Feb. 20, 1951 J. A. HANNUM 2,542,194

GAS GENERATOR

Filed June 14, 1947 3 Sheets-Sheet 1

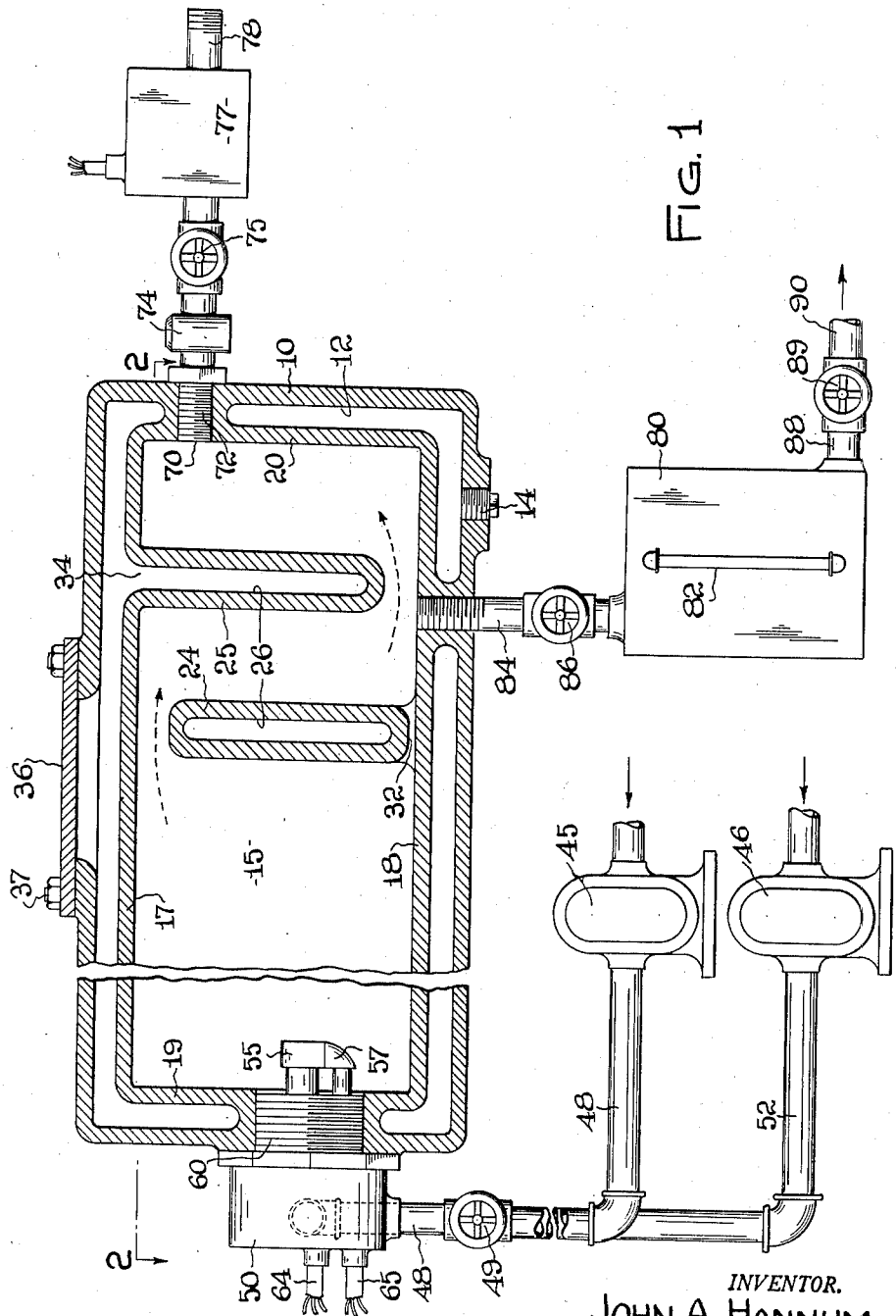


FIG. 1

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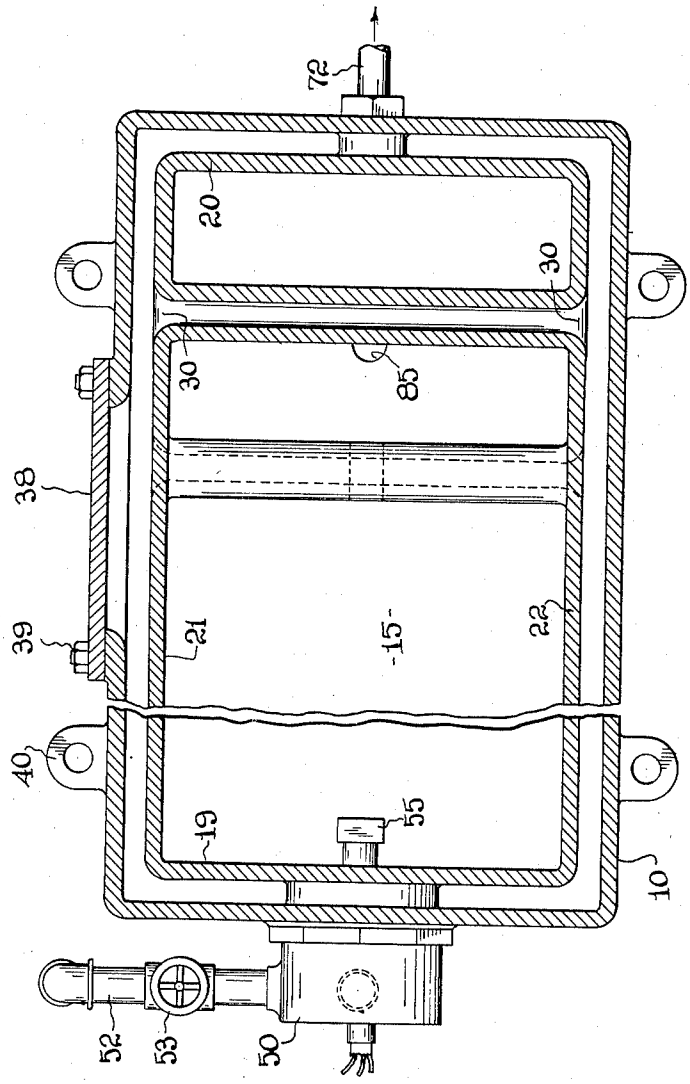


FIG. 2

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Feb. 20, 1951 J. A. HANNUM 2,542,194

GAS GENERATOR

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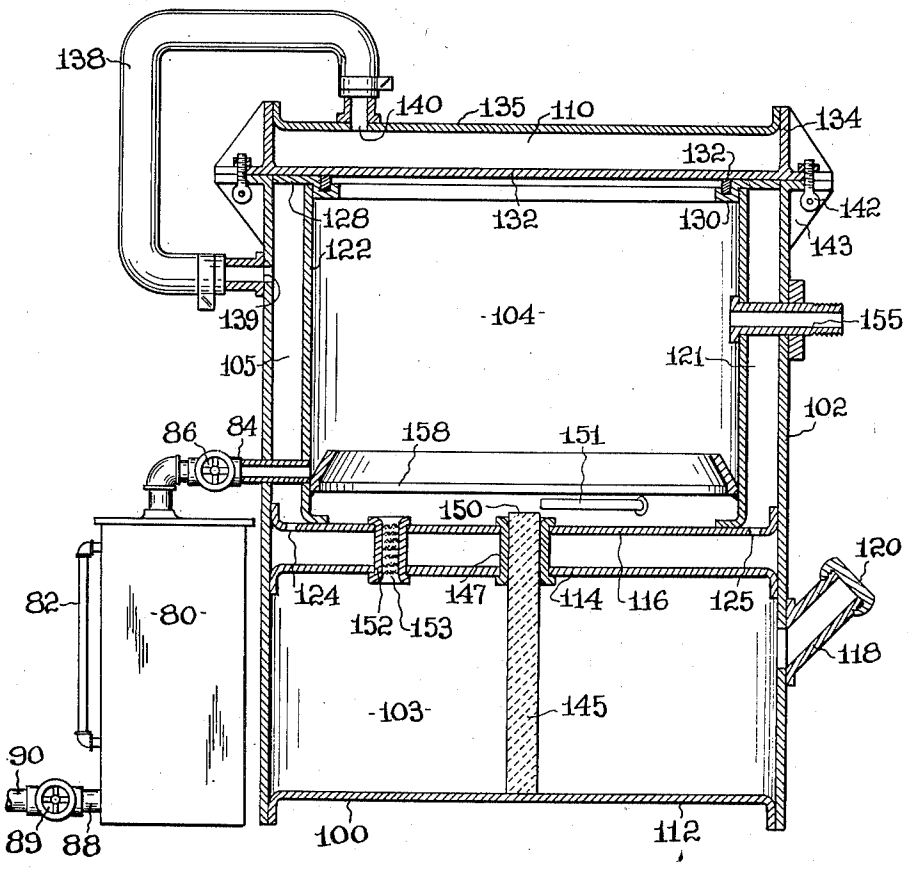


FIG. 3

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GAS GENERATOR

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Application June 14, 1947, Serial No. 754,788

5 Claims. (Cl. 23—281)

1

This invention relates to a method and apparatus for producing gas under pressure by confined combustion of a fuel and oxidant and more particularly to the conversion of a small volume of a liquid of relatively high specific gravity into a large volume of permanent or semi-permanent gas of low specific gravity.

Apparatus constructed in accord with this invention performs the same ultimate function as an ordinary gas compressor that employs a rotor, reciprocating piston or the like to receive gas at low pressure, compress it and transmit it at a higher pressure. Such compressors require numerous moving parts that must fit closely with each other to avoid gas leakage and that must be replaced from time to time as they wear during use. Furthermore considerable amounts of power are required to drive the moving parts, particularly when the gas is to be compressed to high pressures and the presence of the moving parts results in noise and vibration.

A general object of the present invention is to provide an improved method and apparatus for producing a compressible fluid, including steam, at high pressure. Another object is to decompose under controlled conditions a liquid with a relatively high specific gravity into a relatively large volume of gas under pressure. A further object is to provide a method and apparatus for producing a compressible fluid under conditions where quietness of operation and freedom from vibration of the apparatus is essential. Still a further object is to supply fuel and oxidant in continuous streams to be burned in a confined combustion chamber to produce elastic fluids under pressure.

An additional object is to provide apparatus by which fuel and oxidant fed as nongaseous material in the required proportions are mixed and ignited in a continuous reaction to decompose to gases. Still a further object of the invention is to provide an apparatus as indicated that may be conveniently cooled and from which condensate accumulating within the combustion chamber may readily be removed during operation without appreciable loss of pressure in the chamber. Other objects of the invention include the provision of apparatus that is automatically controlled in its operation to feed the required amounts of fuel and oxidant to the nozzle and to afford continuous operation with safety against excess pressures that may be built up as combustion of the fuel and oxidant proceeds.

Further objects of the invention will become apparent from the following specification when

2

read with reference to the accompanying drawings. The novel features of the invention are summarized in the claims.

Referring now to the drawings: Figure 1 is a vertical transverse section through a combustion apparatus embodying the present invention; Figure 2 is a section through Figure 1 as indicated by the lines 2—2 thereon and Figure 3 is a vertical transverse section through a modified form of apparatus embodying the present invention.

The apparatus by which the present invention is practiced is preferably provided in one of the forms shown in the drawings and in the first case includes as a central component a combustion unit 10 in the form of a metal casting. The casting is cored to provide a cooling jacket 12 over substantially its entire surface through which cooling water or the like may be circulated continuously. The water is admitted through a fitting connected at 14 and after it has circulated through the jacket is removed at a similar fitting placed as desired to accomplish most efficient coolant flow over the entire surface of the combustion chamber.

The combustion chamber is indicated at 15 and is bounded over its entire surface by top and bottom walls 17 and 18, end walls 19 and 20 and side walls 21 and 22 of the casting. This chamber includes two, although more or less may be provided, hollow transverse webs 24 and 25 that act as radiation shields or baffles between the outlet and the major combustion region within the chamber. Each web is cored as indicated at 26 and the hollow portion thereof opens into the cooling jacket 12 where the transverse webs merge with the side walls 21 and 22 at 30 as shown in Figure 2. The web 24 is closed at the center of the bottom to provide a drain passage 32 for purposes hereafter described and opens into the jacket 12 through the bottom 18 on each side of the passage 32 in the same manner as indicated at 30 in connection with the side walls. The web 25 is open at the top as indicated at 34 in Figure 1 to communicate with the interior of the jacket 12 through the top wall 17. It will be evident that coolant circulated through the jacket 12 also cools the webs 24 and 25 to maintain them at the desired operating temperature.

In order that the webs may properly act as radiation shields or baffles they are so arranged that gas traveling from the left-hand side of the combustion chamber (Figure 1) must travel a circuitous path over web 24 and under web 25 as indicated by the dotted arrow to reach the outlet. This passes the gases in contact with appreciable

cooling surface and effectively prevents heat due to the high temperatures at the point of combustion from traveling across the combustion chamber to the outlet.

In order to permit access to the jacket 12 and the hollow webs, both for the removal of core sand after the casting is poured and also for maintenance purposes during its life a plate 36 is provided bolted as at 37 to the top and a similar plate 38 is provided bolted at 39 to the side. The unit may be bolted to a suitable foundation by bolts passing through lugs 40 as shown in Figure 2.

The material that is burned within the central portion of the combustion chamber preferably consists of nitromethane as a fuel and tetranitromethane as an oxidizing agent supplied to the point of combustion in stoichiometric proportions that burn to end products of carbon dioxide, water and free nitrogen. To supply these materials two conventional gear pumps 45 and 46 are provided, the one to pump nitromethane and the other to pump tetranitromethane from separate suitable storage tanks. The pump 45 pumps through piping 48 and a valve 49 to discharge into a burner 50 as shown in Figure 1 and the pump 46 pumps through piping 52 and a valve 53 also to discharge into the burner 50.

In the burner the two materials are brought together at a suitable mixing nozzle 55 and discharged from the end thereof into the combustion chamber 15.

An electric igniter 57 of any well-known construction forms an integral part of the burner and assures combustion of the mixed and vaporized liquids leaving the nozzle. The igniter may be intermittent in operation in the sense that it is used only when the device is started or it may be continuous in operation to insure continuous combustion under all conditions. The burner is provided with a nose 60 that is threadedly received in a corresponding opening of the unit 10 and is secured tightly in place therein. Two sets of leads indicated at 64 and 65 are provided, the former to supply current for the operation of the igniter and the latter to operate electric control valves to control the supply from the pumps 45 and 46 in accord with the pressure at the outlet of the combustion chamber as hereafter described.

The fuel and oxidant that are discharged from the nozzle are burned in the enlarged part of the combustion chamber 15 between the end wall 18 and the transverse web 24 and the volume of gas generated thereby fills the entire chamber 15, circulating past the webs and ultimately passing out of the chamber due to the pressure created by the continuous combustion of the fuel and oxidant supplied. The products of combustion leave the chamber at a threaded opening 70 in which is secured a pipe fitting 72. The fitting in turn communicates with a pressure safety relief valve 74, a hand valve 75 and a pressure operated control box 77 all of conventional construction. After passing through these devices the gas continues through piping 78 to its place of use or to a storage tank.

The safety valve 74 functions quickly to relieve the pressure within the combustion chamber if it builds up beyond a safe value. The hand valve 75 may be closed as desired to cut off the flow of gas between the combustion chamber and the piping 78.

Automatic control of the burning cycle is provided by means of the mechanism indicated at 77 which is connected through leads 79 with the leads 65 of the burner 50. Since this control mechanism operates in a well-known manner it will not be described in detail. As stated above the burner 50 includes electric control valves by which the supply of either or both fuel and oxidant may be cut off. If the pressure of the gas passing through the control mechanism 77 falls below a predetermined value current travels through the leads 79 into the burner 50 at 65 to open the required valves and supply more of either or both fuel and oxidant. On the other hand if the pressure within the control mechanism 77 rises beyond a predetermined point the supply of fuel and oxidant is in like manner decreased. There is thus provided an automatic throttling means to control automatically in accord with a predetermined pressure to be maintained at the outlet 78 that proper amount of fuel and oxidant necessary at the nozzle 55.

Due to the cooling action of the jacket 12 and the fact that water is normally one of the end products of the reaction taking place in the combustion chamber a certain amount of condensate will accumulate therein. This condensate gradually increases to a point where it covers the bottom 18 of the chamber 15, being free to pass from one side of the web 24 to the other through the opening 32. From time to time this condensate may be removed from the system without substantially decreasing the pressure therein by use of the mechanism now to be described. A tank 80 with a gauge glass 82 to indicate liquid level is connected through piping 84 into a threaded opening 85 communicating with the interior of the combustion chamber. A hand valve 86 permits this line to be closed as desired. In like manner piping 88 leads from the tank 80 through a hand valve 89 to piping 90 that discharges into a drain. The tank 80 and the piping 84 are strong enough to withstand pressures as great as any reached within the combustion chamber 15.

In operation the valve 89 is normally closed and the valve 86 is opened when it is desired to drain liquid into the tank 80 and empty the combustion chamber. The volume of the tank is so small in relation to the volume of the chamber 15 that there is no appreciable pressure drop in the latter when this is done. After the tank 80 has been filled to the desired height as indicated by the gauge glass the valve 86 is closed and the valve 89 is opened to drain the tank after which this latter valve is again closed. The operation may be repeated when needed.

A modified form of apparatus embodying the present invention is illustrated in Figure 3, that figure being a transverse vertical section through a cylindrical apparatus constructed of sheet or plate material welded together as hereafter described and, among other ways, differing from the apparatus previously described in that the fuel and oxidant are not supplied separately as components of a bi-fuel but as a true mono-fuel stored in a reservoir formed in the apparatus.

Referring now to Figure 3 the apparatus is generally indicated at 100 and comprises a cylindrical sheet metal and welded tank 102 divided into a fuel reservoir 103, a combustion chamber 104 and a cooling jacket 105. The combustion chamber is open at the top and in operation is closed by a removable cap or top 110 that is also provided with a cooling jacket.

The reservoir 103 is formed within the side

wall 102 between a bottom plate 112 and a bulkhead 114 extending across the tank and welded to the side wall. A second bulkhead 116, spaced above the first, provides a region between the reservoir and combustion chamber for the circulation of coolant so that high temperatures developed in the combustion chamber do not transmit heat to the fuel in the reservoir. A feed pipe 118 is flanged and welded to the side 102 as indicated to permit fuel to be added to the reservoir and this feed pipe is normally closed by a removable cap 120.

The combustion chamber 104 is formed within a circular shell 122 spaced concentrically within the shell 102 to provide a vertical portion 121 of the cooling jacket 105 through which coolant may be circulated. The portion 121 communicates at 124 and 125 with the region between the bulkheads 114 and 116 providing for substantially continuous circulation of coolant throughout the jacket 105 of the container. The vertical side part 121 of the jacket 105 is sealed at the top by an annular ring shaped plate 128 welded in place and provided with a downturned annular lip 130 and a sealing gasket 131 to provide a tight seal with the removable top 110.

The top portion comprises a circular steel plate 132 to which is secured an upstanding steel ring 134 welded thereto. An outer steel plate 135 is flanged and welded to the ring 134 as indicated providing within the top a part of the general cooling jacket surrounding the combustion chamber. A hose 138 communicates at 139 with the vertical portion 121 of the cooling jacket and at 140 with the top part insuring complete circulation of coolant over the entire surface of the combustion chamber. Coolant may be admitted to and removed from the system at convenient points. The top is secured in place on the container by bolts 142 pivotally pinned to flanges 143 of the tank 102.

The mono-fuel, preferably a mixture of nitromethane and tetranitromethane, is transferred from the reservoir 103 to the combustion chamber 104 by a porous ceramic wick 145 resting on the bottom plate 112 and passing through a ring or sleeve 147 secured to each of the bulkheads 114 and 116. The wick is tightly cemented in the sleeve 147 to prevent any leakage between the wick and sleeve side walls from the combustion chamber to the reservoir. Liquid fuel is transferred by the porous wick from the reservoir to its upper surface 150 where it is ignited by an igniter 151 and burned to form gas as previously described in connection with the apparatus of Figures 1 and 2. As the fuel burns the pressure in the combustion chamber is increased over that in the reservoir 103 and this pressure is equalized by means of a sleeve 152 that acts as a duct permitting communication between the two parts of the apparatus. The sleeve 152 is tightly packed with screening material 153 that operates as a flame check in accordance with the well-known principle of the Davey safety lamp to prevent flame transfer from the combustion chamber to the reservoir.

Products of combustion formed in the combustion chamber are removed from the apparatus through a sleeve 155 that may be connected to a hose or other container in which the gases are to be received. If desired safety mechanism may be incorporated at this point in the form of a safety blow-off valve that operates automatically

in the event the pressure within the combustion chamber becomes excessive.

As combustion proceeds the aqueous product of combustion will condense out as liquid on the wall of the jacket 122 due to the cooling effect of the circulating coolant and this condensate will drop down the shell wall and lie in a V-shaped annular trough formed between the shell and an annular ring 158 welded thereto. When the liquid in this trough has accumulated in sufficient quantity it may be removed from the system in exactly the same manner as described in connection with the tank 80 and the valves and related equipment illustrated in Figure 1 and described above. In order to avoid duplication of description the elements of the apparatus so used are given identical reference characters in Figure 3 as their similar parts that perform the same function have been given in Figure 1.

While both forms of the apparatus described herein employ cooling jackets to remove excess heat from the walls of the combustion chamber under certain conditions this is neither necessary or desirable as for instance in production of hot gases or steam. In such case insulating material of any well-known form, such as glass fiber, is tightly packed around the combustion chamber effectively to insulate its interior from the outer surroundings. Thus in either of the constructions described all of the space occupied by the cooling jacket construction in the side, end, top and bottom walls of the combustion chamber is replaced by such an insulating packing or jacket. This may best be illustrated in connection with the construction of Figure 3 where such a modification would consist in packing the space between the bulkheads 114 and 116, the vertical portion 121 of the cooling jacket, and the top portion 110 of the top thereof with such insulating material as glass wool. The hose 138 would be dispensed with. There thus would be provided a complete shell of insulating material surrounding the entire combustion chamber.

From the foregoing description it will be evident that by means of the invention gas under pressure may be generated by confined combustion of fuel and oxidant without the necessity of employing numerous moving parts such as are found in the conventional compressor.

It is intended that the patent shall cover, by suitable expression in the appended claims, whatever features of patentable novelty reside in the invention.

I claim:

1. Apparatus for generating gas under pressure comprising an enclosed combustion chamber, a cooling jacket surrounding said chamber to cool the walls thereof, a burner nozzle discharging into said chamber, an igniter in said chamber adjacent the point of discharge of said nozzle, two conduits leading to said nozzle, one for fuel and the other for oxidant, pumps to transmit said fuel and oxidant respectively through said conduits to said nozzle, electrical control valves in said conduits interposed between said pumps and said nozzle, a first outlet from said chamber including a condensate tank, a second outlet from said chamber including a pressure responsive device, and electrical connections between said pressure-responsive device and said valves to operate said valves in predetermined manner in accord with pressure changes in said second outlet.

2. Apparatus for generating gas under pres-

sure comprising an enclosed combustion chamber, a cooling jacket surrounding said chamber to cool the walls thereof, a burner nozzle discharging into said chamber, an igniter in said chamber adjacent the point of discharge of said nozzle, two conduits leading to said nozzle, one for fuel and the other for oxidant, pumps to transmit said fuel and oxidant respectively through said conduits to said nozzle, electrical control valves in said conduits interposed between said pumps and said nozzle, an outlet for removing gaseous products of combustion from said chamber, said outlet including a pressure responsive device, electrical connections between said pressure-responsive device and said valves to operate said valves in predetermined manner in accord with pressure changes in said outlet, and an outlet for removing condensate from said chamber, said outlet comprising a first conduit including a shut off valve, a condensate tank connected to said first conduit, and a second conduit including a shut off valve, whereby to permit condensate to be drained from said chamber into said tank and then out of said tank without releasing the pressure therein.

3. Apparatus for generating gas under pressure comprising an enclosed combustion chamber, an enclosed reservoir in communication therewith, a first passage connecting said reservoir and said combustion chamber, a fuel transfer device in said first passage, a second passage connecting said reservoir and said combustion chamber, a flame check in said second passage, and, traversed by said passages, a jacket surrounding said combustion chamber.

4. Apparatus for generating gas under pressure comprising an enclosed combustion chamber, an enclosed reservoir in communication therewith, first passage connecting said reservoir and said combustion chamber, a ceramic wick in said first passage, a second passage connecting said reservoir and said combustion chamber,

a flame check in said second passage, and, traversed by said passages, a jacket surrounding said combustion chamber.

5. Apparatus for generating gas under pressure comprising an enclosed combustion chamber; a cooling jacket surrounding the sides and ends of said chamber; a supply system including means traversing said jacket for delivering fuel and oxidant to said chamber; an igniter in proximity thereto, said igniter likewise traversing said jacket; a valve-controlled conduit traversing said jacket for removing gaseous products of combustion from said chamber; means communicating to said supply system deviations in pressure in the gaseous products of combustion being removed from said chamber; a valve-controlled conduit traversing said jacket in the bottom portion of said chamber; means for guiding condensate collecting in said chamber for discharge into said last-mentioned conduit; and, connected to said last-mentioned conduit, a condensate tank disposed outside said jacket below the bottom of said chamber.

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