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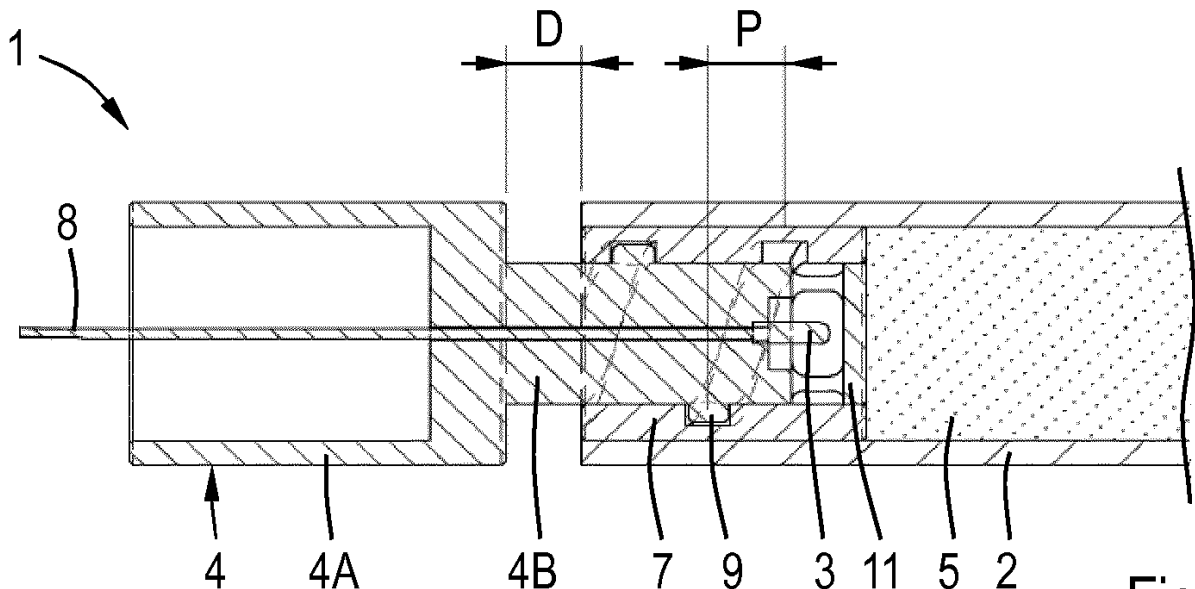
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(54) **DEVICE FOR AND METHOD OF CLEANING INSTALLATIONS**

(57) The invention relates to a cartridge (1) for cleaning installations, such as incinerators, heat exchangers, flue gas channels, and silos, comprising a casing, e.g. a sleeve (2), containing a pyrotechnical mixture (5) and/or components of a pyrotechnical mixture and comprising an electrical detonator (3) for initiating deflagration of the mixture. The cartridge further comprises a housing (4) which accommodates the detonator (3) and which housing (4) is attached to the casing (2) and movable between a first position, wherein the detonator (3) is isolated from the pyrotechnical mixture (5), and a second position, wherein the detonator (3) extends in the pyrotechnical mixture (5).



**Fig.2**

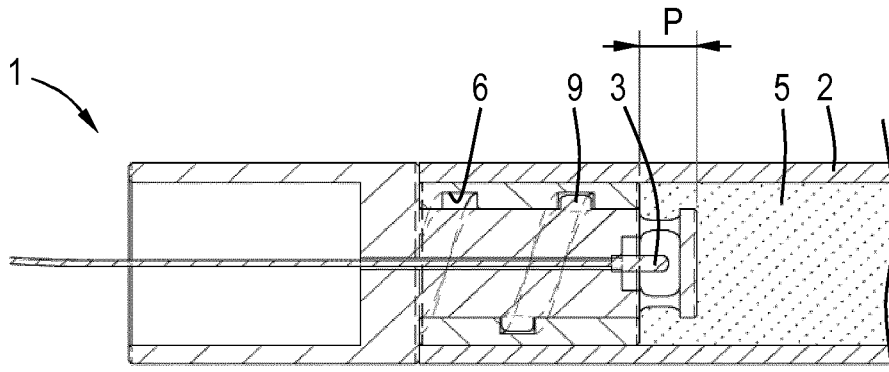


Fig.3

## Description

**[0001]** The invention relates to a cartridge for on- or offline cleaning installations, such as incinerators, heat exchangers, flue gas channels, and silos, comprising a casing, e.g. a sleeve, containing a pyrotechnical mixture, in particular a class P2 pyrotechnical mixture, and/or components of a pyrotechnical mixture and comprising an electrical detonator for initiating deflagration of the mixture. Other applications include, but are not limited to, bundles of heat exchanger pipes, evaporators, economizers, washers/scrubbers, cyclones, catalysts, absorbers, spray dryers, cooling towers, funnels, and various filters.

**[0002]** The invention also relates to a system comprising such a cartridge and a lance for holding, cooling, and positioning the cartridge inside an installation.

**[0003]** WO 2011/096872 relates to a rock cracker cartridge (numeral 1 in the figures of WO 2011/096872) which contains a cracking powder charge (6) and an ignition capsule (30) with an ignition powder charge (29) in an ignition unit sleeve (31) which does not possess the mechanical strength that would be required for the ignition powder charge to be exploded in the open air when ignited. In the rock cracker cartridge there is also provided an ignition assembly sleeve (7a) which surrounds the ignition unit sleeve when the rock cracker cartridge is primed. In combination, the assembly which surrounds the cracking powder charge, and which comprises the ignition unit sleeve and the ignition assembly sleeve, has a sufficient strength for an adequate pressure to be developed in the assembly such that the ignition powder charge will explode and generate a flame of fire and the ignition unit sleeve as well as the ignition assembly sleeve be penetrated by the pressure and the flame of fire, said flame of fire igniting the cracking powder charge.

**[0004]** DE 20 2017 001549 relates to a system for deslagging containers and plants by means of blasting, wherein a classified as a so-called firecrackers / pyrotechnics, disintegrants (z. B. class IV, T1 or T2), in the vicinity of the pollution or Caking or slagging is brought, and the explosive mixture is made to explode.

**[0005]** Although pyrotechnics are by some perceived as relatively safe when compared to gelatinous explosives, such as ethylene glycol dinitrate, diethylene glycol dinitrate, nitro-glycerine, in practice they are not safer.

**[0006]** It is an object of the present invention to provide an improved cartridge for cleaning installations by means of pyrotechnics.

**[0007]** To this end, the cartridge according to the present invention is characterized by a housing which accommodates the detonator and which housing is attached to the casing and movable between a first (safe) position, wherein the detonator is isolated from the pyrotechnical mixture, and a second (primed) position, wherein the detonator extends in the pyrotechnical mixture.

**[0008]** In an embodiment, the housing or detonator on the one hand and the casing on the other hand comprise engaging parts that enable moving, and preferably also locking after priming, of the detonator to inside the mixture by relative sliding and/or rotation of the detonator and the casing.

**[0009]** In a refinement, the housing or detonator on the one hand comprises at least one protrusion, such as a cam, key, or external screw thread, or a groove, such as an bayonet slot or an internal screw thread, and the casing on the other hand comprises a groove or protrusion, respectively, cooperating with the protrusion or groove in or on the housing to define a path of the relative movement.

**[0010]** Thus, the cartridge can be primed at the work, e.g. some moments prior to its use, by establishing e.g. a screw, bayonet, or snap fit connection between the detonator and the casing.

**[0011]** In an embodiment, a blocking mechanism, such as a ring that can be torn off e.g. by breaking it, is located between the housing and the casing, to prevent inadvertent priming.

**[0012]** In an embodiment, the donator is at the distal end of the housing and exposed at least laterally.

**[0013]** In another embodiment, the mixture is a suspended, e.g. fluidized (upon shaking) powder, i.e. a powder loose in the casing, a compactable powder, i.e. a coherent mass which can still be compacted to such an extent that it allows the detonator to be extended directly into the mixture, or a compacted powder with a defined cavity for receiving the detonator.

**[0014]** The invention also relates to a cartridge comprising a casing containing a pyrotechnical mixture and/or components of a pyrotechnical mixture and comprising an electrical detonator for initiating deflagration of the mixture, wherein the detonator is configured to initiate deflagration of the mixture at a current of at least five Ampere, preferably at least ten Ampere, preferably at least twenty Ampere.

**[0015]** The Meta-pyro pyrotechnical igniter mentioned in WO 2011/096872 has a firing current of max 2,12 A, see <http://www.meta-pyro.cz/en/technical-specifications>. By providing, in accordance with the present invention a detonator having a firing current of at least 5 A, the risk of accidental detonation resulting from sparks or static electricity, occurring e.g. during transport or at a work, is reduced.

**[0016]** In an embodiment, to shield it from static electricity and/or moist, in the first position of the housing, the detonator is enclosed or encapsulated by a synthetic material, such as a thermoplastic polymer.

**[0017]** In a refinement the casing is made of or laminated with a synthetic material. In another embodiment, the casing is water- and/or dust tight.

**[0018]** This will increase safety in that contamination of the work with pyrotechnical mixture leaking from the cartridge is avoided or at least reduced and in that the risk a dud cartridge, e.g. a misfire, is reduced.

**[0019]** In an embodiment, the casing is enveloped by a thermally insulating material and/or a liquid absorbing material.

**[0020]** Thus, the cartridge is for, e.g. a few minutes, protected from heat and/or cooled by a coolant, such as water soaking the liquid absorbing material.

**[0021]** The invention also relates to a cartridge comprising a casing containing a pyrotechnical mixture and/or components of a pyrotechnical mixture and comprising an electrical detonator for initiating deflagration of the mixture, comprising a plurality of compartments and wherein the compartments contain different components of the pyrotechnical mixture.

**[0022]** This allows mixing of these components, e.g. by removing or breaking the wall(s) between the compartments and shaking the cartridge, a short time before its use, thus further increasing safety, in particular during transport.

**[0023]** In an embodiment, the nett mass (NEM) of the mixture is in a range from 20 to 1000 grams, preferably in a range from 20 to 500 grams.

**[0024]** The nett mass of the mixture and the dimensions and shape of the cartridge determine to some extent the speed of the deflagration and the size and shape of the shock wave. E.g. a smaller nett mass will typically result in a higher deflagration speed and a shock wave of relatively small dimensions, providing a fierce and localized blow.

**[0025]** In another embodiment, the 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.

**[0026]** In an embodiment, the detonator is a wireless detonator configured to initiated deflagration upon receiving an encrypted radio signal.

**[0027]** In another embodiment, the cartridge is coupled to a controller by a set of wires, which controller is configured to continually measure electrical resistance of the wires and the detonator.

**[0028]** Thus, it is possible to continually monitor the condition of the system and reduce the risk of a misfire.

**[0029]** The invention also relates to a system for on- or offline cleaning installations, such as incinerators, heat exchangers, flue gas channels, and silos, comprising a cartridge according to any one of the preceding claims, a lance, which is provided at its proximal end, i.e. the end (to be) held by and thus close to an operator, 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, with a head for holding the cartridge and provided with outlets,

e.g. nozzles, or ducts for supplying coolant to or about the cartridge.

**[0030]** In an example, the wires of the detonator are connected to the wires in the lance, the cartridge is primed and the cartridge is fixed in the head of the lance. Next, the coolant supply is turned on and the cartridge is inserted, by means of the lance, through an opening, such as a manhole, in an online installation and positioned adjacent a surface or element, such as a bundle of heat exchanger pipes, to be cleaned. A spray or mist of coolant surrounds the cartridge to prevent it from untimely deflagration. When at the desired location, the detonator is activated and the mixture deflagrates, thus cleaning the adjacent surface or element.

**[0031]** 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.

**[0032]** 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.

**[0033]** Handbuch Sprengtechnik, VEB Deutscher Verlag für Grundstoffindustrie, Leipzig 1975, pages 344-351 discloses the cooling of explosive charges.

**[0034]** US 5,494,004 relates to an online pulsed detonation/deflagration soot blower.

**[0035]** 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 a perspective of a cartridge according to the present invention comprising a detonator and containing a pyrotechnical mixture.

Figure 2 is partial cross-section of the cartridge shown in Figure 1 with the detonator in a safe position.

Figure 3 is partial cross-section of the cartridge shown in Figure 1 with the detonator in the primed position.

Figure 4A and 4B show the housing of the detonator. Figures 5A and 5B show an insert for rotatably receiving the housing of the detonator.

**[0036]** Figure 1 shows a cartridge 1 for on- or offline cleaning installations, such as incinerators, heat exchangers, flue gas channels, and silos. The cartridge comprises a casing, in this example, a cylindrical sleeve 2 closed at one end and open at the other end, a detonator 3 that is accommodated in a housing 4, which housing in turn is mounted in the open end of the sleeve, such

that it is movable between a first (safe) position, shown in cross-section in Figure 2, wherein the detonator is isolated from the pyrotechnical mixture 5 inside the sleeve, and a second (primed) position, shown in cross-section in Figure 3, wherein the detonator extends directly in the pyrotechnical mixture.

**[0037]** The open end of the sleeve 2 is provided with an internal groove 6, in this this example an internal screw thread that defined in an insert 7, shown in more detail in Figures 5A and 5B, that is fixed, e.g. clamped, welded, or glued, in the open end of the sleeve.

**[0038]** The housing 4 accommodating the detonator 3 has a first section 4A, that has the same cylindrical shape and the same diameter as the sleeve 2 and from which section the wires 8 of the detonator 3 extend, and a second section 4B that carries at least one protrusion, e.g. two projections 9, or an external screw thread.

**[0039]** The (distal) end of the second section 4B contains the actual detonator 3 and comprises a plurality of openings 10 and a disc-shaped front wall 11 having a diameter that is equal to the internal diameter on the insert 7. Thus, when the housing 4 is in the first (safe) position, the detonator 3 is in a closed chamber defined by the inner wall of the insert 7 and the front wall 11 of the housing 4 and, when the housing 4 has been moved to the second (primed) position, the detonator 3 is, via the openings, in direct contact with the pyrotechnical mixture 5 of at least communicates directly with the cavity in the sleeve 2 containing the mixture 5.

**[0040]** In this example, the angle between the safe and primed positions of the housing and the detonator is defined by the pitch,  $P$ , of the internal screw thread and the distance,  $D$ , between the (proximal) end of the sleeve and the (distal) end of the first section 4A of the housing 4. If the pitch,  $P$ , of the internal thread is twice the distance,  $D$ , the housing must be turned over an angle of 180 degrees to prime that cartridge and lock, by friction, the housing and the detonator with respect to the sleeve. In an embodiment, a blocking mechanism, such as a ring (not shown) that can be torn off e.g. by breaking it, is placed in the space provided by the distance,  $D$ , to prevent inadvertent priming.

**[0041]** The casing, housing, and insert were made from an thermoplastic material. Suitable manufacturing methods include injection moulding, extrusion, and 3D printing.

**[0042]** The cartridge of the present invention can be primed at the work, e.g. some moments prior to its use, efficiently and by a straightforward act.

**[0043]** 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.

## Claims

1. Cartridge (1) for cleaning installations, such as incinerators, heat exchangers, flue gas channels, and

silos, comprising a casing, e.g. a sleeve (2), containing a pyrotechnical mixture (5) and/or components of a pyrotechnical mixture and comprising an electrical detonator (3) for initiating deflagration of the mixture, **characterized by** a housing (4) which accommodates the detonator (3) and which housing (4) is attached to the casing (3) and movable between a first position, wherein the detonator (3) is isolated from the pyrotechnical mixture (5), and a second position, wherein the detonator (3) extends in the pyrotechnical mixture (5).

2. Cartridge (1) according to claim 1, wherein the housing (4) or detonator (3) on the one hand and the casing (2) on the other hand comprise engaging parts (9; 6) that enable moving of the detonator (3) to inside the mixture (5) by relative sliding and/or rotation of the detonator (3) and the casing (2).

3. Cartridge (1) according to claim 1 or 2, wherein the housing (4) or detonator (2) on the one hand comprises at least one protrusion (9) or a groove and the casing (2) on the other hand comprises a groove (6) or protrusion, respectively.

4. Cartridge (1) according to any one of the preceding claims, wherein the donator (3) is located at or near the distal end of the housing (4) and exposed at least laterally.

5. Cartridge (1) according to any one of the preceding claims, wherein the mixture (5) is a suspended powder, a compactable powder, or a compacted powder with a defined cavity for receiving the detonator (3).

6. Cartridge (1) according to any one of the preceding claims or the pre-amble of claim 1, wherein the detonator (3) is configured to initiate deflagration at a current of at least five Ampere, preferably at least ten Ampere, preferably at least twenty Ampere.

7. Cartridge (1) according to any one of the preceding claims, wherein, in the first position of the housing (4), the detonator (3) is enclosed or encapsulated by a synthetic material, such as a thermoplastic polymer.

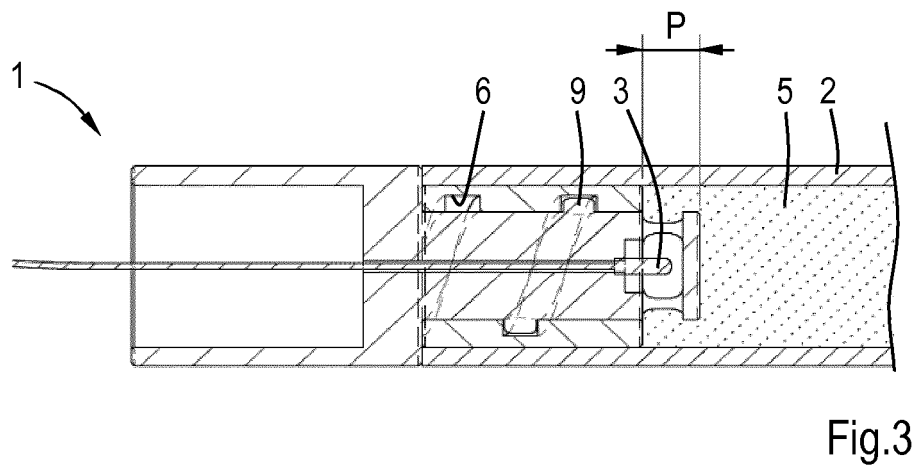
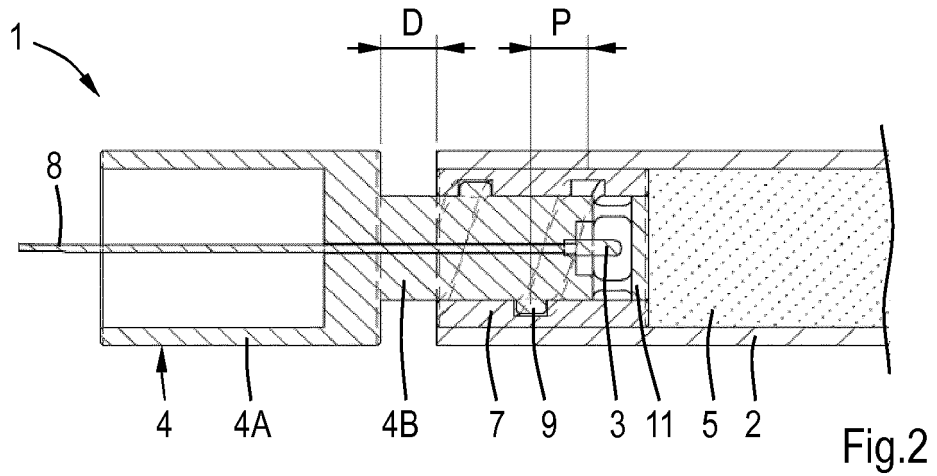
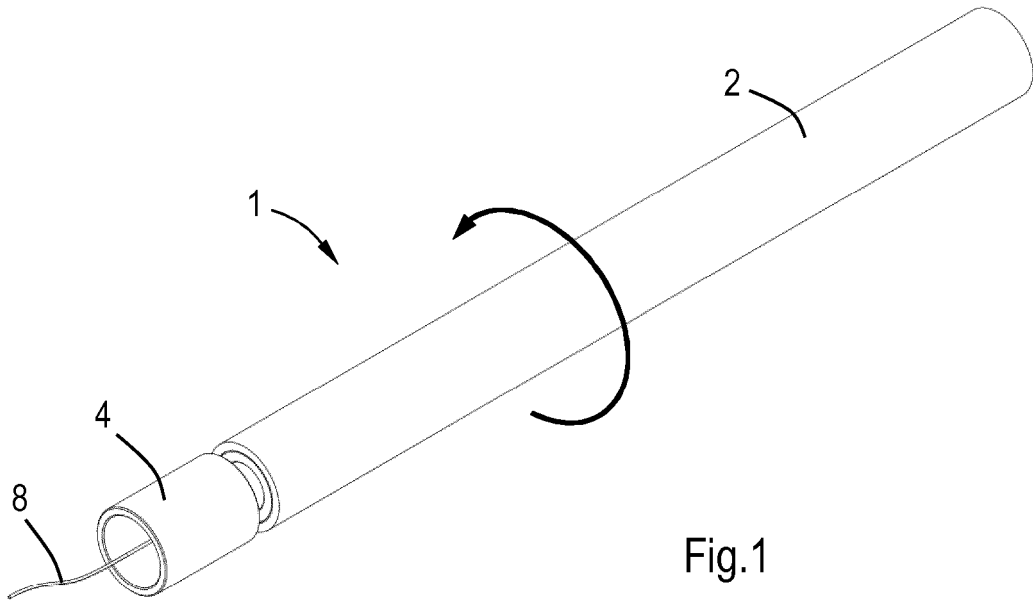
8. Cartridge (1) according to any one of the preceding claims, wherein the casing (2) and/or the housing (4) is made of or laminated with a synthetic material.

9. Cartridge (1) according to any one of the preceding claims, wherein the casing (2) is water- and/or dust tight.

10. Cartridge (1) according to any one of the preceding claims, wherein the casing (2) is enveloped by a thermally insulating material and/or a liquid absorbing

material.

- 11. Cartridge (1) according to any one of the preceding claims or the pre-amble of claim 1, comprising a plurality of compartments and wherein the compartments contain different components of the pyrotechnical mixture (5) . 5
  
- 12. Cartridge (1) according to any one of the preceding claims, wherein the nett mass (NEM) of the mixture is in a range from 20 to 1000 grams. 10
  
- 13. Cartridge (1) according to any one of the preceding claims, wherein the mixture (5) comprises 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. 15
  
- 14. Cartridge (1) according to any one of the preceding claims, that is coupled to a controller by a set of wires (8), which controller is configured to continually measure electrical resistance of the wires (8) and the detonator (3). 20
  
- 15. System for cleaning installations, such as incinerators, heat exchangers, flue gas channels, and silos, comprising a cartridge (1) according to any one of the preceding claims, a lance, which is provided at its proximal end with a supply for a coolant and a connector and/or electrical wires to connect the detonator to a controller and which is provided at its distal end with a head for holding the cartridge and provided with outlets or ducts for supplying coolant to or about the cartridge (1). 25
  
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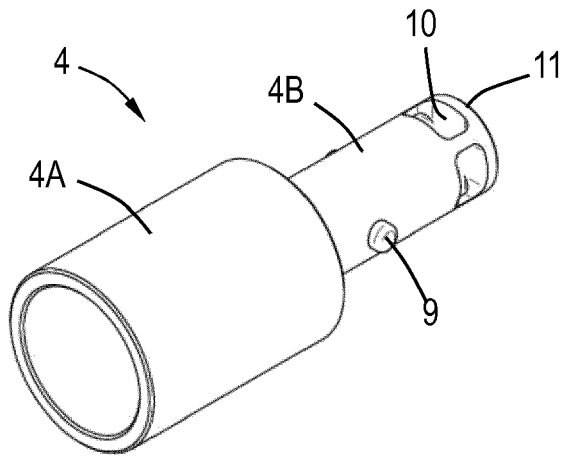


Fig.4A

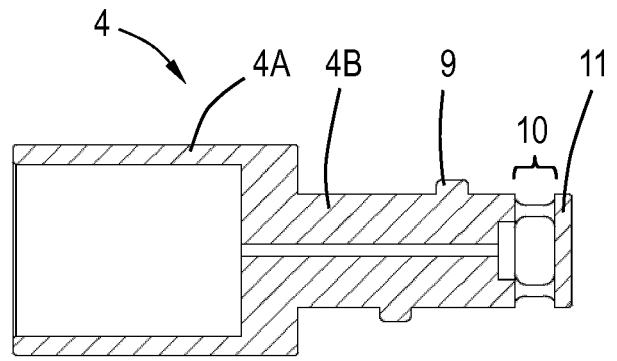


Fig.4B

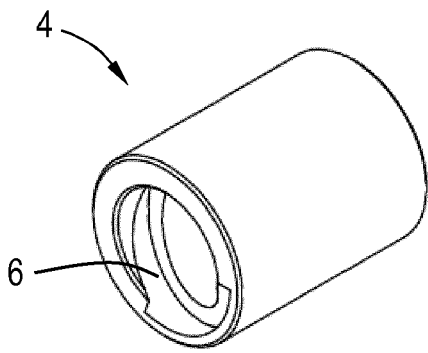


Fig.5A

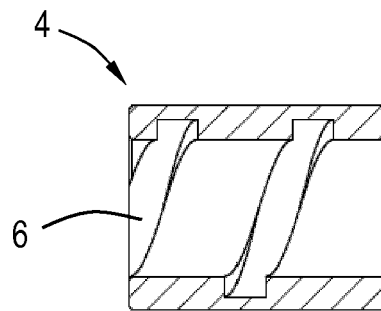


Fig.5B



EUROPEAN SEARCH REPORT

Application Number  
EP 19 18 7636

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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 13 May 2020	Examiner Kasten, Klaus
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			

EPO FORM 1503 03/02 (P04C01)



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**CLAIMS INCURRING FEES**

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

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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):

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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.

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**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:

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see sheet B

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

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

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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:

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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:

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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 19 18 7636

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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:

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1. claims: 1-15

Cartridge with movable detonator

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2. claims: 6-15

Selection of detonator

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3. claims: 11-15

Optimization of the casing

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

EP 19 18 7636

5 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  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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*This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.*

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