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(54) **The method of gas production from at least partially gasifiable solid material and the device for implementation of this method**

(57) Into the reaction zone (2), which is located inside the reactor (1), the inlet (3) of at least partially gasifiable solid material, at least one inlet (4) of the gasification agent, the outlet (5) of the produced gas and the outlet (6) of the non-gasified residue are introduced. A part of the reaction zone (2) is the space (7) for forming the fixed bed (8) of at least partially gasifiable solid material, to which the inlet (3) of at least partially gasifiable solid material is introduced. The reactor (1) involves at least one grid (10) which is located between the reaction zone (2) and the outlet (6) of the non-gasified residue. With advantage, an inlet of gasifiable liquid may be introduced into the reaction zone (2). An equipment for preheating of at least partially gasifiable material may be located in the inlet (3) of at least partially gasifiable solid material. To preheat the gasification agent, the equipment (13) for preheating the gasification agent may be located in the inlet (4) of the gasification agent. The equipment for preheating of gasified liquid may be located in the inlet of gasified liquid. With benefit, the reaction zone (2) is surrounded by the thermal insulation (15), which is resistant to the temperature of 1600° C.

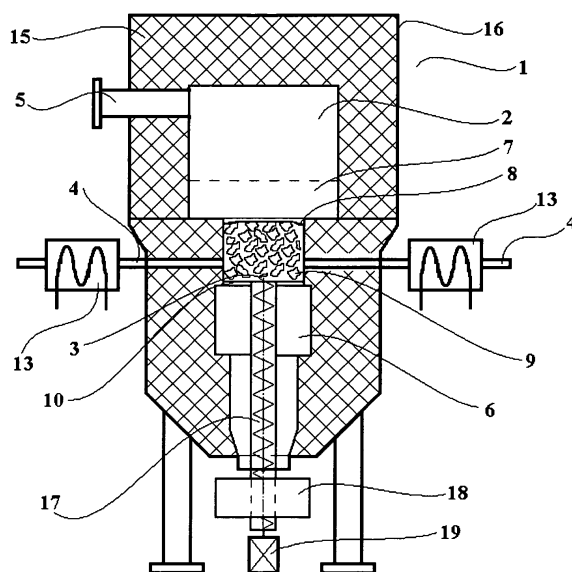


Fig. 1

Description

Technical Field

[0001] The invention refers to the method of gas production from at least partially gasifiable solid material and the device for the implementation of this method and it solves especially the production of gas intended for the use as a fuel for spark-ignition combustion engine or for turbine for driving of an electric generator, or the production of gas as resource for chemical production.

Description of Prior Art

[0002] It is known that reactors with fixed bed, fluidized bed, or entrained flow reactors, which have the reaction zone, separated from the surrounding atmosphere are used for gasification of fuels and wastes for the purpose of production of an energetically or chemically utilizable gas. In case of gasification of biomass, fossil fuels, sorted municipal solid waste and similar matters, the disadvantage of the gas being produced is its insufficient purity that causes complications during subsequent processing. The gas produced by such technique, has generally a higher content of tar compounds and solid particles, which are unacceptable for gas use in recent equipments.

[0003] Whereas the removal of solid particles from the produced gas does not represent any major technical problem, the removal of condensable components, e.g. tars, represents a technical - economic problems to be solved. In the case the temperature of the produced gas does not reach at least 800°C, it is not possible to use a catalytic destruction of organic impurities and scrubbing must be used for the gas cleaning, which is problematic at an equipment with output up to 500 kW/h, because the ecologic regeneration of scrubbing medium is very expensive and represents an increase of both, the capital and operational expenditures.

[0004] From the CZ patent No. 285142 it is known a generator for gasification of biomass, to the reaction zone of which an inlet of gasification agent is introduced. The generator has a top entry and arising gas leaves the reaction zone together with the non-gasified residue through a grid located at the lower part of the generator. Consequently, the arising gas gets out while passing the inter-space in the wall of the generator and its heat preheats biomass that is located in the reaction zone. The disadvantage of this generator is that the gas going out of the generator contains a large amount of condensable impurities, especially tar compounds which, with respect to low temperature of the gas, are not possible to remove immediately by catalytic destruction. Another disadvantage is that, in case of the material being gasified contains fine fractions, the processes run unevenly and some local overheating occurs. This leads partly to decreasing the quality of the produced gas, and partly it may cause a damage of the generator.

Disclosure of Invention

[0005] The mentioned disadvantages are solved by the method of gas production from at least partially gasifiable solid material and the device for implementation of this method, according to this invention.

[0006] The basis of the method is that the first portion of particles of at least partially gasifiable solid material is piled inside the reaction zone into a fixed bed of at least partially gasifiable solid material, whereas the other portions of at least partially gasifiable solid material are continually and/or by pulse procedure introduced under the surface of this fixed bed. In this way, the particles creating the fixed bed of at least partially gasifiable solid material are transported from the inside of this fixed bed towards periphery of it, and at the same time, they are exposed to the influence of gasification agent, which is introduced into the reaction zone. At the same time the gasification agent penetrates at least partially under the surface of the fixed bed of at least partially gasifiable solid material. Particles of at least partially gasifiable solid material which reached the surface of the fixed bed of at least partially gasifiable solid material pass into the fluidized bed due to flow of gases and/or to the outlet of the non-gasified residue due to gravity. Particles that remain in fluidized bed are exposed further to the influence of gases that are present in the reaction zone until the conversion of these particles into the produced gas and the non-gasified residue. Non-gasified residue is removed from the reaction zone separately and/or it is carried out by the produced gas. Alternatively, gasified liquid is introduced additionally into the reaction zone. According to another alternative, at least one compound, selected from the group: at least partially gasifiable material, gasification agent, gasified liquid, is preheated before its introduction into the reaction zone.

[0007] The basis of the device, formed by the reactor, into the reaction zone of which the inlet of at least partially gasifiable solid material, at least one inlet of gasification agent, an outlet of the produced gas and an outlet of the non-gasified residue are introduced is that a part of the reaction zone is formed by a space for forming the fixed bed of at least partially gasifiable solid material, into which the inlet of at least partially gasifiable solid material is introduced. Alternatively, the reactor involves further at least one grid located between the reaction zone and the outlet of non-gasified residue. According another alternative, at least one inlet of gasified liquid is introduced into the reaction zone. According to other alternatives, an equipment for preheating of at least partially gasifiable material is located in the inlet of at least partially gasifiable material, the equipment for preheating of gasification agent is located in the inlet of the gasification agent, and the equipment for preheating of gasified liquid is located in the inlet of gasified liquid. Alternatively, the reaction zone is surrounded by the thermal insulation that is resistant to the temperature of 1600°C.

[0008] The Advantage of this method according to the

invention is, that using of this method enables an ecological transformation of raw material and waste into further utilisable material. The advantage of the device, according to the invention, is the possibility to optimize the process control by accurate dosage of the gasified substance, and the possibility to reach temperature of the produced gas within the range of 600 and 1200°C, which allows an effective catalytic destruction of organic compounds. Another advantage relating to the produced gas is a low content of impurities that could condense when cooled down, e.g. tars, and therefore a subsequent cleaning method of the gas is not expensive.

Description of the Drawings

[0009]

Figure 1 illustrates schematically a vertical section of the device according to the example 1, whereas the figure 2 represents the same according to the example 2.

Examples of Embodiments

Example 1

[0010] According to the example 1, the reaction zone 2 is situated inside the reactor 1. The reaction zone 2 is surrounded by thermal insulation 15, which is covered by the steel casing 16 from the outside of the reactor 1. At the lower part of the reaction zone 2 the grid 10 with the shape of annulus is located. Vertically oriented screw conveyor 17 passes through the centre of the grid 10 and is driven by a driving mechanism 19 that represents the inlet 3 of at least partially gasifiable solid material from the storage hopper 18 into the reaction zone 2. Lower part of the reaction zone 2 is the space 7 for forming the fixed bed 8 of at least partially gasifiable solid material. In the space 7 for forming the fixed bed 8 of at least partially gasifiable solid material, four inlets 4 of the gasification agent are introduced equidistantly around the circumference of the reactor 1. Inlets 4 of the gasification agent are fitted by the equipment 13 for preheating of the gasification agent. The outlet 5 of the produced gas is located at the upper part of the reaction zone 2.

[0011] In the device according to the example 1, the produced gas is made by gasification of a mixture of wood chips and sorted communal waste. Particles 9 of at least partially gasifiable solid material are placed in the storage hopper 18, from where they are transferred by the screw conveyor 17 to the space 7 for forming the fixed bed 8 of at least partially gasifiable solid material. When starting the process, the space 7 for forming the fixed bed 8 of at least partially gasifiable solid material is filled with particles 9 by the screw conveyor 17 at first, whereupon blowing of the gasification agent consisting of a mixture of air with pure oxygen, preheated to temperature of 500°C, is started into the fixed bed 8 of at least partially

gasifiable solid material. Thanks to the increased temperature in the environment, consisting of increased content of oxygen, a spontaneous ignition of particles 9 of at least partially gasifiable solid material occur around the inlets 4 of the gasification agent into the reaction zone 2. Subsequently, the other portions of the particles 9 of at least partially gasifiable solid material are added by the screw conveyor 17 with continuous run to the space 7 for forming the fixed bed 8 of at least partially gasifiable solid material. The new added particles 9 drive gradually the particles 9 transferred sooner into the reaction zone 2 out from the centre of the reaction zone 2 to the periphery of the fixed bed 8 of at least partially gasifiable solid material. From the periphery of this fixed bed these particles 9 pass to the fluidized bed, which is located in the reaction zone 2 above the fixed bed 8 of at least partially gasifiable solid material. After the reaction zone 2 was heated up sufficiently, the gasification agent starts to be enriched by water vapour. Through the reaction of the particles 9 with gases, which are present in the reaction zone 2, the gasification of the particles 9 occurs, whereas the smaller particles of the non-gasified residue are carried out from the reaction zone 2 through the outlet 5 of the produced gas, together with the produced gas and the heavier particles of the non-gasified residue fall down through the grid 10 to the outlet 6 of the non-gasified residue. Additionally to nitrogen, the produced gas contains followed significant fraction: Carbon monoxide, carbon dioxide, methane, hydrogen and water vapour. Since virtually all nitrogen presented in the produced gas came from the gasification agent, which is the air, the content of nitrogen is, thanks to the addition of oxygen in the gasification agent, lower than it would be in the case of using only air as the gasification agent.

Example 2

[0012] Inside the reactor 1, according to the example 2, the reaction zone 2 is situated. Reaction zone 2 is surrounded by the thermal insulation 15, which is from the outside of the reactor 1 covered by the steel casing 16. At the lower part of the reaction zone 2 the circular grid 10 is situated. Diagonally oriented screw conveyor 17 is driven by driving mechanism 19 and passes through sidewall of the reactor 1. The screw conveyor 17, represents the inlet 3 of at least partially gasifiable solid material from the storage hopper 18 to the reaction zone 2. The screw conveyor 17 is fitted with the equipment 12 for preheating of at least partially gasifiable solid material. The lower part of the reaction zone 2 represents the space 7 for forming the fixed bed 8 of at least partially gasifiable solid material. Into the space 7 for forming the fixed bed 8 of at least partially gasifiable solid material, four inlets 4 of the gasification agent are introduced. Further, to the space 7 for forming the fixed bed 8 of at least partially gasifiable material, second inlet 20 of gasified liquid is introduced. Second inlet 20 of gasified liquid is fitted with the equipment 14 for preheating of gasified

liquid. The first inlet 11 of the gasified liquid is introduced into the reaction zone 2 above the space 7 for forming the fixed bed 8 of at least partially gasifiable solid material. The outlet 5 of the produced gas is located in the upper part of the reaction zone 2.

[0013] In the device, according to the example 2, the produced gas is made by gasification of wood pellets of cylindrical shape, with diameter 0,8 cm and length 3 cm, that have been produced by pressing of wood saw dust remained after cutting of chipboard. Saw dust contain, except wood, also binders, which were used in production of chipboard. Differently from the example 1, only air at ambient temperature, e.g. 20°C, is used as gasification agent, the process is initiated by ignition of the first batch of pellets using a burner, which is not shown in the drawing, the wood pellets are dosed periodically to the reaction zone based on a signal from sensors, measuring the height of the fixed bed 8 of at least partially gasifiable solid material. Thermal balance in the reaction zone 2 is increased by preheating of at least partially gasifiable solid material to temperature 400°C. Furthermore, the production according to the example 2 differs from the production according to the example 1 in that the gasified liquid is additionally, introduced into the reaction zone 2 through two inlets 11, 20 of gasified liquid, which is waste oil from a food production. The part of the waste oil which is introduced in the fluidized bed has the ambient temperature, 20°C in this case, whereas the part of oil which is introduced into the fixed bed 8 of at least partially gasifiable solid material is preheated, prior the entering into the reaction zone 2, to the temperature within the interval from 100 to 200° C. The produced gas contains the same gases as the gas produced according to the example 1, however the content of nitrogen is higher than it was at the gas produced according to the example 1.

Industrial Applicability

[0014] The invention is possible to use wherever it is appropriate to convert the combustible solid material to flammable or chemically treatable gas, especially in disposals of wood-based wastes, cellulose-based wastes and plastic wastes.

Claims

1. The method of gas production from at least partially gasifiable solid material, using the effect of gasification agent, **characterised in that** the first portion of particles of at least partially gasifiable solid material is piled inside the reaction zone into a fixed bed of at least partially gasifiable solid material, whereas the other portions of at least partially gasifiable solid material are continually and/or by pulse procedure introduced under the surface of this fixed bed, thereby the particles creating the fixed bed of at least partially gasifiable solid material are transferred from

the inside of this fixed bed of at least partially gasifiable solid material towards its periphery, and at the same time, the particles of at least partially gasifiable solid material are exposed to the influence of the gasification agent, which is introduced into the reaction zone, in the process the gasification agent penetrates at least partially under the surface of the fixed bed of at least partially gasifiable solid material and furthermore, the particles of at least partially gasifiable solid material which reached to the surface of this fixed bed pass into the fluidized bed, due to the flow of gases and/or pass into the outlet of the non-gasified residue due to gravity, whereas the particles in the fluidized bed are exposed further to the influence of gases that are present in the reaction zone until the conversion of these particles into the produced gas and the non-gasified residue, which is removed from the reaction zone separately and/or is carried out by the produced gas.

2. The method according to the claim 1 **characterised in that** gasified liquid is introduced additionally into the reaction zone.

3. The method according to the claim 1 or 2 **characterised in that** at least one compound selected from the group: at least partially gasifiable material, gasification agent, gasified liquid, is preheated before its introduction into the reaction zone.

4. The device for the gas production formed by the reactor (1), into the reaction zone (2) of which the inlet (3) of at least partially gasifiable solid material, at least one inlet (4) of gasification agent, the outlet (5) of the produced gas, the outlet (6) of the non-gasified residue are introduced, **characterised in that** a part of reaction zone (2) is formed by the space (7) for forming the fixed bed (8) of at least partially gasifiable solid material, into which the inlet (3) of at least partially gasifiable solid material is introduced.

5. The device according to the claim 4 **characterised in that** the reactor (1) involves further at least one grid (10) which is located between the reaction zone (2) and the outlet (6) of the non-gasified residue.

6. The device according to the claim 4 **characterised in that** at least one inlet (11) of gasifiable liquid is introduced additionally into the reaction zone (2).

7. The device according to the claim 4 **characterised in that** the equipment (12) for preheating of at least partially gasifiable solid material is located in the inlet (3) of at least partially gasifiable solid material.

8. The device according to the claim 4 **characterised in that** an equipment (13) for preheating of gasification agent is located in the inlet (4) of the gasification

agent.

9. The device according to the claim 4 **characterised in that** a equipment (14) for preheating of gasified liquid is located in the inlet (11) of gasified liquid. 5
10. The device according to the claim 4 **characterised in that** the reaction zone (2) is surrounded by the thermal insulation (15) that is resistant to the temperature of 1600° C. 10

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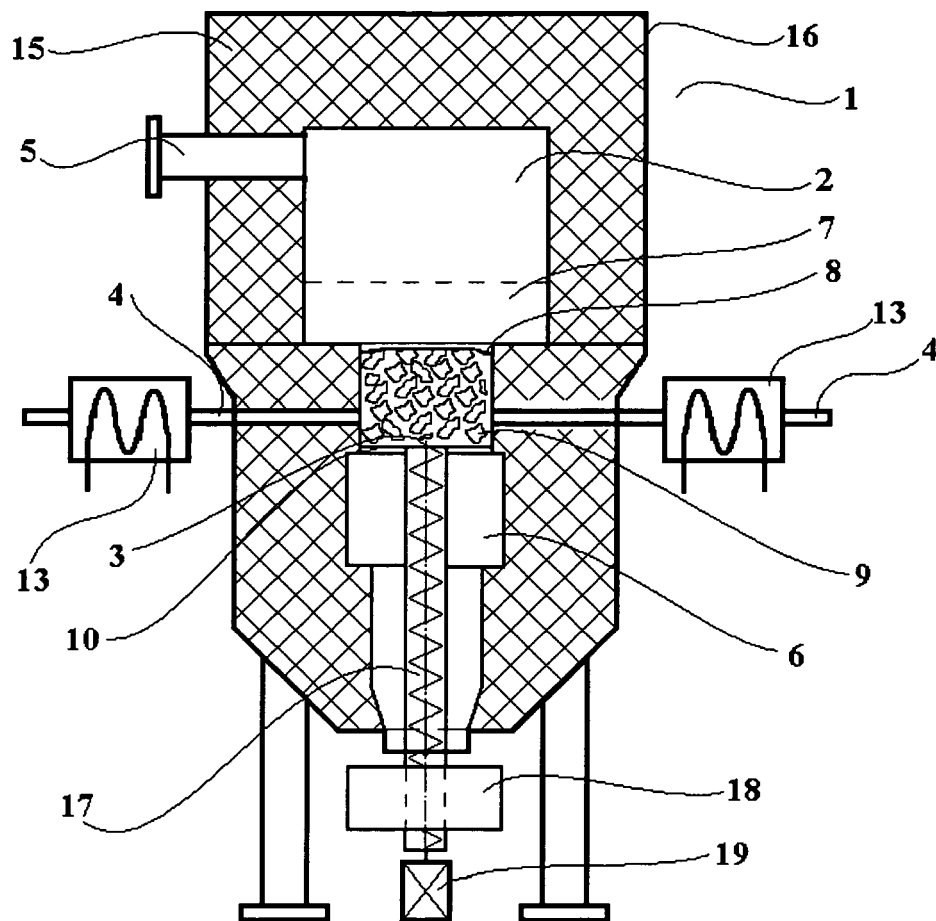


Fig. 1

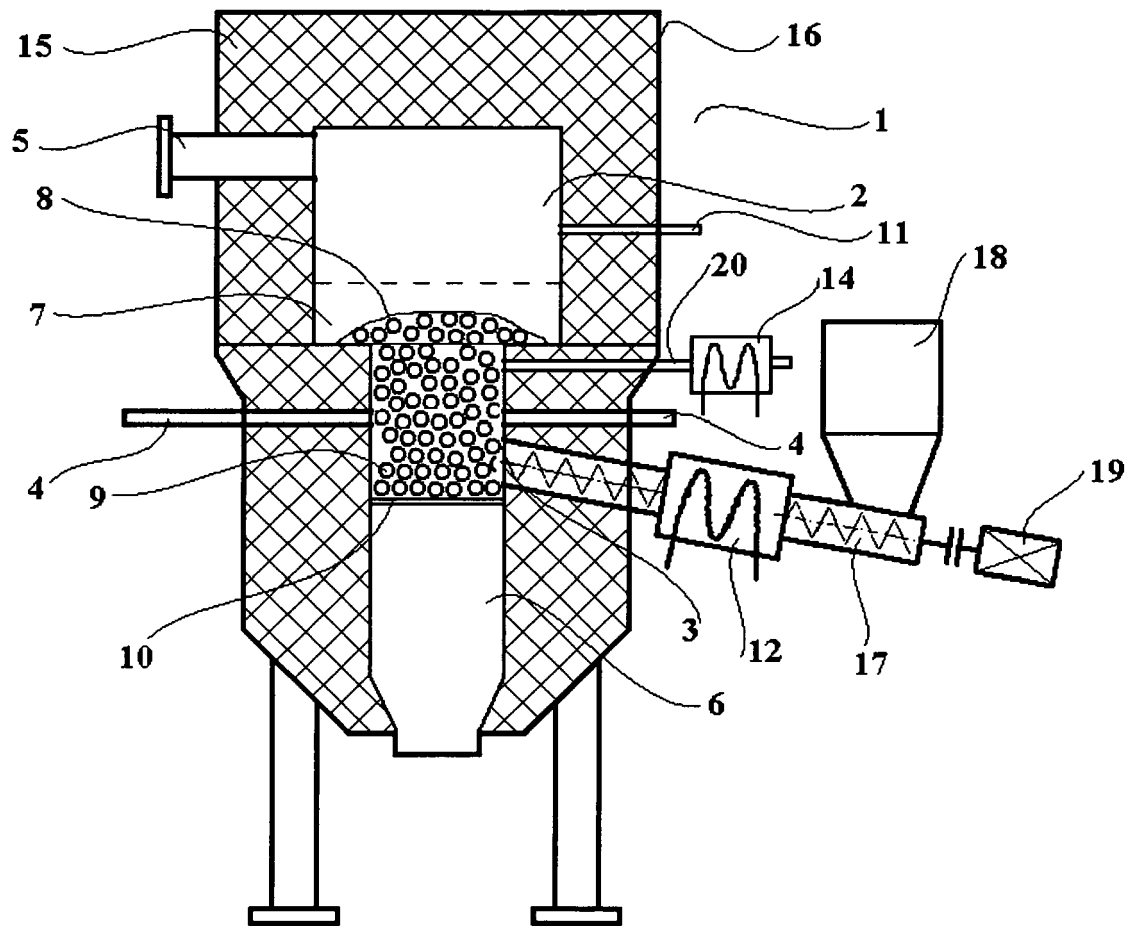


Fig. 2



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 07 46 6024

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 5 026 403 A (MICHEL-KIM HERWIG [DE]) 25 June 1991 (1991-06-25) * figure 3 * * figure 4 * * claim 1 * * column 2, lines 52-68 * * column 3, lines 1-7 * * column 5, lines 63,64 * * column 6, lines 31-66 * * column 7, lines 2-6,46-49,55-58 * * column 8, lines 37-43 * -----	1-10	INV. C10J3/66 C10J3/06 C10J3/30 C10J3/48
A	WO 99/35214 A (GREENPOWER ENGINEERING & TECHN [CH]; JACCARD LEON [CH]; JACCARD JEAN P) 15 July 1999 (1999-07-15) * figures 6a,6b * * paragraphs [0037], [0038] * -----	1-10	
A	US 2004/107638 A1 (GRAHAM ROBERT G [US] ET AL) 10 June 2004 (2004-06-10) * the whole document * -----	1-10	TECHNICAL FIELDS SEARCHED (IPC)
A	US 6 120 567 A (CORDELL HENRY L [US] ET AL) 19 September 2000 (2000-09-19) * the whole document * -----	1-10	C10J
A	WO 2006/056053 A (DAVISON KENNETH [CA]) 1 June 2006 (2006-06-01) * the whole document * -----	1-10	
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 28 April 2008	Examiner Lachmann, Richard
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 07 46 6024

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28-04-2008

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 5026403	A	25-06-1991	DE 3335544 A1	04-04-1985
			EP 0136255 A2	03-04-1985
			JP 1896021 C	23-01-1995
			JP 6013718 B	23-02-1994
			JP 60092393 A	23-05-1985

W0 9935214	A	15-07-1999	AU 739245 B2	04-10-2001
			AU 1574299 A	26-07-1999
			BR 9906798 A	17-10-2000
			CA 2348406 A1	15-07-1999
			CH 693034 A5	31-01-2003
			EP 1044248 A1	18-10-2000
			PL 341437 A1	09-04-2001
			SK 10472000 A3	11-12-2000
			US 6786943 B1	07-09-2004

US 2004107638	A1	10-06-2004	NONE	

US 6120567	A	19-09-2000	NONE	

W0 2006056053	A	01-06-2006	AU 2005309273 A1	01-06-2006
			CA 2527662 A1	23-05-2006
			EP 1838817 A1	03-10-2007

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- CZ 285142 [0004]