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Giacopelli

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[54] **ELECTROLYSIS CELL WITH VERTICAL BIPOLAR ELECTRODES**

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[30] **Foreign Application Priority Data**

Dec. 23, 1971 Belgium 112096

[52] **U.S. Cl.** **204/256;** 204/255; 204/257; 204/258; 204/269; 204/270

[51] **Int. Cl.²** **C25B 13/00**

[58] **Field of Search** 204/255, 256, 257, 258, 204/263, 270, 278, 269

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Assistant Examiner—W. I. Solomon
Attorney, Agent, or Firm—Robert E. Burns; Emmanuel J. Lobato; Bruce L. Adams

[57] **ABSTRACT**

An electrolyser of the series connected filter press type with vertical bipolar electrodes for the production of chlorine, hydrogen and caustic alkali by the electrolysis of a solution of an alkali metal chloride comprises a series of elementary electrolysis cells surmounted by a tank containing the solution. Each of the elementary cells is in communication with the tank by an individual duct of insulating material which extends approximately over the entire height of the cell and opens into the anode chamber at the bottom of the cell. A duct for the evaculation of chlorine from each cell passes up through the bottom of the tank and extends up inside the tank to a point above the level of the solution. Duct means are formed in the bottom portion of the cell frame members, with one duct means registering with a U-shaped tube in each cell for withdrawing caustic alkali from the cell, a second duct means registering with a tube extending to the upper part in each cell for withdrawing hydrogen from each cell, and with a third duct means registering with a transverse distributor in each cell for supplying reagent to each cell.

3 Claims, 8 Drawing Figures

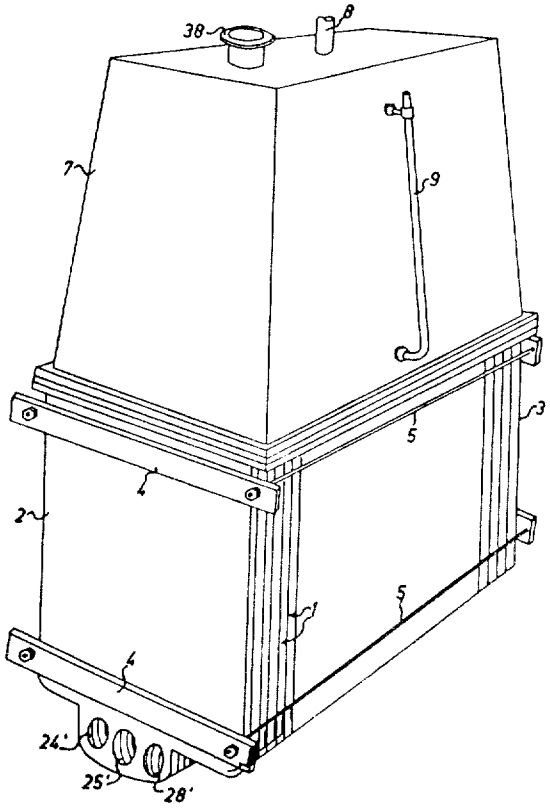


FIG. 1

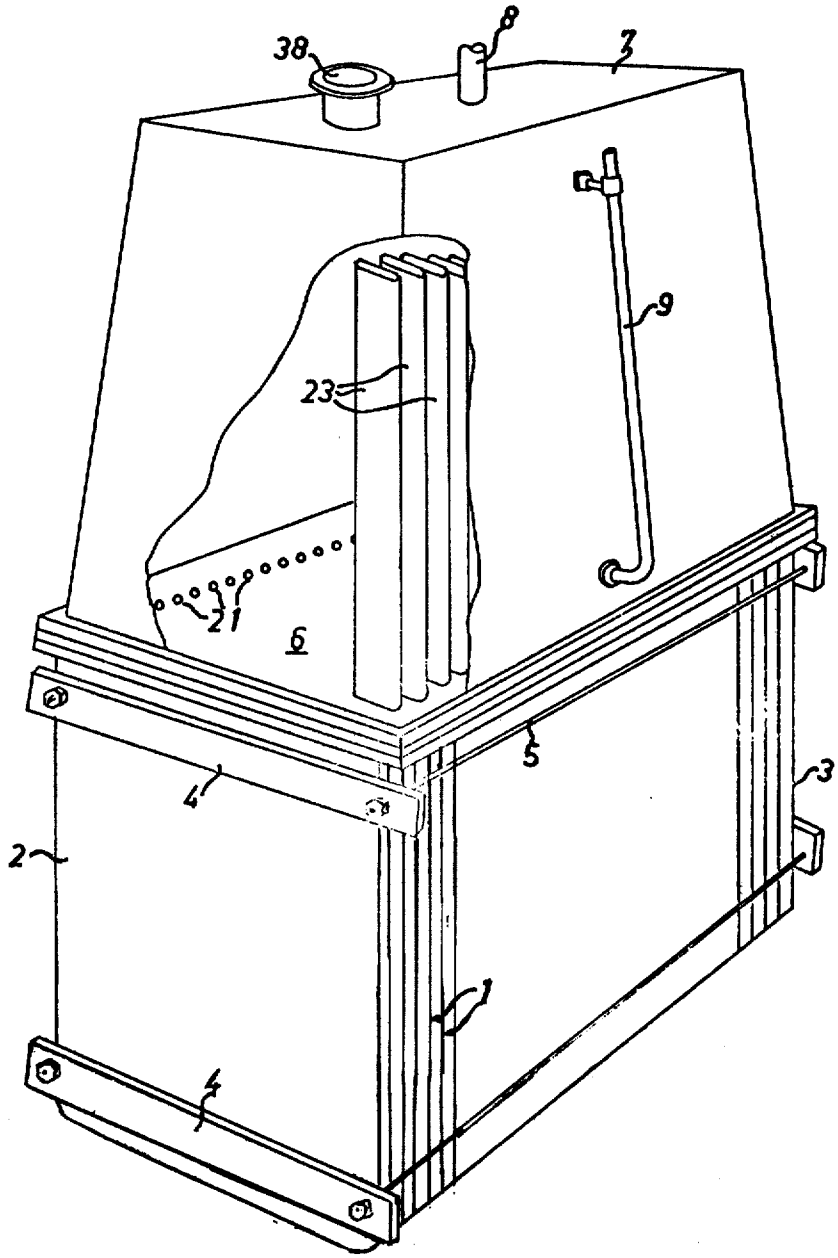


FIG. 2

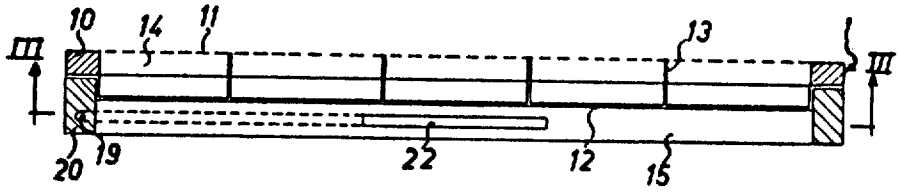


FIG. 3

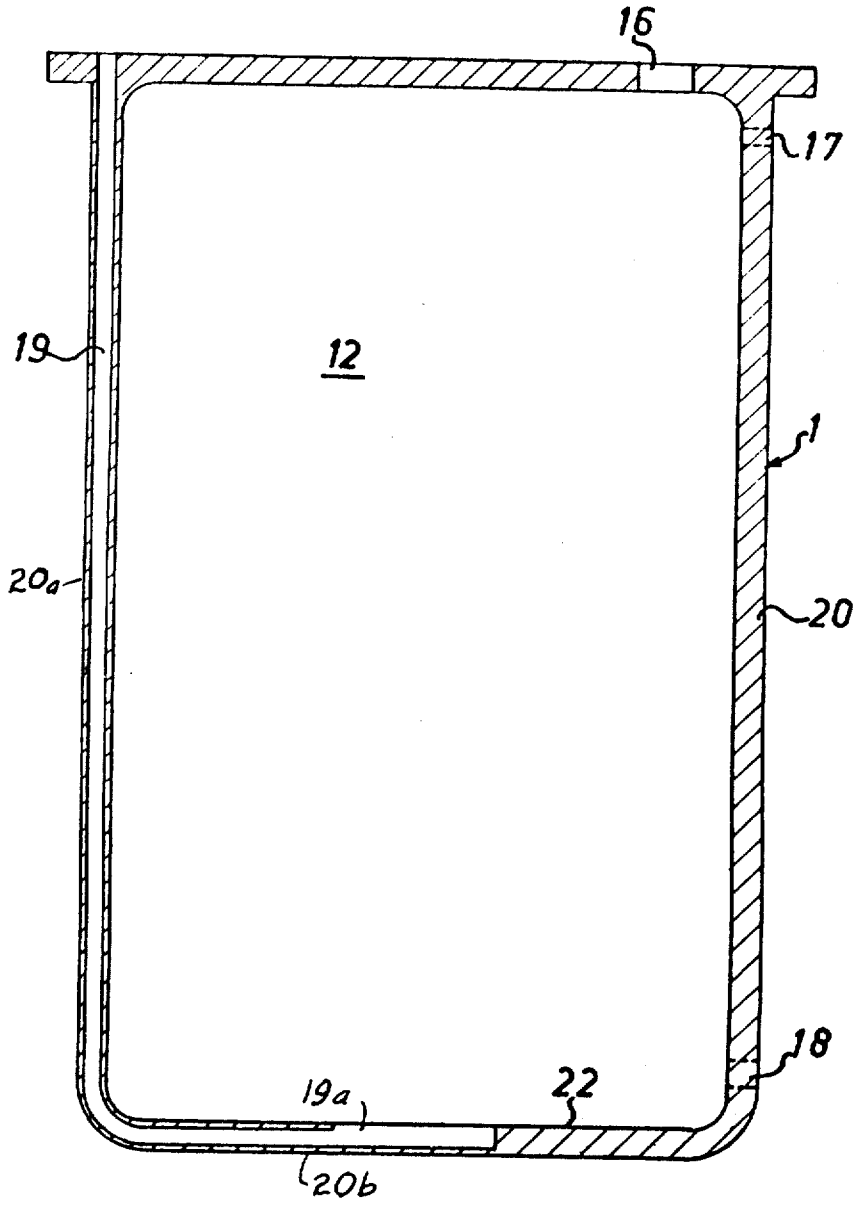


FIG. 4

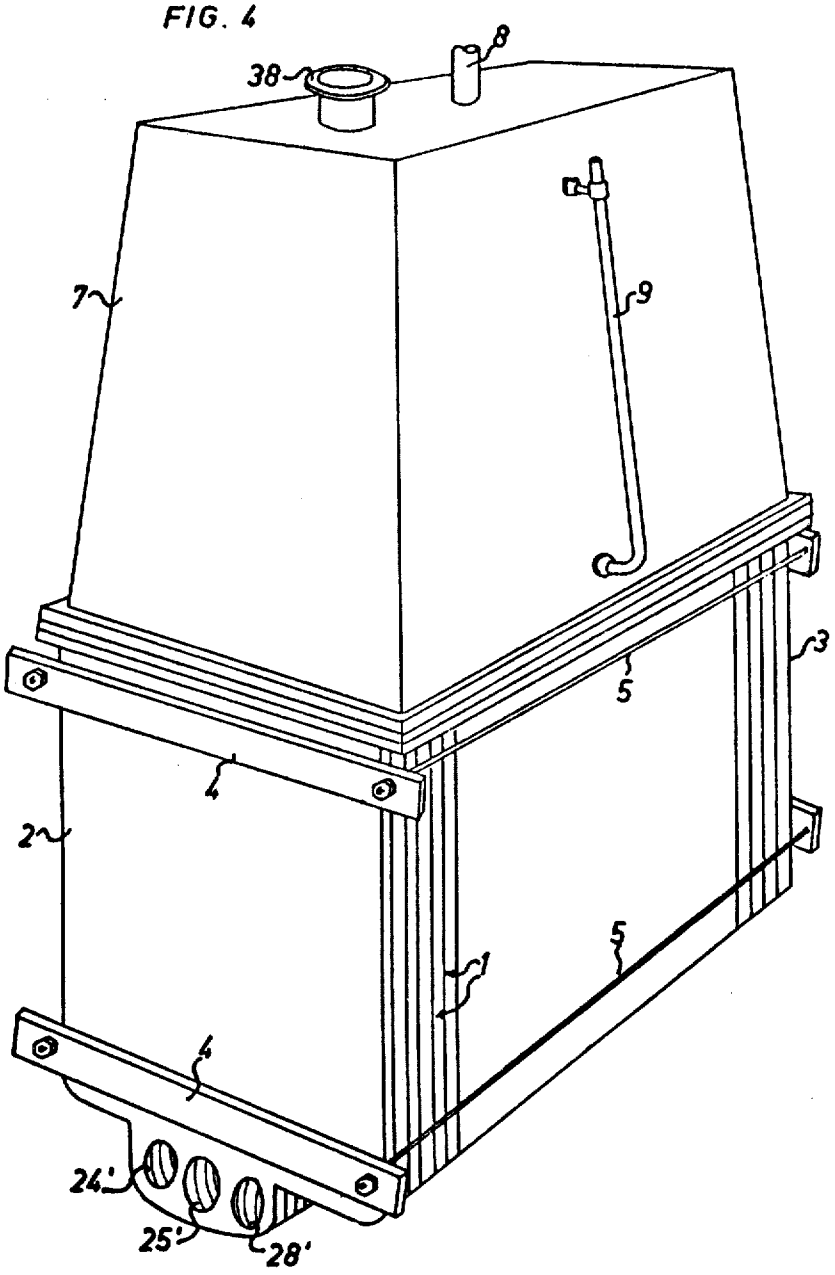


FIG. 5

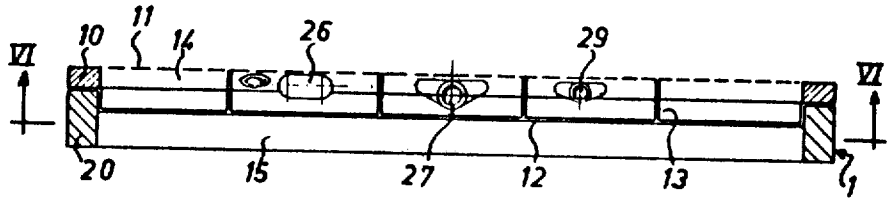


FIG. 6

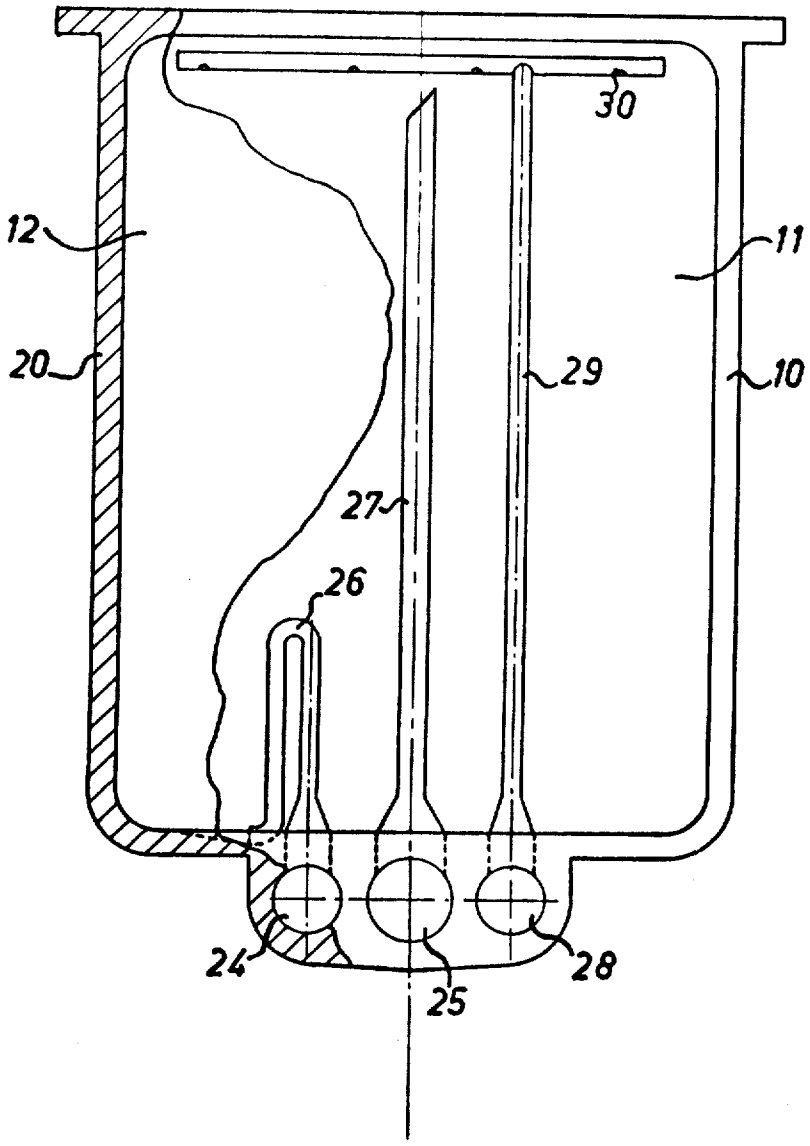


FIG. 7

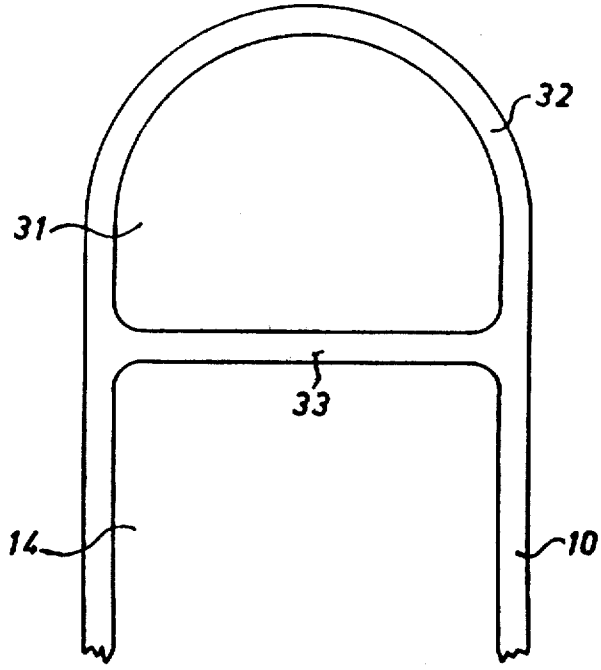
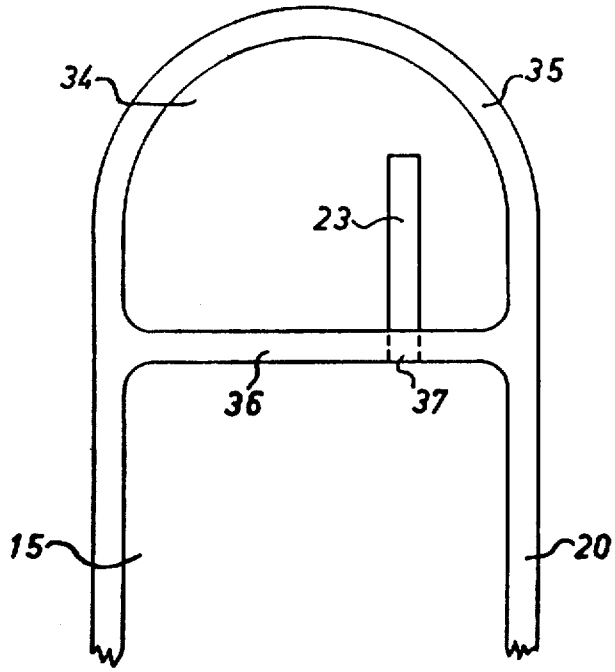


FIG. 8



ELECTROLYSIS CELL WITH VERTICAL BIPOLAR ELECTRODES

The present invention relates to the production of chlorine, hydrogen and caustic alkali by the electrolysis of a solution of a chloride of an alkali metal, for example a sodium chloride brine.

The invention relates more particularly to an electrolyser of the diaphragm type comprising a number of elementary cells with vertical bipolar electrodes connected in series to a source of direct current.

In known electrolysers of this type the elementary cells are fed individually with electrolyte from a tank arranged above the elementary cells.

In these electrolysers of the series type it is important to reduce to as low a value as possible the electric current branched through the electrolyte contained in the tank. In order to increase the electrical resistance of this branched circuit it is known that one can divide the tank into the same number of compartments as there are elementary cells, using transverse partitions drilled with apertures of small cross-section aimed at maintaining the electrolyte at the same level in all the compartments. An electrolyser of this type is described, for example, in U.S. Pat. No. 2,282,058 filed in the name of HUNTER et al. on the Jan. 24, 1939.

A disadvantage of these known electrolysers with a partitioned tank resides in fact in the necessity of arranging partitions in this tank, which is of such a nature as to increase its weight and reduce its useful capacity.

Furthermore, the small cross-section of the orifices made in the partitions of the tank makes it necessary to feed this tank with electrolyte simultaneously in a number of the compartments of this tank if one wishes to avoid a variation in the concentration of the electrolyte between these compartments.

The invention overcomes these drawbacks. It relates for this purpose to a diaphragm electrolyser of the series type with vertical bipolar electrodes for the production of chlorine, hydrogen and a caustic alkali by the electrolysis of a solution of an alkali metal chloride. The electrolyser comprises at least two elementary electrolysis cells surmounted by a tank containing the solution, each elementary cell being connected with the tank and comprising separate ducts for the evacuation of the chlorine, the hydrogen and the caustic alkali. According to the invention, the electrolyser is characterised by the fact that each elementary cell is connected with the tank by an individual pipe of insulating material which extends approximately over the entire height of the cell and which leads out near the bottom or into the bottom of the latter, and by the fact that the pipe for evacuating the chlorine from each elementary cell passes through the bottom of the tank and leads out into a pipe extending up inside the tank to a point above the level of the solution.

In the electrolyser according to the invention, the electric circuit of the current branched through the electrolyte contained in the tank comprises the above-mentioned pipes connecting this tank with the elementary cells. These pipes extend approximately over the entire height of these bipolar elements, this branched circuit has a high electrical resistance so that it is possible in the electrolyser according to the invention to do away with the above-mentioned partitions with which the tank of known cells is equipped.

Furthermore, in the electrolyser according to the invention the anolyte is subjected to an ascending movement in the elementary cells, which advantageously facilitates the evacuation of the chlorine discharged at the anodes.

In the electrolyser according to the invention the chlorine discharged at the anodes does not percolate through the considerable mass of electrolyte contained in the tank, which facilitates its evacuation from the elementary cells and, all other things being equal, permits of higher current densities. The upper part of the tank constitutes also a pocket of high capacity where the chlorine produced in the different elementary cells accumulates, which is of such a nature as to facilitate its extraction from the electrolyser. According to a particularly advantageous form of embodiment, the electrolyser according to the invention is of the filter press type and formed by the juxtaposition of a series of frames constituting the lateral walls of the elementary cells According to the invention, the tank is bounded between a partition fitted in a waterproof manner on the whole of the frames and a lid in the form of a bell of large dimensions placed on this partition. The partition is drilled on one side with a first series of apertures which communicate with the above-mentioned pipes for the admission of the solution arranged in the frames, and on the other hand with a second series of apertures which communicate with the anode chambers of the elementary cells so as to ensure the evacuation of the chlorine produced in these cells. According to the invention, the latter apertures each lead out into a distinct tube or in a group into a common tube, this tube being fixed transversely to the partition and emerging above the level of the solution in the tank.

As a variant, the tubes may be replaced by a single duct fixed transversely to the partition, around the above-mentioned second series of apertures, and emerging above the level of the solution in the tank.

Particular features and details of the invention will be seen from the description which follows of the attached drawings which represent, by way of examples and without restricting the scope of the invention, a few forms of embodiment of the electrolyser according to the invention.

FIG. 1 shows in perspective, with a partial cut-away, a first form of embodiment of the electrolyser according to the invention.

FIG. 2 shows in horizontal transverse section an elementary cell of the electrolyser of FIG. 1.

FIG. 3 is a section along the line III—III of FIG. 2.

FIG. 4 shows a perspective of a second form of embodiment of the electrolyser according to the invention.

FIG. 5 shows in horizontal transverse section an elementary cell of the electrolyser of FIG. 4.

FIG. 6 is a section along the plane VI—VI of FIG. 5, with partial cut-away.

FIG. 7 shows partly in elevation a particular form of embodiment of a frame surrounding the cathode chamber of an elementary cell of an electrolyser of the filter press type in accordance with the invention.

FIG. 8 shows partially in elevation a frame surrounding the anode chamber of the elementary cell of FIG. 7.

In these figures the same reference numbers designate identical elements.

The electrolyser according to the invention, shown diagrammatically in FIG. 1, is of the series connected filter press type. It comprises a number of elementary

cells 1 with bipolar electrodes, arranged between two end elements 2 and 3 which are anodic and cathodic respectively, and connected in series with a source of direct voltage which is not shown in the drawing. Cross-pieces 4 and tie-rods 5 hold the whole together.

A partition 6 of insulating material covers the whole assembly of the elementary cells 1, and a lid in the form of a bell is placed in a fluid tight manner on the partition 6. The partition 6 and the lid 7 form a tank of large capacity for the electrolyte, in this case a sodium chloride brine. An inlet pipe 8 for supplying electrolyte into this tank is connected to the upper part of the lid 7 and a level indicator 9 makes it possible to check the amount of electrolyte in the tank.

An elementary cell 1 of the electrolyser of FIG. 1 is shown in greater detail in FIGS. 2 and 3.

This elementary cell comprises a rectangular frame 10 made of steel adjoining a rectangular frame 20 made of a material which does not conduct electricity. The frame 10 serves as a support for an anode 12 and a perforated cathode 11 consisting for example of a wire mesh or an expanded steel plate. The anode 12 may consist of a graphite plate or a plate of a metal of the titanium group, the active surface of which, facing the outside, is covered at least partially by a layer comprising a metal or a compound of a metal of the platinum group. The cathode 11 is covered on its outer surface by a diaphragm not shown in the drawing. Advantageously, in a manner not shown in the attached drawings, the electrodes may be corrugated so as to increase their surface area. The cathode 11 and the anode 12 may be provided with metal struts 13.

The chamber 14 bounded between the cathode 11, the anode 12 and the frame 10 constitute the cathode chamber 14 of the elementary cell. The anode chamber 15 of the elementary cell is bounded between the anode 12, the frame 20 and the cathode 11 of an adjacent elementary cell 1.

Apertures 16, 17 and 18 are arranged through the frames 10 and 20 so as to provide for the evacuation of the products of the electrolysis: chlorine, hydrogen and caustic brine respectively.

According to the invention, a pipe 19 for the admission of electrolyte into the anode chamber 15 is arranged in one of the vertical walls 20*a* of the frame 20. This pipe 19 extends over the entire height of the frame 20 and leads out through an opening 19*a* in the bottom wall 20*b* of the frame 20 into the bottom 22 of the anode chamber 15. It communicates in its upper part with an aperture 21 (FIG. 1) arranged through the partition 6 and leading into the tank containing the electrolyte.

The partition 6 is also drilled with apertures registering with the apertures 16 for the evacuation of the chlorine, and carries tubes 23 in extension of these apertures. These tubes 23 lead out to the inside of the above-mentioned tank, under the lid 7, above the level of the electrolyte. An aperture 38 arranged in the top of the lid 7 provides for the evacuation of the chlorine produced in the elementary cells 1 and collected under the lid 7.

As a variant, the tubes 23 may be fixed directly to the frames 20 in the extension of the apertures 16, which makes it possible to do away with the partition 6. In this event the upper walls of the frames 10 and 20 form the bottom of the electrolyte tank. With such construction, the frames 10, like the frames 20, are preferably made of insulating material or an insulating layer is provided on the top of each frame 10. However, the use of the partition 6 is advantageous in the case of a filter press cell, in that it avoids any possible leakage of electrolyte between the adjacent frames 10 and 20.

During the operation of the cell shown in FIG. 1, the brine contained in the tank is introduced into the lower part of the elementary cells 1 by apertures 21 and pipes 19. The anolyte is thus subjected to an ascending movement in the elementary cells 1, which facilitates the evacuation of the chlorine discharged at the anodes 12. The anolyte entrained by the chlorine falls back into the tank at the outlet from the tubes 23.

The use of insulating pipes 19 which extend approximately over the entire height of the elementary cells 1 for the purpose of connecting these cells to the tank for electrolyte has the effect of reducing to a very low figure the electric current which is branched off by the electrolyte contained in the tank.

In a particular variant, not shown in the drawing, of the electrolyser of FIG. 1, the whole of the tubes 23 for the evacuation of chlorine is replaced by a single duct fixed to the partition 6 and emerging above the level of the electrolyte under the lid 7.

In a modified form of embodiment not shown in the drawing of the electrolyser according to the invention, the pipes 19 mentioned above are replaced by flexible tubes arranged outside the electrolyser and leading out on the one hand near the bottom 22 of the elementary cells 1 and on the other hand into the electrolyte tank. These tubes may also be arranged inside the cell and be made of a material which is a non-conductor for electricity.

The electrolyser which has just been described above may obviously present numerous variant forms of embodiment without thereby falling outside the scope of the invention. For example all the elementary cells may, as a variant, be enclosed in a single case, the electrolyser being no longer of the filter press type.

In FIGS. 4, 5 and 6 a modified form of embodiment of the electrolyser of the filter press type of FIGS. 1 to 3 is shown.

In the electrolyser of FIGS. 4 to 6, the frame 10 and the frame 20 of each elementary cell 1 are each drilled with two tubular sections 24 and 25 (FIG. 6). The tubular sections 24 of the adjacent frames are in the extension of one another, as is the case with the tubular sections 25, so as to form two collectors 24' and 25' (FIG. 4).

The collector 24' is intended for the evacuation of the caustic solution from each of the elementary cells 1. For this purpose the tubular section 24 of the frame 10 of each cell 1 communicates with the cathode chamber 14 of this cell via an evacuation duct 26 made of insulating material, and extending to the interior of the cell 1 and leading out near the bottom of same. This evacuation duct 26 is bent back on itself so as to have a sufficient length to avoid a gross short-circuit of the elementary cells 1 by the caustic alkali.

The collector 25 is intended for the evacuation of the hydrogen given off at the cathodes of the elementary cells 1. For this purpose the tubular section 25 of the frame 10 of each cell 1 communicates with the upper part of the cathode chamber 14 of this cell 1, via an evacuation duct 27 extending to the interior of the chamber 14 and leading out near to the upper end of the latter.

As a variant, a pipe 28' (FIG. 4) may be provided for feeding in a reagent (for example CO_2 or a solution of

$NaHCO_3$) into the elementary cells **1**. This pipe **28'** is advantageously formed according to the invention by the juxtaposition of tubular sections **28** drilled through the frames **10** and **20** of the elementary cells **1**. The tubular section **28** of the frame **10** of each cell **1** communicates with a pipe **29** of insulating material extending to the interior of the cathode chamber **14** and leading out into a transverse distributor **30** for distributing the reagent in the upper zone of the chamber **14**.

Although it is advantageous from the point of view of space required, to arrange the collectors **24'** and **25'** and the pipe **28'** in the middle zone of the cell, below the bottom **22** of the cathode chamber **14** and the anode chamber **15**, these collectors and this pipe may if desired be arranged in another zone of frames **10** and **20**.

The tank for the electrolyte and the means for feeding the electrolyte to the cells and for evacuating the chlorine in the electrolyser of FIGS. **4** to **6** is the same as in FIGS. **1** to **3**.

FIG. **7** shows the upper part of a particular form of embodiment of the frame **10** surrounding the cathode chamber **14** of an elementary cell **1**.

The frame **10** represented in FIG. **7** is formed with an aperture **31** in its upper part. This aperture **31** is bounded at the top by a curved wall **32** and at the bottom by a wall **33** which extends above the electrodes **11** and **12** of the cell **1** and bounds the cathode chamber **14** of the cell. The lateral wall of the frame **10** is drilled with two ducts, not shown in the drawing, one of which opens into the upper part of the cathode chamber and is intended for the evacuation of the hydrogen produced in the cathode chamber **14** and the other of which opens into the lower part of the cathode chamber and is intended for the evacuation of the caustic alkali also produced in the chamber **14**.

FIG. **8** shows the upper part of the frame **20** corresponding to the frame **10** of the FIG. **7**. This frame **20** surrounds the anode chamber **15** of the elementary cell **1**. It is drilled in its upper part with an aperture **34** corresponding to the above-mentioned aperture **31** of the frame **10**. This aperture **34** is bounded at the top by a curved wall **35** and at the bottom by a wall **36** which correspond respectively to the walls **32** and **33** of the frame **10** of FIG. **7**. The wall **36** bounds the anode chamber **15** of the elementary cell. It is drilled with an aperture **37** for the evacuation of the chlorine produced in the anode chamber **15**. This aperture **37** is prolonged by a tube **23** which extends upwards in the aperture **34** underneath the wall **35**.

In the electrolyser of the filter press type, the whole of the walls **32** and **35** justaposed forms the lid **7** as above-mentioned of the cell, whilst the whole of the walls **33** and **36** juxtaposed constitutes the bottom of the above-mentioned tank containing the electrolyte. The walls **33** and **36** are formed of or covered with insulating material to avoid short circuiting through the brine in the tank formed by the openings **31** and **34**. As in the embodiments previously described, a separate feed duct (not shown) of insulating material leads from the bottom of the electrolyte tank to the bottom of each of the cells. Such duct may be formed in the wall of the duct or as a separate tube. The end walls of this tank are formed by above-mentioned end elements **2** and **3** which are not drilled with apertures like **31** and **34**.

The wall **32** or **35** of at least one of the frame sets **10** or **20** is drilled with an orifice for the admission of electrolyte into the tank. FUrthermore, the upper part of the wall **32** or **35** of at least one of the sets of frames **10** or **20** is drilled with an orifice for the evacuation of chlorine coming from tubes **23**, these tubes **23** leading out above the level of the electrolyte in the tank bounded underneath the walls **32** and **35**.

One of the frames **10** or **20** may also have its curved wall **32** or **35** drilled with an aperture for connecting a level indicator tube similar to the tube **9** of FIGS. **1** and **4**.

The walls **32** and **35** of the frames of FIGS. **7** and **8** may obviously have a different contour from a curved contour. They may, for example, have a rectangular or trapezoidal contour.

The present invention is obviously not restricted to the forms of embodiment described above. Numerous modifications may be made therein without thereby falling outside the scope of he following claims.

What I claim and desire to secure by Letters Patent is:

1. A bipolar filter press type diaphragm electrolyser for the production of chlorine, hydrogen and caustic alkali by the electrolysis of a solution of an alkali metal chloride, said electrolyser comprising:

a. a plurality of vertical elementary cells disposed face-to-face, connected in series and each having an anode, a cathode, a diaphragm between said anode and cathode and at least one peripheral frame made of insulating material and having openings through the upper part thereof;

b. means defining a tank above said cells for holding said solution comprising a partition tightly overlying all the frames and insulated from the latter and having holes and apertures therein, and a lid tightly fitted over said partition;

c. means for feeding said solution to said tank;

d. means for supplying said solution from said tank to said cells, said means including channels in said frames opening at one end inside said tank through said holes provided in the partition and opening at the other end in the respective cells through a bottom portion thereof, whereby the electric current by-passed through said solution in said tank is limited;

e. means for evacuating chlorine out of the cells, said means including said openings provided through the upper part of the frames, said apertures provided through the partition and registering with said openings and at least one duct attached to the partition and disposed about said apertures and extending upward from said partition and beneath the lid; and

f. means for evacuating hydrogen and caustic alkali out of the cells, each of said cells having at least one peripheral frame having an opening through a bottom portion thereof, and said means for evacuating caustic alkali out of the cells comprising, for each cell, a U-shaped tube of insulating material which extends upward into the cell, doubles back on itself and opens at one end in a bottom portion of the cell, and at the other end in said opening provided through the bottom of the peripheral frame of the cell, the openings of all the peripheral frames of the cells registering to form a duct for the caustic alkali.

2. A diaphragm electrolyser for the production of chlorine, hydrogen and caustic alkali by the electrolysis of a solution of an alkali metal, said electrolyser com-

prising:

a. a plurality of vertical elementary cells each having an anode, a cathode and a diaphragm between said anode and cathode, said cells being disposed face-to-face and being connected in series;

b. means defining a tank above said cells for holding said solution comprising a partition overlying said cells and electrically insulated from the latter and having apertures therein and a lid tightly fitted over said partition;

c. means for feeding said solution to said tank;

d. means for supplying said solution from said tank to said cells, said means including, for each cell, a separate feed duct of insulating material extending substantially over the whole height of the cell and opening at one end in the tank and opening at the other end in the cell through a bottom portion of the cell, whereby the electric current by-passed through said solution in said tank is limited;

e. means for evacuating chlorine out of the cells, said means including, said apertures provided through the partition and communicating with the cells and at least one duct attached to the partition and disposed about said apertures and extending upward from said partition and beneath the lid; and

f. means for evacuating hydrogen and caustic alkali out of the cells, each of said cells having at least one peripheral frame each having an opening through a bottom portion thereof, and said means for evacuating hydrogen out of the cells comprising, for each cell, a tube extending upward into the cell and opening, at one end, in the upper part of the cell and, at the other end, in said opening provided through the bottom of the peripheral frame of the cell, the openings of all the peripheral frames of the cells registering to form a duct for the hydrogen.

3. A diaphragm electrolyser for the production of chlorine, hydrogen and caustic alkali by the electrolysis of a solution of an alkali metal, said electrolyser comprising:

a. a plurality of vertical elementary cells each having an anode, a cathode and a diaphragm between said anode and cathode, said cells being disposed face-to-face and being connected in series;

b. means defining a tank above said cells for holding said solution comprising a partition overlying said cells and electrically insulated from the latter and having apertures therein and a lid tightly fitted over said partition;

c. means for feeding said solution to said tank;

d. means for supplying said solution from said tank to said cells, said means including, for each cell, a separate feed duct of insulating material extending substantially over the whole height of the cell and opening at one end in the tank and opening at the other end in the cell through a bottom portion of the cell, whereby the electric current by-passed through said solution in said tank is limited;

e. means for evacuating chlorine out of the cells, said means including, said apertures provided through the partition and communicating with the cells and at least one duct attached to the partition and disposed about said apertures and extending upward from said partition and beneath the lid; and

f. means for evacuating hydrogen and caustic alkali out of the cells, each of said cells having a transverse distributor and having at least one peripheral frame having an opening through a bottom portion thereof, means for supplying a reagent to the cells, said reagent supplying means comprising, for each cell, a tube which extends upward in the cell, and which opens, at its upper end, in the transverse distributor inside the cell and, at its lower end, in the opening provided through the bottom of the peripheral frame of the cell, the openings of all the peripheral frames of the cells registering to form a duct for the reagent.

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