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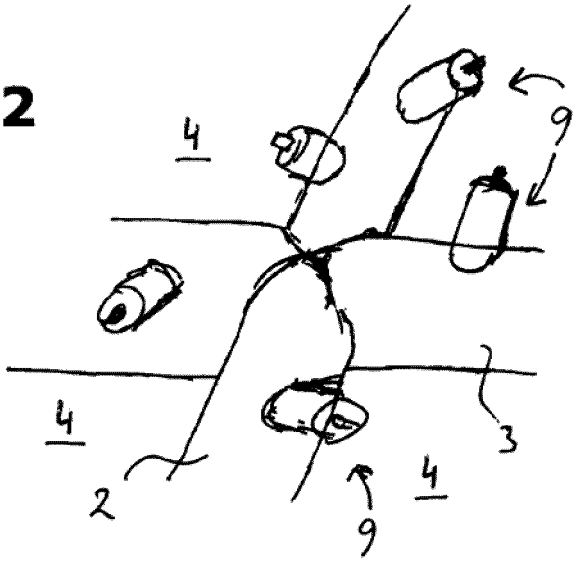
(54) A DEVICE FOR CLEANING AN EXHAUST GAS AND A METHOD FOR USING SAID DEVICE

(57) The invention relates to a device for cleaning a gas in a gas flow, comprising a burner to be positioned in said gas flow, said device comprising at least one first element (2) that extends in a first direction and that comprises burner nozzles (9) that are positioned at mutual distances. The device further comprises at least one second element (3) that extends in a second direction that is different from said first direction and that comprises burner nozzles (9) that are positioned at mutual distances, said first and second element are positioned in substantially the same plane, substantially perpendicular with respect to said gas flow, and said burner nozzles being positioned at an angle of 0° tot 80° with respect to the gas flow. Said device is embodied for igniting in said gas flow a gas to be fed through said burner nozzles.The invention further relates also to a method for cleaning a gas to be fed through a conduit, comprising the step of positioning in a channel at least one device according to any of the preceding claims, supplying said cleaning gas into said gas mixture through said burner nozzles and igniting said cleaning gas.

Fig. 2



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Description

[0001] The present invention relates to a device for cleaning a gas according to the preamble of claim 1. The invention also relates to a method for cleaning a gas by using this device.

[0002] Such a device is known in the art. For example, afterburners are used for burning not or incompletely burned fuels in flue gases.

[0003] Such known device can only provide a partial treatment of the products that need after treatment, like unburned fuels. Such yields environmental pollution due to these unburned fuels entering the environment. Furthermore, there is no sufficiently cleaning device for cleaning other pollutants.

[0004] As a consequence, a device is required that provides an adequate cleaning.

[0005] The invention aims at providing an improved device of the kind mentioned in the preamble.

[0006] The invention especially aims at providing a device of the kind mentioned above that is able to convert other products than unburned fuel into harmless substances.

[0007] Within the present description, the term "harmless substances" relates to substances and products that are less harmful to the environment and to people, than substances that were originally present in the gas flow to be cleaned.

[0008] The invention also aims at providing an improved method for cleaning a gas flow by using the present device.

[0009] So as to obtain at least one of the above mentioned goals, the invention provides according to a first embodiment a device comprising the features of claim 1. Said device has the advantage that the gas flow to be cleaned is brought in a condition that substantially all substances of said gas flow are brought into contact with the flames provided at the burner nozzles. This yields an excellent cleaning that could not be obtained thus far.

[0010] In this respect, it has shown that the shape of the elements is not of much importance. A square shape of said elements (beam-like elements) provides results that are much like results obtained with elements that are of round or oval shape (rod like elements).

[0011] The perpendicular or slanted positioning of the flames with respect to the gas flow provide an optimum mixing, such that cleaning is optimized. As mentioned before, it is especially preferred for the burner nozzles to be positioned at an angle of 0° to 80° with respect to the gas flow. The value of 0° means that the flames are directed perpendicular with respect to the gas flow, whereas a value of 80° means a difference of 10° with respect to the flow direction of the gas flow.

[0012] Preference is given to a device wherein said elements extend at an angle of 45° to 70° with respect to each other and wherein the combination of first elements and second elements is grid shaped. It has shown that such yields an optimum contact of the gas flow to be cleaned with the flames from the burner nozzles, thus yielding an excellent cleaning of the gas flow.

[0013] So as to be able to reach the complete gas flow it is referred that the elements extend over a substantially complete flow surface of said gas flow. The flow surface may be the inner cross section of a flue gas channel, like a chimney, but may also be the inner cross section of gas mixing chamber, as they are used in air conditioning systems of office buildings and the like. These latter applications have the advantage that any germs will be cleaned by the device before any treated air is returned to rooms or the like. The device is preferably placed a a position after the air conditioning system and before the return into the rooms. The invention provides the advantage that at the same time a solution for contaminated air conditioning systems is obtained, since the contamination is cleaned by means of the device according to the invention.

[0014] It is furthermore preferred that the device comprises a supply pipe that is connected to said elements, for feeding a cleaning gas to said burner nozzles. Such provides a compact device, especially when said device comprises conduits provided in said elements, said conduits extending from a supply pipe for cleaning gas to said burner nozzles; provided that separate conduits are provided for each separate gas if a plurality of gases is provided.

[0015] An excellent and unsurpassed cleaning is obtained when said cleaning gas comprises hydrogen and oxygen, preferably in a stoichiometric ratio of 2:1. Such provides a quick and direct oxidation of virtually all contaminating substances in the gas to be cleaned. When using the invention in an air conditioning system for offices and other rooms the device has the advantage that when using hydrogen and oxygen only water is produced, adding to the quality of the air sent into said offices and rooms.

[0016] Especially upon application of hydrogen and oxygen it is preferred that the device comprises a first supply pipe for hydrogen gas and a second supply pipe for oxygen gas, both supply pipes being connected to the burner nozzle so as to provide a mixing of said gases near said burner nozzle. Such provides an optimum and safe supply of said gases to the burner nozzles. Backfire will thus not occur.

[0017] A stable operation is guaranteed by providing each burner nozzle with an ignition for igniting said cleaning gas. If some unstable supply of gas to be cleaned would occur, or in case of any other unforeseen circumstance that would lead to dying of the flame of one or more burner nozzles, the gas mixture of said cleaning gas may be easily re-ignited.

[0018] An excellent mixing of the gases may be obtained when said first and second elements are positioned in a same plane and are embodied as at least one of a cross shape and a grid shape. The cross shape, for example by

mutually connecting a single first and a single second element at a position in between their respective outer ends, can be easily positioned in a conduit with a relatively small cross section. When a conduit, also mentioned gas discharge, through which a gas flow of a gas to be cleaned is fed, has a diameter of for example maximally 30 cm, preferably maximally 20 cm, more preferably maximally 15 cm, a cross shape device may be used. The elements each have such a diameter and are provided in such numbers, that the flow area, i.e. the cross sectional area, is reduced by maximally 70%, preferably by less than 60%, with respect to the cross sectional area preceding the position of the device according to the invention. As a matter of fact, at the position of the device according to the invention, an increase of the cross sectional area of the conduit may be applied, such that substantially no change of the gas velocity is obtained. Preceding the device the diameter may increase gradually and after the device the diameter may optionally be decreased. However, said last mentioned measure is not obligatory. A diameter that remains wider for some distance (and residence time in said gas mixture) may provide an improved mixing thus leading to an improved cleaning.

[0019] According to a further aspect, the invention also relates to a method for cleaning a gas to be fed through a conduit (also mentioned discharge channel or gas channel in this description), comprising the step of positioning in a channel at least one device according to any of the preceding claims, supplying said cleaning gas into said gas mixture through said burner nozzles and igniting said cleaning gas. The advantages as mentioned above with respect to the device are obtained with this method as well.

[0020] According to a preferred embodiment hydrogen gas is supplied at a first supply connection and oxygen gas is supplied at a second supply connection; wherein each supply connection is connected to a burner nozzle by means of a gas conduit provided inside said device, such that by supplying said gases to said supply connections, said gases are mixed ear each burner nozzle.

[0021] According to an especially preferred embodiment in de method according to the invention a third supply connection for a third gas is provided, such that said third gas can be fed to the burner nozzles, together with said cleaning gas that preferably comprises hydrogen and oxygen.

[0022] Preferably, said third gas is carbon dioxide, with the consequence that the method comprises the step of adding through said third supply connection CO_2 and mixing said CO_2 with the other gases near said burner nozzles. By mixing said carbon dioxide, CO_2, the maximum temperature and the physical length of the flame of the cleaning gas can be easily controlled. Thus, the cleaning characteristics of the flame can be easily adapted to the current situation in the gas flow to be cleaned.

[0023] So as to obtain an optimum oxidation it is preferred that the method according to the invention comprises the step of supplying through at least one of said first and second supply connections CO_2 , such that the gas mixture that is supplied to said burner nozzles comprises a stoichiometric amount of hydrogen and oxygen.

[0024] It has shown that the method according to the invention provides especially advantageous results if the gas mixture that is burned from said burner nozzles has sufficient space for mixing with the gas to be cleaned. For this purpose, it is preferred for the method according to the invention to comprise the step of clearing the gas flow from obstructions for a distance of at least 5 cm downstream from the device of the present invention, preferably at least 10 cm, more preferably at least 15 cm, and still more preferably at least 20 cm. When no obstructions are present in the gas flow an excellent cleaning is obtained.

[0025] The invention will be explained hereafter with reference to a drawing. The drawing shows in:

Fig. 1 a schematical top view of a device according to the invention,
Fig. 2 a perspective view of a part of a device according to the invention,
Fig. 3 a schematic cross view of a part of a device according to the invention.

[0026] In the figures, the same parts are denoted by the same reference numerals. However, for ease of understanding the figures, not all parts that are necessary for a practical embodiment are shown in the figures.

[0027] Fig. 1 shows a schematic top view of a device 1 according to the invention. The device 1 has a substantial square shape for positioning in a comparatively shaped gas channel. Through said gas channel a gas to be cleaned is fed. The device 1 will cover the complete gas flow area of said channel. The device 1 comprises longitudinal elements 2 and cross elements 3 that, in the embodiment shown in Fig. 1, are positioned substantially perpendicularly with respect to each other. The elementen 2, 3 define passages 4 for letting through the gas to be cleaned. The dimensions of the elements 2, 3 is not shown in correct relationship with respect to the passages 4, for improving the clarity of the figure. In Fig. 1 longitudinal element 2 extends further than a cross element that is positioned at the side of the device, *vice versa.*

[0028] These extensions 5 may be used for placing the device on lifting lugs in the gas channel. Also, the extensions 5 may be provided with supply connections 6, 7, 8 for a cleaning gas that s to be fed through elements 2, 3 to the gas to be cleaned. In Fig. 1 a single set of supply connections 6, 7, 8 is provided. According to the invention a plurality thereof may be provided to the device.

[0029] The cleaning gas may preferably feed a mixture of hydrogen gas and oxygen gas to the burner nozzles 9 (see also Fig. 2 and 3), wherein preferably separate supply connections 6, 7 for hydrogen gas and for oxygen gas are provided.

[0030] An optimum cleaning of several contaminants may be obtained when the temperature of the flame from the burner nozzles can be controlled. The temperature and the length of the flame, as well as the temperature distribution of the hydrogen and oxygen flame, of so-called Brown's gas, may be controlled by adding CO_2 to the gas mixture. To that end, a separate supply connection 8 may be provided.

[0031] Fig. 2 shows a perspective view of a device 1 according to the invention. The longitudnal elements 2 and cross elements 3 are each provided with burner nozzles 9, such that the flame is directed towards the passage 4 between said elements 2, 3. The gas flowing through said passage 4 thus is contacted with the falmes yielded by said burner nozzles 9 or are in any way contacted with the high temperature of the combustions gases. It has shown that the elements 2, 3 provide for such whirling of the gas flow of the gas to be cleaned that an optimum contact with the flames is obtained. It has also shown that an optimum mixing is obtained when for some distance after the burner nozzles no obstacles are positioned in the gas mixture. This distance is preferably at least 5 cm in the downstream direction, preferably at least 10 cm, more preferably at least 15 cm, and still more preferably at least 20 cm. Such effect is especially obtained when a Brown's gas is used as cleaning gas that is ignited in the gas flow of the gas to be cleaned.

[0032] In Fig. 3 a schematic cross section s of a part of a device 1 according to the invention is shown, wherein the gas channel 10 for feeding cleaning gas to the burner nozzles 9, said channel 10 being positioned inside an element 2; 3, are shown. The gas channel 10 is connected to a supply connection 6, 7 (not shown in this figure). So as to be able to connect more gases to the burner nozzles 9 , a plurality of has conduits 10 must be provided inside said elements 2; 3.

[0033] The burner nozzles may be separate organs that are connected to the longitudinal and cross elements, but may also be simple openings in said elements, through which the gas may flow out of the elements and in the gas channel. For example, the elements may be hollow elements in which said gas mixture is present and that is kept under sufficient pressure to ensure a constant outflow of said gas through said burner nozzles.

[0034] The length of the flames is referaly such that the end of the flame, that is the part of the flame that has a sufficient temperature for converting the contaminants into harmless substances, reaches to a position near adjacent longitudinal or cross elements. As a consequence, the surface that is obtained by said grid is substantially completely covered by flames.

Example I: Cleaning of a flue gas

[0035] It has shown in this experiment that flue gasses obtained when burning coal can be cleaned terrifically with a device according to the present invention.

[0036] In a chimney a device according to the invention was installed. The amount of cleaning gas that was fed, in this case obtained by a stoichiometric amount of hydrogen gas and oxygen gas (volume ratio 2:1), amounted 2 vol.% (based on normal conditions) with respect to the amount of gas to be cleaned.

[0037] The gas to be cleaned was obtained from a coal burner.

[0038] The results are as follows:

Step	T(°C)	O_2(%)	CO (ppm)	NO (ppm)	NO_2 (ppm)	SO_2 (ppm)	NO_x (ppm)
No HHO	-	17,1	9030	46	1	295	47
With HHO	-	15,4	1856	463	27	14	477
No HHO	-	16,8	8522	48	1	253	48
With HHO	-	15,8	1860	402	56	<1	440
No HHO	73	18,9	4854	39	<1	144	40
With HHO	423	18,9	1228	305	57	<1	362
No HHO	80	20,4	1747	14	<1	47	14
With HHO	380	20,1	781	134	31	<1	165

[0039] Furthermore, the decrease of the concentration was measured when the step of burning HHO as a cleaning step was applied:

Step	CO (ppm)	CO (mg/Nm^3)	% reduction	SO_2 (ppm)	SO_2 (mg/Nm^3)	% reduction
No HHO	9030	10345	79.0	295	773	95.0
With HHO	1856	2126		14	37	

(continued)

Step	CO (ppm)	CO (mg/Nm^3)	% reduction	SO_2 (ppm)	SO_2 (mg/Nm^3)	% reduction
No HHO	8522	9763	78.0	253	663	>99.5
With HHO	1860	2131		<1	<3	
No HHO	4854	5561	75.0	144	377	>99.3
With HHO	1228	1407		<1	<3	
No HHO	1747	2001	55.0	47	123	>97.6
With HHO	781	895		<1	<3	

Example	HHO (Yes/No)	Temp (°C)	Conc. O2	Difference conc. O2
1	N	222	15.8	
	Y	305	15.8	0.00
2	N	204	16.9	
	Y	227	17.2	1.78
3	N	188	17.1	
	Y	216	17.3	1.17
4	N	178	17.1	
	Y	214	17.3	1.17
5	N	171	17.2	
	Y	208	17.4	1.16
6	N	166	17.4	
	Y	201	17.7	1.72
7	N	157	17.7	
	Y	192	18.0	1.69
8	N	152	18.0	
	Y	169	18.5	2.78
9	N	132	18.4	
	Y	163	18.7	1.63
10	N	124	18.6	
	Y	161	18.6	0.00
11	N	116	18.4	
	Y	154	18.3	-0.54
12	N	97	18.6	
	Y	148	18.8	1.08
13	N	98	18.9	
	Y	166	19.0	0.53

[0040] The decrease of the amount of carbon monoxide when applyng a cleaning step of HHO is between 55% and 79%.

[0041] Carbon monoxide CO is decreased when using the device according to the present invention decreased with at least 55% to a maximum of 80%.

[0042] Sulphur dioxide is decreased with more than 95%.

[0043] The concentration of nitrogen in the gas that is fed to the device increases, however, the concentration obtained is far below legal standards. This increase therefore poses no problem for implementation of the present invention.

Example II: Oxygen concentration

[0044] It was also measured if the concentration of oxygen in the gases is altered by the method according to the invention. The measuring results are as follows:

Measurement	HHO	Temp (°C)	Conc. O2	Difference conc. O2
1	N	222	15.8	
	Y	305	15.8	0.00
2	N	204	16.9	
	Y	227	17.2	1.78
3	N	188	17.1	
	Y	216	17.3	1.17
4	N	178	17.1	
	Y	214	17.3	1.17
5	N	171	17.2	
	Y	208	17.4	1.16
6	N	166	17.4	
	Y	201	17.7	1.72
7	N	157	17.7	
	Y	192	18.0	1.69
8	N	152	18.0	
	Y	169	18.5	2.78
9	N	132	18.4	
	Y	163	18.7	1.63
10	N	124	18.6	
	Y	161	18.6	0.00
11	N	116	18.4	
	Y	154	18.3	-0.54
12	N	97	18.6	
	Y	148	18.8	1.08
13	N	98	18.9	
	Y	166	19.0	0.53

[0045] The avarage increase of concentration of 02 is 0.54%. This increase is negligible and will be due to measurement incertainties.

[0046] The gas flow during the tests amounted to 1 m3 of gas to be cleaned per minute.

[0047] A special improvement in cleaning is obtained when at least two devices according to the present invention are positioned consecutively in a gas flow. The second device is positioned in the gas flow that has already been subjected to treatment by the first device, which yielded a further cleaning of the gas flow. It was shown surprisingly that the percentual decrease of contaminating substances, like CO and SO_2, remains at least the same for consecutively positioned devices. Cleaning by using the devices and methods according to the state of the art only yields a smaller

percentual decrease in a first step whereas even a still smaller decrease of cleaning is obtained in consecutive steps. As a matter of fact, the availability of the cleaning power of HHO therefore is substantially greater than might be expected on the basis of known cleaning devices and techniques.

[0048] The invention is not limited to the embodiments as described above and as shown in the figures. The invention is limited only by the appending claims.

[0049] The invention also embodies all combinations of measures that have been mentioned above independently from each other.

Claims

1. A device for cleaning a gas in a gas flow, comprising a burner to be positioned in said gas flow, said device comprising:

- at least one first element that extends in a first direction and that comprises burner nozzles that are positioned at mutual distances,

characterized in that:

- said device further comprises at least one second element that extends in a second direction that is different from said first direction and that comprises burner nozzles that are positioned at mutual distances,
- said first and second element are positioned in substantially the same plane, substantially perpendicular with respect to said gas flow, and
- said burner nozzles being positioned at an angle of 0° tot 80° with respect to the gas flow,
- said device being embodied for igniting in said gas flow a gas to be fed through said burner nozzles.

2. A device according to claim 1, wherein said elements extend at an angle of 45° to 70° with respect to each other and wherein the combination of first elements and second elements is grid shaped.

3. A device according to claim 1 or 2, wherein the elements extend over a substantially complete flow surface of said gas flow.

4. A device according to claim 1, 2 or 3, said device comprising a supply pipe that is connected to said elements, for feeding a cleaning gas to said burner nozzles.

5. A device according to claim 4, said cleaning gas comprising hydrogen and oxygen, preferably in a stoichiometric ratio of 2:1.

6. A device according to claim 4 or 5, said device comprising a first supply pipe for hydrogen gas and a second supply pipe for oxygen gas, both supply pipes being connected to the burner nozzle so as to provide a mixing of said gases near said burner nozzle.

7. A device according to any of claims 4 - 6, said device comprising conduits provided in said elements, said conduits extending from a supply pipe for cleaning gas to said burner nozzles; provided that separate conduits are provided for each separate gas if a plurality of gases is provided.

8. A device according to any of the preceding claims, each burner nozzle being provided with an ignition for igniting said cleaning gas.

9. A device according to any of the preceding claims, said first and second elements being positioned in a same plane and are embodied as at least one of a cross shape and a grid shape.

10. A method for cleaning a gas to be fed through a conduit, comprising the step of positioning in a channel at least one device according to any of the preceding claims, supplying said cleaning gas into said gas mixture through said burner nozzles and igniting said cleaning gas.

11. A method according to claim 10, wherein a hydrogen gas is supplied at a first supply connection and oxygen gas is supplied at a second supply connection; wherein each supply connection is connected to a burner nozzle by means of a gas conduit provided inside said device, such that by supplying said gases to said supply connections, said gases are mixed ear each burner nozzle.

12. A method according to claim 10 or 11, further comprising a third supply connection for a third gas, said method comprising the step of adding through said third supply connection CO_2 and mixing said CO_2 with the other gases near said burner nozzles.

13. A method according to claim 10 or 11, comprising the step of supplying through at least one of said first and second supply connections CO_2, such that the gas mixture that is supplied to said burner nozzles comprises a stoichiometric amount of hydrogen and oxygen.

14. A method according to any of claims 9 - 13, comprising the step of positioning at least two devices according to the present invention at a mutual distance, preferably at least two devices according to claim 9.

15. A method according to claim 10-14, comprising the step of clearing the gas flow from obstructions for a distance of at least 5 cm downstream from the device of the present invention, preferably at least 10 cm, more preferably at least 15 cm, and still more preferably at least 20 cm.

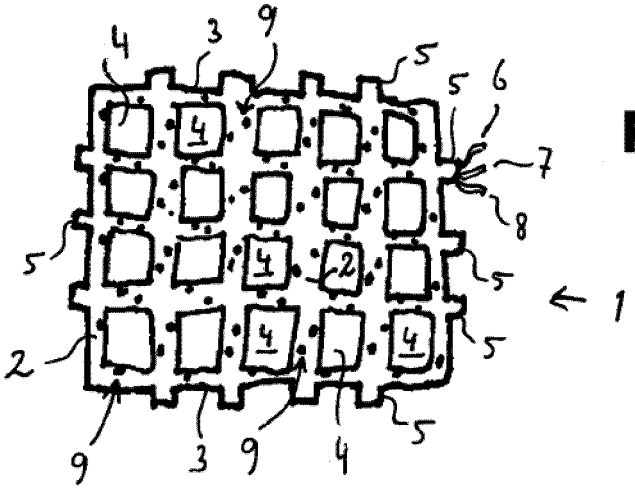
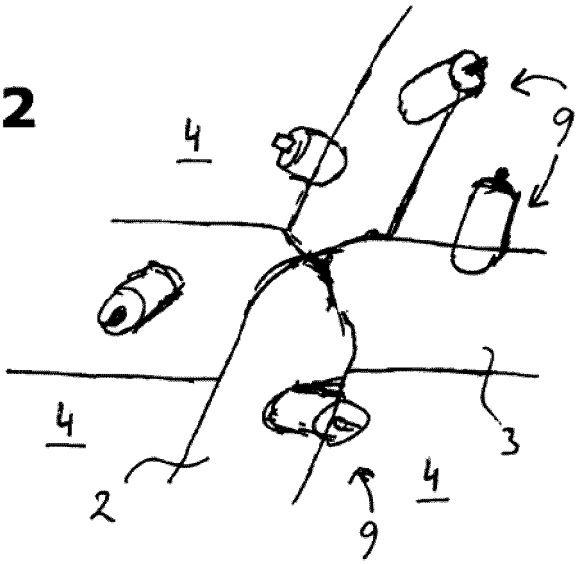


Fig. 1

Fig. 2



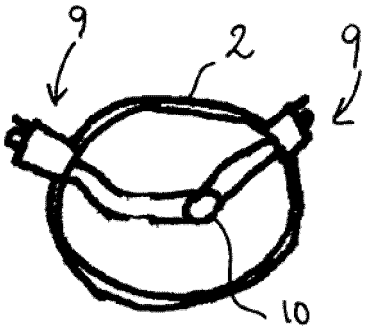


Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 15 16 8195

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 Y	WO 02/27238 A1 (MAXON CORP [US]; PERRY DOUGLAS M [US]) 4 April 2002 (2002-04-04) * page 2, lines 9-19 * * page 6, line 2 - page 7, line 12; figures 4, 15, 18 *	1,3,4,9, 10 5-7,11, 13	INV. F23D99/00 F23G7/06 F23D14/32
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	3 November 2015	Coli, Enrico

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 15 16 8195

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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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82