(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 448 530 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
26.10.2022 Bulletin 2022/43

(21) Application number: **17721448.3**

(22) Date of filing: **28.04.2017**

(51) International Patent Classification (IPC):
A62C 4/00 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
A62C 4/00

(86) International application number:
PCT/GB2017/051196

(87) International publication number:
WO 2017/187188 (02.11.2017 Gazette 2017/44)

(54) FLAME ARRESTERS

FLAMMENSPERREN

PARE-FLAMMES

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **29.04.2016 GB 201607505**

(43) Date of publication of application:
06.03.2019 Bulletin 2019/10

(73) Proprietor: **Elmac Technologies Limited**
Holywell, Flintshire CH8 9DP (GB)

(72) Inventors:
- **BINGHAM, Lewis**
  Holywell
  Flintshire CH8 9DP (GB)
- **HONG, Daomin**
  Holywell
  Flintshire CH8 9DP (GB)

(74) Representative: **HGF**
HGF Limited
1 City Walk
Leeds LS11 9DX (GB)

(56) References cited:
EP-A1- 0 568 326
EP-A2- 3 081 266
WO-A1-2009/136674
CN-A- 103 104 322
GB-A- 2 017 269
GB-A- 2 342 980
GB-A- 191 410 960
US-A1- 2002 000 310
US-A1- 2012 189 966

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 3 448 530 B1

Description

[0001] This invention relates generally to flame arresters for the prevention or mitigation of flame propagation, for example in the event of an explosion. More specifically, although not exclusively, this invention relates to flame arrester devices, systems and components thereof and to methods of preventing or mitigating flame propagation.

[0002] Flame arresters are widely used in the chemical and oil industry for preventing flame transmission, normally whilst minimising flow resistance. It is usual for conduits through which flammable gases or mixtures of vapours and gases, are conveyed (or indeed conduits through which by-products or precursors of flammable gases are conveyed) and/or containers containing such species to be protected by flame arresters. Typically, flame arresters slow down the flame front or otherwise interfere with propagation so as to reduce the velocity of the flame front, dissipate or disperse the energy therein and convert a detonation, if present, into a deflagration and/or to reduce the energy in a propagating deflagration so that the combustion can be controlled, contained, attenuated and/or avoided.

[0003] Flame arresters are designed for certain predetermined operating conditions and a misuse of flame arresters can lead to unintentional or inadvertent flame transmission. Flame arresters must also be designed to function without interfering with the normal operation of the conduit within which they are incorporated. For example, they should not cause substantial impediment to gas flowing under normal operating conditions or otherwise cause a substantial drop in pressure. A substantial flow impediment may well increase operating costs and may cause problems due to over compression of the conveyed gas and/or the limit of the allowable overpressure of the conduit, vessel or equipment.

[0004] Flame arresters operate by transferring heat through a thermally conductive body and endurance burning flame arresters release the main combustion heat to the ambient air. Effective heat transfer can be achieved, for example in inline applications, by exposing the hot combustion products to a large contact surface as they pass through the flame arrester and this is achieved in some flame arresters using multiple narrow passages through which the flame is forced to pass. The size and configuration of these passages are selected to provide a balance between heat transfer and flow resistance and this balance often depends on the specific characteristics of the application. Careful consideration of all of the above (and other) factors is advisable when designing a flame arrester for any particular application.

[0005] One known safety measure for inline applications is to incorporate within a flame arrester or an enclosure or pipework system that incorporates a flame arrester a means for detecting the presence of stabilised burn on or within the flame arrester and for activating an emergency system to cut off the flow of the explosive mixture within a predetermined period after sustained, stabilised burning situation is detected. This predetermined period is set lower than the rated safe burning time of the flame arrester incorporated in the system in order to ensure that flame transmission is prevented.

[0006] However, some applications require a continuous flow of an explosive mixture through the flame arrester or the flow of the explosive mixture cannot or should not be stopped (e.g. for operating reasons), thereby preventing the use of such safety means. Such applications require flame arresters that are commonly referred to as endurance burn proof or endurance burning flame arresters. More particularly, such flame arresters must be capable of withstanding sustained, stabilised burning times, generally in excess of 2 hours, and be able to prevent flame transmission during and after endurance burning.

[0007] One flame arrester design is disclosed in EP0333924 and includes a hood that is pivotable between a closed position in which it is over the flame arrester element and an open position in which the flame arrester element is exposed. The hood is held in the closed position by a fuse link and is urged toward the open position by a spring such that the hood moves from the closed position to the open position when a flame is stabilised on the flame arrester element such that the fuse link melts or breaks. When the hood opens, the combustion heat is released to atmosphere, thereby increasing drastically the dissipation of heat. However, as the skilled person will appreciate the use of a moving part can be disadvantageous.

[0008] Another flame arrester design is described in WO2015/091747 and includes a plurality of identical annular plates and a solid end plate stacked in a spaced relationship by spacers located between each pair of plates to provide a central, axial inlet flow passage and a plurality of radial outlet flow passages. This document describes arrangements having particular configurations, sizes and dimensions that are purported to meet endurance burning requirements. However, these predetermined characteristics can limit the flow distribution and may present significant flow resistance.

[0009] CN103104322 discloses a flame arrester for a diesel engine. GB10960 discloses a safety device for preventing explosions in tanks. US2012/189966, GB2342980, EP0568326, GB2017269 and WO2009/136674 disclose various flame arresters.

[0010] It would therefore be desirable to provide a flame arrester design that is more easily configurable for the conditions in which it is required to operate, particularly in endurance burn conditions. It would also be desirable to provide an improved flame arrester, particularly one that at least mitigates one or more issues associated with known designs.

[0011] Accordingly, a first aspect of the invention provides an end-of-line flame arrester in accordance with Claim 1

[0012] The stack of spaced plates may comprise a

height dimension described by the height of the stack and/or a width dimension described by the periphery of the intermediate plates. The width dimension is preferably perpendicular to the height dimension. In embodiments, the one or more or two or more intermediate plates comprises first and second intermediate plates.

[0013] Although we do not wish to be bound by any theory, we believe that the use of a stack of spaced plates which includes intermediate plate(s) with a tapering periphery and/or with varying flow apertures provides greater flexibility in the design of the flame arrester. For example, the length and/or other dimensions of the second flow passages may be optimised for flow resistance whilst preventing flame transmission, and the size and/or configuration of the apertures in the intermediate plates may be optimised for a better flow distribution and improved heat dissipation.

[0014] For the avoidance of doubt, the term "intermediate plate" as used herein refers to any plate in the stack of spaced plates that is not the end plate. For example, where the flame arrester comprises a body with a mounting surface to which the stack of spaced plates are mounted, any plate between the end plate and the mounting surface, including the plate located closest to the mounting flange, may comprise or be referred to an "intermediate plate".

[0015] Preferably, the stack of spaced plates includes a plurality of intermediate plates, for example two, three or more intermediate plates. At least two of the intermediate plates may comprise different peripheries or may be non-coextensive and/or may comprise apertures of different sizes and/or configurations. At least two of the intermediate plates may comprise respective peripheries and/or apertures that are different, e.g. different in size. In embodiments, one of the plates, e.g. one of the intermediate plates, extends beyond the periphery of another of the intermediate plates and/or one of intermediate plates has an aperture that is larger than the aperture of another of the intermediate plates.

[0016] In embodiments, the periphery of, and/or the aperture in, the intermediate plates increases in size from the end plate, for example to provide an outer or peripheral profile, and/or inner profile, that tapers and/or forms or defines a substantially conical or frusto-conical shape, e.g. having a round, elliptical or any curved shape in cross-section, or pyramidal, e.g. having any polygonal shape in cross-section, or any other suitable shape. The periphery of, and/or the aperture in, the intermediate plates may increase by the same or a similar amount, e. g. from one to the next, for example from one to a further intermediate plate adjacent or not adjacent thereto. Alternatively, the periphery of, and/or aperture in, the intermediate plates may increase by a variable or differing amount, e.g. from one to the next, for example from one to a further intermediate plate adjacent or not adjacent thereto. In other embodiments, two or more or all of the intermediate plates may comprise respective apertures that are substantially the same size and/or are aligned.

[0017] The flame arrester may comprise a body, which may comprise a mounting surface to which the stack of spaced plates may be mounted. The body may comprise a flange or mounting portion, which may have any suitable configuration and/or which may comprise the mounting surface. The mounting surface or flange or mounting portion may be on the opposite side of the stack of spaced plates to the end plate. The flame arrester may comprise one or more spacers, for example between plates or each plate in the stack of spaced plates. The flame arrester may comprise one or more fasteners, such as one or more bolts, e.g. connecting or securing the stack of plates together or to one another. The or each bolt may extend through a spacer, e.g. through a hole in the spacer, located between the plates. The or each spacer may comprise a tubular or disc shaped element. Preferably, the flame arrester comprises a plurality of fasteners spaced, e.g. equally, about the first flow passage and/or about the periphery of the end plate.

[0018] The periphery of, and/or the aperture in, the intermediate plates may increase from the end plate toward the body or the mounting surface, flange or mounting portion thereof. Of course, it is also envisaged that the periphery of, and/or the aperture in, the intermediate plates may increase and then decrease in size, or vice versa, without departing from the scope of the invention.

[0019] The stack of spaced plates may include intermediate plates arranged in groups, for example groups of two or more, such as pairs. Each group may comprise a similar or substantially the same periphery and/or aperture shape, size or configuration. The stack of spaced plates may also include one or more, e.g. a group of, intermediate plate(s) having a similar or substantially the same periphery as the end plate. The periphery of, and/or apertures in, each plate group may increase in size from the end plate, for example to provide an outer or peripheral profile, and/or an inner profile, that tapers or forms or defines a substantially conical shape. The periphery of, and/or apertures in, the plate groups may increase by the same or a similar amount from one to the next. The periphery of, and/or apertures in, the plate groups may increase from the end plate toward the body or the mounting surface thereof. Of course, it is also envisaged that the periphery of, and/or apertures in, the plate groups may increase and then decrease in size, or vice versa, without departing from the scope of the invention.

[0020] In embodiments, the stack of spaced plates comprises a first intermediate plate having a larger periphery than the end plate. The stack of spaced plates may comprise a second intermediate plate, which may be between the first intermediate plate and the end plate. The second intermediate plate may comprise a periphery that is smaller than, larger than or similar or substantially the same as the periphery of the end plate. Preferably, the second intermediate plate comprises a periphery that is smaller than or equal to the periphery of the first intermediate plate and/or equal to or larger than the periphery of the end plate. The stack of spaced plates may com-

prise a third intermediate plate, which may be between the second intermediate plate and the end plate. The third intermediate plate may comprise a periphery that is smaller than, larger than or similar or substantially the same as the periphery of the end plate. Preferably, the third intermediate plate comprises a periphery that is smaller than or equal to the periphery of the second intermediate plate and/or equal to or larger than the periphery of the end plate. The stack of spaced plates may comprise a fourth or subsequent intermediate plate, which may be between the third, fourth or subsequent intermediate plate, if present, and the end plate. Preferably, the fourth or subsequent intermediate plate comprises a periphery that is smaller than or equal to the periphery of the third or immediately prior intermediate plate and/or equal to or larger than the periphery of the end plate.

[0021] In embodiments, the periphery of, and/or the aperture in, each of the first, second, third, fourth and subsequent intermediate plates, if present, decreases in size, for example from one to the next or from the first intermediate plate, e.g. to provide an outer or peripheral profile, and/or an inner profile, that tapers or forms or defines a substantially conical or frusto-conical shape, e.g. having a round, elliptical or any curved shape in cross-section, or pyramidal, e.g. having any polygonal shape in cross-section, or any other suitable shape. The periphery of the each plate may decrease by the same or a similar amount, e.g. from one to the next. Of course, it is also envisaged that the periphery of the intermediate plates may increase and then decrease in size, or vice versa, without departing from the scope of the invention.

[0022] In embodiments, the stack of spaced plates comprises two or more, e.g. a pair of, first intermediate plates and/or two or more, e.g. a pair of, second intermediate plates and/or two or more, e.g. a pair of, third intermediate plates and/or two or more, e.g. a pair of, fourth intermediate plates and/or two or more, e.g. a pair of, subsequent intermediate plates.

[0023] In embodiments, at least part of at least one second flow passage is not perpendicular to the first flow passage.

[0024] Thus, the flame arrester may be configured to divert the flow therethrough along a predetermined path, at least part of which is not radial. The second flow passage may be configured to provide or improve a gas cooling effect and/or be provided in two portions or segments configured to optimise different factors and/or to perform different functions. For example, a first portion of the second flow passage may be configured primarily to prevent flame transmission, while another portion may be configured to divert the flow more gradually (e.g. to reduce pressure drop) and/or to generate or promote a gas cooling effect.

[0025] The first flow passage may comprise an inlet flow passage and/or extend from an inlet. The or each second flow passage may comprise an outlet flow passage and/or extend to or terminate at an outlet. It will be appreciated that the terms inlet and outlet as used herein relate to features in use, but these features may equally be reversed, for example the first flow passage may comprise an outlet flow passage and/or extend to or terminate at an outlet or at the flame arrester connection flange and/or the or each second flow passage may comprise an inlet flow passage and/or extend from an inlet, e.g. a single inlet or respective inlets.

[0026] The first flow passage may comprise or provide or define or promote, in use, a primary direction of flow, e.g. a first or inlet flow direction. The or each second flow passage may comprise or provide or define a or a respective secondary direction of flow, e.g. a second or outlet flow direction or a respective second or outlet flow direction. Preferably, at least part of at least one second or outlet flow direction is not perpendicular to the first or inlet flow direction.

[0027] The aperture in the intermediate plate(s) and/or the first flow passage may extend from or be aligned with an inlet of the flame arrester or of the body thereof. Preferably, the flame arrester comprises a hollow body defining part of the first flow passage. More preferably, the first flow passage is defined in part by the aperture in the intermediate plate(s) and in part by a hollow body of the flame arrester. The hollow body may define a first flow passage part that is larger, smaller, similar or substantially the same size as the aperture in an adjacent intermediate plate. In embodiments, the entire first flow passage has a similar or substantially the same size, for example a substantially constant effective cross-section.

[0028] At least part of the at least one second flow passage or at least one second flow direction may be or lie or extend at an oblique or non-perpendicular angle relative to the first flow passage or first flow direction. At least one of the plates may comprise at least a portion that is non-planar and/or that is not perpendicular to the first flow passage or first flow direction. The plate or plate portion may be or lie or extend at an oblique or non-perpendicular angle relative to the first flow passage or first flow direction. The plate or plate portion may taper or form or define a substantially conical or frusto-conical shape, e.g. having a round, elliptical or any curved shape in cross-section, or pyramidal, e.g. having any polygonal shape in cross-section, or any other suitable shape.

[0029] At least a portion of each of an adjacent pair of intermediate plates may taper, e.g. to form a substantially conical or pyramidal shape, for example wherein the second flow passage portion defined between the adjacent intermediate plate pair may extend in a direction that is not perpendicular to the first flow passage. Additionally or alternatively, at least a portion of each of the end plate and an adjacent intermediate plate may taper, e.g. to form a substantially conical or pyramidal shape, for example wherein the second flow passage portion defined therebetween may extend in a direction that is not perpendicular to the first flow passage. The end plate and/or one or more of the intermediate plates may comprise a dome or hemispheroidal shape or shaped portion. The

end plate may comprise a convex or concave portion, for example a convex or concave surface portion, or may be convex or concave.

[0030] At least one of the intermediate plates preferably comprises first and second portions. At least one of the intermediate plates preferably comprises an inner portion and/or an outer or peripheral portion. In embodiments, the first portion comprises an inner portion and/or the second portion comprises an outer or peripheral portion. Additionally or alternatively, the end plate may comprise first and second portions or inner and/or outer or peripheral portions which may correspond to the first and second portions. In some embodiments, at least one of the intermediate plates comprises a third and/or intermediate portion.

[0031] In embodiments, each plate comprises a first, inner portion and a second, outer plate portion, wherein the second flow passage includes a first flow passage portion defined between the first portions of adjacent plates and a second flow passage portion defined between the second portions of adjacent plates. The second flow passage may comprise a composite flow passage including or made up of the first and second flow passage portions and/or including or made up of part-passages defined between each plate pair.

[0032] At least one of the first and second portions may be flat and/or planar and/or disc-shaped. At least one of the first and second portions may be non-planar or tapered, for example conical or frusto-conical or pyramidal. Where the first or inner portion is non-planar or tapered, it preferably extends outwardly and/or toward the end plate. Where the first or inner portion is non-planar or tapered, it is preferably configured to define a first or inner flow passage portion that extends outwardly from the first flow passage and/or toward the end plate. Where the second or outer portion is non-planar or tapered, it preferably extends outwardly and/or away from the end plate. Where the second or outer portion is non-planar or tapered, it is preferably configured to define a second or outer flow passage portion that extends outwardly from the first flow passage and/or outwardly from the first or inner flow passage portion and/or away from the end plate.

[0033] The first and second portions may be integral and/or comprise portions of the same plate. The third portion may be integral with at least one of the first and second portions and/or comprise a portion of the same plate. The first and second portions, and if present the third portion, may each comprise different, e.g. initially separate, parts. The first and second portions may be joined together or mounted or secured relative to one another, for example to the flame arrester or to the body thereof. The portions may be joined together by one or more of welding, brazing or another connection means, for example a mechanical connection means, such as one or more fasteners and/or brackets.

[0034] A second flow passage, e.g. a respective second flow passage, may be defined between each plate pair. The space between one plate pair may be different from the space between at least one other plate pair. The thickness of the one or each intermediate plate is the same or is different from at least one other intermediate plate.

[0035] The thickness of the intermediate plates and the end plate may or may not be the same or similar. For example, the thickness of a second intermediate plate may be equal to or greater than a first intermediate plate. The thickness of the end plate may be greater than the closest adjacent intermediate plate. The thickness of the intermediate plates may vary, for example increase. The intermediate plate closest to the end plate may be thicker than the next adjacent plate, which may be thicker than the following adjacent plate and so on. This may improve the capability of the flame arrester against endurance burning.

[0036] Thus, the flow distribution through the flame arrester may be optimised to maximise effectiveness whilst minimising pressure drop. However, it is generally preferable from a manufacturing perspective for the space between plate pairs to be substantially the same. The flame arrester may comprise one or more elements, e. g. support and/or heat transfer elements, between at least one plate pair and/or within at least one second flow passage. Support elements may be useful, particularly where the space between plate pairs is greater than the thickness of each plate. Heat transfer elements may be useful to enhance the ability of the flame arrester to dissipate heat in the event of a deflagration flame. In embodiments, the support elements provide heat transfer functionality.

[0037] In embodiments, the flame arrester comprises at least one wall extending between at least one plate pair and/or in a direction perpendicular or substantially perpendicular to the first flow passage, e.g. wherein a second flow passage is defined at least in part by the wall. The flame arrester may comprise two or more walls extending between at least one plate pair, e.g. wherein a second flow passage is defined between the or each wall pair. The flame arrester comprises a plurality of walls extending between one or more plate pairs, e.g. some, most or all of the plate pairs.

[0038] At least one or each wall may be perpendicular or orthogonal or substantially perpendicular or orthogonal to each plate of the plate pair. In embodiments, at least one or each wall may be at an oblique angle relative to each plate of the plate pair. The spacing between the walls may be selected so as to create narrow slots, e.g. to enhance thermal transfer.

[0039] The flame arrester may comprise a gauze, corrugated sheet or crimped ribbon, which may be located between the or at least one or each plate pair and/or within the or at least one or each second flow passage. The gauze, corrugated sheet or crimped ribbon may comprise or define one or more or a plurality of channels that may extend along the second flow passage or one of the second flow passages or part thereof. The gauze, corru-

gated sheet or crimped ribbon may be located in the second, outer plate portion. In embodiments, the gauze, corrugated sheet or crimped ribbon comprises or provides the one or more walls or channels. In embodiments, the gauze, corrugated sheet or crimped ribbon comprises or provides the or a heat transfer element. The flame arrester may comprise a plurality of such elements.

[0040] At least one wall or channel, e.g. some, most or all of the walls or channels, may extend in a non-radial direction, e.g. in a direction that extends at an angle or a non-zero angle relative to a radial direction of the flame arrester. The wall or walls or channels are preferably configured to divert the flow through the or each second flow passage, e.g. in a non-radial direction. The one or more elements may be formed by cutting and/or bending or otherwise manipulating a block or substrate, which may incorporate or define the walls, channels, gauze, corrugated sheet or crimped ribbon.

[0041] The flame arrester may comprise a honeycomb, mesh or porous element, core or pad, which may be located between the or at least one or each plate pair and/or within the or at least one or each second flow passage. The porous element may comprise a monolithic and/or perforated medium or perforated plates. The honeycomb, mesh or porous element may, e.g. together with the adjacent plates, form or define a plurality of channels or interstices that provide a convoluted or tortuous or labyrinth path. Such arrangements can be configured with increased contact surface area to enhance thermal transfer, thereby maximising heat dissipation and improving capability against endurance burning. Such arrangements may also serve to support the plates.

[0042] At least one or each intermediate plate may comprise an annular or disc shaped plate, for example with a central aperture or hole, e.g. through its thickness. The or each second flow passage may be defined by the space between each plate pair and/or by opposed portions of each plate pair and/or the spacer(s) between each plate pair.

[0043] The flame arrester may comprise one or more of a bursting disc, a pressure relief valve, a vacuum relief valve and/or one or more pressure/vacuum relief valves. The flame arrester may comprise an endurance burning flame arrester. The flame arrester is preferably capable of withstanding burning times, e.g. sustained and/or stabilised burning times, in excess of 1 hour, preferably in excess of 2 hours.

[0044] There is further provided a flame arrester block comprising a stack of spaced plates including an end plate and one or more intermediate plates, a first flow passage defined at least in part by an aperture in the, each or at least one of the intermediate plate(s) and a second flow passage defined between adjacent plates, wherein the stack includes one or more features as described above in respect of any aspect of the invention.

[0045] The end plate may be planar. Alternatively, the end plate may be non-planar or may comprise a first portion which is planar and a second portion which is non-planar (or vice *versa).* For example, the first portion may be a peripheral portion and the second portion may be an inner portion, for example a central portion. The inner or central portion may be domed or curved, pyramidal, or otherwise raised or rebated with respect to the peripheral portion. The end plate may comprise a dome or dished-end shape, or a shaped portion of a convex or concave surface.

[0046] For the avoidance of doubt, any of the features described herein apply equally to any aspect of the invention. Indeed, either of the aforementioned methods may comprise one or more features or steps relevant to a flame arrester according to any of the aspects described above.

[0047] Embodiments of the invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 is a section view of a flame arrester according to a first embodiment of the invention;

Figure 2 is a schematic section view of a stack of spaced plates of a flame arrester according to a second embodiment of the invention;

Figure 3 is a schematic section view of a stack of spaced plates of a flame arrester according to a third embodiment of the invention;

Figure 4 is a schematic section view of a stack of spaced plates of a flame arrester according to a fourth embodiment of the invention;

Figure 5 is a schematic section view of a stack of spaced plates of a flame arrester not covered by the claimed invention;

Figure 6 is a schematic section view of a stack of spaced plates of a flame arrester not covered by the claimed invention;

Figure 7 is a schematic section view of a stack of spaced plates of a flame arrester not covered by the claimed invention;

Figure 8 is a schematic view showing an optional support and heat transfer element in the form of a corrugated sheet sandwiched between adjacent plate pairs of any of the aforementioned embodiments;

Figure 9 is a schematic view of a stack of spaced plates of a flame arrester according to another embodiment of the invention

Figures 10 and 11 are schematic views showing yet another alternative embodiment of the invention in the form of a series of vertical or perpendicular plates of a flame arrester;

Figure 12 is a schematic view illustrating a support and heat transfer element or an arrangement that extends in a non-radial direction; and

Figure 13 is a schematic view illustrating flame arresters according to the invention incorporating additional safety features.

[0048] Referring now to Figure 1, there is shown a

flame arrester 1 including a hollow body 2 and a flame arrester element in the form of a stack of spaced plates 3. In this embodiment, the flame arrester 1 has a circular shape in plan, but it will be appreciated that it may have any other suitable shape.

[0049] The hollow body 2 in this embodiment includes a conical central inlet passageway 20 that tapers outwardly from a first end having an outwardly extending attachment flange 21 to a second end having an outwardly extending mounting flange 22. It is also envisaged that the inlet passageway 20 may be cylindrical or any other suitable shape. The attachment flange 21 is configured for attachment to a site of use, e.g. the end of a vent pipe of a storage tank or process vessel, which may be attached thereto by any suitable means. The mounting flange 22 includes a mounting surface 23 which is generally perpendicular to a primary direction of flow along the inlet passageway 20. The flame arrester 1 may also include one or more of a bursting disc, a pressure relief valve, a vacuum relief valve and/or one or more pressure/vacuum relief valves (none of which is shown), which may be located in and/or attached to the hollow body 2 and/or a suitable aperture (not shown) therein.

[0050] The stack of spaced plates 3 includes an end plate 30 and plural intermediate plates 31, including first to seventh intermediate plates 31a, 31b, 31c, 31d, 31e, 31f, 31g, although the number may vary depending on the application. All of the plates 30, 31 are circular in plan and each of the intermediate plates 31 includes a central aperture 32 through its thickness. Whilst the intermediate plates 31 may be formed as unitary bodies, they may also be formed from plural parts secularly connected together.

[0051] Disc shaped spacers 33 are located between each pair of plates 30, 31 and between the first intermediate plate 31a and the mounting surface 23 of the hollow body 2. The spacers 33 have a thickness selected based on the requirements of the particular application. The thickness of the spacers 33 may all be the same or may be configured to be different to provide corresponding spaces between the plates 30, 31 and the mounting surface 23.

[0052] The flame arrester 1 includes a plurality of bolts 4, which secure the stack of spaced plates 3 together and to the mounting surface 23 of the hollow body 2. Each bolt 4 extends through a hole (not shown) in a spacer 33, through holes in the plates 30, 31 and into threaded holes in the body 2, thereby securing the spacers 33 in position. The bolts 4 are evenly spaced about the inlet flow passage 20 and spaced inwardly of the periphery of the end plate 30.

[0053] The end plate 30 is solid and is located on the opposite side of the stack of spaced plates 3 to the mounting surface 23 of the hollow body 2. When secured in position the central apertures 32 in the intermediate plates 31 are aligned or substantially aligned with the inlet passageway 20 of the hollow body 2, thereby defining an inlet flow passage. In this embodiment, the central apertures 32 have substantially the same size and configuration, but it is also envisaged that they may vary in size, shape, configuration and/or number.

[0054] The stack of spaced plates 3 is arranged in groups of two, or pairs, such that the first and second intermediate plates 31a, 31b, located adjacent one another, have substantially the same periphery, as do the third and fourth intermediate plates 31c, 31d and the fifth and sixth intermediate plates 31e, 31f. In addition, the seventh intermediate plate 31g has substantially the same periphery as the end plate 30.

[0055] The peripheries of the first and second intermediate plates 31a, 31b are larger than those of the third and fourth intermediate plates 31c, 31d, which are in turn larger than the peripheries of the fifth and sixth intermediate plates 31e, 31f. Similarly, the peripheries of the fifth and sixth intermediate plates 31e, 31f are larger than the peripheries of the seventh intermediate plate 31g and the end plate 30. In this way, the outer profile of the stack of spaced plates 3 tapers outwardly from the end plate 30 toward the hollow body 2, thereby defining a substantially conical, or frusto-conical, shape. The difference in size between each adjacent plate pair 30, 31 increases in a step-wise fashion by substantially the same change in diameter. Whilst the stack of spaced plates 3 is arranged in pairs in this embodiment, this is but one suitable arrangement and other arrangements are envisaged and may be preferable in some circumstances. For example, the difference in size between each adjacent plates 30, 31 in the stack may increase in a step-wise fashion by substantially the same change in diameter. In other embodiments, the stack of spaced plates 3 need not be arranged in pairs, for example, a first intermediate plate, e.g. the intermediate plate 31a, may have different size to an adjacent intermediate plate, *e.g.* the intermediate plate 31b, and so on.

[0056] Outlet flow passages 37 are formed between each plate pair (i.e. a plate and a succeeding, adjacent plate) of the stack of spaced plates 3 and extend radially with respect to the inlet flow passage 32 and define respective outlet flow directions. The inlet flow direction and outlet flow directions are substantially perpendicular to one another in this embodiment.

[0057] The flame arrester 1 is preferably assembled prior to installation at a site of use. Assembly involves stacking the plates 30, 31 in a spaced manner by introducing a spacer 33 between each plate pair (i.e. a plate and a succeeding, adjacent plate), passing bolts 4 through holes in both the plates and spacers 33 and into the threaded holes in the mounting flange 22, thereby to secure the stack of spaced plates 3 together. The flame arrester 1 is then attached by the attachment flange 21 to a site of use.

[0058] A source of ignitable gas is conveyed from the site of use through the inlet passageway 20, through the inlet passage 32 and along the outlet flow passages 37 and passes out to the surrounds of the flame arrester 1. If exposed to a spark or an explosion the ignitable gas

surrounding the flame arrester 1 may be ignited. If the flow velocity of ignitable gas emitted from the flame arrester 1 is lower than the velocity of flame propagation (burning velocity) then the flame front will propagate back to the flame arrester 1 and may stabilise thereagainst. The flame front will then gradually pass into the flame arrester 1 through the outlet passageways. The plates 30, 31 of the stack of spaced plates 3 conduct heat from the flame front and dissipate that heat away therefrom, the main combustion heat being released to the atmosphere or surroundings. In this way, the heat energy from the flame front is dissipated at a rate which prevents the stack of plates 3 from reaching excessive temperatures.

[0059] The space between the plates 30, 31 is selected to mitigate flame propagation and promote heat transfer, but it is also important that the outlet passageways 37 do not overly restrict the flow of ignitable gas therethrough under normal operating conditions. By providing outlet passageways 37 of differing lengths, the operation of the flame arrester 1 can be optimised. Longer outlet passageways 37 provide increased surface area which results in increased heat conduction away from the flame front and subsequent dissipation of heat energy, enabling heat to dissipate quickly and slowing any temperature rise of the stack of plates 3. Shorter outlet passageways 37 provide for less restricted passage of venting gases therethrough, and hence more optima! normal operation. We have surprisingly found that a stack of spaced plates 3 configured as described above facilitates optimisation of the design to provide a better flow during normal operation of the flame arrester 1, whilst also providing enhanced flame arresting capabilities in the event of an external deflagration or explosion. Without wishing to be bound by any theory, it is believed that the frusto-conical shape to the outer profile of the stack of spaced plates 3 increases the heat dissipative area thereof, hence improving its resistance to flame front propagation.

[0060] Moreover, by providing outlet passageways 37 of different lengths it is possible to optimise outlet passageways 37 to reduce the resistance to flow and improve the capability against endurance burning via enhanced heat dissipation.

[0061] Turning now to Figure 2, there is shown a stack of spaced plates 103 of a flame arrester part 101 according to a second embodiment of the invention, wherein integers similar or identical to those of the first embodiment are identified by a preceding '1'. In this embodiment, the central apertures 132 of each plate pair 131a and 131b, 131c and 131d, 131e and 131f, 131g and 130 varies in size. The central apertures 132 through the first and second intermediate plates 131a, 131b are larger than those through the third and fourth intermediate plates 131c, 131d, which in turn are larger than those through the fifth and sixth intermediate plates 131e, 131f. The central apertures 132 through the fifth and sixth intermediate plates 131e, 131f are substantially the same as the central aperture 132 through the seventh intermediate plate 131g. Accordingly, the inner profile of the stack of spaced plates 103 also tapers outwardly from the end plate 130 towards the hollow body 2, thereby defining a conical, or frusto-conical, shape.

[0062] In this embodiment, the size of the apertures 132 increases in a step-wise fashion by substantially the same change in diameter. In addition, the step-wise increase in diameter of the apertures 132 is substantially the same as the step-wise increase in diameter of the peripheries such that the radial width of all of the intermediate plates 131, apart from the seventh intermediate plate 131g, is substantially the same. However, this step-wise variation may be different to enable further control of the characteristics of the outlet passageways 137. The outlet passages 137 comprise channels between each plate pair (such as 131a and 131b) and between adjacent plates of different plate pairs. The inner profile and/or outer profiles or the periphery of the stack of spaced plates 103 may be configured independently, for example to reduce the flow resistance and/or improve the performance.

[0063] In other embodiments, spaced stake 103 need not be arranged in pairs, for example, the size of the intermediate plate 131d may be between the intermediate plates 131c and 131e.

[0064] Referring now to Figure 3, there is shown a stack of spaced plates 203 of a flame arrester part 201 according to a third embodiment of the invention similar to the first and second embodiments, wherein similar integers are identified by similar reference numbers with a preceding '2'. In this embodiment, the intermediate plates 231 are tapered or frusto-conical, i.e. they are non-perpendicular to the inlet flow passage 232. The end plate 230 includes a first, inner portion 234 which is perpendicular to the inlet flow passage and a second, peripheral portion 235 that extends at an oblique angle relative to the first portion 234 and substantially parallel to the intermediate plates 231. The periphery of each adjacent intermediate plate 231 also increases in size from the end plate 230 toward the hollow body (not shown).

[0065] In this embodiment, it will be appreciated that the outlet flow passages 237 formed between each plate pair of the stack of spaced plates 203 extend at an oblique angle relative to the inlet flow passage 232. We have surprisingly found that providing a stack of spaced plates 203 arranged in this way results in enhanced resistance to flame propagation thereinto.

[0066] Without wishing to be bound by any theory it is believed that providing an outlet flow direction which extends obliquely with respect to the inlet flow direction produces flow of ignitable gas therefrom that more readily entrains air at ambient (relatively low) temperatures into its flow and therefore improves the flame arrester performance. In addition, under normal operating conditions the stack of spaced plates 203 enhances draining and thus mitigates freezing at sub-zero temperatures.

[0067] Referring now to Figure 4 there is shown a stack of spaced plates 303 of a flame arrester part 301 according to a fourth embodiment of the invention which is sim-

ilar to the third embodiment, wherein similar integers are identified by a preceding '3'. This embodiment differs from the flame arrester part 201 according to the third embodiment in that each of the intermediate plates 331 includes a first, inner portion 331a having the same periphery as the inner portion 334 of the end plate 330. The apertures 332 in each intermediate plate 331 also have the approximately the same shape and size. The flame arrester part 301 also includes a further intermediate plate 331b at the opposite end to the end plate 330. The further intermediate plate 331b is coextensive with the inner portion 331a of the other intermediate plates 331 and blocks the flow passage by seals (not shown) between the further intermediate plate 331b and an adjacent one of the other intermediate plates 331. The inner and outer portions of each plate 330, 331 are formed integrally, although it is also envisaged that they may be initially separate parts joined together (e.g. via welding, brazing or some mechanical means). In other embodiments, the inner and outer portions of each intermediate plate (331) may be separate parts.

[0068] Accordingly, each outlet flow passage 337a, 337b includes a first, inner portion 337a and second, outer portion 337b formed between each plate pair of the stack of spaced plates 303. The first outlet flow passage portion 337a of the outlet flow passage is configured to distribute the flow and/or prevent flame transmission, whilst the second outlet flow passage portion 337b of the outlet flow passage is configured to distribute the flow and prevent flame transmission.

[0069] Figure 5 illustrates a stack of spaced plates 403 of a flame arrester part 401 similar to the fourth embodiment, wherein similar integers are identified by a preceding '4'. Figure 5 is not covered by the claimed invention. The stack of spaced plates 403 in this embodiment differs from the stack of spaced plates 303 of the fourth embodiment in that the intermediate plates 431 (except the first intermediate plate 431b) of this embodiment all have peripheries that are coextensive to that of the end plate 430. In other embodiments, the intermediate plates 431a and 431b may not be provided.

[0070] Figure 6 illustrates a stack of spaced plates 503 of a flame arrester part 501 similar to Figure 5, wherein similar integers are identified by a preceding '5'. Figure 6 is not covered by the claimed invention. In this embodiment, the inner portions 531a of the intermediate plates 531 taper at an angle between the primary flow direction through the inlet flow passage 532 and that of the second, outer outlet flow passage portions 537b.

[0071] Figure 7 illustrates a stack of spaced plates 603 of a flame arrester part 601 similar to Figure 6, wherein similar integers are identified by a preceding '6'. Figure 7 is not covered by the claimed invention. In this embodiment, the end plate 630 is similar to the end plates 30, 130 according to the first and second embodiments and the outer portions of each of the intermediate plates 631 is perpendicular or substantially perpendicular to the primary flow direction of the inlet flow passage 632 and generally parallel to the end plate 630.

[0072] It is envisaged that the inner and outer portions of the intermediate plates 331, 431, 531, 631 in the embodiments shown in Figures 4 to 7 need not be completely connected and may even be separated with a gap therebetween.

[0073] Referring now to Figure 8, there is shown a support and heat transfer element 750 in the form of a crimped or corrugated sheet 751 sandwiched between adjacent plate pairs 730, 731 (e.g. between adjacent intermediate plates 731 and/or between an end plate 730 and an intermediate plate 731) of a stack of spaced plates 703. In embodiments, one or more corrugated sheets 751 may be provided in addition to the plates 730, 731 of the stack of spaced plates 703. Alternatively, one or more corrugated sheets 751 may be provided instead of one or more of the intermediate plates 731. The corrugated sheet 751 is located within one or more outlet flow passage(s) of the stack of spaced plates 703, thereby providing a plurality of channels extending outwardly along the outlet flow passage thus filled. In other embodiments, the intermediate plates 731 may be a kind of shim/ribbon, sheet, or foil when the crimped or corrugated sheet 751 is present.

[0074] Advantageously, the corrugated sheet 751 provides support between the plates 730, 731 whilst also acting as a heat transfer element with increased surface area, therefore providing improved heat dissipation. Moreover, the pathway is more tortuous through an outlet flow passageway including a corrugated sheet 751 and therefore the resistance of the stack of spaced plates 703 to flame propagation is enhanced. Furthermore, the distance between the plates 730, 731 is more readily controlled via location therebetween of a corrugated sheet 751, where control of the distance between plates 730, 731 may be an issue, particularly for plates 730, 731 of relatively large size.

[0075] It will be appreciated that the support and/or heat transfer elements may be arranged in a non-radial orientation with respect to the inlet flow passage.

[0076] It is also envisaged that an insert formed of a honeycomb core or mesh pad or a porous medium, for example a monolithic perforated medium or perforated plates, may be provided as an alternative support and heat transfer element.

[0077] Figure 9 illustrates a stack of spaced plates 803 of a flame arrester part 801 according to a further embodiment of the invention similar to the second embodiment, wherein similar integers are identified by a preceding '8'. This embodiment differs in that the outer periphery of each of the intermediate plates 831a, 831b, 831c, 831d, 831e, 831f, 831g, 831h, 831i, 831j, 831k, 8311 is coextensive to that of the end plate 830.

[0078] In other embodiments, the intermediate plates 831 may be partly in pairs or need not be in pair at all. The intermediate plates 831 may be of different sizes for each intermediate plate.

[0079] Referring now to Figures 10 and 11 there is

shown a stack of spaced plates 903 of a flame arrester part 901 according to a ninth embodiment of the invention, wherein integers similar or identical to those of the first embodiment are identified by a preceding '9'. In this embodiment, the stack of spaced plates 903 includes vertical intermediate plates 931. The vertical intermediate plates 931 are generally perpendicular with respect to the end plate 930 and generally parallel with the inlet passageway 932. The vertical channels 937 defined between adjacent plates 931 form outwardly extending outlet flow passages 937. The spaces between the vertical intermediate plates 931 may comprise quenching channels, for example, equivalent to the spaces between the intermediate plates in earlier embodiments.

[0080] It is believed that this particular orientation and geometry are helpful to the design of flame arresters, in particular to endurance burning flame arresters. In embodiments, the vertical plates 951 may be configured to extend radially between the plates (e.g. where the plates are circular or arranged in the form of a circle), defining radially extending outlet flow passages therebetween. It is believed that this particular orientation and geometry are helpful to the design of flame arrester, in particular to endurance burning flame arresters. The vertical intermediate plates 931 may extend at a predetermined angle to make ambient air more readily entrained.

[0081] Figure 12 illustrates another possible configuration in which one or more vertical walls 1050 are provided that extend in a non-radial direction from the centre of the plates 1031. In this arrangement, a flow of an ignitable gas (designated by arrow A) through a flame arrester is directed outwardly in a non-radial direction thereabout, producing ignitable gas flow into which surrounding ambient air is more readily entrained. This entrainment of surrounding ambient (relatively colder) air into the thus expelled flow of ignitable gas results in a cooling of the flame, thereby improving heat dissipation and preventing the flame arrester element heating up. In this way a flame arrester according to the invention may be produced in which dynamic equilibrium may be reached between heat supplied by a flame front and heat dissipation and cold air entrainment. A steady state temperature profile may thus be generated in the flame arrester element such that the flame front will not propagate therethrough.

[0082] It will be appreciated that any of the above described supports and/or heat transfer elements may be arranged in a non-radial orientation with respect to the inlet flow passage.

[0083] Figure 13 illustrates three configurations of flame arrester 1a, 1b, 1c each of which incorporates a respective safety feature 5a, 5b, 5c. The first flame arrester 1a incorporates a pressure or vacuum valve 5a. The second flame arrester 1b incorporates a pressure/vacuum relief valve 5b. The third flame arrester 1c incorporates a bursting disc 5c. Other arrangements are envisaged and would be apparent to the skilled person.

[0084] It will be appreciated by those skilled in the art that variations to the aforementioned embodiments are envisaged without departing from the scope of the invention. For example, the variation between plate peripheries in the first embodiment and/or between aperture sizes in the second embodiment need not be in a step-wise fashion, the amount of increase may vary and/or the plates 30, 31 need not be grouped or may in groups of more than two and/or of varying numbers. Moreover, the number of plates, for example the number of intermediate plates may be selected for the particular use of the flame arrester.

[0085] Although the outer mounting surface is shown as being generally perpendicular to the inlet flow passage this need not be the case and the mounting surface may be oriented at any suitable orientation relative to the inlet flow passage and/or may not include a generally planar surface. Additionally or alternatively, although only one inlet flow passage is shown this need not be the case and instead there may be multiple inlet flow passages, for example two or more inlet flow passages, which may be located adjacent or separate to one another and/or may extend in the same or similar or different (e.g. diverging or converging) directions relative to one another. Additionally or alternatively, although the embodiments of the stack of spaced plates shown in Figures 1 and 2 are shown in pairs this need not be the case and instead the stack of spaced plates may be arranged in any suitable manner, for example arranged with plates in groups of three, four or more, or with plates in individual arrangement (e.g. such that each adjacent plate may have a different periphery). Additionally or alternatively, securement means other than bolts may be used to secure the stack of spaced plates together and/or to the mounting surface of the hollow body, for example clips or rivets or welding may be used.

Claims

1. A flame arrester (1) comprising a stack of spaced plates (3) including an end plate (30) and a plurality of intermediate plates (31), a first flow passage defined at least in part by an aperture in each intermediate plate (31) and a second flow passage (37) defined between adjacent plates, wherein at least a portion of the periphery of the intermediate plates (31) or their apertures tapers to provide second flow passageways (37) between adjacent plates of different lengths.

2. A flame arrester (1) according to Claim 1, wherein the stack of spaced plates (3) comprises a height dimension described by the height of the stack and a width dimension described by the periphery of the intermediate plates (31), wherein the width dimension tapers along the height dimension.

3. A flame arrester (1) according to Claim 1 or Claim 2, wherein the periphery of the intermediate plates

(31) increases in size from the end plate (30) to provide an outer profile that tapers to form a substantially conical or pyramidal shape.

4. A flame arrester (1) according to any preceding Claim, wherein the apertures in the intermediate plates (31) increase in size from the end plate (30) to provide an inner profile that tapers to form a substantially conical or pyramidal shape.

5. A flame arrester (1) according to any preceding Claim, wherein the intermediate plates (31) are arranged in groups, each group comprising a similar or substantially the same periphery and/or aperture size.

6. A flame arrester (1) according to any preceding Claim, wherein at least a portion of one or more of the intermediate plates (31) tapers to form a substantially conical or pyramidal shape.

7. A flame arrester (1) according to Claim 6, wherein the or each tapered plate portion comprises an outer portion thereof, the inner portion being flat or planar.

8. A flame arrester (1) according to Claim 6, wherein the or each tapered plate portion comprises an inner portion thereof, the outer portion being flat or planar.

9. A flame arrester (1) according to Claim 7 or Claim 8, wherein the inner and outer plate portions comprise integral portions of the same plate.

10. A flame arrester (1) according to any preceding Claim, wherein the end plate (30) comprises a solid plate and the or each intermediate plate (31) comprises an annular plate with a central aperture through its thickness.

11. A flame arrester (1) according to any preceding Claim comprising a body (2) with a mounting surface (23) to which the stack of spaced plates (3) is mounted, one or more spacers (33) between each plate in the stack and one or more fasteners (4) connecting the stack of spaced plates (3) together.

12. A flame arrester according to Claim 11, wherein the body (2) is hollow and the first flow passage is defined in part by the aperture in the or each intermediate plate (31) and in part by a hollow body (2) of the flame arrester.

Patentansprüche

1. Flammensperre (1), die einen Stapel beabstandeter Platten (3) einschließlich einer Endplatte (30) und einer Vielzahl von Zwischenplatten (31) umfasst, wobei ein erster Strömungskanal mindestens teilweise durch eine Öffnung in jeder Zwischenplatte (31) definiert ist und ein zweiter Strömungskanal (37) zwischen benachbarten Platten definiert ist, wobei sich mindestens ein Abschnitt des Umfangs der Zwischenplatten (31) oder ihrer Öffnungen verjüngt, um zweite Strömungsdurchlässe (37) zwischen benachbarten Platten mit unterschiedlichen Längen bereitzustellen.

2. Flammensperre (1) nach Anspruch 1, wobei der Stapel beabstandeter Platten (3) eine durch die Höhe des Stapels beschriebene Höhenabmessung und eine durch den Umfang der Zwischenplatten (31) beschriebene Breitenabmessung umfasst, wobei sich die Breitenabmessung entlang der Höhenabmessung verjüngt.

3. Flammensperre (1) nach Anspruch 1 oder Anspruch 2, wobei der Umfang der Zwischenplatten (31) von der Endplatte (30) an größenmäßig zunimmt, um ein Außenprofil bereitzustellen, das sich verjüngt, um eine im Wesentlichen konische oder pyramidale Form auszubilden.

4. Flammensperre (1) nach einem vorhergehenden Anspruch, wobei die Öffnungen in den Zwischenplatten (31) von der Endplatte (30) an größenmäßig zunehmen, um ein Innenprofil bereitzustellen, das sich verjüngt, um eine im Wesentlichen konische oder pyramidale Form auszubilden.

5. Flammensperre (1) nach einem vorhergehenden Anspruch, wobei die Zwischenplatten (31) in Gruppen angeordnet sind, wobei jede Gruppe einen ähnlichen oder im Wesentlichen den gleichen Umfang und/oder eine ähnliche oder im Wesentlichen die gleiche Öffnungsgröße umfasst.

6. Flammensperre (1) nach einem vorhergehenden Anspruch, wobei sich mindestens ein Abschnitt einer oder mehrerer der Zwischenplatten (31) verjüngt, um eine im Wesentlichen konische oder pyramidale Form auszubilden.

7. Flammensperre (1) nach Anspruch 6, wobei der oder jeder sich verjüngende Plattenabschnitt einen äußeren Abschnitt davon umfasst, wobei der innere Abschnitt flach oder planar ist.

8. Flammensperre (1) nach Anspruch 6, wobei der oder jeder sich verjüngende Plattenabschnitt einen inneren Abschnitt davon umfasst, wobei der äußere Abschnitt flach oder planar ist.

9. Flammensperre (1) nach Anspruch 7 oder Anspruch 8, wobei die inneren und äußeren Plattenabschnitte integrale Abschnitte der gleichen Platte umfassen.

10. Flammensperre (1) nach einem vorhergehenden Anspruch, wobei die Endplatte (30) eine massive Platte umfasst und die oder jede Zwischenplatte (31) eine ringförmige Platte mit einer zentralen Öffnung durch ihre Dicke umfasst.

11. Flammensperre (1) nach einem vorhergehenden Anspruch, die einen Körper (2) mit einer Montageoberfläche (23), an der der Stapel beabstandeter Platten (3) montiert ist, einen oder mehrere Abstandshalter (33) zwischen jeder Platte in dem Stapel und ein oder mehrere Befestigungsmittel (4), die den Stapel beabstandeter Platten (3) miteinander verbinden, umfasst.

12. Flammensperre nach Anspruch 11, wobei der Körper (2) hohl ist und der erste Strömungskanal teilweise durch die Öffnung in der oder jeder Zwischenplatte (31) und teilweise durch einen Hohlkörper (2) der Flammensperre definiert ist.

Revendications

1. Pare-flammes (1) comprenant un empilement de plaques espacées (3) comprenant une plaque d'extrémité (30) et une pluralité de plaques intermédiaires (31), un premier passage d'écoulement défini au moins en partie par une ouverture dans chaque plaque intermédiaire (31) et un second passage d'écoulement (37) défini entre des plaques adjacentes, dans lequel au moins une partie de la périphérie des plaques intermédiaires (31) ou de leurs ouvertures s'effile pour fournir des seconds passages d'écoulement (37) entre des plaques adjacentes de différentes longueurs.

2. Pare-flammes (1) selon la revendication 1, dans lequel l'empilement de plaques espacées (3) comprend une dimension en hauteur **caractérisée par** la hauteur de l'empilement et une dimension en largeur **caractérisée par** la périphérie des plaques intermédiaires (31), dans lequel la dimension en largeur s'effile le long de la dimension en hauteur.

3. Pare-flammes (1) selon la revendication 1 ou la revendication 2, dans lequel la périphérie des plaques intermédiaires (31) augmente en taille à partir de la plaque d'extrémité (30) pour fournir un profil externe qui s'effile pour former une forme sensiblement conique ou pyramidale.

4. Pare-flammes (1) selon l'une quelconque des revendications précédentes, dans lequel les ouvertures dans les plaques intermédiaires (31) augmentent en taille à partir de la plaque d'extrémité (30) pour fournir un profil interne qui s'effile pour former une forme sensiblement conique ou pyramidale.

5. Pare-flammes (1) selon l'une quelconque des revendications précédentes, dans lequel les plaques intermédiaires (31) sont agencées en groupes, chaque groupe comprenant une périphérie et/ou une taille d'ouverture similaires ou sensiblement identiques.

6. Pare-flammes (1) selon l'une quelconque des revendications précédentes, dans lequel au moins une partie d'une ou plusieurs des plaques intermédiaires (31) s'effile pour former une forme sensiblement conique ou pyramidale.

7. Pare-flammes (1) selon la revendication 6, dans lequel la ou chaque partie de plaque effilée comprend une partie externe de celle-ci, la partie interne étant plate ou plane.

8. Pare-flammes (1) selon la revendication 6, dans lequel la ou chaque partie de plaque effilée comprend une partie interne de celle-ci, la partie externe étant plate ou plane.

9. Pare-flammes (1) selon la revendication 7 ou la revendication 8, dans lequel les parties de plaque interne et externe comprennent des parties solidaires de la même plaque.

10. Pare-flammes (1) selon l'une quelconque des revendications précédentes, dans lequel la plaque d'extrémité (30) comprend une plaque pleine et la ou chaque plaque intermédiaire (31) comprend une plaque annulaire avec une ouverture centrale à travers son épaisseur.

11. Pare-flammes (1) selon l'une quelconque des revendications précédentes, comprenant un corps (2) avec une surface de montage (23) sur laquelle l'empilement de plaques espacées (3) est monté, une ou plusieurs entretoises (33) entre chaque plaque dans l'empilement et une ou plusieurs attaches (4) reliant ensemble l'empilement de plaques espacées (3).

12. Pare-flammes selon la revendication 11, dans lequel le corps (2) est creux et le premier passage d'écoulement est défini en partie par l'ouverture dans la ou chaque plaque intermédiaire (31) et en partie par un corps creux (2) du pare-flammes.

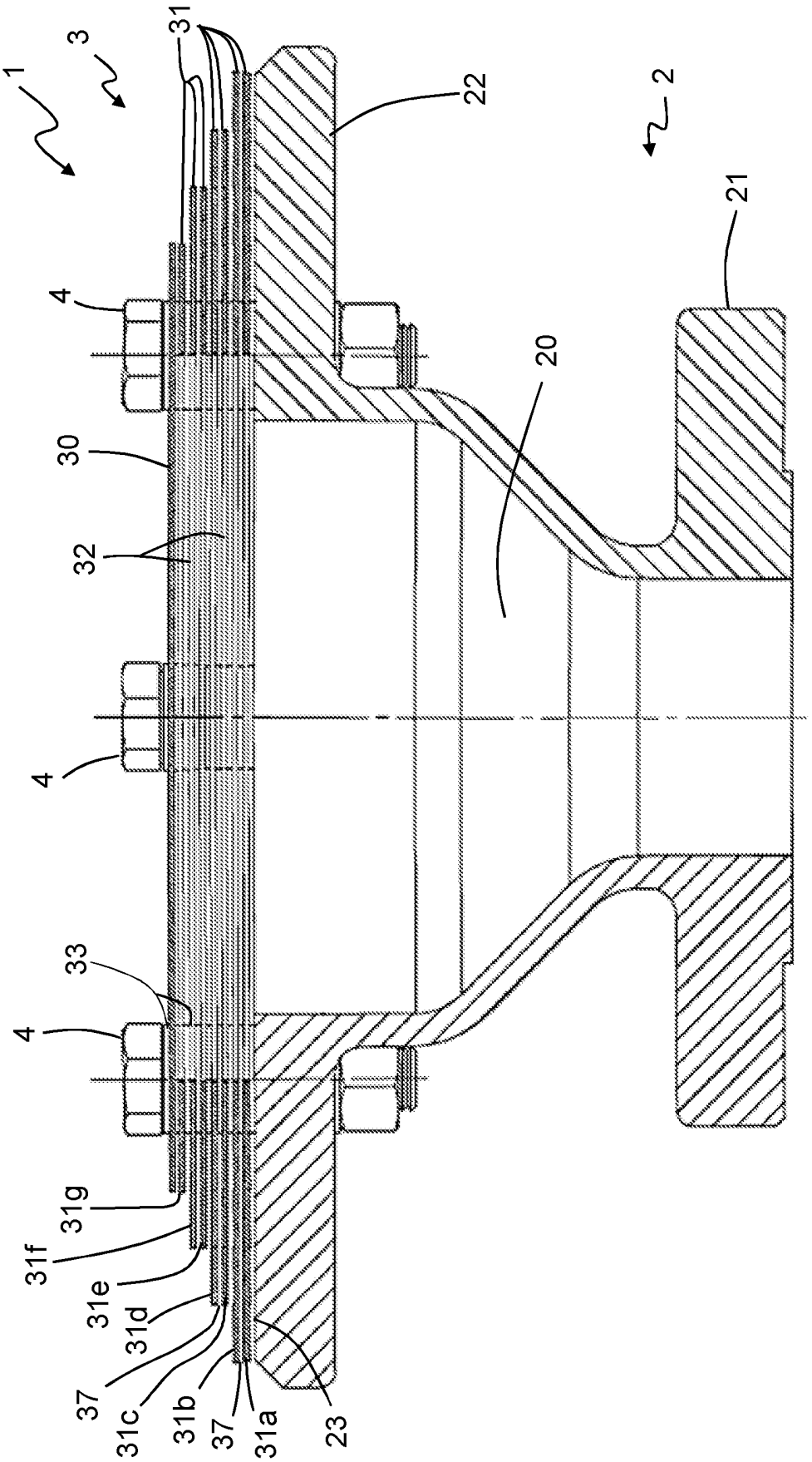


FIGURE 1

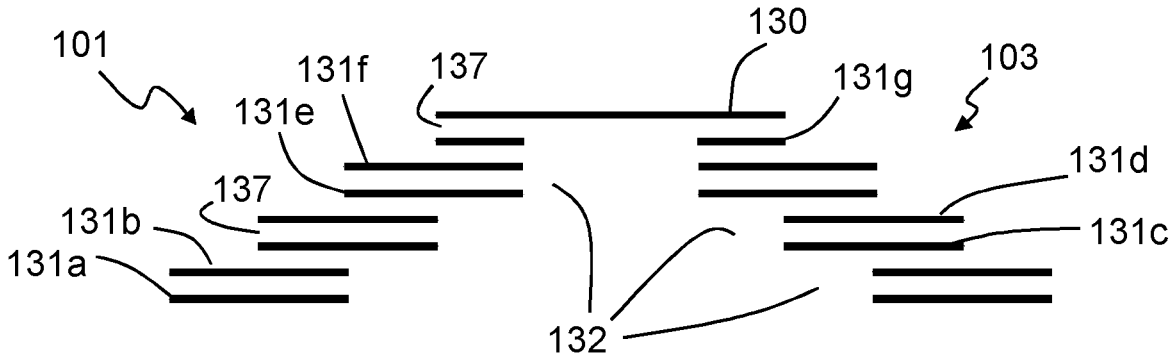


FIGURE 2

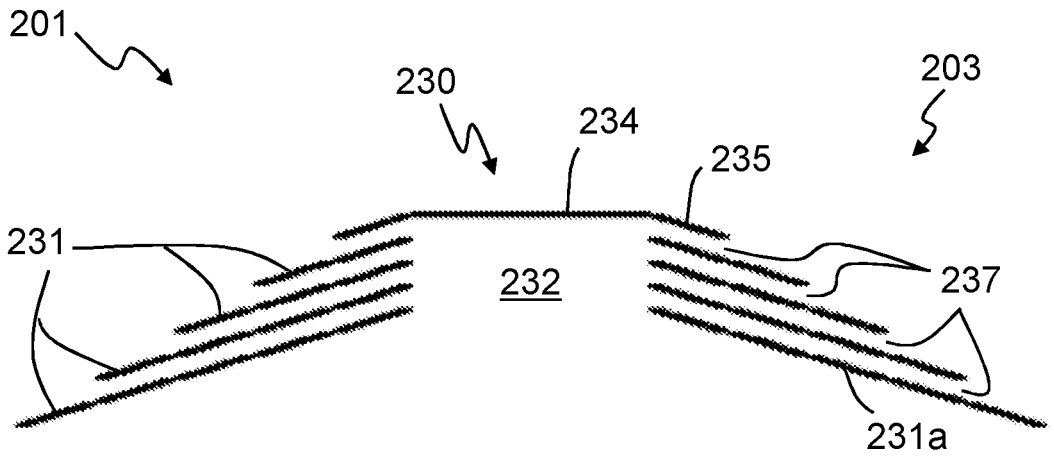


FIGURE 3

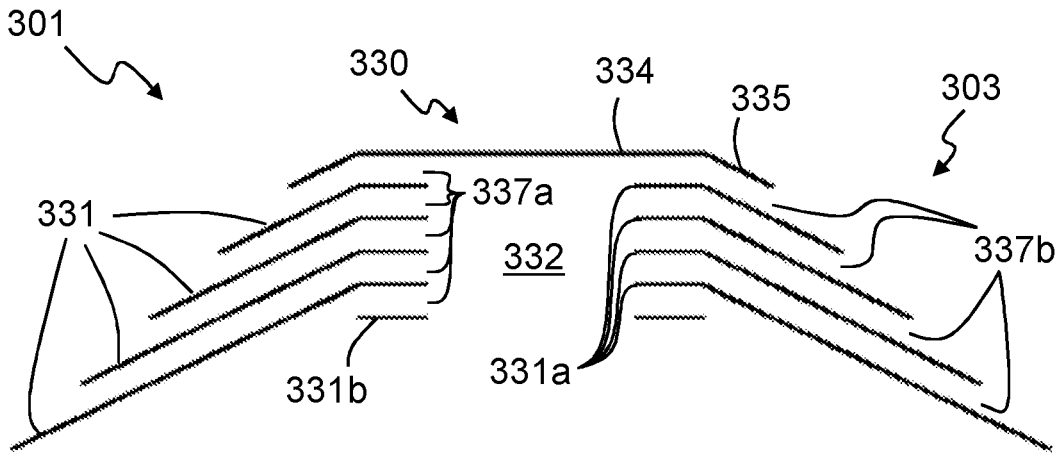


FIGURE 4

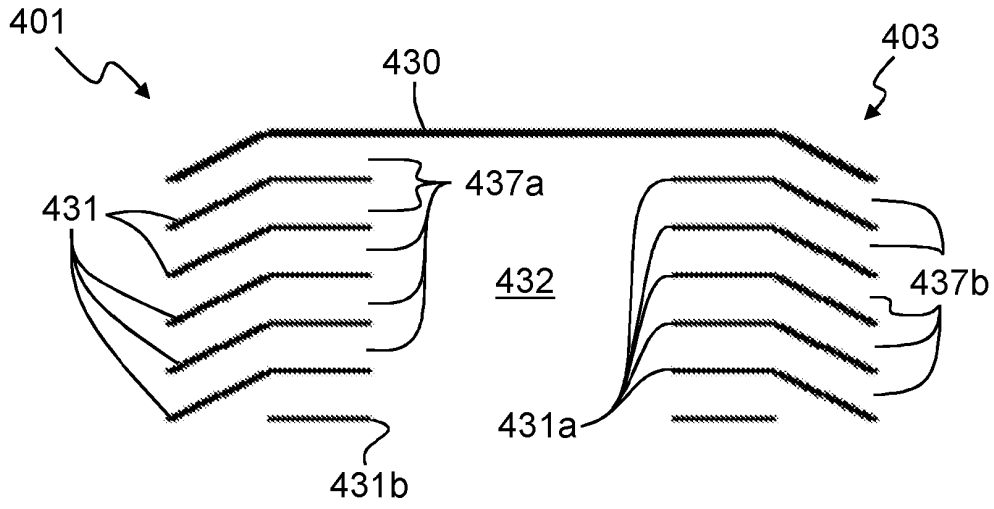


FIGURE 5

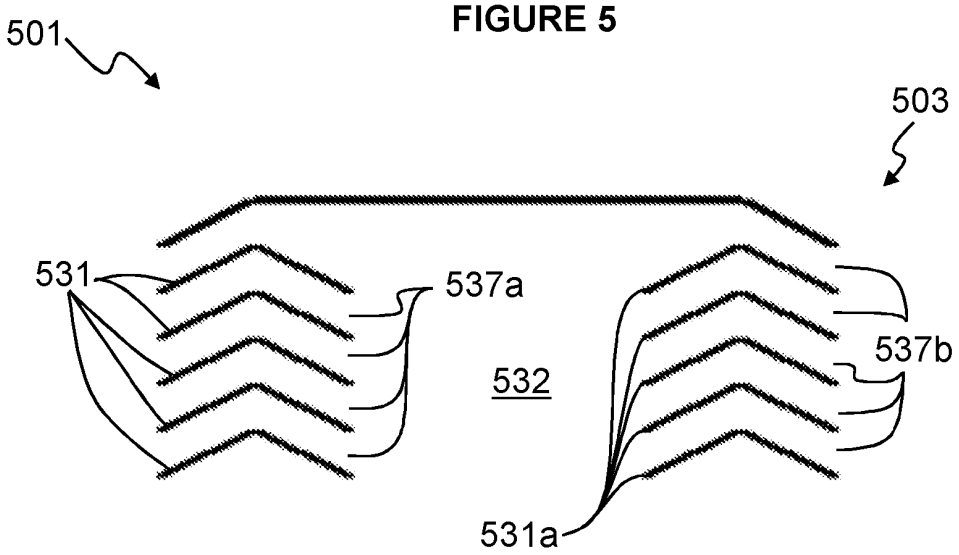


FIGURE 6

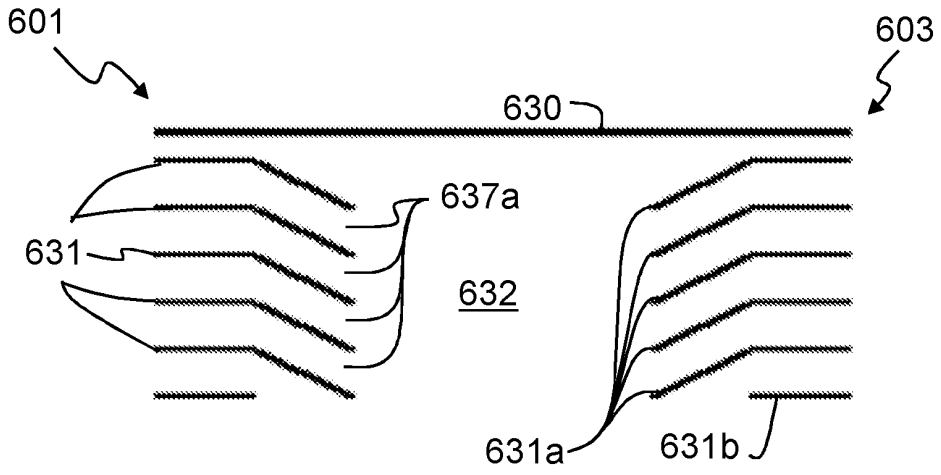


FIGURE 7

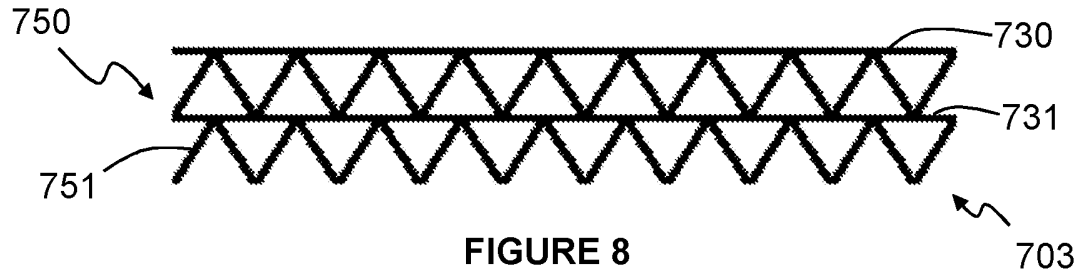


FIGURE 8

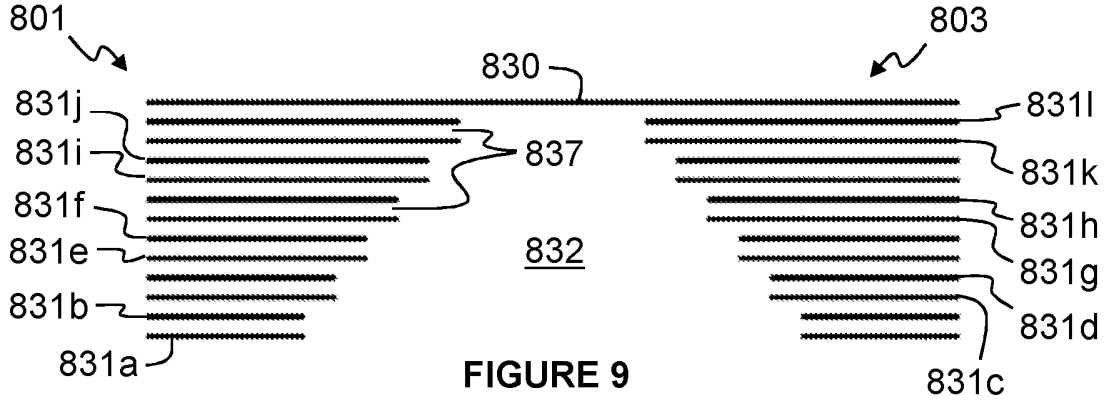


FIGURE 9

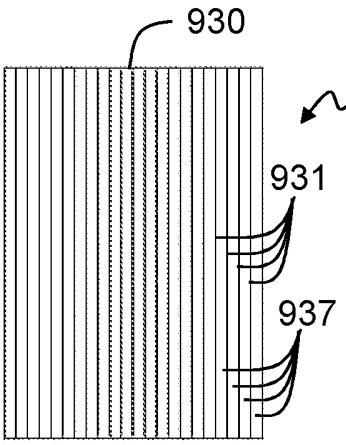


FIGURE 10

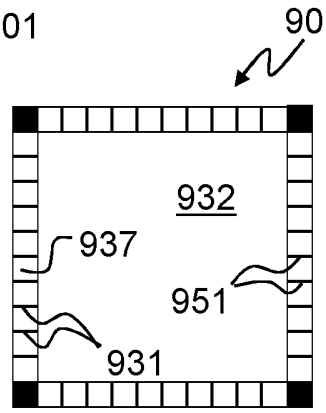


FIGURE 11

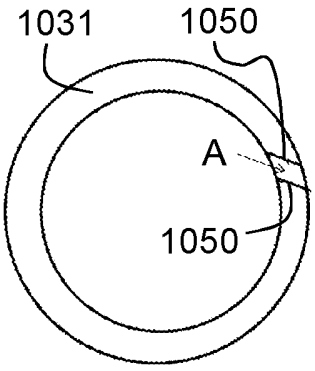


FIGURE 12

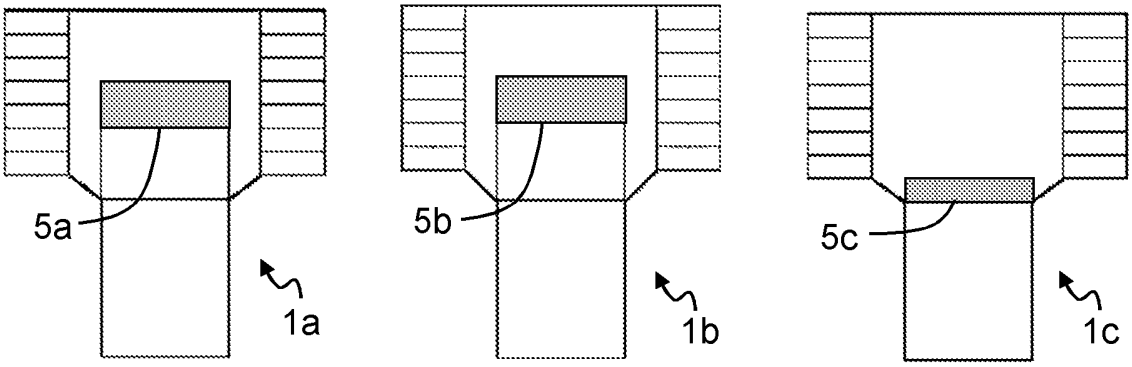


FIGURE 13

REFERENCES CITED IN THE DESCRIPTION

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

Patent documents cited in the description

- EP 0333924 A **[0007]**
- WO 2015091747 A **[0008]**
- CN 103104322 **[0009]**
- GB 10960 A **[0009]**
- US 2012189966 A **[0009]**
- GB 2342980 A **[0009]**
- EP 0568326 A **[0009]**
- GB 2017269 A **[0009]**
- WO 2009136674 A **[0009]**