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FLAME ARRESTOR

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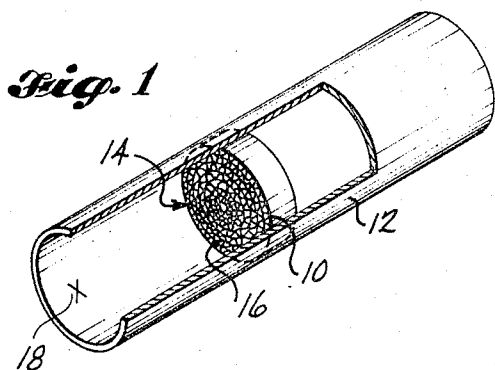
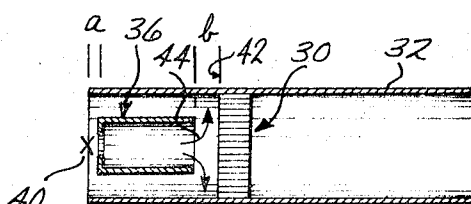


Fig. 2

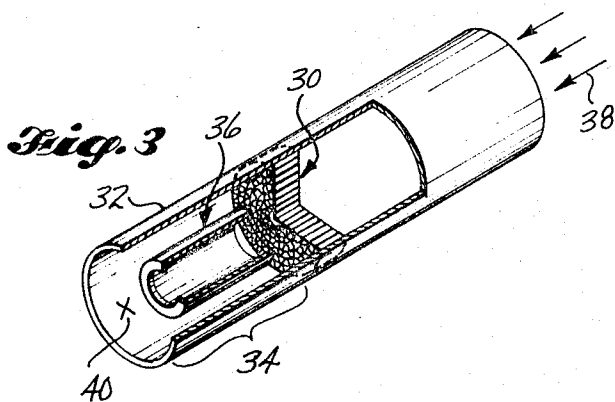
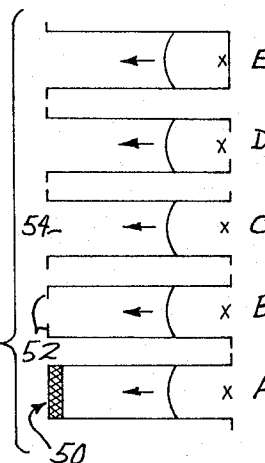


Fig. 4

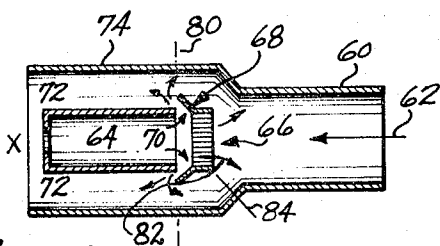


Fig. 5

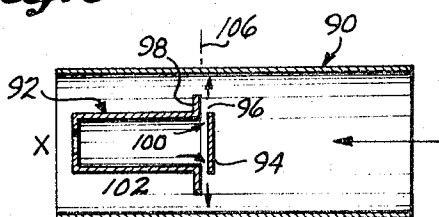


Fig. 6

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FLAME ARRESTOR

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10 Claims

ABSTRACT OF THE DISCLOSURE

A flame arrestor for flammable gas vents provided with a mechanical means for dividing a single propagating flame into at least two fronts. The mechanical means may comprise a substantially concentrically positioned shorter tube disposed within a hood tube. Flame propagation in the concentric tube accelerates faster than in the hood tube and will move through the short tube and back into the hood tube ahead of the slower-traveling flame front in the hood tube so that a back fire is created for the hood tube flame front. An absence of flammable gas supply is created for the hood flame front and nonburnable inert gases are supplied instead so that both flame fronts automatically extinguish.

BACKGROUND OF THE INVENTION

(a) Field of the invention

This invention relates to flame arrestors, particularly to flame arrestors of the type used to prevent propagation of flame through vent means carrying explosive or flammable gases, vapors or mixtures.

The invention is applicable to both static and flowing vapors or gases, but its most significant application is in the latter instance, where devices designed according to the basic principles of the invention will not have the inherent limitations of present state of the art methods of flame arrest.

(b) Description of the prior art

Various types of flame arrestors can be found in the prior art; however, none of the existing known devices operate on the herein-disclosed principles or uses the identical combined structural configuration.

The closest approach to the present invention was found in the U.S. Pat. No. 2,087,170 issued to A. Stephenson which teaches the temporary stopping of the flow of flammable material when a flame occurs, as does the present invention. However, in Stephenson the flow of flammable material is halted by the expansion of the burned gas vapor against closely spaced baffle plates, while the flow of flammable gas is halted in the present invention by the expansion of the inert gas through the fuel carrying conduit.

Specifically, present state of the art flame arrestors exhibit the following limitations:

- (1) In a flowing stream of gas, the flame often comes to rest at the face of the arrestor and continues to burn, eventually heating the arrestor or surrounding structure sufficiently to cause failure of either or both.
- (2) In applications such as fuel tank vents in airplanes the multiplicity of small passageways in most flame arrestors makes them subject to plugging by ice formation under some airplane flight conditions.

Flame arrest systems designed utilizing the principles disclosed herein not only arrest the propagation of flame through a passageway, they also snuff out the flame. The design principles also permit flame arrestor designs not subject to ice plugging.

In principle, the concept consists of mechanically dividing the single propagating flame front into several or more parts and then, by utilizing present state of the art meth-

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ods, accelerates some of the newly formed fronts and possibly in some designs even decelerates some. With several or more fronts propagating at different velocities a position vs. time separation between fronts develops. It is this position vs. time separation which is used in this invention to accomplish the flame arrest and flame snuffing action.

SUMMARY OF THE INVENTION

- One of the preferred embodiments of this invention comprises a flame arrestor composed of a hood-type tubular structure having a standard flame arresting screen located at the upstream end of the hood and a small diameter open-ended tube located in the axial center of the downstream portion of the hood such that one end is a fraction of an inch away from the hood exit plane and the other end is a fraction of an inch away from the flame arresting screen or flame arrestor.

This small diameter tube acts as an accelerator for the flame; that is, as the unwanted flame, caused by a lightning bolt or other igniting action, appears at the hood exit, it will travel faster through the small diameter tube than it does through the concentric or ringshaped hood passage.

- Thus, a first flame front will exist in the hood passage and a second flame front in the accelerator tube which last one will travel through the small tube and jump over into the hood passage ahead of the first flame front; thereafter, both flames will burn toward each other and when they meet the flame is extinguished for lack of burnable material because in part each flame front leaves a section of inert gas behind it.

It is therefore an object of the present invention to provide for an improved flame arrestor having means to interrupt the supply of flammable material temporarily when a flame is formed.

- It is another object of the invention to provide for an improved flame arrestor having means which provide for a backfire to the propagating flame so that a snuff-out action takes place.

In general, the present invention provides for an improved flame arresting device for vent means carrying flammable gases, which comprises an open exit hood means forming the vent means end portion. An accelerator tube, having a first and a second end, is disposed internally and concentrically within the hood means so that the tube separates within the hood means a center tube channel from a surrounding hood channel. Furthermore, a flame arrestor means is mounted at a predetermined distance from the second end of the tube for forming a connecting passage between the tube channel and the hood channel whereby upon associated ignition of the flammable gases at the hood exit a hood flame front and a tube flame front propagate within the hood channel and the tube channel and whereby accordingly the tube flame front reaches the connecting passage for expansion into the hood channel prior to the hood flame front, thereby becoming a backfire to the hood flame front.

- More specifically, the improved flame arresting device for vent means carrying flammable gases comprises in combination, a cylindrical extended hood connected to the vent means which cylindrical hood ends in an open exit. A flame arrestor is mounted in the vent means at said hood connection for preventing the flame propagation through the vent means. Furthermore, there is an accelerator tube having a first end and a second end mounted concentrically within the hood so that the tube longitudinal axis is substantially coincident with the hood longitudinal axis and the tube thereby separates within the hood a center tube channel from a surrounding hood channel. More concisely, however, the tube is mounted with its

first open end and in respect to the hood exit at a slightly inward position and the tube second end is positioned at a predetermined distance from the flame arrestor so that a passage exists interconnecting the tube channel with the hood channel. The passage serves to provide expansion of an eventual associated flame front traveling via said tube channel to expand in the passage over the flame arrestor face so that a backfire flame front is created in the hood channel opposing flame fronts propagating in said hood channel which accordingly suffocates or extinguishes all present flames.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective illustration of a vent means carrying a present state of the art flame arrestor.

FIGS. 2 and 3 are a perspective and a sectional view of the preferred flame arrestor embodiment in accordance with the present invention.

FIG. 4 shows diagrammatically a series of tube configurations needed to explain the theory of operation of the invention.

FIG. 5 is a sectional view of a second preferred embodiment of a flame arrestor.

FIG. 6 is a sectional view of a third preferred embodiment of a flame arrestor.

DESCRIPTION AND OPERATION OF THE INVENTION

Flame arrestors presently used in industry are of many types. However, nearly all designs depend for their action on the inability of flame to propagate through small diameter (cross-sectional) passages.

One of the simpler means of attaining a multiplicity of small cross-sectional passages for flame arrest is illustrated in FIG. 1. A corrugated metal ribbon 10 is wound concentrically inside a metal cylinder 12, thus forming a screen type flame arrestor 14. The shape and cross-sectional area of each of the individual flame passages 16 formed thereby is established by the shape of the ribbon convolutes, and the width of the ribbon establishes the length of the passages.

The reliability of this typical device is adversely affected in some applications by operational conditions. One such condition is that in which a flammable mixture is continuously being expelled through the device. Under these conditions, ignition of the gas or vapor mixture on the external surface of the arrestor 14 causes the flame to "attach" to the external surface. Heat from the flame then gradually heats the structure of the arrestor. The flame quenching ability of the small passageways 16 is reduced as they become hot and the flame propagates through; or if the latter does not occur, the intense heat in contact with the thin-webbed structure gradually burns through the device or the structure surrounding the arrestor 14. The latter is particularly hazardous in cases such as in airplane fuel tank vents where flame arrestors are inserted some distance inward from the vent exit 18. A structural burn through of the vent tube 12 or even a high vent tube wall temperature downstream of the flame arrestor could in these systems result in a disastrous explosion or fire.

The present invention, in one of its simpler forms, is illustrated in FIGS. 2 and 3. The device can be envisioned as a standard state of the art flame arrestor 30 with modifications. The modifications consist of lengthening the metal cylinder 32 containing the flame arrestor 30 so that a "hood" 34 is formed ahead of the flame arrestor 30. Inside this hood 34 is then inserted an accelerator tube 36, open at both ends, and shorter than the hood by only a small fraction of total accelerator length a . Its inner end is positioned a very small distance b away from the front face of the flame arrestor.

The theory of operation is as follows: In a flowing system, both the hood tube 34 and the accelerator tube 36

contain the flowing, flammable vapor 38. On ignition, at the hood exit 40, flame will propagate upstream (left to right in FIGS. 2 and 3, against the arrow) through both tubes to the face of the flame arrestor 30. However, in the case of the accelerator tube 36 if correctly proportioned, as explained in a later paragraph, the rate of flame propagation will be considerably faster than in the hood tube 34.

The flame front, therefore, in the accelerator tube 36 reaches the flame arrestor face 42 first. It here ignites the vapors across the whole face of the arrestor 30 and in essence starts a backfire 44 which propagates downstream (right to left) to meet the flame front propagating in the hood.

The purpose of the backfire is to create a momentary separation of the flame and ignitable vapor and thereby, with the aid of the flame arrestor 30, snuff out the flame. This latter action occurs since the burning at the face of the arrestor 30 occurs with normal static flame propagation followed by considerable flow turbulence as the two flame fronts meet in the hood 34. The burned inert gases expand upstream into the tubes 16 of 30, as well as expanding downstream. The result is a total momentary absence of burnable vapor at the arrestor face 42 and a discontinuity in the burning and cooling of the hot gases results. The net result is a self-extinguishing flame arrestor action. Because of the inert products of combustion in 34 and 36, re-ignition of the system will occur only when unburned gases again appear at the end 40 of the hood 34, and then only if an ignition source still exists.

The basic mechanics of the flame acceleration in an "accelerator tube" are shown diagrammatically by the tube configurations in FIG. 4. Of the configurations shown, configurations 4A and 4B can be expected to produce the lowest average flame speed since the burned gases exhaust from the point of ignition X without appreciably compressing the gas in the tube. They do, however, offer some restriction to flow of expanding gases to the left because of the restrictive nature of the exits at the left end of the tubes, which in configuration A is covered by an acoustic material or sintered (porous) metal closure 50, and in B flow is restricted by tube wall extensions 52. Their average flame speeds, therefore, should be less than configuration C, in which no restriction of the left exit 54 exists. Configuration E should result in the highest flame speed since all of the expanding burned gas drives the unburned gas ahead of it. The average flame speed in configuration D should fall between the two extremes.

Experiments described in the literature bear out these expectations. However, acoustical vibrations are known to accompany combustion processes; therefore, the actual resultant flame accelerations in a particular configuration can be affected by complex acoustic vibrations within the accelerators, and secondary vibrations ahead and behind it. These latter effects must be reckoned with in the design of the accelerators. The specific proportions and shape of the accelerators therefore becomes a function of the overall flame arrestor configuration, and while in general an accelerator of the type in FIG. 4D would result in the desired flame acceleration, in some arrestors a uniform passageway having a particular ratio of cross section to length would accelerate the flame. The flame accelerator concepts described herein are therefore merely illustrative and it is not the intent to restrict the invention to the use of a particular type or design.

It is also not the intent to restrict the invention to the particular configuration used to illustrate the basic flame arresting and flame snuffing action of the invention. Many combinations and shapes of metal or non-metal enclosures can be arranged in a manner to result in flame quenching utilizing the basic concepts of this invention. Typical variations of such designs are shown by FIGS. 5 and 6.

Both versions are particularly suited to applications such as airplane fuel tank vent systems where vent plug-

ging by ice formation in restrictive type passageways can occur.

In FIG. 5 a section of vent tubing 60 is shown in cross section. In this design sketch the flammable vapor 62 flows from right to left. Installed within the vent tubing is an accelerator tube 64 and a state of the art flame arrestor 66. The accelerator tube 64 is similar to the one described for FIGS. 2 and 3, and again, is positioned a small distance away from the front face of the arrestor 66. The housing containing the state of the art flame arrestor 66 is provided with an extension skirt 68, which forms an annular passage connecting channel 70 in the accelerator 64 with channel 72 in the main vent duct 74.

In operation, flammable vapor flows through both channels 64 and 72. Ignition occurs anywhere downstream (to the left) of the accelerator tube 64. Flame then travels upstream (left to right) in both channels 70 and 72. However, because of the particular design of the accelerator 64, the flame front accelerates faster in channel 70 than in channel 72. The flame front in channel 70 therefore reaches position 80 earlier than does the flame front in channel 72. Position 80 is the vertical (normal) plane located at the exit end of the accelerator tube 64. Flame exits now from channel 70 into channel 72 by means of the passage 82 formed by skirt 68. This flame now starts another flame front in channel 72 which propagates downstream (right to left)—in essence, a backfire in channel 72.

Little, if any, propagation of this latest flame front in channel 72 occurs in the upstream direction (left to right) since a barrier of inert gases has been established upstream of position 80 by inert products of combustion expanding in channel 70 and exiting upstream through the flame quenching tubes of arrestor 66. Arrows show the path of the flame exiting from channel 70 into channel 72 and of the path 82 of the inert products of combustion exiting from arrestor 66.

The backfire in channel 72 propagates downstream (right to left) until it meets the original flame front which has been propagating upstream (left to right). At the point where these flame fronts meet, the flame goes out. The expanding non-flammable products of combustion from the flame fronts now form a barrier to re-ignition of the flowing flammable vapor until the products of combustion are expelled at the vent exit.

Flame arresting in channel 72 at position 80 (no flame propagation upstream) is dependent on the expanded inert products of combustion from channel 70 passing through the flame arrestor 66 and mixing with (and thereby inerting) the flowing flammable vapor. For successful arrest this mixing must occur faster than flame can propagate from channel 70 through the passage formed by skirt 68 into channel 72 establish a new flame front in channel 72 and propagate upstream to position 84. Position 84 is the plane (normal to the duct) located at the start of the angle bend in the main vent duct. Since the time to accomplish this is primarily a function of relative distances, rates of flame front travel and rates of gas expansion, the aforementioned required sequence can be established by physical design of the flow passages through which the respective gases and/or flame fronts must flow.

FIG. 6 shows a duct 90 in cross section. Mounted internally therein is again an accelerator tube 92. However, unlike the previous examples, the state of the art flame arrestor located at the exit end of the accelerator is of a slightly different type. It consists of a member which is positioned such that an annular passage 96 of suitable width and depth inhibits passage of flame. The passage 96 is formed by mounting a flat plate member 94 a suitable distance from a base flange 98 attached to the accelerator tube 92. The separation between the two establishes the passage width 96, and the difference in internal diameter of the tube 92 and the plate 94 establishes the depth of the passage 96.

In operation the flammable gas flow is again from right to left. Ignition again occurs downstream (to the left) X of the accelerator tube 92 and flame again travels (left to right) through both channels 100 and 102. The flame front in channel 100 is accelerated and reaches the annular arrestor channel 96 at position 106 sooner than flame front in channel 102. The inert products of combustion from the burned gases in channel 100 now expand through the annular arrestor passage 96 and mix with the flammable vapors in channel 102 at position 106. This mixing is very turbulent and acts to inert the flammable gases as they pass position 106. When the flame front, moving from left to right in channel 102, reaches the mixture of flammable vapors, and products of combustion at position 106, the flame goes out. (Position 106 is the vertical—normal—plane located at the exit end of the accelerator tube 92.)

As stated previously, the illustrated examples are typical designs which operate on the basic principles of this invention. They are not to be judged the only types possible, nor the only types within the scope of this invention. Also the state of the art flame arrestors referred to in the foregoing descriptions can be of many types other than those used in the illustrations. To name a few—sintered metal plates, tube bundles of small cross-sectional area, wire gauge, parallel plates, and reticulated foam. However, it should be understood that such variations and changes fall within the scope and spirit of the present invention.

Now, therefore, I claim:

1. A flame arresting device for vent means carrying flammable gases, comprising:

- a hood means forming a flammable gas passageway having a forward end and a rear end,
- an accelerator tube, having a first forward end and a second rear end, disposed within said hood means so that said tube forms within said hood an accelerator tube channel and a hood channel,
- a flame arrestor means mounted in said hood means a short distance rearwardly from said second end of said tube for forming a connecting passage between said accelerator tube channel and said hood channel whereby upon associated ignition of said flammable gases at said hood forward end, a hood flame front and an accelerated tube flame front propagate within said hood channel and said tube channel, and said accelerator tube flame front reaches said connecting passage for expansion into said hood channel prior to said hood flame front, thereby becoming a backfire to said hood flame front.

2. A flame arresting device for vent means as claimed in claim 1 wherein said accelerator tube first end starts at a recessed position from said hood forward end.

3. A flame arresting device for vent means as claimed in claim 2 wherein said accelerator tube first end has an internally normally protruding flange to form a restricted opening at the first end of the accelerator tube.

4. The device as recited in claim 1, wherein said accelerator tube is mounted generally concentrically in said hood means so as to form with said hood means a generally annular hood channel surrounding said accelerator tube channel.

5. A flame arresting apparatus comprising:

- first hood means defining a main flammable gas passageway portion having a first forward end and a second rear end,
- an accelerator tube having a first forward end and a second rear end, said accelerator tube being disposed in said first hood means and defining an accelerator tube channel in said main flammable gas passageway,
- a flame arrestor means mounted in said main passageway a short distance rearwardly from the second end of said accelerator tube,
- skirt means located at said flame arrestor means radially outwardly thereof, and positioned to form a

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connecting passage between said accelerator tube second end and said main passageway, whereby upon ignition of flammable gases at the first end of said main passageway portion, a flame front travels through said accelerator tube at an accelerated rate, with combustion gases from said accelerator tube being directed into said main passageway to extinguish a flame front traveling through said main passageway.

6. The apparatus as recited in claim 5, wherein said accelerator tube first end has an internally normally protruding flange to form a restricted opening at the first end of the accelerator tube.

7. The apparatus as recited in claim 5, wherein said skirt means projects outwardly and forwardly so as to provide a forwardly directed connecting passage to said main passageway.

8. A flame arresting apparatus, comprising:

- (a) a first hood means defining a main flammable gas passageway portion having a first forward end and a second rear end,
- (b) an accelerator tube having a first forward end and a second rear end, said accelerator tube being disposed in said first hood means so as to define an accelerator tube channel in said main passageway,
- (c) flame arresting plate means mounted a short distance rearwardly of the rear end of said accelerator tube so as to form a small flame arresting passage connected to and directed laterally into said main

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passageway, whereby upon ignition of flammable gases at the first end of said main passageway portion a flame front travels through said accelerator tube at an accelerated rate, with combustion gases passing from said accelerator tube through said flame arresting passage into said main passageway so as to extinguish a flame front traveling through said main passageway.

9. The apparatus as recited in claim 8, wherein said plate means comprises a substantially normally positioned flat plate member having an outside diameter smaller than an internal diameter of said first hood means.

10. The apparatus as recited in claim 8, wherein said accelerator tube is positioned generally concentrically within said first tube means, with said flame arresting plate means defining with the second end of the accelerator tube a generally annular flame arresting connecting passageway directed into said main passageway.

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JOSEPH SCOVRONEK, Primary Examiner

U.S. Cl. X.R.

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