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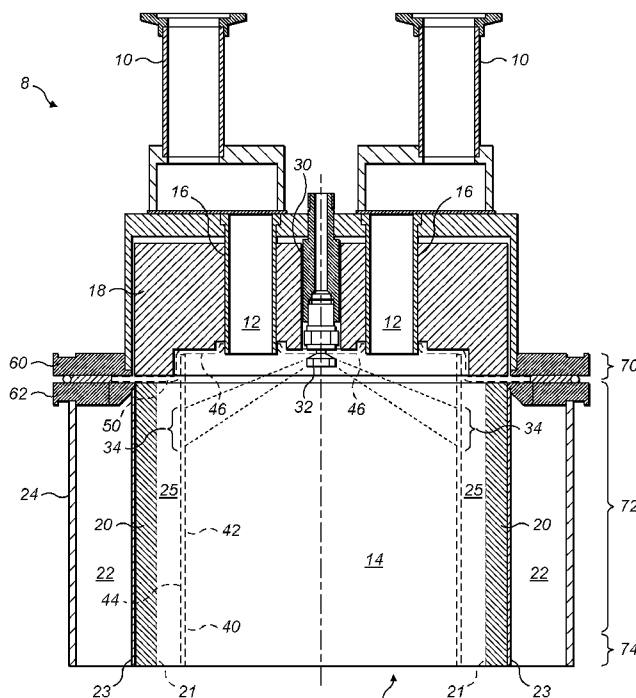
(54) **Title:** RADIANT BURNER

FIG. 1

(57) **Abstract:** A radiant burner and method are disclosed. The radiant burner is for treating an effluent gas stream from a manufacturing process tool and comprises: a combustion chamber having a porous sleeve through which combustion materials pass for combustion proximate to a combustion surface of the porous sleeve; at least one effluent nozzle for ejecting the effluent gas stream into the combustion chamber; and a perforated liner proximate to the combustion surface. Providing a perforated liner controls the combustion materials passing into the combustion chamber to treat the effluent gas stream and also provides a surface onto which residual combustion deposits may be received. Accordingly, the liner can both improve the efficiency of the treatment of the effluent gas stream and can act as a sacrificial surface which may be replaced or cleaned either in accordance with a maintenance regime or when the performance of the radiant burner reduces. Such replacement or cleaning of the liner saves having to replace the porous sleeve or other components of the combustion chamber which cannot readily be removed or cleaned. This enables the radiant burner to operate at higher flow rates and avoids needing to increase the size of the radiant burner or needing to add further radiant burners.

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RADIANT BURNER

FIELD OF THE INVENTION

The present invention relates to a radiant burner and method.

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BACKGROUND

Radiant burners are known and are typically used for treating an effluent gas stream from a manufacturing process tool used in, for example, the semiconductor or flat panel display manufacturing industry. During such manufacturing, residual perfluorinated compounds (PFCs) and other compounds exist in the effluent gas stream pumped from the process tool. PFCs are difficult to remove from the effluent gas and their release into the environment is undesirable because they are known to have relatively high greenhouse activity.

Known radiant burners use combustion to remove the PFCs and other compounds from the effluent gas stream. Typically, the effluent gas stream is a nitrogen stream containing PFCs and other compounds. A fuel gas is mixed with the effluent gas stream and that gas stream mixture is conveyed into a combustion chamber that is laterally surrounded by the exit surface of a foraminous gas burner. Fuel gas and air are simultaneously supplied to the foraminous burner to affect flameless combustion at the exit surface, with the amount of air passing through the foraminous burner being sufficient to consume not only the fuel gas supplied to the burner, but also all the combustibles in the gas stream mixture injected into the combustion chamber.

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As the surface areas of the semiconductors being produced increases, the flow rate of the effluent gas also increases.

Although techniques exist for processing the effluent gas stream, they each have their own shortcomings. Accordingly, it is desired to provide an improved technique for processing an effluent gas stream.

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SUMMARY

According to a first aspect, there is provided a radiant burner for treating an effluent gas stream from a manufacturing process tool, the radiant burner comprising: a combustion chamber having a porous sleeve through which
5 combustion materials pass for combustion proximate to a combustion surface of the porous sleeve; at least one effluent nozzle for ejecting the effluent gas stream into the combustion chamber; and a perforated liner proximate to the combustion surface.

- 10 The first aspect recognizes that a problem with the increasing flow rates is that greater quantities of effluent gas need to be processed. One approach would be to increase the size of the radiant burner. However, the first aspect recognizes that a problem with this approach is that the combustion mechanisms within the radiant burner are complex and simply increasing the size of the radiant burner to
15 match the increased flow rate of the effluent gas can lead to reduced performance of the radiant burner. Also, even if it were possible to produce a larger radiant burner with adequate performance, it is not straightforward to integrate such a larger radiant burner with existing processing equipment at the manufacturing site. Another approach would be to add further radiant burners to
20 increase the processing capacity. However, the first aspect also recognises that a problem with this approach is that it is not straightforward to integrate such further radiant burners with existing processing equipment at the manufacturing site. The first aspect further recognizes that whilst it is possible to increase the flow rate of the effluent gas through a radiant burner, this can lead to increased
25 combustion residues or deposits on the radiant burner caused by the non-PFC compounds, which significantly impair its performance over time.

- Accordingly, a gas abatement apparatus or radiant burner is provided. The radiant burner may treat an effluent gas stream from a manufacturing process
30 tool. The radiant burner may comprise a combustion chamber. The combustion chamber may have a porous or permeable sleeve through which combustion materials pass. The combustion materials may combust proximate to, near to or

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adjacent a combustion surface of the porous sleeve. One or more effluent nozzles may be provided which eject the effluent gas stream into the combustion chamber. A perforated, porous or punched liner may be provided proximate to, near to or adjacent the combustion surface. Providing a perforated liner controls
5 the combustion materials passing into the combustion chamber to treat the effluent gas stream and also provides a surface onto which residual combustion deposits may be received. Accordingly, the liner can both improve the efficiency of the treatment of the effluent gas stream and can act as a sacrificial surface which may be replaced or cleaned either in accordance with a maintenance
10 regime or when the performance of the radiant burner reduces. Such replacement or cleaning of the liner saves having to replace the porous sleeve or other components of the combustion chamber which cannot readily be removed or cleaned. This enables the radiant burner to operate at higher flow rates and avoids needing to increase the size of the radiant burner or needing to add
15 further radiant burners.

In one embodiment, the perforated liner is accommodated within the combustion chamber. Accordingly, the liner may be located within the combustion chamber itself to receive the combustion residues and protect other components of the
20 combustion chamber.

In one embodiment, the combustion materials combust in a combustion zone proximate to the combustion surface of the porous sleeve to produce combustion products and the perforated liner is located adjacent the combustion zone.

25 Accordingly, the liner may be located adjacent, near or proximate to the combustion zone where the combustion products are generated. The exact position of the liner may vary depending on the characteristics of the combustion zone. In embodiments, the combustion products comprise, for example, oxygen.

30 In one embodiment, the perforated liner extends at least partially along an axial length of the combustion chamber. Accordingly, the liner may extend along the axial length of all or a part of the combustion chamber.

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In one embodiment, the perforated liner is perforated with a plurality of holes. Providing holes or apertures enables the combustion products to pass from the combustion zone into the combustion chamber to mix and treat the effluent gas stream. It will be appreciated that the exact placement of the holes or apertures will affect or control the flow of the combustion products into the combustion chamber.

In one embodiment, a density of the holes of the perforated liner changes along the axial length. Accordingly, the density, concentration or quantity per unit surface area of the perforations, or the ratio of aperture surface area to non-aperture surface area of the liner may vary along the axial length of the liner. This variation in the size and density of holes or apertures in the liner helps to vary the rate of flow, concentration or amount of combustion products within different parts of the combustion chamber. Varying the flow rate, concentration or amounts of combustion products within the combustion chamber can help to improve the efficiency of the effluent treatment process by providing the right amounts of combustion products at the right locations.

In one embodiment, the combustion chamber has a nozzle end proximate to the at least one effluent nozzle and an exhaust end axially distal from the at least one effluent nozzle, the density of the holes of the perforated liner decreases towards the exhaust end. Accordingly, the density or concentration of apertures in the liner may decrease along the axial length of the liner. That is to say that the amount of aperture surface area of the liner is higher towards the effluent nozzles than it is the exhaust end. This helps to increase the amount of combustion products near where the effluent gas enters the combustion chamber and decreases the amount of combustion products near the exhaust end where the quantity of untreated effluent gas is reduced.

In one embodiment, the combustion chamber has an exhaust zone extending axially proximate to the exhaust end, the density of the holes of the perforated

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liner increases towards the exhaust zone. Accordingly, a region of the liner near the exhaust end may have an increased or high concentration of aperture surface area in order to increase the concentration of combustion products near the exhaust end where the treatment of the effluent gas is least effective.

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In one embodiment, the combustion chamber has a nozzle zone extending axially proximate to the nozzle end, the density of the holes of the perforated liner decreases towards the nozzle zone. Accordingly, a region of the liner near the nozzle end may have a decreased or low concentration of aperture surface area in order to decrease the concentration of combustion products in a region where combustion residues or deposits cause particular performance degradation or where cleaning such residues or deposits is difficult.

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In one embodiment, the perforated liner is unperforated proximate to the nozzle zone.

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In one embodiment, the radiant burner comprises a plurality of the nozzles positioned circumferentially around the combustion chamber and the density of the holes of the perforated liner increases circumferentially proximate to the plurality of the nozzles. Accordingly, the amount of aperture surface area of the liner may increase near the nozzles in order to deliver more combustion products in the vicinity of the effluent gas stream being ejected from the nozzles. This helps to ensure that the combustion products are concentrated in the regions where they are most needed to react with the effluent gas stream.

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In one embodiment, the radiant burner comprises at least one spray nozzle for ejection of a cleaning fluid onto a cleaning zone of the perforated liner, the density of the holes of the perforated liner decreases towards the cleaning zone. Accordingly, cleaning fluids may be sprayed from the nozzle onto the liner. The density of holes in the region where the cleaning fluid impacts the liner may be decreased or even no holes are provided at all in order to prevent the cleaning

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fluid from passing through the liner and contacting the porous sleeve or other potentially damageable components of the radiant burner.

5 In one embodiment, the perforated liner comprises one of a mesh, a wire screen, a perforated sheet and a louvered sheet.

10 In one embodiment, the louvers of the louvered sheet are orientated to direct the combustion products within the combustion chamber. It will be appreciated that the louvers provide both a mechanism for directing the flow of the combustion products to specified regions within the combustion chamber, whilst also providing an effective barrier to prevent cleaning fluid from passing through the liner.

15 In one embodiment, louvers of the louvered sheet are orientated to receive on a major surface the cleaning fluid from the at least one spray nozzle. Hence, it will be appreciated that the use of louvers enables perforations to be provided within the cleaning zone. It will be appreciated that that a louver is typically a long, thin, planar member; the major surface would be one of the large (typically 'upper' or 'lower') surfaces of the louver as opposed to a minor surface which would in effect be its edges.

20 In one embodiment, the perforated liner is axially displaceable between an accommodated position where the perforated liner is accommodated within the combustion chamber and an unaccommodated position where the perforated liner protrudes from the combustion chamber. Accordingly, the liner may be movable within the combustion chamber to protrude from the combustion chamber to facilitate cleaning. It will be appreciated that such displacement may be provided in addition to or instead of providing the spray nozzle.

30 In one embodiment, the perforated liner fully extends from the combustion chamber in the unaccommodated position. Fully removing of the liner from the combustion chamber further helps to aid its cleaning or replacement.

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In one embodiment, the radiant burner comprises a cleaning tank for holding a cleaning fluid and wherein the perforated liner extends into the cleaning tank in the unaccommodated position. Immersing the liner within the cleaning tank helps
5 to remove the combustion residues and clean the liner.

In one embodiment, the radiant burner comprises means for agitating the perforated liner in the cleaning tank. It will be appreciated that agitating further helps to clean the liner.

10

In one embodiment, the perforated liner comprises an aperture for receiving an associated one of the effluent nozzles, displacement of the perforated liner causing movement of the aperture with respect to the associated one of the effluent nozzles to dislodge any effluent treatment deposit located on an outer
15 surface thereof. Accordingly, the act of displacing the liner may facilitate the removal of combustion deposits or residues that may have been deposited on the nozzles, which may in time otherwise reduce the performance of these nozzles.

In one embodiment, the perforated liner is metallic. Providing a metallic liner
20 enables increased mechanical and thermal shock stress to be applied when performing the cleaning compared to that which would be possible when trying to clean the porous sleeve or other components of the combustion chamber.

In one embodiment, the perforated liner comprises nickel.

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In one embodiment, the combustion zone and the perforated liner are cylindrical.

According to a second aspect, there is provided a method of treating an effluent gas stream from a manufacturing process tool, the method comprising the steps
30 of: passing combustion materials through a porous sleeve of a combustion chamber for combustion proximate to a combustion surface of the porous sleeve; ejecting the effluent gas stream from at least one effluent nozzle into the

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combustion chamber; and providing a perforated liner proximate to the combustion surface.

5 In one embodiment, the perforated liner is accommodated within the combustion chamber.

In one embodiment, the combustion materials combust in a combustion zone proximate to the combustion surface of the porous sleeve to produce combustion products and the perforated liner is located adjacent the combustion zone.

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In one embodiment, the perforated liner extends at least partially along an axial length of the combustion chamber.

In one embodiment, the perforated liner is perforated with a plurality of holes.

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In one embodiment, a density of the holes of the perforated liner changes along the axial length.

20 In one embodiment, the combustion chamber has a nozzle end proximate to the at least one effluent nozzle and an exhaust end axially distal from the at least one effluent nozzle, the density of the holes of the perforated liner decreases towards the exhaust end.

25 In one embodiment, the combustion chamber has an exhaust zone extending axially proximate to the exhaust end, the density of the holes of the perforated liner increases towards the exhaust zone.

30 In one embodiment, the combustion chamber has a nozzle zone extending axially proximate to the nozzle end, the density of the holes of the perforated liner decreases towards the nozzle zone.

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In one embodiment, the perforated liner is unperforated proximate to the nozzle zone.

5 In one embodiment, the step of ejecting comprises ejecting from a plurality of the nozzles positioned circumferentially around the combustion chamber and wherein the density of the holes of the perforated liner increases circumferentially proximate to the plurality of the nozzles.

10 In one embodiment, the method comprises the step of ejecting a cleaning fluid from at least one spray nozzle for onto a cleaning zone of the perforated liner and wherein the density of the holes of the perforated liner decreases towards the cleaning zone.

15 In one embodiment, the perforated liner comprises one of a mesh, a wire screen, a perforated sheet and a louvered sheet.

In one embodiment, the louvers of the louvered sheet are orientated to direct the combustion products within the combustion chamber.

20 In one embodiment, the louvers of the louvered sheet are orientated to receive on a major surface the cleaning fluid from the at least one spray nozzle.

25 In one embodiment, the method comprises the step of axially displacing the perforated liner between an accommodated position where the perforated liner is accommodated within the combustion chamber and an unaccommodated position where the perforated liner protrudes from the combustion chamber.

In one embodiment, the perforated liner fully extends from the combustion chamber in the unaccommodated position.

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In one embodiment, the step of axially extending comprises extending the perforated liner into a cleaning tank holding a cleaning fluid.

- 10 -

In one embodiment, the method comprises the step of agitating the perforated liner in the cleaning tank.

- 5 In one embodiment, the perforated liner comprises an aperture for receiving an associated one of the effluent nozzles and the method comprises the step of displacing the perforated liner to cause movement of the aperture with respect to the associated one of the effluent nozzles to dislodge any effluent treatment deposit located on an outer surface thereof.

10

In one embodiment, the perforated liner is metallic.

In one embodiment, the perforated liner comprises nickel.

- 15 In one embodiment, the combustion chamber and the perforated liner are cylindrical.

According to a third aspect, there is provided a perforated liner for a radiant burner for treating an effluent gas stream from a manufacturing process tool, the
20 radiant burner comprising a combustion chamber having a porous sleeve through which combustion materials pass for combustion proximate to a combustion surface of the porous sleeve; at least one effluent nozzle for ejecting the effluent gas stream into the combustion chamber, the perforated liner being shaped and configured for placement proximate to the combustion surface.

25

In one embodiment, the perforated liner is shaped and configured for accommodation within the combustion chamber.

In one embodiment, the combustion materials combust in a combustion zone
30 proximate to the combustion surface of the porous sleeve to produce combustion products and the perforated liner is shaped and configured for location adjacent the combustion zone.

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In one embodiment, the perforated liner is dimensioned to extend at least partially along an axial length of the combustion chamber.

- 5 In one embodiment, the perforated liner is perforated with a plurality of holes.

In one embodiment, a density of the holes changes along the axial length.

In one embodiment, the density of the holes decreases towards an exhaust end.

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In one embodiment, the density of the holes increases towards an exhaust zone.

In one embodiment, the density of the holes of the perforated liner decreases towards a nozzle zone.

15

In one embodiment, the perforated liner is unperforated proximate to the nozzle zone.

- 20 In one embodiment, the density of the holes of the perforated liner increases circumferentially proximate a plurality of nozzle regions.

In one embodiment, the density of the holes of the perforated liner decreases towards a cleaning zone.

- 25 In one embodiment, the perforated liner comprises one of a mesh, a wire screen, a perforated sheet and a louvered sheet.

In one embodiment, the louvers are orientated to direct the combustion products within the combustion chamber.

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In one embodiment, the louvers are orientated to receive on a major surface the cleaning fluid from the at least one spray nozzle.

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In one embodiment, the liner comprises an aperture for receiving an associated effluent nozzle.

5 In one embodiment, the perforated liner is metallic.

In one embodiment, the perforated liner comprises nickel.

In one embodiment, the perforated liner is cylindrical.

10

According to a fourth aspect, there is provided a radiant burner perforated liner for treating an effluent gas stream from a manufacturing process tool, the radiant burner comprising a combustion chamber having a porous sleeve through which combustion materials pass for combustion proximate to a combustion surface of
15 the porous sleeve; at least one effluent nozzle for ejecting the effluent gas stream into the combustion chamber, the perforated liner being shaped and configured for placement proximate to the combustion surface.

Further particular and preferred aspects are set out in the accompanying
20 independent and dependent claims. Features of the dependent claims may be combined with features of the independent claims as appropriate, and in combinations other than those explicitly set out in the claims.

Where an apparatus feature is described as being operable to provide a function,
25 it will be appreciated that this includes an apparatus feature which provides that function or which is adapted or configured to provide that function.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention will now be described further, with reference to the accompanying drawings, in which:

Figure 1 illustrates a radiant burner according to one embodiment;

5 Figure 2 is an enlarged view of the interface between a liner and nozzle shown in Figure 1;

Figures 3 to 5 illustrate regions of differing perforation density according to embodiments;

Figures 6 and 7 illustrate displacement of the liner according to one embodiment.

10

DESCRIPTION OF THE EMBODIMENTS

Overview

Before discussing the embodiments in any more detail, first an overview will be provided. As mentioned above, the conditions within the combustion chamber of a radiant burner may be such that combustion residues deposit on surfaces
15 within the combustion chamber due to changes in flow rate of effluent gases into the combustion chamber. These residues affect the performance of the combustion chamber typically by preventing flow of the combustion materials through a burner element and by blocking nozzles providing the effluent gas
20 stream. In addition, the residues can potentially affect the chemistry of the combustion within the combustion chamber.

Providing a perforated or porous liner within the combustion chamber protects the burner element and/or nozzles from such combustion deposits since the
25 combustion residues deposit on the liner, which can be cleaned more conveniently and in any of a variety of different ways than is possible for the burner element or the nozzles. For example, the liner may be mechanically cleaned using a scraper or by spraying water onto the liner. Such cleaning would typically damage the burner element. This cleaning may be performed in-situ or
30 by removing the liner from the combustion chamber. Again, this is something that is not easy to do with the burner element or the nozzles. This approach makes it easier and faster to clean the radiant burner.

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Also, the mechanical arrangement of the liner may be configured to adjust the combustion properties of the combustion chamber. For example, the perforations or apertures within the liner may be sized and distributed to affect the

5 concentration and flow of the combustion gases within the combustion chamber.

Also, the size and location of the perforations may be configured to prevent or reduce the likelihood of any cleaning material being used to clean the liner from contacting and potentially damaging the combustion element.

10 Hence, it can be seen that the arrangement of a liner helps to improve the performance of the radiant burner.

Radiant Burner - General Configuration and Operation

Figure 1 illustrates a radiant burner, generally 8 according to one embodiment.

15 The radiant burner 8 treats an effluent gas stream pumped from a manufacturing process tool such as a semiconductor or flat panel display process tool typically by means of a vacuum pumping system. The effluent stream is received at inlets 10. The effluent stream is conveyed from the inlet 10 to a nozzle 12 which injects the effluent stream into a cylindrical combustion chamber 14. In this
20 embodiment, the radiant burner 8 comprises four inlets 10 arranged circumferentially, each conveying an effluent stream pumped from a respective tool by a respective vacuum pumping system. Alternatively, the effluent stream from a single processed tool may be split into a plurality of streams, each one of which is conveyed to a respective inlet 10. Each nozzle 12 is located within a
25 respective bore 16 formed in a ceramic top plate 18 which defines an upper or inlet surface of the combustion chamber 14.

The combustion chamber 14 has sidewalls defined by an exit surface 21 of a foraminous burner element 20 such as that described in EP0694735. The burner
30 element 20 is cylindrical and is retained within a cylindrical outer shell 24. A plenum volume 22 is defined between an entry surface 23 of the burner element 20 and the cylindrical outer shell 24. A mixture of fuel gas, such as natural gas or

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a hydrocarbon, and air is introduced into the plenum volume 22 via one or more inlet nozzles [not shown]. The mixture of fuel gas and air passes from the entry surface 23 of the burner element 20 to the exit surface 21 of the burner element 20 for combustion within the combustion chamber 14.

5

The ratio of the mixture of fuel gas and air is varied to vary the temperature within the combustion chamber 14 to that which is appropriate for the effluent gas stream to be treated. Also, the rate at which the mixture of fuel gas and air is introduced into the plenum volume 22 is adjusted so that the mixture will burn without visible flame at the exit surface 21 of the burner element 20. The exhaust 15 of the combustion chamber 40 is open to enable the combustion products to be output from the radiant burner 8.

Accordingly, it can be seen that the effluent gas received through the inlets 10 and provided by the nozzles 12 to the combustion chamber 14 is combusted within the combustion chamber 14 which is heated by the mixture of fuel gas and air which combusts near the exit surface 21 of the burner element 20. Such combustion causes heating of the chamber 14 and provides combustion products, such as oxygen, typically within a range of 7.5% to 10.5% depending on the air/fuel mixture [CH_4 , C_3H_8 , C_4H_{10}], provided to the combustion chamber 14. This heat and the combustion products react with the effluent gas stream within the combustion chamber 14 to clean the effluent gas stream. For example, SiH_4 and NH_3 may be provided within the effluent gas stream, which reacts with O_2 within the combustion chamber 14 to generate SiO_2 , N_2 , H_2O , NO_x . Similarly, N_2 , CH_4 , C_2F_6 may be provided within the effluent gas stream, which reacts with O_2 within the combustion chamber 14 to generate CO_2 , HF , H_2O .

Perforated Liner - Fixed Arrangement

Provided within the combustion chamber 14 is a liner 40. In this embodiment, the liner 40 is cylindrical and it is received within the combustion chamber 14 adjacent the exit surface 21 of the burner elements 20. The combustion of the mixture of fuel gas and air occurs within a combustion zone 25 adjacent the exit

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surface 21 of the burner element 20. In this embodiment, the outer surface 44 of the liner 40 is positioned adjacent the combustion zone 25 so that combustion products pass through perforations of the liner 40 and enter the combustion chamber 14. However, it will be appreciated that the exact location of the liner 40 with respect to the exit surface 21 of the burner element 20 and the combustion zone 25 may be varied to vary the conditions within the combustion chamber 14.

The liner 40 is perforated to enable the combustion products to pass from the combustion zone 25 into the combustion chamber 14. The size and distribution of these perforations are selected to facilitate the distribution and flow of combustion products from the combustion zone 25 into the combustion chamber 14, as will be described in more detail below. Also, the size and distribution of the perforations can be varied to protect the burner elements 20 from damage during cleaning of the liner 40. It will be appreciated that the perforations can be provided in a variety of different ways; for example, the liner 40 may be punched or rolled to create apertures at the correct locations or may even be louvered.

In this embodiment, the liner 40 is formed of two parts; namely a cylindrical section and a top plate section. The cylindrical section and the top plate section 46 are affixed. The top plate 46 has a radially outer circumferential flange which is clamped between an upper section 60 and a lower section 62 of the radiant burner 8. This retains the liner 40 in place within the combustion chamber 14.

Spray Nozzle

In order to clean the fixed liner, a further bore 30 in the ceramic top plate 18 is provided through which a spray nozzle 32 extends at the inlet end of the combustion chamber 14. The spray nozzle 32 is supplied with a cleaning fluid, such as water, from an accumulator which operates to dispense a selected or fixed amount of fluid, such as water, from the spray nozzle 32 at a selected pressure. The geometry of the spray nozzle 32 defines a spray pattern for the cleaning fluid. In this example, a 120° ejection nozzle is provided which directs

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the fluid in a 120° cone having an angular tolerance which causes cleaning fluids to impact on an impact zone 34 of the liner 40.

5 The mechanical impact, vaporisation and/or thermal shock of the cleaning fluid contacting the inner surface of the hot liner 40 causes combustion residues deposited on the liner 40 to become detached.

Nozzle Cleaning

10 As can be seen in more detail in Figure 2, the top plate 46 comprises apertures, each of which receives a respective nozzle 12. The apertures are defined by upstanding edges 48 of the top plate which may be toleranced to provide an interference fit with an outer surface 13 of the nozzles 12. The presence of the upstanding edges 48 of the top plate 46 enables any combustion residues deposited on the outer surface 13 of the nozzles 12 to be scraped off when the
15 liner 40 is removed from the combustion chamber 14.

In the embodiment shown in Figure 1, removal of the liner 40 is achieved by separating the upper section 60 and lower section 62 of the radiant burner 8. However, in embodiments described in more detail below, the liner 40 may be
20 displaced from the combustion chamber 14 without separating the upper section 60 and lower section 62.

Perforated Liner - Displaceable Arrangement

Figure 6 illustrates a displaceable arrangement according to one embodiment
25 where the spray nozzle 32 is omitted. In order to clean the liner 14, it is displaced from the exhaust 15 of the combustion chamber 14 for cleaning. Typically, the liner 40 is displaced into a water bath 90. Immersing the liner 40 in the water bath causes a mechanical impact, vaporisation and/or thermal shock which dislodges combustion residues. The liner 40 may then be agitated within the
30 water bath or the water bath itself may be agitated to facilitate cleaning.

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In particular, the perforated liner 42 is retained by a fixing 80 coupled with an actuator 82 which is shown in the accommodated or retracted position. Coupled with the cylindrical outer shell 24 is a lower chamber, generally 92. The lower chamber 92 provides for cooling of the processed effluent gases exiting the combustion chamber 14. The processed effluent gases enter a cylindrical tube 83, flow through an aperture 85 and out of an outlet 88. The cylindrical tube 83 has a water curtain which flows in the direction A and is fed by a water curtain feed 84. A cooling spray 86 is directed towards the aperture 85 the water curtain. The cooling spray 86 helps to cool the processed effluent gases and to trap particulate material. The water bath 90 is maintained at the lower portion of the container 92.

Figure 7 shows the perforated liner 42 in the unaccommodated or protruding position. The perforated liner 42 is displaced by the actuator 82 into the water bath 90. The immersion of the perforated liner 42 within the water bath 90 causes residues deposits to be removed. Reciprocating the actuator 82 helps to agitate the liner 42 within the water bath 90. The actuator 82 may be retracted to displaced the perforated liner 42 and accommodate this back within the combustion chamber 14. Displacement of the perforated liner 42 helps to remove any residue deposits on the nozzles 12.

It will be appreciated that for such an arrangement, the circumferential flange 50 is omitted and the liner 40 is instead retained within the combustion chamber 14 by the fixing 80 and actuator 82. The displacement mechanism can then return the liner 40 to the accommodated position as shown in Figure 1.

The displacement of the liner 40 causes combustion residue on the outer surface 13 of the nozzles 12 to be removed.

In both the fixed and displaceable arrangements, a mechanical scrapper may be inserted which contacts with the inner surface 42 of the liner 40 and provides mechanical cleaning. Alternatively, or additionally, the mechanical scraper may

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be located in the water bath 90 and may engage the liner 40 during displacement of the liner 40 to the unaccommodated position.

Liner Perforations - Combustion Product General Flow Control

5 In order to control the introduction of combustion products from the combustion zone 25 into the combustion chamber 14, the size and distribution of perforations is varied as shown in Figure 3. To improve clarity, the cylindrical portion is shown as a rectangular net.

10 As can be seen, in a region 70 which is adjacent the ceramic top plate 18, no or a lower density of perforations is provided. Optionally, in a region 74 which is adjacent the exhaust 15 of the combustion chamber 14, a higher density of perforations is provided. In a region 72 between the regions 70 and 74, the density of perforations changes from a higher density of perforations towards the
15 region 70 to a lower density of perforations towards the region 74.

Providing a higher density of perforations in the region 72 close to the nozzles 12 helps to increase the distribution of combustion products in the region where the effluent gas stream combusts within the combustion chamber 14. Generally
20 reducing the density of perforations towards the outlet 15 reduces the amount of combustion products as the amount of untreated effluent gas stream reduces.

Providing the region 74 with a high density of perforations also increases the density of combustion products in the vicinity of the outlet 15 where combustion is
25 likely to be less efficient. Reducing the density of perforations in the region 70 helps to decrease the distribution of combustion products in the region where the effluent gas stream undergoes little combustion within the combustion chamber 14.

30 Liner Perforations - Combustion Product Flow - Nozzle Optimisation

In order to control the introduction of combustion products from the combustion zone 25 into the combustion chamber 14, the size and distribution of perforations

- 20 -

is varied as shown in Figure 4. To improve clarity, the cylindrical portion is shown as a rectangular net.

5 In the embodiment shown in Figure 1, there are provided four nozzles 12 equally spaced circumferentially. The relative positions of those nozzles 12 are indicated schematically in Figure 4. In order to concentrate the presence of combustion products in the vicinity of each of those nozzles 12, the density of perforations in the regions 12a is increased compared to the density of perforations in the regions 12b.

10

It will be appreciated that depending on the particular number and configuration of the nozzles 12, the precise location of the regions 12a and 12b will vary to match.

15 Liner Perforations - Spray Protection

In order to prevent damage to the burner element 20, the size and distribution of perforations is varied as shown in Figure 5. To improve clarity, the cylindrical portion is shown as a rectangular net.

20 As can be seen, a region 34 of no or a low density of perforations is provided. This prevents or reduces the likelihood of any cleaning fluid ejected from the spray nozzle from passing through the liner 40 and contacting and causing damage to the burner element 20.

25 It will be appreciated that in embodiments utilising louvers rather than perforations, the presence of the zone 34 is not required.

Liner Perforations - Density Combinations

30 In order to provide combustion product control and spray protection, the densities shown in Figures 3, 4 and/or 5 may be combined to arrive at an appropriate density profile for the perforated liner. In particular, the zones 70 and 74 may, for example, be omitted.

- 21 -

As mentioned above, the processing of effluent gases such as silane, chloro-silanes and organo-silane produces solid by-products such as SiO_2 and Si_3N_4 . These tend to deposit on surfaces within the radiant burner. The rate of deposit
5 is sufficient that, typically, turbulent flame burners are instead used for processing of such gases which are typically produced during photovoltaic solar and flat panel display processes.

In embodiments, a perforated screen is interposed between the burner element
10 and the combustion chamber. For example, a 6 inch diameter screen is mounted within a 7 inch diameter burner element. The burner is fired in a conventional way, with the perforated screen forming a gas purged radiant boundary to the combustion chamber. The screen may be capped with a metallic plate which is perforated to allow for various head fixtures to protrude, for example a pilot
15 burner, process nozzles, thermocouple, etc. This provides for a sacrificial surface, covering the areas ordinarily prone to deposition, but made of substantially more robust material than the base parts [which are currently ceramic fibre for the head insulation and composite metal fibre/ceramic fibre for the burner elements]. Providing a perforated screen provides surfaces that can
20 be cleaned. In one embodiment, the parts are cleaned by impacting water droplets from a high pressure spray nozzle. In another embodiment, the liner is mounted on an actuator, allowing it to be translated out of the burner and dipped into a tank of water immediately below the burner.

25 The screen may be a simple perforated sheet which is rolled and welded, or may be punched with louvers such that the combustion bi-products are directed downwards, but any water spray or steam [if admitted through the top of the combustion chamber] is prevented from coming into contact with the surface of the burner. Alternatively, a knitted wire braided wire screen may be employed.

30

The liner needs to be able to withstand the high temperature oxidizing conditions of the combustion chamber and also to withstand the high thermal shock of

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cleaning events. Accordingly, the liner may include inconel 600 or similar alloys. Alternatively, mild steel may be used with a heavy high phosphorus electrode-less nickel plating. When heated to braising temperatures in a vacuum furnace [800°C 250°C] the nickel coating flows into the surface of the mild steel and the
5 phosphorus is subsequently burned out, leaving a non-porous coating of essentially pure nickel which has a melting point of approximately 1440°C and a coating melting point of 800°C to 1200°C, depending on phosphorus content.

Although illustrative embodiments of the invention have been disclosed in detail
10 herein, with reference to the accompanying drawings, it is understood that the invention is not limited to the precise embodiment and that various changes and modifications can be effected therein by one skilled in the art without departing from the scope of the invention as defined by the appended claims and their equivalents.

15

CLAIMS

1. A radiant burner for treating an effluent gas stream from a manufacturing process tool, said radiant burner comprising:
 - 5 a combustion chamber having a porous sleeve through which combustion materials pass for combustion proximate to a combustion surface of said porous sleeve;
at least one effluent nozzle for ejecting said effluent gas stream into said combustion chamber; and
 - 10 a perforated liner proximate to said combustion surface.
2. The radiant burner of claim 1, wherein a density of holes of said perforated liner changes along said axial length.
- 15 3. The radiant burner of claim 2, wherein said combustion chamber has a nozzle end proximate to said at least one effluent nozzle and an exhaust end axially distal from said at least one effluent nozzle, said density of said holes of said perforated liner decreases towards said exhaust end.
- 20 4. The radiant burner of claims 2 or 3, wherein said combustion chamber has an exhaust zone extending axially proximate to said exhaust end, said density of said holes of said perforated liner increases towards said exhaust zone.
- 25 5. The radiant burner of any one of claims 2 to 4, wherein said combustion chamber has a nozzle zone extending axially proximate to said nozzle end, said density of said holes of said perforated liner decreases towards said nozzle zone.
- 30 6. The radiant burner of claim 5, wherein said perforated liner is unperforated proximate to said nozzle zone.

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7. The radiant burner of any one of claims 2 to 6, comprising a plurality of said nozzles positioned circumferentially around said combustion chamber and wherein said density of said holes of said perforated liner increases circumferentially proximate to said plurality of said nozzles.

5

8. The radiant burner of any one of claims 2 to 7, comprising at least one spray nozzle for ejection of a cleaning fluid onto a cleaning zone of said perforated liner, said density of said holes of said perforated liner decreases towards said cleaning zone.

10

9. The radiant burner of any preceding claim, wherein said perforated liner comprises a louvered sheet and louvers of said louvered sheet are orientated to direct said combustion products within said combustion chamber

15

10. The radiant burner of any one of claims 1 to 8, wherein said perforated liner comprises a louvered sheet and louvers of said louvered sheet are orientated to receive on a major surface said cleaning fluid from said at least one spray nozzle.

20

11. The radiant burner of any preceding claim, wherein said perforated liner is axially displaceable between an accommodated position where said perforated liner is accommodated within said combustion chamber and an unaccommodated position where said perforated liner protrudes from said combustion chamber.

25

12. The radiant burner of claim 11, comprising a cleaning tank for holding a cleaning fluid and wherein said perforated liner extends into said cleaning tank in said unaccommodated position.

30

13. The radiant burner of any preceding claim, wherein said perforated liner comprises an aperture for receiving an associated effluent nozzle,

- 25 -

displacement of said perforated liner causing movement of said aperture with respect to said associated effluent nozzle to dislodge any effluent treatment deposit located on an outer surface thereof.

- 5 14. A method of treating an effluent gas stream from a manufacturing process tool, said method comprising the steps of:

passing combustion materials through a porous sleeve of a combustion chamber for combustion proximate to a combustion surface of said porous sleeve;

- 10 ejecting said effluent gas stream from at least one effluent nozzle into said combustion chamber; and

providing a perforated liner proximate to said combustion surface.

- 15 15. A perforated liner for a radiant burner for treating an effluent gas stream from a manufacturing process tool, said radiant burner comprising a combustion chamber having a porous sleeve through which combustion materials pass for combustion proximate to a combustion surface of said porous sleeve; at least one effluent nozzle for ejecting said effluent gas stream into said combustion chamber, said perforated liner being shaped and configured for placement proximate to said combustion surface.

- 20 16. A radiant burner as herein described with reference to the accompanying drawings.

- 25 17. A method as herein described with reference to the accompanying drawings.

18. A liner for a radiant burner as herein described with reference to the accompanying drawings.

1 / 5

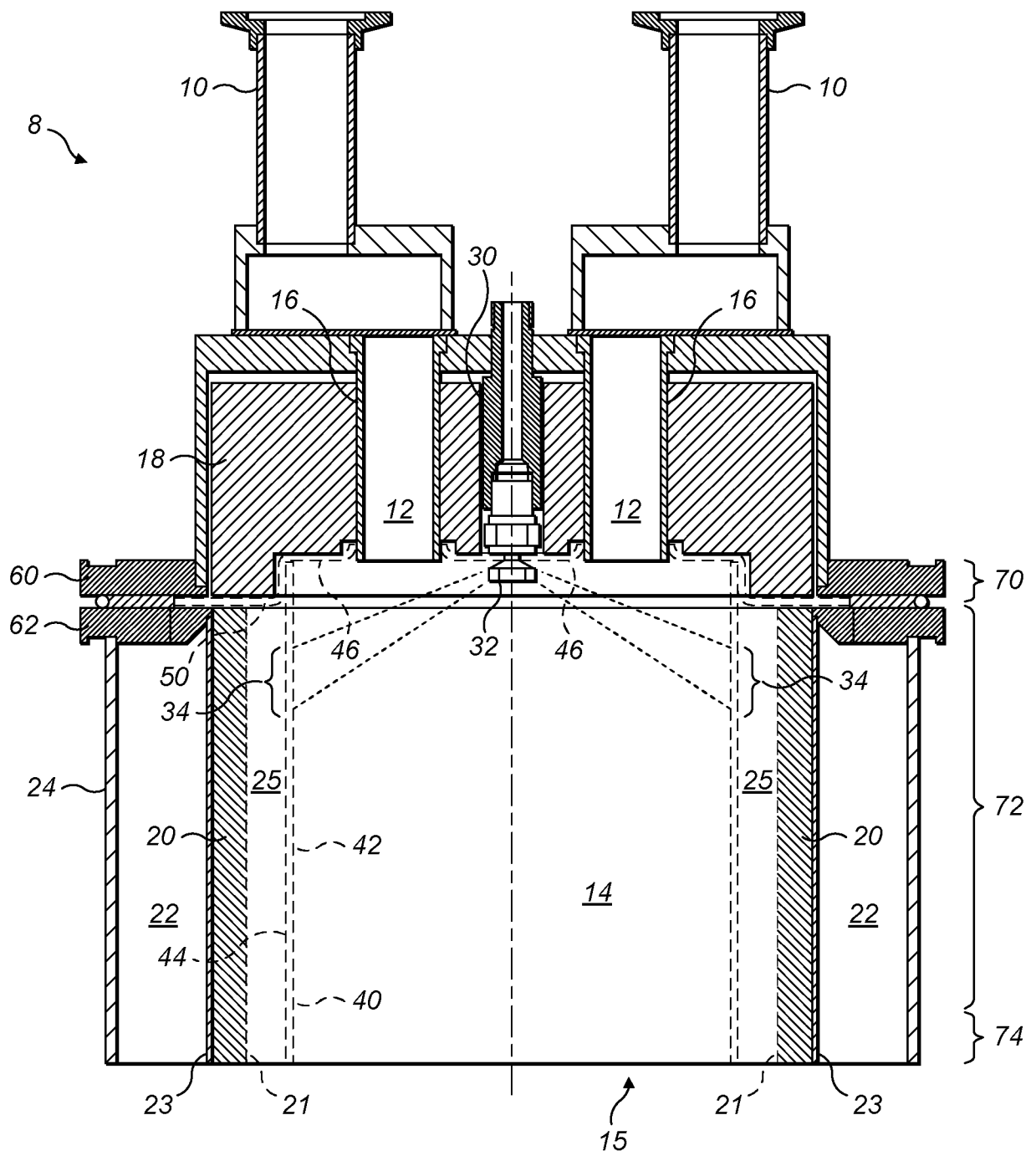


FIG. 1

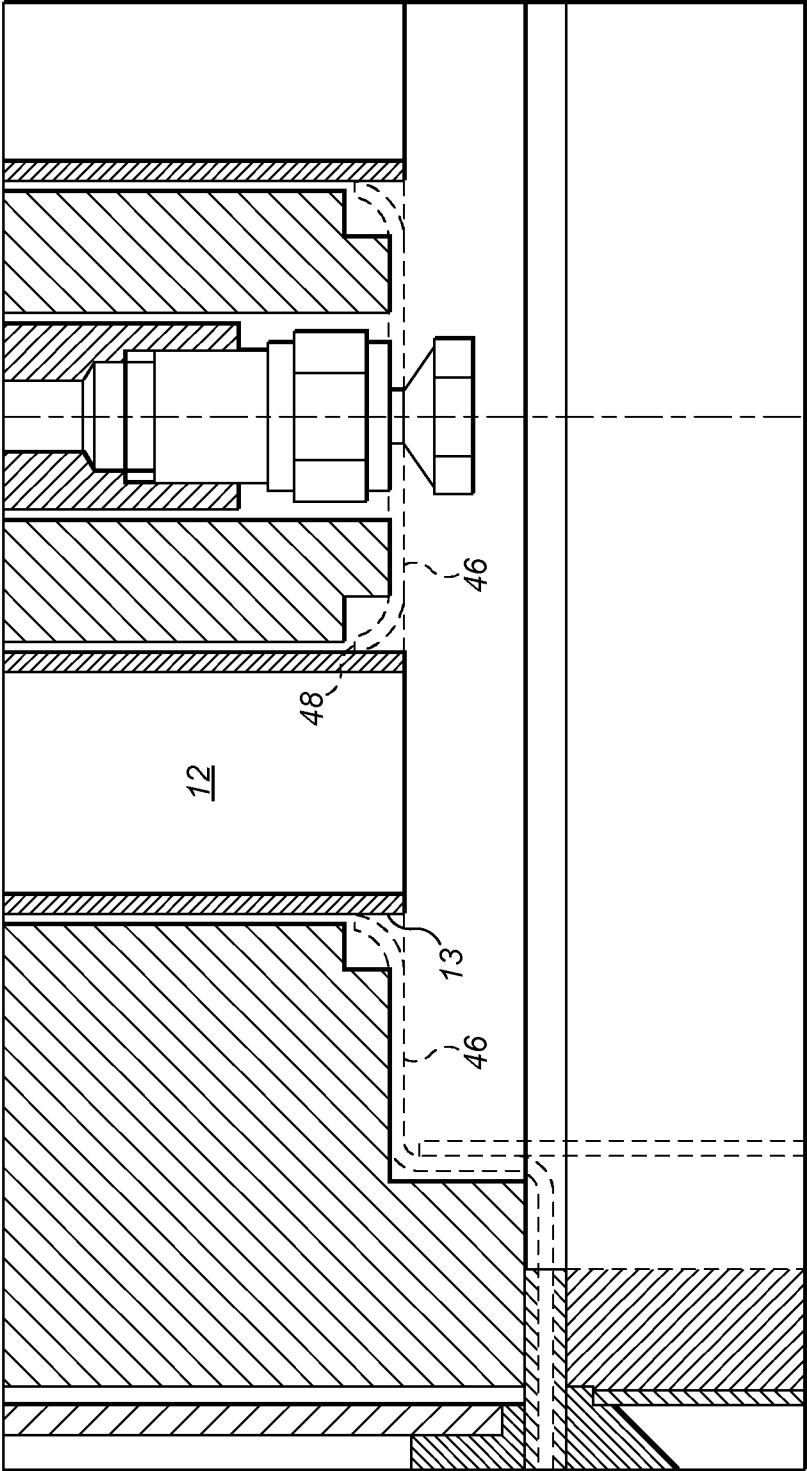


FIG. 2

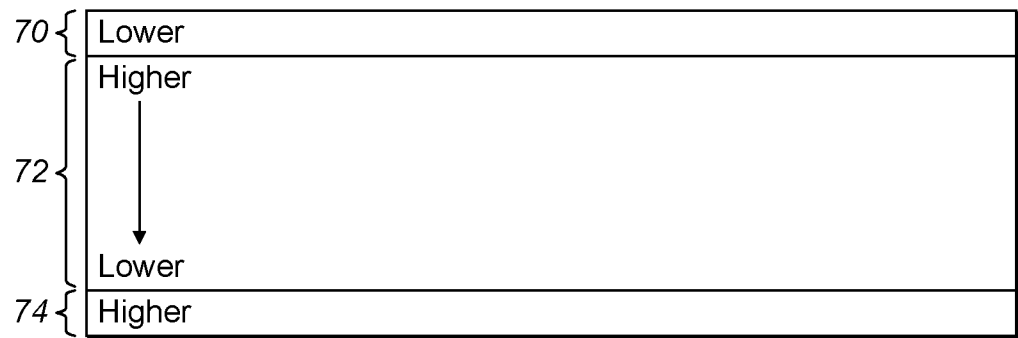


FIG. 3

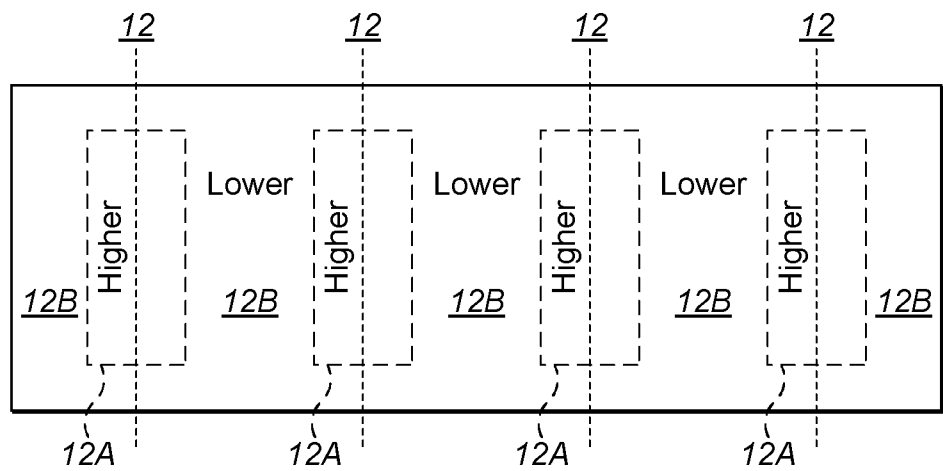


FIG. 4

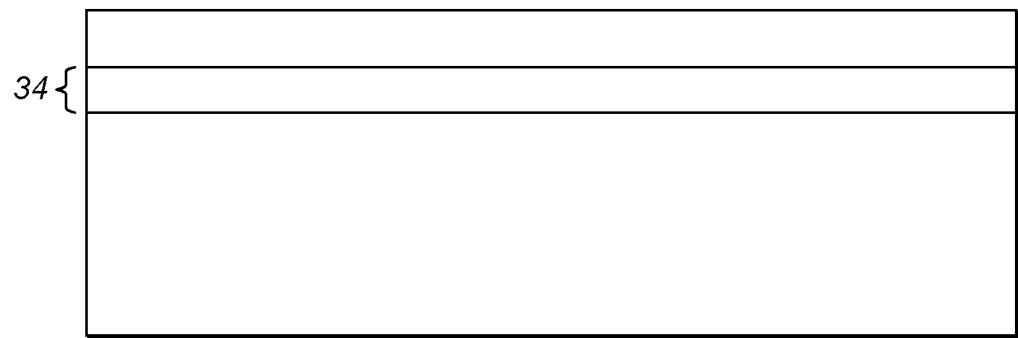


FIG. 5

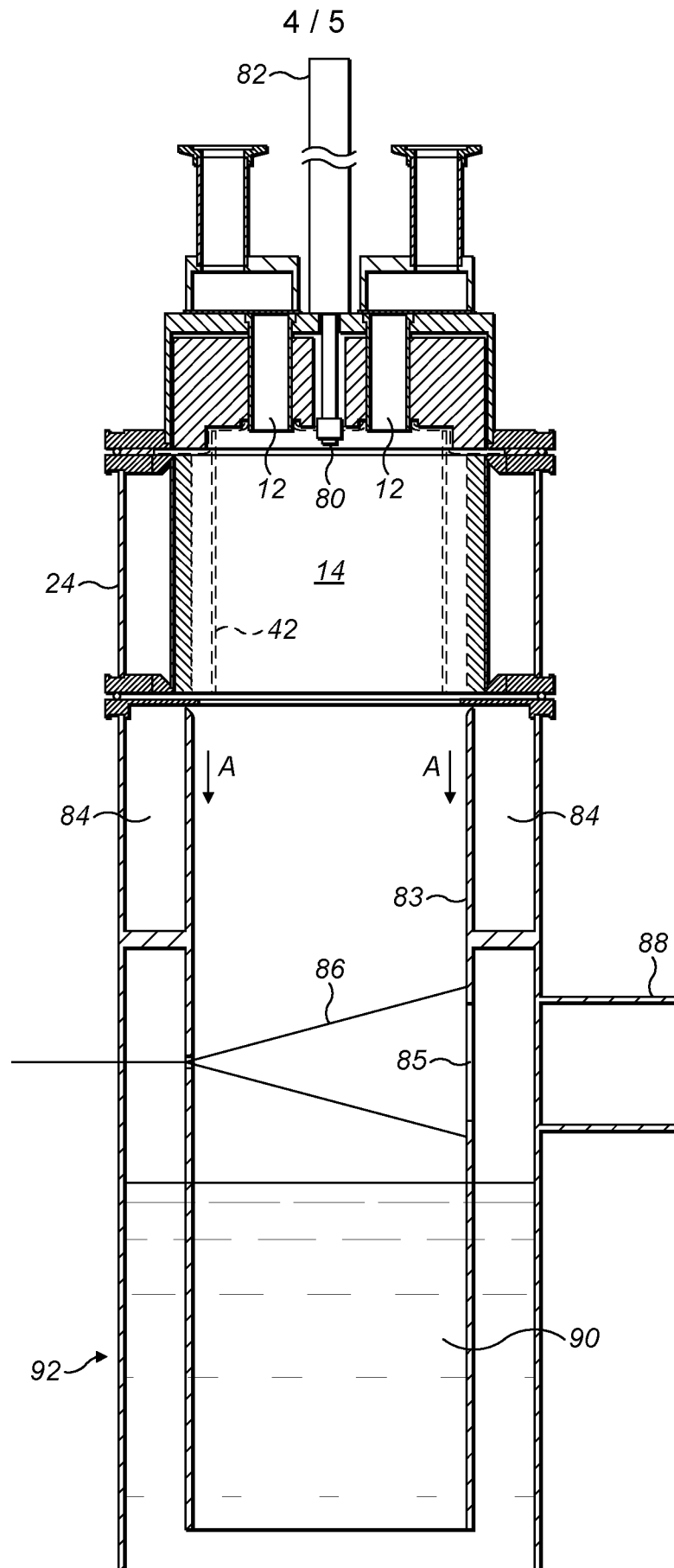


FIG. 6

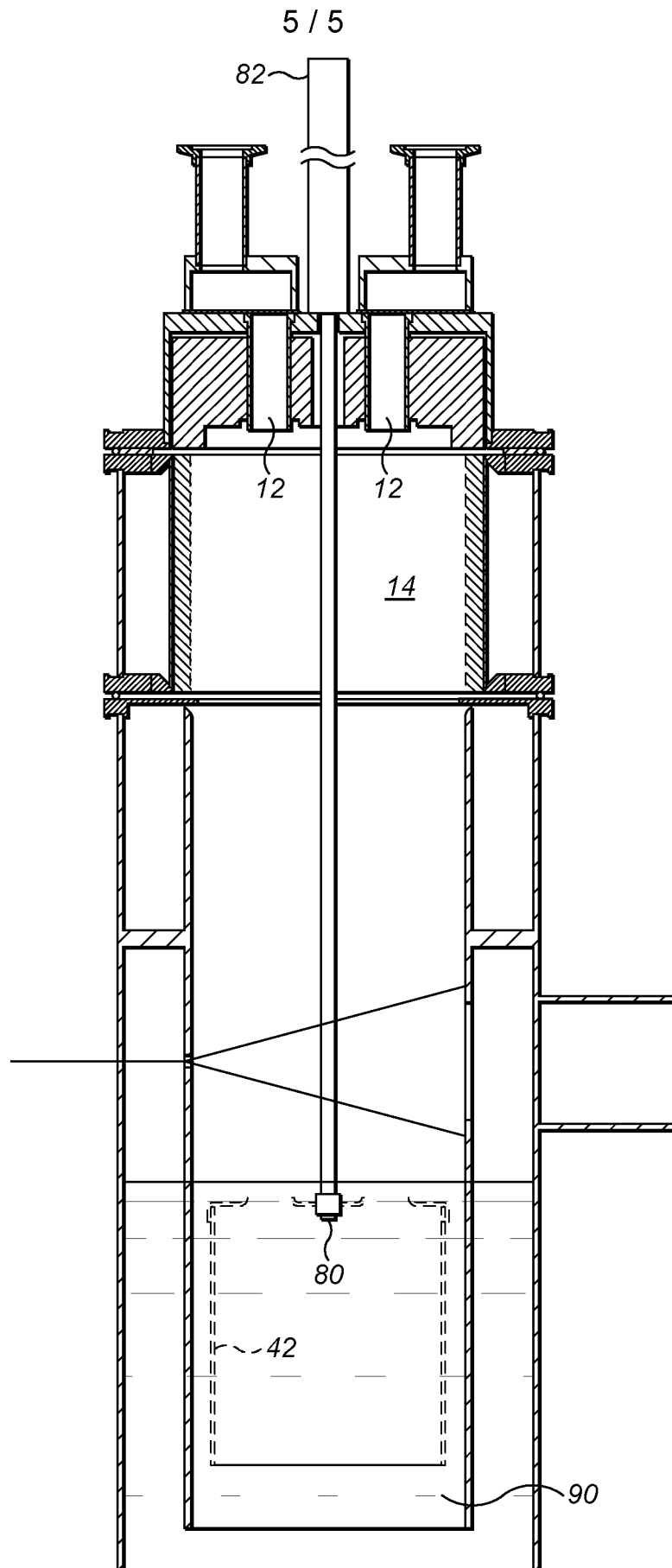


FIG. 7