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(54) **HIGH INTENSITY GAS FIRED INFRARED EMITTER AND METHOD OF OPERATING THE SAME**

HOCHINTENSIVER GASBEFEUERTER INFRAROTSTRAHLER UND BETRIEBSVERFAHREN DAFÜR

ÉMETTEUR INFRAROUGE ALIMENTÉ AU GAZ À HAUTE INTENSITÉ ET PROCÉDÉ DE SON FONCTIONNEMENT

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(73) Proprietor: **Solaronics**

**59280 Armentières (FR)**

(72) Inventors:

- **VANDEGRIFT, Chris, E.**  
**Milford**  
**OH 45150 (US)**
- **CORNELIUS, Mitchell, D.**  
**Cuyahoga Falls**  
**OH 44221 (US)**
- **MEYER, Jens-Uwe**  
**Titusville**  
**FL 32796 (US)**

• **O'NEAL, Timothy, M.**

**Streetsboro**  
**OH 44241 (US)**

(74) Representative: **Cabinet Beau de Loménie**

**Immeuble Eurocentre**  
**179 Boulevard de Turin**  
**59777 Lille (FR)**

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**EP 3 426 980 B1**

## Description

### Cross-Reference to Related Applications

[0001] This patent claims the benefit of U.S. Provisional Patent Application Serial No. 62/306,214, filed on March 10, 2016 and entitled "High Intensity Gas Fired Infrared Emitter".

### Field of the Invention

[0002] The present invention is directed generally to high intensity gas-fired infrared emitters, and more specifically, to high intensity gas-fired infrared emitters including a flame arrestor and a cellular combustion member to provide improved conversion efficiency.

### Background

[0003] Gas-fired radiant emitters are used, for example, for drying coating, controlling moisture profiles, processing industrial building equipment, curing, and other applications that require a large amount of heat to be transferred to a load in a very short amount of time. Typically, many emitters are positioned side-by-side to extend across an industrial automated machine or production line.

[0004] Unfortunately, a lot of time is required to maintain a large number of emitters positioned side-by-side. Moreover, conventional gas-fired radiant emitters produce carbon monoxide (CO) emissions at 100 ppm and nitrogen oxide (NO<sub>x</sub>) emissions at 30 ppm, both referenced to 3% O<sub>2</sub> in dry flue products, which are undesirable. It is advantageous to improve the overall conversion efficiency of gas-fired radiant emitters.

[0005] DE19718898C1 discloses a gas burner in which fuel gas is supplied to a porous combustion body (10) of a gas burner. In the area on the sides of the combustion body transverse to the direction of flow of the gas, combustion devices (19) are located, producing flames (18). Preferably the combustion devices are positioned around the whole periphery of the combustion body and both are supplied with combustion gas from a common incoming line (14).

[0006] CN104879753A discloses a monolayer multiporous foamed ceramic plate fullpremix gas fuel burner. CN100462625C discloses an infrared radiation burner for fuel gas. DE19746202A1 discloses a shutoff valve for gas pipe fire prevention. CN101556040A discloses a porous medium combustion apparatus of combustion use liquid fuel.

### Summary of the Invention

[0007] The present invention is directed generally to high intensity gas-fired infrared emitters including a flame arrestor and a cellular combustion member to provide improved conversion efficiency. The disclosed embodi-

ments of the invention provide advantages over conventional emitters by making the device less prone to instances of backfire during operation. Additionally, the disclosed embodiments minimize energy loss through components of the emitter near the external surface which transfers heat. The combination of a flame arrestor and cellular surface panel allows for a high surface area with minimal losses, resulting in improved conversion efficiency.

[0008] Generally, in one aspect according to the invention, a high intensity gas-fired infrared emitter is provided as it is set out in claim 1. The high intensity gas-fired infrared emitter includes (i) a frame having a plurality of side walls, an open bottom, and an open top; (ii) a flame arrestor mounted inside the frame and including a bottom, a top surface having a recess, and a plurality of apertures extending from the bottom to the recessed top surface; and (iii) a cellular surface panel formed of a plurality of cells and mounted inside the recess of the flame arrestor such that the plurality of apertures of the flame arrestor form pathways which extend into the cellular surface panel, wherein the plurality of cells comprises consecutively connected and layered cells, and each cell of the plurality of cells is a truncated cube or truncated hexahedron.

[0009] According to an embodiment, each of the plurality of cells of the cellular surface panel comprises a geometry to form a restricted path for products of combustion.

[0010] According to an embodiment, the cellular surface panel comprises at least two consecutively connected solid porous bodies.

[0011] According to an embodiment, at least two consecutively connected solid porous bodies have different sizes.

[0012] According to an embodiment, the emitter further includes a body mounted within the frame and a resilient element configured to retain the flame arrestor, the cellular surface panel and the body within the frame.

[0013] According to an embodiment, the body supports a deflector plate positioned dimensionally offset relative to the body.

[0014] According to an embodiment, an offset is arranged between the flame arrestor and the body mounted within the frame to increase a volume of a chamber formed therein.

[0015] According to an embodiment, the flame arrestor is made of a lightweight ceramic fiber material composed principally of aluminum oxide and silicon dioxide.

[0016] According to an embodiment, the emitter further includes a fire check assembly coupled to the body to stop gas flow to the cellular surface panel in a failure event.

[0017] According to an embodiment, the high intensity gas-fired infrared emitter also includes (iv) a fire check assembly coupled with the emitter. The assembly includes a solder joint positioned proximate a gas outlet, and a plunger rod fixed to the solder joint and in a com-

pressed state via a resilient member. The solder joint is configured to break when exposed to a flame causing the plunger rod to be displaced to close a gas inlet.

**[0018]** According to an embodiment, the resilient member is a spring urging the plunger rod towards the gas inlet.

**[0019]** According to an embodiment, the cellular surface panel is formed from silicon carbide (Si-SiC).

**[0020]** Generally, in a further aspect according to the invention, a method of operating a high intensity gas-fired infrared emitter is provided as it is set out in claim 13. The emitter includes a frame, a flame arrestor mounted inside the frame, and a cellular surface panel mounted inside the flame arrestor. The method of operating includes the steps of (i) introducing a combustible mixture into the high intensity gas-fired infrared emitter through an inlet manifold; (ii) dispersing the combustible mixture into a cavity; (iii) forcing, by a deflector plate, the combustible mixture to fill a chamber, (iv) forming a pressure tight seal within the chamber; (v) passing the combustible mixture through apertures within the flame arrestor to maintain a low air-gas temperature prior to combustion; and (vi) igniting the mixture to heat cells of the cellular surface panel.

**[0021]** According to an embodiment, the chamber is formed by at least one gasket, the flame arrestor, a cast iron body, the frame, and at least one resilient member.

**[0022]** It should be appreciated that all combinations of the foregoing concepts and additional concepts discussed in greater detail below (provided such concepts are not mutually inconsistent, and come within the subject-matter defined in the claims) are contemplated as being part of the inventive subject matter disclosed herein. In particular, all combinations of claimed subject matter appearing at the end of this disclosure are contemplated as being part of the inventive subject matter disclosed herein.

### **Brief Description of the Drawings**

**[0023]** The foregoing will be apparent from the following more particular description of example embodiments of the present invention, as illustrated in the accompanying drawings in which like reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating embodiments of the present invention.

FIG. 1 is a schematic cross-sectional view of a high intensity gas-fired infrared emitter assembly, according to an embodiment of the present invention.

FIG. 2 is a schematic perspective view of a flame arrestor, according to an embodiment of the present invention.

FIG. 3 is a schematic view of a cellular surface panel,

according to an embodiment of the present invention.

FIG. 4 is a schematic top view of a cast iron body, according to an embodiment of the present invention.

FIG. 5 is a schematic cross-sectional view of a fire check assembly, according to an embodiment of the present invention.

### **Detailed Description of Embodiments**

**[0024]** A description of example embodiments of the invention follows. Although the gas-fired infrared emitter assembly shown in the figures is shown in an upward orientation, the gas-fired infrared emitter is typically operated in the downward orientation. Thus, the description of the assembly shown in the figures is not intended to be limited to a particular orientation. The terms "top" and "bottom" as used herein describe elements of the assembly based on the upward orientation of the assembly shown in the figures. In other words, for example, the "open bottom side 4A" also represents "an open top side" when the assembly is rotated 180 degrees in use.

**[0025]** Referring to FIG. 1, a high intensity gas-fired infrared emitter assembly is shown schematically in a cross-sectional view according to an example embodiment of the present disclosure. A metallic housing is formed from a high temperature metal, such as, stainless steel. The high intensity gas-fired infrared emitter broadly includes a frame 1, a flame arrestor 9, and a cellular surface panel 10. In the embodiment shown in FIG. 1, the frame 1 comprises four vertical side walls 2, four horizontal edges 3 formed as a 90-degree continuation of each of the side walls 2, an open bottom side 4A, a substantially open top side 4B defined by the horizontal edges 3 and extensions 7, and four tabs 2A (two on each of the side walls 2) that contain slots 5. The flame arrestor 9 is mounted inside the frame 1 and includes a bottom, a top surface having a recess, and apertures 44 extending from the bottom to the recessed top surface. Cellular surface panel 10 is formed from silicon carbide (Si-SiC) and located within the confines of the flame arrestor 9.

**[0026]** To retain the cellular surface panel in place within the flame arrestor 9, extensions 7 are included either integrally or otherwise within frame 1. Extensions 7 extend from horizontal edges 3 in a direction away from side walls 2. Extensions 7 can be made of any suitable metal, for example, stainless steel. In an example embodiment, two extensions 7 are arranged on each of the longer sides of a rectangular frame 1. Additional or fewer extensions are contemplated. Any suitable sizes and shapes of extensions are contemplated. In an example embodiment, the horizontal edges 3 include indentations such that the nonindented portions retain the cellular surface panel in place within the flame arrestor 9. The slots 5 within the frame 1 are arranged to receive resilient el-

elements 6 on each side of the emitter. Resilient elements 6 can be springs or any suitable alternative.

**[0027]** In an example embodiment, metallic components are formed inside each of the four corners of the frame 1. Such metallic components can be formed from a high temperature metal, such as, stainless steel, or any suitable alternative. The metallic corner components can be sized such that at least 0.0127 m (0.5 inches) of metallic material, for example, extends in length and width directions, normal to the open horizontal face 4B. The corner components can be fixed into position mechanically via a weld or any suitable alternative along with additional compression force produced by resilient elements 6.

**[0028]** A rectangular gasket 8 is arranged inside the outer edge of frame 1 and within the boundary of the horizontal edges 3. The rectangular gasket 8 can be made from high temperature ceramic paper or any suitable alternative. Coincident to the bottom side of paper gasket 8 is a flame arrestor 9, formed of high temperature ceramic fiber insulation or any suitable alternative.

**[0029]** Referring to FIG. 2, a perspective schematic view of the flame arrestor 9 is shown according to an example embodiment of the present disclosure. The flame arrestor 9 includes four side walls 40 that fit dimensionally inside metallic frame 1. The side walls 40 can be integral or separately formed. In an example embodiment, each of the four side walls 40 is defined by a wall thickness 41 of approximately 0.0084 m (0.33 inches). Wall thickness 41 may define the shape of recess 42. Recess 42 extends vertically downward to a point approximately forty percent of the total height of side walls 40 of the flame arrestor 9. Apertures 44 are formed from the bottom 43 through the top plane of recess 42 within the remaining sixty percent of the total height of side walls 40. In an example embodiment, apertures 44 are approximately 0.0010-0.0015 m (0.04-0.06 inches) in diameter and formed by drilling. However, any suitable method of forming apertures 44 is contemplated. In an example embodiment, the apertures are arranged in a regular pattern. In an example embodiment, the apertures are arranged in an irregular pattern. The center-to-center distance between apertures 44 may be in the range of 0.0038-0.0076 m (0.15-0.3 inches), for example, and the density of the apertures 44 may be spread evenly across the plane of recess 42 to provide a total number of apertures in the range of 600-800. However, additional or fewer apertures are contemplated and the apertures need not be spread evenly across the plane of recess 42. The apertures 44 are arranged such that the apertures communicate with (i.e., form pathways which extend into) the cellular geometry of cellular surface panel 10 (shown in FIG. 1).

**[0030]** The flame arrestor 9 may be formed of a lightweight ceramic fiber material suitable for 1649°C (3000 °F) and composed principally of aluminum oxide ( $\text{Al}_2\text{O}_3$ ) and silicon dioxide ( $\text{SiO}_2$ ). In an example embodiment, the suitable material is composed of approximately 78 percent aluminum oxide ( $\text{Al}_2\text{O}_3$ ) and/or 22 percent silicon

dioxide ( $\text{SiO}_2$ ) and/or a density of 400 kg/m<sup>3</sup> (25 lb/ft<sup>3</sup>). The flame arrestor 9 also may exhibit continuous use up to 1621 °C (2950 degrees Fahrenheit) (or 1649 °C, 3000 degrees Fahrenheit), thermal conductivity of 0.180 W/mK (1.25 Btu/(hr)(ft<sup>2</sup>)(°F/in)), and 2.3 percent shrinkage at 1371 °C (2500 degrees Fahrenheit). The high temperature range, high compressive strength, and minimal shrinkage allow the material to be processed with 400-800 holes, for example, without any surface cracking ensuring long emitter life. The insulation properties of the flame arrestor 9 effectively hold an air/gas mixture temperature on the bottom side of the flame arrestor 9 (where an air/gas mixture enters the emitter) approximately 1260°C (2300 degrees Fahrenheit) lower than a main combustion zone on the opposite side. The flame arrestor 9 effectively insulates the frame 1 from the cellular surface panel 10, thus minimizing losses and increasing conversion efficiency of the emitter.

**[0031]** The cellular surface panel 10 may have a profile that substantially corresponds in shape and size to the flame arrestor recess 42 and to the top opening 4B of the frame 1. FIG. 3 shows a schematic view of the cellular surface panel 10 including an inner surface 45, side walls 46, and an external surface 47, opposite the inner surface 45. The cellular surface panel 10 may be made of Si-SiC, which provides a high thermal conductivity, emissivity, shock resistance, and lower coefficient of thermal expansion required to retain overall life of the emitter as it is subjected to extremely high thermomechanical loading. Any suitable alternative or combination of alternatives which provide(s) substantially similar characteristics is contemplated. Viewing the cellular surface panel in detail, cell 48 can be embodied as a truncated cube or truncated hexahedron having about fourteen regular faces, thirty-six edges, and twenty-four vertices. Cell 48, and all consecutively connected cells, may have diameters of differing sizes ranging from 0.0013-0.0038 m (0.05-0.15 inches), for example, extruded through each of the faces, increasing viewpoint surface area exposure through the external surface 47. The increased surface area created by the consecutively connected and layered cells (truncated cubes) provides over five times the amount of surface area than the surface area of the external surface 47.

**[0032]** Referring back to FIG. 1, a ceramic paper gasket 8A that is of similar shape and size of the ceramic paper gasket 8 is arranged coincident to the underside of the flame arrestor 9. On the bottom side of the ceramic paper gasket 8A may be rectangular gasket 11 of graphite composition, sized to correspond with the ceramic paper gasket 8A. A cast iron body 12 may be positioned to rest against the graphite gasket 11 inside the confines of the frame 1. The general convex envelope of the cast iron body 12 and the offset distance created by the ceramic paper gaskets 8 A and 11 forms chamber 13 between cast iron body 12 and the flame arrestor 9.

**[0033]** Referring to FIG. 4, a schematic top view of a cast iron body 12 is shown including pegs 49 positioned within the cast iron body 12. Pegs 49 extend vertically to

support the deflector plate 15 (shown in FIG. 1). The pegs 49 may be positioned such that the total amount on each side of axis 50 is equal. However, the number of pegs shown in FIG. 4 is only illustrative and additional or fewer pegs are contemplated. The deflector plate 15 may be formed from alloy or mild steel and can include four side walls that are offset dimensionally relative to the inside of the inner side walls 52 of the cast iron body 12. Dimensional offset 16 (shown in FIG. 1) between the deflector plate 15 and the inner side walls 52 (shown in FIG. 4) of the cast iron body 12 may be equal around all four sides. Two pegs 51 can be arranged on each side of axis 50 and can include female threads that communicate with openings in the deflector plate 15. Screws can be included to retain the deflector plate 15 in place within the cast iron body 12. Vertical support pegs 49 and a casting inlet manifold 17 (shown in FIG. 1) form a cavity 19 underneath the deflector plate 15, which communicates with the chamber 13 through the offset gap 16 around all sides of the casting body 12. Cast iron body 12 may include female threads at an inlet manifold 17 to accept a fire check assembly 18 in an example embodiment.

**[0034]** FIG. 5 illustrates a schematic cross-sectional view of a fire check assembly 18. The fire check assembly can include a short pipe nipple 53, a union 54, a pipe nipple 55, an insert 56, a frame 61, a plunger 62, and a resilient element 67. The resilient element 67 can be a spring or any suitable alternative. The short iron pipe nipple 53 communicates with the union 54, and the iron pipe nipple 55 maintains a threaded connection relationship with the union 54. The insert 56 may have an outer diameter that allows it to be press fitted into position inside the iron pipe nipple 55, flush with a bottom face 57. The insert 56 may include a bore 58, a counter-bore 59, and two slots 60 to accept both sides 61A of the frame 61. The counter-bore 59 may be dimensioned such that it accepts plunger 62 if the two surfaces have a coincident relationship. Frame 61 may be formed of mild steel strip of approximately 0.0032 m (1/8 inches) thickness and 0.0051 m (0.2 inches) width, for example. Two 90-degree bends form sides 61 A, which correspond to the inner diameter/length of the pipe run, which includes the short nipple 53, union 54, and pipe nipple 55. Cross members 64 and 66 may be positioned to support sides 61 A, which may be fixed in position by mechanical weld or any suitable alternative. Each frame cross member includes a hole drilled concentric to bore 58 to communicate/guide plunger rod 65. Plunger rod 65 is fixed in place at solder joint 63. Resilient element 67 is compressed against cross member 66. Resilient element 67 may be dimensioned such that its inner diameter corresponds with the outer diameter of plunger rod 65 (allowing ease of movement), and has a length such that sufficient compression force remains present with plunger 62 in a coincident position with counter-bore 59. The fire check assembly 18 may be dimensioned such that the top of the frame 61 may be inserted inside the inlet casting manifold 17 of the emitter with, for example, approximately 0.0084 m

(1/3 inches) clearance to the bottom side of the deflector plate 15.

**[0035]** With reference to FIGS. 1 -5, operation of the high intensity gas-fired infrared emitter is explained as follows. A pre-mixed air/gas (e.g., natural gas or propane) mixture can be introduced into fire check assembly 18 in an air-to-gas ratio of, for example, approximately 10:1 for natural gas (25:1 for propane) sufficient to, when ignited, produce flames and products of combustion. The flame arrestor 9 allows for a reduced amount of excess air compared to prior technologies as excess air is not required for cooling of the emitter. A reduction in flow path area is encountered by the air-gas mixture upon entering assembly 18, caused by insert 56 as well as frame 61 and plunger 62. The reduction in flow path area may be sufficient to limit the overall energy input to the emitter (based on its maximum operating conditions), while at the same time providing enough back pressure to allow any premix manifold to distribute the proper mixture equally to pluralities of emitters when positioned side-by-side to extend cross directionally.

**[0036]** Once the air-gas mixture exits the fire check assembly 18, the air-gas mixture is introduced into the infrared emitter through the casting inlet manifold 17 where it expands into the annular casting manifold before dispersing into the cavity 19, formed from the general convex envelope of the cast iron body 12. Once the air/gas mixture reaches the cavity 19, it encounters the deflector plate 15, which forces the air-gas mixture to fill the chamber 13 through the offset gap 16 (around all sides of the casting body 12), ensuring equal distribution and uniform emitter surface temperature profile.

**[0037]** The ceramic paper gasket 8 A, graphite gasket 11, flame arrestor 9, casting body 12, frame 1, and resilient elements 6 not only allow the formation of chamber 13, but can also create a pressure tight seal. The gasket combination 8A and 11 can create an increased offset between the flame arrestor 9 and the casting body 12, increasing the volume of chamber 13 and dwell time of the air/gas mixture, further improving distribution effectiveness. The casting body 12, frame 1, and resilient elements 6 may be configured such that when in the assembled position, resilient elements 6 exert a homogeneous compressive force on the casting body 12, which compresses gaskets 8 A and 11 and the flame arrestor 9 against the horizontal edges 3 of the frame 1. The composition of gasket 11 is such that the gasket spreads when compressed to fill any small voids that may be present between the casting body 12, frame 1, and flame arrestor 9. Additional sealing characteristics are achieved as the temperature of the graphite gasket 11 is increased beyond room temperature.

**[0038]** Once the reactants have reached the chamber 13, the mixture is forced to pass through apertures 44 in the flame arrestor 9. In an example embodiment, apertures 44 are annular nozzles. The flow path travel distance through each aperture in the flame arrestor 9 is such that there is enough material to insulate the air-gas

mixture in the chamber 13 from the combustion zone temperatures on the recess 42, maintaining a low air-gas premix temperature inside of the emitter (prior to combustion), which is vital in reducing the occurrence of backfire during normal operation of the emitter. The flame arrestor 9 also insulates the metallic vertical side walls 2 of the frame 1 from the cellular surface panel 10. This effect minimizes energy loss through parts of the emitter near the external surface 4B (the surface of the emitter that is meant to transfer heat). The material composition of the flame arrestor 9 can both ensure proper function through the insulation of the chamber 13 and minimize losses through the frame 1.

**[0039]** As the gas mixture enters the inlet of each aperture 44, the fluid velocity increases, creating well defined fluid streams that extend into the interconnected truncated cubes of the cellular surface panel 10. An external ignition source may ignite the mixture and each of the apertures 44 can form very well defined flames that reach the top of the surface 47 of the cellular surface panel (shown in FIG. 3). As the individual flames heat the portion of the cells into which they extend, the reaction also releases products of combustion that circulate within the cellular structure prior to reaching the external surface 47. The complex geometry of the cellular surface panel 10 forms a restricted path for the products of combustion, which, through transmission, transfer heat to the steady stream of reactants that continue to flow through the emitter body. The combustion methodology forces all flames to dissipate, moving the combustion zone into the lower half of the cellular surface panel 10, concurrently. The stabilization of combustion within the bottom half of the cellular surface panel permits an ongoing internal recuperation of heat and forms a homogeneous temperature field across the surface of the infrared emitter, referred to herein as "cellular combustion." Cellular combustion generates a very large temperature difference in the products of combustion when measured at the initial point of generation and at the point of exiting the external surface 47, increasing overall emitter conversion efficiency and creating a peak energy wavelength that extends well into the short wavelength spectrum. The peak energy wavelength ranges between 780 nm to 1 mm. The combination of the disclosed flame arrestor and cellular surface panel provides a high surface area with minimal losses, resulting in a very high conversion efficiency. Further, nitrogen oxide (NOx) emissions are less than 15 ppm at ten percent excess air at nominal firing rates and carbon monoxide (CO) emissions are typically at less than 100 ppm at ten percent excess air at nominal firing rates. Moreover, in installations using multiple emitters, significantly fewer emitters are required due to the emitters' efficiency, thus decreasing the time required for routine maintenance.

**[0040]** In an event that the emitter is operated outside the specified operating range and/or in an event or string of events that leads to failure (e.g., backfire into the chamber 13), solder joint 63 of the frame 61 and the plunger

rod 65 are positioned to cause quick failure of the joint 63. Failure of the joint 63 releases the compression force caused by resilient element 67 resting in a compressed position against cross member 66. Movement of resilient element 67 from a compressed state to an uncompressed state releases the compression force, moving plunger 62 into a coincident position with counter-bore 59. The length of resilient element 67 is such that the opposite side of resilient element 67 remains in contact with cross member 66 causing enough of a compression force on plunger 62 to shut off the air/gas flow into the emitter.

**[0041]** While this invention has been particularly shown and described with references to example embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention encompassed by the appended claims. In an example not according to the invention, the cells 48 of the cellular surface panel 10 can be formed of any particular solid porous body geometry. The cellular surface panel 10 can be formed of any number of consecutively connected solid porous body geometries, can have any number of layers, and can be held in place using additional structural support extending from horizontal edges 3 of the frame 1. The flame arrestor 9 can have a recess 42 of any depth and wall thickness to accommodate the dimensional boundaries that define the cellular surface panel 10, can have any number of apertures, not necessarily round, in any pattern, and the apertures may contain larger recessed holes for increased retention aperture surface area.

**[0042]** While several embodiments have been described and illustrated herein, those of ordinary skill in the art will readily envision a variety of other means and/or structures for performing the function and/or obtaining the results and/or one or more of the advantages described herein. More generally, those skilled in the art will readily appreciate that all parameters, dimensions, materials, and configurations described herein are meant to be exemplary and that the actual parameters, dimensions, materials, and/or configurations will depend upon the specific application or applications for which the teachings is/are used. Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific embodiments described herein. It is, therefore, to be understood that the foregoing embodiments are presented by way of example only and that, within the scope of the appended claims, embodiments may be practiced otherwise than as specifically described. Embodiments of the present disclosure are directed to each individual feature, system, article, material, and/or method described herein. In addition, any combination of two or more such features, systems, articles, materials, and/or methods, if such features, systems, articles, materials, and/or methods are not mutually inconsistent, is included within the scope of the present disclosure.

## Claims

1. A high intensity gas-fired infrared emitter, comprising:
 

(4B); a frame (1) having a plurality of side walls (2), an open bottom (4A), and an open top a flame arrestor (9) mounted inside the frame (1) and including a bottom, a top surface having a recess, and a plurality of apertures (44) extending from the bottom to the recessed top surface; and a cellular surface panel (10) formed of a plurality of cells and mounted inside the recess of the flame arrestor (9) such that the plurality of apertures (44) of the flame arrestor (9) form pathways which extend into the cellular surface panel (10), wherein the plurality of cells comprise consecutively connected cells, **characterized in that** said plurality of cells comprise consecutively connected and layered cells, and **in that** each cell of the plurality of cells is a truncated cube or truncated hexahedron.
2. The high intensity gas-fired infrared emitter of claim 1, wherein each of the plurality of cells of the cellular surface panel (10) comprises a geometry to form a restricted path for products of combustion.
3. The high intensity gas-fired infrared emitter of claim 1, wherein the cellular surface panel (10) comprises at least two consecutively connected solid porous bodies.
4. The high intensity gas-fired infrared emitter of claim 3, wherein the at least two consecutively connected solid porous bodies have different sizes.
5. The high intensity gas-fired infrared emitter of claim 1, further comprising a body (12) mounted within the frame (1) and a resilient element configured to retain the flame arrestor (9), the cellular surface panel (10) and the body (12) within the frame.
6. The high intensity gas-fired infrared emitter of claim 5, wherein the body (12) supports a deflector plate (15) positioned dimensionally offset relative to the body (12).
7. The high intensity gas-fired infrared emitter of claim 5, wherein an offset is arranged between the flame arrestor (9) and the body (12) mounted within the frame (1) to increase a volume of a chamber formed therein.
8. The high intensity gas-fired infrared emitter of claim 1, wherein the flame arrestor (9) is made of a light-weight ceramic fiber material composed principally of aluminum oxide and silicon dioxide.
9. The high intensity gas-fired infrared emitter of claim 1, further comprising a fire check assembly (18) coupled to the body (12) to stop gas flow to the cellular surface panel (10) in a failure event.
10. The high intensity gas-fired infrared emitter of claim 1, also comprising:
 

a fire check assembly coupled with the emitter, the assembly further comprising:

a solder joint positioned proximate a gas outlet; and  
a plunger rod fixed to the solder joint and in a compressed state via a resilient member;

wherein the solder joint is configured to break when exposed to a flame causing the plunger rod to be displaced to close a gas inlet.
11. The high intensity gas-fired infrared emitter of claim 10, wherein the resilient member is a spring urging the plunger rod towards the gas inlet.
12. The high intensity gas-fired infrared emitter of claim 10, wherein the cellular surface panel is formed from silicon carbide (Si-SiC).
13. A method of operating a high intensity gas-fired infrared emitter, the emitter comprising a frame (1), a flame arrestor (9) mounted inside the frame (1), and a cellular surface panel (10) mounted inside the flame arrestor (9), the cellular surface panel (10) comprising a plurality of cells that are consecutively connected and layered where each cell of the plurality of cells is a truncated cube or truncated hexahedron,, the method comprising the steps of:
 

introducing a combustible mixture into the high intensity gas-fired infrared emitter through an inlet manifold (17);  
dispersing the combustible mixture into a cavity (19);  
forcing, by a deflector plate (15), the combustible mixture to fill a chamber (13);  
forming a pressure tight seal within the chamber (13);  
passing the combustible mixture through apertures (44) within the flame arrestor (9) to maintain a low air-gas temperature prior to combustion; and  
igniting the mixture to heat cells of the cellular surface panel (10).
14. The method of claim 13, wherein the chamber (13) is formed by at least one gasket, the flame arrestor

(9), a cast iron body (12), the frame (1), and at least one resilient member.

## Patentansprüche

1. Gasbefeuerter Hochintensitäts-Infrarotstrahler, umfassend:

einen Rahmen (1) mit mehreren Seitenwänden (2), einem offenen Boden (4A) und einer offenen Oberseite (4B),  
eine Flammendurchschlagsicherung (9), die im Inneren des Rahmens (1) montiert ist und einen Boden, eine obere Oberfläche mit einer Aussparung und mehrere Öffnungen (44) beinhaltet, die sich von dem Boden zu der ausgesparten oberen Oberfläche erstrecken, und  
eine Zellenoberflächenplatte (10), die aus mehreren Zellen gebildet und im Inneren der Aussparung der Flammendurchschlagsicherung (9) derart montiert ist, dass die mehreren Öffnungen (44) der Flammendurchschlagsicherung (9) Wege bilden, die sich in die Zellenoberflächenplatte (10) erstrecken, wobei die mehreren Zellen fortlaufend verbundene Zellen umfassen, **dadurch gekennzeichnet, dass** die mehreren Zellen fortlaufend verbundene und geschichtete Zellen umfassen und dass jede Zelle der mehreren Zellen ein abgestumpfter Würfel oder Hexaederstumpf ist.

2. Gasbefeuerter Hochintensitäts-Infrarotstrahler nach Anspruch 1, wobei jede der mehreren Zellen der Zellenoberflächenplatte (10) eine Geometrie umfasst, um einen begrenzten Pfad für Verbrennungsprodukte zu bilden.

3. Gasbefeuerter Hochintensitäts-Infrarotstrahler nach Anspruch 1, wobei die Zellenoberflächenplatte (10) mindestens zwei fortlaufend verbundene feste, poröse Körper umfasst.

4. Gasbefeuerter Hochintensitäts-Infrarotstrahler nach Anspruch 3, wobei die mindestens zwei fortlaufend verbundenen festen, porösen Körper unterschiedliche Größen aufweisen.

5. Gasbefeuerter Hochintensitäts-Infrarotstrahler nach Anspruch 1, ferner umfassend einen Körper (12), der innerhalb des Rahmens (1) montiert ist, und ein elastisches Element, das dazu ausgestaltet ist, die Flammendurchschlagsicherung (9), die Zellenoberflächenplatte (10) und den Körper (12) innerhalb des Rahmens zu halten.

6. Gasbefeuerter Hochintensitäts-Infrarotstrahler nach Anspruch 5, wobei der Körper (12) eine Ablenplatte

(15) trägt, die im Verhältnis zu dem Körper (12) maßversetzt positioniert ist.

7. Gasbefeuerter Hochintensitäts-Infrarotstrahler nach Anspruch 5, wobei ein Versatz zwischen der Flammendurchschlagsicherung (9) und dem Körper (12), die innerhalb des Rahmens (1) montiert sind, angeordnet ist, um ein Volumen einer darin gebildeten Kammer zu erhöhen.

8. Gasbefeuerter Hochintensitäts-Infrarotstrahler nach Anspruch 1, wobei die Flammendurchschlagsicherung (9) aus einem leichten Keramikfasermaterial hergestellt ist, das hauptsächlich aus Aluminiumoxid und Siliziumoxid besteht.

9. Gasbefeuerter Hochintensitäts-Infrarotstrahler nach Anspruch 1, ferner umfassend eine brandhemmende Anordnung (18), die mit dem Körper (12) gekoppelt ist, um eine Gasströmung zu der Zellenoberflächenplatte (10) bei einem Ausfallereignis aufzuhalten.

10. Gasbefeuerter Hochintensitäts-Infrarotstrahler nach Anspruch 1, ferner umfassend:

eine brandhemmende Anordnung, die mit dem Strahler gekoppelt ist, wobei die Anordnung ferner umfasst:

eine Lötverbindung, die in der Nähe eines Gasauslasses positioniert ist, und  
eine Kolbenstange, die an der Lötverbindung und in einem über ein elastisches Element zusammengedrückten Zustand befestigt ist,

wobei die Lötverbindung dazu ausgestaltet ist zu zerbrechen, wenn sie einer Flamme ausgesetzt wird, was bewirkt, dass die Kolbenstange so verschoben wird, dass sie einen Gaseinlass verschließt.

11. Gasbefeuerter Hochintensitäts-Infrarotstrahler nach Anspruch 10, wobei das elastische Element eine Feder ist, welche die Kolbenstange in Richtung des Gaseinlasses drückt.

12. Gasbefeuerter Hochintensitäts-Infrarotstrahler nach Anspruch 10, wobei die Zellenoberflächenplatte aus Siliziumcarbid (Si-SiC) gebildet ist.

13. Verfahren zum Betreiben eines gasbefeuerter Hochintensitäts-Infrarotstrahlers, wobei der Strahler einen Rahmen (1), eine Flammendurchschlagsicherung (9), die im Inneren des Rahmens (1) montiert ist, und eine Zellenoberflächenplatte (10), die im Inneren der Flammendurchschlagsicherung (9) mon-

tiert ist, umfasst, wobei die Zellenoberflächenplatte (10) mehrere Zellen umfasst, die fortlaufend verbunden und geschichtet sind, wobei jede Zelle der mehreren Zellen ein abgestumpfter Würfel oder Hexaederstumpf ist, wobei das Verfahren die Schritte umfasst des:

Einführens eines brennbaren Gemischs in den hochintensiven gasbefeuchten Infrarotstrahler durch einen Einlasskrümmer (17),  
Verteilens des brennbaren Gemischs in einem Hohlraum (19),  
Erzwingens, durch eine Ablenkplatte (15), dass das brennbare Gemisch eine Kammer (13) füllt, Bildens einer druckdichten Dichtung innerhalb der Kammer (13),  
Leitens des brennbaren Gemischs durch Öffnungen (44) innerhalb der Flammendurchschlagsicherung (9), um eine niedrige Luft-Gas-Temperatur vor der Verbrennung aufrechtzuerhalten, und  
Entzündens des Gemischs, um Zellen der Zellenoberflächenplatte (10) zu erhitzen.

14. Verfahren nach Anspruch 13, wobei die Kammer (13) durch mindestens eine Flachdichtung, die Flammendurchschlagsicherung (9), einen gusseisernen Körper (12), den Rahmen (1) und mindestens ein elastisches Element gebildet wird.

#### Revendications

1. Émetteur infrarouge alimenté au gaz à haute intensité comprenant :

un bâti (1) ayant une pluralité de parois latérales (2), un fond ouvert (4A) et une partie supérieure ouverte (4B) ;  
un pare-flammes (9) monté à l'intérieur du bâti (1) et comprenant un fond, une surface supérieure ayant un évidement, et une pluralité d'ouvertures (44) s'étendant du fond à la surface supérieure évidée ; et  
un panneau de surface cellulaire (10) formé avec une pluralité de cellules et monté à l'intérieur de l'évidement du pare-flammes (9) de sorte que la pluralité d'ouvertures (44) du pare-flammes (9) forme des voies de passage qui s'étendant dans le panneau de surface cellulaire (10), dans lequel la pluralité de cellules comprend consécutivement des cellules raccordées, **caractérisé en ce que** ladite pluralité de cellules comprend des cellules consécutivement raccordées et déposées en couche, et **en ce que** chaque cellule de la pluralité de cellules est un cube tronqué ou un hexaèdre tronqué.

2. Émetteur infrarouge alimenté au gaz à haute intensité selon la revendication 1, dans lequel chacune de la pluralité de cellules du panneau de surface cellulaire (10) comprend une géométrie pour former une trajectoire limitée pour les produits de combustion.

3. Émetteur infrarouge alimenté au gaz à haute intensité selon la revendication 1, dans lequel le panneau de surface cellulaire (10) comprend au moins deux corps poreux solides consécutivement raccordés.

4. Émetteur infrarouge alimenté au gaz à haute intensité selon la revendication 3, dans lequel les au moins deux corps poreux solides consécutivement raccordés ont des tailles différentes.

5. Émetteur infrarouge alimenté au gaz à haute intensité selon la revendication 1, comprenant en outre un corps (12) monté à l'intérieur du bâti (1) et un élément résilient configuré pour retenir le pare-flammes (9), le panneau de surface cellulaire (10) et le corps (12) à l'intérieur du bâti.

6. Émetteur infrarouge alimenté au gaz à haute intensité selon la revendication 5, dans lequel le corps (12) supporte une plaque de déflecteur (15) positionnée de manière dimensionnellement décalée par rapport au corps (12).

7. Émetteur infrarouge alimenté au gaz à haute intensité selon la revendication 5, dans lequel un décalage est agencé entre le pare-flammes (9) et le corps (12) monté à l'intérieur du bâti (1) pour augmenter un volume d'une chambre formée dans ce dernier.

8. Émetteur infrarouge alimenté au gaz à haute intensité selon la revendication 1, dans lequel le pare-flammes (9) est réalisé avec un matériau léger en fibres de céramique principalement composé d'oxyde d'aluminium et de dioxyde de silicium.

9. Émetteur infrarouge alimenté au gaz à haute intensité selon la revendication 1, comprenant en outre un ensemble coupe-feu (18) couplé au corps (12) pour arrêter l'écoulement de gaz sur le panneau de surface cellulaire (10) en cas de défaillance.

10. Émetteur infrarouge alimenté au gaz à haute intensité selon la revendication 1, comprenant également :  
un ensemble coupe-feu couplé à l'émetteur, l'ensemble comprenant en outre :

un joint à brasure tendre positionné à proximité d'une sortie de gaz ; et  
une tige de piston plongeur fixée au joint à brasure tendre et dans un état comprimé via un

élément résilient ;  
 dans lequel le joint à brasure tendre est confi-  
 guré pour se casser lorsqu'il est exposé à une  
 flamme, amenant la tige de piston plongeur à  
 être déplacée pour fermer une entrée de gaz. 5

11. Émetteur infrarouge alimenté au gaz à haute inten-  
 sité selon la revendication 10, dans lequel l'élément  
 résilient est un ressort poussant la tige de piston  
 plongeur vers l'entrée de gaz. 10

12. Émetteur infrarouge alimenté au gaz à haute inten-  
 sité selon la revendication 10, dans lequel le pan-  
 neau de surface cellulaire est formé à partir de car-  
 bure de silicium (Si-SiC). 15

13. Procédé pour actionner un émetteur infrarouge ali-  
 menté au gaz à haute intensité, l'émetteur compren-  
 ant un bâti (1), un pare-flammes (9) monté à l'inté-  
 rieur du bâti (1), et un panneau de surface cellulaire 20  
 (10) monté à l'intérieur du pare-flammes (9), le pan-  
 neau de surface cellulaire (10) comprenant une plu-  
 ralité de cellules qui sont consécutivement raccor-  
 dées et déposées en couche où chaque cellule de  
 la pluralité de cellules est un cube tronqué ou un 25  
 hexaèdre tronqué, le procédé comprenant les éta-  
 pes consistant à :

introduire un mélange combustible dans l'émet-  
 teur infrarouge alimenté au gaz à haute intensité 30  
 par un collecteur d'entrée (17) ;  
 disperser le mélange combustible dans une ca-  
 vité (19) ;  
 forcer, par une plaque de déflecteur (15), le mé-  
 lange combustible à remplir une chambre (13) ; 35  
 former un joint d'étanchéité étanche à la pres-  
 sion à l'intérieur de la chambre (13) ;  
 faire passer le mélange combustible par des  
 ouvertures (44) à l'intérieur du pare-flammes (9)  
 pour maintenir une température air-gaz basse 40  
 avant la combustion ; et  
 allumer le mélange pour faire chauffer les cel-  
 lules du panneau de surface cellulaire (10).

14. Procédé selon la revendication 13, dans lequel la 45  
 chambre (13) est formée par au moins un joint, le  
 pare-flammes (9), un corps en fonte (12), le bâti (1)  
 et au moins un élément résilient.

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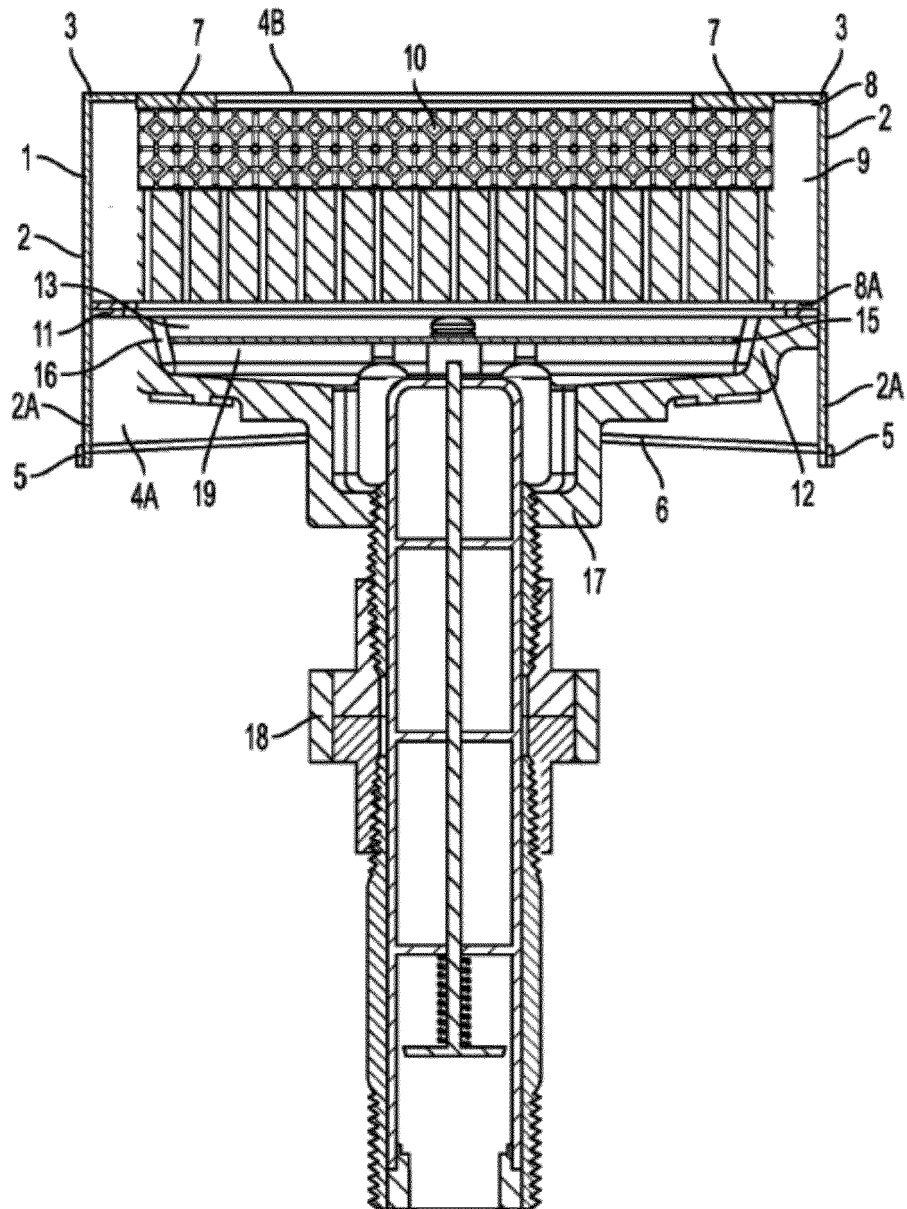


FIG. 1

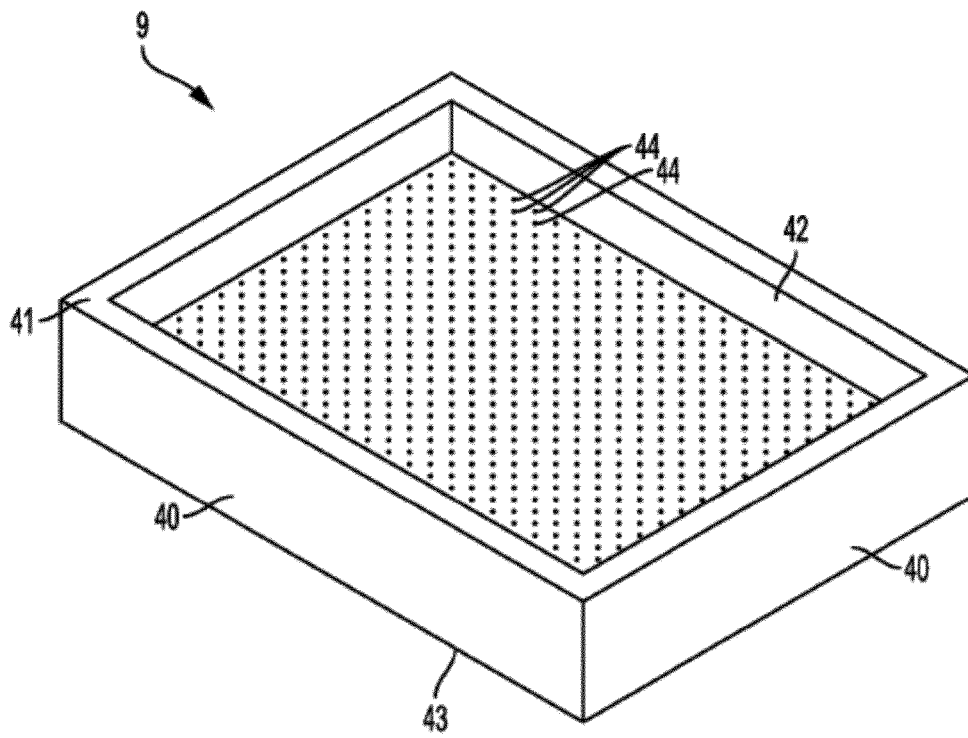


FIG. 2

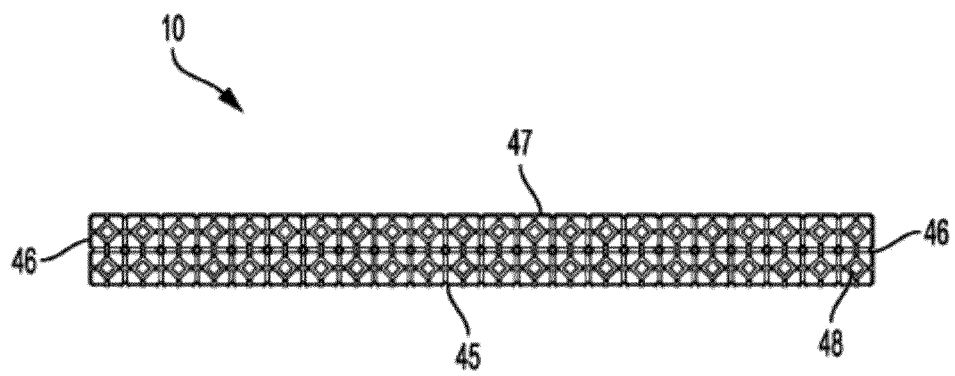


FIG. 3

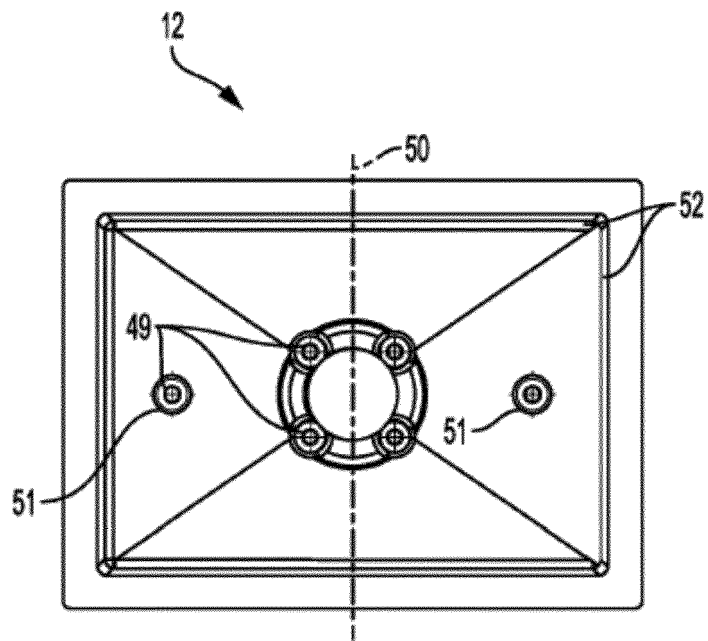


FIG. 4

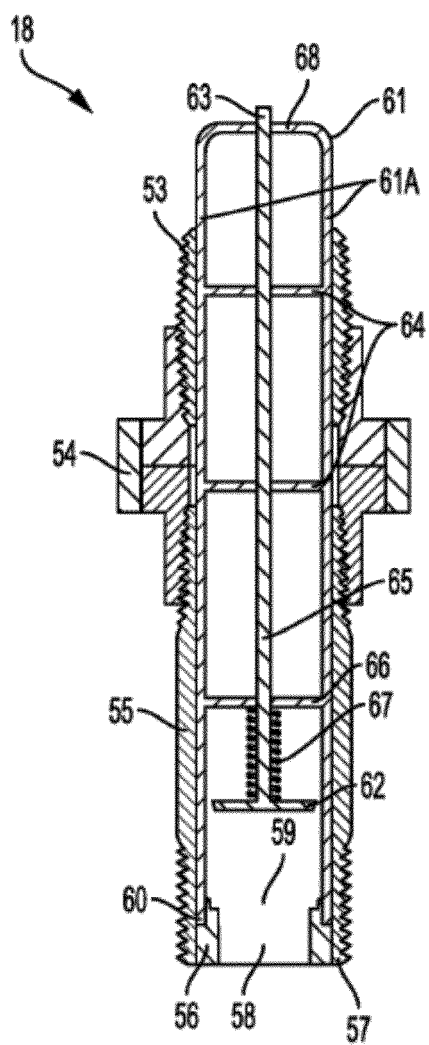


FIG. 5

**REFERENCES CITED IN THE DESCRIPTION**

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