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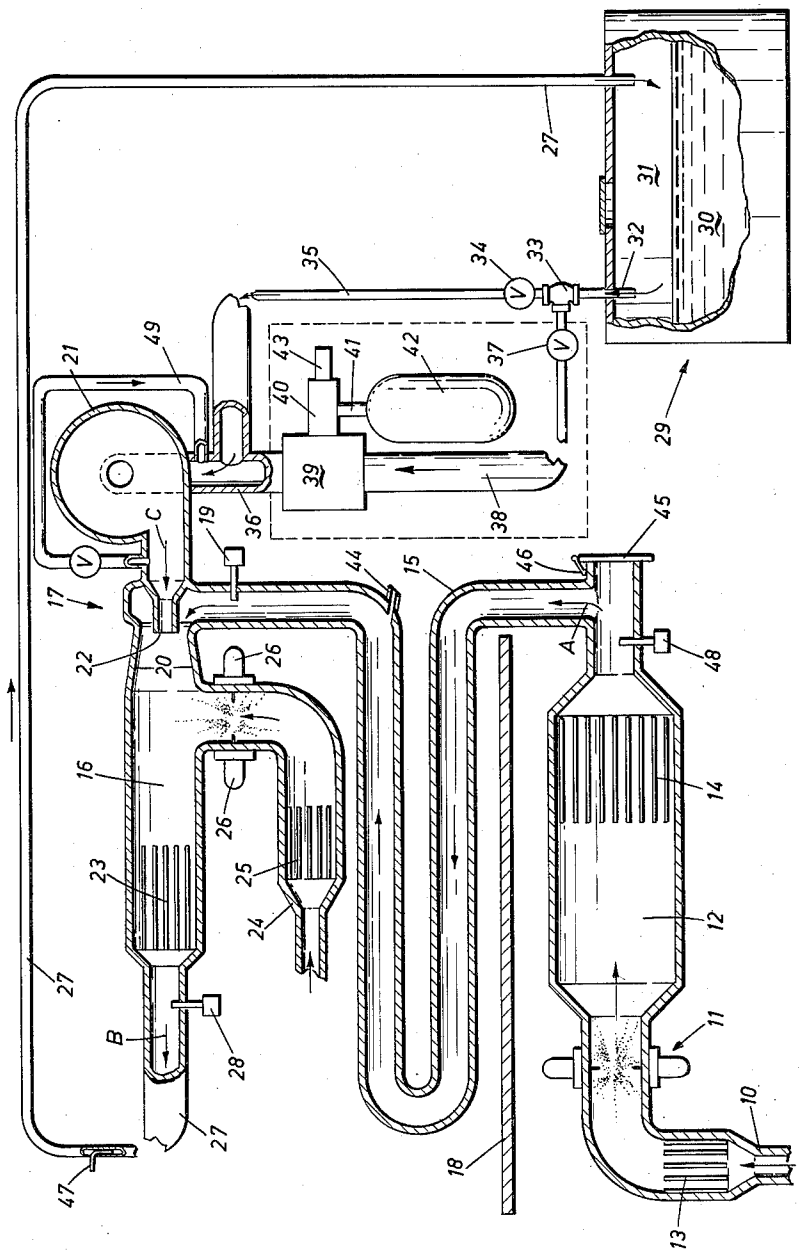

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METHOD AND APPARATUS FOR PROVIDING COMBUSTIBLY INERT GAS TO A VARIETY OF LOCATIONS

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This invention relates to an improved method and system of rendering safe for handling a vessel containing a volatile liquid and evolved gases and vapours thereof.

Although prior attempts have been made to economically produce a combustibly inert gas, in most applications, portions of the gas are still capable of combining with oxygen to form explosive mixtures, or at least capable of supporting combustion. The prior methods include the use of exhaust gases from internal combustion engines in addition to supplying exhaust gas through burning a fuel directly.

Previous systems for supplying and utilizing such gases have purportedly been useful for providing an inert atmosphere within the confines of a container within which welding, soldering, cutting, etc., may be effected and wherein the danger of explosion due to sparks and flames may be minimized.

In the main, the containers must be drained of combustible liquid before purging and subsequent repairs may be effected, thus accounting for a large proportion of the expense involved.

Upon exposure to a combustible gas, often under conditions of increased pressure, the container walls have been found to "absorb" an amount of gas which, after removing the liquid, and purging with inert gas, still remains. Upon subsequent heating of the tank through external sunlight or other sources, this trapped or residual gas is expelled, often increasing the explosive content to the danger point. It has been attempted to remove such entrapped gas through applying steam to the interior of the container, thus adding to the expense of the operation.

In addition to problems of effecting repairs to storage tanks or other containers, a constant source of danger in volatile liquid storage containers resides in the fact that due to adding or removing liquid, portions of the container are caused to move, thus being capable of producing sparks through friction or static generation. Coupled with this danger, upon adding liquid to a container, the space volume is reduced, causing increased pressure which is relieved through exhaust valves, leaving the dangerous condition of volatile explosive gases in the vicinity of sparks. Alternatively, upon normal removal of liquid from a container, a larger space volume is produced in which is created a reduced pressure which is often obviated by the introduction of air through inlet valves. Either situation is obviously conducive to explosion or fire.

Upon consideration of the above noted possibilities and/or conditions, it will be apparent that prior methods are at best risky, and in employing prior methods it has been a slow and costly process to attempt to prevent damage and/or loss of life or injury in the maintenance of storage containers either for repairs or for normal use.

There are a number of other uses for combustibly inert gases which will become apparent upon consideration of the disclosure herein.

It is a main object of this invention to provide a method and apparatus of purging areas above the liquid surface of a container and the like without the necessity of draining the contents.

It is another main object of the invention to provide an inert gas which has been substantially deprived of combustible products.

It is a further object of this invention to provide a method of continually purging areas at a tank or the like whereby a circulating system is provided together with secondary combustion so that the gases purged may be combined with the former inert gases to provide a larger volume of inert gas within the circulatory system.

It is another object of this invention to provide a partially cooled inert gas to the circulating system.

Other objects and advantages of the invention will become apparent upon study of the description and drawing.

The invention generally comprises in a system for providing a combustibly inert gas to an enclosed space, a source of exhaust gas formed in a combustion chamber, passage of the gas to a second combustion chamber, formation of added exhaust gas in the second chamber, passage of the production gas to at least one volatile liquid container, removal of the combined gas from a container, and introduction of the gas into a blower unit for recirculation thereof into the second combustion chamber to combine with gas from the first combustion chamber.

The drawing indicates a general schematic view of the system of the invention with a single storage tank and connecting conduit lines shown to a reduced scale and including an embodiment within an area marked in broken line as explained in the accompanying description.

Fuel is introduced into the system through conduit 10 and ignited by ignition system 11 providing a continuous spark for combustion within chamber 12. Anti-flash back baffles 13 are provided in the conduit as a safety measure to prevent pre-ignition of input fuel. The combustion chamber 12 contains baffles or tubes 14 to retard the free passage of gases forming products of the combustion to ensure complete combustion by providing high turbulence within the chamber. A portion of conduit 10 is preferably disposed adjacent the chamber 12 to pre-heat the fuel introduced.

The exhaust gases are conducted through conduit 15 in the direction of arrow A, the conduit being preferably formed into a coil to provide an adequate cooling area for the gas which is then introduced into a second combustion chamber 16 through an entrance portion generally indicated by the reference numeral 17. Conduit 15 may be protected from heat of radiation from chamber 12 by means of baffle plate 18. A temperature indicating device 19 is inserted within conduit 15 adjacent the entrance 17 of chamber 16.

The entrance portion 17 comprises a section of relatively small area, to be denoted the point of entry, which communicates with chamber 16 through outwardly flaring path 20, thereby providing a cross-sectional area at the combustion chamber 16 greater than that at the point of entry.

A blower 21 adjacent the entrance portion, has an outlet nozzle 22 of reduced diameter inserted at the point of entry.

Combustion chamber 16 is basically similar to chamber 12, containing turbulence inducing baffles 23 for the same purposes as hereinbefore disclosed for baffle 14.

A fuel line 24 having anti-flash baffles 25 is in communication with chamber 16 to provide a curtain of flame across the chamber, the fuel being ignited by ignition means 26 when mixed with air.

The gases from chamber 16 are conducted through conduit 27 in the direction of arrow B past temperature indicating device 28 adjacent the outlet from the chamber, the conduit 27 communicating with a storage tank 29 of any size utilized for volatile liquid storage use. The combustibly inert gas may be directed to any space for purging thereof, but for the convenience of illustration a portion of conduit 27 and tank 29 are indicated to a

reduced scale. A number of tanks 29 may be connected to the system for the purposes outlined hereinafter.

The end of conduit 27 is inserted within tank 29 through any convenient opening. Preferably, however, to ensure optimum mixing within the tank, the combustibly inert gas should be admitted through a plurality of openings to create turbulence of volatile and input gases within the space above the surface of volatile liquid 30, the space being indicated by the reference numeral 31.

A gas removal conduit 32 is provided with preferably substantially leak-proof fittings known in the art, to lead the mixed gases removed from the tank past junction fitting 33 and valve 34. The input conduit 27 need not be provided with pressure tight fittings so long as the input gas volume is maintained to provide a pressure differential within the tank to prevent the introduction of an excess amount of air into the tank.

When the apparatus is to be used to purge the interior of a tank above the liquid surface for subsequent repair of the tank, the gas removed from the tank is conducted past valve 34 and through conduits 35 and 36 to the blower unit 21, that portion of conduits 35 and 36 adjacent the blower 21 being shown to enlarged scale in comparison to that of conduits 27 and 35, for purposes of illustration.

The gas removed from space 31 is urged through blower 21 in the direction of arrow C for entry into the combustion chamber 16 through nozzle 22 at the point of entry to the outwardly flaring path 20 defined by walls of the chamber. The gas from space 31 is therefore inserted into the combustion chamber 16 to mix with gases provided therein through conduit 15 together with gas produced due to combustion of fuel provided through conduit 24 for recirculation.

For the provision of a "blanket" of inert gas to one or more volatile liquid storage units as a combustibly inert atmosphere thereover, and to prevent substantial evaporation of gases from the liquid, an embodiment is shown in the drawings.

The gas from the tanks is conducted through various conduits through junction fitting 33 and past valve 37, valve 34 being preferably closed to prevent passage into conduit 35.

The gas removed from the tanks, formed of input exhaust gas mixed with some vaporized liquid is conducted through conduit 38 into a check valve, pressure release valve and regulating valve assembly, indicated by block 39. Particulars of the valve assembly 39 are not shown. However as explained hereinafter the valve assembly 39 will permit normal flow of gas into conduit 36, but if a pressure is exerted within conduit 38 of a predetermined magnitude, entry of the gas will be afforded through conduits 40 and 41 into surge tank 42, indicated as of small size for the convenience of illustration, but actually of large capacity depending upon the volume of the tanks to be purged. Upon formation of any unduly high pressure within the system, provision may be made for pressure release of the gas to atmosphere through a blow-off valve and conduit 43. The surge tank has a return valve so that if a pressure decrease is experienced, the stored gas within the surge tank is released to conduit 36 to maintain flow within the circulating system.

In the event of the formaton of condensate during cooling of the exhaust gases, a condensate outlet 44 is provided in conduit 15. A valve 45 is retained by a spring 46 or other suitable means, in a closed position adjacent conduit 15 close to the combustion chamber 12 so that in the event of an explosion within the chamber the force exerted will cause the valve 45 to open against the bias of spring 46 to release the pressure in the system, whereupon the valve 45 will be urged to its closed position by the spring 46 which is sufficient in tension to overcome the normal pressures formed within the system.

A tube 47 is preferably inserted in conduit 27 against the flow of gas to which may be attached a device for measuring volume of flow and/or indicating an analysis of the gas, which devices are not shown but are commonly known in the art. In addition, a gas drying device of any suitable type known in the art may be inserted in the system before entry to the purging area.

For the purpose of safety, a temperature indicating device 48 is provided adjacent the outlet of chamber 12 to indicate gas temperature. A temperature responsive alarm is preferably inserted at this piont to issue warning if the outlet temperature becomes excessively high, and to cause the flow of fuel to cease, while warning the operator to enable him to leave the tank if repairs are being effected.

A conduit 49 is provided to form a by-pass flow line, the conduit being in communication with the input to blower 21 and in communication with the output end of the blower. A suitable valve, as indicated, is provided for controlling by-pass flow volume.

In the embodiment shown in the drawings, a single tank or container has been indicated for purposes of illustrating the preferred embodiment. However, it will be obvious that the method and apparatus may be utilized in purging a series of tank containers and may with equal effect be utilized in the fighting of fires in confined spaces as hereinafter explained.

The combustion chamber 12 and cooling conduit coils 15, together with chamber 16, are preferably maintained within a flow of air produced by a blower or other suitable means to effect preliminary cooling of the exhaust gases. Fuel in any suitable form is introduced to the system through conduit 10 and past anti-flash baffles 13 for igniting by ignition means 11, which at this stage is preferably in the form of a continuous spark, after suitable mixing with air.

Combustion is effected within the enlarged chamber 12, within which baffles 14 are provided to effect high turbulence of the gases within the chamber to induce a more complete combustion. If, at this point, an explosion should occur of sufficient magnitude to overcome the bias of spring 46, valve 45 will be opened to permit a reduction of the effect of the explosion. Upon return of the system to its normal operating pressure, the valve 45 will be closed by spring 46 to permit normal flow of exhaust gases through conduit 15, which, though indicated in the drawings as containing two secondary coils, may be preferably formed into any number of coils to effect the required cooling by the passage of air.

The valve 45 should be maintained in an open position upon initially firing chamber 12, to permit exhaust to atmosphere. It has been found that such a safety device is necessary in the event that misfiring should occur, thus preventing the introduction of explosive gases or liquids into the system before adequate combustion can be achieved. Upon the exhaust gases reaching operating temperature, the valve is automatically or manually closed under guidance of the temperature indicating device 48 adjacent the exhaust end of the chamber 12.

Condensate formed within the unit due to cooling or expansion of the gases may be removed through the tube 44. The exhaust gases, now being substantially inert for the purposes of combustion, are directed towards secondary combustion chamber 16 through entrance portion 17 and past a secondary ignition means 26 which at this stage, should preferably be of a continuous flame type, the fuel for which being provided from conduit 24. The fuel input from conduit 24 is provided under sufficient pressure to admit the fuel mixed with air to provide adequate burning. The flame within the chamber should be adjustable to permit complete combustion of any combustible gases introduced, yet capable of effecting economy of the fuel utilized, the air-fuel mixture being dependent upon the volume of input gases to be burned and their analysis as registered by device 47. A neutral flame should be provided when the system commences operation. Suitable safety devices should be

provided as hereinbefore noted in relation to chamber **12** in the event that misfiring should occur. The entrance portion **17** is of a reduced diameter at the point of entry, the opening flaring outwardly towards the ignition means **26**.

The secondary combustion chamber ensures complete burning of any combustible gases remaining, with baffles **23** being provided to create excessive turbulence within the chamber.

The exhaust gases from chamber **16** are conducted through conduit **27** past analysis recording device **47** and temperature indicating device **28** for admission into a single tank for effecting repair thereof, or into a series of suitably connected tanks to provide a blanket of combustibly inert gas over the volatile liquids stored therein.

It will be realized of course that gases removed from the tank or tanks will comprise a mixture of inserted inert gas and combustible gas evolved from the liquid.

In the event that the device is to be used during repairing of a single tank, the gas removed is conducted through conduits **32**, **35** and **36** by means of the valve **34** to the blower unit **21**.

The removed gases are introduced into combustion chamber **16** and intermixed with exhaust gases from conduit **15** through the expanding entrance portion **17**, whereby the continuous flame provided acts upon the combustible gases collected from the tank **29** to render the same combustibly inactive.

The temperature indicating devices **19** and **28** record the temperature of exhaust gas introduced from conduit **15** and of burned gases emitted from chamber **16**, respectively. It has been found that upon commencing the operation described, the combustible gases introduced from the blower **21** (as removed from the tanks) form a high percentage of gases introduced into chamber **16**. Accordingly, the heat developed due to their burning will be noted on thermometer **28**, indicating a substantially higher reading than that provided by thermometer **19** indicating cooled exhaust gas from chamber **12**.

Upon recycling the gas as described, the relative percentage of combustible gases decreases as the volume of inert gases increases. Thus, a differential reading from thermometers **19** and **28**, together with a gas analysis reading from device **47**, will indicate when substantial purging has taken place, at which point the temperature indicated by device **28** will become lower. The readings of devices **19** and **28** will not necessarily be identical, however a particular range will be indicated.

The recycling feature of the invention and other features disclosed provide a means of removing explosive gases from a container, utilizing the explosive gases transformed into combustibly inert gases and recirculating the inert gas into the container to provide a depressant blanket of inert gas to reduce the evolution of combustible gas and to combine therewith to render the mixture into a safe ratio for subsequent burning of entrapped explosive gas for re-introduction to the tank or tanks, so that a workman with suitable breathing apparatus may enter the container to effect repairs without danger of causing explosion due to open flame, etc.

When utilizing the invention for creating a depressant blanket of inert gas in a series of containers to prevent loss due to excessive vaporization, or to reduce the danger of explosion due to static electricity or other ignition causes, the invention contemplates the use of a surge tank **42** as noted.

In this embodiment, valve **34** is closed and the gas is introduced through valve **37** and conduit **38** into the valve assembly **39**. The valve assembly is devised to permit normal flow of gas to be conducted directly into blower or pump unit **21** through conduit **36**. However, as is often the case, when liquid is pumped into a storage tank, the pressure of the gas above the liquid is increased due to the decreased space volume. The pressure increase causes the gas to be diverted, within the valve assembly, the increased volume of gas being stored within the surge tank **42**, which is provided with a suitable check valve to prevent immediate outward flow from the surge tank upon return of the system to normal operating pressure, at which point the gas from line **38** is redirected into the blower or pump unit **21** as previously described.

Similarly, if liquid is removed from the tank, the increased space volume provides a reduction in pressure within the storage tank and conduit system. In such an event, a suitable regulating valve within the valve assembly will permit a flow of inert gas from the surge tank to maintain substantially normal flow into pump unit **21**.

The invention contemplates the retarding of volatilization of gas within a container for obvious reasons of economy. To accomplish this, at times it becomes necessary to vary the flow within the system to either increase or decrease gas input volume. A simple but effective means of control is provided by by-pass conduit **49** in communication with conduit **36** and the output portion of pump unit **21**.

A suitable valve, which may be either manually or automatically operated, is capable of varying the amount of flow within conduit **49**, thereby to vary the volume of gas expelled from nozzle **22** into the system through combustion chamber **16**, and alternatively varying the flow of gas from the storage tanks to the blower or pump unit.

It will be seen from the foregoing disclosure that the invention presents a method and system of rendering safe for handling a vessel or vessels each containing a volatile liquid and evolved gases and vapours thereof, wherein said gases and vapours are pumped from the vessel for mixture with combustion gases provided through combustion of a fuel with oxygen, said latter gases having a low oxygen content. The mixture is burned within another heat source wherein the volatile portions are rendered substantially combustibly inert, the mixture being introduced into the vessel, thereby to purge the interior and to replace the gases and vapours pumped therefrom.

Although for the purposes of illustrating and describing the invention, certain preferred details have been explained, it will be readily apparent that the invention contemplates use of the method and system for railway tank cars, tanker ships, loading platforms where liquid is transferred, and other previously dangerous locations.

The device may also be used in conjunction with exhaust gases from tank trucks powered by internal combustion engines, wherein the gas, provided from chamber **12** of the invention, is derived from the engine exhaust, and introduced into chamber **16** in accordance with the invention.

The apparatus of the invention may be portable, for effecting repairs to tanks at various locations, or preferably stationary when used to provide a continuous combustibly inert atmosphere to a series of tanks.

What I claim is:

1. The method of rendering a vessel safe for handling, said vessel containing combustible gases and vapours, said method comprising the steps of: igniting a mixture of fuel and oxygen to provide combustion gases low in oxygen content; mixing said combustion gases and said combustible gases and vapours to provide a gas mixture within said vessel, pumping said gas mixture from said vessel; mixing said gas mixture with fuel and oxygen and igniting the same under controlled conditions to provide a substantially oxygen free combustion mixture; monitoring said combustion mixture to determine the proportions of combustible gases remaining therein; and communicating said oxygen free gas mixture to said vessel to replace said gases and vapours pumped therefrom.

2. Apparatus for rendering safe for handling a vessel containing combustible gases and vapours and comprising: a pump; means for communicating said pump with said vessel for removal of said gases and vapours therefrom; primary fuel ignition means; secondary fuel igni-

tion means; communicating means adapted to conduct the products of combustion from said primary means to said secondary means; communicating means adapted to conduct said gases and vapours from said pump to a point in advance of said secondary ignition means for mixture with said products of combustion; means for testing products of combustion from said secondary fuel ignition means to determine the proportions of combustible gases remaining therein; and means for communicating said products of combustion from said secondary ignition means to said vessel, thereby to replace said gases and vapours therein.

3. Apparatus for producing combustibly inert gases for the continuous purging of combustible gases within an enclosed space and comprising in combination; a primary fuel source; a primary combustion chamber for burning said fuel, thereby to provide a volume of exhaust gases; a secondary combustion embodying an entrance portion therein; exhaust gas conduit means adapted to communicate said primary chamber with said entrance portion; a pump unit; an impeller nozzle in association with said pump unit and disposed adjacent said secondary chamber and in communication with said entrance portion at a point of entry thereof; ignition means within said secondary chamber adapted to effect burning of gases introduced thereto; second conduit means for directing gases emitted from said secondary chamber into said enclosed space, thereby to effect mixture of input and gases therein; means for testing products of combustion from said secondary combustion chamber to determine the proportion of combustible gases remaining therein; and gas removal conduit means communicating said enclosed space with said pump unit, whereby said mixture of input and volatile gases may be directed through said impeller nozzle into said entrance portion for mixture with said exhaust gases at said point of entry.

4. Apparatus according to claim 3 in which said entrance portion comprises outwardly flaring walls, said walls defining a space of minimum diameter at said point

of entry thereof and of maximum diameter adjacent said secondary chamber.

5. Apparatus according to claim 3, wherein said testing means includes an exhaust gas temperature measuring device adjacent said entrance portion and a second temperature measuring device for determining the temperature of gases emitted from said secondary chamber toward said enclosed space.

6. A method for purging an enclosed space of combustible gas comprising the steps of igniting a fuel in a first combustion chamber to provide a volume of combustibly inert gas; cooling said gas and communicating the same to a second combustion chamber; combustion fuel in said second chamber to provide a flame therein, conveying said gas from the second chamber to an enclosed space; mixing said gas with combustible gas present within said enclosed space; extracting said mixture from said enclosed space; transmitting the same to said second combustion chamber; mixing said mixture with metered proportions of gases from said first combustion chamber; adding fuel and oxygen in metered proportions to said mixture; igniting said mixture and said fuel under controlled conditions; continuously monitoring the effluent gases from said second chamber to determine the percentage of combustible gases remaining therein, and recirculating effluent gas from said second chamber to said enclosed space.

7. The method according to claim 6 and the step of obtaining a differential temperature reading between the temperatures of the effluent gases from said first and second combustion chamber.

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