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# Apparatus for Producing Gases

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 APPARATUS FOR PRODUCING GASES.  
 APPLICATION FILED JAN. 4, 1915.

1,154,009.

Patented Sept. 21, 1915.

2 SHEETS—SHEET 1.

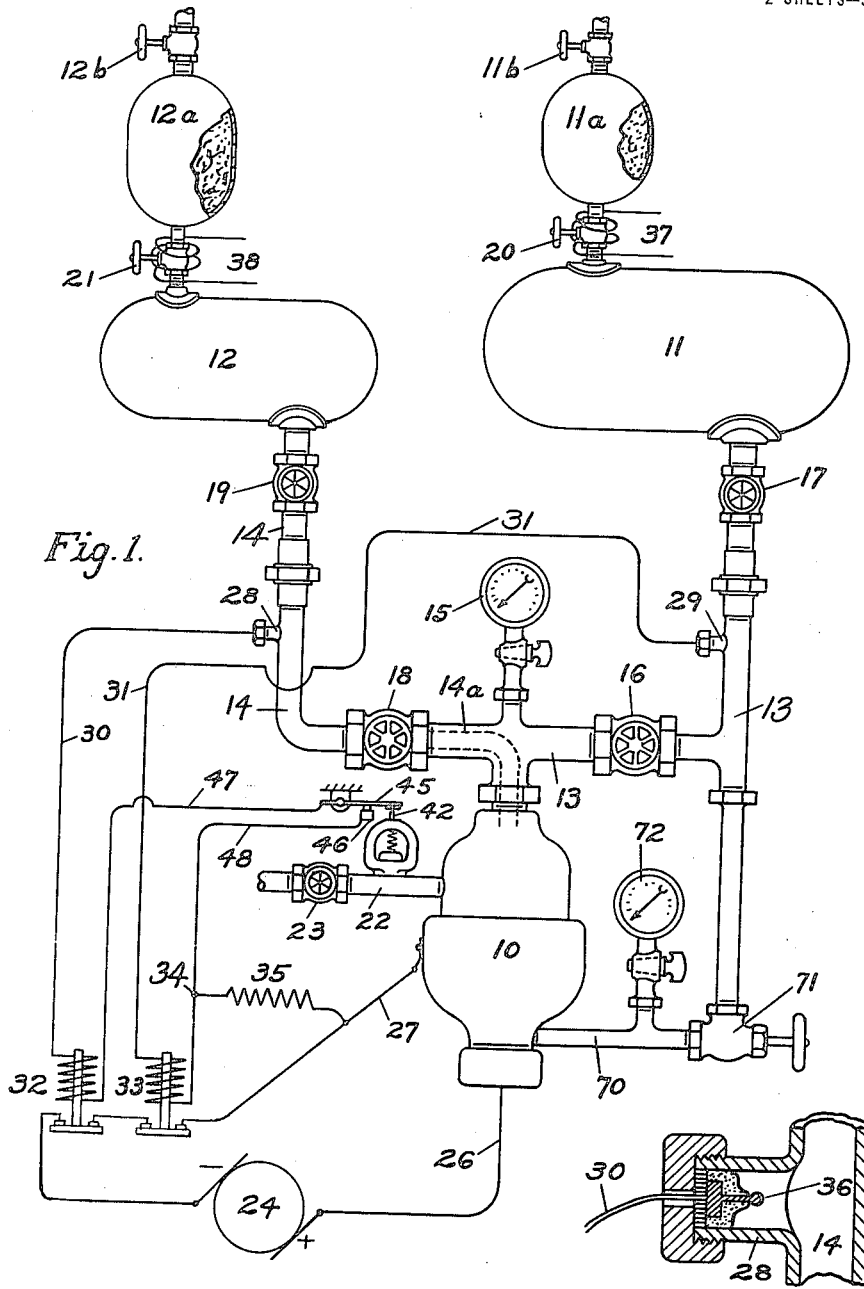


Fig. 1.

Fig. 4.

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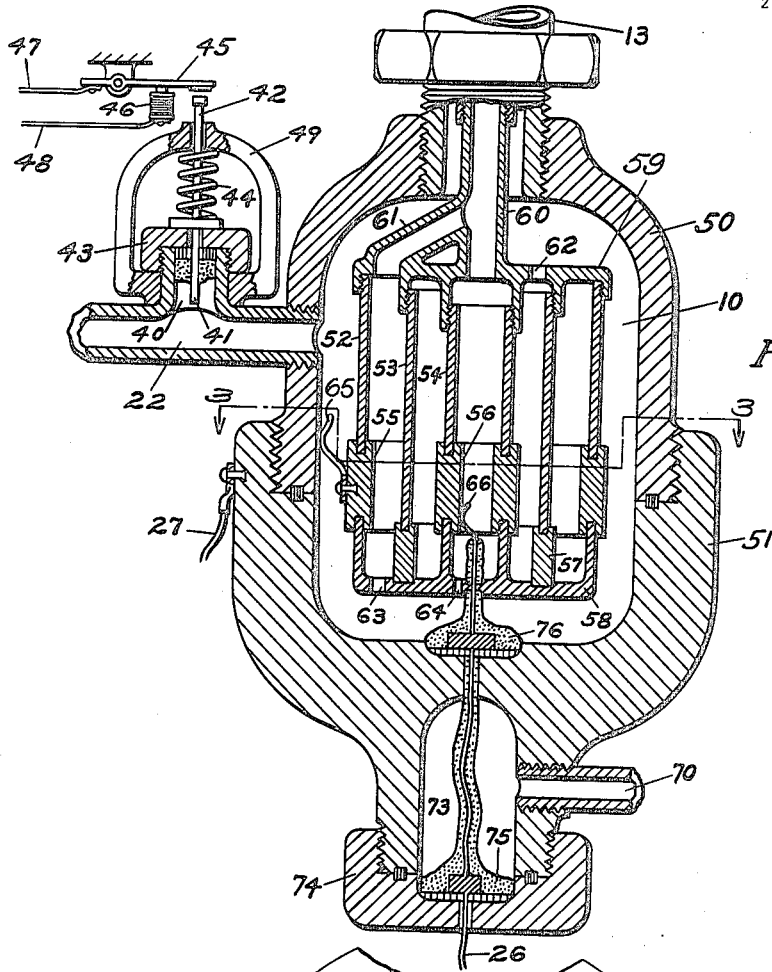


Fig. 2.

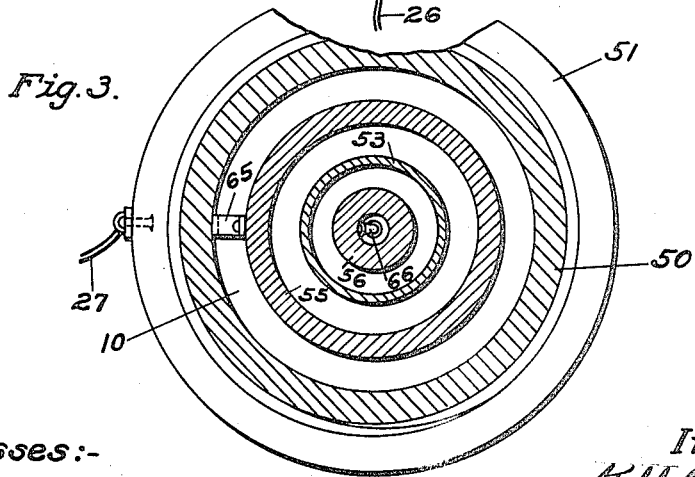


Fig. 3.

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# UNITED STATES PATENT OFFICE.

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## APPARATUS FOR PRODUCING GASES.

1,154,009.

Specification of Letters Patent. Patented Sept. 21, 1915.

Application filed January 4, 1915. Serial No. 348.

*To all whom it may concern:*

Be it known that I, ROBERT H. GODDARD, a citizen of the United States, residing at Worcester, in the county of Worcester and State of Massachusetts, have invented a new and useful Apparatus for Producing Gases, of which the following is a specification.

This invention relates to apparatus for producing gases and is in the nature of an improvement upon the well known method and apparatus for producing gases by electrolysis in which a liquid is separated into its component gases by passing a current of electricity through a suitable liquid which is termed the electrolyte. This method of producing gases has been heretofore practised at atmospheric pressure. In order that the gases thus produced may be thereafter liquefied, it is necessary that they should be placed under enormous pressure to secure the necessary compression and reduction in volume. This compression of the gases, whether for the purpose above described or for other purposes, requires the provision of costly and troublesome machines, and the operation of these machines is not without danger.

It is the principal object of my invention to provide apparatus by which the production and the compression of the gases may be substantially simultaneous, the process being capable of performance in a single simple apparatus.

A further object of my invention is concerned with the provision of an improved form of electrolysis chamber.

Other features of my invention relate to devices for automatically interrupting the operation of the apparatus on the occurrence of certain predetermined conditions and also to an improved arrangement of parts by which the pressure sustained by the packing of the electrolysis chamber is materially reduced.

My invention further consists in certain devices, arrangements and combinations of parts which will be hereinafter described and more particularly pointed out in the appended claims.

A preferred form of my invention is shown in the drawings in which—

Figure 1 is a diagrammatic view of the entire apparatus in elevation; Fig. 2 is a vertical sectional view of the electrolysis chamber and pressure cut-out; Fig. 3 is a transverse section of the chamber taken on

the line 3—3 in Fig. 2, and Fig. 4 is an enlarged detail view also in vertical section.

Referring to Fig. 1, the apparatus comprises an electrolysis chamber 10 and gas receiving tanks 11 and 12. The tank 11 is connected by a pipe 13 with the chamber 10. The chamber 12 is also connected to the upper end of a pipe 14, the lower end of which extends downwardly within the pipe 13 as indicated in dotted lines at 14<sup>a</sup> in Fig. 1. The pipe 13 is rigidly secured to the chamber 10. (Fig. 2) and the connections of the pipe 14<sup>a</sup> with the chamber will be hereinafter described. A pressure gage 15 is mounted upon the pipe 13 and a plurality of valves 16, 17, 18 and 19 control the passage of the gas to the chambers 11 and 12. Additional valves 20 and 21 prevent the escape of gas therefrom.

A pipe 22 is threaded into the side of the chamber 10, the other end of the pipe being connected to any suitable supply of electrolyte, and the flow through the pipe being controlled by a valve 23. The current for separating the liquid into its component gases may be obtained from a direct current dynamo 24 or from any other suitable source of electricity, the current being led to and from the electrolysis chamber through conductors 26 and 27.

The operation of the apparatus thus far described is as follows: The valves 16, 17, 18, 19, 20, 21 and 23 are first opened, thus permitting a flow of electrolyte into the chamber 10 through the pipe 22 while the air or gases within the apparatus are forced upward through the tanks 11 and 12. The electrolyte is allowed to flow until the entire apparatus including the tanks 11 and 12 is filled with the liquid. The valves 20, 21 and 23 are then closed and a current of electricity is passed through the conductors 26 and 27.

The separation of the liquid into its component gases immediately begins in the chamber 10 and the gases themselves pass upward through the liquid into the chambers 11 and 12. As the gases pass upward the liquid within the tanks flows downward through the pipes 13 and 14 so that the operation in the chamber 10 is continuous. In order to permit the flow of the gases in one direction and the flow of the liquid in the opposite direction, it is essential that all of the pipes and valves shall be of comparatively large size.

It will thus be seen that I am able to produce a very large quantity of gas in the tanks 11 and 12, by the use of a comparatively small electrolysis chamber. It will also appear that the gases thus produced are confined under very great pressure, as the gases themselves occupy merely the space previously occupied by the liquid from which they were derived. The tanks 11 and 12 may thus be filled with their respective gases under strong compression without the use of auxiliary compressing apparatus.

The tanks should be properly proportioned to the volumes of the gases contained in the liquid. This may be done by providing tanks of different sizes as shown or by providing a plurality of tanks for receiving the gas of greater volume.

It is often desirable that the operation of the apparatus should cease when the tanks 11 and 12 have been filled with gas and I will now describe an apparatus for automatically interrupting the current passing through the electrolyte whenever either tank is filled with its respective gas. The pipes 13 and 14 are provided near their upper ends with side outlets 28 and 29 through which conductors 30 and 31 are introduced into the interior of the pipes. (Fig. 4). The conductor 30 is connected to a circuit breaker or relay 32 and the conductor 31 similarly controls a relay 33. The conductors 30 and 31 are united at 34 and are connected through a high resistance 35 to the conductor 27. The voltage in the auxiliary or shunt circuit is so reduced by the resistance 35 that practically no electrolytic action is caused by the passage of this low current through the electrolyte.

The electrolyte is commonly a weak acid solution which acts to a certain extent as a conductor of electricity. As the conductors 30 and 31 are insulated from the pipes 13 and 14 it follows that current will flow through the conductors only when their inner ends 36 are covered by the electrolyte. The current then flowing through the conductors 30 and 31 is sufficient to energize the relays 32 and 33 and the passage of current from the dynamo 24 through the conductors 26 and 27 is continuous. As soon however as the electrolyte falls below the terminal 36 in either of the pipes 13 or 14, current will cease to flow through the corresponding conductor and the corresponding relay will open the circuit through the conductor 27, thus preventing further gas production in the chamber 10. The valves 17 and 19 may then be closed and the tanks 11 and 12 may be removed while other similar tanks are substituted therefor. These new tanks will preferably be filled with the electrolyte before connecting them with the apparatus. If however, the production of gases at lower pressure is desired the tanks may be merely

filled with their respective gases or with part gas and part electrolyte at substantially atmospheric pressure and the apparatus may be thereafter operated until any desired pressure is attained in the tank, as indicated by the gage 15.

The apparatus may be used to continuously produce gases at atmospheric pressure by opening the valves 20 and 21 and making the usual provision for collecting the gases escaping therefrom, but it is particularly designed for operation under pressure.

If the production of dry gases is essential, supplemental tanks 11<sup>a</sup> and 12<sup>a</sup> may be attached to the tanks 11 and 12 either before or after their removal from the apparatus. These tanks contain a suitable drying agent, such as calcium chlorid, and should also contain gases at atmospheric pressure corresponding in nature to that contained in the tanks 11 and 12 respectively. The drying tanks are provided with valves 11<sup>b</sup> and 12<sup>b</sup>, by which escape of the gases therefrom may be controlled.

As the valves 20 and 21 are opened to permit the expansion of the gases from the tanks 11 and 12 into the drying tanks 11<sup>a</sup> and 12<sup>a</sup>, the expansion of the gases produces intense cold which will tend to solidify the moisture in the gases and will clog the valves unless suitable provision is made for counteracting this effect. For this purpose I supply heating coils 37 and 38 which surround the valves 20 and 21, adding heat to the gases and thereby preventing clogging of the apparatus.

Gas may be admitted into the drying tanks 11<sup>a</sup> and 12<sup>a</sup> until any desired pressure is attained therein. Dry gases may then be withdrawn through the valves 11<sup>b</sup> and 12<sup>b</sup> and it will be evident that a series of storage tanks may be successively filled with dry gases at lower pressure by expansion from the high pressure tanks 11 and 12 through the drying tanks 11<sup>a</sup> and 12<sup>a</sup>.

I make special provision for interrupting the flow of current through the electrolysis chamber when the pressure in the chamber and connections exceeds a predetermined amount. For this purpose I provide an outlet or projection 40 upon the pipe 22. This projection contains a sliding piston 41 integral with a piston rod 42 projecting through a cap 43 covering the projection 40. A coil spring 44 surrounds the piston rod 42 within the guard 49 and prevents movement of the piston and piston rod until a definite predetermined pressure is exerted thereon. At its outer end the piston rod 42 engages a movable contact member 45 normally resting against a fixed contact member 46. The contact members 45 and 46 are connected by wires 47 and 48 to any suitable point in the relay conductors 30 or 31.

Whenever the pressure within the cham-

ber 10 and its connections is sufficient to overcome the resistance of the spring 44, the piston 41 and its rod 42 will be moved outwardly, thus separating the contacts 45 and 46 and causing one of the relays to interrupt the flow of current through the chamber 10.

I will now describe the specific construction of the electrolysis chamber 10. The chamber 10 consists of an upper casing 50 having its lower end closed by a heavy cap 51. Within the chamber there are supported a series of concentric cylindrical shells 52, 53 and 54, which shells are formed of a thin non-conducting material impervious to gases and not likely to crack under great pressure, vulcanized fiber being commonly used. The cylinder 52 is formed in upper and lower portions supporting between them a metallic ring 55, while the cylinder 54 supports a similar ring 56. The cylinder 53 is cut away and rests upon a porous non-conducting ring 57.

At their lower ends the cylinders 52, 53 and 54 are supported upon a bottom or head 58 also of hard non-conducting material and at their upper ends they are likewise connected to a head 59 of similar material. The head 59 is extended upwardly into the form of pipes 60 and 61, the pipe 60 connecting the space within the cylinder 54 with the depending end of the pipe 14<sup>a</sup>, while the pipe 61 forms a branch connection from the pipe 60 to the space between the cylinders 52 and 53. Holes 62, 63 and 64 are provided in the heads 58 and 59 to permit free circulation of the electrolyte and gases.

The metal ring 55 is provided with contact springs 65 which engage the inner surface of the electrolysis chamber and are thereby electrically connected with the conductor 27. The conductor 26 is introduced through the cap 51 and is provided at its upper end with a platinum point 66 contacting with the inner metal ring 56. The interior of all the metallic parts of the apparatus including the electrolysis chamber and connections and the storage tanks should be completely covered with a non-conducting and insoluble varnish to prevent corrosion of the parts. This varnish may be applied while the springs 65 and the point 66 are in electrical contact with the wall of the chamber and the ring 56 so that the varnish shall not prevent the attainment of suitable contacts. It should be noted further that no varnish should be applied to the outer surface of the ring 56 or to the inner surface of the ring 55 as the application of varnish in these surfaces would interfere with the passage of current through the chamber. Current should always flow from the conductor 26 to the conductor 27 so that the unvarnished or exposed portion of the chamber 10 and parts connected therewith may not be oxidized.

The action within the chamber will be readily apparent. The current from the dynamo 24 passes up through the conductor 26 to the inside of the ring 56 thence through the ring to the outer surface thereof, through the electrolyte and the porous ring 57 to the inner side of the ring 55, through the latter to the springs 65 and thence through the wall of the chamber 10 to the conductor 27.

While I have shown only a single ring 57 and a single pair of metallic rings 55 and 56 it will be evident that these parts may be increased to any desired number in the production of larger forms of the apparatus. Such duplication of parts would practically amount to the operation of a plurality of electrolytic cells in series, calling for a correspondingly greater voltage but at the same time increasing the amount of gas derived from a given current. The electrical resistance to this form of electrolysis chamber is very low and the efficiency is correspondingly high.

In the operation of the apparatus substantially proportionate amounts of gas should be retained at all times in the tanks 11 and 12. It is therefore not advisable to withdraw a large amount of gas from one tank without withdrawing a proportionate amount from the other. Otherwise when the apparatus is again placed in operation the excessive pressure in the full tank may force some of the gas into the partially filled tank, resulting in a mixture of gases in the apparatus. Similar results may occur if an excessive current is used, especially at the beginning of the operation of the apparatus when the pressure is comparatively low. Bubbles of gas may then be forced downward through the bottom plate 58 and through the porous ring 57 from one chamber to the other.

On account of the excessive pressures encountered in the use of this apparatus the prevention of gas leakage at the point where the conductor 26 is introduced into the chamber 10 is a matter of much importance. In order to reduce the pressures exerted upon the packing I provide a by-pass connection 70 having a valve 71 (Fig. 1) and a pressure gage 72. The by-pass 70 is connected at one end to a recess 73 (Fig. 2) formed in the lower end of the cap 51. The recess is in turn covered by a cap 74. The conductor 26 is suitably insulated at the point where it passes through the caps 74 and 51 and is provided with packing at these points as indicated at 75 and 76.

When the apparatus is started I open the valve 71 and allow the same to remain open until the gage 72 indicates one half of the maximum pressure to be obtained in the apparatus. I then close the valve 71 thus fixing the pressure in the chamber 73

at one half of the maximum. Accordingly the highest pressure sustained by the packing 76 is only one half of that sustained by the walls of the chamber 10, while a corresponding difference in pressure occurs upon the opposite sides of the packing 75. The difference in pressure is thus distributed between two packings each of which sustains only one-half the pressure which would be sustained by a single packing. Such subdivision of pressures may be carried still further by the provision of additional chambers 73 and caps 74, but a single reduction will usually be found sufficient.

Having thus described my invention it will be evident that changes and modifications can be made therein without departing from the spirit and scope thereof as set forth in the claims and I do not wish to be otherwise limited to the details herein disclosed, but

What I claim is:—

1. An apparatus for producing gas by electrolysis comprising a single comparatively small electrolysis chamber formed of two heavy rigid cast portions screw-threaded together, a pair of tanks of relatively large capacity, normally-open heavy pipe connections from said tanks to said chamber, means for closing all external passages from said tanks and chamber, and a circuit for passing a current of electricity through said chamber, the gases thereby produced being collected in said tanks under pressure generated by the evolution of the gases in a closed apparatus.

2. An apparatus for producing gases by electrolysis comprising an electrolysis chamber, a plurality of gas receiving tanks, concentrically arranged connections leading from said chamber to said tanks and permitting a flow of gas therethrough in one direction and a flow of electrolyte in the opposite direction, means independent of said tanks for filling said apparatus with electrolyte, a plurality of valves for closing all external passages from said tanks and chamber, and a circuit for passing a current of electricity through said chamber whereby after said valves are closed the evolution of gases in said chamber will take place under excessive pressure.

3. In an apparatus for producing gas by electrolysis, an electrolysis chamber, gas-receiving tanks connected therewith, a circuit for passing a current of electricity through the electrolyte in said chamber, and a shunt circuit controlling means for automatically interrupting said current when the surface of the electrolyte in the apparatus falls below a predetermined level, the electrolyte itself forming a part of said shunt circuit.

4. An apparatus for producing gases by

electrolysis, comprising an electrolysis chamber, a pair of gas-receiving tanks, connections from said chamber to said tanks arranged to convey different gases to different tanks, an electric circuit connected to pass current through the electrolyte in said chamber, and means to break said circuit whenever the electrolyte falls below either one of two predetermined points in said apparatus, each fixed with relation to one of said tanks.

5. In an apparatus for producing gases by electrolysis, an electrolysis chamber, gas-collecting tanks connected therewith, an electric circuit for passing a current of electricity through the electrolyte in said chamber, and means for automatically interrupting said current when the surface of the electrolyte in the apparatus falls below a predetermined level, said means comprising a relay in the electric circuit energized by current in a shunt circuit containing a terminal positioned at said level and insulated from said apparatus, the electrolyte in the apparatus constituting part of the shunt circuit and permitting flow therethrough whenever said terminal in the shunt circuit is covered by the electrolyte.

6. In a gas producing apparatus, in combination, an electrolysis chamber, a circuit for passing a current of electricity through the electrolyte in said chamber, and pressure-controlled means for breaking said circuit when the pressure in the chamber exceeds a predetermined amount.

7. An electrolysis chamber comprising a casing, a plurality of concentric non-conducting cylindrical shells mounted in said casing, metal rings supported by alternate shells, and electrical connections to said rings, the remaining shell positioning a porous non-metallic ring at its lower end.

8. An electrolysis chamber having, in combination, a casing, a recess in said casing, a cap covering said recess, a conductor passing through said cap, recess and casing to the interior of said chamber, inner and outer packings for said conductor, and means for reducing the pressure on the inner packing, said means comprising pipe connections from said chamber to said recess and a valve in said connections, whereby said recess may be filled with gas under any desired pressure, thereby reducing the difference in pressure sustained by the inner packing.

In testimony whereof I have hereunto set my hand, in the presence of two subscribing witnesses.

ROBERT H. GODDARD.

Witnesses:

CHAS. T. HAWLEY,  
C. FORREST WESSON.