

(19)



(11)

EP 2 548 662 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:

23.01.2013 Bulletin 2013/04

(21) Application number: **11175095.6**

(22) Date of filing: **22.07.2011**

(51) Int Cl.:

B08B 7/00 (2006.01)

B08B 9/08 (2006.01)

F23J 3/02 (2006.01)

F28G 15/02 (2006.01)

B08B 9/00 (2006.01)

B25J 5/00 (2006.01)

F27D 25/00 (2010.01)

(84) Designated Contracting States:

**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**

Designated Extension States:

BA ME

(71) Applicant: **Online Cleaning B.V.**

2992 LA Barendrecht (NL)

(72) Inventor: **Wanschers, Freddy Tom**

7641 KH Wierden (NL)

(74) Representative: **Aalbers, Arnt Reinier**

De Vries & Metman

Overschiestraat 180

1062 XK Amsterdam (NL)

(54) Device for and method of cleaning installations online

(57) The invention relates to a device (1) for cleaning installations (2), in particular incinerators, scrubbers, and silos, comprising a first arm (3) containing or carrying at least one explosive and connected to a second arm (5)

for manipulating the first arm (3) inside an installation (2). The second arm (5) comprises two or more parallel elongated elements (6) interconnected at a plurality of longitudinal positions.

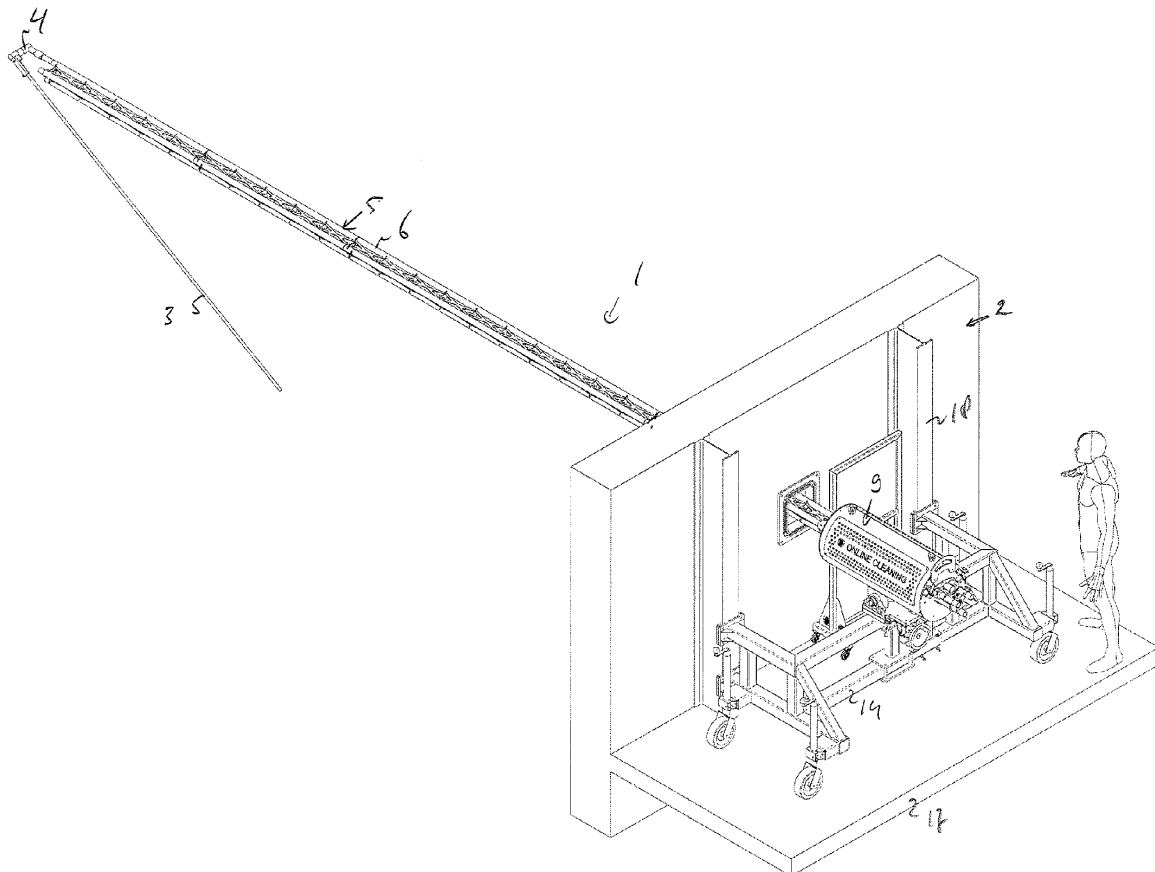


Fig. 1

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Description

[0001] The invention relates to a device for cleaning installations, in particular incinerators, such as (brown) coal and biomass fired power stations, and also e.g. scrubbers and silos, comprising a first arm containing or carrying at least one explosive, preferably a solid explosive such as a detonation cord, and connected to a second arm for manipulating the first arm inside an installation. The invention further relates to a method of cleaning installations, preferably online.

[0002] EP 1 544 567 relates to an explosive cleaning system which uses a first fixed tube (denoted as "Rohr-1" in Figure 4 of EP 1 544 567) with a water inlet (Wassereinlass) and an air inlet (Lufteinlass). A mixture of water and air flows through the tube, and passes through a hinge (Gelenk) to a second movable tube (Rohr-2). A wire (Zundleitung) passes through the first tube and the link to an igniter (Zunder) and an explosive cord (Sprengschnur) in the second tube. The device shown in EP 1 544 567 is effective, but less suitable for cleaning larger scale installations, such as power plants generating in excess of 150 megawatt and having an internal width in excess of 10 meters.

[0003] It is an object of the present invention to provide an improved device for cleaning installations.

[0004] To this end, the device according to the present invention is characterized in that the second arm comprises two or more parallel elongated elements interconnected at a plurality of longitudinal positions.

[0005] The device according to the present invention enables efficient and optionally online cleaning of large volume installations, e.g. having an internal width in excess of 10 meters, e.g. 20 meters.

[0006] In an embodiment, one element extends within the other, e.g. a smaller diameter rod or tube extends coaxially within a larger diameter tube. In another embodiment, the second arm comprises at least three parallel and spatially separated elongated elements, preferably arranged on a circle (seen in cross-section). This arrangement was found to provide a good balance between (small) effective diameter, enabling it to fit through small openings in the installation to be cleaned, (low) weight and bending stiffness. In a more detailed embodiment, the second arm is formed as a so-called truss comprising a plurality, e.g. three parallel elongated elements arranged on a circle (seen in cross-section) and interconnected at regular intervals by further elements, e.g. crosses or inclined rods, extending primarily in longitudinal (axial) direction and interconnecting two parallel elongated elements and by elements extending primarily in lateral (radial) direction and connecting all parallel elongated elements.

[0007] In another embodiment, the second arm has an effective diameter in a range from 8 to 25 centimeters, preferably 10 to 18 centimeters. Thus, the second arm will fit through manholes and inspection doors and openings typically found in installations such as large scale

incinerators. Within the framework of the present invention, the effective diameter is defined as the diameter of the imaginary (outer) circle obtained by a full rotation of the second arm about its central longitudinal axis.

[0008] In another embodiment, the second arm has a length in excess of 5 meters, preferably in a range from 6 to 15 meters, more preferably in a range from 7 to 12 meters.

[0009] In a further embodiment, the second arm comprises a plurality of releasably interconnected segments. Thus, the second arm can be taken apart, facilitating transport, storage, and repair. It is preferred that the segments have a length in a range from 1 to 4 meters, e.g. two different lengths of 1,5 and 3 meters.

[0010] In yet a further embodiment, at least one of the elongated elements of the second arm is a tube. It is preferred that the first arm comprises a tube and that the distal end of the at least one tube in the second arm is fluidly connected to the tube in the first arm and, e.g. at its proximal end, is fluidly connected or connectable to a supply for coolant. It is further preferred that the tube is destroyed during the explosion and/or that the tube has a length in a range from 1 to 6 meters and/or a diameter in a range from 10 to 50 millimeters, preferably 15 to 35 millimeters. It is preferred that the aspect ratio (L/D) of the tube is in excess of 20, thus generating, upon detonation, a linear explosion.

[0011] In another embodiment, which is independent of the structure of the second arm, the device comprises a holder to be positioned outside the installation and in turn comprising bearings slidingly and/or rotatably supporting the second arm. This holder provides an effective means for, on the one hand, accurately manoeuvring the second (and thus the first) arm inside the installation and, on the other hand, bearing the bending moment resulting from the weight of the parts extending into the installation, such as the first arm, part of the second arm and coolant present in the first and second arms. In a more detailed embodiment, the holder comprises one or more motors, suitable transmissions (gears, toothed racks), and a controller for sliding and rotating the second arm relative to the holder, i.e. for manoeuvring the first arm inside the installation.

[0012] In another embodiment, to provide a stable base, the holder is fixable or fixed to structural elements of the installation.

[0013] In yet another embodiment, the first arm is connected to the second arm by means of a hinge and is preferably provided with a motor to rotate the first arm with the hinge. If the motor is an hydraulic motor, the hydraulic fluid is preferably supplied and returned via tubes in the truss.

[0014] The invention further relates to a method of cleaning installations, preferably online, preferably by means of a device according to the invention as described above, comprising the steps of introducing the first arm containing or carrying an explosive into the installation, manoeuvring - by means of the second arm

and, if present, the hinge - the first arm to a desired position, and detonating the explosive thus removing deposits from the entrails of the installation and destroying the first arm.

[0015] In an embodiment, the second arm is mounted in a holder and the second arm is slid and/or rotated inside and relative to the holder to manoeuvre the first arm inside the installation.

[0016] In a further embodiment, the method comprises, after detonating the explosive, the steps of withdrawing the second arm from the installation, mounting another first arm to the second arm and introducing the other first arm into the installation.

[0017] In yet another embodiment, the first arm is inserted between entrails of the installation, in particular between the tubes of a heat exchanger, and is pushed or pulled against the entrails, e.g. a row of tubes, by means of the second arm and maintained in this position up to and including detonation. Thus, the energy of the blast is efficiently transfer to deposits on the entrails.

[0018] It is preferred that the length of the first arm, e.g. a tube containing a detonation cord, exceeds the width of the entrails to be cleaned, such as a bundle of tubes.

[0019] For the sake of completeness, attention is drawn to the following prior art.

[0020] EP 1 275 925 relates to a process and device for local destruction of compact material, e.g. clinker coating, masonry remains, etc., in hot thermal systems such as heat exchangers, industrial ovens, furnaces, and metallurgical melting vessels, which uses an explosive (numeral 5 in the Figures) arranged on the front end of a lance (3) in a cooling container (1) through which coolant (4) flows. The coolant flows into the cooling container designed as a double tube having a cooling head (10) and a supply head (11) over the lance into the supply head, through the inner tube/inner cooling casing (27) to the front end of the cooling head, past the explosive container (25), between the inner cooling casing and the cooling head housing (23) back to the supply head, and from this out of the hot thermal system.

[0021] EP 1 067 349 relates to a device, system and method permitting online explosives-based cleaning and deslagging of a fuel burning facility (31) such as a boiler, furnace, incinerator, or scrubber. A coolant, such as ordinary water, is delivered to the explosives (101) to prevent them from detonating due to the heat of the online facility. similar device.

[0022] Handbuch Sprengtechnik, VEB Deutscher Verlag für Grundstoffindustrie, Leipzig 1975, pages 344-351 discloses the cooling of explosive charges.

[0023] US 5,494,004 relates to an online pulsed detonation/deflagration soot blower comprising a pivotal housing member which has an end pivotally coupled to an end of a base housing member for movement between a retracted or folded position and an extended position. When the pivotal member is in its folded position, the two housing members may be moved through an opening formed through the wall of a boiler, etc. for cleaning the

interior surface of the wall with the pulsed pressure waves. In order to increase the wall area cleaned from a given wall opening, the two housing members may be rotated about an axis of the base housing member and the pivotal housing member pivoted to different extended positions from its folded position.

[0024] WO98/16329 discloses a system for cleaning a nuclear power plant steam generator, the system comprising a deployment subsystem (numeral 50, Fig. 2), which is used to deploy a spray head vertically within the steam generator to the elevation of the tube support plate to be accessed.

[0025] "Wärmeüberträger-Reinigungssysteme" Publi-co Publications, 2001, page 382 (enclosed) discloses cleaning with water jets.

[0026] The invention will now be explained in more detail with reference to the drawings, which show a preferred embodiment of the present invention.

Figure 1 is an isometric view of a device for online cleaning installations, such as incinerators.

Figure 2 is a side view of the device shown in Figure 1.

Figure 3 is a detail of the device shown in Figure 1.

Figure 4 is an isometric view a holder for a truss, as used in the device shown in Figures 1 to 3.

Figure 5 is a side view of the holder shown in Figure 4.

[0027] Figure 1 shows a device 1 for the online cleaning of installations 2, in particular incinerators, such as (brown) coal and biomass fired power stations, by means of explosives. The device 1 comprises a first arm 3, in this example a metal, e.g. aluminium, or plastic tube, containing an explosive, e.g., a detonation cord and a detonator (not shown). This tube (hereafter also referred to as "explosive tube") has a length in a range from 1 to 6 meters, in this example 3 meters, and is connected via a hinge 4 to the distal end of a second arm 5 for manipulating the first arm 3 inside the installation 2.

[0028] In this example, the second arm 5 is formed as a truss and comprises three parallel straight tubes 6 arranged on a circle (seen in cross-section) and interconnected at regular intervals i) by welded elements 7 (see Figure 3), e.g. crosses or inclined rods, extending primarily in longitudinal (axial) direction and interconnecting two tubes and ii) by welded elements 8 (Figure 3) extending primarily in lateral (radial) direction and interconnecting all three tubes 6.

[0029] The second arm 5 is slidingly and rotatably supported inside a holder 9, which, to this end, comprises a plurality, e.g. two rotary guides or bearings 10 (Figure 4), such as ball or slide bearings, spaced apart in axial direction by at least 50 centimeters and a plurality of linear bearings or guides 11 (Figure 4), e.g. wheels having concave running surfaces to accommodate the tubes 6. The second arm 5 has an effective diameter of 115 millimeters. Further, in this example, the second arm has a length of nine meters and comprises four (3 + 3 + 1,5 +

1,5 m) truss segments 12 releasably interconnected e.g. by means of flanges 13 and bolts.

[0030] The proximal end of each of the tubes 6 is connected to a fluid supply (not shown). Wires (not shown) for operating the detonator extend through one of the tubes, typically through the tube that also comprises the hinge 4.

[0031] The holder 9 is mounted on a mobile frame 14 by means of an adjustable head, which comprises at least a vertical pivot 15 for swivelling the truss 5 and a horizontal pivot 16 for tilting the truss 5. The frame 14 is positioned on a platform 17 next to the installation 2 and, in addition, is clamped, at least in this example, to structural beams 18 of the installation to provide extra stability and reduce the load on the platform. Alternatively, the holder can be mounted on a heavy base, e.g. a base filled with water.

[0032] Cleaning of e.g. the tube bundles of an online heat exchanger at a temperature in a range of 500 to 1000 °C, e.g. at 800 °C inside an incinerator having an internal width (at the location of the heat exchanger) of 20 meters is performed e.g. by the following steps:

folding the explosive tube containing the detonation cord onto the truss,
turning on the water supply such that all three tubes in the truss and the explosive tube are filled with flowing water or a mixture of water and air, cooling the tubes in the truss and the explosive tube and exiting through the distal end of the explosive tube,
positioning the holder in front of an inspection opening in the wall of the incinerator,
introducing the explosive tube and part of the truss into the installation through the inspection opening by sliding the truss through the holder,
manoeuvring, by swivelling and tilting the truss inside respectively by means of the holder and by the rotating the hinge, the explosive tube to a desired position, e.g. between the tubes of the heat exchanger, pulling or pushing the explosive tube against a row of tubes in the heat exchanger, and, once in the desired position,
detonating the explosive, thus removing deposits from the entrails of the installation (and inevitably destroying the first arm).

[0033] After detonating the explosive, the truss is withdrawn from the incinerator through the inspection opening, and another explosive tube is attached, e.g. screwed onto, the hinge and the above process is repeated, typically with the explosive tube being detonated at a different location, e.g. shifted over a suitable distance relative to the former location. When one side of the incinerator has been cleaned, the device is moved to the opposite side to clean the remainder.

[0034] The device according to the present invention enables efficient and optionally online cleaning of large volume installations, e.g. having an internal width in ex-

cess of 10 meters, e.g. 20 meters.

[0035] The invention is not restricted to the above-described embodiments, which can be varied in a number of ways within the scope of the claims. E.g., the second arm can be provided with one or more inspections camera's. Further, the holder can comprises means, such as brushes and water jets, to clean the second arm when in is withdrawn from the installation.

Claims

1. Device (1) for cleaning installations (2), in particular incinerators, scrubbers, and silos, comprising a first arm (3) containing or carrying at least one explosive and connected to a second arm (5) for manipulating the first arm (3) inside an installation (2), **characterized in that**, the second arm (5) comprises two or more parallel elongated elements (6) interconnected at a plurality of longitudinal positions (7, 8).
2. Device (1) according to claim 1, wherein the second arm (5) comprises at least two elements, one extending within the other, or the second arm comprises at least three parallel and spatially separated elongated elements (6), preferably arranged on a circle and preferably interconnected at regular intervals by further elements (7) extending primarily in the longitudinal direction and interconnecting two parallel elongated elements (6) and by elements (8) extending primarily in the lateral direction and connecting all parallel elongated elements (6).
3. Device (1) according to claim 1 or 2, wherein the second arm (5) has an effective diameter in a range from 8 to 25 centimeters, preferably 10 to 15 centimeters and/or a length in excess of 5 meters, preferably in a range from 5 to 15 meters, more preferably 6 to 12 meters.
4. Device (1) according to any one of the preceding claims, wherein the second arm (5) comprises a plurality of releasably interconnected segments (12).
5. Device according to any one of the preceding claims, wherein at least one, preferably all, of the elongated elements of the second arm is a tube.
6. Device according to any one of the preceding claims, wherein the first arm comprises a tube (3) having a length in a range from 1 to 6 meters and/or a diameter in a range from 10 to 50 millimeters, preferably 15 to 35 millimeters.
7. Device according to claim 6, wherein one end of the at least one tube (6) in the second arm (5) is fluidly connected to the tube (3) in the first arm and is fluidly connected or connectable to a supply for coolant.

8. Device (1) according to the preamble of claim 1 or any one of the preceding claims, comprising a holder (9) to be positioned outside the installation (2) and in turn comprising bearings (10, 11) slidingly and/or rotatably supporting the second arm (5). 5
9. Device (1) according to claim 8, wherein the holder (9) is fixable or fixed to one or more structural elements (18) of the installation (2). 10
10. Device (1) according to any one of the preceding claims, wherein the first arm (3) is connected to the second arm (5) by means of a hinge (4).
11. Device (1) according to claim 10, comprising one or more motors for sliding and/or rotating the second arm (5) relative to the holder (9) and/or for rotating the first arm (3) relative to the second arm (5). 15
12. Method of cleaning installations (2), preferably on-line, comprising the steps of introducing a first arm (3) containing or carrying an explosive into the installation, manoeuvring, by means of a second arm (5) and, if present, a hinge (4) connecting the arms (3, 4), the first arm (3) to a desired position, and detonating the explosive, thus removing deposits from the entrails of the installation (2). 20 25
13. Method according to claim 12, wherein the second arm is mounted in a holder and the second arms is slid and/or rotated inside the holder to manoeuvre the first arm inside the installation. 30
14. Method according to claim 12 or 13, comprising, after detonating the explosive, the steps of slidingly withdrawing the second arm (5) from the installation (2), attaching another first arm (3) to the second arm (5) and introducing the other first arm (3) into the installation (2). 35 40
15. Method according to any one of the claims 12-14, wherein the first arm (3) is inserted between entrails of the installation (2), in particular between the tubes of a heat exchanger, and the first arm (3) is pulled or pushed against the entrails, in particular against a row of tubes, by means of the second arm (5). 45

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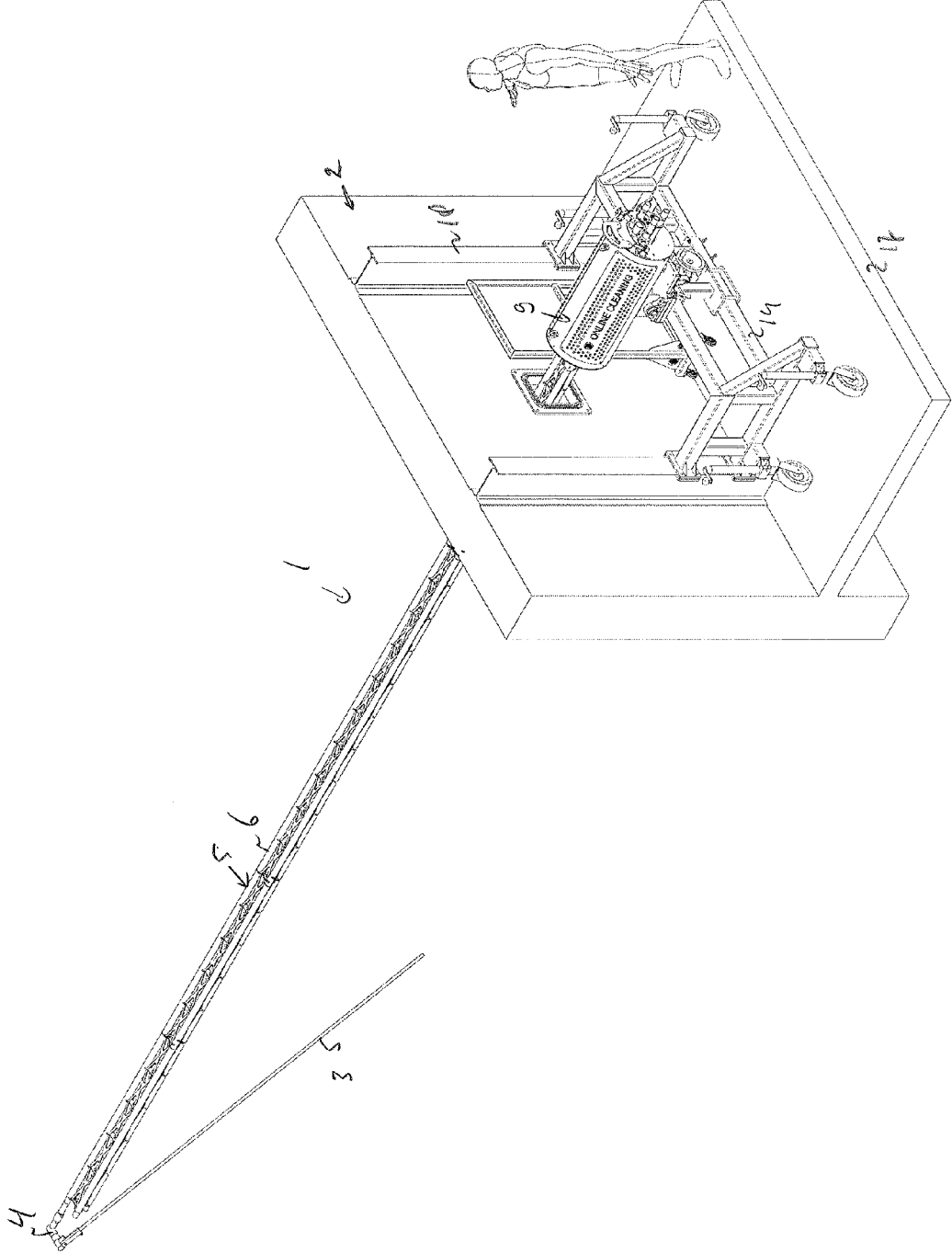


Fig. 1

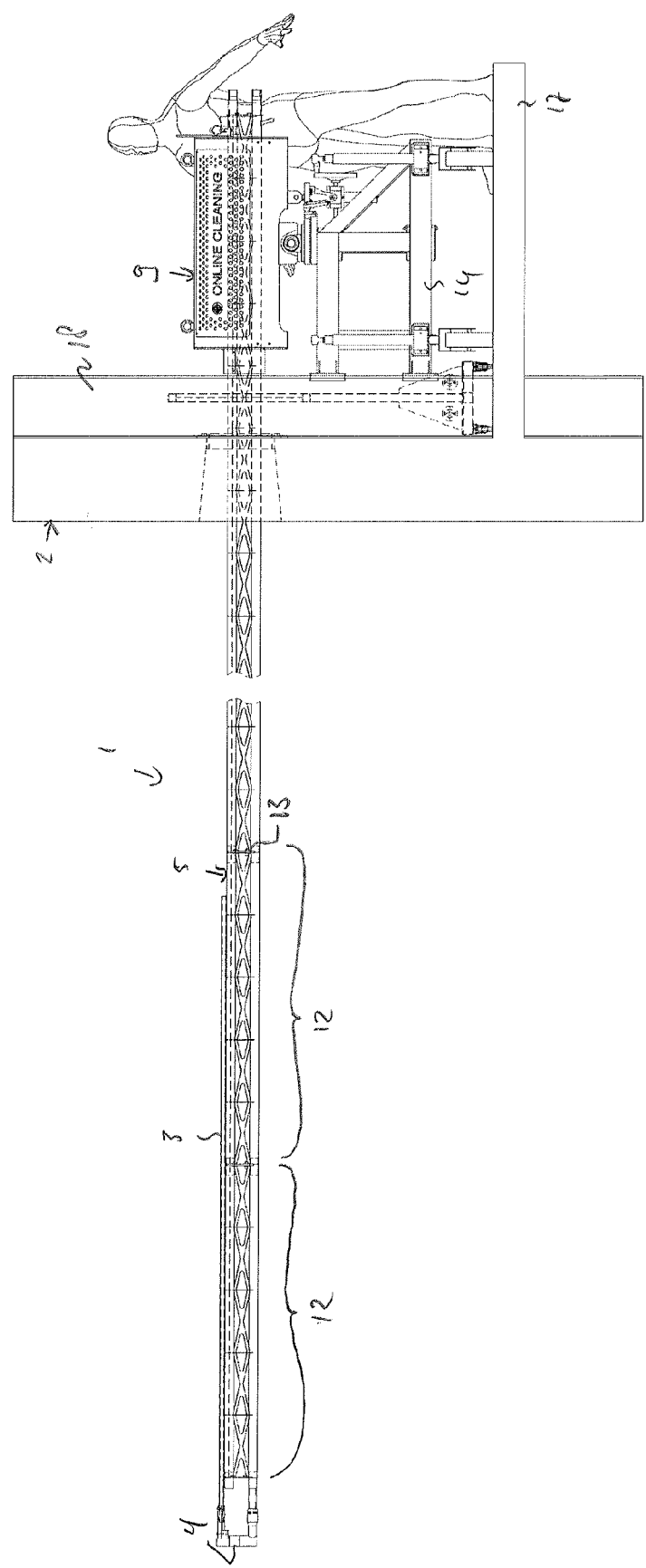


Fig. 2

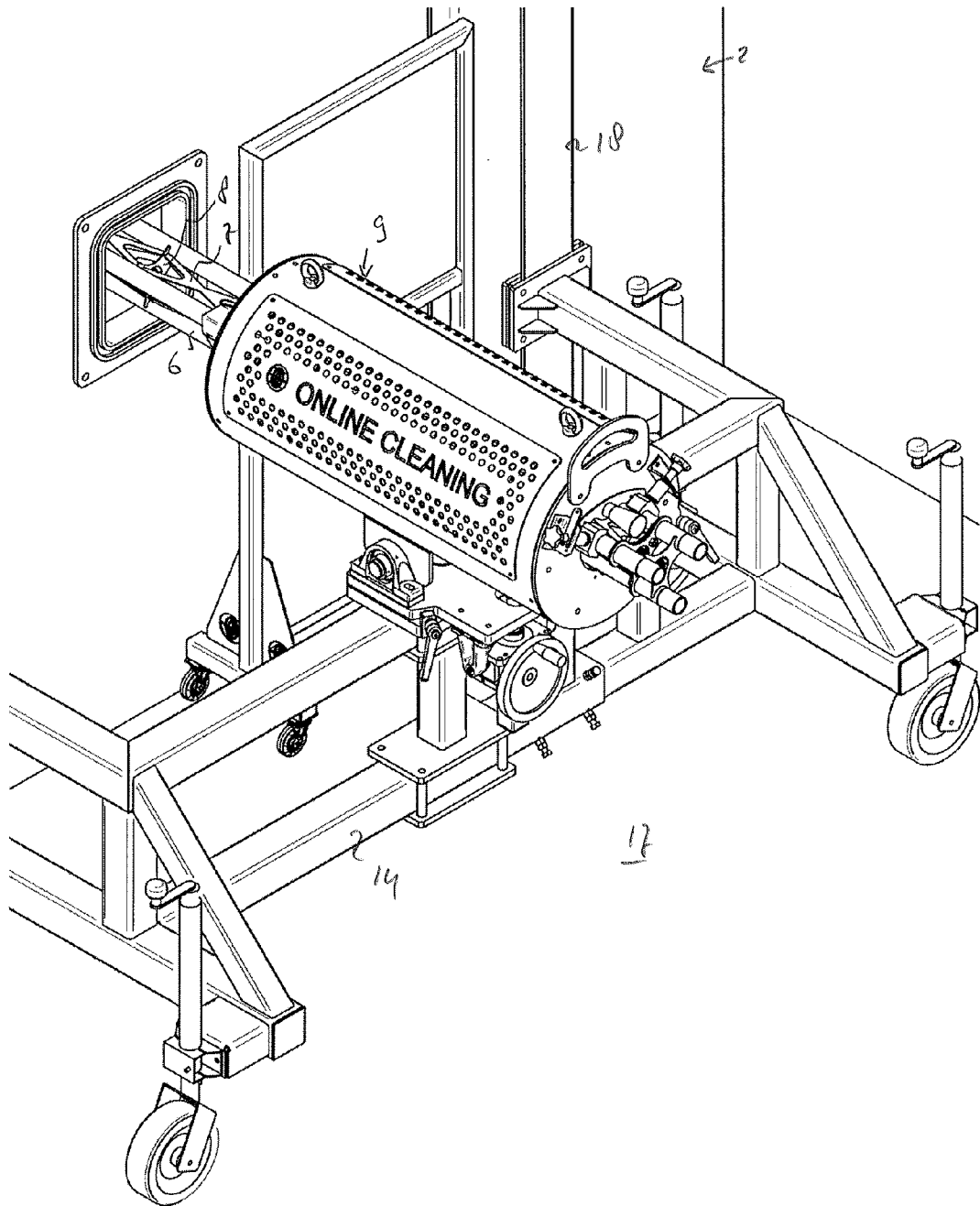


Fig. 3

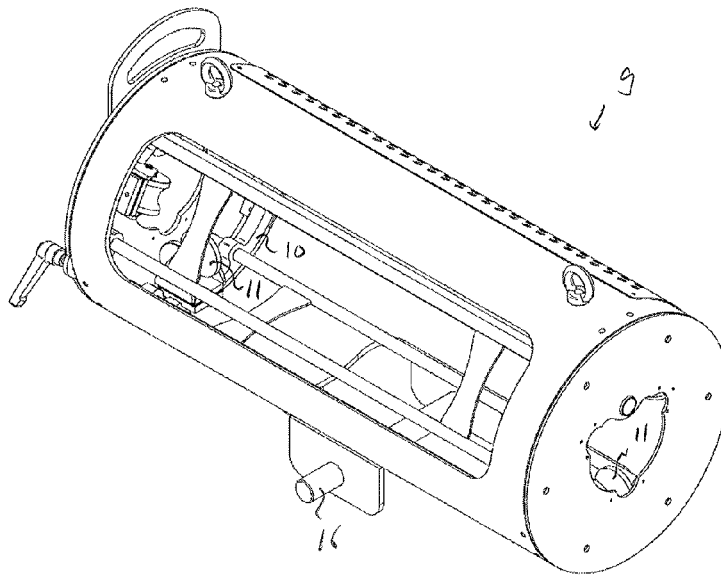


Fig. 4

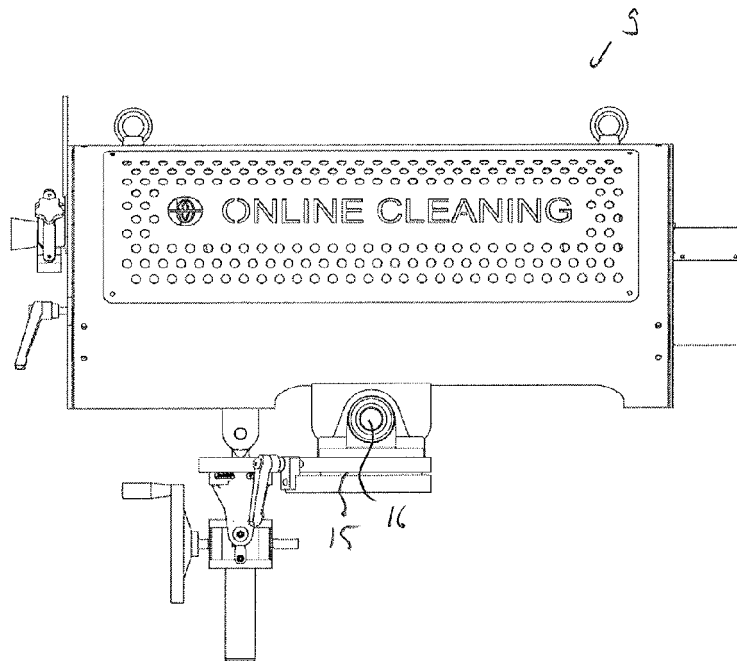


Fig. 5



EUROPEAN SEARCH REPORT

Application Number
EP 11 17 5095

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 27 February 2012	Examiner Appelt, Lothar
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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EUROPEAN SEARCH REPORT

Application Number
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DOCUMENTS CONSIDERED TO BE RELEVANT			
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Place of search The Hague		Date of completion of the search 27 February 2012	Examiner Appelt, Lothar
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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Application Number

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CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

**LACK OF UNITY OF INVENTION
SHEET B**

Application Number

EP 11 17 5095

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-7, 10

Device for cleaning installations comprising a first arm carrying an explosive and a second arm for manipulating the first arm wherein the second arm comprises a plurality of parallel interconnected elements

2. claims: 8, 9, 11-13, 15

Device and method for cleaning installations comprising a first arm carrying an explosive and a second arm for manipulating the first arm wherein a holder outside the installation comprises bearings for supporting the second arm

3. claims: 12, 14

Method for cleaning installations using a device which comprises a first arm carrying an explosive and a second arm for manipulating the first arm wherein the first arm is replaceable after destruction

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

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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

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