Dec. 2, 1969 M. CRANE 3,481,149

GAS GENERATOR

Filed May 9, 1968 2 Sheets-Sheet 1

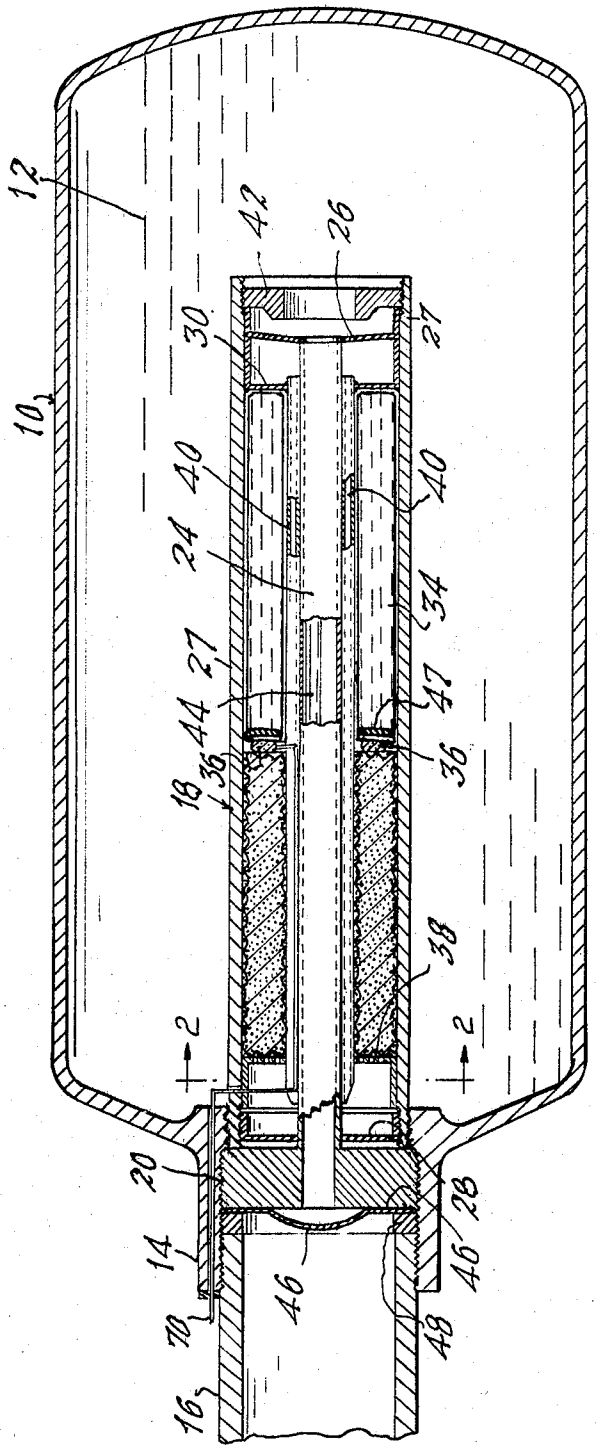

FIG. 1

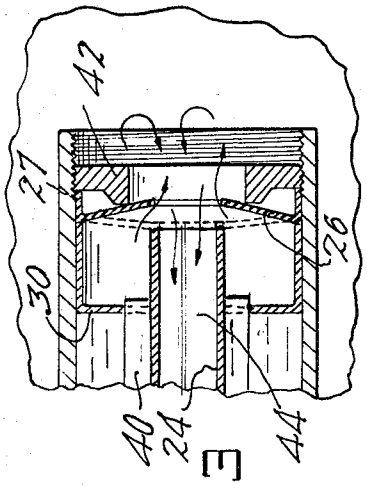

FIG. 3

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Fig 4

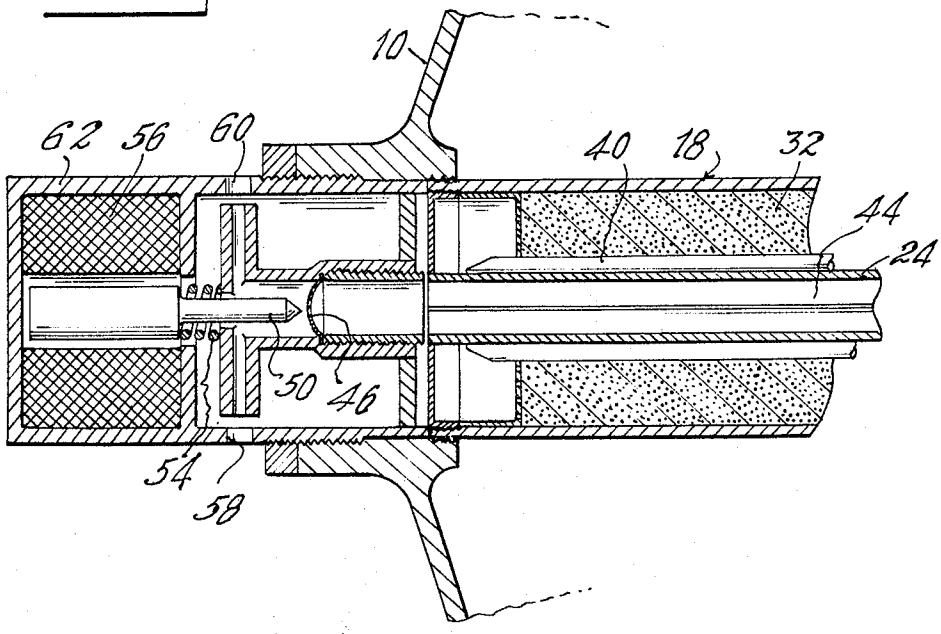
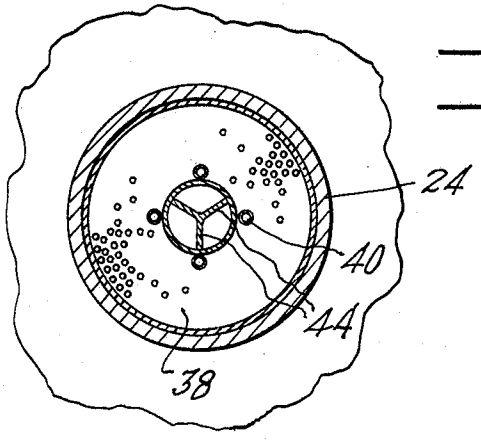


Fig 2



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GAS GENERATOR

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U.S. Cl. 62—45 8 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus for evaporating a liquified gas wherein the heat of vaporization is supplied by means of initiating a chemical reaction in proximity to the liquid and the gas is ported from the apparatus via a tubular heat exchanger, the heat exchanger being in contact with the region in which the chemical reaction occurs. The apparatus also comprises pressure sensitive valve means for selectively releasing the products of the chemical reaction into the reservoir for the liquified gas to maintain pressure therein.

BACKGROUND OF THE INVENTION

Field of the invention

The present invention relates to the generation of gas. More particularly, the present invention is directed to apparatus for producing and delivering sufficient heat to a liquified gas to evaporate the gas, the thus generated gas thereafter being delivered from the apparatus to a device or environment which utilizes the same. Accordingly, the general objects of the present invention are to provide novel and improved methods and apparatus of such character.

Description of the prior art

Gas generators wherein a liquified gas, usually carbon dioxide, is evaporated to provide a pressurized gas are well known in the art. The heat for vaporization of the liquified gas has typically been provided by the combustion of a charge of material located in proximity to the reservoir for the liquified gas. The thus generated gas would thereafter be released to the desired environment via a port which was usually opened simultaneously with the ignition of the charge.

Gas generators of the type described above, particularly those which are portable in nature, have found wide utility. Examples of such utility may be found in flotation equipment, such as life rafts or jackets, and safety and convenience equipment, such as inflatable pads or mattresses. However, despite their wide usage, the prior art gas generators have had certain inherent deficiences.

One of the major problems with prior art gas generators has been overcooling of the discharge passage for the generated gas. Where the gas is carbon dioxide, it is not uncommon to have restriction of the exit passage through the formation of solid carbon dioxide.

Another problem inherent in the prior art resides in the maintenance of pressure within the reservoir as the evaporation process continues. Prior art gas generators have not provided for self-regulation of output pressure which, for many uses is desirable.

SUMMARY OF THE INVENTION

The present invention overcomes the foregoing and other disadvantages of the prior art by providing a novel method for the evaporation of a liquified gas and apparatus embodying that method. The apparatus comprises a reservoir for the liquified gas and, disposed therein, a reaction chamber wherein a pair of reactable materials are stored in spaced apart relationship. A chemical reaction between these materials is initiated by melting a separating

barrier, the melting preferably being accomplished by electric heating, and the thus initiated chemical reaction produces heat for the vaporization of the liquified gas. The generated gas is discharged from the reservoir through a heat exchange tube which passes through the reaction chamber whereby heat is applied in the region where the gas exits from the apparatus.

In accordance with the present invention, the reaction chamber may be placed into communication with the interior of the reservoir by means of a pressure sensitive valve which operates in response to the pressure differential between the reaction chamber and reservoir. Accordingly, when the pressure within the reservoir drops below a predetermined level, gaseous reaction products will be released from the reaction chamber into the reservoir thereby providing a degree of self-regulation of the apparatus output pressure.

Communication between the interior of the apparatus of the present invention and the utilization device, when use of the apparatus is desired, is achieved by means of puncturing a rupture disc which normally closes the exit port of the apparatus. Fracturing of this rupture disc, in a preferred embodiment, is accomplished by means of a solenoid operated plunger.

BRIEF DESCRIPTION OF THE DRAWING

The present invention may be better understood and its numerous advantages will become apparent to those skilled in the art by reference to the accompanying drawing wherein like reference numerals refer to like elements in the various figures and in which:

FIGURE 1 is a cross-sectional view of a preferred embodiment of the present invention;

FIGURE 2 is a partial, cross-sectional view, taken along line 2—2 of FIGURE 1, of the reaction chamber of the preferred embodiment of the present invention;

FIGURE 3 is an enlarged, cross-sectional view of an end of the reaction chamber portion of the preferred embodiment of the present invention, FIGURE 3 depicting the pressure regulating valve of the present invention.

FIGURE 4 is a partial cross-sectional view of an embodiment of the present invention employing a solenoid operated rupture disc fracturing means.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIGURE 1, the present invention comprises a bottle or reservoir **10** which is charged with a liquified gas **12**, the gas typically being carbon dioxide. In order to withstand the pressures and temperatures to which it will be subjected, and also to provide a safety factor which will prevent any undesired release of the liquified gas, bottle **10** will be formed of a metallic material and will, at its discharge end or neck **14**, be internally threaded so that it may be mated with a nipple, such as shown at **16**, on an inflatible or other gas utilization device.

A cylindrically shaped device, indicated generally at **18**, will be suspended within reservoir **10**. The disposition of the member **18** within the reservoir is accomplished by means of its having an externally threaded first or discharge end **20** which mates with the internally threaded neck **14** of the reservoir. Member **18** comprises a reaction chamber **22**, a heat exchanger tube **24** through which the gas will be discharged from the reservoir and a pressure sensitive check valve device **26**. The check valve **26** operates in the manner to be described below and may be of the leaf spring type. The reaction chamber **22** is defined by the inner wall of a cylindrical outer member **27** and the outer wall of heat exchanger tube **24** and the reaction chamber extends between a first spacer-retaining member **28** located adjacent the discharge

end of the heat exchanger tube and a second or upstream spacer-retaining membr **30** located adjacent the entrance end of the heat exchanger tube. Positioned within reaction chamber **22** will be chemicals which, when brought into contact, will spontaneously react chemically, and exothermic reaction being desired. Such a reaction may be achieved by reacting an acid with a carbonate, a hypochlorite with a carbamate or by the hydration of an anhydride. In FIGURE 1, the chemicals are indicated by a solid chemical cartridge **32** and a liquid cartridge **34**. Liquid chemical cartridge **34** will butt, at one end, against spacer ring **30**, the other end of the liquid chemical cartridge being separated from the solid chemical cartridge by means of a cartridge seam melter **36**. In a preferred embodiment, the seam melter **36** may comprise electrical contacts which, in combination with a metallized strip on the seam of the plastic cartridge **34**, forms an electric heater. The end of the solid chemical cartridge **32** disposed opposite to the cartridge seam melter **36** will butt against a perforated spacer ring **38** which may be integral with the first spacer ring **28**.

As may best be seen from a simultaneous consideration of FIGURES 1 and 2, a plurality of gas tubes **40—40** provide communication between the region between spacer ring **28** and perforated spacer **38** and the region between spacer ring **30** and the regulating valve means **26**. Spacer ring **28** is sealed about the periphery of the heat exchanger tube **24** while spacer ring **30** is sealed about the heat exchange tube and the gas tubes **40**. Accordingly, through the action of gas tubes **40** and the perforated spacer ring **38**, the interior of reaction chamber **22** is in communication with a first side of the valve means **26**. The opposite side of the valve means **26** is in direct communication with the interior reservoir **10** via apertured retaining member **42** which threadably engages the cylindrical member **27** adjacent its inwardly disposed end.

As may also be seen from FIGURE 2, the heat exchanger tube **24** is provided with internal fin members **44**. As will become more apparent from the discussion below of the operation of the disclosed embodiment, presence of the fin members aids in the transfer of heat to the gas being discharged from the apparatus, the fins being heated by conduction from the wall of the heat exchanger tube **24** which defines the inner wall of the reaction chamber.

Prior to utilization of the gas generator of the present invention, leakage of the contents of reservoir **10** is prevented by means of a rupture disc **46** which bridges the neck **14** of reservoir **10**. Rupture disc **46** is held in position between a retaining nut **48** and the downstream or discharge end **20** of member **18**. Rupture disc **46** may be fractured manually with a suitable tool, the rupture disc may be pressure sensitive and thus will fracture when the pressure within reservoir **10** reaches a predetermined level or the rupture disc may be shattered by means of the apparatus of FIGURE 4. In FIGURE 4, the rupture disc is punctured by a pointed extension **50** of a plunger **52**. Plunger **52** is normally spring loaded via spring **54** in a direction away from the rupture disc. However, upon energization of a solenoid **56**, the plunger will be urged forward compressing spring **54** and pointed extension **50** will puncture the rupture disc thus releasing the contents of reservoir **10**. The gas escaping from the reservoir will be directed outwardly through oppositely disposed discharge ports **58** and **60** in the solenoid housing **62**. It is also to be noted that the rupture disc **46** forms a part of the solenoid assembly in the embodiment of FIGURE 4 and, of course, the device may be reused by removing apertured retaining nut **48** and inserting a new rupture disc.

In the preferred embodiment of the present invention, as noted above, the cartridge seam melter **36** is an electrical heating element. Current is supplied to seam melter **36** via conductors **70** which communicate between the exterior and interior of the apparatus. Conductors **70** pass through the wall of reservoir **10**, preferably in the vicinity of the neck portion **14** as shown, and thereafter pass into the interior of the reaction chamber through the walls of cylindrical member **27**. Sealing means, not shown, are provided to prevent leakage between the interior and exterior of reservoir **10** around conductors **70**. In the reaction chamber **22**, the conductors are positioned along one of gas tubes **40**.

In operation, the device **18** is loaded by the insertion in reaction chamber **22**, of the solid chemical cartridge **32** and the liquid chemical cartridge **34**. The solid chemical will typically be in granular form and the cartridge therefore will be a perforated basket or woven wire cage. The liquid chemical cartridge will be an annular shaped plastic bag. In loading member **18**, chemical cartridges **32** and **34** will be inserted serially. After loading, the spacer ring or rings and retaining nuts will be threadably engaged with member **27** thus completing the assembly of the exothermic chemical reactor and heat exchanger.

Once device **18** has been loaded, it will be inserted into reservoir **10**. The discharge end **20** of device **18** will threadably engage the internally threaded neck **14** of reservoir **10** thus locking the device **18** into position. Reservoir **10** is then suitably charged with a liquified gas in a manner well known in the art. Thereafter, the rupture disc **46** will be positioned so as to seal off the interior of the apparatus and the retaining nut **48** will be inserted to complete the assembly.

When it is desired to employ the present invention, current will be supplied to seam melter **36** via conductors **70**. The passage of current through the metallized strip which is in contact with the bottom seam of the plastic liquid cartridge **34** melts the plastic allowing the chemicals of the liquid and solid cartridges to contact each other thereby starting an exothermic chemical reaction. Restated, the melting of the seam on the liquid cartridge **34** results in the liquid pouring out of its container or in the solid chemical cartridge falling into the now open liquid cartridge. The attitude or orientation of the apparatus at the time of actuation will determine which occurs.

Independently, at this time, the rupture disc **46** will be punctured either manually or by energization of solenoid **56** of the embodiment of FIGURE 4. The chemical reaction which takes place in reaction chamber **22** furnishes the heat required to vaporize the liquified gas which flows through the heat exchanger tube **24** upon the breaking of the rupture disc **46**. Restated, the chemical reaction in reaction chamber **22** results in the heating of the walls and fins of the heat exchanger tube **24** and thus results in the vaporizing of material escaping from the reservoir **10** through the heat exchanger tube. Heat is thus applied in the region where the gas exists from the reservoir by reacting the heat producing chemicals in an annular chamber which surrounds the exit passage. The heat demand is maximized in the discharge passage by restricting the latter so that a significant portion of the total pressure differential between the reservoir and utilization device is incurred where the material passes from the interior to exterior of the apparatus.

As the reaction proceeds, gaseous reaction products are generated within reaction chamber **22** thereby developing a positive pressure within the reaction chamber. As the liquified gas **12** flashes into vapor and discharges from the apparatus, the pressure within reservoir **10** decreases. When the pressure differential across valve means **26** becomes great enough, the valve opens, as shown in FIGURE 3, and the gaseous reaction products enter the reservoir where they mix with the remaining charge material. Thus, use of a chemical reaction where the reaction products are gases, in combination with the pressure sensitive valve means, provides a degree of self-regulation in the present invention.

It should also be noted that the problems of the prior art which resulted from overcooling in the discharge path

are overcome by the present invention. Further, any cooling which does occur in the discharge passage results in a self-compensating action through the efficient heat exchange of the present invention. That is, overcooling of the discharge passage will result in a lower temperature in the reaction chamber thereby reducing the reaction chamber pressure and consequently speeding up the exothermic chemical reaction.

A heat insulator **47** retards conduction of heat from the seam melter **36** to the liquid in the cartridge, thereby concentrating the heat on the cartridge seam.

While a preferred embodiment has been shown and described, various modifications and substitutions may be made thereto without departing from the spirit and scope of the present invention. Accordingly, it is to be understood that the present invention has been disclosed by way of illustration and not limitation.

I claim:

1. A gas generator comprising a reservoir for an inert liquid to be vaporized into gaseous form, said reservoir having a gas discharge port therein;

a reaction chamber disposed within said reservoir;

means for initiating a chemical reaction within said reaction chamber to thereby generate heat within said reservoir to vaporize said liquid, and

tubular surface heat exchanger means extending through said reaction chamber and communicating at its ends, respectively, with said gas discharge port and the interior of said reservoir, whereby heat generated in said reaction chamber by said chemical reaction will be transferred to fluid passing through said heat exchanger means.

2. The gas generator of claim **1** wherein said reservoir, reaction chamber and heat exchanger are coaxial, said gas discharge port is at one end of said reservoir and the ends of said reaction chamber are disposed, respectively, adjacent said gas discharge port and between the ends of said reservoir.

3. The gas generator of claim **2** with the addition of

pressure sensitive valve means communicating between the interior of said reaction chamber and the interior of said reservoir, said valve means operating to permit mixing of reaction products with the contents of the reservoir.

4. The gas generator of claim **1** wherein said means for initiating a chemical reaction comprises:

a first cartridge containing a first chemical in liquid form;

a second chemical, said first and second chemicals reacting exothermically when mixed, and

electric heater means for rupturing said first cartridge.

5. The gas generator of claim **2** wherein said means for initiating a chemical reaction comprises:

a first plastic cartridge containing a first chemical in liquid form;

a second chemical, said first and second chemicals reacting exothermically when mixed, and

electric heater means for melting a portion of said first cartridge to thereby allow mixing of said chemicals.

6. The gas generator of claim **5** further comprising:

pressure sensitive valve means communicating between the interior of said reaction chamber and the reservoir, said valve means operating to permit mixing of products of said exothermic chemical reaction with the contents of the reservoir to maintain reservoir pressure.

7. The gas generator of claim **6** further comprising:

rupture disc means for sealing said gas discharge port prior to use of the apparatus.

8. The gas generator of claim **7** wherein said rupture disc means comprises:

a rupture disc;

pointed rod means for rupturing said disc, and

solenoid means for urging said rod into contact with said disc upon energization.

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U.S. Cl. X.R.

60—39.48; 62—52