

Oct. 28, 1958

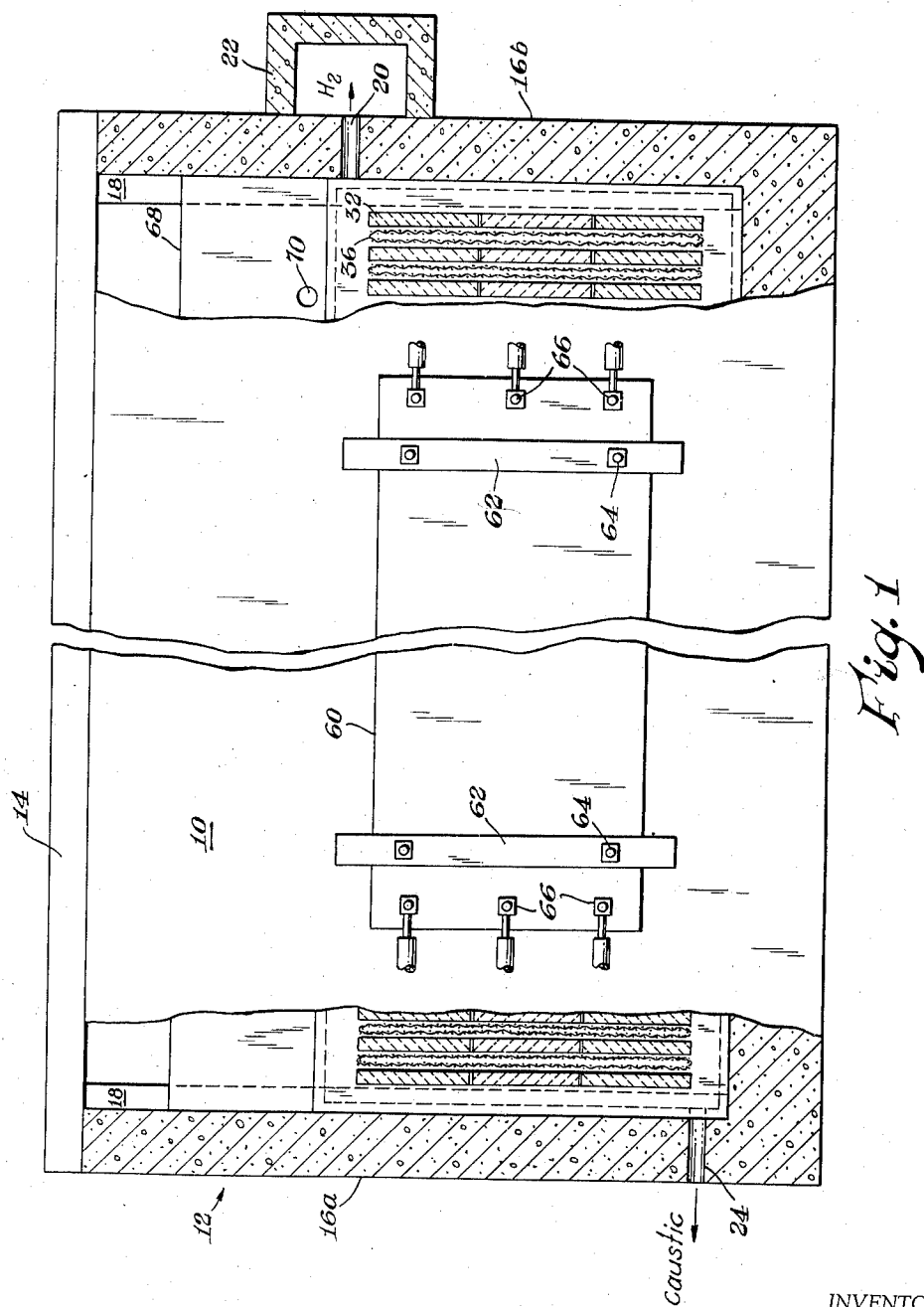
J. L. LUCAS ET AL

2,858,263

DIAPHRAGM TYPE ELECTROLYTIC CELL

Filed Aug. 25, 1954

4 Sheets-Sheet 1



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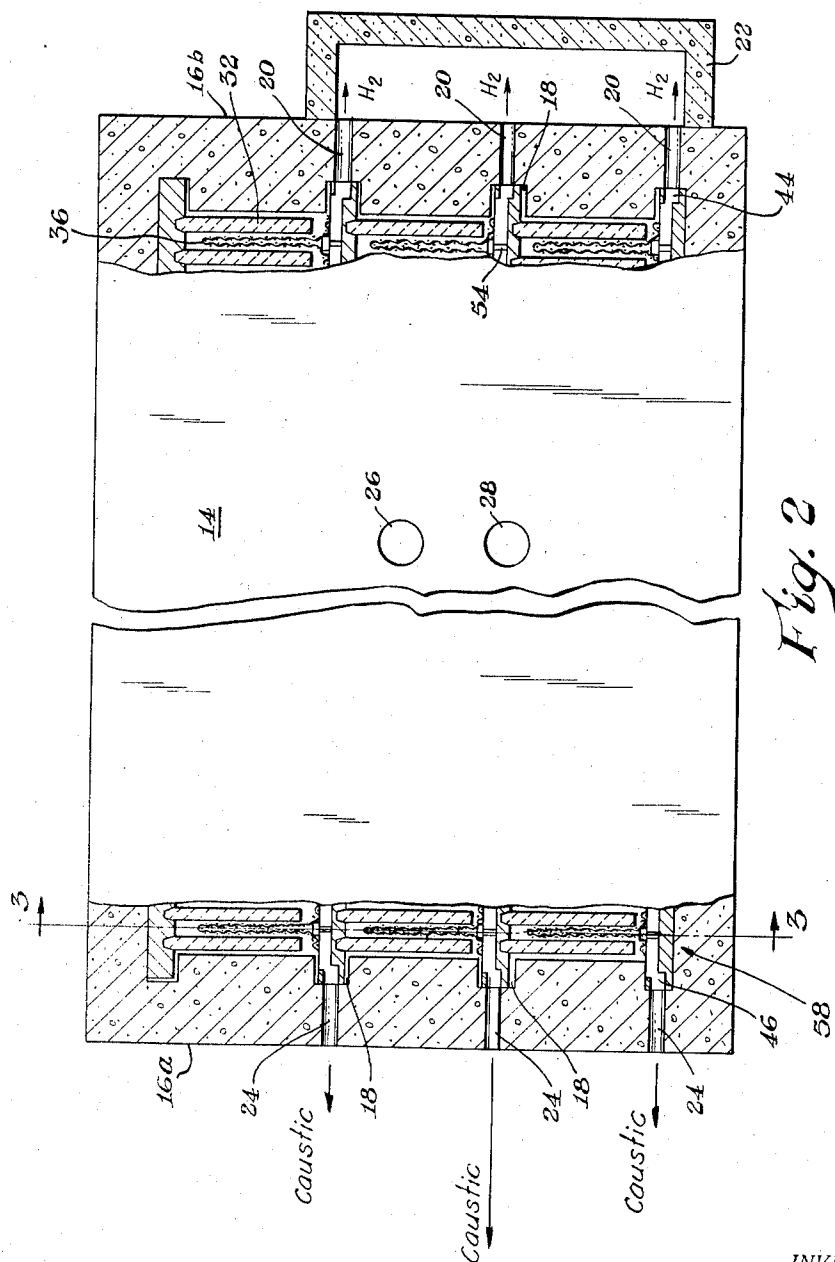


Fig. 2

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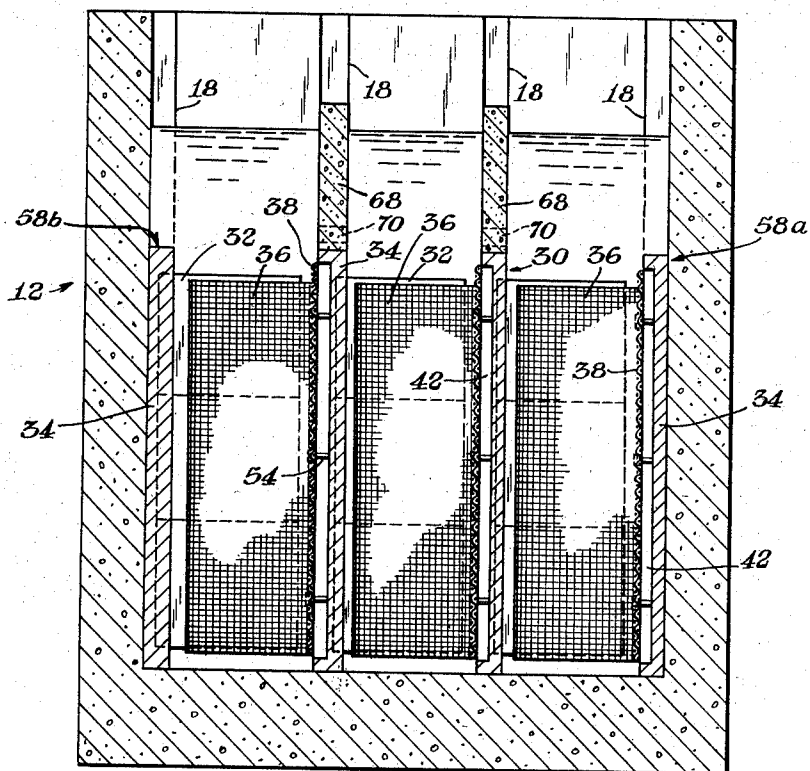


Fig. 3

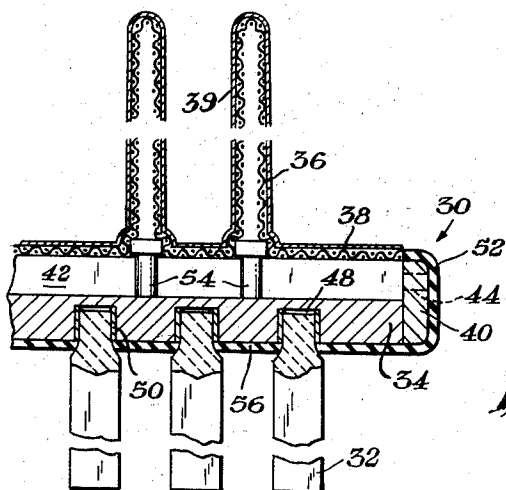


Fig. 4

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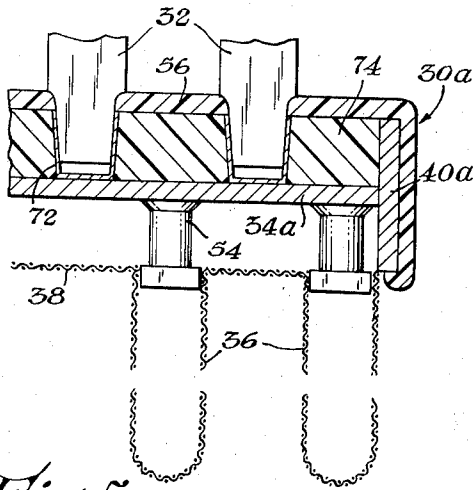


Fig. 5

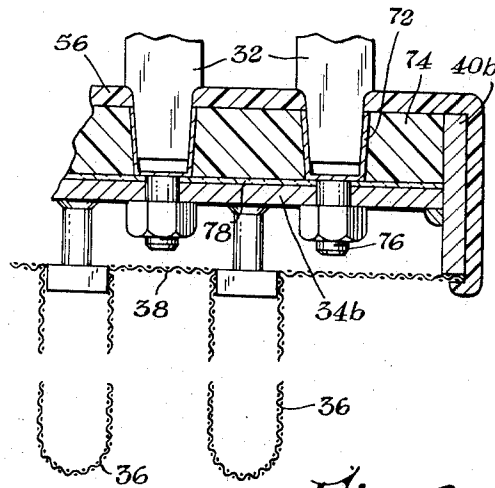


Fig. 6

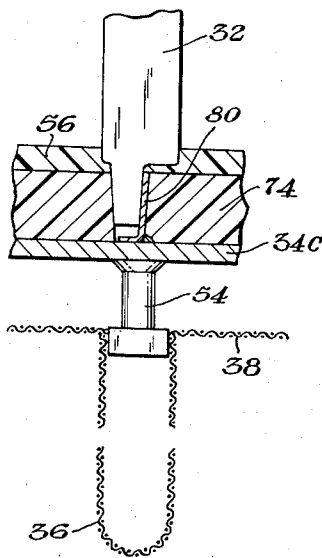


Fig. 7

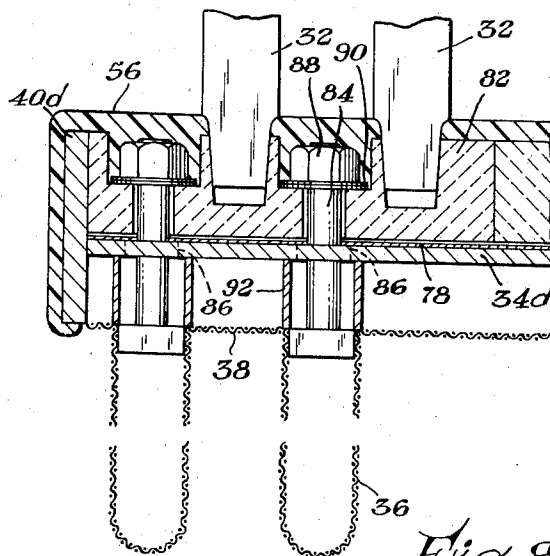


Fig. 8

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DIAPHRAGM TYPE ELECTROLYTIC CELL

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3 Claims. (Cl. 204—256)

This invention relates to diaphragm type electrolytic cells, and particularly to diaphragm type cells having bipolar electrode structures.

One type electrolytic cell utilizing so-called bipolar electrode structures is described and claimed in U. S. Patent No. 2,282,058 to Hunter et al. The Hunter et al. cell comprises a series of abutting frames or unit cells, each comprising one cathode and one anode, the anode of one unit cell being electrically connected within the cell frames to the cathode of the succeeding unit cell. The unit cells are interleaved and the anode backboard of each unit cell serves as the partition or separator between successive unit cells.

This electrolytic cell of this invention is a modification and improvement of the Hunter et al. cell structure.

A principal object of this invention is to provide an improved diaphragm type electrolytic cell having high power-efficiency.

Another object of this invention is to provide an improved diaphragm type electrolytic cell which requires a minimum of attention during operation and which may readily be repaired when damaged.

A further object of this invention is to provide an improved diaphragm type electrolytic cell having a long useful life and which requires less floor space per cell output capacity than other diaphragm cells.

Yet another object of this invention is to provide an improved diaphragm type electrolytic cell assembly which requires no cell-to-cell electrical connection to be made when an anode or diaphragm is replaced.

In accordance with the present invention there is provided a diaphragm type electrolytic cell assembly in which bipolar unitary electrode assemblies are interleaved one with another within a box-like housing. The unitary electrode assemblies, which are mounted in the housing in a detachable manner, each comprise an anode structure and a cathode structure mounted in back-to-back relationship with a hydrogen and caustic collecting compartment formed between the two structures.

The invention, as well as additional objects and advantages thereof will best be understood when the following detailed description is read in connection with the accompanying drawings, in which:

Fig. 1 is an end elevation view, partly broken away and in section, of an assembled diaphragm type electrolytic cell series in accordance with this invention;

Fig. 2 is a plan view of the assembly shown in Fig. 1, partly broken away on the left side to show the caustic outlet tubes and broken away on the upper right side to show the hydrogen outlet tubes.

Fig. 3 is a sectional view taken along the lines 3—3 of Fig. 2, with the cell cover and hydrogen outlet header removed.

Fig. 4 is a fragmentary sectional view in plan, on an enlarged scale, of the unitary electrode assembly embodied in each cell of the assembly of Figs. 1 to 3.

Fig. 5 is a fragmentary sectional view, on an enlarged

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scale, of an alternative embodiment of bipolar electrode assembly in which the anode plates are held in copper channels which are welded to a steel backplate;

Fig. 6 is an enlarged sectional view similar to Fig. 5, showing an alternative construction in which the anode holding copper channels are bolted to the back plate rather than welded thereto;

Fig. 7 is a fragmentary sectional view of another alternative electrode assembly in which only half the channel into which the anode is driven is lined with copper, and

Fig. 8 is a fragmentary view of a further alternative electrode assembly in which the anode plates are carried by a graphite plate to which the cathode pockets and an intermediate metal backing plate are secured.

The cell series illustrated is especially useful for the electrolysis of sodium chloride brine to produce chlorine, hydrogen, and caustic soda solution.

Referring to Figs. 1, 2, and 3 the electrolytic cell series 10 is housed in a rectangular box-like housing or container 12 made of concrete, preferably lined with acid resistant brick (not shown). The container 12 has a removable top 14 which may conveniently be made of concrete, of chlorine and brine resistant plastic or of metal having a surface coating which is resistant to attack by chlorine and brine. The side walls 16a, 16b of the container 12 each have formed therein vertical slots 18 extending from the top to the bottom. The slots 18 are similarly disposed in each side and are wide enough to receive an end of a unit cell partition board hereinafter described. An outlet passageway 20 for hydrogen or other cathode gas communicates with each slot in the side 16b of the housing, the passageways 20 being located above the operating level of the liquid in the cell.

A hydrogen removal conduit or header 22, which may be in the form of a "blister" surrounds and interconnects the openings of the individual hydrogen outlet passageways 20, being sealed to one end wall (16b) of the cell 10.

A series of caustic soda or other catholyte outlet tubes 24 extend through the wall 16a of the housing 12 near the bottom of the housing, each tube 24 communicating with one of the slots 18 in wall surface 16a.

A chlorine or anode gas outlet port 26 is shown provided in the top or cover 14 of the cell, although it may be located elsewhere in the cell provided it is above the fluid level of the cell. The brine inlet to the cell also may be conveniently made through the top or cover of the cell. The brine inlet may be a separate entry port 28 or may be combined with the chlorine outlet port 26.

The interior of the housing contains a plurality of bi-polar electrode assemblies which define the unit cells making up the cell series. In the drawings, the series is shown as composed of three unit cells, although a much larger number may be assembled together in similar fashion by lengthening the housing. Each electrode assembly comprises a plurality of graphite anodes 32 in the form of rectangular plates which extend from one side of a backer plate 34 and a plurality of metal mesh cathode pockets 36 which extend from a mesh back screen 38 which is secured to but spaced from the backer plate 34. A metal frame strip 40 around the periphery of the electrode assembly 30 encloses the space between the mesh back screen 38 and the backer plate 34, forming a cathode compartment 42 therebetween in which hydrogen and caustic collects. The interior of the cathode pockets also open into the compartment 42. Each of the electrode assemblies 30 is adapted to fit into the housing 12 with the ends of the frame 40 extending into the previously mentioned slots 18 in the side walls 16a, 16b. A sealing compound is used between the frame of the electrode assembly and the slots 18 in the housing to prevent catholyte

and hydrogen, the products of electrolysis which are inside the cathode compartment 42, from leaking into the anode diaphragm space between adjacent electrode assemblies by way of the slots 18. Hydrogen and caustic soda removal apertures (44, 46 respectively) are provided in the frame ends of each electrode assembly 30. The apertures 44, 46 are so located as to be aligned with the caustic and hydrogen outlet passageways or tubes 24, 20 when the electrode assemblies 30 are properly inserted and mounted in the cell housing 12.

Referring in more detail to Figs. 3 and 4, the electrode assembly 30 includes a flat surfaced backer plate 34, of steel or other electrically conducting material, which has a plurality of paralleled slots 48 in one surface thereof spaced apart equal distances about equal to the thickness of the anodes 32. Anode electrodes 32, which are composed of suitable impregnated graphite blocks, are formed with tapered edges of reduced thickness which are driven into the slots 48 in the steel backer plate 34. The tapered edge of each anode block or plate 32 is conveniently wedged into the steel backer plate 34 by shims 50 which may be made of copper, lead, or other readily deformable conductive material. The deformable shims 50 aid both in making the mechanical connection of the anode blocks to the backer plate and in making good electrical contact therewith. A steel framing strip 40, which may be in the form of a flat bar, is welded to the peripheral edges of the backer plate 34. Part of the strip extends outwardly from the backer plate 34 on the cathode side thereof. The mesh back screen 38 for the cathode section of the assembly is secured by bolts or welded to the edge of the framing strip 40 which extends behind the anode backer plate 34 and is covered by a permeable diaphragm 39, of asbestos fibers, for example. That part of the frame or framing strip 40 which is exposed to brine or chlorine during the operation of the cell is covered by a coating 52, of rubber, for example, which protects the steel from attack by the brine. Each of the cathode pockets or hollow plate-like mesh cathode electrodes or elements 36 abuts against or is secured to the mesh back screen 38 of the cathode and is connected to the un-grooved or back side of the anode backer plate 34 by bolts or studs 54 which are welded to both the pockets 36 and the backer plate 34. The inner area of each pocket 36 communicates with or opens into the compartment 42 which is enclosed by the backer plate 34, the mesh cathode back screen 38 and the framing strip.

Since the anode side of the electrode assembly is exposed to brine during the operation of the cell, the slotted or grooved side of the backer plate 34 (and the outer surface of the framing strip as previously mentioned) is covered with a resinous, rubber or other suitable coating 56 which is not readily attacked by the chlorinated brine. The cathode pockets 36 are so mounted in relation to the backer plate 34 that they register with the spaces between the anode plates 32. Thus, when two electrode assemblies 30 are mounted in the housing in side by side relationship, the anodes 32 of one assembly are interleaved with the cathode pockets 36 of another assembly. Although only three cell units or electrode assemblies 30 are included in the cell series 10 shown in Figs. 1, 2 and 3, a larger or smaller number of cell units could be used in a single housing. In fact, cell series having a large number of electrode assemblies 30 are advantageous in saving floor space and in the initial cost of the cell (when output capabilities are considered).

In order to provide means for applying current to the cell series, half-cell electrode assemblies 58 are utilized at each end of the cell. The half cell 58a at the cathode end, for example, comprises a steel backer plate 34 to which is attached the cathode pockets and mesh cathode back screen 38. The cathode half cell 58a includes a compartment 42 as do the "normal" electrode assemblies 30. The cell housing has an opening 60, illustrated

as rectangular in Fig. 1, in each side of the housing through which current connections to the cell are made. The appropriate half cell 58a is installed in the cell against the end wall thereof before the full or normal electrode assemblies 30 are inserted. The side of the backer plate 34 which faces the outside of the cell is coated with suitable gasket material, and the half cell is then clamped against the side of the housing by means of the bars 62 and bolts 64 arrangement shown in Fig. 1. The negative bus bar connections are made to connect to terminals 66 on the externally exposed side of the backer plate of the cathode half-cell 58.

The anode half-cell 58b is similarly mounted on the opposite end of the housing and is similar in structure except that the backer plate 34 has anodes 32 extending therefrom and has no cathode compartment 42 or pockets 36. The positive bus connections are made to the backer plate of this half-cell in the same manner as with the half-cell 58a. The electrodes of each half-cell interleave with electrodes of the next adjacent electrode assembly 30 in the manner previously described in connection with the bipolar or normal electrode assemblies 30.

Since the anode end of the anode half-cell 58b is exposed to brine during the operation of the cell, the grooved side of the backer plate 34 and the outer surface of the framing strip 40 are covered with a resinous, rubber or other suitable coating which is not readily attacked by the brine.

As is clearly seen in Figs. 1 and 3, the electrode assemblies 30 do not extend to the top of the housing. A slab 68 of acid resistant material, concrete, for example, fits into the same end slots as does the frame of each electrode assembly 30, and extends from the top of the frame of each bipolar electrode assembly 30 to above the fluid level of the cell, functioning as a partition between adjacent cells. A small aperture 70 is provided in each slab 68 below the fluid level of the cell in order to permit circulation of the brine within the cell. The slabs serve to limit stray current which, unless restricted, tends to pass through the brine around the electrode assemblies 30 rather than between anode and cathode as desired. The apertures 70 in the slabs, while large enough to permit the brine to circulate, do not permit excessive current loss therethrough.

The diaphragm of each unit cell is formed on the pockets 36 and back screen 38 conveniently by depositing a coating of asbestos fibers, for example, on the pockets 36 and the cathode mesh back screen 38. The pockets 36 and cathode mesh back screens 38 of each electrode assembly 30 are coated (on the "brine" or outer surface) with asbestos particles or fibers by inserting the pockets 36 and screen 38 in an aqueous slurry of asbestos particles and then drawing the particles into the mesh surface under vacuum.

In the operation of the electrolytic cell series of this invention, the brine level in the cell is kept above the top of the electrode assemblies 30 at all times, with brine being continuously introduced into the cell through the inlet passageway 28 in the top or cover 14 of the cell. Brine gradually percolates through the cathode diaphragm of each unit cell into contact with the cathode mesh back screen 38 and mesh pockets 36, and is there transformed by the electric current flowing through the cell into gaseous hydrogen and a solution of caustic soda. The hydrogen thus liberated in the cathode partition or compartment 42 (formed by the backer plate 34, mesh back screen 38, and frame strip 42) escapes upwardly and is withdrawn through the hydrogen passageway 20 in the slot 18 in the end of the cell housing. The caustic soda solution forms on the walls of the cathode compartment 42 and runs down out of each unit cell through the caustic outlet passageway 24 in the lower part of the recess or slot 18 in the wall 16a or 16b into which the electrode assembly 30 fits.

Likewise, during electrolysis the brine in the cell is

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transformed at the surface of the anode plates 32 of each electrode assembly 30 into chlorine gas which bubbles upwardly and escapes from the cell through the chlorine outlet 26 in the cell cover 14.

Alternative forms of electrode assemblies are shown in Figs. 5 through 8.

The electrode assembly 30a as shown in Fig. 5 comprises a backer plate 34a to which are welded copper channels 72 for receiving and holding the anode blocks 32. The pockets 36 and back screen 38 are mounted as in the electrode assemblies 30 previously described. The space between adjacent copper channels 72 is filled by spacer blocks 74 which are made of a brine and chlorine resisting plastic such as a phenol-formaldehyde resin. The spacer blocks 74 add rigidity to the assembly as well as isolate the backer plate 34a from the chlorinated brine present in the cell. The frame strip 40a extends on each side of the thin backer plate 34a, which may be a steel plate of about 1/4 inch thickness, for example. The cathode back screen 38 is attached to one edge of the frame strip 40a and the plastic filler or spacer blocks 74 abut against the frame strip 40a on the other side of the backer plate 34a. When the anodes 32 are mounted, a further protective resin coating 56 is applied over the anode spacer blocks 74 and around the anode copper channel junction area in order to protect the channels 72 and the backer plate 34a from attack by the chlorinated brine.

The combination of a thin backer plate 34a, the copper channels 72, and the resin blocks 74 provides good structural strength and good electrical conductivity between the anode blocks 32 and the backer plate 34a, yet is considerably lighter than when a grooved steel backer plate 34 is used. This results in an assembly which is easier to handle when installing or repairing the cell.

Since the copper channels 72 are themselves readily deformable, no shims are needed between the channels 72 and the anodes 32 to insure good electrical contact therebetween.

The voltage path between the anodes 32 and cathode pockets 36 is kept short, since the pocket mounting bolts 54 as well as the copper channels 72 are welded to the backer plate 34a, and electrical losses through the corrosion of electrode contacts is substantially eliminated.

In the electrode assembly 30b shown in Fig. 6, a copper gasket-like sheet 78 is disposed between the backer plate 34b and the copper channels 72. The gasket-like copper-sheet 78, in addition to providing a compressible material against which the channels 72 may be tightened, also improves the electrical current distribution over the backer plate area. It will be noted that the cathode pockets 36 are aligned with the anode plates 32. The pockets 36 are mounted on the backer plate as in Fig. 5, but the bolts 54 are on different mounting centers than the bolts 76. This arrangement of the anode and cathode electrodes provides a desired short electrical connection between the anodes and cathodes and results in high electrical efficiency. However, the in-line electrode arrangement of the electrodes necessitates that in adjacent cells the electrodes must be off-set half the distance between two adjacent anodes, for example, in order that the electrodes of adjacent assemblies will interleave as required when assembled in the cell 10. As in the electrode assembly 30a, an additional protective coating 56 is applied, after the anodes 32 are mounted, to the surfaces on the anode side of the assembly which are exposed to the chlorinated brine (except the anodes 32).

Fig. 7 illustrates an electrode assembly 30c in which only "half-channels" 80 of copper angular stock are used to make electrical contact with the anode electrodes 32. The copper angle stock is welded or brazed to the steel backer plate 34c, which is thinner than the backer plate 34 of the electrode assemblies 30.

It was found that the anode blocks 32 were mounted in a mechanically secure manner when driven between

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the copper half-channels 80 and the adjacent block of phenol formaldehyde resin 74. The pockets 36 are mounted in the in-line manner shown in Fig. 6, although they could be mounted as in Fig. 5 or in other suitable manners.

Fig. 8 illustrates an electrode assembly 30d in which is used an adaptation of a graphite backer plate of the type used in the Hunter et al., cell previously referred to. Grooved strips of graphite 82 are bolted to a thin backer plate 34d with a copper sheet 78 disposed between the graphite strips 82 and the backer plate 34d in order to improve the electrical conductivity from the anodes 32 through to the cathode side of the backer plate.

The bolts 84 utilized in clamping the graphite strips 82 to the backer plate 34d also constitute the means by which the cathode pockets 38 are mounted. The heads of the bolts 84 are welded to the pockets 36 and when the pocket 36 is in the mounting position, the body of the bolt 84 extends through a bore 86 in the backer plate 34d and the graphite strip 82. The bore 86 is counter-bored to permit the nut 88 and washers 90 to be below the surface of the graphite strip 82 when the nut is tightened on the bolt 84. The pockets 36 and mesh back screen 38 are spaced from the steel backer plate 34d by means of the sleeves 92 which fit over the bolts 84 and are clamped between the pockets 36 and the steel backer plate 34d.

When the new cell series must be shipped to the location where it will be used, assemblies made in accordance with this invention result in an economy in shipping cost, since the housing (which is made of materials which are available locally) can be constructed at the location where the cell is to be used. Only the electrode assemblies need be shipped to the plant where the cell is to be located. Since in most diaphragm cells, the cell housing is shipped with the electrode assemblies, cells made in accordance with this invention permit an appreciable saving in shipping costs of the cell.

It has also been felt that the moving of the cell housing of diaphragm cells during the rebuilding or repairing thereof subjects the housing to damaging stresses as well as to the possibility of breakage due to mishandling. Since the cell housing of the present invention need not be moved when the cell is serviced, the housing will have a longer useful life than other cells where the housing is moved when repairs of electrodes are made.

Also, during the assembly of cell series of the Hunter et al. type and other similar diaphragm cells, considerable care must be taken to insure that the diaphragm is not damaged when the electrode assemblies are interleaved. Since in the cell of this invention each electrode assembly is installed by sliding it down the guide slots 18 in the ends of the housing, proper alignment of and spacings between the anode and cathode electrodes is easily achieved. In addition, visual inspection of the parts can easily be made as they are being interleaved.

Also, cell series made in accordance with this invention can be made which have extremely large capacities by the expedient of having banks of electrode assemblies in which the frames are disposed end to end (or in parallel, electrically speaking) as well as interleaved one with another.

The larger cells referred to above would be economical in cost of cell housing per unit of output capacity and would require less electrical connections than would a series of smaller cells, thus resulting in a savings in the operating costs of the cell.

The practice of connecting a plurality of electrode assemblies 30 in parallel or in end-to-end relationship also proves helpful in another respect. The electrode assemblies 30 tend to become quite heavy if made in very large sizes, necessitating heavier framing if the units are to be sufficiently rigid to interleave easily with other assemblies. It can be appreciated that any bowing of the frame during the installing of the assemblies would hamper the inter-leaving of the electrodes with those of other as-

semblies. Thus, to save weight while maintaining rigidity of the assembly and to provide, in effect, a longer assembly, a plurality of smaller assemblies mounted in end-to-end relationship may be used.

While only a limited number of examples of cells made in accordance with the invention have been given, it is obvious that many modifications within the scope of this invention will suggest themselves to those skilled in the art.

We claim:

1. A diaphragm type electrolytic cell series comprising a rectangular box like cell housing having an acid resistant inner surface, a removable cover made of chlorine resistant material, said housing having correspondingly disposed slots in opposite side walls of said housing, means including a passageway extending through the wall of said housing and into said slots near the bottom of said housing for withdrawing caustic from said cell, means for withdrawing hydrogen from the upper part of said cell, a plurality of bipolar electrode assemblies mounted in said slots, each of said assemblies including a backer plate having graphite anode blocks extending therefrom and a cathode compartment having foraminous cathode pocket electrodes extending therefrom, said cathode electrodes carrying a fluid permeable diaphragm, the slots in said housing being so disposed that assemblies mounted therein have the anode blocks of one assembly interleaved with the foraminous cathode pocket electrodes of the next adjacent assembly, and a half cell disposed adjacent to each side wall of said cell, one of said half cells having anode blocks extending therefrom to interleave with the cathode pocket electrodes of the bipolar electrode assembly which is adjacent thereto, and the other of said half cells including a cathode compartment which has cathode pocket electrodes extending therefrom to interleave with the anode blocks of an adjacent bipolar electrode assembly, means for conducting caustic and hydrogen from said half cell having the cathode compartment and from said electrode assemblies to said wall slots, means for withdrawing chlorine from said cell, and means for applying suitable electrical potentials to said half cells.

2. A diaphragm type electrolytic cell series for producing caustic and chlorine, comprising a rectangular box-like cell housing having an acid resistant inner surface, said housing having a removable top cover and having correspondingly disposed slots in opposite end walls of said housing, means including passageways extending through the cell housing and opening into said slots for withdrawing caustic and hydrogen from the cell housing, a plurality

of bipolar electrode assemblies mounted in said slots, each of said assemblies including a backer plate having graphite anode blocks extending therefrom and a cathode compartment having hollow foraminous cathode pocket electrodes extending therefrom, said pocket electrodes carrying a diaphragm, the slots in said housing being so disposed that the anode blocks of one assembly mounted in said slots are interleaved with the cathode pocket electrodes of an adjacent assembly which is mounted in said slots, and half cells disposed adjacent to each side wall of said cell, one of said half cells having anode blocks extending therefrom which interleave with the cathode pocket electrodes of the bipolar electrode assembly which is adjacent thereto, another of said half cells including a cathode compartment which has foraminous cathode pocket electrodes extending therefrom which interleave with the anode blocks of an adjacent bipolar electrode assembly, means for conducting caustic from said half cell having said cathode compartment and from said bipolar electrode assemblies to said wall slots, means for withdrawing chlorine from said cell, and means for applying suitable electrical potentials to said half cells.

3. An electrode assembly for a diaphragm type brine cell, comprising a rectangular steel backer plate having an anode side which contains a plurality of parallel grooves therein, and a cathode side, a plurality of graphite anodes secured to said grooves and extending substantially perpendicularly from the anode side of said backer plate, said backer plate being covered on the anode side thereof with a coating of phenol formaldehyde, a steel framing strip secured to the edge surface of said backer plate in a fluid tight manner and extending beyond the surface of the cathode side of said backer plate, the surfaces of said framing strip which are exposed to chlorinated brine during cell operation being coated with rubber, a steel mesh back screen secured to the extending edges of said framing strip to form a cathode compartment enclosed by said mesh back screen, said backer plate, and said framing strip, and a plurality of hollow mesh cathode electrodes extending outwardly from said back screen, the hollow interior of said cathode electrodes opening into said compartment, and means for removing products of electrolysis from said compartment.

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