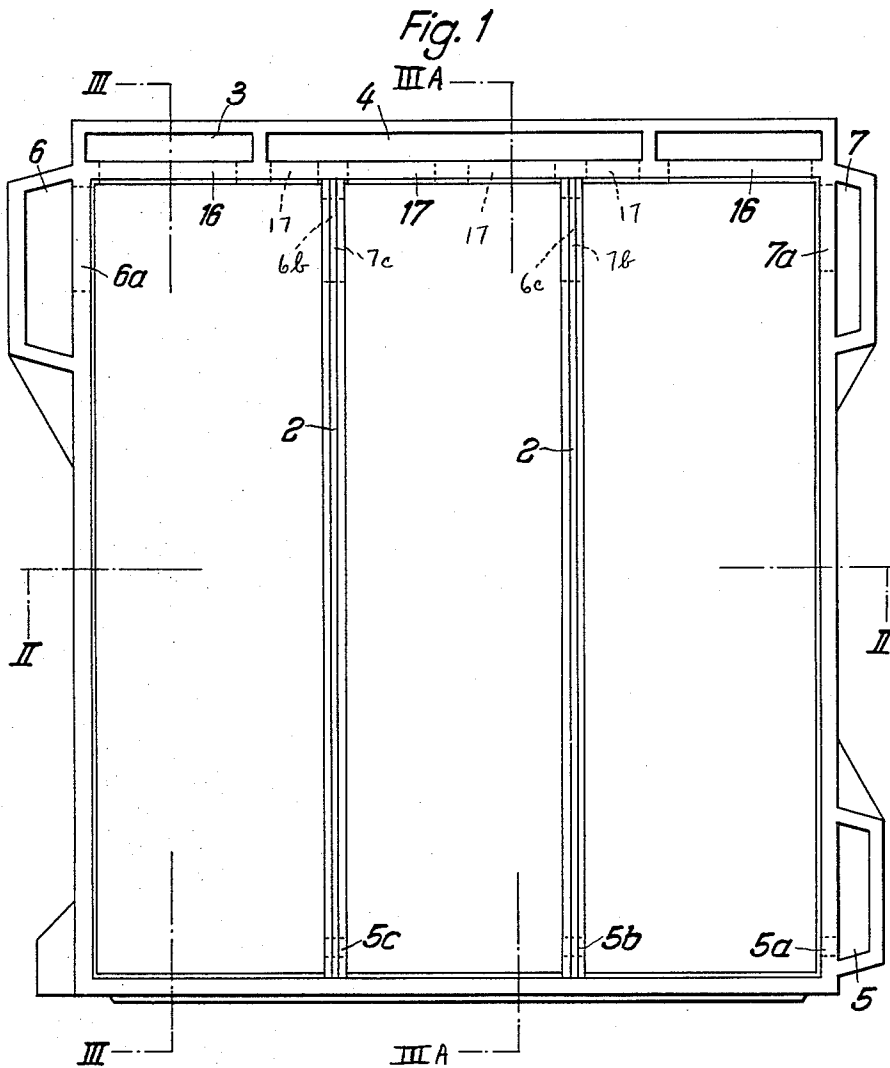


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FRAMES FOR ELECTROLYTIC DIAPHRAGM CELLS

Filed Sept. 27, 1961

6 Sheets-Sheet 1



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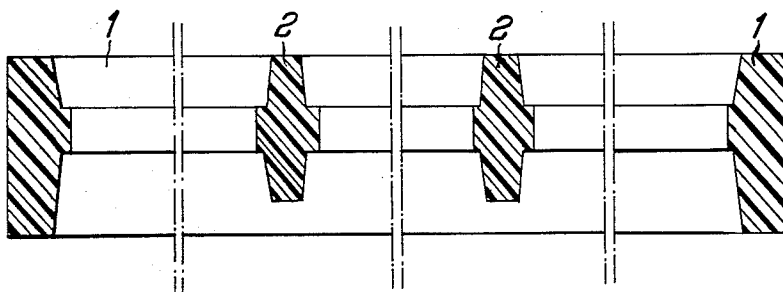
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FRAMES FOR ELECTROLYTIC DIAPHRAGM CELLS

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6 Sheets-Sheet 2

Fig. 2



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FRAMES FOR ELECTROLYTIC DIAPHRAGM CELLS

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6 Sheets-Sheet 3

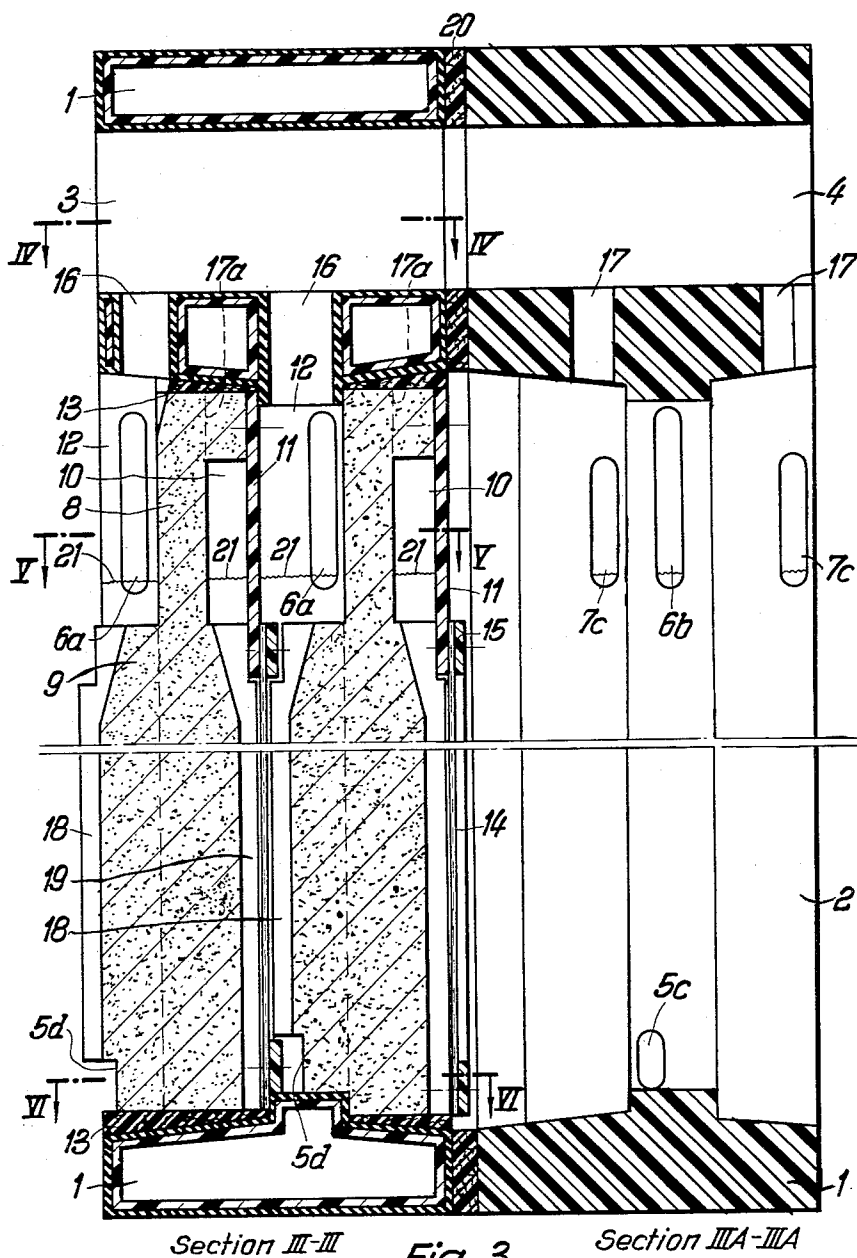


Fig. 3

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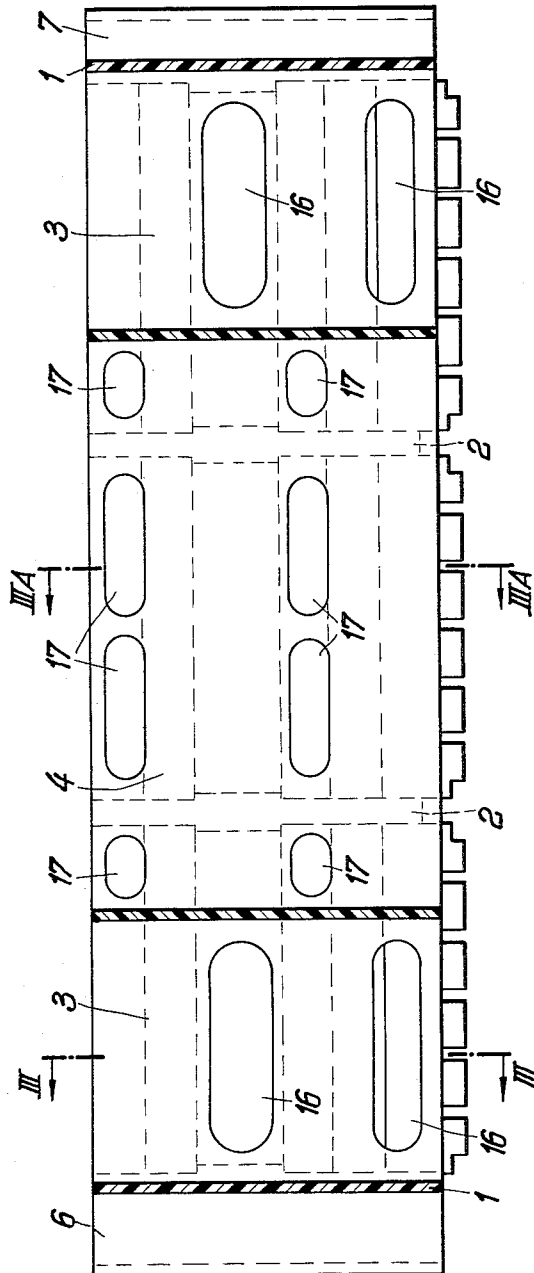
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FRAMES FOR ELECTROLYTIC DIAPHRAGM CELLS

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6 Sheets-Sheet 4



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FRAMES FOR ELECTROLYTIC DIAPHRAGM CELLS

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6 Sheets-Sheet 6

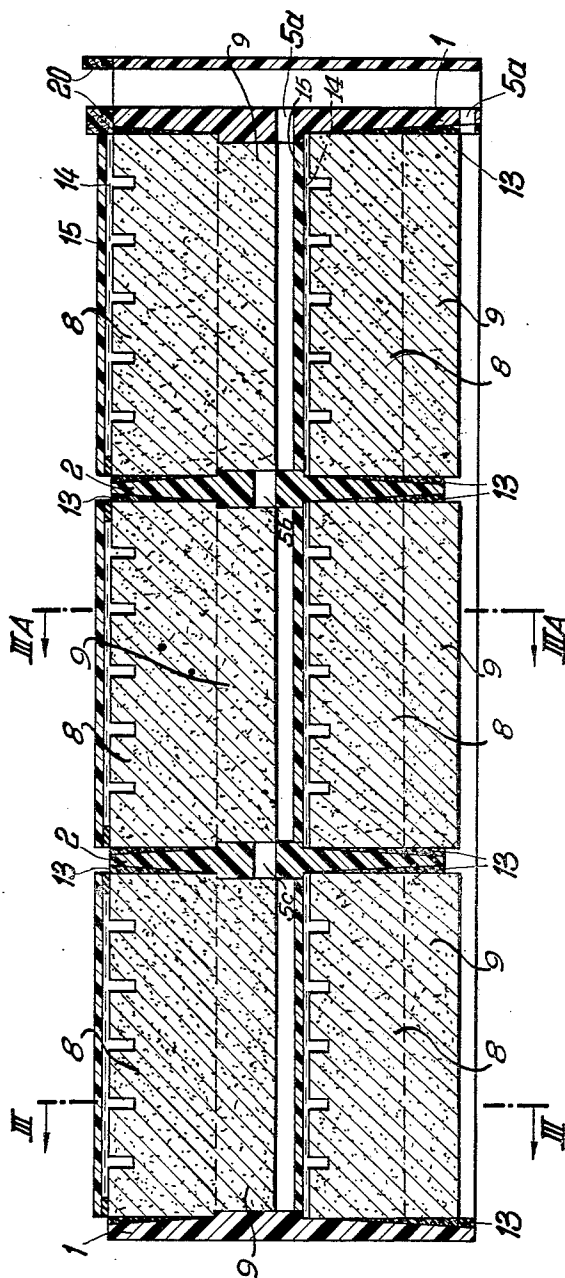


Fig. 6

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3,252,883

FRAMES FOR ELECTROLYTIC DIAPHRAGM CELLS

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Filed Sept. 27, 1961, Ser. No. 141,093

16 Claims. (Cl. 204-279)

The present invention relates to frames for electrolytic diaphragm cells having bipolar graphite electrodes, and more particularly to such frames forming a diaphragm cell substantially completely occupied by the electrode, said electrodes being bonded to said frame with a minimum of exposed bonding material.

Generally, frames for electrolytic diaphragm cells having bipolar graphite electrodes are provided with supply conduits or inlet conduits at their lower ends and discharging or outlet conduits for the anolyte and catholyte respectively at their upper ends. A plurality of such diaphragm cells is formed by arranging the electrodes in series relationship in a similar manner to the cells of a filter press. The diaphragm cells of the foregoing type are conveniently used, for example, in the electrolysis of hydrochloric acid to form hydrogen at the cathode and chlorine at the anode.

Specifically, the diaphragm cells for the electrolysis of hydrochloric acid, such as the so-called "Bitterfeld" cells are well known. Cells of this type include a frame having supply conduit means for the concentrated hydrochloric acid and outlet conduit means for the chlorine, hydrogen and dilute hydrochloric acid formed during the electrolysis. Such frames contain a rigid graphite cathode and a hollow anode body filled with granulated material or a hollow cathode body and a hollow anode body both being filled with granulated graphite. Sealing gaskets are provided in the frame between the individual diaphragm cells in order to prevent the escape of concentrated acid, gaseous chlorine discharged at the anode, or gaseous hydrogen discharged at the cathode. The size of the sealing surface is of prime importance in such cells, especially since the gaseous chlorine passing through the outlet means readily attacks the sealing gaskets situated therealong.

The chlorination of organic compounds for use in present-day large scale commercial chemical processes yields, as a by-product, huge quantities of hydrochloric acid. This acid being in dilute form cannot be sold as such and therefore, the regeneration of chlorine from the aqueous hydrochloric acid by-products has become a major problem in the chemical industry. It will be appreciated obviously that it is most expedient to electrolytically decompose the hydrochloric acid obtained as a by-product of the chlorination of organic compounds in order to recover elemental chlorine which may again be used such as for the chlorination of organic compounds as well as for other desired purposes.

Various constructions have been developed in recent years employing several electric cells arranged in series in the manner of filter press cells which construction have been used for the production of oxygen or hydrogen as the case may be. Preferably bipolar electrodes are used for this purpose. The operation is carried out by mounting a bipolar electrode in a frame having a thickness and therefore a size with respect to each individual frame corresponding to the thickness and size of the electrodes and their necessarily small distance from the separating diaphragm between the anode of one electrode and the cathode of another. Such frames have an effective anode area of about 1.5 sq. meters.

The economy of operation of electrolytic diaphragm apparatus of the foregoing type, whether used for the

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electrolysis of hydrochloric acid or for the electrolysis of water, depends substantially upon the effective anode area of each frame and furthermore upon the effective anode area per sq. meter of floor space occupied by the apparatus.

It is an object of the present invention to overcome the foregoing drawbacks and to provide an efficient frame means construction for electrolytic diaphragm cells which are compact and substantially free from exposed packing or sealing gaskets, the electrodes substantially completely occupying the space defined by the frame.

It is another object of the invention to provide a frame construction having an increased effective anode area per frame as well as an increased effective area of each frame per sq. meter of floor space occupied thereby.

It is a further object of the invention to provide a substantially reduced area of the sealing surfaces which are exposed to attack by the produce of electrolysis or by the electrolyte itself.

It is a still further object of the invention to provide a multifold increase in the reliability of operation of the electrolytic diaphragm cell arrangement while correspondingly reducing considerably the required floor space occupied by the apparatus.

Other and further objects of the invention will become apparent from a study of the within specification and accompanying drawings in which:

FIG. 1 is a schematic side elevation of a frame for an electrolytic diaphragm cell in accordance with the invention,

FIG. 2 is a schematic sectional view, taken along the line II—II of FIG. 1,

FIG. 3 is a partial schematic view of an arrangement in accordance with the invention shown in step-wise section, the left section being taken along line III—III and the right section being taken along the line IIIA—IIIA of FIG. 1,

FIG. 4 is a schematic cross sectional view taken along the lines IV—IV in FIG. 3 showing the discharging ports for the gaseous products of the electrolysis,

FIG. 5 is a view similar to FIG. 4 but taken at the level of the line V—V in FIG. 3 showing the end outlet and intermediate passageways for anolyte and catholyte,

FIG. 6 is a view similar to FIGS. 4 and 5 taken at the level of line VI—VI in FIG. 3 showing the feeding inlet and intermediate bores for supplying the electrolyte.

In accordance with the invention, it has been found that an effective frame for an electrolytic diaphragm cell arrangement may be provided wherein preferably more than one bipolar electrode member is compactly disposed in a frame for an electrolytic diaphragm cell, such that the cell space is substantially completely occupied by the electrodes. Preferably, the diaphragm is disposed adjacent the anode surface of each electrode. The frame may be made of sectional members or elements which are manufactured from a material resistant to the electrolyte and to the products of electrolysis, the frame extending over substantially the entire thickness of the electrode members.

Conveniently, the outlet conduit means for the products of the electrolysis are arranged on the upper end of the frame such that the same are structurally separated from the outlet conduits used for discharging the catholyte and anolyte material from the cell. Accordingly, the feeding conduits are provided on the lower end of the frame.

Advantageously, the frame extends over substantially the entire width of the bipolar electrodes and is made from closed channel or tubular material such as that manufactured by extrusion or by welding techniques in the conventional manner. These frame elements may be suitably covered in known manner with an inert rubber

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coating with respect to the electrolyte and products of the electrolysis. The frame, on the other hand, may also be made from solid material, such as plastic or hard rubber material, which is resistant to the corrosive influence of the electrolyte or products of electrolysis in the same way.

Preferably the anode side of the bipolar electrode in each instance extends along the entire inner height of the frame and its upper end is provided with a collecting channel sealed off by a partition wall from the next adjacent cathode. The anode space is defined by a plurality of slots or recesses in the anode surface and this anode space flow communicates with the outlet conduit therefor by means of said collecting channel. On the other hand, the bipolar electrode on its cathode surface terminates at a point in height below the top end of the frame such that a collecting channel or gas space is formed above the top end of the terminating cathode. A similar plurality of slots or recesses are defined in the cathode surface to form the cathode space, this cathode space being flow communicated with the outlet conduit therefor by means of said collecting channel or cathode gas space.

Inasmuch as the upper portion of the electrode, preferably the anode surface, is closed off via a sealing partition wall to form an anode gas space or collecting channel, it is not necessary to extend the diaphragm over the entire inner height of the frame. Preferably, the diaphragm extends only a short distance beyond the lower end of the partition wall and is fastened to the corresponding anode surface across which it extends by means of a frame-like structure. Where the electrodes are rectangular in shape, of course, the diaphragm frame-like structure may also be correspondingly rectangular in shape.

In accordance with the construction of the invention, it is possible to fasten the bipolar electrodes to the frame by merely cementing or bonding them to the bottom and sides of the frame up to the level of the top end of the anode. The bonding area conveniently extends substantially across the entire thickness or depth of the frame. In addition, the upper end of the anodes which extend to the top of the frame are conveniently cemented to the frame along their upper sides and top surface. The bonding is effected across the entire thickness of the upper portion of the anode in each instance with respect to the adjacent frame.

In accordance with the preferred embodiments of the invention, the frame is provided with intermediate brace elements which, in the same manner, may be rubber coated hollow elements or solid elements made from hard rubber or suitable plastic material, such that the same will be inert to the corrosive action of the electrolyte or the products of electrolysis. In accordance with this embodiment, the brace elements extend from top to bottom intermediate the ends of the frame but do not extend over the entire thickness or depth of the frame. These brace elements thus serve as reinforcement means rather than as partition means dividing the electrode members into separate cells.

Referring to the drawing, FIG. 1 shows a solid sectional member made from a suitable plastic material or hard rubber although the frame 1 may be made, in the alternative, of extruded or welded closed channel or tubular members. Frame 1 is reinforced by brace elements 2 which preferably do not extend over the entire thickness or depth of frame 1. In the same way, brace elements 2 while shown as solid elements may also be constructed as hollow sections of suitable material. At the upper end of the frame 1, end outlet conduits 3 and intermediate outlet conduit 4 are provided. The outlet conduits 3, positioned at both lateral sides of frame 1, serve as outlet means for the products of electrolysis produced or generated for example at the cathode whereas the outlet conduit 4 serves as outlet means for the products of elec-

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trolysis produced or generated, for example, at the anode. Outlet conduits 3 are connected to the interior of frame 1 by means of discharge ports 16 while outlet conduits 4 are connected to the interior of the frame by means of discharge ports 17.

At the lower right-hand side of frame 1, as viewed in FIG. 1, a feed or inlet conduit 5, for the electrolyte is provided. Inlet conduit 5 is connected to the different spaces within frame 1 by means of a plurality of bores 5a in frame 1 and 5b and 5c in brace elements 2.

On the upper right-hand side of frame 1, as viewed in FIG. 1, an outlet channel 7, for example, for the anolyte is provided which flow communicates with the interior of frame 1 by bore 7a while, on the upper left-hand side of frame 1, and outlet channel 6 is provided, for example, for the catholyte which is connected to the interior of frame 1 by bore 6a.

With respect to FIG. 2, the vertically extending brace elements 2 are shown intermediate the side walls of frame 1 whereby the electrode members may be suitably disposed within frame 1 between brace elements 2. Brace elements 2 do not completely extend from the forward wall to the rearward wall of frame 1 but instead permit open communication between the intermediate spaces defined in frame 1 by brace elements 2.

In FIG. 3, specifically, two frames in accordance with the invention are shown, which are arranged in tandem in diaphragm cell series relationship. The frame on the left, as viewed in FIG. 3, shows the structural details of one portion of the frame and the electrodes while the frame, on the right, shows other structural details with the electrodes being omitted. Two bipolar electrodes are bonded to frame 1 so that the same substantially completely occupy the cell space or chamber within the respective frame 1. The rearward face of the left bipolar electrode may, for instance, be an anode surface 8 while the forward face of the left electrode may be the cathode surface 9. At the upper end of the portion of the electrode which, for instance, is used as an anode surface, a collecting channel 10 is provided which is sealed off by partition wall 11 from the adjacent electrode. This collecting channel or gas space 10 serves to collect the gases generated at the anode surface. The top of the cathode 9 terminates below the top end of frame 1 and in the area above the top end of cathode 9 a collecting channel or gas space 12 is provided in the same manner as collecting channel or gas space 10. Bipolar electrodes 8, 9 are bonded to frame 1 by an acid proof cement material of the customary type. The entire bipolar electrode in each instance along its lower end and the entire anode along its upper end are bonded across their entire outer surface to the corresponding surfaces of frame 1. The electrodes are cemented to frame 1 in order to achieve a structural stability which is substantially greater than that heretofore possible.

Adjacent each anode surface 8, for example, a diaphragm 14, is positioned by means of rectangular frame 15. The mounting of frame 15 is such that the upper side thereof also serves to mount partition wall 11 on anode 8.

It will be appreciated that the collecting channel or gas space 12 for the cathode flow communicates with outlet conduit 3 by means of discharge ports 16. In the same way, the collecting channels 10 are connected via bores or recesses 17a closed off by partition walls 11 to the outlet conduit 4 by means of discharge ports 17. The recesses 17a, as indicated by broken lines in the left portion of FIG. 3, are disposed within the upper parts of the anodes 8 such that they are registered with the appropriate discharge ports 17. On both surfaces of the electrode, grooves or recesses 18 and 19 are provided which define with the surrounding portions of the frame 1, the appropriate cathode space and anode space respectively. Outlet channel 6 is flow connected to the collecting channels or gas spaces 12 for the cathode by means of a plurality of passageways 6a in frame 1 and 6b and 6c in brace ele-

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ments 2. Since brace elements do not extend over the whole thickness of frame 1 passageways 6b and 6c are not necessary for connecting the left ones (as viewed in FIG. 3) of cathode gas spaces 12. In a similar manner outlet channel 7 is flow connected to the collecting channels or gas spaces 10 for the anode by means of a plurality of passageways 7a in frame 1 and 7b and 7c in brace elements 2.

Electrode portions 9 are recessed at 5d to allow electrolyte supplied through bores 5a, 5b and 5c to flow laterally. The electrolyte need be supplied only to one of the electrode portions usually to the anode so that, with respect to the feeding circuit shown in FIG. 3 (and accordingly in FIG. 6), the electrode portion 9 which is above indicated as cathode would have to be operated as anode and vice versa.

Where a double cell arrangement of the frame apparatus, in accordance with the invention is used, for the electrolysis of hydrochloric acid, however, it is advisable for best results to connect the electrodes in such a way that the portions be operated as formerly designated, e.g. surfaces 9 as cathodes and surfaces 8 as anodes. Inlet bores 5a, 5b and 5c as well as recesses 5d would then, however, have to be disposed such that they flow connect feeding channel 5 with electrode portions 8 rather than with electrode portions 9.

By means of connecting the electrodes in this way, the extremely aggressive chlorine gas is drawn off via discharge ports 17 located in the middle of frame 1 which lead to a central outlet conduit 4. Additionally, the collecting channels for the chlorine gas, which would otherwise have been adjacent the sealing surfaces, are positioned in the center of frame 1. This results in an arrangement such that the area of the sealing surfaces or packing material 13, which can be attacked by elemental or molecular chlorine is still further reduced.

It will be seen that the packing gasket or bonding material 13 is substantially completely retained between frame 1 and the appropriate electrode such that the packing or bonding material 13 is, for the most part, unexposed to the anode space and the cathode space and therefore not subjected to the corrosive action of the electrolyte or products of electrolysis.

Concerning the second frame 1 on the right, as viewed in FIG. 3, the collecting channels or gas spaces 10 flow connected to the anode spaces defined by recesses 19 where the electrode is provided with an anode 8 extending to the top of the frame 1, pass the products of electrolysis from recesses 19 to outlet conduit 4 via recesses 17a and discharge ports 17. For comparison, while the frame on the left side of FIGURE 3 is shown as a hollow tubular frame member, that on the right is shown in solid form to illustrate both possibilities of construction.

FIGURES 4, 5 and 6 show cross sectional views of the embodiment of the invention shown in FIGURES 1 to 3 taken at different levels.

Thus, FIG. 4 shows actually a plan view of the discharge ports for the gaseous products of the electrolysis. Discharge ports 16 connect gas spaces 12 with outlet conduits 3 while discharge ports 17 via recesses 17a registered therewith connect gas spaces 10 with outlet conduit 4.

FIG. 5 shows a cross sectional view taken at the height of the gas collecting channels or gas spaces 10 and 12. As it will be seen from this view, end outlet passageways 6a and 7a in frame 1 and intermediate outlet passageways 6b, 6c and 7b, 7c in brace elements 2 serve to discharge catholyte and anolyte respectively.

At the left hand side of FIG. 5 there is partially shown the next following cell the main portion of which is broken away, and which is secured to the previous cell sealed off along all abutting edges by sealing gaskets 20.

The cross sectional view shown in FIG. 6 is taken at the level of the inlet bores 5a, 5b and 5c, thus showing

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the feeding or supply circuit for the electrolyte supplied through channel 5.

If the sealing gasket 20 is omitted in the region of the forward bore 5a (at the side edge of the frame as shown in the upper portion of FIG. 6) this forward bore 5a may also be omitted.

In the left portion of FIG. 3 the approximate level of the electrolyte within the electrode spaces is indicated by wavy lines 21.

As particularly seen from FIGURES 5 and 6, the packing or bonding material 13 is shown to be practically completely covered by the adjacent surfaces of frame 1 and the electrode. Only a very thin strip of material 13 is, therefore, exposed to the action of the electrolyte or products of electrolysis. The drawings furthermore illustrate clearly that the electrodes substantially completely occupy the cell space within frame 1 to afford a very strong structural arrangement and a compact condition with respect to the anode area as well as the floor area occupied by the over-all apparatus.

The frame arrangement in accordance with the invention is at least twice the thickness of frames used heretofore in view of the fact that it contains in the preferred embodiment at least two bipolar electrodes each having an anode and cathode surface so as to form a single member. Two diaphragms are accordingly also provided. The two complete cells are arranged one behind the other such that all channels and conduits carrying the very aggressive gaseous or fluid media to and from the cells are positioned within the double cell frame structure. It will be appreciated, in accordance with the construction of the invention, that these channels carrying the gaseous or fluid media are not provided in the vicinity of any of the sealing surfaces between adjacent double cell frame structures. Where a double cell frame structure, in accordance with the preferred embodiment of the invention is provided, the area of sealing surfaces between the individual frames of the apparatus are advantageously reduced by about 70% in comparison with conventional single cell frames.

The increased rigidity of the frame structure of the invention furthermore permits the construction of comparatively larger frames than could be heretofore constructed in practice. Thus, the frames of the invention provide a substantially increased anode area per frame unit as well as an increased anode area per square unit of floor space.

By effectively and efficiently surrounding and enclosing at last the two bipolar electrodes and accompanying diaphragms with the frame means of the invention, including channels and conduits defined therein, a compact structurally reinforced arrangement is obtained. By providing separate discharge and supply means for the frame, efficient separation of the different gaseous and liquid media used or produced during the electrolysis operation is advantageously effected. Thus, the arrangement in accordance with the invention may be employed for the hydrolysis of hydrochloric acid to separately obtain the desired chlorine and hydrogen for further use.

Besides the substantial reduction in the cost involved in manufacturing an apparatus in accordance with the invention, the reduction of the sealing surface area by about 70% is of prime importance. Nevertheless, the cost of the frame members per sq. meter of effective anode area as well as the cost of coating the hollow sectional frame members where this is necessary to protect the same from the corrosive fluids are considerably reduced. By separating the anode and cathode gas spaces, by means of solid walls an increase in the reliability of operation of the apparatus in accordance with the invention is achieved especially where the apparatus is used for the electrolysis of hydrochloric acid. The reliability of operation is further improved by fixedly connecting the diaphragms to the electrodes instead of to the frame in the manner formerly used. Consequently, the

greatly increased cementing areas between the electrodes and the frame result in a considerably more stable overall structure.

By means of the compact construction, in accordance with the invention, a substantially increased rigidity against torsion or twisting is achieved, since the frame is twice as thick as previously provided frames and said frame is reinforced not only by intermediate brace elements but also by the physical occupation of the electrode in substantial abutment with the frame. In accordance with the invention, it is now possible to construct larger frames of more stable construction wherein the floor space required is nevertheless considerably reduced. In the same way, an increase in the number of square meters of effective anode area per square meter of floor space of the apparatus is achieved.

In its broadest aspects, the invention concerns a frame for electrolytic diaphragm cells having bipolar electrodes which defines a hollow chamber having inlet means for supplying material to be electrolytically treated and outlet means for the products of electrolytic treatment. At least two bipolar electrodes, each having an anode side and a cathode side, are disposed in tandem in the frame chamber in series connected arrangement wherein the anode side of one electrode faces the cathode side of the next. The electrodes extend across and substantially completely occupy the frame chamber and are in bonded abutment with the adjacent chamber walls along the common extent of the bottom and lateral portions of the electrodes with respect to the chamber. The forward side of the first electrode and the rearward side of the last electrode are generally adjacent the corresponding forward and rearward chamber walls and the forward and rearward sides of each electrode are provided with recesses defined therein. The rearward side of each electrode and the forward side of the electrode series connected therewith are separated by membrane diaphragms along the common extent of the recesses therebetween. The top end of the forward (as viewed from the left in FIG. 3) face of each electrode terminates in height below the top wall of the frame chamber while the top end of the rearward face of each electrode extends to the top wall of the chamber and is in bonded abutment with the adjacent chamber walls along their common extent. A first forward collecting chamber is defined above the top end of the forward face of the first electrode between the adjacent portion of the chamber wall and the adjacent top end of the rearward face of the first electrode. A last rearward collecting channel is partially defined in the same way in the rearward face of the last electrode as well as by the adjacent portion of the chamber wall. The forward faces of the remaining electrodes, save the first, are provided with a forward collecting channel, partially defined above the top end of the forward face between the adjacent chamber wall and the top end of the rearward face of the same electrode adjacent thereto. In the same manner, in the rearward face of each electrode, save the last, a rearward collecting channel is partially defined, the channel being further defined by the adjacent wall portion of the chamber. Conveniently, the rearward collecting channel of each electrode and the forward collecting channel of the electrode series connected therewith are further defined by partition means above and in abutment with the corresponding membrane diaphragms separating the corresponding recesses. All of these collecting channels separately flow communicate the corresponding forward and rearward recesses of the electrodes with the outlet means for recovering as desired the product of electrolytic treatment, such as chlorine gas and hydrogen gas.

What is claimed is:

1. Frame for electrolytic diaphragm cells having bipolar electrodes which comprises single unit frame means defining a diaphragm cell space therewithin, said cell space being provided with inlet means for material to be elec-

trically decomposed and outlet means for the products of electrolysis, at least two bipolar electrodes each having an anode portion and a cathode portion being disposed in said cell space completely within said single unit frame means in series relationship with each bipolar electrode having a diaphragm adjacent one of said anode and cathode portions and attached directly thereto within said frame means, said electrodes occupying said frame means and in turn said cell space substantially completely.

2. Frame according to claim 1 wherein separate outlet means for the anolyte and catholyte respectively are positioned at the upper portion of the cell space and the inlet means are positioned at the lower portion of the cell space.

3. Frame according to claim 1 wherein the frame means is made of hollow sectional elements provided with a rubber coating resistant to electrolyte and products of electrolysis.

4. Frame according to claim 1 wherein the frame means is made of solid sectional elements of synthetic resin material resistant to electrolyte and products of electrolysis.

5. Frame according to claim 4 wherein hard rubber material is used for the solid sectional elements.

6. Frame according to claim 1 wherein the anode portion of each bipolar electrode extends substantially over the entire inner height of said frame means with each electrode being bonded to the adjacent portion of the frame means along their common abutting extent, a plurality of anode recesses being defined in the surface of said anode portion to form with said diaphragm an anode space therebetween, an anolyte collecting channel being at least partially defined in the upper end of said anode portion flow communicating said anode recesses with the outlet means for the products of electrolysis.

7. Frame for electrolytic diaphragm cells having bipolar electrodes which comprises frame means defining a diaphragm cell space therewithin, said cell space being provided with inlet means for material to be electrically decomposed and outlet means for the products of electrolysis, more than one bipolar electrode having an anode portion and a cathode portion being disposed in said cell space in series relationship with each bipolar electrode having a diaphragm adjacent one of said anode and cathode portions, the anode portion of each bipolar electrode extending substantially over the entire inner height of said frame means, a plurality of anode recesses being defined in the surface of said anode portion to form with said diaphragm an anode space therebetween, an anolyte collecting channel being at least partially defined in the upper end of said anode portion flow communicating said anode recesses with the outlet means for the products of electrolysis, said anode recesses merging at their upper ends into said anolyte collecting channel, said diaphragm extending across the part of said anode portion provided with said anode recesses to define said anode space therebetween and a partition wall extending across the upper end of said anode portion provided with said anolyte collecting channel to at least partially define said channel therebetween.

8. Frame according to claim 7 wherein the cathode portion of said bipolar electrode terminates below the upper end of said frame means, a plurality of cathode recesses being defined in the surface of said cathode portion to form with the adjacent diaphragm a cathode space therebetween, a catholyte collecting channel being defined in the space between the top end of said cathode portion and the upper end of said frame means flow communicating said cathode recesses with the outlet means for the products of electrolysis.

9. Frame according to claim 8 wherein said outlet means include separate outlet conduits connected to said anolyte and catholyte collecting channels for separately removing the products decomposed in said anode and cathode spaces respectively.

10. Frame according to claim 9 wherein said bipolar electrode is bonded to said frame means along its bottom and side surfaces up to the point where said cathode portion terminates, the part of said anode portion extending above the top end of said cathode portion being bonded along its top and side surfaces to said frame means.

11. Frame according to claim 10 wherein intermediate brace elements are provided in said frame means between laterally adjacent bipolar electrodes.

12. Frame according to claim 11 wherein said brace elements are hollow.

13. Frame according to claim 11 wherein said brace elements are solid.

14. Frame for electrolytic diaphragm cells having bipolar graphite electrodes which comprises frame means defining an enclosed diaphragm cell space therewithin having top, bottom, side, rear and forward walls, at least one intermediate brace element connected to the top, bottom and rear walls of said frame and being spaced from the forward wall thereof, at least two bipolar graphite electrodes each having an anode portion and a cathode portion being disposed in said cell space in series relationship on each side of said intermediate brace element with the cathode portion of one bipolar electrode facing the anode portion of the next adjacent bipolar electrode, one of said anode and cathode portions terminating in height at a point below the top wall of said frame means and the other extending in height to said top wall, the medial surfaces of said bipolar electrodes correspondingly adjacent said intermediate brace element being bonded to said brace element along their common extent, the lateral and bottom surfaces of said bipolar electrodes correspondingly adjacent the side and bottom walls of said frame means being bonded to said frame means along their common extent, the other of said anode and cathode portions extending in height to said top wall being bonded to said top wall along their common extent, recess means being defined in the surfaces of said anode and cathode portions, a collecting channel being disposed above the point of terminating of the one of said anode and cathode portions defined by the top surface of said one portion, the adjacent walls of said frame means and the adjacent surface of the other of said anode and cathode portions extending in height to the top wall of said frame means, the recesses of said one portion flow communicating via said collecting channel with separate outlet means for the corresponding decomposition product produced, a collecting channel being partially defined in the other of said portions extending in height to the top wall of said frame means, the said other collecting channel being separated by a partition wall from the next adjacent collecting channel of the next adjacent bipolar electrode portion terminating in height at a point below the top wall of said frame means, the recess of said other portion flow communicating via said other collecting channel with separate collect outlet means for the corresponding decomposition product produced, a diaphragm means being disposed below and in abutment with said partition wall separating the recesses of said other portion from those of the next adjacent collecting channel of the next adjacent bipolar electrode portion, and inlet means for supplying the material to be decomposed to said bipolar electrodes.

15. Frame means for electrolytic diaphragm cells having bipolar electrodes which comprises frame means defining a diaphragm cell space therewithin having inlet means for supplying material to be electrolytically decomposed and outlet means for the products of electrolysis, at least two bipolar electrodes each having an anode surface and a cathode surface being disposed in tandem relationship in said cell space with the anode surface of one electrode facing the cathode surface of the other, said electrodes substantially completely occupying said cell space with the end and bottom portions of said electrodes being in bonded abutment with the corresponding portion of said frame means sealing the anode and cathode sur-

faces of each electrode from flow communication therealong, said anode and cathode surfaces being provided with recesses therein, the recesses of said anode surface of one electrode facing the recesses of said cathode surface of the other electrode being separated along their common extent by diaphragm means, one of said anode and cathode surfaces terminating in height at a point below the top of said frame means and the other extending in height to the top of said frame means being in bonded abutment therewith along their common extent, a collecting channel being defined between the top end of the terminating surface, the adjacent frame means and the adjacent other surface extending to the top of said frame means separately flow communicating the corresponding recesses of said terminating surface with said outlet means, a collecting channel being partially defined in the other surface extending in height to the top of said frame means separately flow communicating the corresponding recesses of said other surface with said outlet means, and partition means positioned between the anode surface of one electrode facing the cathode surface of the other above and in abutment with said diaphragm means for separating the corresponding collecting channel of one electrode surface extending to the top of the frame means from the collecting channel of the next adjacent electrode surface terminating in height at a point below the top of said frame means.

16. Frame means for electrolytic diaphragm cells having bipolar electrodes which comprises means defining a hollow chamber having inlet means for supplying material to be electrolytically treated and outlet means for the products of electrolytic treatment, at least two bipolar electrodes, each having an anode side and a cathode side, disposed in tandem in said chamber and being series connected, the anode side of one electrode facing the cathode side of the next, said electrodes extending across and substantially completely occupying said chamber and being in bonded abutment with the adjacent chamber portion along the common extent of the bottom and lateral portions of said electrodes with said chamber portion, the forward side of the first electrode and the rearward side of the last electrode being adjacent the corresponding chamber portions, the forward and rearward sides of each electrode being provided with recesses defined therein, the rearward side of each electrode and the forward side of the electrode series connected therewith being separated by membrane means along the common extent of said recesses therein, the top end of the forward face of each electrode terminating in height below the top portion of said chamber and the top end of the rearward face of each electrode extending to the top portion of said chamber and being in bonded abutment with the adjacent chamber portion along their common extent, a first forward collecting channel being defined above the top end of the forward face of the first electrode between the adjacent portion of said chamber and the adjacent top end of the rearward face of said first electrode, a last rearward collecting channel being partially defined in the rearward face of the last electrode and partially defined by the adjacent portion of said chamber, a forward collecting channel being partially defined above the top end of the forward face of each electrode save the first between the adjacent portion of the chamber and the adjacent top end of the rearward face of the same electrode, a rearward collecting channel being partially defined in the rearward face of each electrode save the last and partially defined by the adjacent portion of said chamber, the rearward collecting channel of each electrode and the forward collecting channel of the electrode series connected therewith being further defined by partition means above and in abutment with the corresponding membrane

means separating the recesses thereof, all of said collecting channels separately flow communicating the forward and rearward recesses of said electrodes with said outlet means.

References Cited by the Examiner

UNITED STATES PATENTS

987,717	3/1911	Griswold	-----	204—256
1,272,397	7/1918	Dohmen	-----	204—256

FOREIGN PATENTS

391,022	4/1933	Great Britain.
892,885	1/1944	France.

OTHER REFERENCES

Rasche: German application 1,011,855, printed July 11, 1957, (Kl 12h 1), 2 pages spec., 1 sheet dwg.

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