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(54) **Circulating fluidized bed boiler**

(57) The invention relates to a circulating fluidized bed boiler (1) comprising a combustion chamber (2), characterized in that the combustion chamber (2) comprises:
- first heat transfer surfaces (7) forming at least one vertical chamber extending from a lower part (5) of the combustion chamber (2), and
- second heat transfer surfaces (8) having an inlet part and an outlet part which extend both from an upper part (6) of the combustion chamber (2), said second heat transfer surfaces (8) being fixed to vertical chambers (7).

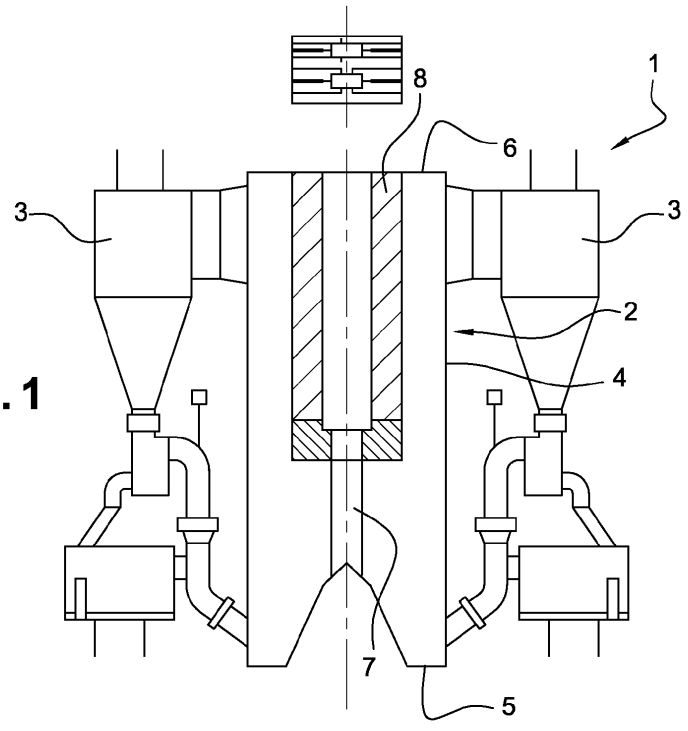

Fig. 1

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Description

[0001] The present invention is related to a circulating fluidized bed (CFB) boiler, including a reactor where the solid particles are fluidized and where chemical reactions and/or combustion reactions can take place. The circulating fluidized regime enhances the mixing of particles along with potential exothermic or endothermic chemical reactions.

[0002] The furnace of a conventional fluidized bed boiler is defined by four external side walls, a bottom and a roof and potentially inner walls to ensure the sealing with the outside if multiple fluidizing grates are used. All the walls constitute an ash-tight enclosure in which the solid particles including the fuel material are fluidized.

[0003] Air is introduced into the furnace to fluidize the solid particles and also brings the needed oxygen for combustion. Two air streams can be used. Primary air is mostly used to fluidize the particles, flows through the fluidizing grate which constitutes the bottom of the furnace. Secondary air is the additional air required for a complete combustion and is introduced through several ports located over the external side walls and/or inner walls if the bottom part of the furnace comprises a dual fluidizing grate and whose shape can be described like a pant leg.

[0004] The furnace enclosure is usually made of gastight panels formed with finned tubes. The heat released from the combustion of fuel is transferred to water or steam flowing inside the tubes and also allowing the tubes to be cooled. When increasing the capacity of the boiler, the overall surface of the furnace enclosure cannot match the total heat released from the combustion and additional surfaces have to be implemented either in the furnace and/or potentially in external devices of the furnace that are supplied with the solid particles escaping the furnace and collected by the cyclones before returning to the furnace. Increasing the height of the furnace may be also considered but this solution is not cost-effective and can result in mechanical problems or worst performances.

[0005] Wing walls or U-shaped panels can be implemented for increasing the heating surface in the furnace. Wing walls are usually made of panels with totally or partly finned tubes and are laid out in a vertical area. A header is usually located at the top of the wing and a header is usually located at the bottom of the wing. The panels cross the vertical side wall of furnace with a gastight connection which prevents any displacement of panels over the crossing zone with the side wall. The panels also cross the roof where a vertical displacement due to the thermal expansion is allowed via the expansion joint.

[0006] A U-shaped panel is made of two panels with or without finned tubes that are laid out in a vertical plan and are connected at one of their extremities by tubes for ensuring a continuous path for the fluid. The fluid inside the tubes flows down through the first panel and flows up through the second panel after being returned into the bottom of the U shape. A U-shaped panel is usually not drainable due to the location of the headers which are at the top of panel. When using a U-shaped panel in the CFB furnace the inlet and outlet headers can be located above the roof so that the tip of the U-shaped panel is free to displace in all the horizontal directions. A fluidizing regime can lead to vibrations of the U-shaped panel which leads to mechanical failures. The magnitude of the displacement is linked to the height of the U-panel so that the risk of failure due to vibration increases with the height of U-shaped panel.

[0007] Thus, an object of the present invention is to provide a circulating fluidized bed boiler as to solve the above- described problems.

[0008] The object mentioned above is accomplished by a circulating fluidized bed boiler comprising a combustion chamber comprising:

- first heat transfer surfaces forming at least one vertical chamber extending from a lower part of the combustion chamber, and
- second heat transfer surfaces having an inlet part and an outlet part which extend both from an upper part of the combustion chamber, said second heat transfer surfaces being fixed to vertical chambers.

[0009] Every vertical chamber is preferably made of gastight panels formed with finned tubes and every second heat transfer surface can be made of tube panels.

[0010] Each second heat transfer surface is preferably U-shaped.

[0011] The combustion chamber being defined by side walls, a roof and a bottom, the first heat transfer surfaces can extend from the bottom or from inclined walls joining the bottom and the second heat transfer surfaces can extend from the roof of the combustion chamber. The second heat transfer surfaces could alternatively extend from an upper part of the side walls.

[0012] Every U-shaped second heat transfer surface can comprise two vertical parts that are fixed at its lower extremity to a chamber.

[0013] Each U-shaped second heat transfer surface can extend downwards at least 40% of the height of the combustion chamber, and preferably between 40 and 70% of the height of the combustion chamber. This high extension rate is made possible thanks to the specific heat transfer structure according to the invention.

[0014] Several second heat transfer surfaces can be fixed to the same vertical chamber.

[0015] Every second heat transfer surface can pass through the chamber.

[0016] The part of the second heat transfer surface that is located inside the chamber preferably comprises at least one bended portion.

[0017] The second heat transfer surface can be made of tube panels, the tubes entering and leaving the vertical chamber in a direction parallel to a vertical axis of symmetry of the second heat transfer surface (for instance

the longitudinal axe in the case the horizontal cross-section of the vertical chamber is a rectangle), and the tubes can have a first bended portion on one side of the axis of symmetry followed by a second bended portion on the other side of the axis of symmetry.

[0018] The horizontal cross-section of the vertical chamber can be a polygon (for instance a rectangle) or a circle.

[0019] Each second heat transfer surface can comprise a bottle for draining the condensates during the start-up of the boiler.

[0020] Other features and advantages of the invention will become apparent from the following description, and with reference to the accompanying drawings, in which:

- Figure 1 is a vertical, cross-sectional view of a circulating fluidized bed boiler of the invention,
- Figure 2 is a partial vertical section view of the boiler,
- Figure 3 is a partial horizontal section view of the boiler,
- Figure 4 is a partial vertical section view of the boiler,
- Figure 5 is a partial horizontal section view of the boiler
- Figure 6 is a partial horizontal section view of a first embodiment,
- Figure 7 is a partial horizontal section view of a second embodiment, and
- Figure 8 is a partial horizontal section view of a third embodiment.

[0021] Figure 1 illustrates a fluidized bed reactor having an exemplary structure according to the present invention. The main parts of the boiler 1 are the furnace 2 and the particle separators 3. The furnace 2 is defined by side walls 4, a bottom 5 and a roof 6. The furnace 2 is provided with ports for feeding fuel and other bed material, e.g. sand and limestone. The bottom 5 of the furnace 2 is provided with means for supplying air for fluidizing the bed material. The lower portion of the furnace 2 is also provided with ducts for supplying secondary air.

[0022] By means of the air deliveries to the boiler 1 the combustion of fuel is maintained. Ash and bed material are discharged together with the fluidizing air and flue gases through ducts to the separators 3, where most part of the solid material is separated from the flue gases and returned through a return pipe to the lower portion of the furnace 2.

[0023] The side walls 4 of the furnace can be formed of tube panels consisting of finned tubes not shown in detail in the figure. The energy released from the combustion of fuel is used for vaporizing the water flowing in the tubes of the side walls 4.

[0024] Inside the furnace there are chambers 7, for instance gas-tight chambers, made of tube walls extending from the bottom 5 of the furnace 2 to the top thereof. The walls of the chambers 7 are made of tube panels, the tubes of which are joined to feed pipes below the furnace and to header pipes above the furnace. Inside the chambers 7 there are preferably means for supplying secondary air and fuel to the center part of the furnace 2. The chambers 7 can be spaced away from the side walls 4 and arranged separately within the furnace 2, for the furnace volume to be free for the particles to move even in the proximity of said chambers 7.

[0025] The chambers 7 can extend from the bottom 5 of the furnace 2, or, as illustrated in figure 1, can extend from an inclined wall of a pant-leg configuration, i.e. a configuration in which inclined walls extend upwards the bottom 5. The pant-leg design is typical for higher capacity boilers because it allows for better secondary air penetration, maintaining good air-coal mixing as well as efficient combustion. The pant-leg structured CFB boiler features two separated legs with solid particles fluidized by independent primary air supplies.

[0026] The possible shapes of the chambers 7 are illustrated in figure 3. The cross-section of the chambers can be a rectangle, a circle or a polygon.

[0027] The furnace 2 further includes U-shaped panels 8 made of tubes and which are heating or superheating surfaces. The panels 8 are supported by headers located above the roof 6. In addition, the bottoms of the panels 8 are fixed to the chambers 7. This fixation makes it possible to prevent horizontal displacements of the bottom part of the panels 8.

[0028] As illustrated in Figure 2, every U-shaped panel 8 can be constituted of two L-shaped parts that are each fixed at a wall of a chamber 7.

[0029] The free space inside the box can be used for implementing a bottle 10 to drain the condensates during the start-up of the boiler. A drain pipe 11 is fitted to the bottom of the bottle 10 to evacuate the condensates (Figure 4).

[0030] As the U-shaped panel 8 is fixed to the chamber 7 over two different zones, the tubes of the panel 8 can be bended inside the box to make up for the difference of thermal expansion between the chamber 7 and the panel 8. As illustrated in Figure 5, the tubes can enter and leave the chamber in a direction parallel to the longitudinal axe of the rectangle, the tubes having a first bended portion on one side of the longitudinal axe followed by a second bended portion on the other side of the longitudinal axe. For instance, the tubes can have an inlet portion that is parallel to the longitudinal axe of the rectangle, followed by a first bended portion deflecting from the longitudinal axe on one side (for instance on the left-hand side), followed by a second bended portion deflecting from the longitudinal axe on the other side (on the right-hand side), followed by an outlet portion that is parallel to the longitudinal axe of the rectangle. The inlet portion and the first bended portion can be located in one half length of the rectangle whereas the second bended portion and the outlet portion can be located in the other half length of the rectangle.

[0031] Figure 6

[0032] illustrates a first embodiment of the boiler 1. In this embodiment, every panel 8 is connected to a cham-

ber 7 along with a dual grate design.

[0033] According to a second embodiment, panels 8 connected to chambers 7 alternate with panels 9 which are not connected to a chamber (Figure 7).

[0034] As illustrated in Figure 8, and according to a third embodiment, several panels 8 are connected to each chamber 7.

Claims

1. A circulating fluidized bed boiler (1) comprising a combustion chamber (2), **characterized in that** the combustion chamber (2) comprises:

   - first heat transfer surfaces (7) forming at least one vertical chamber extending from a lower part (5) of the combustion chamber (2), and
   - second heat transfer surfaces (8) having an inlet part and an outlet part which extend both from an upper part (6) of the combustion chamber (2), said second heat transfer surfaces (8) being fixed to vertical chambers (7).

2. A boiler (1) according to claim 1, **characterized in that** every vertical chamber (7) is made of gastight panels formed with finned tubes and **in that** every second heat transfer surface (8) is made of tube panels.

3. A boiler (1) according to claim 1 or 2, **characterized in that** each second heat transfer surface (8) is U-shaped.

4. A boiler (1) according to any of claim 1 to 3, **characterized in that** the combustion chamber (2) is defined by side walls (4), a roof (6) and a bottom (5), and **in that** the first heat transfer surfaces (7) extend from the bottom (5) or from inclined walls joining the bottom (5) and **in that** the second heat transfer surfaces (8) extend from the roof (6) of the combustion chamber (2).

5. A boiler (1) according to claim 3 or 4, **characterized in that** every U-shaped second heat transfer surface (8) comprises two vertical parts that are fixed at its lower extremity to a vertical chamber (7).

6. A boiler (1) according to any of claim 3 to 5, **characterized in that** each U-shaped second heat transfer surface (8) extends downwards at least 40% of the height of the combustion chamber (2).

7. A boiler (1) according to any of claim 1 to 6, **characterized in that** several second heat transfer surfaces (8) are fixed to the same vertical chamber (7).

8. A boiler (1) according to any of claim 1 to 7, **characterized in that** every second heat transfer surface (8) passes through the vertical chamber (7).

9. A boiler (1) according to claim 8, **characterized in that** the part of the second heat transfer surface (8) that is located inside the vertical chamber (7) comprises at least one bended portion.

10. A boiler (1) according to claim 9, **characterized in that** second heat
transfer surface (8) is made of tube panels, the tubes entering and leaving the vertical chamber (7) in a direction parallel to a vertical axis of symmetry of the second heat transfer surface and **in that** the tubes have a first bended portion on one side of the axis of symmetry followed by a second bended portion on the other side of the axis of symmetry.

11. A boiler (1) according to claim 10, **characterized in that** the horizontal
cross-section of the vertical chamber (7) is a polygon or a circle.

12. A boiler (1) according to any of claim 1 to 11, **characterized in that**
every second heat transfer surface (8) comprises a bottle (10) for draining the condensates during the start-up of the boiler (1).

Fig. 1

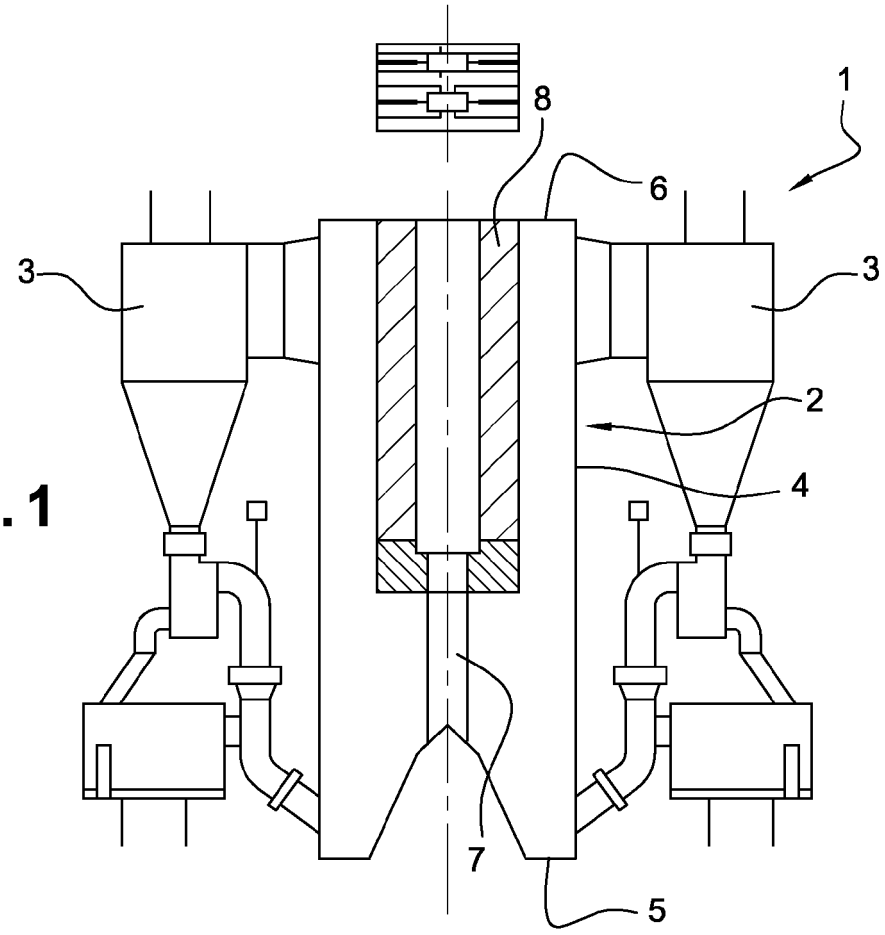
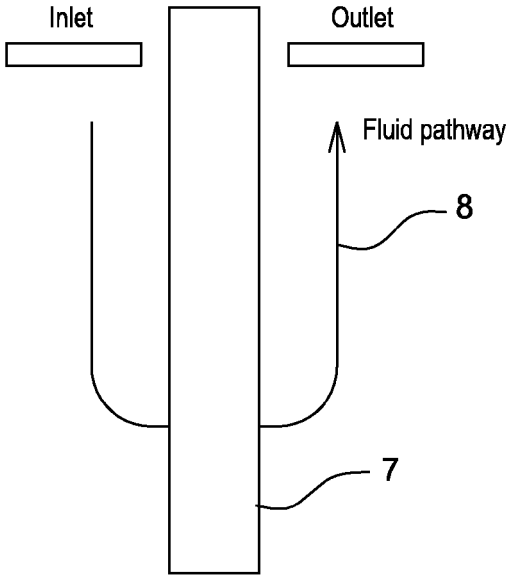


Fig. 2



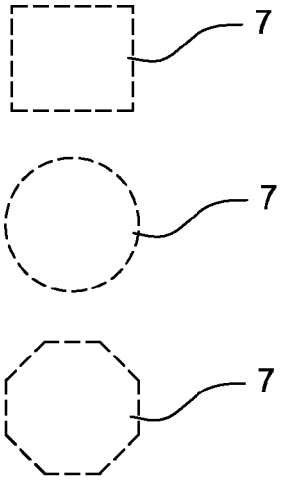


Fig. 3

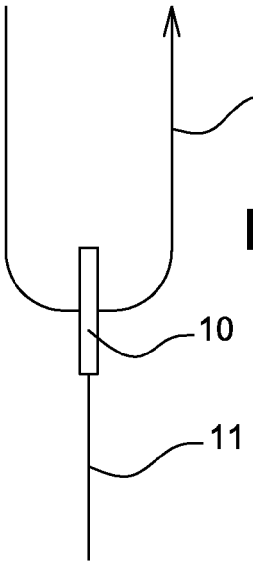


Fig. 4

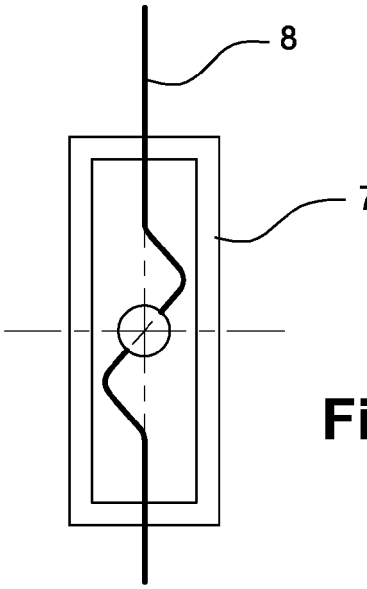


Fig. 5

Fig. 6

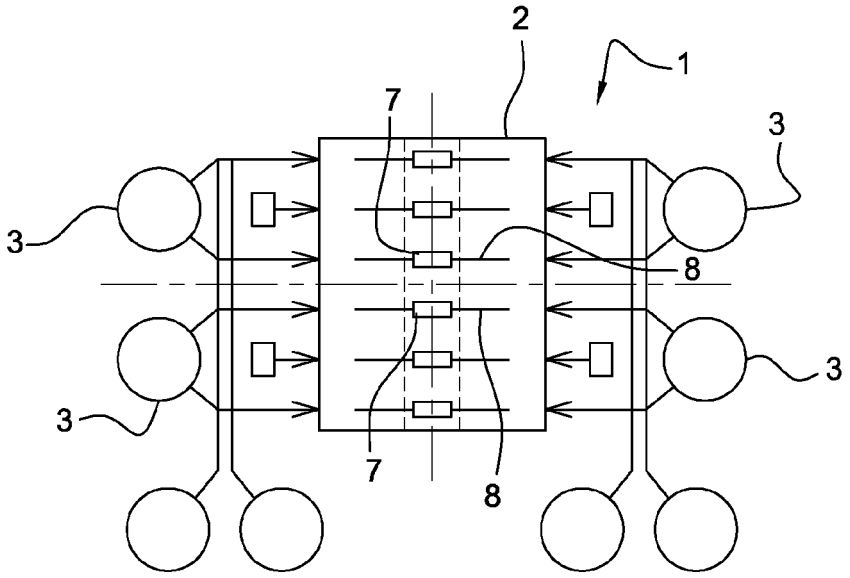


Fig. 7

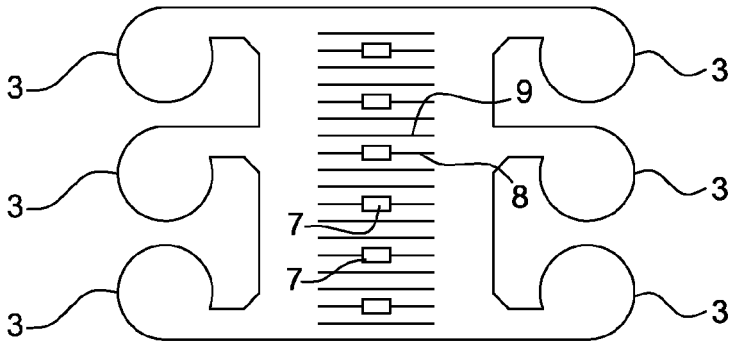
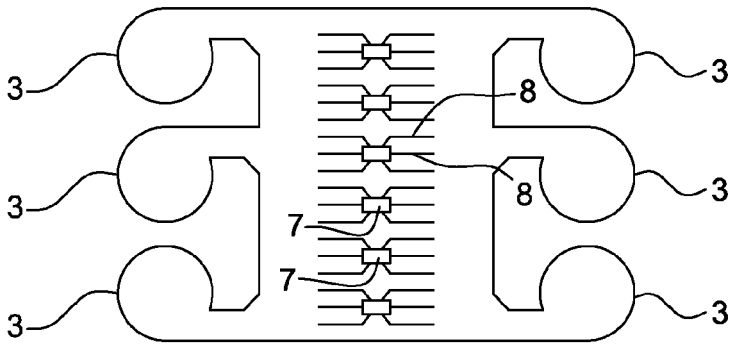


Fig. 8



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EUROPEAN SEARCH REPORT

Application Number
EP 12 16 0406

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	US 6 470 833 B1 (HYPPAENEN TIMO [FI]) 29 October 2002 (2002-10-29) * column 5, line 20 - line 49 * * column 6, line 5 - line 11 * * column 6, line 24 - line 29 * * figures 1-3,5 *	1-12	INV. F23C10/10 F23M5/08 F22B21/40 F22B31/00
Y	WO 92/11499 A1 (AHLSTROEM OY [FI]) 9 July 1992 (1992-07-09) * page 1, line 4 - line 9 * * page 12, line 36 - page 13, line 5 * * figure *	1-12	
A	US 2009/084293 A1 (MORIN JEAN-XAVIER [FR] ET AL) 2 April 2009 (2009-04-02) * page 1, paragraph 1 * * page 2, paragraph 45 - paragraph 46 * * figures 12c,14a-14g *	1	
A	US 2006/124077 A1 (WEISSINGER GERHARD [GB] ET AL WEISSINGER GERHARD [DE] ET AL) 15 June 2006 (2006-06-15) * page 3, paragraph 46 * * page 4, paragraph 55 * * figures 2,3,6 *	1	

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F23C
F23M
F22B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	19 July 2012	Gavriliu, Costin

CATEGORY OF CITED DOCUMENTS

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