Aug. 1, 1950 E. R. WEAVER 2,516,934

GAS GENERATOR

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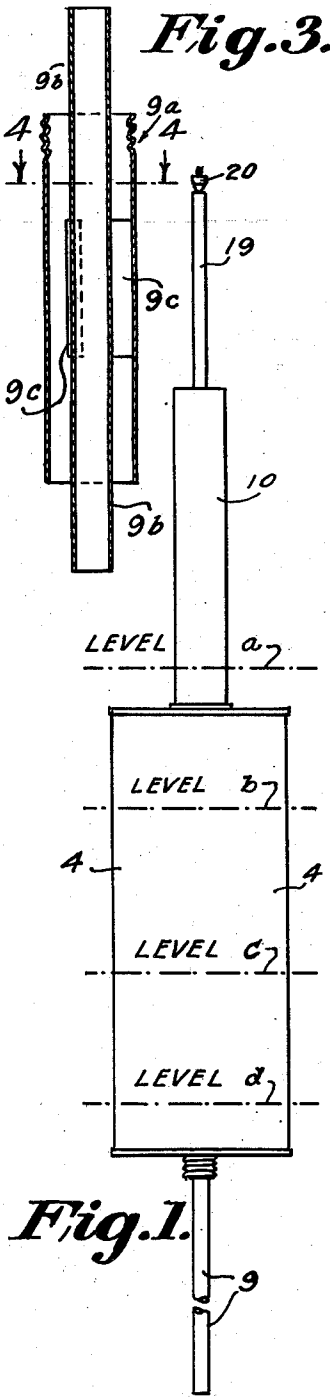


Fig. 3.

Fig. 1.

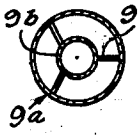


Fig. 4.

Fig. 2.

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GAS GENERATOR

Elmer R. Weaver, Chevy Chase, Md.

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9 Claims. (Cl. 23—281)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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The invention described herein may be manufactured and used by or for the Government of the United States for governmental purposes without the payment to me of any royalty thereon in accordance with the provisions of the act of April 30, 1928 (Ch. 460, 45 Stat. L. 467).

This invention relates to a hydrogen generator and more particularly to a hydrogen generator for inflating a balloon at sea.

Lifeboats and rafts for use in case of a disaster at sea are frequently provided with small radio transmitters for signalling for aid and for guiding rescuers to the survivors. One method of raising an antenna for such a transmitter is by a balloon, which must be inflated after the disaster.

It is therefore desirable to provide, along with the transmitter and balloon, a suitable hydrogen generator for inflating the balloon. Hydrogen may be prepared by reacting any of a number of reagents with water. Among the reagents having the most desirable characteristics for this purpose are lithium hydride, sodium hydride and calcium hydride. In time of war, when hydrogen generators of the type disclosed are the most in demand, sodium hydride is the reagent most likely to be available in sufficient quantities. The generator described herein, while advantageous for use with other reagents, is particularly advantageous for use with sodium hydride.

Sodium hydride is so active that only a small area of contact is necessary to produce gas at a high rate, particularly during the early stages of the reaction. The generation of the hydrogen is accompanied by the production of a considerable amount of heat which under certain circumstances could ignite an explosive or combustible mixture of hydrogen and air. Since the generator is designed to be carried on ships and aircraft, it is necessary to insure that accidental contact of water and the sodium hydride does not occur.

When the sodium hydride is purposely brought in contact with water to inflate the balloon, the balloon must be protected from the heat generated. There are two reasons for cooling the hydrogen as much as possible. High temperature greatly affects the strength of thin rubber balloons, and the steam which necessarily accompanies the hot hydrogen considerably reduces its lifting power. Protection of the rubber against the high temperature is much the more important reason.

Particularly at the beginning of inflation it is difficult to prevent the balloon from folding over

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the end of the delivery tube so that the stream of emerging gas impinges directly on some part of the balloon. The relative resistance of a balloon to bursting and tearing depends on the strength of the weakest part in the same manner that the strength of a chain is that of its weakest link. Hence the overheating of even a very small area of the balloon during inflation is highly important.

The rate of inflation of the balloon is limited by the practicability of controlling the temperature of the liberated hydrogen. The damage done to the balloon is likely to depend more on maximum temperature than on an average temperature and a high temperature at the beginning of inflation, when the rate of evolution tends to be the greatest, is particularly damaging. Hence if time is to be saved in getting the balloon into the air a uniform rate of hydrogen production is important.

The sodium hydride used in the generator may be combined with oil to aid in controlling the reactivity of, and serve as a binder for, the sodium hydride. Since this oil will quickly destroy the balloon if it reaches it, the entrainment of the oil in the hydrogen delivered to the balloon must be avoided with certainty.

It is an object of this invention to provide a hydrogen generator the reagent of which is protected from accidental contact by outside moisture.

It is another object of this invention to provide a hydrogen generator with means for suitably cooling generated hydrogen.

It is an object of this invention to produce a hydrogen generator with means for excluding water from the hydrogen produced.

It is another object of this invention to provide a hydrogen generator with means for excluding oil from the hydrogen produced.

It is also an object of this invention to provide a hydrogen generator with means for automatically controlling the rate at which the hydrogen is produced.

These and other objects will become apparent from the following specification taken in connection with the accompanying drawing in which:

Fig. 1 is an elevation view of the hydrogen generator assembled and ready for use.

Fig. 2 is a detailed elevation view in section of the hydrogen generator.

Fig. 3 is an alternate inlet pipe which may be used with this generator.

Fig. 4 is a plan view of the alternate inlet pipe shown in Fig. 3.

As best seen in Fig. 2, the hydrogen generator consists of an inner cylindrical wall 1 having an upper flat end wall 1b and a conical lower end wall 2. Outer cylindrical wall 4 is provided with a flat upper end wall 4a and flat lower end wall 4b. Inner side wall 1 extends down past the outer periphery of lower end wall 2 and extends down nearly to lower outer end wall 4b. The lower extending part of side wall 1 forms skirt 22. Inner wall 1 extends upward past end wall 1b and is joined to auxiliary end wall 1c. Annular wall 15a extends between inner wall 1 and outer wall 4 at a level near auxiliary end wall 1c. Cylindrical baffle member 15 is attached to said annular wall 15a and extends downwardly therefrom between inner wall 1 and outer wall 2.

Central cylindrical tube 3 extends through end walls 4a, 1c, 1b, 2 and 4b and extends slightly past upper wall 4a and lower wall 4b, screw threads 3a and 3b being placed on the outside of the upper and lower protruding ends, respectively. Inner side wall 1 is fastened and sealed, as by solder, to end walls 1b, 1c and 2. Outer side wall 4 is also sealed to end walls 4a and 4b. Central tube 3 is sealed to end walls 4a, 1c, 1b, 2 and 4b.

Between upper end wall 4a and auxiliary end wall 1c is formed a gas chamber D. Between auxiliary wall 1c and upper end wall 1b is formed a filter chamber C which is mostly filled with a filter substance 13 which may be glass wool. Between central tube 3, inner side wall 1, upper end wall 1b and lower end wall 2 is a reagent chamber A which is filled with a reagent, such as sodium hydride, adapted to produce hydrogen on reaction with sea water. Between lower end walls 2 and 4b and side walls 1 and 4 is a water chamber B.

A first set of holes 17 and lower set of holes 26 form a first group of holes communicating from the interior of central tube 3 to upper gas chamber D. A second group of holes 12 communicate from the interior of central tube 3 to the filter chamber C. A third group of holes consisting of a large number of relatively closely spaced holes 11 communicate from the interior of central tube 3 with reagent chamber A. A fourth group of holes 21 communicate from the interior of central tube 3 with water chamber B.

Central tube 3 has at the lower and upper ends thereof frangible diaphragms 5 and 8, respectively. There is also a frangible diaphragm 7 between holes 12 and holes 11 and another fragible diaphragm 6 between holes 11 and holes 21. There is a permanent diaphragm 7a between holes 26 and holes 12. Slightly below frangible diaphragm 8 is an annular valve seat 24a. Below seat 24a is a ball float 24 which is maintained in a position slightly under seat 24a by a pin 25 which extends through central tube 3.

Holes 16 are provided in the outer periphery of annular member 15a communicating from upper chamber D to the space between baffle member 15 and outer wall 4. Holes 23 are also provided in the upper portion of skirt 22. Between skirt 22 and the outer periphery of lower conical end wall 2 is placed an annular member 27 of a substance which is pervious to air but, when wet, impervious to the passage of oil. Member 27 may be a coarsely porous paper such as unimpregnated roofing felt. The member 27 covers the holes 23. A series of holes 14 are placed in the upper part of inner side wall 1 between upper end wall 1b and auxiliary end wall 1c.

It will be seen that the generator is thus provided with an outer sealed shell impervious to the entry of water, said outer shell consisting of side wall 4, end walls 4a and 4b and frangible diaphragms 5 and 8. The generator is also provided with an inner sealed shell impervious to the entry of water consisting of side wall 1, end walls 1b and 2 and frangible diaphragms 6 and 7. It will further be seen that auxiliary end wall 1c, annular member 15a, and baffle member 15 taken with holes 14 provide a bell member under which gas may escape from central tube 3 through holes 12 and eventually into upper chamber D as will be explained more in detail below.

Outlet tube 10 is provided, the bottom part of which is internally threaded and is adapted to be screwed onto the upper protruding end of central tube 3. The lower portion of outlet tube 10 is of a relatively large diameter and houses a trap 27 consisting of an inner tube 27a of relatively small diameter mounted concentrically with tube 10. The bottom part of tube 27a has an outwardly extending flange which is fastened and sealed at its outer periphery to the tube 10. The upper end of tube 27a is sealed to, and covered by, a disk-like member 27b which has a downwardly extending flange. The upper portion of tube 27a contains holes 27c which are under the downwardly extending flange of member 27b.

The upper part 19 of delivery tube 10 is of a relatively small diameter and it is adapted to receive thereover the neck of the balloon to be inflated. Portion 19 of delivery tube 10 contains holes 19a for the egress of gas. The upper end of portion 19 of outlet tube 10 is internally threaded to receive in threaded engagement therewith the intermediate threads 20a of a bayonet member 20. Bayonet member 20 when screwed into delivery tube 10 by threads 20a extends throughout the length of the portion 19 of outlet tube 10. Bayonet member 20 also has screw threads 20b at the end remote from the point.

Hence bayonet member may have its threads 20a disengaged from outlet tube 10 and the bayonet 20 may be reconnected with outlet tube 10 by threads 20b. The diameter of the restricted portion 19 and the diameter of bayonet 20 are such that both members may be thrust into central tube 3. The combined length of the portion 19 and the bayonet 20 must be such that the bayonet when thrust through the bottom end of central tube 3 will pierce the frangible diaphragm 7.

An inlet tube 9 is provided for attachment to the screw threads 3b on the lower protruding end of the central tube 3. Caps, not shown, may be provided for attachment to the upper and lower ends, respectively, of the central tube 3 when outlet tube 10 and inlet tube 9 are not in place. The caps are to protect frangible diaphragms 8 and 5, respectively.

When the generator is in storage, bayonet 9 is attached to outlet tube 10 with the shaft and point of the bayonet extending down into the portion 19 of the outlet tube. Outlet tube 10 and inlet tube 9 are both detached from the generator and the protective caps are screwed on. This reduces the space necessary for storing the generator when it is awaiting use.

When the generator is to be used, the protective caps are unscrewed and discarded. The threads 20a of bayonet 20 are disengaged from

the corresponding threads in outlet tube 10. The bayonet is turned end for end and rescrewed to outlet tube 10 by means of end threads 20b. Bayonet 20 and the restricted portion 19 of outlet tube 10 are then thrust upwardly through the bottom end of central tube 3 piercing frangible diaphragms 5, 6 and 7. Bayonet 20 is then used to pierce frangible diaphragm 8 and is unscrewed from outlet tube 10 and discarded.

Outlet tube 10 is now screwed to the upper end of central tube 3 by means of screw threads 3a and inlet tube 9 is screwed to the lower end of central tube 3 by means of screw threads 3b. The neck of the balloon to be inflated is pulled over the restricted portion 19 of outlet tube 10. The entire generator is thrust in the water to approximately the water surface level *a*. The generator will then automatically deliver hydrogen to the balloon at a uniform rate.

When the generator is immersed in water, the surface of which is at the level *a*, hydrogen is steadily produced. Within the space between the inner and outer shells, the water will stand at some level *b* which is lower than level *a* by the pressure required to force the hydrogen through openings 16 and 17, valve 18, and outlet tube 19 plus the back pressure of the balloon.

Since hydrogen bubbles out from under baffle member 15 at level *c*, the pressure at that point is common to both water and gas. Neglecting the very small pressure required to force water through openings 11 and fractured diaphragm 6 into the reagent chamber A at the rate at which it reacts, level *d* of the water in chamber A must be below level *c* by the amount of pressure required to force the hydrogen through the openings 11, 12, filter 13 and openings 14. The steady or average rate of production of hydrogen is simply the rate at which hydrogen will flow from chamber A through the passages to the bottom of baffle member 15 under the hydraulic head represented by the difference between levels *c* and *d*.

If the rate of hydrogen production decreases, the pressure required to deliver the hydrogen to level *c* diminishes; level *d* rises a little and more water comes into contact with the hydride. If the rate of production increases, so does the pressure in chamber A and water is forced out until the rate again falls back to normal. Hence the production of hydrogen at a nearly constant rate is controlled automatically and is entirely independent of the immersion of the generator until level *b* at which water stands between the inner and outer shell becomes lower than the bottom of the baffle member 15. If this occurs the hydraulic head on the generator becomes the difference between the levels *b*—*d* instead of the difference between the levels *c*—*d*.

The sodium hydride is so active that only a small area of contact between it and the water is necessary to produce gas at a high rate. Hence a small increase in the level *d* results in a large increase in the rate of production. The level *d* may be expected to remain fairly constant and the rate of reaction correspondingly constant from beginning to end.

The condition most likely to cause a serious change in the production rate in any hydraulically controlled generator, especially with a scum forming reagent like sodium hydride and oil, is the partial stoppage of the controlling orifices. In this generator the controlling orifices are particularly well protected. Water cannot rise in the generating chamber A above level *c*, which leaves a relatively large space for the breaking of foam and dropping of spray.

The gas enters the central tube through relatively small holes 11 with a change of direction and velocity both favorable to the dropping of spray. There is another change of direction and velocity at the openings 12 into the filter chamber C so that very little liquid should reach the filter 13. A relatively large volume is available for the filter 13 so that it can be made effective and still loose enough to offer very little resistance to flow in comparison with the orifices 14. Practice has shown that some liquid reaches the filter material but that none of it penetrates to the orifices 14.

The purpose of the conical end wall 2 is to provide gradual access of water to the hydride when the generator is first submerged and to insure prompt drainage of excess water when the rate of reaction becomes too high.

The generator may be made shorter and of greater diameter than the proportions shown in Fig. 1 of the drawing with the object of conserving weight. However, such modified construction limits more closely the depth of immersion possible without causing water to enter the top of the generator through holes 12 and makes deeper submersion necessary if pressure in the balloon forces water out of the generator before the reaction is complete.

One factor that tends to slow down the rate of hydrogen production toward the end of the reaction is the accumulation of sodium hydroxide and oil in the generator. At the beginning of the reaction the column of hydride rests on inner end wall 2 and rising liquid comes into contact with as much of its lateral surfaces as is necessary to maintain the constant rate of reaction automatically. Toward the end of the reaction the remaining solid hydride, immersed in oil and partially supported by bubbles of hydrogen at its under surface, floats on a solution of strong sodium hydroxide of high density and relatively low reactivity. During this stage the hydraulic levels no longer automatically control the rate of reaction which becomes merely the rate at which floating oily fragments of the solid react with a concentrated alkali.

The rate would be no longer under automatic control and the last stages of the reaction considerably hastened if the hydroxide solution could be drained away as formed and replaced with fresh water. This is possible if a double inlet tube 9a shown in Figs. 3 and 4 is substituted for the simple inlet tube 9 shown in Fig. 2. The alternate inlet tube 9a includes an inner tube 9b held concentrically within the outer tube by spacing members 9c. The inner tube 9b is longer than the outer tube and protrudes therefrom at each end. In the use of the alternate inlet tube 9a, diaphragm 6 must be substantially completely removed and the inner tube 9b of the alternate inlet tube 9a must extend above the first few holes 11 leading into the reaction chamber A. A slow but steady flow of heavy hydroxide solution downward in the outer tube and of fresh water upward in the upper tube will occur when the inlet tube of Fig. 3 is used.

The oil, which must be prevented from reaching the baloon, is lighter than water and is mostly retained in the reaction chamber A from which its escape with the hydrogen is prevented by the means already described for keeping the filter 13 clear. However, the escape of the oil into the water between the inner and outer shells from

which it might be picked up and carried on into the balloon requires other preventative means. In the generator as shown in Fig. 2, oil may usually flow through openings 11 and 21 into the water chamber B. One means of preventing any oil in chamber B from being carried into the balloon is the trap formed by skirt 22 and porous paper means 27. The porous paper 27 will pass air but, after being wet with water, will not pass oil.

A second alternate inlet tube, not shown, might also be used to prevent oil from entering the chamber B. For this purpose the upper end of the inner tube would only have to be seated against the edge of the perforated diaphragm 6. This, of course, would prevent the use of the double tube for draining off caustic solution as previously described.

Another means for keeping oil and water out of the balloon is the float valve 18 at the outlet of the generator. The ball float 24 may be a sphere of plastic and should be about half as heavy as water to prevent the possibility of its being held in place by gas pressure. When water enters the valve through openings 26, the ball rises but hydrogen continues to escape until the ball 24 seats against member 24a. Water cannot enter the large chamber D very rapidly because of the resistance to flow of orifices 16, hence the closing of the valve will be very slow and should result in a gradual increase of pressure which will tend to force the water out of chambers D and B. When the water leaves the chamber D the ball will again fall and gas will start to flow.

To prevent any remains of the film of water formed by opening and closing of the valve 18 from reaching the balloon, trap 27 is employed. Any droplets of water turned downward with the hydrogen at the trap will continue downward and remain at the bottom of outlet tube 10, the capacity of which is greater than any volume of water which can possibly reach this point.

The provision of two water-impervious sealed shells surrounding the sodium hydride adds materially to the safety of the generator since accidental puncturing of the outer shell does not allow outside moisture to come in contact with the hydride. The entire generator, because of its small size, and because of its construction with a central tube attached to all of the end walls through which it passes, allows a strong construction with light weight. The chamber B might be filled with carbon dioxide at the time of manufacture of the generator which would give at least some protection against ignition in case both inner and outer shells were punctured by an unusually severe mishap. The carbon dioxide could be inserted by dropping a small piece of solid carbon dioxide into the generator during the last stage of assembly and sealing the last frangible diaphragm 5 or 8 after the solid carbon dioxide had evaporated.

It will be understood that this generator may be advantageously used to produce other gases than hydrogen, with other reagents than the sodium hydride herein described, and for other uses than to inflate balloons. The structures above described are by way of example only and many changes and modifications of this invention will occur to those skilled in the art within the scope of the appended claims.

What is claimed is:

1. In combination an outer enclosing vessel provided with top and bottom openings, an inner closed vessel spaced from the top and bottom walls of the outer vessel and concentrically spaced from the side walls thereof, likewise provided with aligned top and bottom openings, a tube passing through and sealed in said openings, a dependent partition in the annular space between the vessels dividing the upper portion of said space into two annular spaces, and a top closure for said space, said inner vessel being horizontally divided into upper and lower chambers through which said tube extends, said tube being provided with a bottom opening into said outer vessel below the bottom of said inner vessel, intermediate openings into the lower chamber of said inner vessel, an opening into the upper chamber thereof, and an opening into the space between the covering walls of said vessels above the inner vessel, a diaphragm blocking said tube between said two last-mentioned openings, said upper chamber having an opening into the inner annular space provided by the depending wall, said top closure having an opening between the outer annular space and the space between said covering walls.

2. The combination of claim 1, in which frangible diaphragms block said tube, one being at either end, one being between the bottom opening and the intermediate openings, and one being between said intermediate openings and the tube opening into said upper chamber.

3. The combination of claim 1, in which filter material is provided in the upper chamber of the inner vessel.

4. The combination of claim 1, in which a float valve is placed in said tube above the tube opening into the space between the covering walls of said vessels above the inner vessel.

5. The combination of claim 1, in which the bottom wall of said inner vessel slopes toward the outer vessel as it approaches the tube and in which there is at least one hole in said tube communicating with the space within said inner vessel adjacent the point where said bottom wall is connected to said tube.

6. The combination of claim 1, in which there is additionally included a first frangible diaphragm between said bottom opening and the adjacent end of the tube, a second frangible diaphragm between said bottom opening and said intermediate openings, a third frangible diaphragm between said intermediate openings and the opening into said upper chamber, a fourth frangible diaphragm adjacent the top of said tube and in which a delivery tube is provided adapted for detachable connection with the top end of said tube, a pointed puncturing member detachably connected to said delivery tube with its point inside said delivery tube, said puncturing member being also adapted to be detachably connected to said delivery tube with the point outside said delivery tube, whereby in said last condition the combined length of said delivery tube and said puncturing member will permit said third frangible diaphragm to be punctured from the bottom end of said tube.

7. The combination of claim 1, in which the lower chamber of the inner vessel is filled with sodium hydride.

8. The combination of claim 1, in which an inner tube concentric with and inside said first-mentioned tube is provided, extending past said bottom opening in said first-mentioned tube and also extending past at least one of the intermediate holes in said first-mentioned tube.

9. The combination of claim 1, in which the side wall of said inner vessel extends past the bottom wall of said inner vessel forming a skirt, there being holes in said skirt adjacent to and below the bottom wall of said inner vessel, said holes in said skirt being covered by material pervious to air but impervious to oil when said material is wet.

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REFERENCES CITED

The following references are of record in the file of this patent:

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Certificate of Correction

Patent No. 2,516,934 ELMER R. WEAVER August 1, 1950

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:

Column 6, line 49, before the word "longer" strike out "no";

and that the said Letters Patent should be read as corrected above, so that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 7th day of November, A. D. 1950.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.

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