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(54) **DEVICE FOR AND METHOD OF CLEANING THE INTERNALS OF INSTALLATIONS**

(57) The invention relates to a device (1) for on- or offline cleaning the internals of installations, such as a furnace heat exchanger and/or a flue gas heat exchanger in a boiler of an incinerator, the heat exchanger comprising bundles of tubes or a membrane wall formed by or containing tubes, which device (1) comprises a tube (2)

containing an explosive (3) and/or pyrotechnical charge, and a detonator (4) to cause explosion and/or deflagration of the charge. The wall of the tube (2) comprises two or more materials (8,9,10), preferably two or more layers (8,9,10) of different materials.

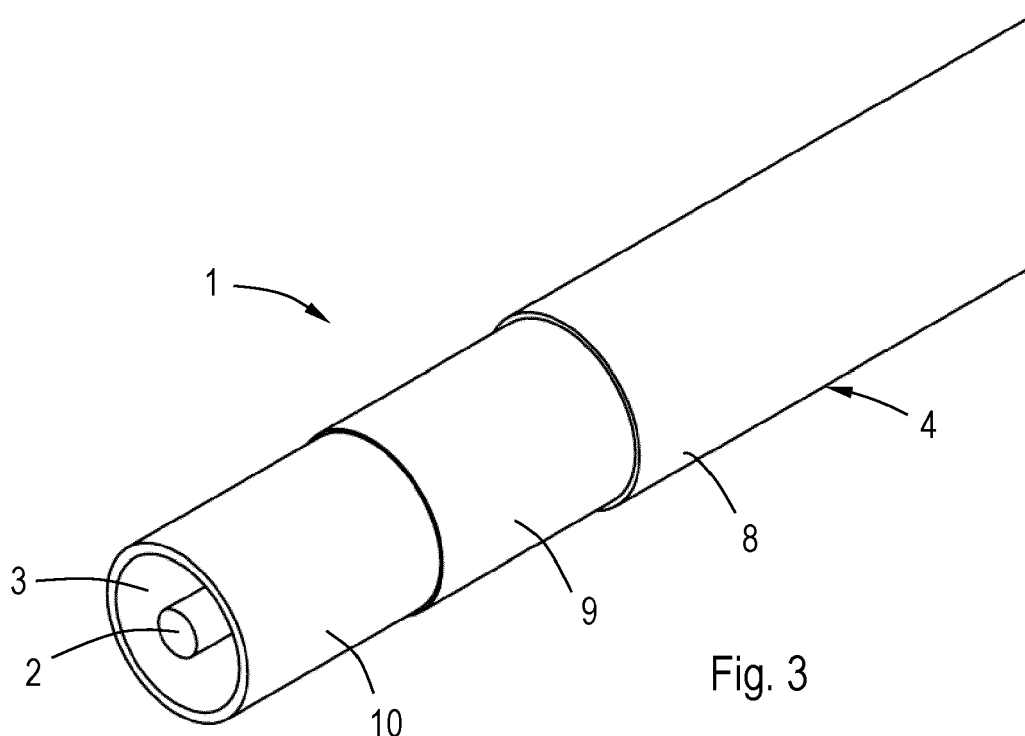


Fig. 3

Description

[0001] The invention relates to a device for on- or offline cleaning the internals of installations, such as a furnace heat exchanger and/or a flue gas heat exchanger in a boiler of an incinerator, the heat exchanger comprising bundles of tubes or a membrane wall formed by or containing tubes, which device comprises a tube containing an explosive and/or pyrotechnical charge, and a detonator to cause explosion and/or deflagration of the charge. The device and method according to the present invention are particularly suitable for removing production residues and/or deposits, e.g. from thermal incineration and recycling plants, power plants and equipment in chemical and production plants, such as deposits that negatively affect the efficiency or the production flow of a plant or equipment and thus have an indirect influence on the running time, performance and/or output of a plant.

[0002] EP 2 383 534 discloses a method for cleaning contaminations from heat exchangers, waste-heat boilers or combustion chambers, wherein the contaminations are loosened and/or removed by a linear blasting between the tubes to be cleaned. A tube is provided inside with a blasting cord, is flowed through by a coolant, is brought between the tubes to be cleaned, the blast is triggered, and the tube is destroyed upon the blast. The tubes may be made of cardboard, glass, metal, copper or plastic.

[0003] DE 1020 16202421 relates to a cooled cleaning device which includes a tube having an inner surface facing a tube interior and an outer surface facing the outer surroundings of the tube, a flammable material in the tube interior and a detonator are provided, and a distribution element to direct a fluid medium along at least a part of the outer surface of the tube.

[0004] It is an object of the present invention to provide an improved device for and method of on- or offline cleaning the internals of installations.

[0005] To this end, the device according to the present invention is characterised in that the wall of the tube comprises two or more materials.

[0006] In an embodiment, the tube comprises two or more layers of different materials, e.g. is made of a laminated material or a coextruded material.

[0007] The composite, e.g. multilayer design enables adjusting, preferably fine-tuning, the properties of the tube to the requirements of the cleaning work that is to be carried out, examples of which will be discussed below.

[0008] In an embodiment, at least one of the materials or layers in the tube comprises a synthetic material, in particular a polymer. Examples include thermoplastic polymers, such as polyethylene, e.g. HDPE, polypropylene, acrylonitrile butadiene styrene (ABS), polyoxymethylene (POM), polyester, e.g. PET, PEN or PBT, polyamide (PA), or polyvinyl chloride (PVC), or a thermoset or cross-linked polymer, e.g. cross-linked polyethylene (PEX), such as PEX-A, -B, or -C, polyethylene of raised

temperature (PE-RT), HDPE-RT, MDPE-RT, HDPEXc-RT, MDPEXc-RT, LDPEXc, LLDPEXc, or combinations thereof.

[0009] In an embodiment, at least one of materials or layers is or comprises a metal, such as aluminium, magnesium or (stainless) steel. It is preferred that the metal layer has a thickness in a range from 5 microns to 0,5 millimeters, preferably in a range from 10 to 400 microns, preferably in a range from 15 to 300 microns, preferably in a range from 20 to 200 microns. The metal layer can be, e.g., a deposited layer, a foil or film, and/or a sheet, e.g. butt welded where the longitudinal rims of the sheet meet. The metal layer can be continuous or discontinuous, e.g. perforated.

[0010] The tubes according to the present invention reduce the risk of damage to the tubes or surfaces that are being cleaned and/or leave virtually no detectable debris in the installation and/or enable the use of smaller amounts of pyrotechnical and/or explosive material, i.e. smaller charges, and/or smaller amounts or more materials that are more environmentally friendly. The metal layer was found to provide a degree of heat shielding and/or contribute considerably to mechanical strength, in particular at temperatures in excess of 75 °C, e.g. in excess of 300 °C.

[0011] In a specific example, the tube comprises three main layers: inner and outer layers of polyethylene of raised temperature (PE-RT) and a middle layer of aluminium film.

[0012] An adhesive or binding layer can be present between the metal layer(s) and adjacent layer(s), such as one or more layers of synthetic material. Examples of suitable adhesive thermoplastic polymers include ethylene vinyl alcohol (EVOH), ethylene vinyl acetate copolymer (EVA), and copolymers of ethylene and acrylic acid or methacrylic acid, i.e. ethylene acrylic acid copolymer (EAA), ethylene methacrylic acid copolymer (EMAA).

[0013] In an embodiment, the tube or a layer of the tube consists of or comprises a composite material, such as PEAL, a blend of low-density polyethylene (LDPE) and aluminium recycled from postconsumer aseptic packaging composed primarily of paper, low-density polyethylene (LDPE), and aluminium.

[0014] In an embodiment, the charge, preferably a detonation cord, contains 18 grams or less of explosive and/or pyrotechnical charge per meter of the tube, preferably less than 15 grams per meter, preferably in a range from 5 to 12 grams per meter, e.g. 6 or 8 grams per meter.

[0015] In an embodiment, the charge provides a linear explosion or deflagration.

[0016] The invention further relates to a device comprising a tube containing an explosive and/or pyrotechnical charge, and a detonator to cause explosion and/deflagration of the charge, wherein the tube with the charge in it is flexible.

[0017] In an embodiment, the tube is elastically bendable with a bending radius equal to or smaller than 2 meter, preferably equal to or smaller than 1 meter, pref-

erably smaller than 75 centimeters.

[0018] In an embodiment, the tube is plastically bendable without breaking with a bending radius equal to or smaller than 1 meter, preferably equal to or smaller than 0,7 meter, preferably equal to or smaller than 40 centimeters.

[0019] The tube is preferably cylindrical, i.e. has a cross-section that is substantially constant over its length. In an example, the tube has a circular cross-section. In another example, the tube has a non-circular cross-section, e.g. an oval cross-section, so that the tube is stiffer in one direction (for manoeuvring) and more flexible in another direction (e.g. for bending along the deposits).

[0020] In an embodiment, the tube comprises, between its inner wall and the charge, such as a detonation cord, a channel or lumen for a (flowing) coolant, such as water, air, carbon dioxide, or a mixture of air and water. In another embodiment, the (distal) end of the tube is open and, during cooling, the coolant flows out through this end. Alternatively, a return duct can be provided to return the coolant to outside of the installation.

[0021] In another embodiment coolant is supplied to the outside of the tube, e.g. flows along the tube and/or is sprayed around the tube.

[0022] In an embodiment, the tube and the charge in it has a length of at least 1 meter (m), preferably at least 1,5 m and/or a diameter smaller than 5 centimeters (cm), preferably in a range from 1 to 4 cm, preferably in a range from 1,5 to 3 cm.

[0023] For cleaning between the tubes of a heat exchanger, the tube and charge typically have a length in a range from 1 to 6 meters. For cleaning e.g. membrane walls, the tube and charge can be bent plastically, e.g. a helix, and can have a length of tens of meters, e.g. up to 100 meters.

[0024] The invention also relates to a system for on- or offline cleaning comprising a tube and charge as described above, a lance, which is provided at its proximal end, i.e. the end (to be) held by and thus close to an operator, with a supply for a coolant, such as water or a mixture of air and water, and a connector and/or electrical wires to connect the detonator to a controller and which is provided at its distal end, i.e. the end far or farthest from the operator that is inserted in the installation, with a head for holding the tube and charge and e.g. provided with outlets, e.g. nozzles, or ducts for supplying coolant to or about the tube and charge, when it is placed in the head.

[0025] In an example, the wires of the detonator are connected to the wires in the lance, and the tube containing the charge is fixed in the head of the lance. Next, the coolant supply is turned on and the charge is inserted, by means of the lance, through an opening, such as a manhole, in an online incinerator, i.e. an incinerator at full or partial load, and positioned between the tubes of a bundle in a heat exchanger to be cleaned. A spray or mist of coolant surrounds the charge to prevent it from

untimely deflagration. When at the desired location, the detonator is activated and the charge deflagrates, thus cleaning the tubes in the bundle.

[0026] In an embodiment, the lance has a length in a range from 3 to 8 meter, preferably a length in a range from 4 to 7 meter.

[0027] The invention further relates to cleaning an on- or offline installation comprising the steps of

- 10 providing a device as described above, inserting, e.g. by means of a lance, the device into the installation,
- positioning the device near residues or deposits, such as slag, to be removed,
- 15 detonating the charge thus destroying the device and removing the residues or deposits.

[0028] In an embodiment, the tube is inserted between the tubes in a bundle of tubes of a heat exchanger.

- 20 **[0029]** In another embodiment, the tube is made from a flexible material and is bent by pulling it towards and/or against the deposits. In another embodiment, the tube is plastically deformed, e.g. in the shape of a loop, a helix, or semi-circle, before it is inserted in the incinerator.

- 25 **[0030]** By adapting the (linear) charge to the shape of the deposits, the number of explosions required to complete a work, and thus costs, time, risk, and material, can be reduced considerably.

- 30 **[0031]** In an embodiment, the explosive material comprises pentaerythritol tetranitrate - also known as PENT, PENTA, TEN, corpent, penthrite or nitropenta -, ammonium nitrate/fuel oil (anfo) and/or gelatinous explosive, such as ethylene glycol dinitrate, diethylene glycol dinitrate, nitro-glycerine.

- 35 **[0032]** In an embodiment, the pyrotechnical mixture is in accordance with class P2 of directive 2007/23/EC of the European Parliament and of the Council of 23 May 2007 on the placing on the market of pyrotechnic articles. The mixture may for example comprise a reducing agent or fuel, such as black powder, aluminum, boron, titanium and/or magnesium; and an oxidant such as sodium nitrate, potassium chlorate and/or potassium perchlorate. Preferred examples of pyrotechnical mixtures include black powder, aluminum and potassium perchlorate.

- 40 **[0033]** In an embodiment, the detonator is a wireless detonator configured to initiate the explosion or deflagration upon receiving an encrypted radio signal.

- 45 **[0034]** In another embodiment, the detonator is coupled to a controller by a set of wires, which controller preferably is configured to continually measure electrical resistance of the wires and the detonator. Thus, it is possible to continually monitor the condition of the system and reduce the risk of a misfire.

- 50 **[0035]** In an embodiment, the charge contains or is surrounded by an abrasive material, such as grit, to enhance the cleaning effect of the explosion and/or deflagration.

- 55 **[0036]** For the sake of completeness, attention is drawn to the following prior art.

[0037] DE 20 2017 001549 relates to a system for deslagging containers and plants by means of blasting so-called firecrackers / pyrotechnics, or disintegrants (z. B. class IV, T1 or T2).

[0038] EP 1 275 925 relates to a process and device for local destruction of compact material, e.g. masonry remains, etc., in hot thermal systems such as heat exchangers, industrial ovens, furnaces, and metallurgical melting vessels, which uses an explosive arranged on the front end of a lance in a cooling container through which coolant flows.

[0039] Handbuch Sprengtechnik, VEB Deutscher Verlag für Grundstoffindustrie, Leipzig 1975, pages 344-351 discloses the cooling of explosive charges.

[0040] US 5,307,743 relates to a method and apparatus for deslagging a cyclone furnace in which a series of flexible hollow tubes are inserted into the combustion chamber and the explosive charges in each hollow tube are detonated sequentially. Each of the hollow tubes is biased outwardly against the accumulated slag and ash in the combustion chamber. The hollow tubes may be formed in arcs or rings in planes perpendicular to the longitudinal axis of the combustion chamber, and spacer rings may be positioned between each ring.

[0041] The invention will now be explained in more detail with reference to the drawings, which show a preferred embodiment of the present invention.

[0042] Figure 1 is a schematic cross-section in length direction a tube according to the present invention.

[0043] Figures 2 and 3 are a front view and a perspective view of the end of the tube of Figure 1, Figure 3 with two layers peeled away.

[0044] Figure 4 show examples of the a tube according to the present invention plastically bent into a two-dimensional shape.

[0045] Figure 5 show examples of the a tube according to the present invention plastically bent into a three-dimensional shape.

[0046] Figure 1 is a cross-section a device 1 for on- or offline cleaning the internals of installations, comprising a tube 2 containing an explosive charge, in this example a detonation cord 3, and a detonator 4 to cause explosion of the charge. The detonator comprises wires 5 to connect the detonator to a controller, such as an electronic blasting system, known in itself. The inner wall and the detonation cord define an annular channel 6 for a coolant. The detonator and wires can be secured e.g. in an opening in the wall of the tube or e.g. by means of a bushing 7, which, in embodiments wherein the tube is cooled on the inside, should allow the coolant to pass, e.g. by means of one or more channels or bores running the length of the bushing.

[0047] In this example, the tube has an external diameter of e.g. 16, 20, or 26 mm, a wall thickness of 2 mm, and comprises three main layers, i.e. inner and outer layers 8, 9 of polyethylene of raised temperature (PE-RT), and a middle layer 10 of aluminium. Additional layers of ethylene vinyl alcohol (EVOH; not visible in the Figures)

are present between the PE-RT and the aluminium to promote adhesion between these main layers.

[0048] The detonations cord contains 18 grams or less of explosive charge per meter, e.g. 6 or 8 grams per meter.

[0049] In an example, the tube containing the charge is fixed in the head of a lance for manoeuvring and positioning the charge, such that the coolant channel in the tube communicates with a coolant supply in or on the lance, and the wires of the detonator are connected to wires in a lance. A suitable embodiment of a(n articulated) land is described in European patent application EP 2 383 534, mentioned above.

[0050] Once the tube and charge are operatively connected, the coolant supply is turned on, causing the coolant to flow through the lance or a tube along the lance and through and/or along the tube containing the charge, to substantially surround the tube and/or the charge inside the tube. Next, the tube is inserted, by means of the lance, through an opening, such as a manhole, in an online incinerator, i.e. an incinerator at full or partial load. In an example, the incinerator was at full at a temperature of 840 °C.

[0051] The tube is manoeuvred inside the incinerator between bundles of heat exchanger tubes and subsequently inserted between the tubes in a bundle. Inside the bundle, the detonator is activated and the charge explodes, thus cleaning the adjacent tubes from within the bundle.

[0052] The tubes according to the present invention, reduce the risk of damage to the tubes or surfaces that are being cleaned and/or leave virtually no detectable debris in the installation and/or enable the use of smaller amounts of pyrotechnical and/or explosive material, i.e. smaller charges.

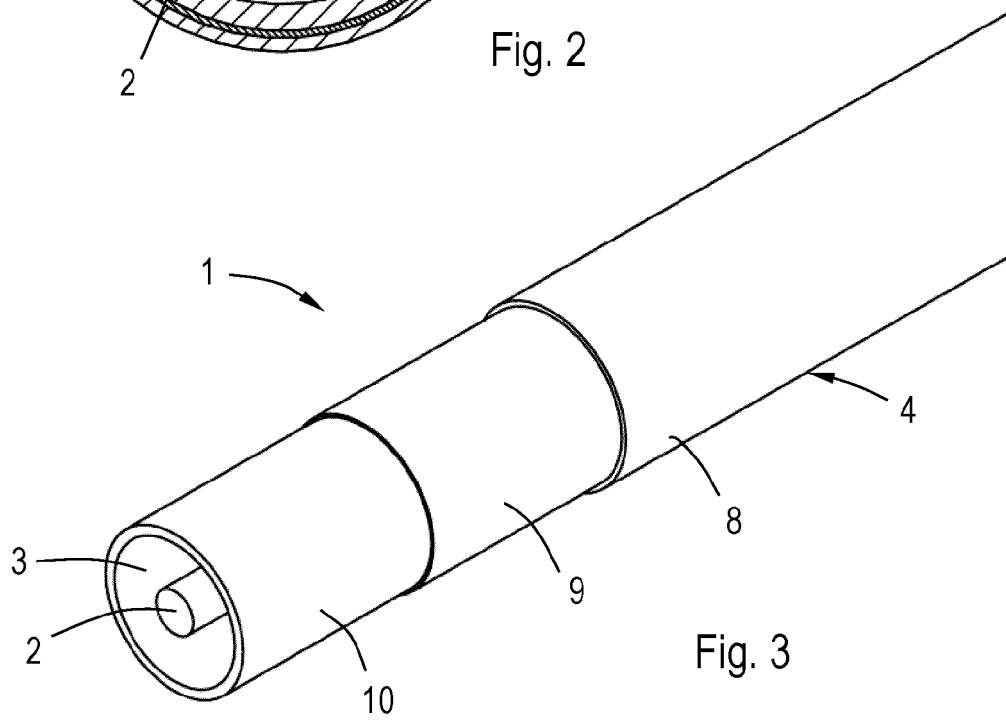
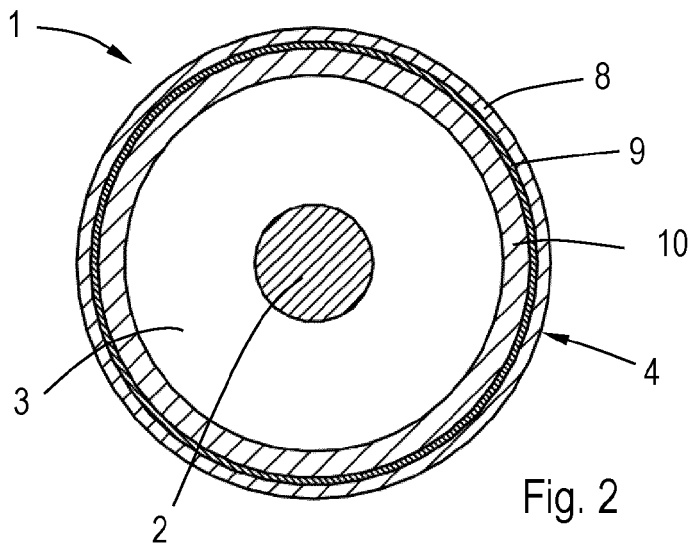
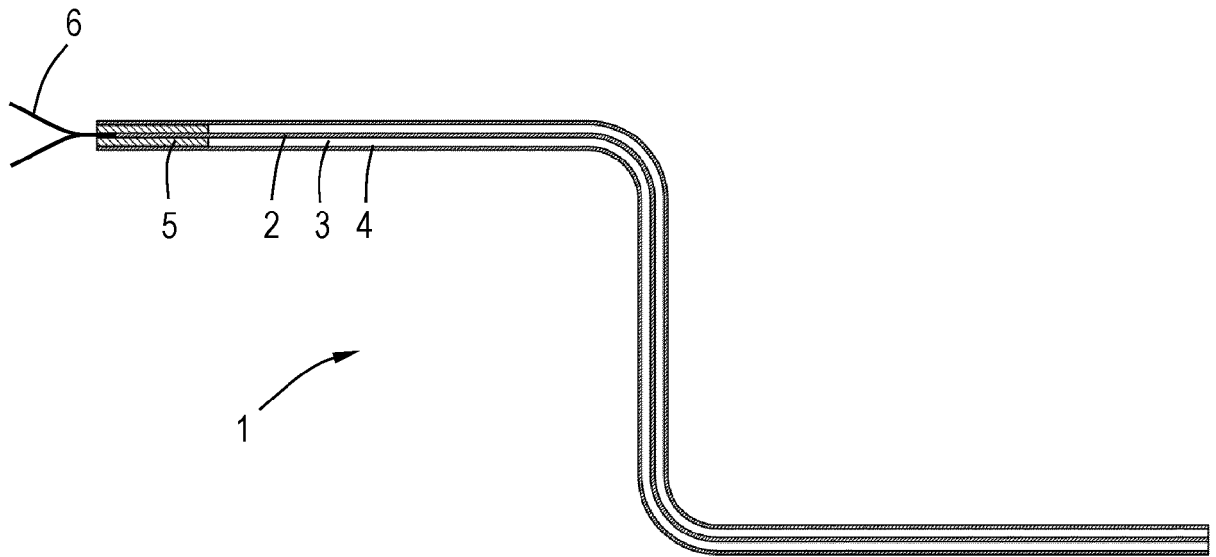
[0053] In another example, the tube with the charge in it is pulled towards and against deposits that have accumulated inside the bundle to follow, at least in part, the shape of the deposits and/or abut against the deposits, and the charge is detonated.

[0054] Further examples are shown in Figures 4 and 5. Figure 4 show examples of the a tube according to the present invention plastically bent into a two-dimensional shape, such as a circle, U-bent, or square. Figure 5 show examples of the a tube according to the present invention plastically bent into a three-dimensional shape, such as a helix. I.e. the shape of the tube and the charge in it is plastically adapted to the shape of the surface or object to be cleaned,

[0055] 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. For instance, the tube can comprise fewer layers, e.g. a metal layer covered by an single outer layer of a synthetic material, or more layers, e.g. additional layers of a synthetic material and/or of metal.

Claims

1. Device (1) for on- or offline cleaning the internals of installations, such as a furnace heat exchanger and/or a flue gas heat exchanger in a boiler of an incinerator, the heat exchanger comprising bundles of tubes or a membrane wall formed by or containing tubes, which device (1) comprises a tube (2) containing an explosive (3) and/or pyrotechnical charge, and a detonator (4) to cause explosion and/or deflagration of the charge, **characterised in that** the wall of the tube (2) comprises two or more materials (8,9,10). 5
2. Device (1) according to claim 1, wherein the tube (2) comprises two or more layers (8,9,10) of different materials. 10
3. Device (1) according to claim 1 or 2, wherein at least one of the materials or layers (8,9,10) in the tube (2) comprises a synthetic material, in particular a polymer. 15
4. Device (1) according to any one of the preceding claims, wherein at least one of materials or layers (8,9,10) is or comprises a metal, such as aluminium (10), magnesium or steel. 20
5. Device (1) according to claim 4, wherein the metal layer (10) has a thickness in a range from 5 microns to 0,5 millimeters, preferably in a range from 10 to 400 microns, preferably in a range from 15 to 300 microns, preferably in a range from 20 to 200 microns. 25
6. Device (1) according to any one of the preceding claims, wherein the charge, preferably a detonation cord (3), contains 18 grams or less of explosive and/or pyrotechnical charge per meter of the tube, preferably less than 15 grams per meter, preferably in a range from 5 to 12 grams per meter. 30
7. Device (1) according to any one of the preceding claims or the preamble of claim 1, wherein the tube (2) with the charge (3) in it is flexible. 35
8. Device (1) according to anyone of the preceding claims, wherein the tube (2) is elastically bendable with a bending radius equal to or smaller than 2 meter (m), preferably equal to or smaller than 1 m, preferably smaller than 75 centimeters (cm). 40
9. Device (1) according to anyone of the preceding claims, wherein the tube (1) is plastically bendable without breaking with a bending radius equal to or smaller than 1 m, preferably equal to or smaller than 0,7 m, preferably equal to or smaller than 40 cm. 45
10. Device (1) according to any one of the preceding claims, wherein the tube (2) comprises, between its inner wall and the charge (3), such as a detonation cord, a channel (6) or lumen for a coolant. 50
11. Device (1) according to any one of the preceding claims, wherein the tube (2) has a length of at least 1 meter, preferably at least 1,5 m and/or a diameter smaller than 5 cm. 55
12. System for on- or offline cleaning the internals of installations, such as a furnace heat exchanger and/or a flue gas heat exchanger in a boiler of an incinerator, which system comprises one or more devices (1) according to any one of the preceding claims and a lance, which is provided at its distal end with a head or connector for attaching the device (1) or one of the devices (1), and which is provided at its proximal end with a supply for a coolant and a connector and/or electrical wires to connect the detonator of the device to a controller.
13. Method of cleaning an on- or offline installation comprising the steps of
 - providing a device (1) according to any one of the preceding claims,
 - inserting the device (1) into the installation,
 - positioning the device (2) near residues or deposits, such as slag, to be removed,
 - detonating the charge (3) thus destroying the device (1) and removing the residues or deposits.
14. Method according to claim 13, wherein the device (1) is inserted between the tubes in a bundle of tubes of a heat exchanger.
15. Method according to claim 13 or 14, wherein the device (1) comprises a tube (2) that is made from a flexible material and the tube (2) is bent by pulling it towards and/or against the residues and/or deposits and/or wherein the tube is plastically deformed, e.g. in the shape of a loop, a helix, or semi-circle, before it is inserted in the incinerator.



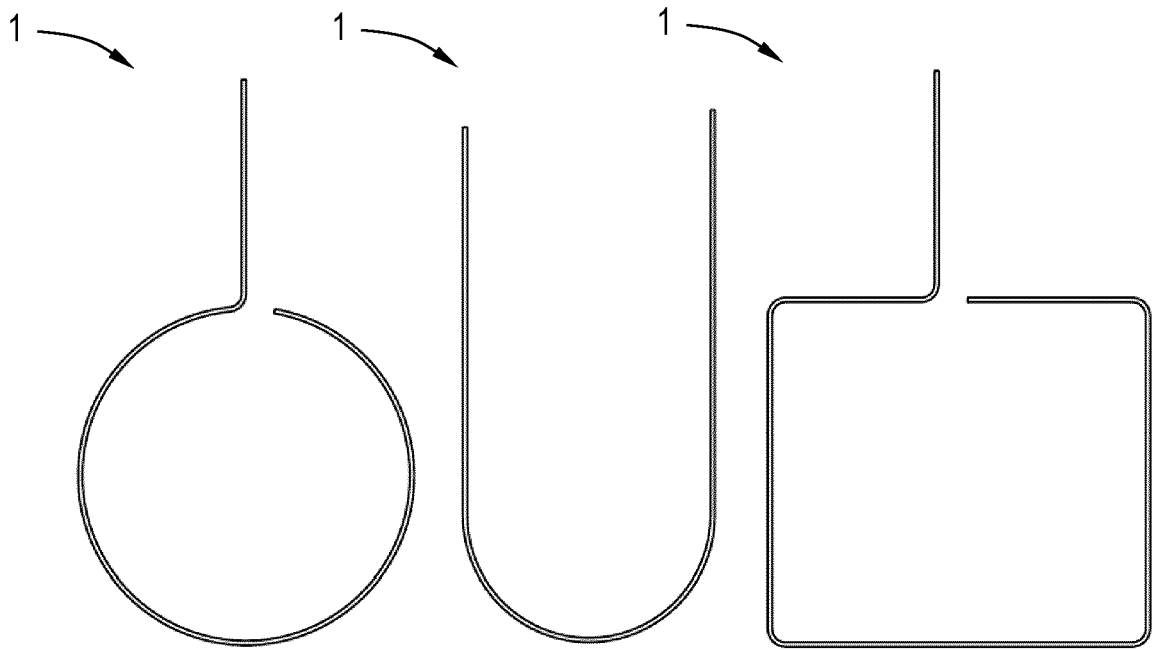


Fig. 4

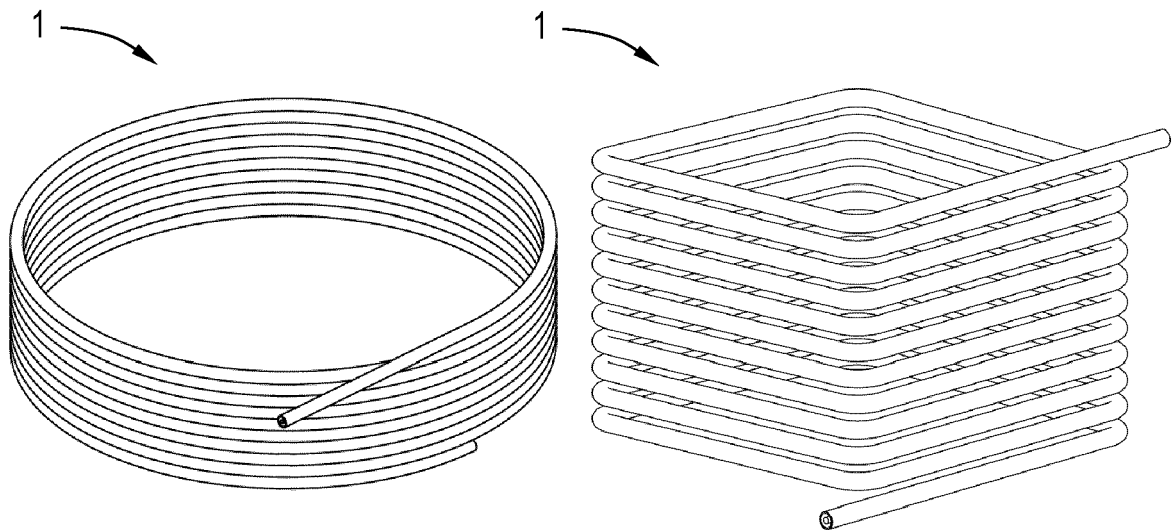


Fig. 5



EUROPEAN SEARCH REPORT

Application Number

EP 21 20 0240

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EPO FORM 1503 03.82 (P04C01)

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			TECHNICAL FIELDS SEARCHED (IPC)
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 16 February 2022	Examiner Delaitre, Maxime
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			

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

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