, it entirely lacks a lower basin of collection of

the particulate sludges in water. In fact, the just-formed sludges descend directly into the second chamber, where the sedimentation process begins.

[0018] The apparatus of the present invention attains the great advantage of not needing any pumping group and hence any accessory devices of control, adjustment and the like.

[0019] A further and non-negligible advantage consists of the reduced use of space to be made available for its installation and maintenance.

[0020] Further characteristics and advantages of the present invention will be clearer from the detailed description of an embodiment of an apparatus for the purification of a synthesis gas flow obtained from the gasification of refuses and/or biomasses, made here below with reference to the attached drawings, which are given as indicative and non-limiting.

Brief description of the drawings

[0021]

Figure 1 schematically represents a side elevation view of an apparatus for the purification of a synthesis gas flow obtained from the gasification of refuses and/or biomasses, according to the present invention.

Figure 2 schematically represents a top plan view of the apparatus of figure 1.

Figure 3 schematically represents a longitudinal median section of a lower portion of the apparatus of figure 1.

Figure 4 schematically represents an enlarged view of a detail of the apparatus of figure 1.

Figure 5 schematically represents a side elevation view of a energy valorization plant of refuses and/or biomasses, comprising the apparatus of figure 1.

Detailed description of a preferred embodiment

[0022] With reference to figures 1-4, an apparatus is shown for the purification of a synthesis gas flow obtained from the gasification of refuses and/or biomasses, in accordance with the present invention and globally indicated with 10. Such apparatus 10 comprises a substantially cylindrical shell 12, closed at the opposite ends by respective upper 16 and lower 18 bottoms.

[0023] A first and second chamber 20 and 22, coaxial, and arranged in substantial mutual alignment, are defined in said shell 12.

[0024] The first chamber 20 has an upper end 20a closed by said upper bottom 16 and the other lower end 20b open in the open upper end 22a of said second chamber 22, the other lower end 22b of said second chamber

22 being closed by said lower bottom 18.

[0025] An inlet duct 24 of a synthesis gas flow to be purified is open in said first chamber 20 and is in a direction substantially tangent to the inner wall 26 thereof.

[0026] A discharge duct 28 of purified synthesis gas is open in said first chamber 20 through said upper bottom 16.

[0027] In accordance with one aspect of the present invention, a plate device of particulate-sedimentation 30 is supported in said second chamber 22, is axially extended therein and has an upper end 32 being in a predetermined spaced relationship from the open lower end 20b of said first chamber 20.

[0028] Said second chamber 22 is filled with water. Generally, the second chamber 22 is filled at least partially with water.

[0029] Furthermore, the apparatus can comprise at least one discharge duct 34 of the sedimented particulate, open in said second chamber 22. In the example of figure 1, the discharge duct 34 crosses the lower bottom 18 of said second chamber 22.

[0030] In the embodiment illustrated in the figures, said substantially cylindrical shell 12 comprises an upper portion 12a having lesser diameter and axial length than the diameter and axial length, respectively, of the remaining portion 12b (or lower portion), for which it substantially constitutes a dome, said first chamber 20 being defined in said upper "dome" portion 12a, said second chamber 22 being defined in the remaining portion or lower portion 12b of said shell 12. Between the upper portion 12a and the lower portion 12b, the shell 12 comprises a connection portion 12c having frustoconical shape.

[0031] In the first chamber 20 (or dome chamber) of the apparatus 10 of the present invention, the purification of the synthesis gas takes place, by means of cyclonic separation of the particulate, and possibly of the cooling water, present therein; this first chamber 20 has the same functionality as a cyclone separator. The particulate and the possible cooling water (in particular, the drops of water present in the synthesis gas which, after exiting from a gasification reactor of a energy valorization plant of refuses and/or biomasses, is cooled with a "washing" of water) fall on the free surface 23 of the water with which the second chamber 22 is filled, and from here the sedimentation process begins.

[0032] In particular, the plate device of particulate-sedimentation 30, immersed in water, comprises a plurality of plates 36, arranged parallel to each other, in mutual spaced relationship and tilted with respect to the axis of the shell 12.

[0033] In the example illustrated in figures 1, 3 and 4, the plates 36 are frustoconically-shaped, with the lesser base turned towards the lower bottom 18 of the shell 12 and with axis coinciding with that of the shell 12: the plates 36 are of equal size and are superimposed on each other, in mutual spaced relationship, in a substantially head-tail arrangement and with partial mutual insertion inside each other: between the plates 36, a plurality of interspaces

38 is identified.

[0034] Below the lower plate 36 of said plurality of plates, a further frustoconical plate 40 is provided, always parallel to the plates 36 but having a more extended lateral surface than the plates 36, said lateral surface reaching the opening 34a of the lower bottom 18 of said second chamber 22 where the discharge duct 34 arrives, positioned at the centre of the lower bottom 18.

[0035] The plate 40 is supported by an annular element 41, connected, at one end 41a, to the inner wall of said second chamber 22, said annular element 41 having an opposite end 41b of frustoconical shape parallel to the plate 40 and ending with a portion 41c curved towards it, on which the plate 40 itself lies.

[0036] Between the plates 36, and between the plate 40 and the lower plate 36, annular elements 37 are provided, connected at one end 37a to the inner wall of said second chamber 22, said annular elements 37 having opposite ends 37b of frustoconical shape parallel to the plates 36 and ending with portions 37c curved towards them, on which the plates 37 themselves lie. The curved portions 37c have a plurality of through openings which permit the sludges to flow along said interspaces 38 between the plates 36 and along the interspace 39 between the plate 40 and the lower plate 36. Between the lower portion 12b of said shell 12 and the upper ends 36a of the plates 36 (and between the lower portion 12b of said shell 12 and the upper end 40a of the plate 40) an annular space is identified, which identifies an interspace 42 between the lower portion 12b of said shell 12 and the plate device of particulate-sedimentation 30, said interspace 42 having cylindrical-annulus shape.

[0037] The sludges contained in the second chamber 22 are forced to ascend through the interspaces 38 between the plates 36 (and the interspace 39 between the plate 40 and the lower plate 36): on the plates 36 and on the plate 40 the separation occurs of most of the particulate contained in the sludges, which is deposited on the plates 36 and 40 themselves and tends to "slide" towards the lower end 36b of the plates 36, and from here it falls on the portion 40b of plate 40 which does not identify the interspace 39, said portion 40b conveying the particulate to the discharge duct 34.

[0038] The sludges which reaches the upper end 36a and 40a of the plates 36 and 40 have an extremely reduced particulate content, and after having run through the interspace 42, they cross the annular element 41 equipped with a plurality of through openings and reaches the lower bottom 18 of the apparatus 10, where at least one duct 44 is provided for the discharge of such sludges with extremely reduced particulate content: such liquid can be reused in the plant where the apparatus 10 is inserted as process water (for example, in the case of a energy valorization plant of RDF, such water can be recycled as such for a cooling with water "washing" of the synthesis gas coming from a gasification reactor). In the example of figure 1, there are two, diametrically-opposed ducts 44: the sedimentation of the sludges in the

central zone of the chamber 22 can be advantageously controlled by the suction itself of liquid which exits from said ducts 44.

[0039] It should be noted that the free surface 23 of the water with which the second chamber 22 is filled has a substantially constant level, due to an appropriate filling up of water coming from a duct 23a, in order to balance the evaporated liquid which exits together with the cooled gas.

[0040] The present invention also refers to a energy valorization plant 50 of refuses and/or biomasses, shown in figure 5, comprising a gasification reactor 52 in which said refuses and/or biomasses are subjected to gasification, for the obtainment of a continuous flow of hot synthesis gas which undergoes a cooling in a station 54 of washing with water, said plant 50 comprising an apparatus 10 for the purification of said synthesis gas flow of the above-indicated type.

[0041] The gasification reactor 52 is of conventional type and comprises a substantially cylindrical shell 53, closed by respective upper 53a and lower 53b bottoms. In the lower portion of the shell 53 an inlet duct 52a is provided for said refuses and/or biomasses, which are gasified by means of a plurality of burners and oxygen lances (not shown in the figures since they are per se conventional).

[0042] Near the lower bottom 53b, below the inlet duct 52a, a discharge duct 53c is provided for the so-called inert melted waste which is produced in the aforesaid gasification reaction.

[0043] Near the upper bottom 53a, an outlet duct 52b is provided for said hot synthesis gas.

[0044] The washing station 54 is of conventional type and comprises a duct 56 equipped with nozzles 58 which inject cooling water. It is specified that the inlet duct 24 of a synthesis gas flow to be purified of the apparatus 10 is in fluid communication and substantially constitutes the last part of the station 54 of washing with water. The discharge duct 28 of the apparatus 10 carries the purified synthesis gas, which is used in high-efficiency energy cycles, such as endothermic engines with recovery boiler and steam cycle with turboalternator, gas turbines with recovery boiler and steam cycle with turboalternator, fuel cells.

[0045] It is evident from the preceding description that the apparatus for the purification of a synthesis gas flow obtained from the gasification of refuses and/or biomasses according to the present invention solves the technical problem and attains numerous advantages, including the fact that it is unusually compact, and that - with respect to the apparatus of the prior art - requires a lower number of accessory devices of control, adjustment and the like, with consequent lower costs of installation and management.

[0046] Moreover, the fact that the apparatus according to the invention comprises a single shell reduces the construction costs with respect to the prior art apparatus, comprising two units (cyclone separator and settler) and

hence two respective shells.

[0047] Of course, a man skilled in the art, in order to satisfy specific and contingent needs, can make numerous modifications and variants to the apparatus for the purification of a synthesis gas flow obtained from the gasification of refuses and/or biomasses described above, all moreover contained within the scope of the present invention as defined by the following claims.

Claims

1. Apparatus (10) for the purification of a synthesis gas flow obtained from the gasification of refuses and/or biomasses, by means of physical removal of solid particles and liquid particles therein contained, **characterized in that** it comprises:

a substantially cylindrical shell (12), closed at the opposite ends by respective upper (16) and lower (18) bottoms,

a first (20) and a second chamber (22), coaxial, defined in said shell (12) and arranged in substantial mutual alignment, said first chamber (12) having an upper end (20a) closed by said upper bottom (16) and the other lower end (20b) open in the upper open end (22a) of said second chamber (22), the other lower end (22b) of said second chamber (22) being closed by said lower bottom (18),

an inlet duct (24) of a synthesis gas flow to be purified, open in said first chamber (20) in a direction substantially tangent to the inner wall (26) thereof,

a discharge duct (28) of purified synthesis gas, open in said first chamber (20) through said upper bottom (16),

a plate device of particulate-sedimentation (30), supported in said second chamber (22), axially extended therein and having an upper end (32) being in predetermined spaced relationship from the open lower end (20b) of said first chamber (20).

2. Apparatus (10) according to claim 1, **characterized in that** it comprises at least one discharge duct (34) of the sedimented particulate, open in said second chamber (22).

3. Apparatus (10) according to claim 2, **characterized in that** said at least one discharge duct (34) crosses the lower bottom (18) of said second chamber (22).

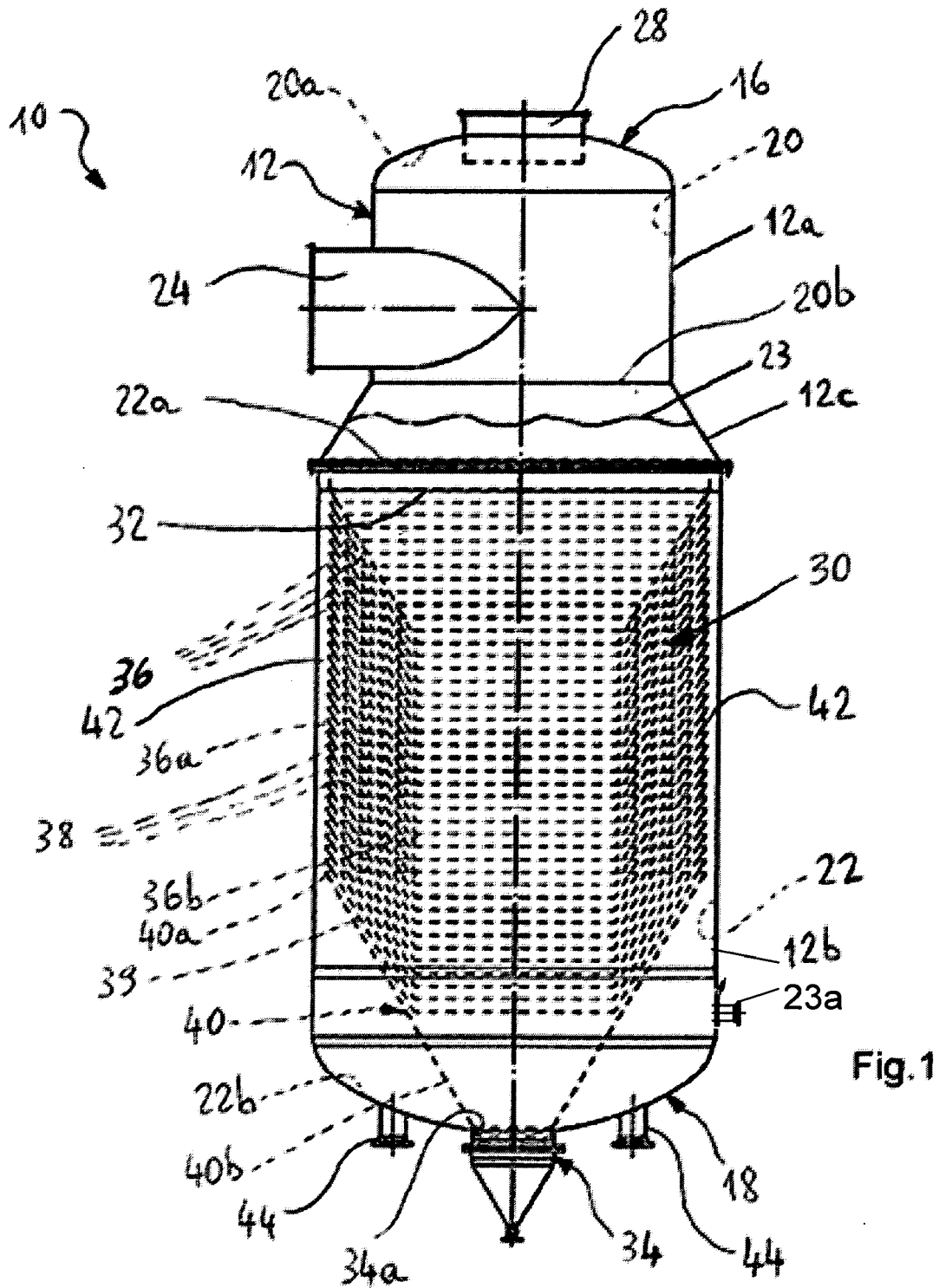
4. Apparatus (10) according to any one of the preceding claims, **characterized in that** said substantially cylindrical shell (12) comprises an upper portion (12a) having lesser diameter and axial length than the diameter and axial length, respectively, of the remain-

ing portion (12b), for which it substantially constitutes a dome, said first chamber (20) being defined in said upper "dome" portion (12a), said second chamber (22) being defined in the remaining portion (12b) of said shell (12).

5. Apparatus (10) according to claim 4, **characterized in that**, between the upper portion (12a) and the remaining portion (12b), the shell (12) comprises a connection portion (12c) having frustoconical shape. 5
6. Apparatus (10) according to any one of the preceding claims, **characterized in that** the plate device of particulate-sedimentation (30) comprises a plurality of plates (36), arranged parallel to each other, in mutual spaced relationship and tilted with respect to the axis of the shell (12). 10
7. Apparatus (10) according to claim 6, **characterized in that** the plates (36) are frustoconically-shaped, with the lesser base turned towards the lower bottom (18) of the shell (12) and with axis coinciding with that of the shell (12), said plates (36) being of equal size and superimposed on each other, in mutual spaced relationship, in a substantially head-tail arrangement and with partial mutual insertion inside each other, a plurality of interspaces (38) being identified between the plates (36). 15
8. Apparatus (10) according to claims 3 and 7, **characterized in that** below the lower plate (36) of said plurality of plates (36), a further frustoconical plate (40) is provided, always parallel to the plates (36) but having a more extended lateral surface than the plates (36), said lateral surface reaching the opening (34a) of the lower bottom (18) of said second chamber (22) where the discharge duct (34) arrives, positioned at the centre of the lower bottom (18). 20
9. Apparatus (10) according to claim 8, **characterized in that** between said shell (12) and the upper ends (36a) of the plates (36), as well as between said shell (12) and the upper end (40a) of the further plate (40), an annular space is identified, which identifies an interspace (42) between the shell (12) and plate device of particulate-sedimentation (30), said interspace (42) having cylindrical-annulus shape. 25
10. Apparatus (10) according to any one of the preceding claims, **characterized in that** at least one duct (44) is provided in the lower bottom (18) for the discharge of sludges with extremely reduced particulate content. 30
11. Apparatus (10) according to any one of the preceding claims, **characterized in that** said inlet duct (24) of a synthesis gas flow to be purified is in fluid communication and substantially constitutes the last part of 35

a station (54) of washing with water, comprising a duct (56) equipped with nozzles (58) which inject cooling water into a flow of hot synthesis gas to be purified.

12. Energy valorization plant (50) of refuses and/or biomasses, comprising a gasification reactor (52) in which said refuses and/or biomasses are subjected to gasification, for the obtainment of a continuous flow of hot synthesis gas which undergoes a cooling in a station (54) of washing with water, **characterized in that** it comprises an apparatus (10) for the purification of said synthesis gas flow according to any one of the preceding claims. 40



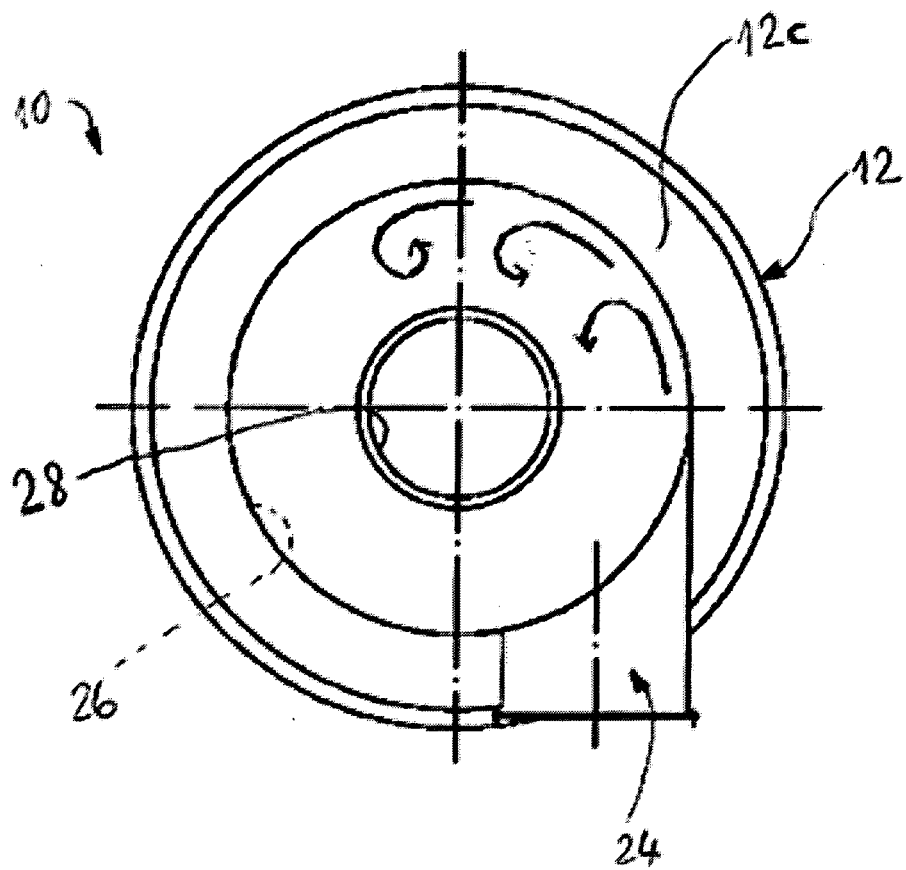


Fig.2

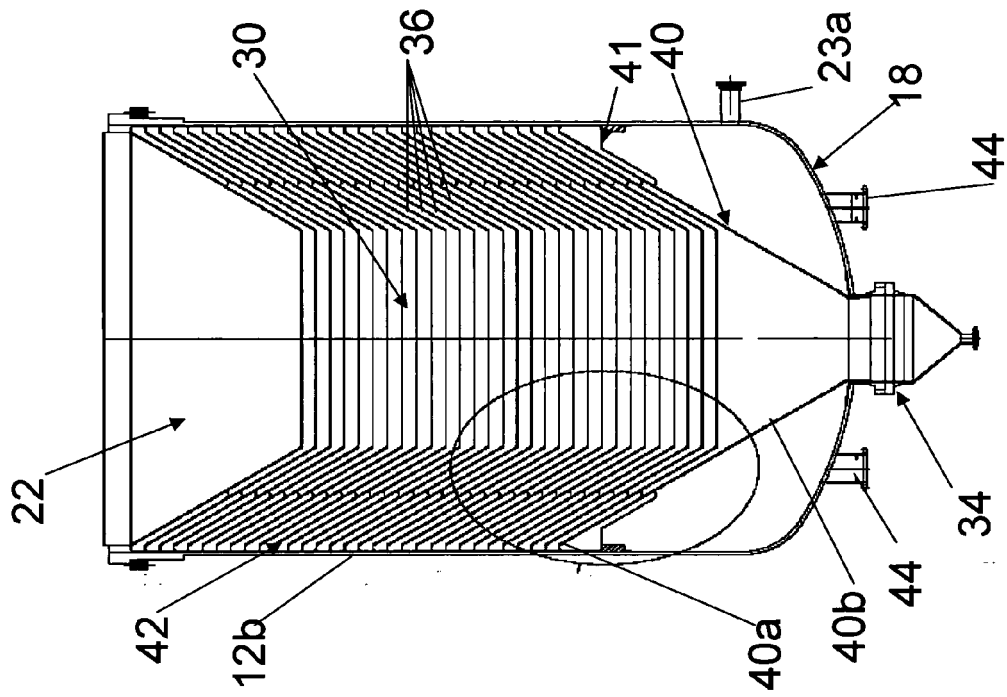


Fig.3

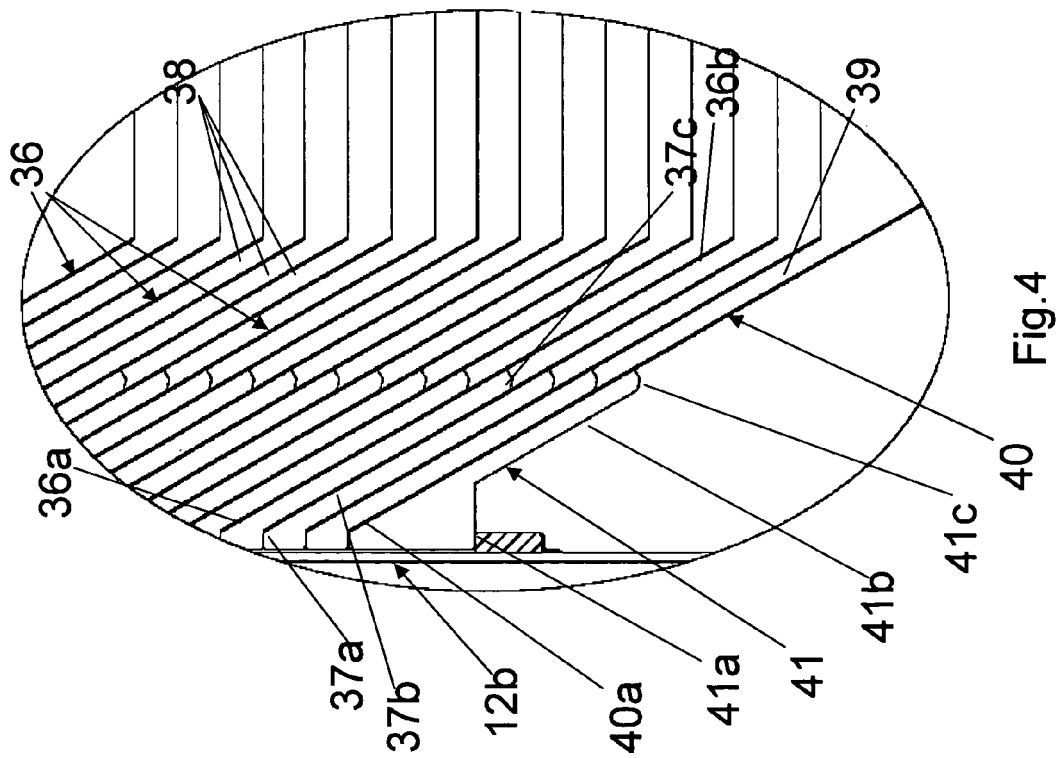
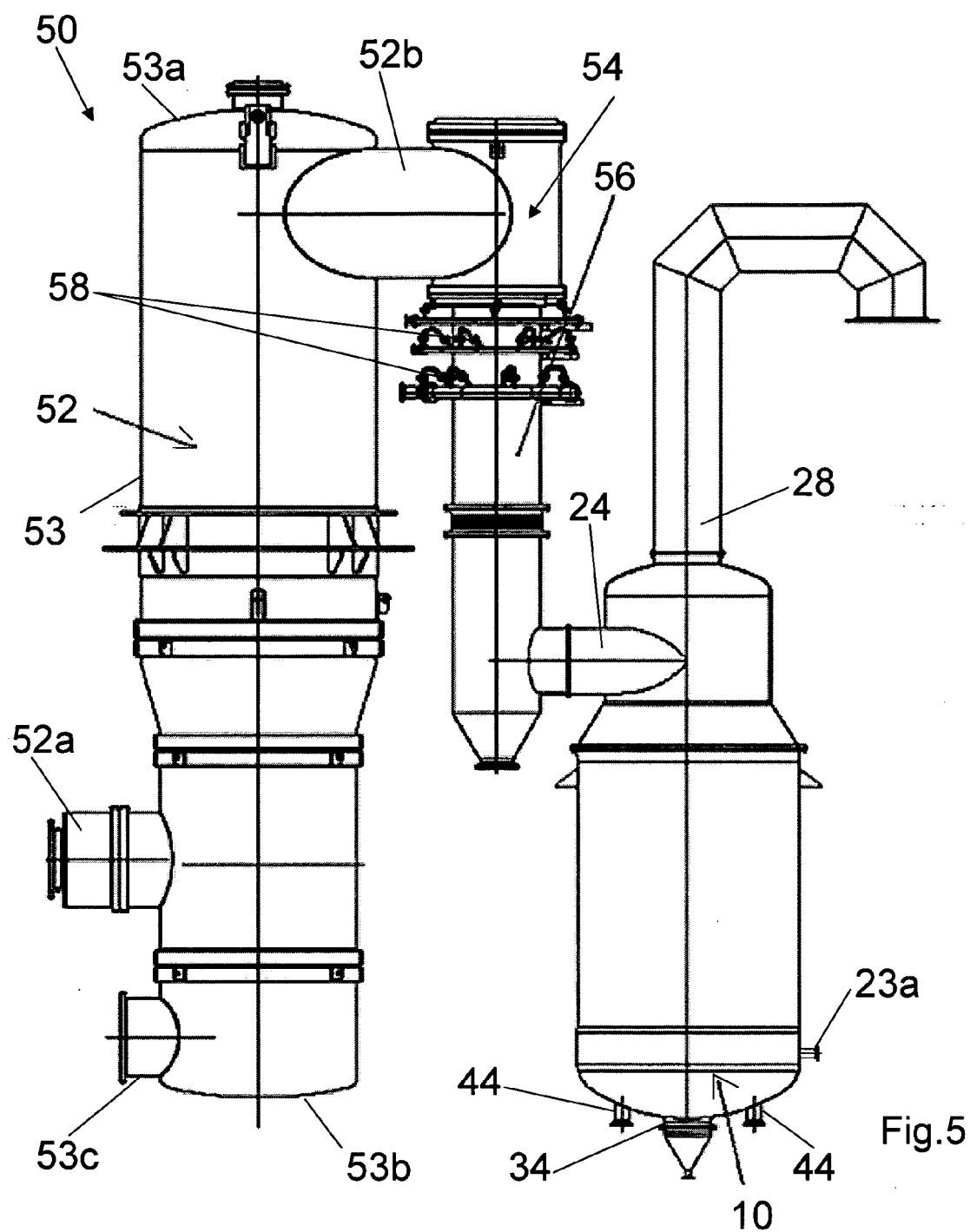


Fig.4





European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 07 00 7269

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
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Place of search		Date of completion of the search	Examiner
The Hague		5 November 2007	Lapeyrère, Jean
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 07 00 7269

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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