Aug. 12, 1969 G. M. KAMARJAN 3,461,057
DIAPHRAGM ELECTROLYZER FOR PRODUCTION OF
CHLORINE, HYDROGEN AND ALKALIES
Filed Aug. 20, 1964 4 Sheets-Sheet 1

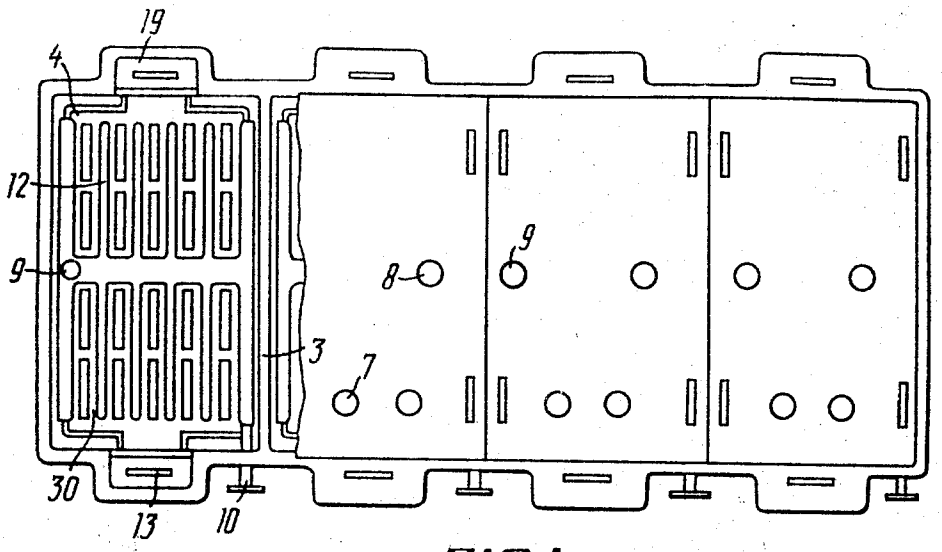

FIG. 1

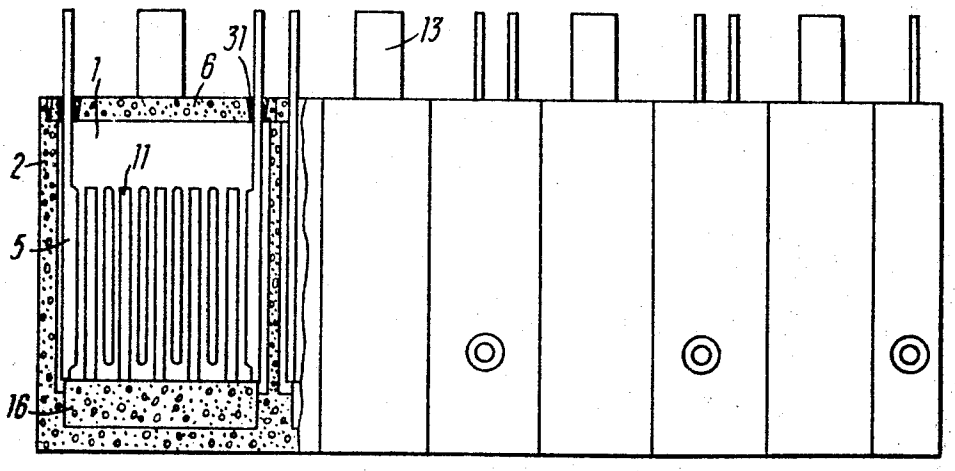

FIG. 2

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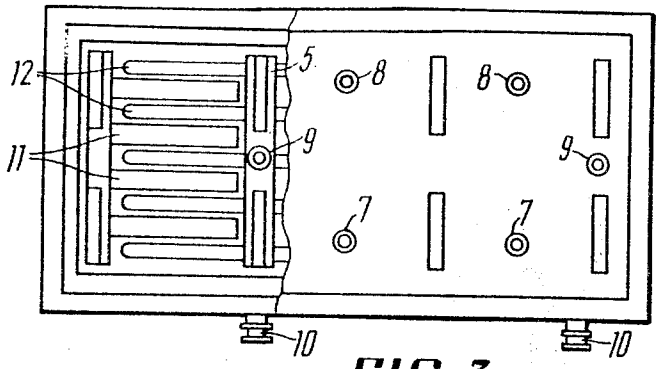

FIG. 3

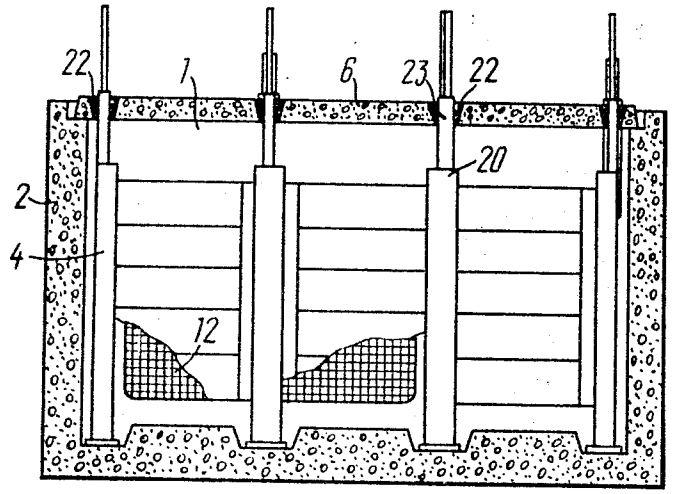

FIG. 4

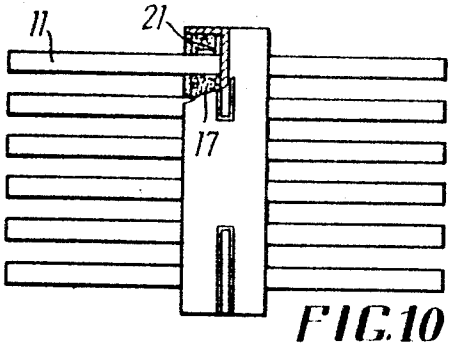

FIG. 10

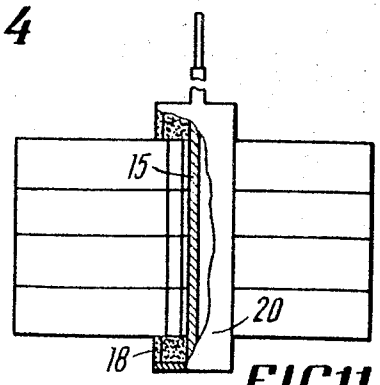

FIG. 11

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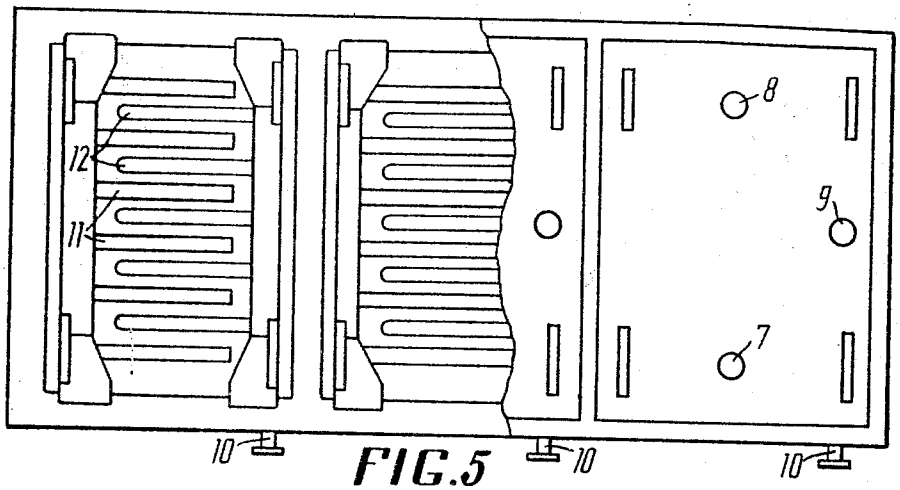

FIG.5

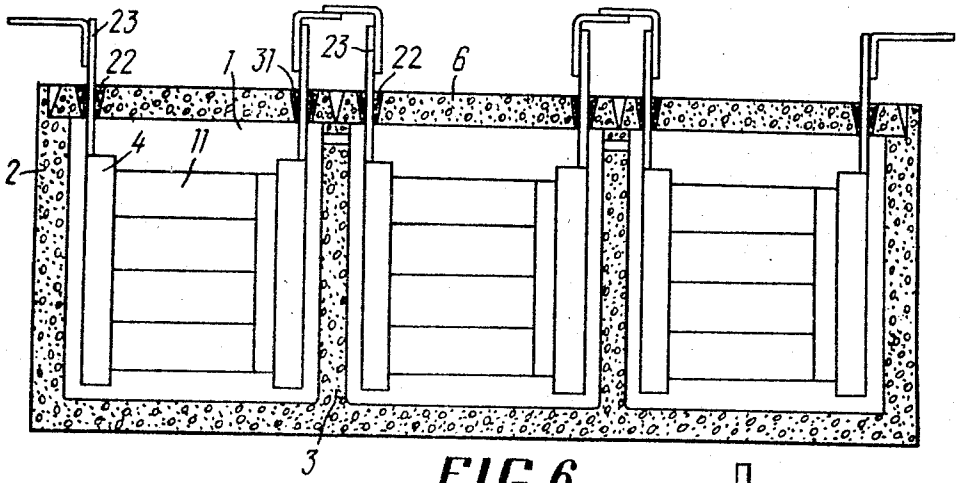

FIG.6

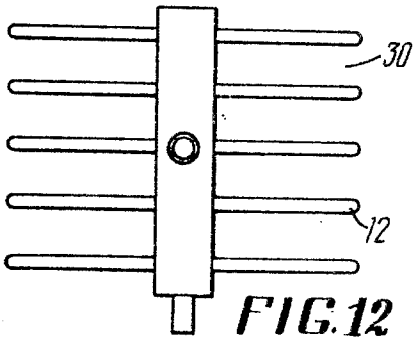

FIG.12

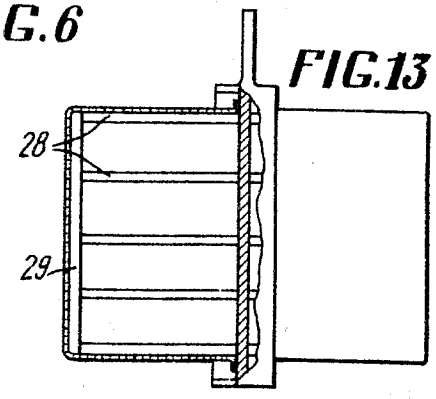

FIG.13

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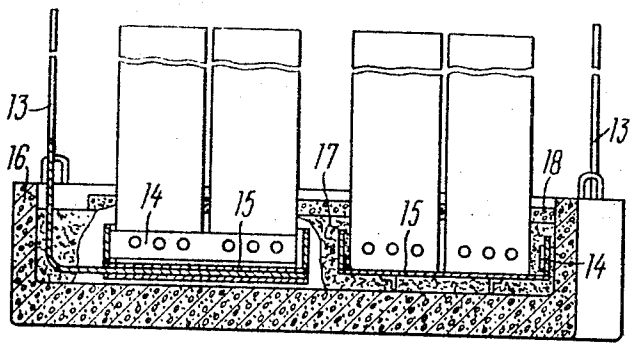

FIG. 9

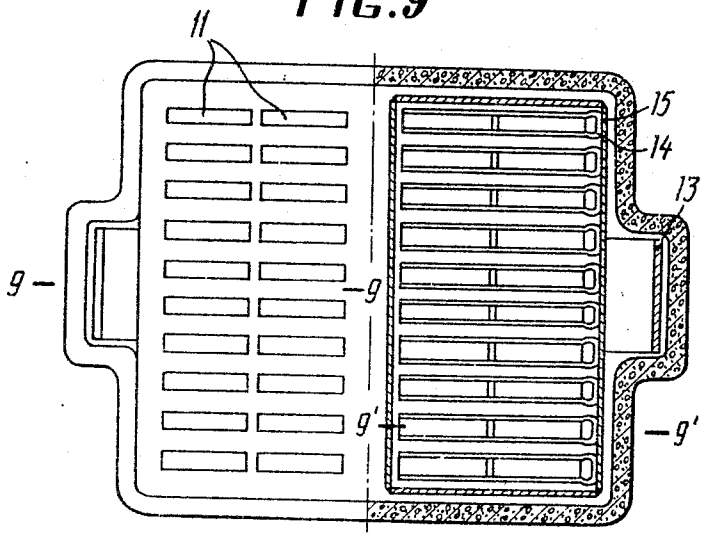

FIG. 8

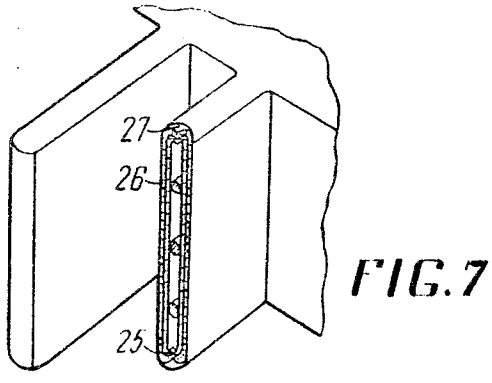

FIG. 7

United States Patent Office 3,461,057
Patented Aug. 12, 1969

3,461,057

DIAPHRAGM ELECTROLYZER FOR PRODUCTION OF CHLORINE, HYDROGEN AND ALKALIES

Georgy Mikirtychevich Kamarjan, Vorontsovskaja Str., 30-b, Apt. 18, Moscow, U.S.S.R.

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Int. Cl. C22d 1/02; B01k 3/10
U.S. Cl. 204—258 10 Claims

ABSTRACT OF THE DISCLOSURE

A diaphragm electrolyzer having sets of identical elementary electrolytic cells consisting of anode and cathode sets and a diaphragm. The cells are housed in a common stationary casing divided with partitions into a plurality of similar sections.

The present invention relates to apparatus for production of chlorine, hydrogen and alkalies by means of electrolysis of chloride solutions employing a diaphragm method.

Hitherto the efficiency of modern diaphragm electrolyzers for production of chlorine, hydrogen and alkalies, was increased by enlarging the units by increasing the number of electrolytic cells, as well as by increasing the electrolysis current density.

As a rule, in the electrolyzers of high output, such as Hucker's, Billiter's, Daw's, etc., the floor space occupied by the electrolyzers is increased proportionally to the output of the electrolyzers; the weight of all the operating elements and components, such as a cathode, set of anode plates, a cover, busbars, is increased in accordance with the dimensions of these electrolyzers.

The considerable size of the electrolyzers, the great weight of their operating elements and components make maintenance and installation of the electrolyzers difficult since it is necessary to employ powerful hoisting-handling equipment, to enlarge the floor area of repair shops, to widen passages in a row and between the rows of electrolyzers.

The designs of anode power supply systems in the known electrolyzers consist in the following:

In case of lower power supply the set of anode plates is lead-filled in the bottom of said electrolyzers, this design making difficult the installation of the cathode and an adequate installation of the anode in the electrolytic cell.

In case of upper power supply the installation of the anodes in the cover of a high output electrolyzer makes the whole construction too cumbersome.

Moreover, the anodes secured in the cover are at a low location which hinders the removal of chlorine from the electrolysis zone.

In the electrolyzers known at present the power supply to the cathode screen is usually effected only along the upper and lower perimeters of the contact area between the cathode and the casing, thus resulting in increased losses of voltage in the cathode.

All these drawbacks reduce the efficiency of modern powerful diaphragm electrolyzers.

An object of the present invention is to provide a powerful diaphragm electrolyzer which is characterized by maximum output per unit of the floor space, is easily dismantled and reassembled when repairing it and replacing diaphragms and sets of anode plates, has a long service life and a reliable protection of the current-carrying parts and the casing from corrosion, minimum losses of current in the busbars, contacts and electrodes, and insures free evolution of gas from the electrolysis zone, as well as stable operation.

The above objectives are achieved by a diaphragm electrolyzer for production of chlorine, hydrogen and alkalies comprising a set of identical elementary electrolytic cells consisting of anode and cathode sets and a diaphragm and being housed in a common stationary casing, said casing being divided with partitions into a plurality of similar sections to house said elementary identical electrolytic cells, the anode set of the cells being made as a set of anode plates secured on a common base, the anode set also being installed on the insulated bottom of the electrolyzer casing. The current to the anode sets is supplied through a busbar which is common for all the anodes, and is located at the top, said busbar being connected through a slot in the lining of the elementary electrolytic cell wall to the lower parts of the anodes in the plate. The current can be also supplied to the anode sets from the top through a busbar which is common for all the anodes, and is connected to metal clamps holding the contact parts of the anodes and passing current to them.

The anode sets of the elementary electrolytic cells can be manufactured as vertical units composed of vertical rows of horizontally located graphitized plates installed one on another, with side location of the current leads to the vertical rows of the anodes, while every two vertical rows of anodes have common current leads at the both sides of which said rows are positioned, said current leads being housed in a chlorine-resistant supporting frame. Each vertical row can have its own current leads located inside the chlorine-resistant frame.

The cathodes of the elementary electrolytic cells are manufactured as two rows of box-shaped cathode elements united by a central housing, said cathode elements being symmetrically located relative to the central housing.

The cathodes of the elementary electrolytic cells can be also manufactured as two rows of box-shaped cathode elements united by a central housing, said cathode elements being symmetrically located relative to the central housing-screen, said cathode elements being provided with special slots for inserting and protecting the edges of the laminated diaphragms, said slots being located at the edges of the cathode pockets in the upper and lower parts of the central housing. The elementary electrolytic cells can be equipped with cathodes having cathode cells formed by box-shaped cathode elements, the width of said elements corresponding to the thickness of the anodes irrespective of wear.

In compliance with the invention, the cathodes of elementary electrolytic cells may be also equipped with current leads running from the top through a slot in the lining of the elementary electrolytic cell.

Other objects and advantages of the invention will be made apparent from the below description and the accompanying drawings in which:

FIG. 1 is a top partial sectional view of the electrolyzer with a lower anode power supply;

FIG. 2 is a side partial sectional view of the electrolyzer with a lower anode power supply;

FIG. 3 is a plan view of an elementary electrolytic cell with a side anode power supply and with anodes located symmetrically relative to the frame carrying said anodes;

FIG. 4 illustrates the location of anodes with a side power supply in the electrolyzer;

FIG. 5 is an elementary electrolytic cell with a side anode power supply and one-sided location of the anodes relative to the frame carrying said anodes;

FIG. 6 illustrates the location of anodes and cathodes in the insulated cells;

FIG. 7 is a cathode with slots for inserting the edges of the laminated diaphragm;

FIG. 8 is a plan view partially in section of the electrolyzer with the anodes having one common lead of the feeding busbar common for said anodes, said lead passing through the lining of walls;

FIG. 9 is a section taken along 9—9 and 9'—9' in FIG. 8;

FIG. 10 is a plan partial sectional view illustrating the fastening of anode plates to the current carrying busbar;

FIG. 11 is a side view, partly in section, illustrating the fastening of cathode plates to the current carrying busbar;

FIG. 12 is a plan of the anode set; and

FIG. 13 is a side partial view of the cathode set.

The diaphragm electrolyzer in accordance with the invention comprises a set of identical, comparatively small elementary electrolytic cells **1** rated at a definite load, said cells being located in a common casing **2** of a unit, said casing being divided with partitions **3** into sections which serve to house elementary electrolytic cells **1**.

The output of such an electrolyzer depends upon the number and capacity of the elementary electrolytic cells.

The elementary electrolytic cells can be dismantled and removed from the casing during repair or maintenance, while the casing itself is to be fixedly installed.

Elementary electrolytic cells **1** housed in the common casing include sets **4** and **5** of anodes and cathodes, respectively, with electric busbars, said cells operating quite independently from the point of view of electrolysis products and current.

Each elementary electrolytic cell can be fitted with an individual cover **6** having brine inlets **7** and holes **8** for discharge of chlorine, as well as pipe unions **9** and **10** to discharge hydrogen and alkali, respectively.

The elementary electrolytic cells can be housed in one casing and not be insulated as to the electrolyte (FIG. 3). In this case each elementary cell is to be series-connected to the respective elementary cells of the neighboring (in series) electrolyzers, the number of the busbars connecting two neighboring (in series) electrolyzers being equal to the number of elementary electrolytic cells in the electrolyzer, and each busbar being rated at the load of the elementary electrolytic cell.

Elementary electrolytic cells can be housed in one casing and be insulated as to the electrolyte (FIGS. 5 and 6). In this case each elementary electrolytic cell is series-connected to the other cells within one electrolyzer, the electrolyzing units of one series being coupled with each other irrespective of their output, with one electric jumper rated at the load of one elementary electrolytic cell.

The anode set of each elementary electrolytic cell is a plurality of specially located graphitized plate anodes **11** with a power supply system and a contact protective device.

The anodes are installed in parallel rows in the electrolytic cells formed by box-shaped cathode elements **12**. The anodes can be fitted with lower current leads (FIGS. 1 and 2) or side current leads (FIGS. 3 and 4).

It is preferable to use a lower anode power supply through busbar **13**, common for the set of anodes and being brought upwards through the lining of the elementary electrolytic cell walls (FIG. 1). In this case the lower parts of the anodes of each row are coupled with anode busbars **14** (FIG. 9), said busbars being formed as copper or steel clamps, bolted to the edges of the graphitized plates.

All the anode busbars are connected by bolts to anode busbar-collector **15** which, in turn, is connected to the output anode busbar.

All the contact parts of the anodes together with the anode busbars and the common anode busbar, located in concrete trough-shaped base **16** of the anode set of the elementary electrolytic cell, is filled up with bituminol layer **17**, and then with cement **18** to protect them from the effect of chlorine and the electrolyte. The part of the common anode busbar is also protected by any of the know means from the effect of chlorine and anolyte.

The anode set made as a concrete plate with the immersed contact parts of the anodes, located in parallel rows, and with protruding parts of said anodes, is installed on the bottom of the electrolyzer casing so that the common anode busbar enters respective slot **19** in the lining of the elementary electrolytic cell wall and its contact end runs upward between the wall and the cover of the elementary electrolytic cell. To protect the common anode busbar from the effect of chlorine and electrolyte, the slot is filled with bituminol and cement.

The use of the anode sets with the lower power supply and the output of the common anode busbar at the top, significantly simplifiies the installation of electrolyzers and, in particular, the installation of the cathodes of the elementary electrolytic cells. The employment of metal clamps, serving as anode busbars, for installation of the anode set does not require any use of expensive lead and permits adjustment of the position of the anodes during the assembly.

The electrolyzer output can be effectively increased without enlarging the floor space occupied by the electrolyzer, by extending the electrode surfaces in height. However, the use of electrodes extended in height with lower or upper power supply results in great losses of voltage, while the combination of the lower anode power supply with the upper one greatly complicates the anode power supply system and creates difficulties in the use of electrolyzers.

In compliance with the proposed invention, electrodes extended in height can be used in case the elementary electrolytic cell has a side current lead into its electrodes. In this case the anode set of the elementary electrolytic cell (FIG. 4) comprises vertical units located in rows. The units are composed of graphitized plates **11** placed on one another, the contact part and all the busbars of said plates being housed in a vertical chlorine-resistant supporting frame **20**. The frame has the shape of a trough with the holes for securing the anode busbars made as metal clamps **21**.

The cover has holes **22** to bring out common anode busbar **23**. The contact part of the anodes assembled in vertical units is bolted in metal plate clamps which are secured to common busbar **23**.

Anodes **11** assembled in vertical rows are secured to the anode busbars with the anodes projecting outwardly on both sides of the supporting chlorine-resistant frame **20** (FIG. 4).

In compliance with the invention, the anode set can be made as vertical rows of anodes secured in the vertical chlorine-resistant supporting frames, with the anodes projecting outwardly from the frame in one direction (FIGS. 5 and 6).

Insulation of the anode contact parts and their power supply system is effected by filling them with concrete and bituminol.

Each anode unit of the elementary electrolytic cell is installed so that the anodes enter the clearance between the neighboring box-shaped cathode elements **12** covered with a metal screen.

The cathode of the elementary electrolytic cell is manufactured as a central metal housing **24** (FIG. 12) with rows of symmetrical cathode pockets **12** covered with a screen and located on both sides of the housing. The housing serves as a current lead to the pockets and has pipe unions for discharge of alkalies and hydrogen.

In compliance with the invention, the cathodes of the elementary electrolytic cells can employ both laminated and deposited diaphragms, for which purpose the edges of the cathode pockets and the upper and lower edges of the cathode housing, mounting said cathode pockets have special slots **25** to insert and secure the edges of a laminated diaphragm **26** with putty **27** (FIG. 7). It is known that a laminated diaphragm is more uniform than a de-

posited one. The use of the laminated diaphragm therefore permits reduction of requirements to the brine supply of the electrolyzer. The cathode pockets represent a metal frame with a screen welded along the upper and lower perimeters, said frame being connected to the cathode housing. The frame of the cathode pockets consists of lateral metal strips **28**, serving as current-carrying busbars, and vertical metal strips **29** (FIG. 13) connecting said busbars along the axis, said strips **29** also supporting the screen and distributing current in this screen.

In compliance with the preferred embodiment of the invention, the elementary electrolytic cells are equipped with cathodes having electrolysis cells **30** of various sizes formed by cathode pockets **12** and used to house the anodes. Owing to this, during the replacement of the diaphragm, the service life of which is shorter than that of the anodes, the cathodes of the elementary electrolytic cells are replaced by the cathodes with narrower electrolytic cells, providing for the required inter-pole distance with due regard to the anode wear. The use of the cathode sets with different width of electrolytic cells results in a significant saving in electricity.

It is not necessary to manufacture two or more sets of cathodes with different cells for all the electrolyzers. It is quite sufficient to have half of the sets of cathodes with electrolytic cells whose size will be rated at the thickness of the anodes before replacement of the diaphragm, and half of the sets with the sizes rated at the thickness of the anodes after replacement of the diaphragm, that is, the number of the cathode sets should correspond to the number of cells in electrolyzers.

In compliance with the invention, the cathode set is arranged in the elementary electrolytic cell by installing the cathodes on the base of the anode set so that the anodes of the anode set symmetrically enter cells **30** between cathode pockets **12**.

Irrespective of the construction, the cathodes of the elementary electrolytic cells are equipped with busbars to deliver current. The cathode busbar coated with rubber or some other chlorine-resistant material is brought out to the top through holes **31** in the cover, and is connected to the busbars of the neighboring electrolytic cells.

Through the invention is described in connection with the preferred embodiment, it is evident that changes and modifications may be made therein without departing from the spirit and scope of the invention, as those skilled in the art will easily understand. For instance, an anode power supply provided with the help of metal clamps can be also accomplished with the anodes secured in the cover, the elementary electrolytic cells being equipped with two or more covers, the elementary electrolytic cell having, depending on its selected output two or more cathodes made as a central housing with symmetrically located parallel rows of cathode pockets; instead of a metal screen, the cathode pockets can be covered with perforated sheet metal.

These changes and modifications are considered to be within the spirit and scope of the invention and the appended claims.

What is claimed is:

1. An electrolyzer for the production of chlorine, hydrogen and alkalis from salt solutions, said electrolyzer comprising a non-conducting casing having a bottom and upstanding walls; at least one anode assembly disposed within said casing and comprising a current-conducting plate mounted vertically on the bottom of said casing and including anodes secured to said plate, said anodes being in the form of rectangular plates secured at right angles to said current-conducting plate on opposite sides thereof, all the anodes of said anode assembly being parallel-connected to said current-conducting plate; at least one perforated cathode mounted on the bottom of said casing and comprising a plurality of parallel flat hollow cathode boxes, one end of each said box being connected to a common duct through which electrolysis products formed at the cathode are to be discharged, so that the inner space of said cathode boxes communicates with the inner space of said duct, said cathode being comb-shaped and including cathode fingers formed by said boxes the disposition of which is such that said hollow cathode boxes are interposed between said anodes of said anode assembly; a porous diaphragm on the perforated cathode surface; and a non-conducting cover which closes the electrolyzer.

2. An electrolyzer for the production of chlorine, hydrogen and alkalis from salt solutions, said electrolyzer comprising a non-conducting casing have a bottom and upstanding walls; at least one anode assembly disposed within said casing and comprising a current-conducting plate mounted vertically on the non-conducting bottom of said casing and anodes in the form of rectangular graphite plates, one-half of said anodes being secured at one end to one vertical surface of said current-conducting plate and the other half of said anodes being secured to the other vertical surface of said current-conducting plate to provide a symmetrical disposition of said anodes at both sides of said current-conducting plate at right angles thereto in rows arranged one adjacent the other; metal cathodes mounted on said non-conducting bottom of said casing and comprising at least one flat porous vertically disposed box constituted of a perforated metal and having one end connected to a common duct through which electrolysis products formed at the cathode are to be discharged, so that the inner space of said cathode boxes communicates with said duct, said cathodes being mounted so as to place said perforated metal boxes in the intervals between rows of said anodes of said anode assembly, provision being made in the cathodes which are disposed between a wall of said casing and said anode assembly for one row of said hollow boxes connected to one side of said common duct and arranged between the anode rows of said anode assembly, while in the cathodes disposed between two said anode assemblies provision is made for two rows of said perforated metal boxes connected symmetrically on both sides of said common duct, one row of said perforated metal boxes being arranged between the anodes of one of said two anode assemblies, and the other row of said perforated metal boxes between the anodes of the other anode assembly; a porous diaphragm on the external perforated surface of said cathodes; and a non-conducting chlorine-resisting cover which closes the electrolyzer.

3. An electrolyzer according to claim **2**, wherein the current-conducting plates of said anode assemblies, the busbars to said anode assemblies and the busbars to said cathodes are coated with a chlorine-resistant material.

4. An electrolyzer according to claim **2**, wherein the current-conducting plates of said anode assemblies and the busbars of said anode assemblies are made from a chlorine-resistant material, the inoperative surfaces of said cathodes and the surfaces of said cathode busbars cathodes which contact moist chlorine and chlorine-containing electrolyte being coated with a chlorine-resistant material.

5. An electrolyzer for the production of chlorine, hydrogen and alkalis from salt electrolytes, said electrolyzer comprising a non-conducting casing having a bottom and upstanding walls and including non-conducting partitions forming a plurality of separate sections; anode assemblies disposed in said sections and comprising current-conducting plates mounted vertically on the non-conducting bottom of said casing and anodes in the form of rectangular plates secured at one end thereof to the opposite vertical surfaces of said current-conducting plates at right angles thereto; comb-shaped cathodes including cathode fingers made from a perforated metal in the form of hollow, flat vertically disposed boxes connected to common ducts through which electrolysis products formed at the cathodes are to be discharged, the inner space of said ducts communicating with the inner space of said cathode boxes, said cathodes being mounted on the non-conducting bottom of the casing so as to place said hollow boxes between said

anodes of said anode assemblies; a diaphragm on the perforated surfaces of said cathodes; non-conducting covers which close said sections from the top; busbars to said anode assemblies and busbars to said cathodes arranged so as to insure parallel connection of all the anodes in each of said sections and also to insure parallel connection of all the cathodes in each of said sections, means for current passage consecutively through all sections of the electrolyzer and shunting means for de-energizing separate sections as desired.

6. An electrolyzer according to claim 5, wherein all said sections are electrically connected in parallel.

7. An electrolyzer according to claim 5, wherein each section is series-connected to respective sections of adjacent electrolyzers.

8. An electrolyzer according to claim 5, wherein said partitions separating said casing into sections have orifices below the electrolyte level, whereby each section is in fluid communication with adjacent sections, said orifices being closable.

9. An electrolyzer for the production of chlorine, hydrogen and alkalis from salt solutions, said electrolyzer comprising a non-conducting casing having a bottom and upstanding walls; at least one anode assembly disposed within said casing and comprising a current-conducting plate mounted vertically on the bottom of said casing and graphite anodes in the form of rectangular plates secured at one end thereof to the vertical opposite surfaces of said plate at right angles thereto, so as to form on both sides of said current-conducting plate at least two rows of said anodes arranged one above another, means providing parallel connection of all the anodes of said anode assembly; metal cathodes, each cathode comprising a plurality of hollow flat vertically disposed boxes made from a perforated metal and connected to a common duct through which electrolysis products formed at the cathodes are to be discharged, and having a comb-type structure in which cathode fingers are formed by said hollow vertically disposed boxes, said comb-shaped cathodes being arranged so as to place said vertical boxes in the intervals between the rows of said anodes of said anode assembly with clearance between the surface of said anodes and the surface of said hollow boxes, a part of said cathodes being adapted for use with partially worn anodes and having accordingly a greater width of said hollow boxes in order to maintain the prescribed clearance where the anodes in the anode assemblies are partially worn and are accordingly thinner.

10. An electrolyzer according to claim 1 wherein a plurality of anode assemblies are provided and the anode plates of the anode assemblies at each end extend from one side of the respective current conducting plates.

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J. H. MACK, Primary Examiner

D. R. VALENTINE, Assistant Examiner

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