

(19)



SUOMI - FINLAND

(FI)

PATENTTI- JA REKISTERIHALLITUS
PATENT- OCH REGISTERSTYRELSEN
FINNISH PATENT AND REGISTRATION OFFICE

(10) **FI 129686 B**
(12) **PATENTTIJULKAISU**
PATENTSKRIFT
PATENT SPECIFICATION

(45) Patentti myönnetty - Patent beviljats - Patent granted **30.06.2022**

(51) Kansainvälinen patenttiluokitus - Internationell patentklassifikation -
International patent classification
F23D 11/36 (2006.01)
F23D 11/10 (2006.01)
F23D 14/22 (2006.01)
F23D 14/46 (2006.01)
F23C 5/14 (2006.01)
F23K 5/00 (2006.01)
F16L 39/00 (2006.01)

(21) Patenttihakemus - Patentansökning - Patent application 20195230

(22) Tekemispäivä - Ingivningsdag - Filing date **26.03.2019**

(23) Saapumispäivä - Ankomstdag - Reception date **26.03.2019**

(43) Tullut julkiseksi - Blivit offentlig - Available to the public **27.09.2020**

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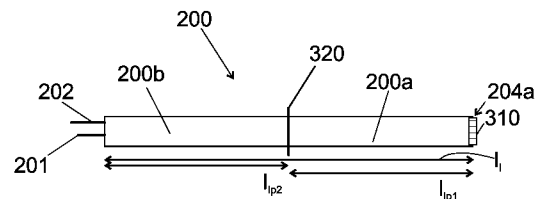
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(54) Keksinnön nimitys - Uppfinningens benämning - Title of the invention
Poltin ja menetelmä poltinputken huoltamiseksi
Brännare och förfarande för att underhålla ett brännarrör
A burner and a method for maintaining a burner lance

(56) Viitejulkaisut - Anförda publikationer - References cited
CA 2016855 C, CN 102380464 B, WO 2017173537 A1, GB 2076687 A, EP 1998111 A2, EP 1517085 A2

(57) Tiivistelmä - Sammandrag - Abstract

Poltinputki (200) käsittää ensimmäisen osan (200a) ja toisen osan (200b). Poltinputki (200) käsittää ensimmäisen avattavan kiinnittimen (320) ensimmäisen osan (200a) kiinnittämiseksi toiseen osaan (200b) ja toisen osan (200b) irrottamiseksi ensimmäisestä osasta (200a). Ensimmäinen osa (200a) käsittää sisäputken (210) ensimmäisen osan (210a) ja ulkoputken (220) ensimmäisen osan (220a). Ensimmäinen osa (200a) on kiinnitettävissä tai on kiinnitetty suuttimeen (310). Toinen osa (200b) käsittää sisäputken (210) toisen osan (210b) ja ulkoputken (220) toisen osan (220a). Poltinputki (200) käsittää ensimmäisen ja toisen sisäänmenon (201, 202) ensimmäisen ja toisen virtaavan aineen päästämiseksi sisäputkeen (210) ja ulkoputkeen (220). Menetelmä poltinputken (200) huoltamiseksi, jossa menetelmässä irrotetaan poltinputken (200) toinen osa (200b) poltinputken (200) ensimmäisestä osasta (200a) ja tämän jälkeen huolletaan tai vaihdetaan ainakin joko suutin (310) tai poltinputken (200) ensimmäinen osa (200a).



A burner lance (200) comprising a first part (200a) and a second part (200b). The burner lance (200) comprises a first openable fastener (320) for fastening the first part (200a) to the second part (200b) and for detaching the second part (200b) from the first part (200a). The first part (200a) comprises a first part (210a) of an inner pipe (210) and a first part (220a) of an outer pipe (220). The first part (200a) is attachable or attached to a nozzle (310). The second part (200b) comprises a second part (210b) of the inner pipe (210) and a second part (220a) of the outer pipe (220). The burner lance (200) comprises first and second inlets (201, 202) for letting in the first and second fluids into the inner pipe (210) and the outer pipe (220). A method for maintaining a burner lance (200), the method comprising detaching a second part (200b) of the burner lance (200) from a first part (200a) of the burner lance (200), and thereafter maintaining or replacing at least one of the nozzle (310) and the first part (200a) of the burner lance (200).

A burner and a method for maintaining a burner lance

Technical field

5 The invention relates to lances suitable for burners. Such lances are commonly called burner lances. The invention relates to burners comprising such lances. Such burners are commonly called lance burners. The invention relates to boilers comprising such lance burners and/or burner lances. The invention relates to maintenance of burner lances and lance burners.

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Background

15 Burner lances and lance burners are used to deliver at least two materials into a furnace separately. Often a first material is a carrier medium for delivering some second material, and the second material is a fuel. The materials are fluids, i.e. they may be liquid or gaseous. The first material may be gaseous, e.g. air or steam, and the second material may be a liquid, e.g. oil or alcohol (e.g. methanol). Burner lances typically deliver the first and the second fluid to a nozzle, which mixes the fluids, e.g. by forming a fine spray of the first fluid together with the second fluid. A lance is commonly called a gun.

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25 Burner lances need to be maintained from time to time. Maintenance may include cleaning the nozzle or changing the nozzle. For maintenance, the burner lance is removed from a furnace or a burner. Burner lances commonly comprise relatively lengthy pipes. Moreover, the furnace, in which the burner lance is used, is typically arranged within a boiler house. For these reasons, a wall of the boiler house needs to be sufficiently far away from the furnace at least at the location, wherein the burner lance is arranged. If not, the relatively lengthy burner lance could not be withdrawn from the furnace, and could therefore not be maintained.

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35 More efficient use of space within a boiler plant would require small boiler houses. However, for the aforementioned reasons, burner lances and their maintenance impose a limit to the degree to which the size of the boiler house can be decreased. In a corresponding manner, an output power of the boiler depends on the size of the furnace. In case the size of the boiler house is fixed,

the size of the furnace, and thus the output power, can only be increased to such a level that the maintenance of the burner lance is still possible. The maintenance is possible, when there is sufficiently free space in between the furnace and the boiler house.

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Burners are known from EP 1 517 085, which discloses feeding fuel and air to a furnace to enable low-NO_x combustion; CA 2,016,855, which discloses a burner lance for feeding oil and air into a furnace, the burner lance having a replaceable nozzle; and CN102380464 discloses an oil-spraying oil-cooling oxygen gun, belonging to the technical field of metallurgical oxygen blowing equipment, the gun having detachable inlet connectors.

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Summary

It has been noticed that the lance burner can be maintained even if the free space in between the furnace and the boiler house is small, when the lengthy lance burner is detached to shorter parts using an openable fastener. Thus, a part of the burner lance can be withdraw from the furnace such that at least the openable fastener is withdrawn from a protective pipe, a part can be detached from the burner lance, and a part of the burner lance can be maintained or replaced, as specifically detailed in claim 15.

20

It has been noticed that the shorter part can be detached from the burner lance easily, when the burner lance comprises an openable fastener, i.e. a first openable fastener. The first openable fastener can be used for detaching a second part of the burner lance from a first part of the burner lance. Moreover, after maintenance, the openable fastener can be used for fastening the first part of the burner lance to the second part of the burner lance. According to the invention, a burner comprises a protective pipe laterally surrounding the burner lance as specifically disclosed in claim 1.

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The invention relates also to a boiler plant as specified in claim 13.

Preferable embodiments are disclosed in the dependent claims. These and other embodiments are disclosed in the description and figures.

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Brief description of the drawings

- Fig. 1a shows a boiler plant having a boiler comprising a burner that comprises a burner lance,
- 5 Fig. 1b shows a boiler plant having a boiler comprising a burner that comprises a burner lance,
- Fig. 1c shows an inner pipe, an outer pipe, and channels for fluids of a burner lance,
- Fig. 1d shows a boiler plant having a burner lance,
- 10 Fig. 1e shows an orientation of a burner lance,
- Figs. 2a and 2b show a burner lance having a first part and a second part, wherein the second part is detachable from the first part,
- Figs. 3a to 3d3 show embodiments of burner lances, in particular attachments in between a first part of an inner pipe and a second part of the inner pipe,
- 15 Figs. 4a to 4c show embodiments of burner lances, in particular attachments in between a first part of an outer pipe and a second part of the outer pipe,
- Figs. 5a to 5c show burner lances attached to a nozzle,
- 20 Fig. 6a shows a burner lance having a first part, a second part, and a third part, wherein the third part is detachable from the second part,
- Fig. 6b shows a burner lance having a secondary outer pipe surrounding the (primary) outer pipe,
- Fig. 6c and 6d show a burner lance having a secondary outer pipe surrounding the (primary) outer pipe and a tertiary outer pipe surrounding the secondary outer pipe,
- 25 Fig. 7a shows a burner comprising the burner lance and a protective pipe,
- Fig. 7b shows an arrangement comprising the burner lance, a protective pipe, and a tool, and
- 30 Fig. 7c shows a burner further comprising an air box.

Detailed description

- 35 Figs. 1a, 1b, and 1d show boiler plant 100 comprising boiler 120 provided with a burner 400 comprising a burner lance 200. Since the burner 400 comprises the lance 200 the burner 400 can be called a lance burner 400. The burner

lance 200 is attached to a nozzle 310 for delivering first fluid and second fluid into a furnace 124 of a boiler 120. The boiler 120 is arranged inside a boiler house 110. In particular, a free space F is arranged in between a wall 122 of a boiler and a wall 112 of the boiler house, and a part of the burner lance 200 is arranged within the free space F. As indicated in the background, the free space F in between the boiler 120 and the boiler house 110 may be small. For maintenance, the nozzle 310 may be detachable from the burner lance 200.

For maintenance, the burner lance 200, in particular the nozzle 310 thereof, needs to be withdrawn from the furnace 124. Referring to Figs. 1a, 1b, and 1d, the burner lance 200 may be withdrawn from the burner 400 e.g. towards an upper left corner of Figs. 1a, 1b, and 1d. Thus, an end of the burner lance 200 may hit a wall 112 of the boiler house 110 before the nozzle 310 is withdrawn from the furnace 124. Thus, if a part (in particular a second part 200b) of the burner lance 200 would not be detachable, maintenance would not be possible. For this reason, a burner lance 200 of an embodiment comprises a first openable fastener 320 for detaching a part of the burner lance 200 from another part of the burner lance 200.

As known, the boiler 120 may comprise various heat exchangers, including a superheater 132 and an economizer 134. Referring to Fig. 1a, the burner lance 200 may be a part of a main burner (e.g. one of main burners) of the boiler. In such a solution fuel(s) is/are only fed to the furnace 124 through the burner lance(s).

However, referring to Figs. 1b and 1d, the burner lance may be part of a start burner, and some other fuel, e.g. main fuel, may be also delivered to the furnace 124 and burnt therein. In particular, when also another fuel than the first fluid is used, the boiler 110 may comprise a combustion air pre-heater 136.

The boiler 120 may comprise a flue gas cleaner 138, which may comprise at least one of an electrostatic precipitator, a filter, and a scrubber. Finally, the cleaned flue gas exits through a chimney 140. A typical construction is one in which the boiler 120 is suspended from a ceiling of the boiler house 110 by suspension means 142. The suspension means 142 may comprise at least one of a beam and a cable. The boiler 120 may be e.g. a fluidized bed boiler. In case the boiler 110 is a circulating fluidized bed boiler, a cyclone 144 (see

Fig. 1d) is used before the superheater 132 to separate bed material from the flue gas before the cleaned flue gas is conveyed to the superheater 132 and economizer 134. In a fluidized bed boiler, the burner lance 200 may be used when running up the fluidized bed combustion. After the bed has been sufficiently heated, the burner lance 200 may be withdrawn from the furnace 124, and the boiler 120 may be operated using only main fuel (e.g. solid fuel), such as biomass derived fuel and/or residue derived fuel, which can be supplied into the furnace via a channel (see the reference "Main fuel") other than the burner lance 200.

Referring to Fig. 1c, the burner lance 200 comprises an inner pipe 210, which limits a first channel 212 for conveying some first fluid to a nozzle 310, and via the nozzle 310 into the furnace 124. The first fluid may be liquid or gaseous, preferably gaseous. The first fluid may comprise oxygen, e.g. the first fluid may comprise or consist of air. The first fluid may comprise or consist of steam. However, combustion air may be fed to the furnace also with other means (see Figs. 1a, 1b and 1d; references 422, 442, and "Air"). The burner lance 200 comprises an outer pipe 220. The outer pipe 220 laterally surrounds the inner pipe 210. Thus, a second channel 222 for conveying the second fluid to the nozzle 310 is arranged in between the inner pipe 210 and the outer pipe 220. The pipes 210, 220 need not be circular in cross section. However, preferably the pipes 210, 220 have a circular cross section, and the pipes 210, 220 extend co-axially. When circular, the outer pipe 220 surrounds the inner pipe 210 radially. The second fluid may be liquid or gaseous. The second fluid may comprise hydrocarbons, e.g. the second fluid may comprise oil, liquid petroleum gas, and/or some alcohol (e.g. methanol). It is noted that the burner lance may comprise further outer pipes 230, 240 (see Figs. 6b to 6d). In such a case, the outer pipe 220 may be referred to as a primary outer pipe 220.

A purpose of the nozzle 310 is to deliver the first fluid and the second fluid into the furnace 124. A purpose of the nozzle 310 is to spray at least one of the first fluid and the second fluid into a furnace 124. A purpose of the nozzle 310 is to spray at least one of the first fluid and the second fluid into a furnace 124 in the form a small droplets. As indicated above, typically, the droplets are formed from the second fluid, while the first fluid acts as the carrier medium (i.e. atomizing medium). It is possible that the small droplets are formed of the

first fluid and the second fluid acts as a carrier. These droplets then rapidly evaporate in the furnace 124, thereby enabling easy combustion of the first and/or the second fluid. Such a principle may be referred to as medium-assisted atomizing principle. One of the first and second fluids may be a medium that assists the atomizing of the other one of the fluids; typically the first fluid is the medium that assists the atomizing of the second fluid. However, in case both the first and second fluids are gaseous, not further atomizing is needed.

10 Referring to Fig. 2a, the burner lance 200 comprises a first inlet 201 for letting in first fluid into the first channel 212, and a second inlet 202 for letting in second fluid into the second channel 222.

15 It has been found that such a burner lance 200 can be maintained in a small space by detaching a part from the burner lance. Correspondingly, an embodiment of a method for maintaining the burner lance 200 comprises detaching a second part 200b of the burner lance 200 from a first part 200a of the burner lance 200. Herein the order of the first and second parts 200a, 200b is defined such that the first part is attached to the nozzle 310 or is attachable to the nozzle 310. In particular, a primary end 204a of the first part 200a is attached or attachable to the nozzle 310. Thus also the nozzle 310 is attached or attachable to primary end 204a of the first part 200a. The primary end 204a of the first part 200a is opposite to a secondary end 205a of the first part 200a, which secondary end 205a is attached or attachable to the second part 200b (see Fig. 2b).

20 The nozzle 310 may e.g. fit tightly to a primary end 204a of the first part 200a of the burner lance. In an embodiment, the first part 200a of burner lance 200 fits with the nozzle 310 so tightly that first and second fluids flow only through the nozzle 310. In an embodiment, the first part 210a of the inner pipe 210 fits with the nozzle 310 so tightly that flow of the first fluid in between the first part 210a of the inner pipe 210 and nozzle 310 is prevented. Thus, in an embodiment, the first part 210a of the inner pipe 210 fits with the nozzle 310 so tightly that the first fluid flows only through the nozzle 310. The nozzle 310 may be attached to the inner pipe 210 in a similar manner as the first part 210a of the inner pipe 210 is attached to the second part 210b of the inner pipe 210

(see below). If a groove of the inner pipe 210 fits with a groove of the nozzle, as shown in Figs. 5a to 5c, a part of the nozzle 310 may radially encircle a part of the inner pipe 210 (Figs. 5a and 5b), or a part of the inner pipe 210 may radially encircle a part of the nozzle 310 (Fig. 5c). As an alternative to fitting the parts together, the nozzle 310 may be welded to the primary end 204a of the first part 200a of the burner lance, e.g. to an end of the inner pipe 210.

The first part 200a of the burner lance 200 comprises a first part 210a of the inner pipe 210 and a first part 220a of the outer pipe 220; and the first part 200a is attachable to the nozzle 310 or is attached to the nozzle 310. When the first part 200a is attached to the nozzle 310, a first part comprises the nozzle 310. If the first part 200a is attachable or attached to the nozzle 310, preferably, the first part 210a of the inner pipe 210 is attachable or attached, respectively, to the nozzle 310. The nozzle 310 may be detachable from the first part 200a to further help maintenance. In this way, a seam 312 may be left in between the nozzle 310 and the first part 200a (see Figs. 5a to 5c). The nozzle 310 may be made from different material than the inner pipe 210 or the outer pipe 220.

The second part 200b of the burner lance 200 comprises a second part 210b of the inner pipe 210 and a second part 220a of the outer pipe 220. As will be detailed, the inlets 201, 202 may be arranged in the second part 200b, a third part 200c, or another part of the burner lance 200. What will be said about preferable lengths of the parts 200a, 200b of the burner lance 200 applies in connection with the method.

In this way, the invention relates also to an arrangement comprising the nozzle 310 and the burner lance 200 as detailed above and below. In the arrangement, the nozzle 310 is attached or attachable to the first part 200a of the burner lance 200, in particular to the primary end 204a thereof.

In particular and with reference to Fig. 1a, 1b, and 1d, when the burner lance 200 is withdrawn from the furnace 124 and an end of burner lance 200 (i.e. the second part of the burner lance 200) approaches the 112 wall of the boiler house 110, the second part 200b of the burner lance 200 can be detached in the aforementioned manner. Thereafter there is sufficient space for

withdrawing the first part 200a of the burner lance 200 from the furnace 124. After also the first part 200a has been withdrawn from the furnace, the first part 200a (in particular the nozzle 310) can be maintained, e.g. cleaned and/or replaced by a new nozzle. Thus, the method comprises maintaining at least
5 the first part 200a of the burner lance 200 and/or the nozzle 310. More precisely, the method comprises maintaining at least the first part 200a of the burner lance 200 and/or the nozzle 310 when no part of the burner lance 200 is arranged within the furnace 124. After maintenance, the first part 200a of the burner lance 200 can be put back to place. At a suitable point, the method
10 comprises fastening the second part 200b of the burner lance 200 to the first part 200a of the burner lance 200.

It has been found that such a method can be relatively easily performed, when the burner lance 200 comprises a first openable fastener 320 for fastening the
15 first part 200a to the second part 200b and for detaching the first part 200a from the second part 200b. Fig. 2a shows a burner lance 200 comprising such a first part 200a and a second part 200b, attached to each other with a first openable fastener 320.

20 Referring to Fig. 2b, the first part 200a is attachable or attached to the nozzle 310 suitable for delivering at least first and second fluid into the furnace 124. The parts 200a, 200b may be sold separately from the nozzle 310. However, at least in use the first part 200a is attached to the nozzle 310. The first part 200a comprises a first part 210a of the inner pipe 210 and a first part 220a of
25 the outer pipe 220. Herein it is considered that when the first part 200a is attached to the nozzle 310, another first part 200a can be defined so that the other first part comprises to the nozzle 310. In particular, when the burner lance is used, it is immaterial whether the burner lance comprises the nozzle or is attached thereto. As indicated above, the inner pipe 210 limits a first channel
30 212 for conveying the first fluid to the nozzle 310. Thus, the first part 210a of the inner pipe 210 limits a part of the first channel 212. Moreover, the part of the first channel 212 is suitable for conveying the first fluid to the nozzle 310, or, if the first part 200a is not attached to the nozzle 310, the part of the first channel 212 is suitable for conveying the first fluid to the such a part that is
35 attachable to the nozzle 310. The first part 220a of the outer pipe 220 laterally surrounds at least a part of the first part 210a of the inner pipe 210. Thus, a

part of the second channel 222 is arranged in between the first part 210a of the inner pipe 210 and the first part 220a of the outer pipe 220. Moreover, the part of the second channel 222 is suitable for conveying the second fluid to the nozzle 310.

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Referring to Fig. 2b, the second part 200b comprises a second part 210b of the inner pipe 210 and a second part 220a of the outer pipe 220. The second part 210b of the inner pipe 210 limits a part of the first channel 212. The second part 220b of the outer pipe 220 laterally surrounds at least a part of the second part 210b of the inner pipe 210. Thus, a part of the second channel 222 is arranged in between the second part 210b of the inner pipe 210 and the second part 220b of the outer pipe 220.

The burner lance 200 comprises the first openable fastener 320. The first openable fastener 320 is configured to fasten the first part 200a to the second part 200b in such a way that [A] the first part 210a of the inner pipe 210 fits with the second part 210b of the inner pipe 210 and [B] the first part 220a of the outer pipe 220 fits with the second part 220b of the outer pipe 220. In addition, the first openable fastener 320 is openable. The first openable fastener 320 is configured to be opened in such a way that, once opened, the second part 200b is detachable from the first part 200a. The first openable fastener 320 is configured to be opened in such a way that, once first openable fastener 320 is opened, the second part 200b is detachable from the first part 200a without using a tool.

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The burner lance 200 comprises a first inlet 201 for letting in the first fluid into the first channel 212 and a second inlet 202 for letting in the second fluid into the second channel 222. Referring to Fig. 6a, the inlets 201, 202 need not be part of the second part 200b. However, preferably, the first part 200a of the burner lance 200 does not comprise the inlets 201, 202. In other words, preferably, the first and second fluids are configured to be conveyed through the second part 200b of the burner lance 200 to the first part 200a of the burner lance 200.

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The inner pipe 210 has a profile shape that extends in the direction of length of the burner lance. In a similar manner, the first 210a and second 210b parts

of the inner pipe 210 have a profile shape that extends in the direction of length of the burner lance 200. Typically the length l_l of the burner lance 200, which is shown in Fig. 2a, in the direction of the length of the lance 200 is at least 1.0 metre, such as from 1.0 m to 5.0 m; e.g. from 1.5 m to 4.0 m. The length l_l of the burner lance 200, if the burner lance consisted of only one integral part, would be proportional to the size of the free space F in between the boiler 120 and the boiler house 110 needed for maintenance. In an embodiment, a length l_{p2} of the second part 200b in the direction length of the burner lance 200 is at least 50 cm. Therefore, the requirement of free space is decreased by an amount proportional to the length l_{p2} of the the second part 200b. In a preferred embodiment, a length l_{p2} of the second part 200b is at most 2.5 m and a length l_{p1} of the first part 200a is at most 2.5 m. More preferably, a length of the second part 200b is at most 2.0 m or at most 1.5 m and a length of the first part 200a is at most 2.0 m or at most 1.5 m. The maximum length affects the requirements for the free space. In a preferred embodiment, a length l_{p2} of the second part 200b is from 0.5 m to 2.5 m and a length l_{p1} of the first part 200a is from 0.5 m to 2.5 m. More preferably, a length l_{p2} of the second part 200b is from 0.5 m to 2.0 m or from 0.5 m to 1.5 m and a length l_{p1} of the first part 200a is from 0.5 m to 2.5 m or from 0.5 m to 1.5 m. When the burner lance 200 comprises a third part 200c, the aforementioned lengths preferably apply also to the third part 200c.

A diameter of the burner lance 200 depends on the needs. Typically, an inner diameter of the inner pipe 210 is from 10 mm to 200 mm, more typically from 30 mm to 70 mm. Typically, an inner diameter of the outer pipe 220 is from 5 mm to 100 mm greater than an outer diameter of the inner pipe 210, more typically from 15 mm to 40 mm greater than an outer diameter of the inner pipe 210.

The first part 200a may be provided with a first primary support 214a, as indicated in Figs. 2b and 3a. The first primary support 214a supports the first part 210a of the inner pipe 210 to the first part 220a of the outer pipe 220. In particular, the first primary support 214a supports an outer surface of the first part 210a of the inner pipe 210 to an inner surface of the first part 220a of the outer pipe 220. Preferably, the first part 200a is provided with at least three first primary supports 214a arranged at the same longitudinal position, and

thus laterally surrounding a part of the first part 210a of the inner pipe 210. Distances between all two neighbouring first primary supports 214a, as measured along the outer surface of the inner pipe 210, in the direction of circumference, may be equal. A distance between the end 205a (see Fig. 2b
5 for the ends 205a and 205b) of the first part 200a and a first primary support 214a, as measured in the longitudinal direction of the inner pipe 210, is preferably small, e.g. up to one third of the length of the first part 210a of the inner pipe 210.

10 In a similar manner, the second part 200b may be provided with a second primary support 214b, as indicated in Figs. 2b and 3a. The second primary support 214b supports the second part 210b of the inner pipe 210 to the second part 220b of the outer pipe 220. Preferably, the second part 200b is provided with at least three second primary supports 214b arranged at the
15 same longitudinal position, and thus laterally surrounding a part of the second part 210b of the inner pipe 210. Distances between all two neighbouring second primary supports 214b, as measured along the outer surface of the inner pipe 210, may be equal. A distance between the end 205b of the second part 200b and a second primary support 214b, as measured in the longitudinal
20 direction of the inner pipe 210, is preferably small, e.g. up to one third of the length of the second part 210b of the inner pipe 210.

The primary supports 214a, 214b have the effect that the parts 210a, 210b of the inner pipe 210 are aligned with each other when the parts 220a, 220b of the outer pipe 220 are aligned with each other. When attaching the parts 200a,
25 200b of the burner lance 200, the parts of the outermost pipes (e.g. 220a, 220b of the outer pipe 220) are easily aligned with each other. In this way the primary supports 214a, 214b help fastening the first part 200a to the second part 200b in such a way that [A] the first part 210a of the inner pipe 210 fits with the
30 second part 210b of the inner pipe 210 and [B] the first part 220a of the outer pipe 220 fits with the second part 220b of the outer pipe 220.

The first primary support 214a should resist the flow within the second channel 222 only minimally. Thus, preferably, the first primary support 214a is
35 thin member with e.g. a thickness of at most 5 mm. What has been said about

the first primary support 214a preferably applies to the second primary support 214b.

5 Referring to Figs. 3c and 4c, in an embodiment, an end 215a of the first part 210a of the inner pipe 210 is provided with threads, and an end 215b of the second part 210b of the inner pipe 210 is provided with treads. Thus, the parts 210a, 210b may be turned to detach and attach the parts 210a, 210b to each other. In an embodiment, due to the treads, the first part 210a of the inner pipe 210 fits with the second part 210b of the inner pipe 210 so tightly that flow of
10 the first fluid and/or the second fluid in between the first part 210a of the inner pipe 210 and the second part 210b of the inner pipe 210 is prevented.

Referring to Figs. 3a, 3b, 4a, and 4b, in a preferable embodiment, an end 215a of the first part 210a of the inner pipe 210 is provided with a first groove 216a.
15 Referring to Fig. 3a, in an embodiment, the first groove 216a is arranged on an outer surface of the first part 210a of an inner pipe 210. Referring to Fig. 3b, in an embodiment, the first groove 216a is arranged on an inner surface of the first part 210a of an inner pipe 210. In a corresponding manner, an end 215b of the second part 210b of the inner pipe 210 is provided with a second
20 groove 216b. Referring to Fig. 3a, in an embodiment, the second groove 216b is arranged on an inner surface of the second part 210b of the inner pipe 210. Referring to Fig. 3b, in an embodiment, the second groove 216b is arranged on an outer surface of the second part 210b of the inner pipe 210.

25 In a solution of Figs. 3a, 3b, 4a, and 4b, the first groove of the first part 210a of the inner pipe 210 fits with the second groove of the second part 210b of the inner pipe 210 because of the matching grooves 216a, 216b. In an embodiment, a length of the first part 210a of the inner pipe 210 is greater than a length of a first part 220a of the outer pipe 220 and/or a length of the second
30 part 220a of the inner pipe 210 is greater than a length of the second part 220b of the outer pipe 220. This has the effect that a seam formed by the first and second grooves (216a and 216b) has a certain length (e.g. at least 1 cm), which improves the tightness of the seam. In an embodiment, the first groove 216a fits with the second groove 216b so tightly that flow of the first fluid and/or
35 the second fluid in between the first part 210a of the inner pipe 210 and the second part 210b of the inner pipe 210 is prevented.

Figure 5a shows the solution of Fig. 4a, wherein the first part 200a is attached to the nozzle 310. As indicated in Figs. 5a (as well as in 3a, 3b, 4a, and 4b), the seam between the first part 210a of the inner pipe and the second part 210b of the inner pipe 210 may be arranged at a same longitudinal position as the first openable fastener 320; e.g. at a same longitudinal position as the flanges 292a, 292b. However, referring to Fig. 5b, in an embodiment, the first part 210a of the inner pipe 210 is longer than the first part 220a of the inner pipe 220 and the second part 210b of the inner pipe 210 is shorter than the second part 220b of the outer pipe 220. In such a case, the seam need not be arranged at a same longitudinal position as the first openable fastener 320. Referring to Fig. 5c, in an embodiment, the first part 210a of the inner pipe 210 is shorter than the first part 220a of the inner pipe 220 and the second part 210b of the inner pipe 210 is longer than the second part 220b of the outer pipe 220. In such a case, the seam need not be arranged at a same longitudinal position as the first openable fastener 320.

Figures 3d1 and 3d2 show the end 215a of the first part 210a of the inner pipe 210 in more detail. As shown therein, a first tongue 218a is arranged at the same longitudinal position as the first groove 216a. The first tongue 218a may be arranged in between the first groove 216a and a central axis of the first part 210a of the inner pipe 210 as in Fig. 3d1. The first groove 216a may be arranged in between the first tongue 218a and a central axis of the first part 210a of the inner pipe 210 as in Fig. 3d2. Preferably, the first tongue 218a tapers towards the first end 215a, as indicated in Figs. 3d1 and 3d2. The tapering may be a result of a bevel 218a1 (see Fig. 3d1) provided at the end 215a of the first part 210a of the inner pipe 210. The bevel 218a1 may be provided at an end of the first tongue 218a. The tapering of the first tongue 218a may be a result of a rounding 218a2 (see Fig. 3d2) provided at the end 215a of the first part 210a of the inner pipe 210. The rounding 218a2 may be provided at an end of the first tongue 218a.

When the first tongue 218a tapers towards the first end 215a, the first part 210a of the inner pipe 210 can be easily fixed to the second part 210b of the inner pipe 210. Such a tapering shape is detail for the first part 200a only in Figs. 3d1 and 3d2. However, this applies in particular, when the grooves 216a,

216b fit to each other tightly in order to form a tight seam therein between, as shown in Figs. 3a, 3b, 4a, 4b, 5a, 5b, and 5c without the tapering. The tongue 218b of the second part 210b of the inner pipe 210 may taper towards the second end 215b of the second part 210b in a similar manner as the first part 210a tapers towards the first end 215a (see Fig. 3d3). As shown in Fig. 3d3, a second tongue 218b is arranged at the same longitudinal position as the second groove 216b. The second tongue 218b may be arranged in between the second groove 216b and a central axis of the first second 210b of the inner pipe 210 (not shown). The second groove 216b may be arranged in between the second tongue 218b and a central axis of the second part 210b of the inner pipe 210 as in Fig. 3d3. Preferably, the second tongue 218b tapers towards the second end 215b. The tapering may be a result of a bevel 218a1 (see Fig. 3d3) provided at the end 215b of the second part 210b of the inner pipe 210. The bevel 218b1 may be provided at an end of the second tongue 218b. The second end 215b of the second part 210a is depicted e.g. in Fig. 3b without the tapering shape.

Referring to Figs. 4a and 4b, in an embodiment, an end 205a (see Fig. 2b for the ends 205a and 205b) of the first part 200a, i.e. the secondary end 205a of the first part 200a as discussed above, is provided with a first flange 292a and an end 205b of the second part 200b is provided with a second flange 292b. The openable fastener 320 is configured to fasten the first flange 292a to the second flange 292b.

Referring to Fig. 4a, in an embodiment, the first openable fastener 320 comprises a screw 321a or bolt 321b. A nut 322 can be provided with a bolt 321b. By screwing the bolt 321b through both the flanges to the nut 322, the flanges 292a, 292b of the parts 200a, 200b can be attached to each other. Alternatively or in addition, by screwing the screw 321a through one of the flanges (292a, 292b) to the other one of the flanges (292b, 292a), the flanges 292a, 292b of the parts 200a, 200b can be attached to each other.

As an alternative to the screw 321a or bolt 321b, a socket 294a may be used. Referring to Fig. 4b, the socket 294a may be used to fasten the first flange 292a to an end of the second part 200b. An end of the second part 220b of the outer pipe 220 may be provided with threads 296b that match threads of the

socket 294a. If a socket 294a is used as the first openable fastener 320 inside a protective pipe 410, which may be a part of a burner 400, an outer diameter of the socket 294a should be smaller than an inner diameter of the protective pipe 410 in order to allow air flow within a channel 420 as will be detailed below.

5 In such a solution, a lance support 430 other than the socket 294a may be provided. In such a case, the lance support 430 may be provided at a different longitudinal position than the socket 294a. More details of the lance support 430 and protective pipe 410 are given below.

10 When the first part 200a comprises the first flange 292a and the second part 200b comprises the second flange 292b, preferably, a gasket 298 (see Fig. 4a) is arranged in between the first flange 292a and the second flange 292b. A purpose of the gasket is to seal the seam in between the parts 220a, 220b of the outer pipe. Thus, more generally, in an embodiment, a gasket 298 is
15 arranged in between an end of the first part 220a of the outer pipe 220 and the second part 220b of the outer pipe 220.

Referring to Fig. 4c, an end of both the parts of the inner and outer pipes may be provided with threads, so that parts of inner and outer pipes can be joined
20 by turning the parts 200a, 200b relative to each other about an axis that is parallel to the length of the burner lance 200. In the embodiment of Fig. 4c, the second part 210b of the inner pipe 210 may be rotatable relative to the second part 220b of the outer pipe 220 about an axis that is unidirectional with the length of the second part 200b.

25 Even if not shown in the figures, the first openable fastener 320 may comprise a latch, by which the second part 200b may be detachably attached to the first part 200a.

30 Referring to Fig. 6a, in an embodiment, the burner lance 200 is detachable to more than two parts. A burner lance 200 according to Fig. 6a comprises a third part 200c. The third part 200c of the burner lance 200 comprises a third part 210c of the inner pipe 210 and a third part 220c of the outer pipe 220. In addition, the burner lance 200 of Fig. 6a comprises a second openable
35 fastener 322. The second openable fastener 322 is configured to fasten the second part 200b of the burner lance 200 to the third part 200c of the burner

lance 200. The parts 200b and 200c are configured to be attached in such a way that [A] the second part 210b of the inner pipe 210 fits with the third part 210c of the inner pipe 210 and [B] the second part 220b of the outer pipe 220 fits with the third part 220c of the outer pipe 220. Moreover, the second
5 openable fastener 322 is openable, and once opened, the second part 200b is detached from the third part 200c or detachable from the third part 200c, preferably without a tool. What has been said about the connection between the first and second parts 210a, 210b of the inner pipe 210 applies to the connection between the second and third parts 210b, 210c of the inner pipe
10 210, *mutatis mutandis*. What has been said about the connection between the first and second parts 220a, 220b of the outer pipe 220 applies to the connection between the second and third parts 220b, 220c of the outer pipe 220, *mutatis mutandis*. What has been said about the first openable fastener 320 applied to the second openable fastener 322 *mutatis mutandis*. If the
15 second openable fastener 322 is configured to operate with flanges, the corresponding ends of the second and third parts 200b, 200c may be provided with flanges.

Even if not shown, the burner lance 200 may comprise a fourth part, and,
20 optionally, also further parts. Such solution may be feasible, if the burner lance 200 is exceptionally long and/or the free space F is exceptionally small.

In some application it may be feasible to use different types of fuels and/or different amounts of a fuel. Therefore, the burner lance 200 may comprise
25 further channels, in addition to the first channel 212 and the second channel 222. Referring to Fig. 6b, in an embodiment, the burner lance 200 comprises a secondary outer pipe 230. The secondary outer pipe 230 laterally surrounds the outer pipe 220, i.e. the primary outer pipe 220. Thus, a third channel 232 for conveying third fluid to the nozzle 310 is arranged in between the primary
30 outer pipe 220 and the secondary outer pipe 230. With reference to Fig. 6d, in a corresponding embodiment, the first part 200a comprises a first part 230a of the secondary outer pipe 230. The first part 230a of the secondary outer pipe 230 laterally surrounds the first part 220a of the primary outer pipe 220. Thus a part of the third channel 232 arranged in between the first part 220a of the
35 primary outer pipe 220 and the first part 230a of the secondary outer pipe 230.

A corresponding burner lance 200 comprises a third inlet for letting in third fluid into the third channel 232.

Typically, if two different fuels are used, different channels are used also for the corresponding carrier fluid. Moreover, even if the same fuel is conveyed through two different channels of the burner lance 200, typically also the carrier fluid is conveyed through two different channels. Therefore, preferably, the burner lance comprises an even number (even herein meaning a number $2 \times N$, wherein N is an integer and at least one) of channels, e.g. an even number of co-axial pipes.

Referring to Fig. 6c, in an embodiment, the burner lance 200 comprises a tertiary outer pipe 240. The tertiary outer pipe 240 laterally surrounds the secondary outer pipe 230. Thus, a fourth channel 242 for conveying fourth fluid to the nozzle 310 is arranged in between the secondary outer pipe 230 and the tertiary outer pipe 240. With reference to Fig. 6d, in a corresponding embodiment, the first part 200a of the burner lance 200 comprises a first part 240a of the tertiary outer pipe 240. The first part 240a of the tertiary outer pipe 240 laterally surrounds the first part 230a of the secondary outer pipe 230. Thus, a part of the fourth channel 242 is arranged in between the first part 230a of the secondary outer pipe 230 and the first part 240a of the tertiary outer pipe 240. A corresponding burner lance 200 comprises a fourth inlet for letting in fourth fluid into the fourth channel 242.

As an example, such a burner lance 200 can be used in such a way that

- the second fluid comprises methanol,
- the first fluid, the carrier for methanol, comprises air (pressurized),
- the fourth fluid comprises pine oil, and
- the third fluid, the carrier for pine oil, comprises steam.

Different channels may be used e.g. for different fuels. Different channels may be used e.g. for only one fuel at different power levels of the boiler. Different channels may be used e.g. for different fuels and at different power levels of the boiler.

If more channels for fluids are needed, further outer pipes may be provided to the burner lance 200 and its parts (200a, 200b, 200c). Such further outer pipe would laterally surround the tertiary outer pipe 240. This applies to the parts 200a, 200b, 200c of the burner lance 200 as well. Such further parts are not
5 shown in the figures.

In such embodiments, the primary outer pipe 220 may be supported to the secondary outer pipe 230. Moreover, provided that the tertiary outer pipe 240 is present, the secondary outer pipe 230 may be supported to the tertiary outer
10 pipe 240. Thus, an embodiment comprises [a] at least a first secondary support 224a supporting an outer surface of the first part 220a of the primary outer pipe 220 to an inner surface of the first part 230a of the secondary outer pipe 230 and [b] at least a second secondary support 224b supporting an outer surface of the second part 220b of the primary outer pipe 220 to an inner surface of
15 the second part 230b of the secondary outer pipe 230. Moreover, an embodiment comprises [a] at least a first tertiary support 234a supporting an outer surface of the first part 230a of the secondary outer pipe 230 to an inner surface of the first part 240a of the tertiary outer pipe 240 and [b] at least a second tertiary support 234b supporting an outer surface of the second part
20 230b of the secondary outer pipe 230 to an inner surface of the second part 240b of the tertiary outer pipe 240. Reference is made to Fig. 6d. What has been said about the number and placement of the first primary supports 214a applies to first secondary supports 224a and first tertiary supports 234a *mutatis mutandis*. What has been said about the number and placement of the second
25 primary supports 214b applies to second secondary supports 224b and second tertiary supports 234b *mutatis mutandis*.

Referring to Figs 7a and 7b, in an embodiment at least a part of the burner lance 200 is arranged within a protective pipe 410. The protective pipe 410
30 may be a part of a burner 400. During maintenance, at least the first part 200a or the second part 200b of the burner lance 200 may be supported to the protective pipe 410. In particular, at least the first part 200a or the second part 200b of the burner lance 200 may be supported to the protective pipe 410 with a tool 710 during maintenance. Thus, an embodiment relates to an
35 arrangement comprising the burner lance 200 as disclosed above and a tool 710 suitable for supporting the first part 200a of the burner lance 200 to the

protective pipe 410. The tool 710 may be used during maintenance. However, the tool 710 may be removed after maintenance.

5 An embodiment of a burner 400 (i.e. a lance burner 400) comprises a burner lance 200 as discussed above. Figs. 1a, 1b, and 1d show such a burner 400 arranged partly in a boiler 120. The type of boiler 110 is irrelevant for details of the burner 400. As shown in Figs. 1a, 1b and 7a, the embodiment of the burner 400 further comprises a protective pipe 410 laterally surrounding the burner lance 200. Thus, a gas channel 420 is arranged in between an outer surface of the burner lance 200 and an inner surface of the protective pipe 410. The outer surface of the burner lance 200 may be an outer surface of the outer pipe 220 (as in Figs. 2a – 4c), an outer surface of the secondary outer pipe 230 (see Fig. 6b), or an outer surface of a tertiary outer pipe 240 (see Fig. 6c); or
10 or an outer surface of an even further outer pipe (not shown). Moreover, the burner 400 comprises an inlet 422 for feeding gas, such as air, into the gas channel 420. In use, gas, such as air, may be fed into the furnace through the gas channel 420. By using such gas, accumulation of solid onto the nozzle 310 may be reduced, whereby a need for maintenance can be made reduced.

20 Referring to Fig. 7a, in an embodiment, the burner 400 comprises a lance support 430 configured to support the outer surface of the burner lance 200 to the inner surface of the protective pipe 410. Preferably, the burner 400 comprises multiple lance supports 430. A function of the lance supports 430 is to support the burner lance 200 to the protective pipe 410. A function of the lance supports 430 is to provide the gas channel 420 in between the lance 200 and the pipe 410.
25

Preferably, the burner lance 200 is supported to the protective pipe 410 at least at the detachment point of the two parts 200a, 200b of the burner lance 200.
30 The burner lance 200 may be supported in such a way by the first openable fastener 320. In addition or alternatively, burner lance 200 may be supported in such a way by the first flange 292a and/or the second flange 292b. Therefore, in an embodiment, the first openable fastener 320 is configured to support the outer surface of the burner lance 200 to the inner surface of the protective pipe 410. For the same reason, in this or another embodiment, [i] an end 205a of the first part 200a of the burner lance 200a is provided with the
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first flange 292a, [ii] an end 205b of the second part 200b of the burner lance 200 is provided with the second flange 292b, [iii] the openable fastener 320 is configured to fasten the first flange 292a to the second flange 292b, and [iv] the first flange 292a and/or the second flange 292b is configured to support
5 the outer surface of the burner lance 200 to the inner surface of the protective pipe 410.

As indicated above, a gasket 298 may be arranged in between an end of the first part 220a of the outer pipe 220 and an end of the second part 220b of the
10 outer pipe 220. The gasket 298 may be arranged in between the first flange 292a and the second flange 292b.

Referring to Figs. 1d and 7c, in an embodiment, the burner 400 comprises an air box 440. As indicated in Fig. 7c, the air box 440 surrounds laterally the
15 protective pipe 410. In this way, an air channel 442 is arranged in between an outer surface of protective pipe 410 and an inner surface of the air box 440. The air channel 442 is configured to convey air into the furnace 124 (see Fig. 1d). The air channel 442 may be configured to convey combustion air into the furnace 124. However, the boiler 120 may comprise also another combustion
20 air channel, as indicated in Figs. 1b and 1d by the reference "Air". By feeding air through the air channel 442, accumulation of solid onto the nozzle 310 may be reduced, whereby a need for maintenance can be made reduced.

As indicated above, during maintenance, at least the first part 200a or the
25 second part 200b of the burner lance 200 may be supported to the protective pipe 410 with a tool 710. Thus, an embodiment relates to an arrangement comprising the burner 400 as disclosed above and a tool 710 suitable for supporting the first part 200a of the burner lance 200 to the protective pipe 410 of the burner 400. The tool 710 may be used during maintenance. However,
30 the tool 710 may be removed after maintenance.

As indicated in Figs. 1a, 1b and 1d, the burner lance 200 or the burner 400 may be comprised by a boiler plant 100. An embodiment of a boiler plant 100 comprises the boiler 120 and the boiler house 110. Referring in particular to
35 Figs. 1a and 1b, the boiler house 110 comprises a primary wall 112. Moreover, the boiler 120 comprises a secondary wall 122, which limits the furnace 124.

Thus, the secondary wall 122 forms a wall of the furnace 124. Moreover the burner lance 200, which may be comprised by the burner 400, extends through the secondary wall 122 of the boiler. The free space F remains in between the secondary wall 122 and the primary wall 112. In particular, the burner lance
5 200 extends through the secondary wall 122 at a location, and the free space F remains in between that location and the primary wall 112. The detachability of the second part 200b of the burner lance 200 has the effect that the free space F may be relatively small. Thus, in a preferred embodiment, a distance d_b of the location wherein the burner lance 200 extends through the secondary
10 wall 122 from the primary wall 112 is at most 3 metres or at most 2 metres. Because of detaching the second part 200b, preferably by using the first openable fastener 320, the burner lance 200 can be maintained also in such a small free space F.

15 Typically, a service platform 130 is used for maintenance. Preferably, the free space F remains above the service platform 130. Moreover, at least a part of the service platform 130 is arranged in between a wall 112 of the boiler house 110 and a wall 122 of the furnace 124. In particular, at least a part of the service platform 130 is arranged in between

- 20
- a secondary wall 122 of the boiler 120, the secondary wall 122 limiting the furnace 124 of the boiler 120, through which secondary wall 122 the burner lance 200 extends and
 - the primary wall 112 of the boiler house 110, which in combination with the secondary wall 122 limits the free space F.

25 Moreover, in an embodiment, at least a part of the burner lance 200 or the burner 400 is arranged above the service platform 130. In this way, the burner lance 200 can be maintained by being supported onto the service platform 130. Preferably, at least a part of the burner lance 200 or the burner 400 is arranged at most 2 metres above the service platform 130. In this way, the burner lance
30 200 can be maintained by standing on the service platform 130. In an embodiment, the burner lance 200 is arranged at a lower part of a boiler 120.

Referring to Figs 1a, 1b, 1d, and 1e, the burner lance 200 is arranged within the boiler plant 100 in such a way that the longitudinal direction dir_l of the burner lance 200 forms an angle α with the vertical direction dir_v , wherein the
35 angle α is from 0 to 90 degrees. Another technical effect of detaching the

second part 200b is related to embodiments, in which the angle α is from 0 to 80 degrees. In other words, the burner lance 200 is not arranged substantially horizontally. In such a case, withdrawing the burner lance 200 from its position, e.g. from the protective pipe 410, implies that an end of the burner lance 200 rises as the burner lance 200 is withdrawn. Thus, the longer the burner lance 200, the harder the handling thereof. Thus, even if the free space F is reasonable large, detaching of the second part 200b is beneficial, since this simplifies handling of the burner lance 200, because an end of the burner lance 200 does not rise too high. This effect is even stronger in embodiment, wherein the angle α is from 10 to 75 degrees or from 30 to 60 degrees.

At least a part of the burner lance 200 is, in an embodiment, arranged within the protective pipe 410. In an embodiment, at least the first openable fastener 320 may be arranged within the protective pipe 410 before maintenance. As indicated above, the burner lance 200 may be comprised by a burner 400 or a boiler plant 100. As indicated above, the burner 400 may be comprised by a boiler plant 100.

As indicated above, the burner lance 200, when used, is attached to a nozzle 310. The burner lance 200 can be maintained as follows:

- withdrawing at least the second part 200b of the burner lance 200 from the protective pipe 410, thereby withdrawing the first openable fastener 320 from the protective pipe 410 and exposing the first openable fastener 320,
- thereafter opening the first openable fastener 320 and detaching the second part 200b of the burner lance 200 from the first part 200a of the burner lance 200,
- thereafter withdrawing also the first part 200a of the burner lance 200 from the protective pipe 410, and
- thereafter maintaining the first part 200a of the burner lance 200, in particular maintaining or replacing the nozzle 310 to which the first part 200a of the burner lance 200 is attached.

An embodiment comprises removing a gasket 298 from the burner lance 200. An embodiment comprises supporting the first part 200a of the burner lance 200 to the protective pipe 410 with a tool 710. The first part 200a of the burner lance 200 may be supported to the protective pipe 410 with the tool 710 when

opening the first openable fastener 320 and detaching the second part 200b of the burner lance 200 from the first part 200a of the burner lance 200.

5 After maintenance, the burner lance 200 may be assembled in reverse order, e.g. as follows:

- if the first part 200a is not attached to the nozzle 310 (e.g. when the nozzle is being replaced), attaching a nozzle 310 (the same nozzle that was maintained or a nozzle that substitutes the old nozzle) to the first part 200a of the burner lance 200,
- 10 - inserting at least the first part 200a of the burner lance 200 into the protective pipe 410, such that the end that is attached to the nozzle 310 is inserted into the protective pipe 410 before the other end of the first part 200a of the burner lance 200,
- thereafter fastening the second part 200b of the burner lance 200 to the first part 200a of the burner lance 200 by using the first openable fastener 320, and
- 15 - thereafter inserting a part of the burner lance 200 into the protective pipe such that at least the first openable fastener 320 is arranged within the protective pipe.

20 As indicated above, the second part 200b of the burner lance 200 is fastened to the first part 200a of the burner lance 200 such that

- the first part 210a of the inner pipe 210 and the second part 210b of the inner pipe 210, in combination, form at least a part of the inner pipe 210 and
- 25 - the first part 220a of the outer pipe 220 and the second part 220b of the outer pipe 220, in combination, form at least a part of the outer pipe 220.

An embodiment comprises arranging a gasket 298 in between the first part 220a of the outer pipe and a second part 220b of the outer pipe 220. An embodiment comprises supporting the first part 200a of the burner lance 200 to the protective pipe 410 with a tool 710. The first part 200a of the burner lance 200 may be supported to the protective pipe 410 with the tool 710 when fastening the second part 200b of the burner lance 200 to the first part 200a of the burner lance 200.

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In case the burner lance consists of the two parts 200a, 200b, the first part 210a of the inner pipe 210 and the second part 210b of the inner pipe 210, in combination, form the inner pipe 210 and the first part 220a of the outer pipe 220 and the second part 220b of the outer pipe 220, in combination, form the
5 outer pipe 220. However, as indicated in Fig. 6a, the burner lance may comprise the third part 200c. In such a case also the third part 210c of the inner pipe 210 constitutes the inner pipe 210 and also the third part 220c of the outer pipe 220 constitutes the outer pipe 220.

10 In case the burner lance comprises the secondary outer pipe 230, and optionally also the tertiary outer pipe 240, the second part 200b of the burner lance 200 is fastened to the first part 200a of the burner lance 200 such that

- the first part 230a of the secondary outer pipe 230 and the second part 230b of the secondary outer pipe 230, in combination, form at least a
15 part of the secondary outer pipe 230 and, optionally also
- the first part 240a of the tertiary outer pipe 240 and the second part 240b of the tertiary outer pipe 240, in combination, form at least a part of the tertiary outer pipe 240.

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Claims:

1. A burner (400) comprising a burner lance (200), the burner lance (200) comprising
- 5 - a first part (200a) and a second part (200b), wherein
- the first part (200a) comprises
- a first part (210a) of an inner pipe (210), the first part (210a) of the inner pipe (210) limiting a part of a first channel (212) for conveying first fluid to a nozzle (310) and
 - 10 • a first part (220a) of an outer pipe (220), the first part (220a) of the outer pipe (220) laterally surrounding at least a part of the first part (210a) of the inner pipe (210), whereby a part of a second channel (222) for conveying second fluid to the nozzle (310) is arranged in between the first part (210a) of the inner pipe (210) and the first part (220a) of the
 - 15 • the nozzle (310) is attachable or attached to a primary end (204a) of the first part (200a), and
- the second part (200b) comprises
- a second part (210b) of the inner pipe (210) limiting a part of the first channel (212), and
 - 20 • a second part (220a) of the outer pipe (220), the second part (220b) of the outer pipe (220) laterally surrounding at least a part of the second part (210b) of the inner pipe (210), thereby limiting a part of the second channel (222), the burner lance (200) comprising
- 25 - a first openable fastener (320) for fastening the first part (200a) to the second part (200b) in such a way that
- the first part (210a) of the inner pipe (210) fits with the second part (210b) of the inner pipe (210) and
 - the first part (220a) of the outer pipe (220) fits with the second part (220b) of the outer pipe (220), wherein
 - 30 - the first openable fastener (320) is openable for detaching the second part (200b) from the first part (200a), the burner lance (200) comprising
 - a first inlet (201) for letting in the first fluid into the first channel (212), and
 - a second inlet (202) for letting in the second fluid into the second channel (222), **characterized** in that the burner (400) comprises
 - 35

- a protective pipe (410) laterally surrounding the burner lance (200) such that a gas channel (420) is arranged in between an outer surface of the burner lance (200) and an inner surface of the protective pipe (410), and such that the first openable fastener (320) is arranged within the protective pipe (410),
- 5 - an inlet (422) for feeding gas, such as air, into the gas channel (420), and
- at least a lance support (430) for supporting the outer surface of the burner lance (200) to the inner surface of the protective pipe (410).

2. The burner (400) of claim 1, wherein

- 10 - an end (215a) of the first part (210a) of the inner pipe (210) is provided with a first groove (216a), wherein the first groove (216a) is arranged on an outer surface or an inner surface of the first part (210a) of the inner pipe (210) and
- an end (215b) of the second part (210b) of the inner pipe (210) is provided with a second groove (216b), wherein the second groove (216b) is arranged
- 15 on an inner surface or an outer surface, respectively, of the second part (210b) of the inner pipe (210), whereby
- the first groove (216a) of the first part (210a) of the inner pipe (210) fits with the second groove (216b) of the second part (210b) of the inner pipe (210); preferably,
- 20 - the first groove (216a) fits with the second groove (216b) so tightly that flow of the first fluid and/or the second fluid in between the first part (210a) of the inner pipe (210) and the second part (210b) of the inner pipe (210) is prevented.

25 3. The burner (400) of claim 2, wherein

- the first part (210a) of the inner pipe (210) comprises a first tongue (218a), wherein
- the first tongue (218a) is arranged at a same longitudinal position as the first groove (216a), and
- 30 - the first tongue (218a) tapers towards the end (215a) of the first part (210a) of the inner pipe (210).

4. The burner (400) of any of the claims 1 to 3, wherein

- 35 - a secondary end (205a) of the first part (200a) of the burner lance (200) is provided with a first flange (292a),

- an end (205b) of the second part (200b) of the burner lance (200) is provided with a second flange (292b), and
- the openable fastener (320) is configured to fasten the first flange (292a) to the second flange (292b);

5 preferably,

- the openable fastener (320) comprises a screw (321a) or a bolt (321b).

5. The burner (400) of any of the claims 1 to 4, wherein the burner lance (200) comprises

- 10 - a gasket (298) arranged in between an end (205a) of the first part (200a) of the burner lance (200) and an end (205b) of the second part (200b) of the burner lance (200);

preferably

- 15 - the gasket (298) arranged in between the first flange (292a) and the second flange (292b) of claim 4.

6. The burner (400) of any of the claims 1 to 5, wherein the burner lance (200) comprises

- 20 - at least a first primary support (214a) supporting an outer surface of the first part (210a) of the inner pipe (210) to an inner surface of the first part (220a) of the outer pipe (220) and

- at least a second primary support (214b) supporting an outer surface of the second part (210b) of the inner pipe (210) to an inner surface of the second part (220b) of the outer pipe (220).

25

7. The burner (400) of any of the claims 1 to 6, wherein the burner lance (200) comprises a third part (200c), the

- the third part (200c) comprising

- 30
- a third part (210c) of the inner pipe (210) limiting a part of the first channel (212), and

- a third part (220c) of the outer pipe (220), the third part (230b) of the outer pipe (230) laterally surrounding at least a part of the third part (210c) of the inner pipe (210), thereby limiting a part of the second channel (222), the burner lance (200) comprising

- a second openable fastener (322) for fastening the second part (200b) of the burner lance (200) to the third part (200c) of the burner lance (200) in such a way that

- 5 • the second part (210b) of the inner pipe (210) fits with the third part (210c) of the inner pipe (210) and
- the second part (220b) of the outer pipe (220) fits with the third part (220c) of the outer pipe (220), wherein

- the second openable fastener (322) is openable for detaching the second part (200b) from the third part (200c).

10

8. The burner (400) of any of the claims 1 to 7, wherein

- the first part (200a) of the burner lance (200) comprises a first part (230a) of a secondary outer pipe (230), the first part (230a) of the secondary outer pipe (230) laterally surrounding at least a part of the first part (220a) of the outer pipe (220), whereby a part of a third channel (232) for conveying some third fluid is arranged in between the first part (220a) of the outer pipe (220) and the first part (230a) of the secondary outer pipe (230);

15

optionally

- the first part (200a) of the burner lance (200) comprises a first part (240a) of a tertiary outer pipe (240), the first part (240a) of the tertiary outer pipe (240) laterally surrounding at least a part of the first part (230a) of the secondary outer pipe (230), whereby a part of a fourth channel (242) for conveying some fourth fluid is arranged in between the first part (230a) of the secondary outer pipe (230) and the first part (240a) of the tertiary outer pipe (240).

20

9. The burner (400) of any of the claims 1 to 8, wherein

- the first openable fastener (320) is configured to support the outer surface of the burner lance (200) to the inner surface of the protective pipe (410).

25

10. The burner (400) of any of the claims 1 to 9, wherein

- a secondary end (205a) of the first part (200a) is provided with a first flange (292a),

- an end (205b) of the second part (200b) is provided with a second flange (292b),

30

- the first openable fastener (320) is configured to fasten the first flange (292a) to the second flange (292b), and

35

- the first flange (292a) and/or the second flange (292b) is/are configured to support the outer surface of the burner lance (200) to the inner surface of the protective pipe (410).

5 11. The burner (400) of any of the claims 1 to 10, comprising
 - an air box (440) laterally surrounding the protective pipe (410) such that an air channel (442) is arranged in between an outer surface of the protective pipe (410) and the air box (440).

10 12. The burner (400) of any of the claims 1 to 11, wherein
 - a length (l_{p2}) of the second part (200b) is at most 2.5 m, and
 - a length (l_{p1}) of the first part (200a) is at most 2.5 m.

13. A boiler plant (100) comprising

15 - a boiler house (110) comprising a primary wall (112),
 - a boiler (120) comprising a secondary wall (122) limiting a furnace (124), and
 - the burner (400) of any of the claims 1 to 12, wherein the burner lance (200) of the burner (400) extends through the secondary wall (122) at a location, and
 [A]

20 - a distance between the location and the primary wall (112) is at most 3 metres and/or
 [B]

- the burner lance (200) or the burner lance (200) of the burner (400) extends in a longitudinal direction (dir_l) that forms an angle (α) of from 0 to 80 degrees
 25 with a vertical direction (dir_v).

14. The boiler plant (100) of claim 13 comprising

- a service platform (130), of which a part is arranged in between the primary wall (112) and the secondary wall (122), wherein

30 - at least a part of the burner lance (200) or the burner (400) is arranged above the service platform (130);

preferably,

- at least a part of the burner lance (200) or the burner (400) is arranged at most 2 metres above the service platform (130).

35

15. A method for maintaining a burner lance (200), wherein

- the burner lance (200) comprises

- an inner pipe (210), the inner pipe (210) limiting a first channel (212) for conveying first fluid to a nozzle (310),
- 5 • an outer pipe (220) laterally surrounding at least a part of the inner pipe (210), whereby a second channel (222) for conveying second fluid to the nozzle (310) is arranged in between the inner pipe (210) and the outer pipe (220),
- a first openable fastener (320),
- 10 • a first inlet (201) for letting in the first fluid into the first channel (212), and
- a second inlet (202) for letting in the second fluid into the second channel (222), wherein
- the burner lance (200) is attached to the nozzle (310), and
- 15 • at least the first openable fastener (320) is arranged within a protective pipe (410),

the method comprising

- withdrawing a part of the burner lance (200) from the protective pipe (410) such that at least the first openable fastener (320) is withdrawn from the protective pipe (410),
- 20 - opening the first openable fastener (320), thereby detaching a second part (200b) of the burner lance (200) from a first part (200a) of the burner lance (200), wherein
 - the first part (200a) of the burner lance (200) comprises a first part (210a) of the inner pipe (210) and a first part (220a) of the outer pipe (220), and the first part (200a) of the burner lance (200) is attached to the nozzle (310) and
 - 25 • the second part (200b) of the burner lance (200) comprises a second part (210b) of the inner pipe (210) and a second part (220a) of the outer pipe (220),
- 30 - thereafter maintaining or replacing at least one of the nozzle (310) and the first part (200a) of the burner lance (200), and
- thereafter fastening the second part (200b) of the burner lance (200) to the first part (200a) of the burner lance (200) by using the first openable fastener
- 35 (320), and

- inserting a part of the burner lance (200) into the protective pipe such that at least the first openable fastener (320) is arranged within the protective pipe (410).

Patenttivaatimukset:

1. Poltin (400), joka käsittää poltinputken (200), joka poltinputki (200) käsittää
- ensimmäisen osan (200a) ja toisen osan (200b), joka
- 5 – ensimmäinen osa (200a) käsittää
- sisäputken (210) ensimmäisen osan (210a), joka sisäputken (210) ensimmäinen osa (210a) rajaa osan ensimmäistä kanavaa (212) ensimmäisen virtaavan aineen johtamiseksi suuttimeen (310), ja
 - ulkoputken (220) ensimmäisen osan (220a), joka ulkoputken (220)
- 10 ensimmäinen osa (220a) ympäröi sivusuunnassa ainakin osaa sisäputken (210) ensimmäisestä osasta (210a), ja sisäputken (210) ensimmäisen osan (210a) ja ulkoputken (220) ensimmäisen osan (220a) väliin on järjestetty osa toista kanavaa (222) toisen virtaavan aineen johtamiseksi suuttimeen (310), joka
- 15 • suutin (310) on kiinnitettävissä tai on kiinnitetty ensimmäisen osan (200a) primaaripäähän (204a), ja
- toinen osa (200b) käsittää
 - sisäputken (210) toisen osan (210b), joka rajaa osan ensimmäistä kanavaa (212), ja
 - ulkoputken (220) toisen osan (220b), joka ulkoputken (220) toinen osa (220b) ympäröi sivusuunnassa ainakin osaa sisäputken (210) toisesta osasta (210b) ja näin rajaa osan toista kanavaa (222), joka poltinputki (200) käsittää
- 20 – ensimmäisen avattavan kiinnittimen (320) ensimmäisen osan (200a) kiinnittämiseksi toiseen osaan (200b) siten, että
- sisäputken (210) ensimmäinen osa (210a) on yhteensopiva sisäputken (210) toisen osan (210b) kanssa, ja
 - ulkoputken (220) ensimmäinen osa (220a) on yhteensopiva ulkoputken (220) toisen osan (220b) kanssa, jolloin
- 25 – ensimmäinen avattava kiinnitin (320) on avattavissa toisen osan (200b) irrottamiseksi ensimmäisestä osasta (200a), joka poltinputki (200) käsittää
- ensimmäisen sisäänmenon (201) ensimmäisen virtaavan aineen päästämiseksi ensimmäiseen kanavaan (212), ja
 - toisen sisäänmenon (202) toisen virtaavan aineen päästämiseksi toiseen
- 30 kanavaan (222),
- 35 **tunnettu** siitä, että poltin (400) käsittää

- suojaputken (410), joka ympäröi poltinputkea (200) sivusuunnassa siten, että poltinputken (200) ulkopinnan ja suojaputken (410) sisäpinnan väliin on järjestetty kaasukanava (420), ja siten että ensimmäinen avattava kiinnitin (320) on järjestetty suojaputken (410) sisään,
- 5
- sisäänmenon (422) kaasun, kuten ilman, syöttämiseksi kaasukanavaan (420), ja
 - ainakin putkikannattimen (430) poltinputken (200) ulkopinnan tukemiseksi suojaputken (410) sisäpintaa vasten.
- 10
2. Patenttivaatimuksen 1 mukainen poltin (400), jossa
- sisäputken (210) ensimmäisen osan (210a) päähän (215a) on järjestetty ensimmäinen ura (216a), joka ensimmäinen ura (216a) on järjestetty sisäputken (210) ensimmäisen osan (210a) ulkopintaan tai sisäpintaan, ja
 - sisäputken (210) toisen osan (210b) päähän (215b) on järjestetty toinen ura (216b), joka toinen ura (216b) on järjestetty sisäputken (210) toisen osan (210b) sisäpintaan tai ulkopintaan vastaavasti, ja
- 15
- sisäputken (210) ensimmäisen osan (210a) ensimmäinen ura (216a) on yhteensopiva sisäputken (210) toisen osan (210b) toisen uran (216b) kanssa; edullisesti
- 20
- ensimmäinen ura (216a) on yhteensopiva toisen uran (216b) kanssa niin tiiviisti, että ensimmäisen virtaavan aineen ja/tai toisen virtaavan aineen virtaus sisäputken (210) ensimmäisen osan (210a) ja sisäputken (210) toisen osan (210b) välistä estyy.
- 25
3. Patenttivaatimuksen 2 mukainen poltin (400), jossa
- sisäputken (210) ensimmäinen osa (210a) käsittää ensimmäisen pontin (218a), joka
 - ensimmäinen pontti (218a) on järjestetty pituussuunnassa samaan kohtaan kuin ensimmäinen ura (216a), ja
- 30
- ensimmäinen pontti (218a) kapenee sisäputken (210) ensimmäisen osan (210a) pään (215a) suuntaan.
- 35
4. Jonkin patenttivaatimuksen 1–3 mukainen poltin (400), jossa
- poltinputken (200) ensimmäisen osan (200a) sekundaaripäähän (205a) on järjestetty ensimmäinen laippa (292a),

- poltinputken (200) toisen osan (200b) päähän (205b) on järjestetty toinen laippa (292b), ja
- avattava kiinnitin (320) on järjestetty kiinnittämään ensimmäinen laippa (292a) toiseen laippaan (292b);

5 edullisesti

- avattava kiinnitin (320) käsittää ruuvin (321a) tai pultin (321b).

5. Jonkin patenttivaatimuksen 1–4 mukainen poltin (400), jossa poltinputki (200) käsittää

- 10 – tiiviste (298), joka on järjestetty poltinputken (200) ensimmäisen osan (200a) pään (205a) ja poltinputken (200) toisen osan (200b) pään (205b) väliin; edullisesti

- tiiviste (298) on järjestetty patenttivaatimuksen 4 mukaisen ensimmäisen laipan (292a) ja toisen laipan (292b) väliin.

15

6. Jonkin patenttivaatimuksen 1–5 mukainen poltin (400), jossa poltinputki (200) käsittää

- ainakin ensimmäisen primaarikannattimen (214a), joka tukee sisäputken (210) ensimmäisen osan (210a) ulkopintaa ulkoputken (220) ensimmäisen osan (220a) sisäpintaa vasten, ja
- 20

- ainakin toisen primaarikannattimen (214b), joka tukee sisäputken (210) toisen osan (210b) ulkopintaa ulkoputken (220) toisen osan (220b) sisäpintaa vasten.

25 7. Jonkin patenttivaatimuksen 1–6 mukainen poltin (400), jossa poltinputki (200) käsittää kolmannen osan (200c), joka

- kolmas osa (200c) käsittää

- sisäputken (210) kolmannen osan (210c), joka rajaa osan ensimmäistä kanavaa (212), ja
 - ulkoputken (220) kolmannen osan (220c), joka ulkoputken (220) kolmas osa (220c) ympäröi sivusuunnassa ainakin osaa sisäputken (210) kolmannesta osasta (210c) ja näin rajaa osan toista kanavaa (222), joka poltinputki (200) käsittää
- 30

- toisen avattavan kiinnittimen (322) poltinputken (200) toisen osan (200b) kiinnittämiseksi poltinputken (200) kolmanteen osaan (200c) siten, että
- 35

- sisäputken (210) toinen osa (210b) on yhteensopiva sisäputken (210) kolmannen osan (210c) kanssa ja
 - ulkoputken (220) toinen osa (220b) on yhteensopiva ulkoputken (220) kolmannen osan (220c) kanssa; jolloin
- 5 – toinen avattava kiinnitin (322) on avattavissa toisen osan (200b) irrottamiseksi kolmannesta osasta (200c).

8. Jonkin patenttivaatimuksen 1–7 mukainen poltin (400), jossa
- poltinputken (200) ensimmäinen osa (200a) käsittää sekundaarisen ulkoputken (230) ensimmäisen osan (230a), joka sekundaarisen ulkoputken (230) ensimmäinen osa (230a) ympäröi sivusuunnassa ainakin osaa ulkoputken (220) ensimmäisestä osasta (220a),
- 10 jolloin osa kolmatta kanavaa (232), joka on tarkoitettu johtamaan kolmatta virtaavaa ainetta, on järjestetty ulkoputken (220) ensimmäisen osan (220a) ja
- sekundaarisen ulkoputken (230) ensimmäisen osan (230a) väliin;
- 15 valinnaisesti
- poltinputken (200) ensimmäinen osa (200a) käsittää tertiaarisen ulkoputken (240) ensimmäisen osan (240a), joka tertiaarisen ulkoputken (240) ensimmäinen osa (240a) ympäröi sivusuunnassa ainakin osaa sekundaarisen ulkoputken (230) ensimmäisestä osasta (230a),
- 20 jolloin osa neljättä kanavaa (242), joka on tarkoitettu johtamaan neljättä virtaavaa ainetta, on järjestetty sekundaarisen ulkoputken (230) ensimmäisen osan (230a) ja tertiaarisen ulkoputken (240) ensimmäisen osan (240a) väliin.

- 25 9. Jonkin patenttivaatimuksen 1–8 mukainen poltin (400), jossa
- ensimmäinen avattava kiinnitin (320) on järjestetty tukemaan poltinputken (200) ulkopintaa suojaputken (410) sisäpintaa vasten.

10. Jonkin patenttivaatimuksen 1–9 mukainen poltin (400), jossa
- ensimmäisen osan (200a) sekundaaripäähän (205a) on järjestetty ensimmäinen laippa (292a),
 - toisen osan (200b) päähän (205b) on järjestetty toinen laippa (292b),
 - ensimmäinen avattava kiinnitin (320) on järjestetty kiinnittämään ensimmäinen laippa (292a) toiseen laippaan (292b), ja
- 35 – ensimmäinen laippa (292a) ja/tai toinen laippa (292b) on järjestetty tukemaan poltinputken (200) ulkopintaa suojaputken (410) sisäpintaa vasten.

11. Jonkin patenttivaatimuksen 1–10 mukainen poltin (400), joka käsittää
– ilmalaatikon (440), joka ympäröi suoja-putkea (410) sivusuunnassa siten, että
suoja-putken (410) ulkopinnan ja ilmalaatikon (440) väliin on järjestetty ilma-
5 kanava (442).

12. Jonkin patenttivaatimuksen 1–11 mukainen poltin (400), jossa
– toisen osan (200b) pituus (l_{p2}) on enintään 2,5 m, ja
– ensimmäisen osan (200a) pituus (l_{p1}) on enintään 2,5 m.

10

13. Kattilalaitos (100), joka käsittää
– kattilarakennuksen (110), joka käsittää primaariseinän (112),
– kattilan (120), joka käsittää sekundaariseinän (122), joka rajaa tulipesän
(124), ja

15 – jonkin patenttivaatimuksen 1–12 mukaisen polttimen (400), jonka polttimen
(400) poltinputki (200) ulottuu sekundaariseinän (122) läpi eräässä kohdassa,
ja

[A]

20 – kyseisen kohdan ja primaariseinän (112) välinen etäisyys on enintään 3 met-
riä, ja/tai

[B]

– poltinputki (200) tai polttimen (400) poltinputki (200) ulottuu pituussuunnassa
(dir_h), joka muodostaa 0–80 asteen kulman (α) pystysuuntaan (dir_v) nähden.

25 14. Patenttivaatimuksen 13 mukainen kattilalaitos (100), joka käsittää
– huoltotason (130), josta osa on järjestetty primaariseinän (112) ja sekundaariseinän (122) väliin, jolloin

– ainakin osa poltinputkesta (200) tai polttimesta (400) on järjestetty huolto-
tason (130) yläpuolelle;

30 edullisesti

– ainakin osa poltinputkesta (200) tai polttimesta (400) on järjestetty enintään
2 metriä huoltotason (130) yläpuolelle.

35 15. Menetelmä poltinputken (200) huoltamiseksi, jossa menetelmässä

– poltinputki (200) käsittää

- sisäputken (210), joka sisäputki (210) rajaa ensimmäisen kanavan (212) ensimmäisen virtaavan aineen johtamiseksi suuttimeen (310),
 - ulkoputken (220), joka ympäröi sivusuunnassa ainakin osaa sisäputkesta (210), jolloin sisäputken (210) ja ulkoputken (220) väliin on järjestetty toinen kanava (222) toisen virtaavan aineen johtamiseksi suuttimeen (310),
 - ensimmäisen avattavan kiinnittimen (320),
 - ensimmäisen sisäänmenon (210) ensimmäisen virtaavan aineen päästämiseksi ensimmäiseen kanavaan (212), ja
 - toisen sisäänmenon (202) toisen virtaavan aineen päästämiseksi toiseen kanavaan (222), jolloin
 - poltinputki (200) on kiinnitetty suuttimeen (310), ja
 - ainakin ensimmäinen avattava kiinnitin (320) on järjestetty suojaputken (410) sisään,
- 15 jossa menetelmässä
- vedetään osa poltinputkesta (200) ulos suojaputkesta (410) siten, että ainakin ensimmäinen avattava kiinnitin (320) tulee ulos suojaputkesta (410),
 - avataan ensimmäinen avattava kiinnitin (320) ja irrotetaan näin poltinputken (200) toinen osa (200b) poltinputken (200) ensimmäisestä osasta (200a), joka
 - poltinputken (200) ensimmäinen osa (200a) käsittää sisäputken (210) ensimmäisen osan (210a) ja ulkoputken (220) ensimmäisen osan (220a), ja poltinputken (200) ensimmäinen osa (200a) on liitetty suuttimeen (310), ja
 - poltinputken (200) toinen osa (200b) käsittää sisäputken (210) toisen osan (210b) ja ulkoputken (220) toisen osan (220a),
 - tämän jälkeen huolletaan tai vaihdetaan ainakin joko suutin (310) tai poltinputken (200) ensimmäinen osa (200a), ja
 - tämän jälkeen kiinnitetään poltinputken (200) toinen osa (200b) poltinputken (200) ensimmäiseen osaan (200a) ensimmäisen avattavan kiinnittimen (320) avulla, ja
 - työnnetään osa poltinputkesta (200) suojaputken sisään siten, että sijoitetaan ainakin ensimmäinen avattava kiinnitin (320) suojaputken (410) sisään.

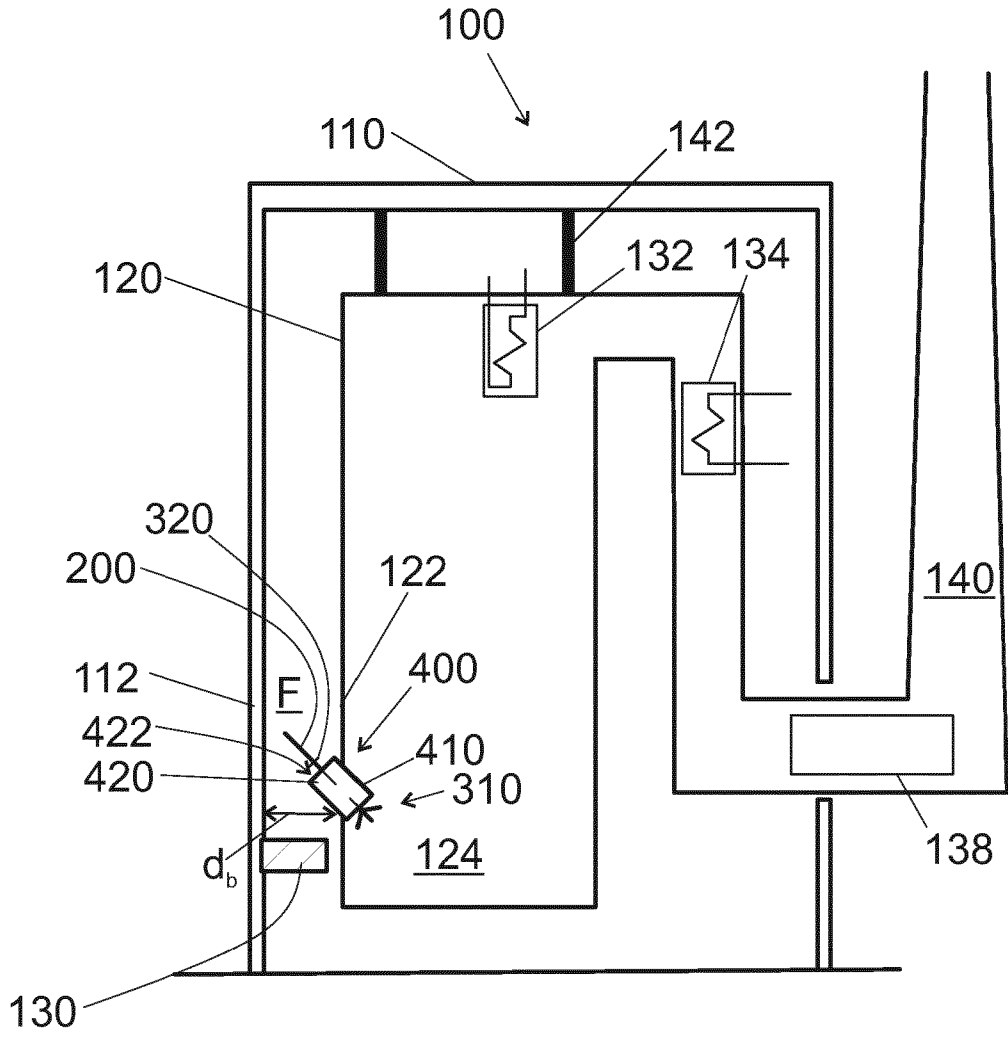


Fig. 1a

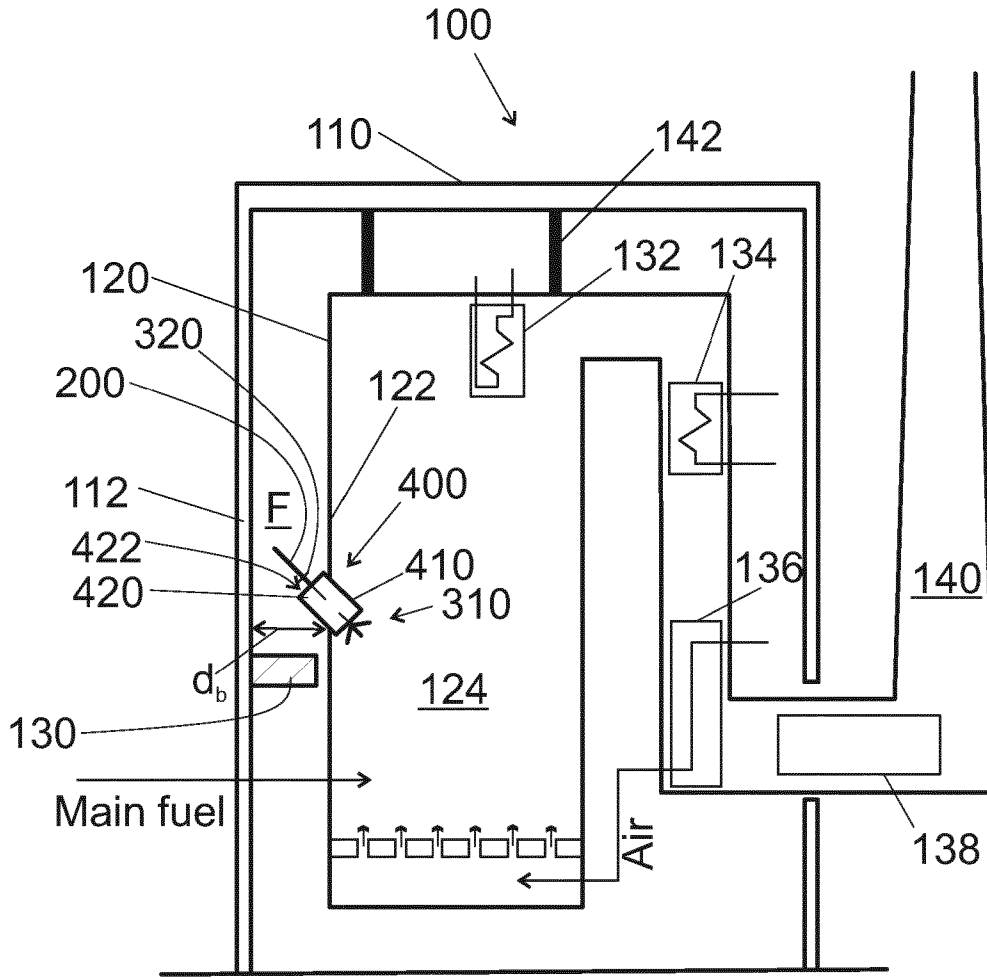


Fig. 1b

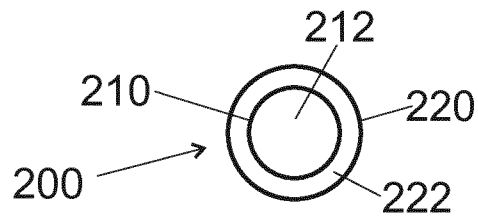


Fig. 1c

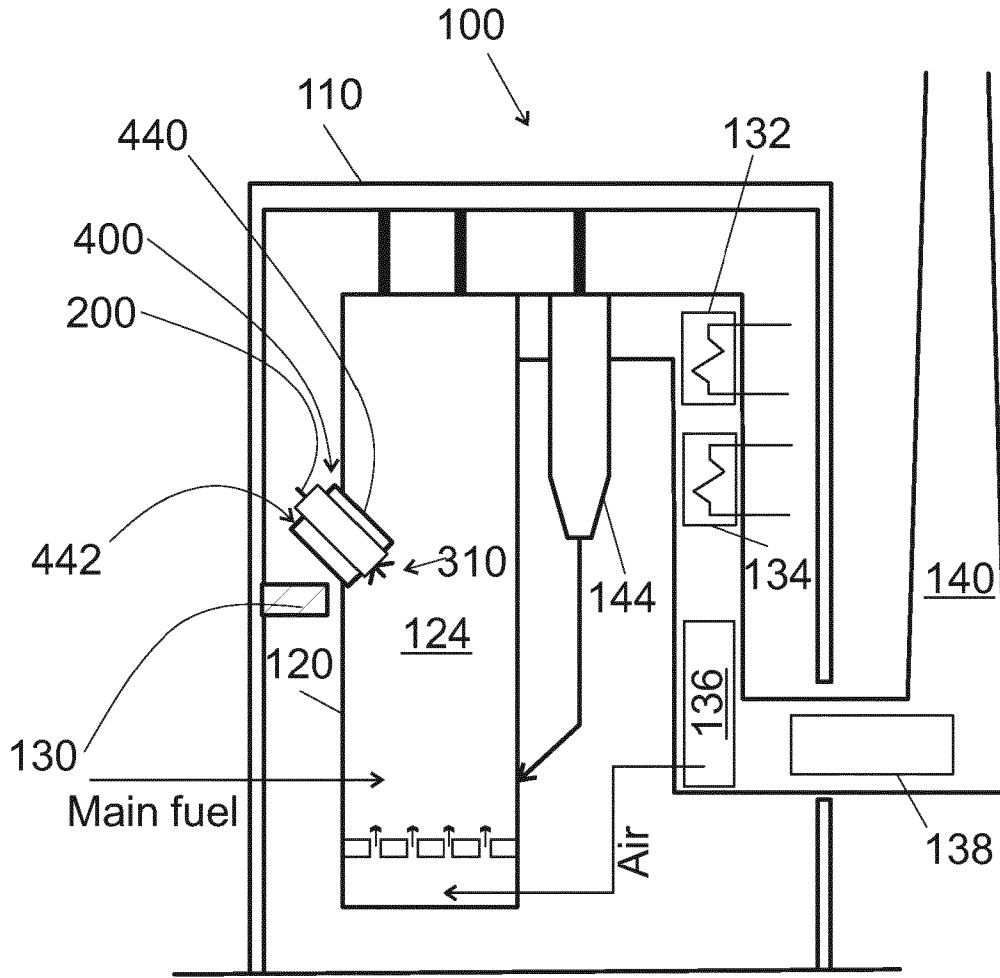


Fig. 1d

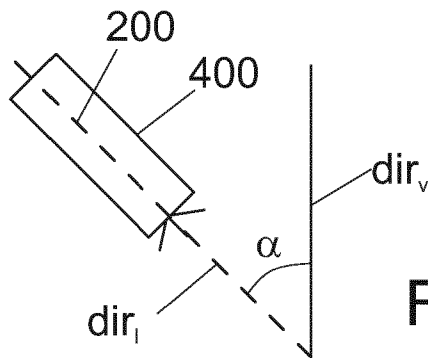


Fig. 1e

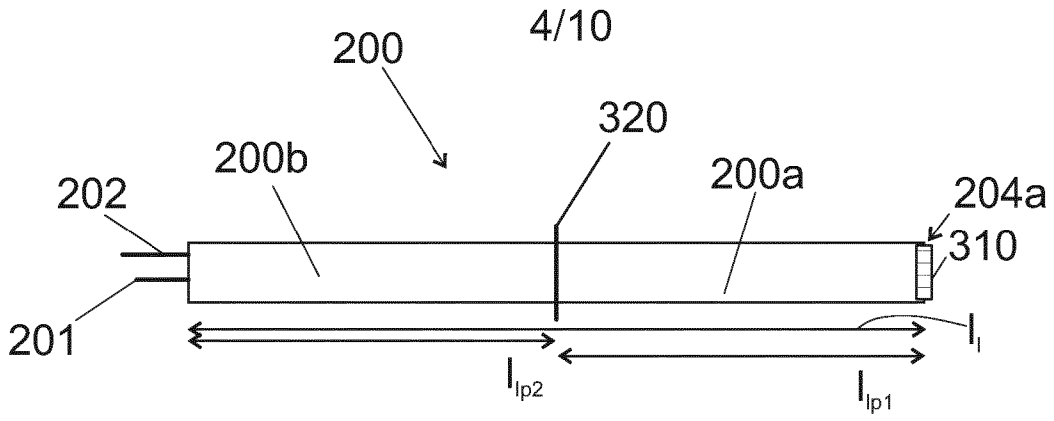


Fig. 2a

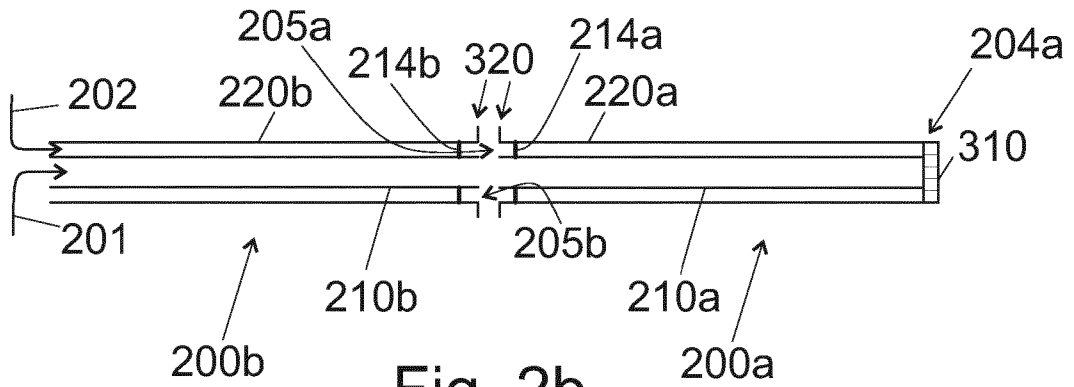


Fig. 2b

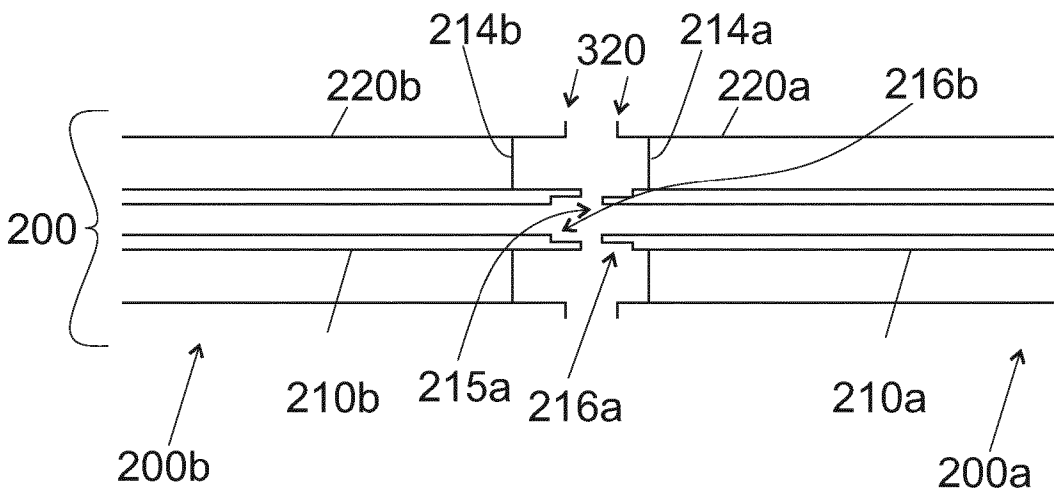


Fig. 3a

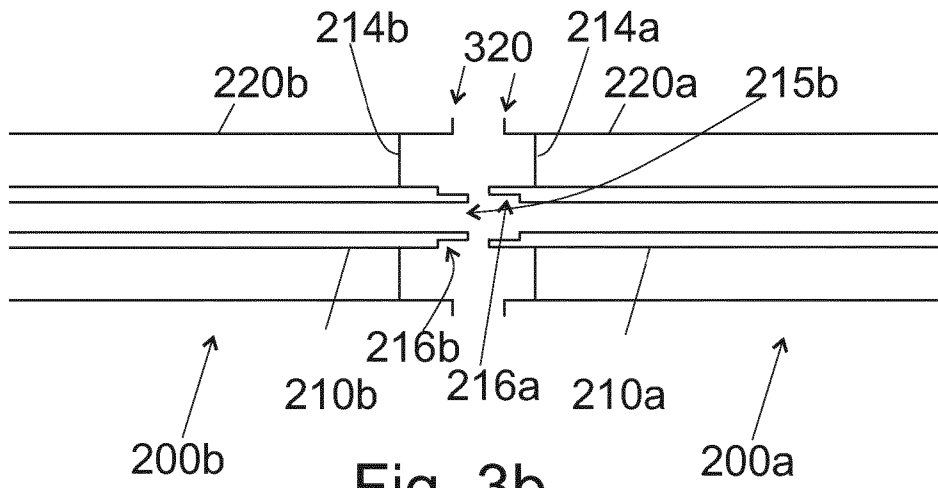


Fig. 3b

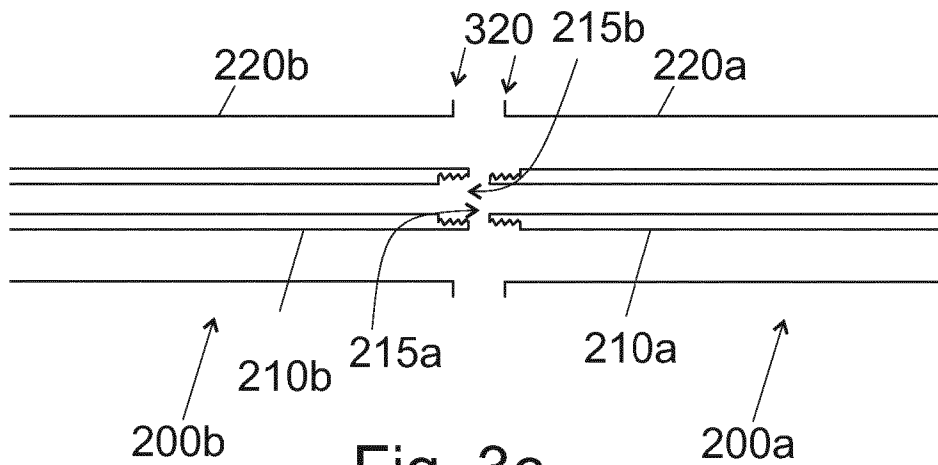


Fig. 3c

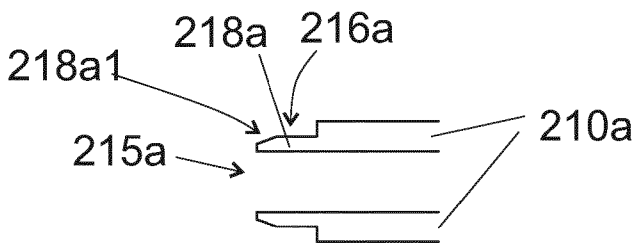


Fig. 3d1

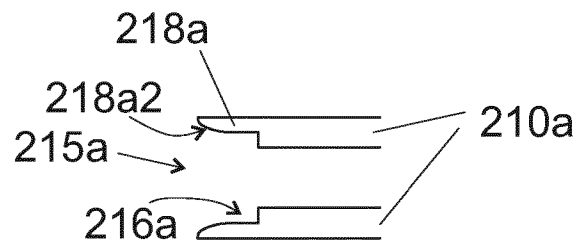


Fig. 3d2

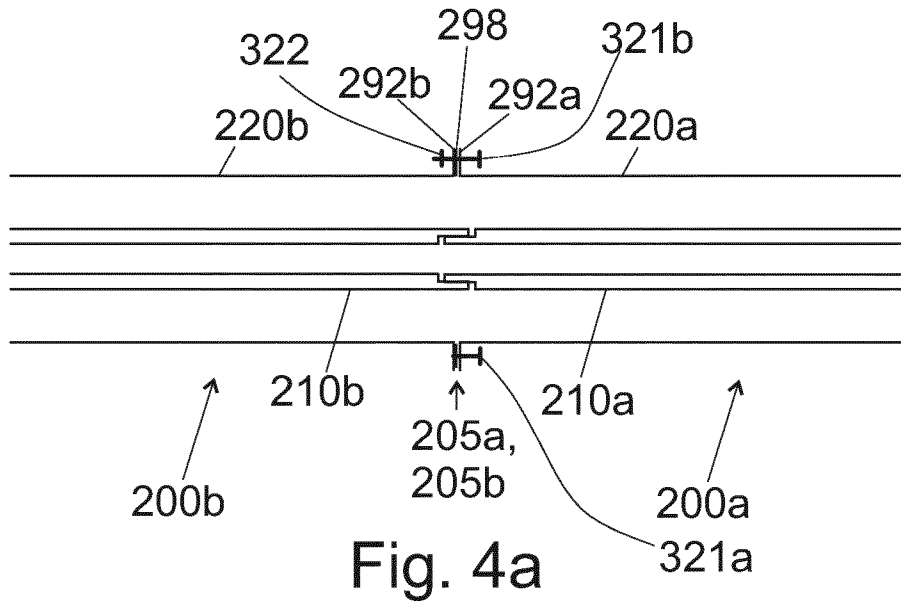


Fig. 4a

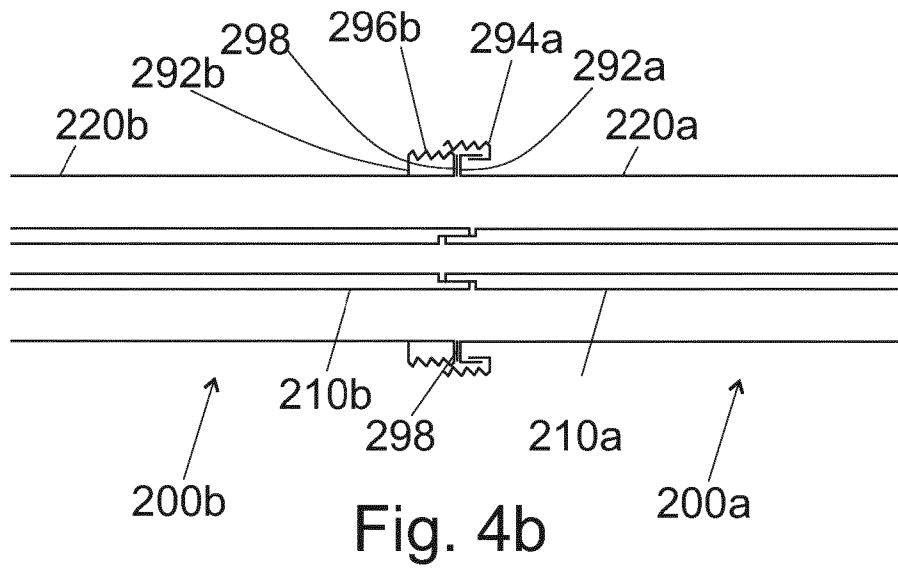


Fig. 4b

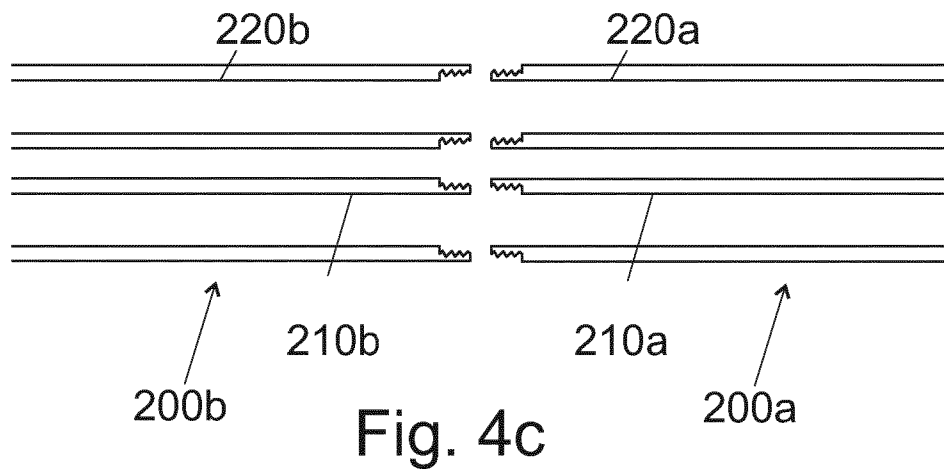


Fig. 4c

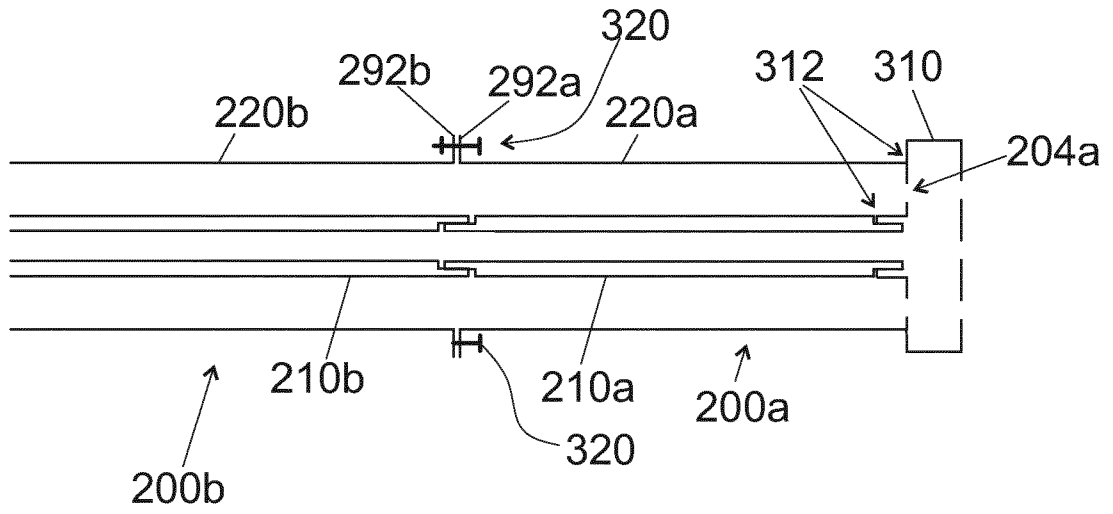


Fig. 5a

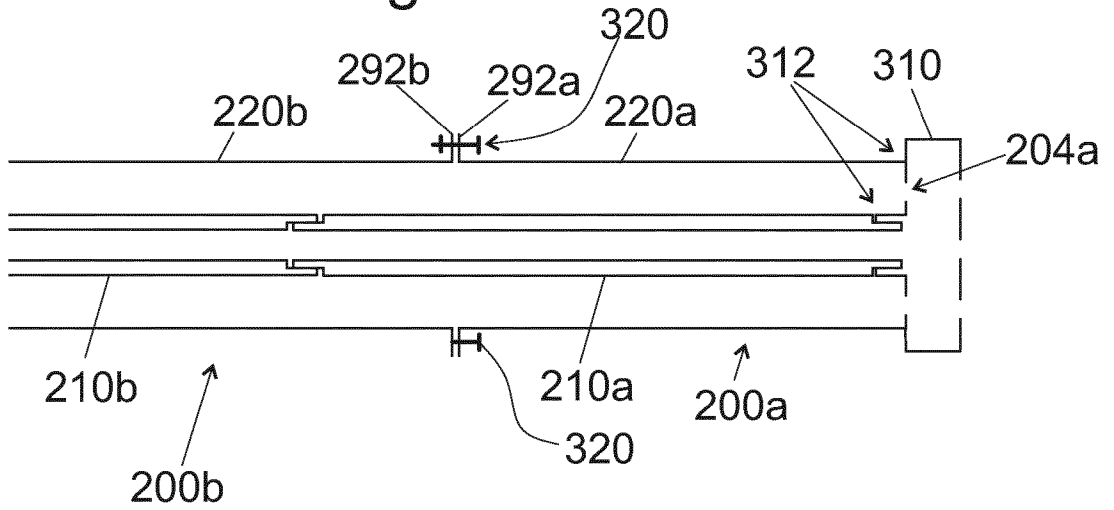


Fig. 5b

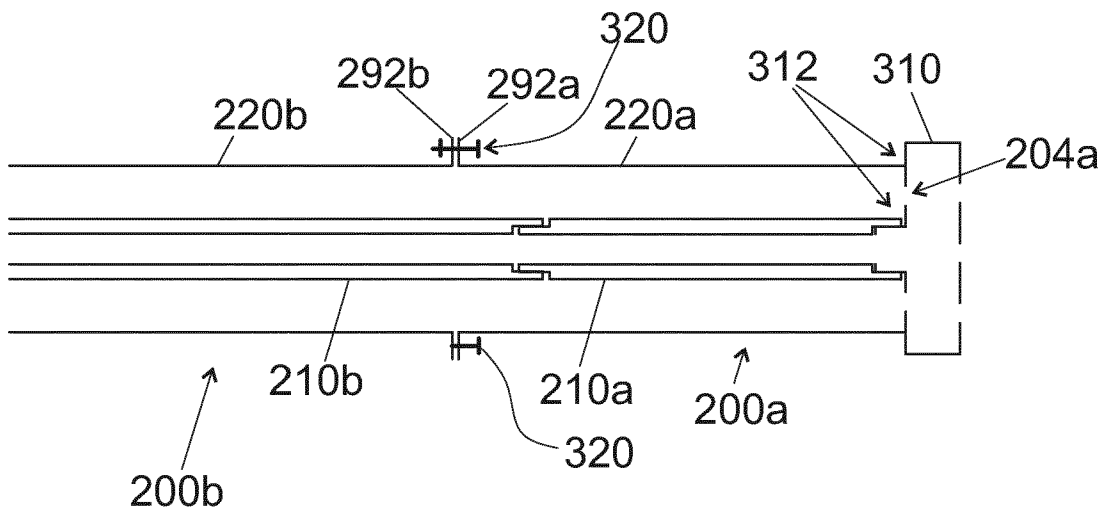


Fig. 5c

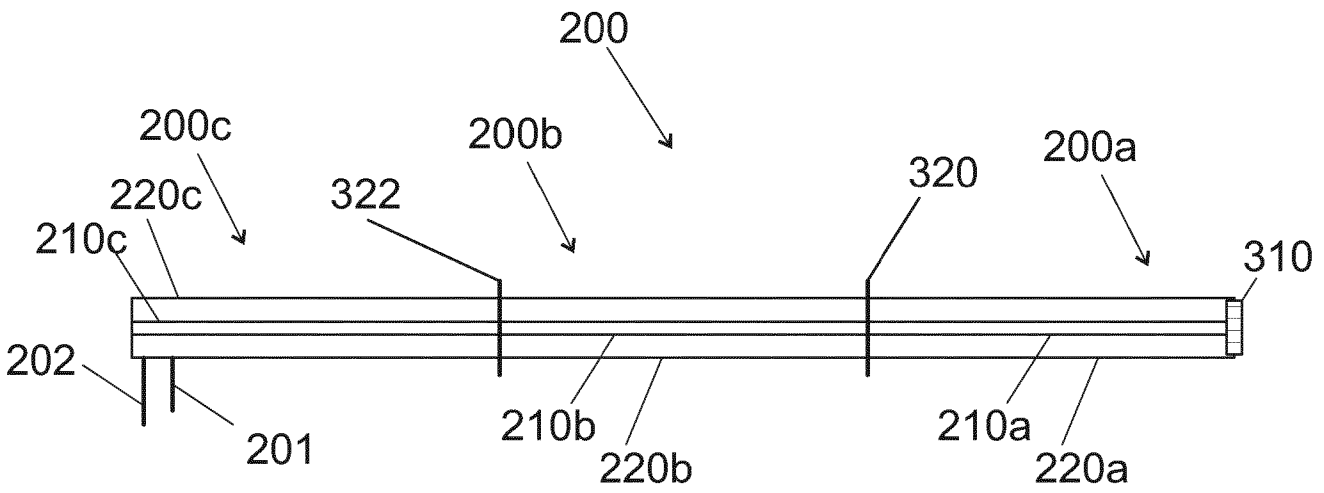


Fig. 6a

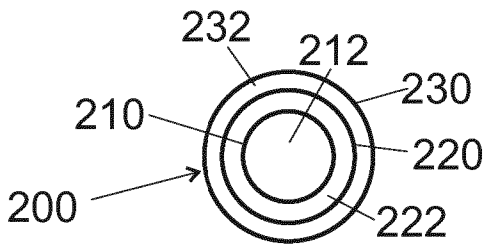


Fig. 6b

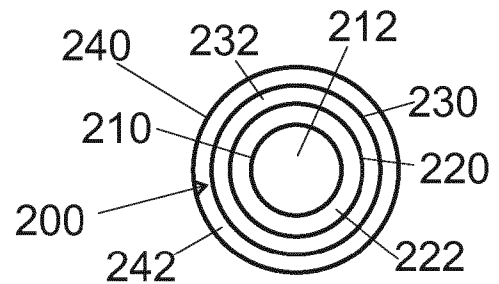


Fig. 6c

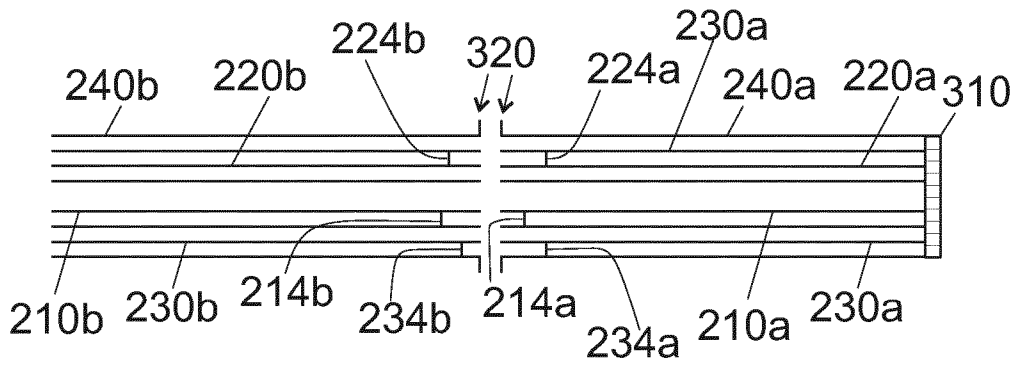


Fig. 6d

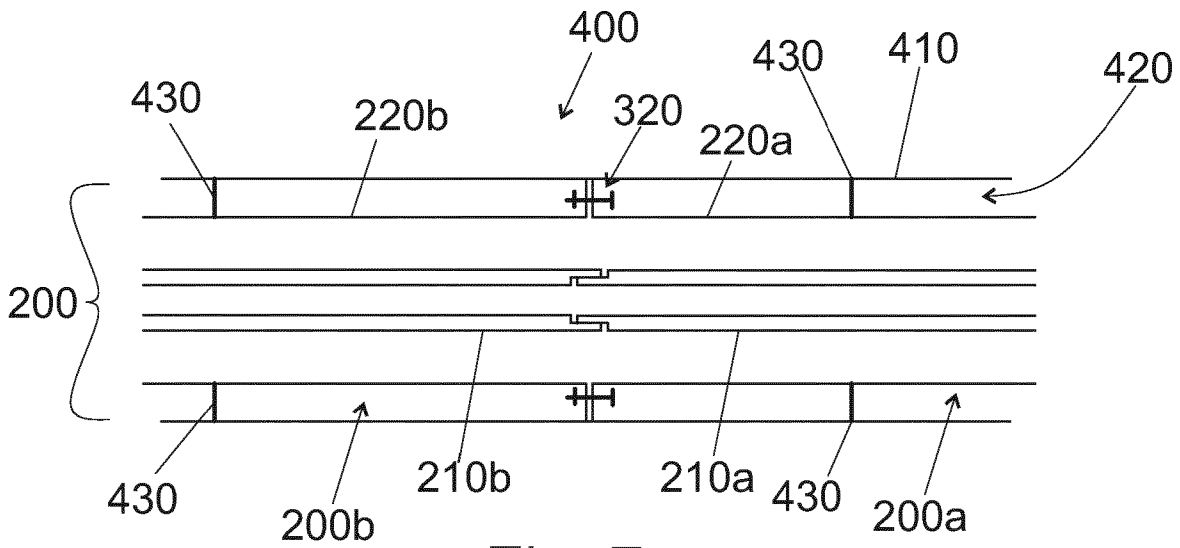


Fig. 7a

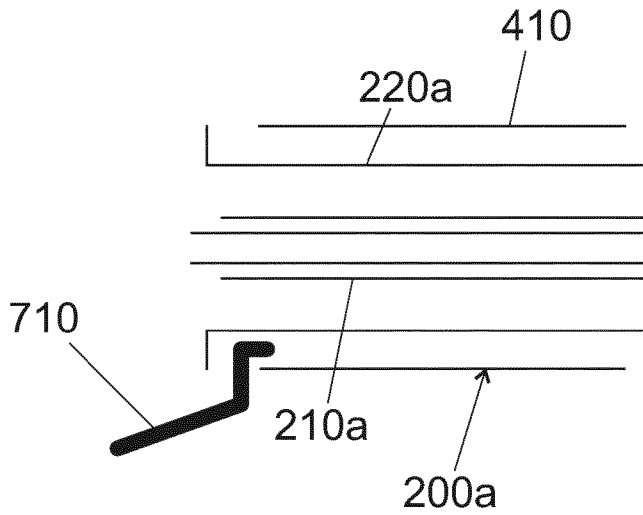


Fig. 7b

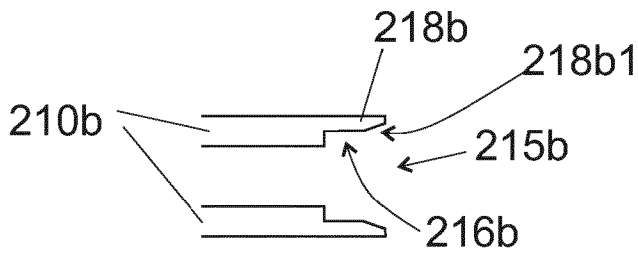


Fig. 3d3

