Dec. 11, 1945. M. JANES 2,390,591

ELECTROLYTIC METHOD FOR PRODUCING OXYGEN

Filed Nov. 8, 1941

Fig. 1.

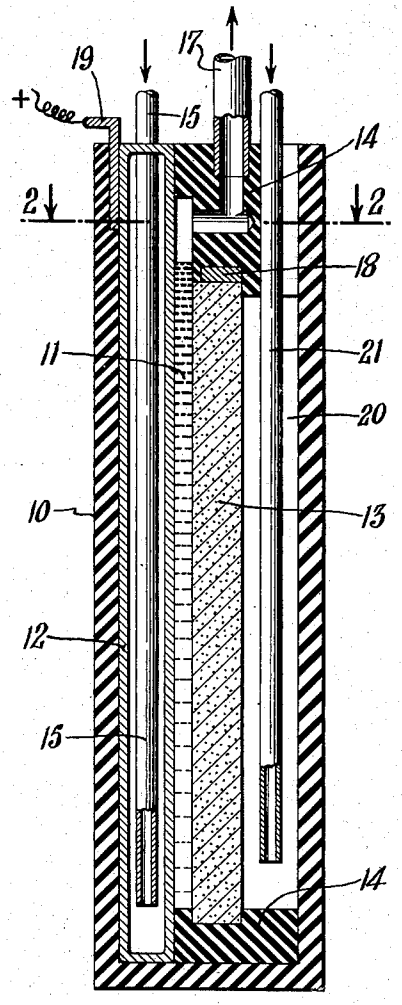
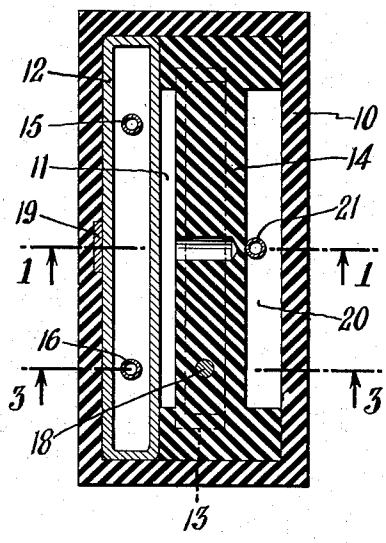


Fig. 2.



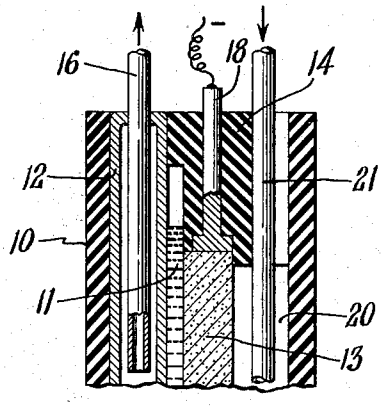


Fig. 3.

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ELECTROLYTIC METHOD FOR PRODUCING OXYGEN

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3 Claims. (Cl. 204—129)

Electrolysis of aqueous solutions of caustic alkalis or of oxygen-containing acids has been used as a method of obtaining very pure hydrogen and oxygen. The best known types of commercial cells for this purpose comprise electrodes of iron-group metal, usually of nickel-plated iron, separated by an asbestos cloth diaphragm, and as an electrolyte a solution of sodium hydroxide or potassium hydroxide in a concentration between 10% and 35%. Published data indicate that such cells can produce about 150 grams of oxygen per kilowatt-hour. Considered solely as a source of oxygen, electrolysis is so much more costly than air-separation methods that it has not competed with the latter methods; rather, it has been used as a source of pure hydrogen, the oxygen being a by-product.

The electrolytic production of oxygen offers some attractive advantages. The necessary equipment is relatively simple, inexpensive, small in volume, and durable, and requires little labor in operation and maintenance. The cost of the electrical energy is, in fact, the main impediment which has prevented the more widespread use of the electrolytic method. Another item of expense, which under some circumstances is material, is the cost of distilled water which is consumed in the process.

It is the principal object of the present invention to increase the yield of oxygen per unit of electrical energy consumed in the electrolytic production of oxygen. Another object is to provide an electrolytic method for producing oxygen, in which no hydrogen gas is liberated and which consumes no water. A further object is to produce pure oxygen by the electrolysis of aqueous caustic solutions without the use of an inter-electrode diaphragm. Another object is a method, capable of producing per unit of electrical energy from two to two and one half, or even more, times as much oxygen as is produced by electrolytic methods and apparatus heretofore used commercially. Still another object is an electrolytic method which consumes little or no water by electrolysis.

The principal feature of the invention is the use of a continuously depolarized cathode, suitably an air-depolarized porous carbon cathode, in combination with an insoluble or passive anode in an aqueous electrolyte of potassium hydroxide or sodium hydroxide. I have found that, at convenient current densities, not only is no hydrogen liberated at such a cathode but there is a substantial production of hydrogen peroxide. The hydrogen not oxidized to the peroxide is oxidized to water. When no inter-electrode diaphragm is used, hydrogen peroxide finds its way to the anode where it gives up oxygen and regenerates water.

By providing a depolarized cathode, and by eliminating the customary diaphragm, the overall voltage drop through the cell at a given current is materially lowered, thereby decreasing the electrical energy consumption. Oxidation at the anode of peroxide produced at the cathode yields twice as much oxygen per unit of electrical current as can be produced by the discharge of hydroxyl ions in the absence of hydrogen peroxide. As a result, it is readily possible to produce, per unit of energy, over twice as much oxygen as can be produced in conventional cells.

An example of an electrolytic cell suitable for use in practicing the invention is illustrated in the accompanying drawing in which:

Fig. 1 is a side sectional view, along 1—1 of Fig. 2, of an electrolytic cell,

Fig. 2 is a top sectional view along 2—2 of Fig. 1, and

Fig. 3 is a side sectional fragmentary view, along 3—3 of Fig. 2, showing a detail of the cell of Figs. 1 and 2.

The cell shown in Figs. 1 to 3 comprises an outer container 10 of caustic-resistant insulating material, or of a metal resistant to caustic, such as iron; a body of caustic alkali electrolyte 11, suitably an aqueous solution containing about 10% to 35% of potassium hydroxide or sodium hydroxide or a mixture thereof, a solution containing 25% potassium hydroxide being preferred; an insoluble or passive metal anode 12, which is preferably hollow and provided with means, such as pipes 15 and 16, for circulating a coolant, and which is preferably composed of one or more metals of the iron group (iron, cobalt, nickel); and a porous carbon cathode 13 sealed into and supported by an insulating frame 14 in such a manner as to provide a space or well for the access of air to the rear surface of the cathode 13. Above the electrolyte 11 is an oxygen-collecting manifold from which oxygen may be withdrawn through a conduit 17. Suitable electrical connections 18 and 19 may be provided for the anode and cathode.

The porous cathode 13 should be composed of "active" carbon, by which is meant herein and in the appended claims carbon of the kind that can transfer oxygen of the air to the cathode: catholyte interface in electrochemically active form where it acts as a depolarizing agent. A suitable material is that used in air-depolarized primary galvanic cells, made in any of the several

known ways, and rendered resistant to penetration by the electrolyte. For example, the electrode materials described in Patents 2,010,608, issued August 6, 1935, to E. A. Schumacher, V. C. Hamister, and G. W. Heise, and 2,017,280 issued October 15, 1935, to G. W. Heise and E. A. Schumacher, are satisfactory for use in the present invention.

Although the cathode 13 shown in the drawing is a single flat plate, modifications can of course be made. For instance, an electrode of large area may be fabricated from a number of small plates, electrically interconnected, supported in a frame in a manner analogous to glass in a multi-paned window. Instead of a flat plate having one wet face and one dry face, a hollow carbon electrode may be used, the hollow being open to the air. Circulation of the air to the bottom of the space behind the cathode may be improved by blowing air through the tube 21 shown in Figs. 1 and 2.

The anode is preferably cooled because best efficiencies are obtained when the cell is operated at a low temperature.

Under some circumstances, as at high current densities, it will be advantageous to have the depolarizing air in the space or well 20 behind the cathode 13 under pressure.

As an example of the results obtainable by the use of the invention, operating data obtained during the use of a cell comprising a nickel gauze anode, a porous carbon air-depolarized cathode, and a 25% solution of potassium hydroxide in water, at an electrolyte temperature of 0° C., are given in the following table:

Average cell voltage	Current, amperes	Cathode current density	Average, grams of oxygen per kilowatt-hour
1.11	2.0	41	380
1.21	2.5	51	340
1.39	3.0	62	305

The cathode current density is in amperes per square foot of nominal plane-surface area; the actual current densities are considerably lower, because the real surface area of porous carbon is much greater than the nominal plane-surface area.

The foregoing data indicate the general magnitude of the increase in yield of oxygen, per unit of energy, afforded by the invention. The electrolytic cell is of simple construction, and can be made of inexpensive yet durable materials. Since no hydrogen is produced, the only loss of water is by evaporation and entrainment, there is no problem of collecting and disposing of hydrogen, nor is there any problem of preventing the diffusion of hydrogen to the anode. There is no hazard of hydrogen explosions in the cell room.

Where electric power is cheap, and where because of intermittent or small demand for oxygen, or for other reasons, it is incovenient or unduly expensive to obtain oxygen manufactured by air-separation methods, the present invention provides pure oxygen at moderate cost and with inexpensive apparatus.

I claim:

1. In a process for producing oxygen by electrolyzing an aqueous solution between an anode and a cathode to produce oxygen at the anode, the improvement which comprises continuously depolarizing the cathode with oxygen to prevent the evolution of hydrogen, and promptly electrolyzing at the anode the product of such cathodic depolarization.

2. A process for producing oxygen at a rate upwards of 300 grams per kilowatt hour of electrical energy which comprises electrolyzing between an anode and a cathode an aqueous caustic alkali solution, collecting the oxygen thereby produced, and depolarizing the cathode continuously with atmospheric oxygen to prevent the evolution of hydrogen, and promptly electrolyzing at the anode the product of such cathodic depolarization.

3. A process for producing oxygen at a rate upwards of 340 grams per kilowatt hour of electrical energy which comprises electrolyzing between an anode and an air-depolarized carbon cathode an aqueous solution essentially comprising potassium hydroxide, mingling catholyte, containing cathodic depolarization product, with the anolyte, and collecting the oxygen thereby produced.

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