

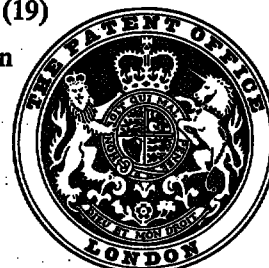
PATENT SPECIFICATION

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(54) IMPROVEMENTS IN OR RELATING TO THE RELEASE OF AN ENTRAINED GAS IN A LIQUID MEDIUM

(71) We, DIAMOND SHAMROCK CORPORATION, of 1100 Superior Avenue, Cleveland, Ohio 44114, United States of America, a Corporation organised and existing under the laws of the State of Delaware, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

The present invention relates generally to devices for separating entrained gaseous substances, e.g. the products of an electrolytic cell, from the cell electrolyte or other liquid in a very short period of time. With the use of the separation devices of the invention, a treated electrolyte solution, for instance, can be passed on to the next electrolytic cell in a bank of cells in a form in which it contains very little entrained gaseous products. This reduces significantly the power requirements of cells toward the end of a cell bank. The present invention also relates to an improved method for the removal of an entrained gaseous substance, e.g. entrained gaseous products from an electrolyte solution, as it is being circulated from one electrolytic cell to the next electrolytic cell in a series or bank of electrolytic cells.

Electrochemical methods of manufacture are becoming ever-increasingly important to the chemical industry due to their greater ecological acceptability, their potential for energy conservation and the resultant cost reductions possible. Some of the reasons advanced for this possible shift in future chemical production include the possible greater restriction upon the travel of dangerous chemical products in the transportation networks of the world, thus necessitating on-site manufacture, and the fact that electrolytic cells can generally be operated as a closed system, thereby allowing greater control over the escape of by-products or waste products from the electrolytic cell which may be environmentally undesirable. If chemical substances are more severely regulated as it is suspected at this point, smaller on-site generation of many of these chemical substances will be necessary and electrolytic cells provide an excellent means by which such substances can be generated in small quantities economically. Also, many fuels are rising rapidly in price thus making electricity a more economical source for many types of production due to expected exhaustion of fossil fuels such as coal, gas and oil and to the use of more economical nuclear generation of electricity. The electrolytic cell promises to be one of the most efficient means of utilizing electricity.

One example of the advances in the electrolytic cell technology is the electrolysis of sea water to produce aqueous hypochlorite solution. This type of electrolytic cell utilizes available sea water to obtain chlorine in a useful form for disinfection of municipal waste water fluids and treatment of industrial cooling waters. Usually these cells are connected in series to form a bank of electrolytic cells to produce the concentrations necessary for a given production need. A particular problem of this type of cell is that by the time the electrolyte is circulated to the final cell in a bank of electrolytic cells the entrained hydrogen content of such an electrolyte is very high. This entrained hydrogen has a tendency to build up on the electrodes within the final cell and thus greatly increase the power consumption by raising the potential necessary to transmit a current across the cell.

One way to separate a gaseous substance from the liquid would be to employ gravity settling. The mixture is allowed to stand at rest or move in laminar flow along a path until the bubbles have risen to the surface. The problem with this method has been that the entrained gaseous substances in the electrolyte from an electrolytic cell are of such small bubble size that a very large system and a long period of time would be required to effect separation.

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Therefore a need exists currently for a device which can release hydrogen from the electrolyte of an electrolytic cell for the production of hypochlorite at a very rapid rate and with a minimum amount of capital investment.

According to one aspect of this invention, a device for the release of an entrained gaseous substance from a liquid comprises a cylindrical top section attached to a conical bottom section at the larger diameter conjugate plane thereof, which is equal in diameter to the cylindrical top section, a feed line for the liquid located adjacent the upper part of the cylindrical top section and attached tangentially thereto so as to communicate with the interior of the device, a planar top member attached to the upper part of the cylindrical top section and including a gas release orifice of sufficient size to allow the escape of the gaseous substance while severely restricting flow of the liquid therethrough, an outlet for the liquid communicating with the interior of the device and attached to the conical bottom section at the smaller diameter conjugate plane thereof, the outlet and the smaller diameter conjugate plane being equal in diameter to the feed line, and a planar baffle attached to the interior wall of the outlet so as to protrude into the conical bottom section, for arresting circular motion of the liquid.

According to another aspect of this invention, a method is provided for removing a gaseous substance from electrolyte flowing through a series of electrolytic cells, which comprises introducing the output from one or more cells of a group of up to three cells in the series into the top cylindrical section of a cyclone having a conical bottom section, the electrolyte being introduced horizontally tangential to the interior surface, so as to form a vortex aided by the form of the conical bottom section of the cyclone, allowing gaseous substances to escape to an exhaust system, through an orifice at the top of the cyclone, arresting circular flow of the electrolyte as it nears the bottom of the cyclone, allowing the electrolyte to pass through the bottom of the cyclone under a back pressure, so as to enhance separation of gaseous substances from the electrolyte, and introducing the electrolyte from which gaseous substances have been removed into one or more cells of a group of up to three electrolytic cells connected in series for further electrochemical production.

A preferred embodiment of the device of the invention, for the release of an entrained gaseous substance from a liquid, is shown by way of example in the accompanying drawings without attempting to show all of the various forms and modifications in which the invention might be embodied; in the drawings:

Figure 1 is a side elevation view with a partial sectional view of a device for the release of an entrained gaseous substance from a liquid according to the concepts of the present invention.

Figure 2 is a side sectional view of the device with partial section views of the top and bottom portions thereof taken substantially along line 2-2 of Figure 1.

Figure 3 is a top plan view of the device with a partial sectional view of the feed line taken substantially along line 3-3 of Figure 2.

Figure 4 is a sectional view of the conical bottom section and outlet of the device taken substantially along line 4-4 of Figure 2.

Referring to the drawings, numeral 10 generally refers to a cyclone to be used for the release of an entrained gaseous substance from a liquid according to the concepts of the present invention. The cyclone 10 according to the drawings is particularly suitable for the release of hydrogen gas from an electrolyte solution exiting from one electrolytic cell in a series of electrolytic cells, passing through the cyclone 10, and into the next cell in the series of electrolytic cells. The cyclone 10 would have environmental structure with respect to connection of the cyclone 10 to an electrolytic system through piping and various other means. The details of this environmental structure have not been shown for ease of illustrating the concepts of present invention.

Referring to Figure 1 the cyclone 10 by a cylindrical top section 12 which is connected to a conical bottom section 14 to form the basic shell of the cyclone 10. If the conical bottom section 14 were a complete cone resting on its base, then a "conjugate plane" as hereinafter referred to shall mean any plane which cuts the conical section to define a circle at the intersection and is parallel to the base of the cone. Therefore, by varying the position vertically of the conjugate plane through the cone, the diameter of the circular intersection between the cone and the plane will vary in direct relationship. The conical bottom section 14 is joined to the cylindrical top section 12 at the larger diameter conjugate plane of the conical bottom section 14 which is equal in diameter to the cylindrical top section 12. Near the top of the cylindrical top section 12 is a feed line 16. The feed line 16 should enter the cylindrical top section 12 at a tangent to the interior surface of the cylindrical top section 12 so as to form an elliptical opening 18 for communication of the feed line 16 with the interior of cyclone 10. It can be seen in Figure 2 that the outermost edge of the feed line 16 is exactly tangential with the inside surface of the cylindrical top section 12, so that flow through the feed line 16 into the cyclone 10 will be in a circular pattern about the interior surface of the cylindrical top section 12. As a liquid falls due to gravity down toward the conical bottom section 14, this

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circular motion of the liquid will be increased in intensity and constricted in diameter until the liquid reaches the bottom of the conical bottom section 14. The conical bottom section 14 has an outlet 20 by which the liquid medium may exit from the cyclone 10. The outlet 20 is sized to handle a liquid flow equal in volume to the feed line 16, so as to provide no constriction of the liquid flow through the cyclone 10, and is connected at the smaller diameter conjugate plane which is equal in diameter to the outlet 20. Positioned within the entrance to the outlet 20 and exit from the conical bottom section 14 is a baffle 22, as best seen in Figures 2 and 4 of the drawings. This baffle 22 serves to arrest the circular motion of the liquid as it enters the outlet 20. This ensures good liquid flow out of the cyclone 10. Down stream from the outlet 20 a valve may be desirable to create some back pressure to maximize the gaseous substance separation process. However, if the cyclone 10 is used in a series of sea water hypochlorite cells, for instance, the cells themselves will create sufficient back pressure for excellent separation. It is believed that any type of baffle which would arrest circular motion within the cyclone 10 will accomplish this purpose but it has been found that a planar baffle constructed according to the drawings is especially suitable for this purpose, in that a solid piece of material is integrally welded across the centre of the outlet 22 and extends a short distance up into the conical bottom section 14.

The cyclone 10 has a planar top 24 attached to the opposite end of the cylindrical top section 12 so as to form a closed container in the form of the cyclone 10. Approximately at the centre of the planar top 24, a piece of tubing 26 is located in an aperture bored therethrough and sealingly engaged to the planar top 24. The end of the tubing 26 inserted through the planar top 24 is cut at a 45 degree angle arranged such that the longest end extends toward the feed line 16, to prevent liquid from splashing into the tube 26. The other end of the tube 26 extending to the exterior of the cyclone 10 has a solid plug 28 sealingly secured therein. A centre portion of the plug 28 has been drilled and tapped so as to accept a threaded bolt 30 which contains a gas release orifice 32 through the centre thereof.

A convenient means for providing for the connection of the gas released from the cyclone 10 to its piping system is to connect a tee joint 34 to the portion of the tubing 26 which extends exterior of the cyclone 10. The straight end of the tee joint 34 can be tapped so as to receive a plug 36 therein in sealing engagement. The angular opening of the tee joint 34 may then be connected to a convenient piping system to exhaust the gaseous substance from the area. When it is desirable to change the gas release orifice 32 size, the plug 36 may be conveniently withdrawn and a socket wrench may be used to withdraw the bolt 30 readily and so replace it with a second bolt 30 having a gas release orifice 32 of different dimensions to meet the requirements of the given situation. Thereafter the plug 36 may be replaced in a sealing manner so as to provide a closed system for the transport of the gaseous substance away from the area.

The components of the cyclone 10 may be made from any material having the inherent mechanical strength and chemical resistance to the solutions involved in its use. It is convenient to make all the components from the same material. Polyvinyl chloride and polypropylene have been found to be suitable examples of such materials. The bolts 30 though are more suitable when metallic in nature, since a more precise size for the orifice 32 may be maintained. A suitable example would be titanium.

The cyclone 10 is very useful for instance with an on-site hypochlorite generation electrolytic cell. The hypochlorite electrolytic cell or sea-water cell, as is more commonly referred to, also produces hydrogen gas as a by-product. For instance, in a single pass hypochlorite generating process producing two grams per litre available chlorine in solution, the electrolyte will have approximately 46 percent by volume entrained hydrogen in the liquid. This hydrogen gas tends to blanket the electrodes, increasing the cell potential and power consumption. There is therefore great advantage to be gained by separating the hydrogen gas from the solution during electrolysis. Some operators of hypochlorite cells accomplish this by recycling the electrolyte, so that the solution is allowed to lie in a recycling tank until hydrogen gas evolves therefrom, but the desired chlorine strength of the solution increases to such an extent as to cause poor current efficiency due to the cell potential increase. Also such practices create long process lag times, making automatic feedback control difficult. With the cyclone 10 inserted between electrolytic cells in a series of electrolytic cells a single pass system can be used which maintains the chlorine content at a given desired strength while allowing for the rapid evolution of hydrogen gas from the liquid.

A gas release orifice 32, sized for a maximum hole area to pass a maximum of one percent of the total liquid flow, can be arrived at by using the equation:

$$A = \frac{Q}{.61 \sqrt{2gh}}$$

wherein Q equals the flow rate, g is the gravity constant, and h is the head. The next consideration for the sizing of the gas release orifice 32 is, will the orifice pass enough



hydrogen gas? This can be shown by applying the equation as further described in ASME Power Test Code No. 10 for 1948, hereby incorporated by reference.

It has been found that the orifice sizes of Table 1, below, are suitable for a series of two or three sea water hypochlorite cells connected in series.

TABLE 1

	Flow Rate of Cell Brine	Orifice Size	
10	20 gal/m (75 l/m)	1/16 inch (1.59 mm)	10
	40 gal/m (150 l/m)	3/32 inch (2.38 mm)	
15	80 gal/m (300 l/m)	1/8 inch (3.18 mm)	15

It has been found that for a series of sea water hypochlorite electrolytic cells having a flow rate of approximately 20 gal/m (75 l/m) a suitable cylindrical top section 12 would be about 6 inches (152 mm) in diameter, 6 inches (152 mm) in length and have a 1.5 inch (38 mm) feed line 16. The conical bottom section 14 would be about 10 inches (254 mm) in length and have a 1.5 inch (38 mm) outlet 20. For a series of sea water hypochlorite electrolytic cells having a flow rate of approximately 80 gal/m (300 l/m) a suitable cylindrical top section 12 would be about 12 inches in diameter (304 mm), 12 inches (304 mm) in length and have a 3 inch (76 mm) feed line 16. The conical bottom section 14 would be about 20 inches (508 mm) in length and have a 3 inch (76 mm) outlet 20.

Since one of the sea water cells of current design produces a maximum of 1.23 cubic feet of hydrogen gas per minute, orifice of the sizes mentioned above are capable of handling the hydrogen produced by 1, 2 or 3 electrolytic cells of the given flow rate size. Therefore, one cyclone 10 can be placed in series with one or two electrolytic cells to obtain maximum allowances for hydrogen build up within the electrolytic cells.

Thus, it should be apparent from the foregoing description of the preferred embodiment that the device for the release of an entrained gaseous substance from a liquid herein shown and described solves the problems attendant upon gaseous build-up in sea water electrolytic cells for the production of on-site hydrochlorite.

WHAT WE CLAIM IS:-

1. A device for the release of an entrained gaseous substance from a liquid, which comprises a cylindrical top section attached to a conical bottom section at the larger diameter conjugate plane thereof, which is equal in diameter to the cylindrical top section, a feed line for the liquid located adjacent the upper part of the cylindrical top section and attached tangentially thereto so as to communicate with the interior of the device, a planar top member attached to the upper part of the cylindrical top section and including a gas release orifice of sufficient size to allow the escape of the gaseous substance while severely restricting flow of the liquid therethrough, an outlet for the liquid communicating with the interior of the device and attached to the conical bottom section at the smaller diameter conjugate plane thereof, the outlet and the smaller diameter conjugate plane being equal in diameter to the feed line, and a planar baffle attached to the interior wall of the outlet so as to protrude into the conical bottom section, for arresting circular motion of the liquid.

2. A device according to claim 1, wherein the feed line is attached to the cylindrical top section so as to define an elliptical opening into the interior of the device, the outermost part of the feed line lying exactly tangential to the interior surface of the cylindrical top section.

3. A device according to claim 1 or 2, wherein the gas release orifice is contained within a tube extending through the planar top member, the inner portion of the tube ending in a plane at 45° to the tube axis and being aligned so that its furthest extension is toward the feed line.

4. A device according to claim 3, wherein the outer end of the tube has a plug sealingly engaged therein, the centre of the plug being drilled and tapped to receive an orifice-containing bolt.

5. A device according to claim 4, wherein the orifice in the bolt has a size in the range from 1/64 to 1/4 inch (0.4 to 6.35 mm).

6. A device according to claim 3, 4 or 5, wherein a tee fitting is connected by one end of its straight limb to the outer end of the tube and has a removable plug on the other end of its straight limb, to allow removal and replacement of the bolt, the side limb of the tee fitting being connected to an exhaust piping system for receiving gaseous substances released.

7. A device according to any preceding claim, wherein the cylindrical top section measures 6 to 12 inches (152 to 304 mm) in diameter and in length, the conical bottom section

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25 Since one of the sea water cells of current design produces a maximum of 1.23 cubic feet of hydrogen gas per minute, orifice of the sizes mentioned above are capable of handling the hydrogen produced by 1, 2 or 3 electrolytic cells of the given flow rate size. Therefore, one cyclone 10 can be placed in series with one or two electrolytic cells to obtain maximum allowances for hydrogen build up within the electrolytic cells.

30 Thus, it should be apparent from the foregoing description of the preferred embodiment that the device for the release of an entrained gaseous substance from a liquid herein shown and described solves the problems attendant upon gaseous build-up in sea water electrolytic cells for the production of on-site hydrochlorite.

35 WHAT WE CLAIM IS:-

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2. A device according to claim 1, wherein the feed line is attached to the cylindrical top section so as to define an elliptical opening into the interior of the device, the outermost part of the feed line lying exactly tangential to the interior surface of the cylindrical top section.

3. A device according to claim 1 or 2, wherein the gas release orifice is contained within a tube extending through the planar top member, the inner portion of the tube ending in a plane at 45° to the tube axis and being aligned so that its furthest extension is toward the feed line.

4. A device according to claim 3, wherein the outer end of the tube has a plug sealingly engaged therein, the centre of the plug being drilled and tapped to receive an orifice-containing bolt.

5. A device according to claim 4, wherein the orifice in the bolt has a size in the range from 1/64 to 1/4 inch (0.4 to 6.35 mm).

60 6. A device according to claim 3, 4 or 5, wherein a tee fitting is connected by one end of its straight limb to the outer end of the tube and has a removable plug on the other end of its straight limb, to allow removal and replacement of the bolt, the side limb of the tee fitting being connected to an exhaust piping system for receiving gaseous substances released.

65 7. A device according to any preceding claim, wherein the cylindrical top section measures 6 to 12 inches (152 to 304 mm) in diameter and in length, the conical bottom section



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measures 10 to 20 inches (254 to 508 mm) in length, the feed line and the outlet each have a diameter of 1.5 to 3 inches (38 to 76 mm) and the gas release orifice has a diameter of 1/64 to 1/4 inch (0.4 to 6.35 mm).

5 8. A device according to any preceding claim, wherein the feed line is connected to the output of one of a series of hypochlorite-generating seawater electrolytic cells, the outlet is attached to the input of another cell in the series and the gas release orifice is connected to an exhaust piping system. 5

10 9. A series of hypochlorite-generating seawater electrolytic cells, having a gas release device as defined in any preceding claim connected according to claim 8 between each adjacent two cells in the series. 10

10. A series of electrolytic cells according to claim 9, wherein the flow rate from each cell is in the range of 20 to 80 gal/m (75 to 300 l/m).

11. A device according to claim 1, substantially as herein described with reference to the accompanying drawings.

15 12. A series of electrolytic cells having connected thereto gas release devices as defined in any of claims 1 to 8, substantially as hereinbefore described. 15

13. A method for removing a gaseous substance from electrolyte flowing through a series of electrolytic cells, which comprises introducing the output from one or more cells of a group of up to three cells in the series into the top cylindrical section of a cyclone having a conical bottom section, the electrolyte being introduced horizontally tangential to the interior surface, so as to form a vortex aided by the form of the conical bottom section of the cyclone, allowing gaseous substances to escape to an exhaust system through an orifice at the top of the cyclone, arresting circular flow of the electrolyte as it nears the bottom of the cyclone, allowing the electrolyte to pass through the bottom of the cyclone under a back pressure, so as to enhance separation of gaseous substances from the electrolyte, and introducing the electrolyte from which gaseous substances have been removed into one or more cells of a group of up to three electrolytic cells connected in series for further electrochemical production. 20 25

14. A method according to claim 13, substantially as herein described. 25

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