Feb. 16, 1971 M. P. GROTHEER 3,563,878

ELECTROLYTIC CELL STRUCTURE

Filed July 5, 1968 5 Sheets-Sheet 1

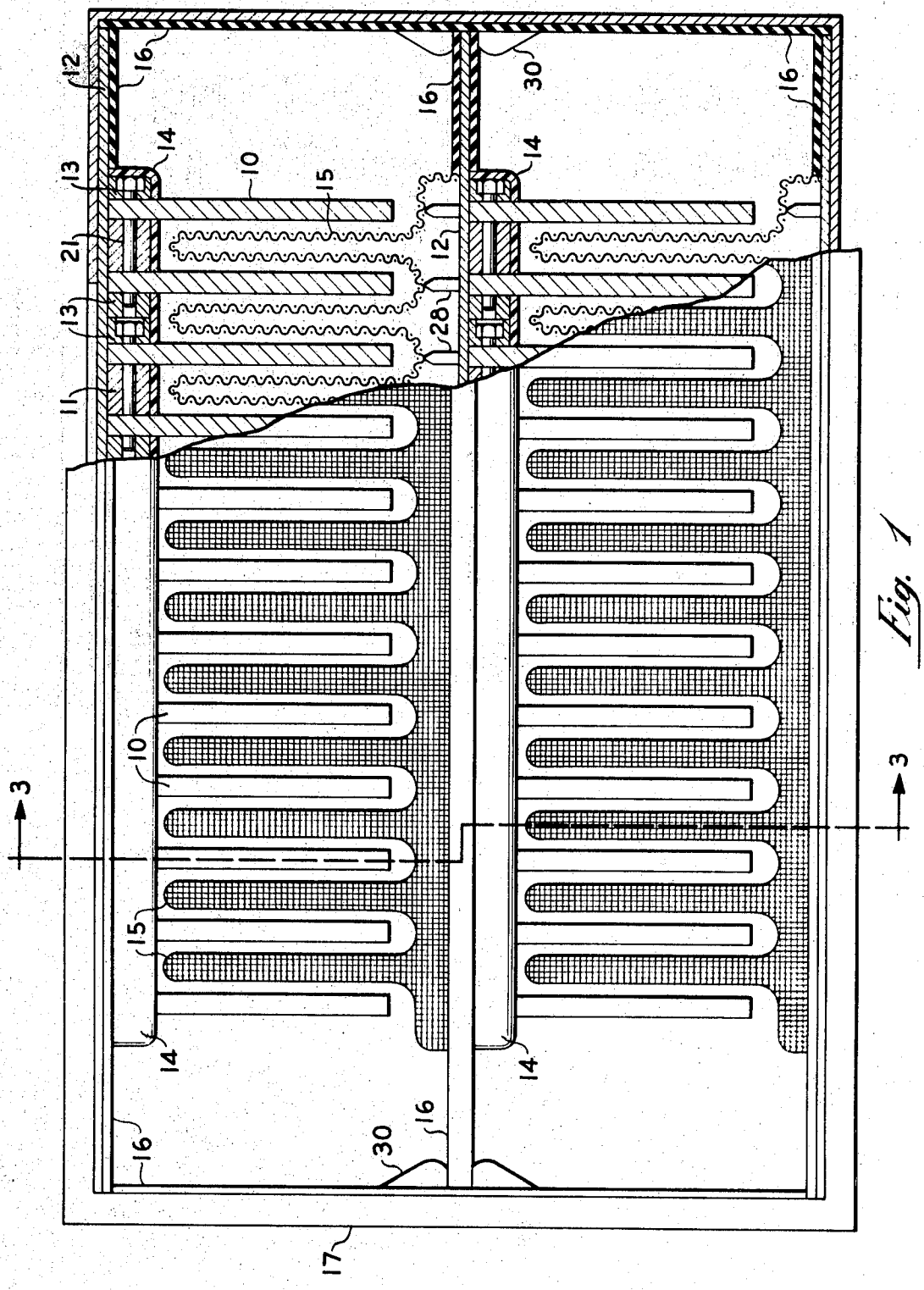


Fig. 1

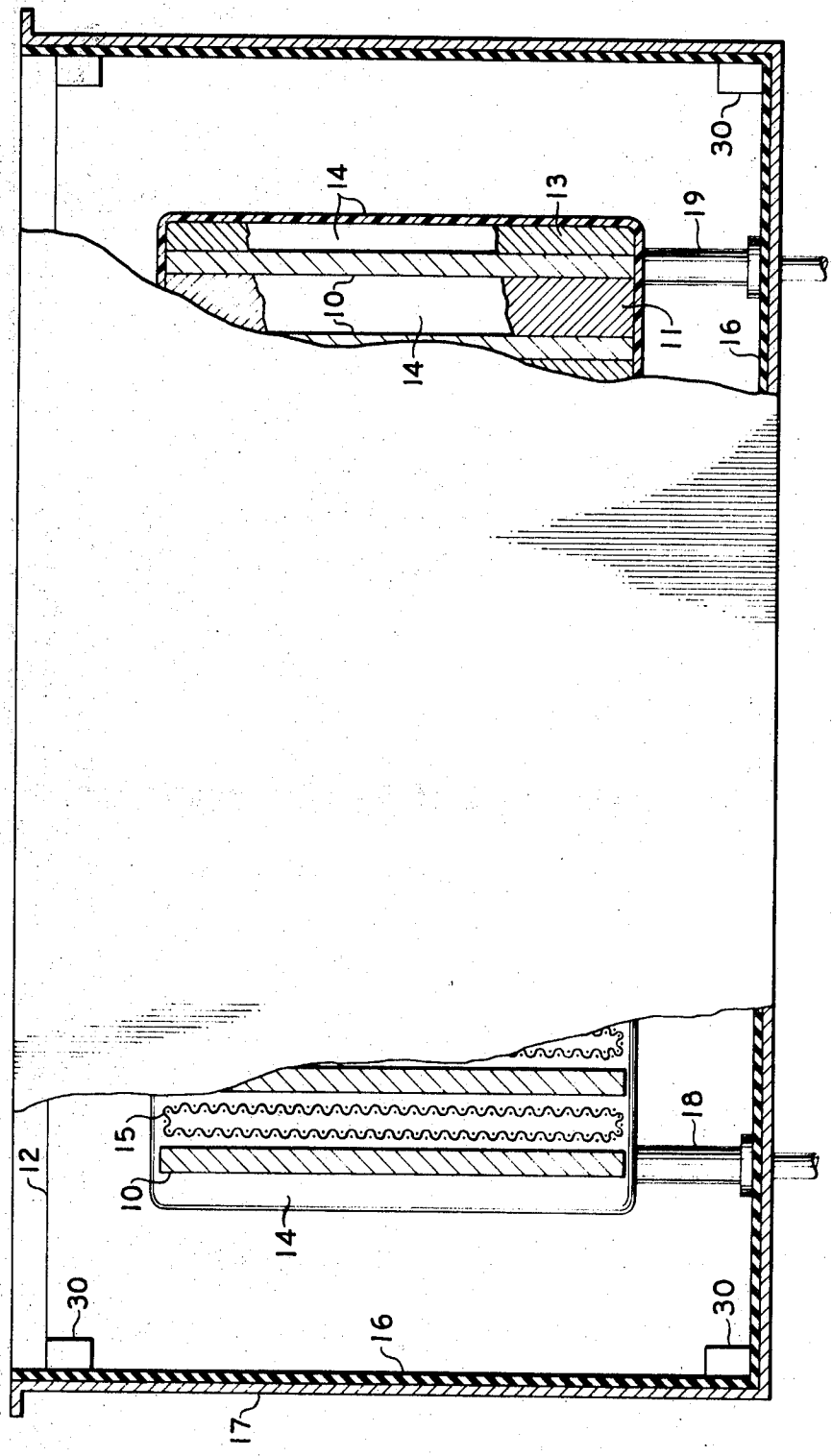


Fig. 2

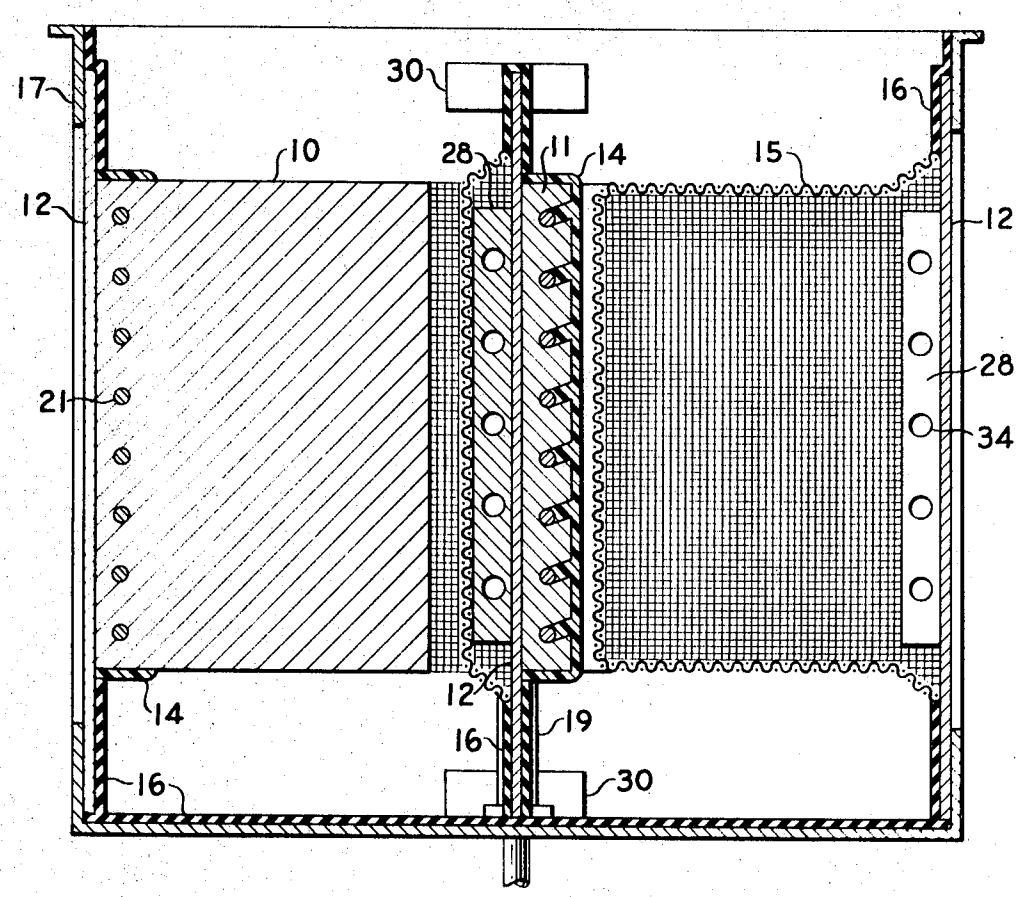


Fig. 3

Feb. 16, 1971 M. P. GROTHEER 3,563,878
ELECTROLYTIC CELL STRUCTURE
Filed July 5, 1968 5 Sheets-Sheet 4

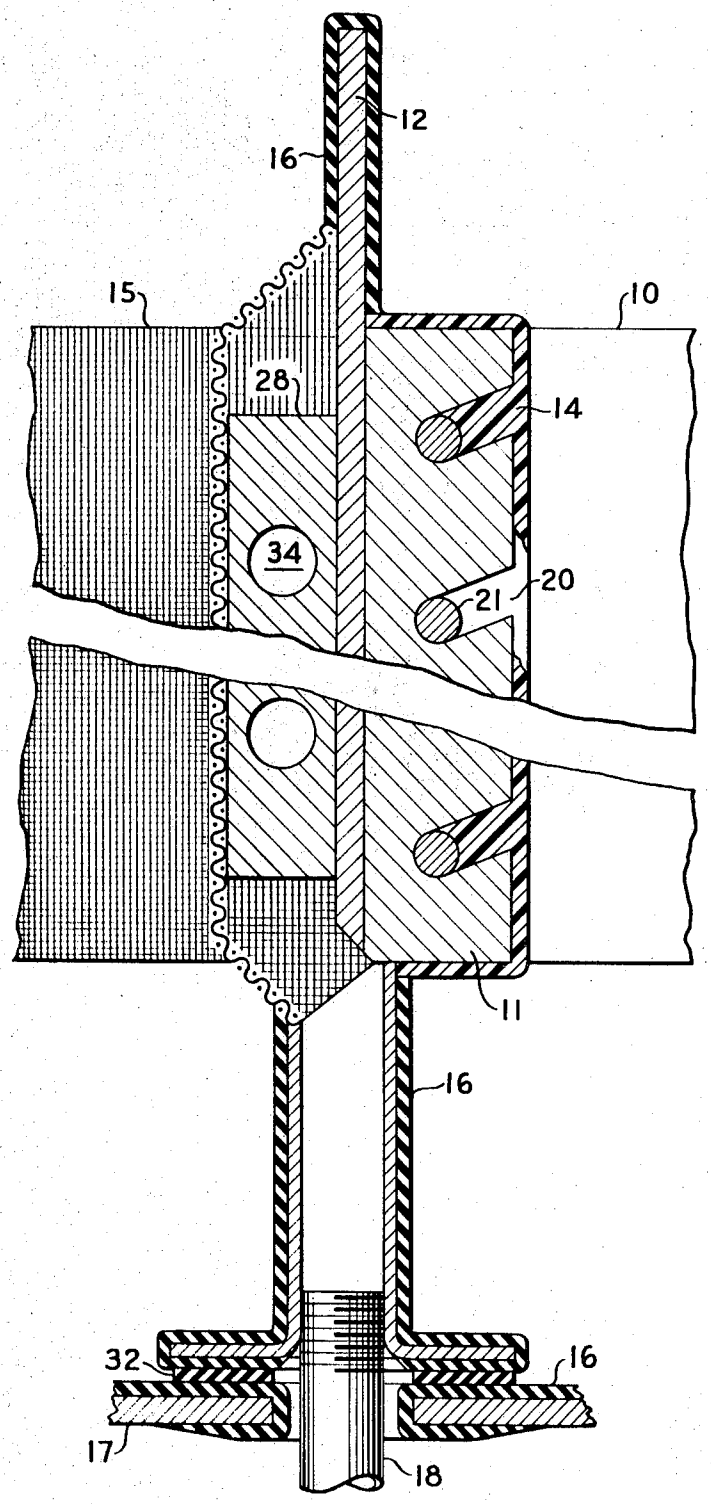


Fig. 4

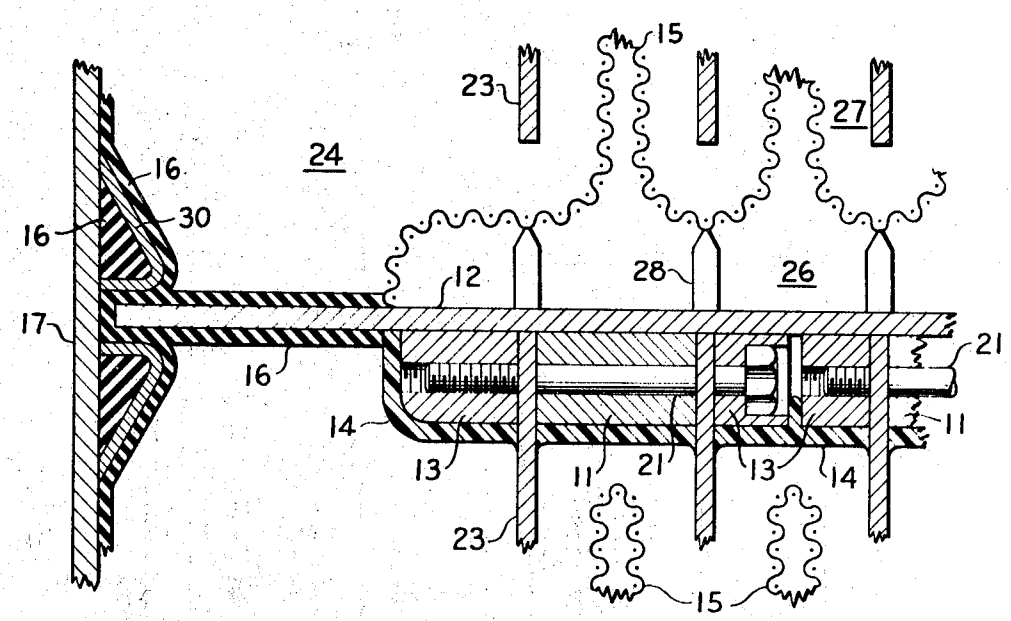

15
23
27
24
16
30
16
12
28
26
17
21
16
14
11
13
21
13
14
11
23
15

Fig. 5

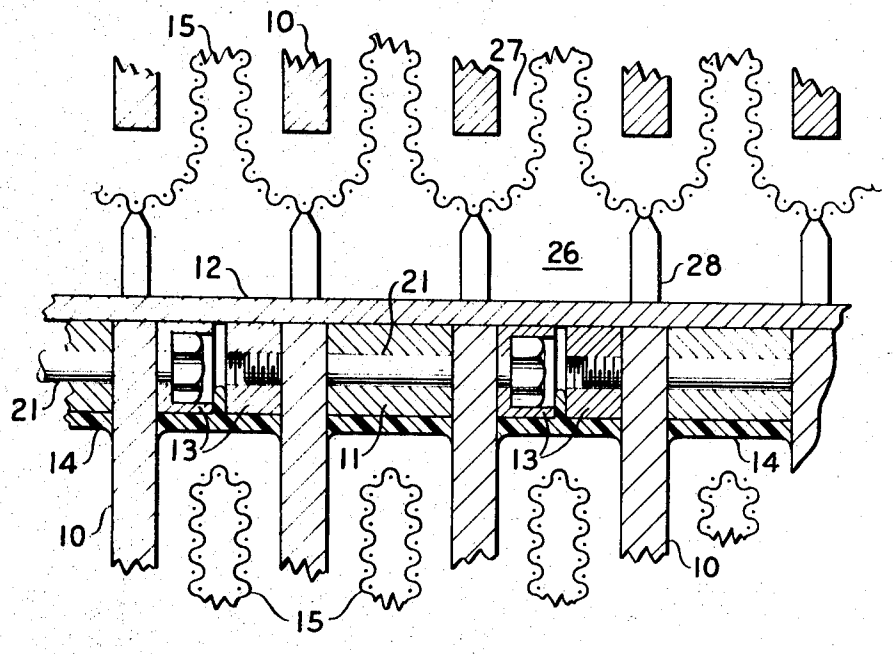

15
10
27
12
21
26
28
21
14
13
11
13
14
10
10
15

Fig. 6

United States Patent Office 3,563,878
Patented Feb. 16, 1971

3,563,878

ELECTROLYTIC CELLSTRUCTURE

Morris P. Grotheer, Lewiston, N.Y., assignor to Hooker Chemical Corporation, Niagara Falls, N.Y., a corporation of New York

Filed July 5, 1968, Ser. No. 742,892
Int. Cl. C22d 1/02
U.S. Cl. 204—256 9 Claims

ABSTRACT OF THE DISCLOSURE

The anodes of diaphragm type electrolytic cells of either monopolar or bipolar design are secured to spacer bars, which are attached to a base plate, with bolts running parallel to the base plate through pressure bars on both sides of the anodes. One pressure bar is threaded to receive the threads of the bolt, while the other pressure bar is drilled and countersunk to receive the head of the bolt. The bolted anode assembly provides a low resistance joint which permits operation of an electrolytic cell at higher current densities without encountering excessive voltages. Furthermore, the anodes may be shorter in the bolted assembly because less stub loss is involved than in the conventional cast lead base covered with mastic.

BACKGROUND OF THE INVENTION

The ever increasing demand for products of electrolytic cells has necessitated a continuous development of new electrolytic cells which operate on higher current capacity and current density in both diaphragm and mercury type cells. Diaphragm cells have two main advantages over mercury type cells. The advantages are low cell voltages and low investment costs. Developments in diaphragm cells trending toward higher current capacities and current densities advantageously will also involve fewer cell parts and minimize the floor area needed to house many units. Generally, electrolytic cells of the fingered bipolar cell design are consistent with the goals of the industry.

Fingered bipolar type electrolytic cells are known. Likewise, in monopolar diaphragm type electrolytic cell design, any improvement leading to operation at lower cell voltage, higher current density and greater output per cell floor area is a decided advantage.

It is an object of this invention to provide a diaphragm type cell of a high current rating.

Furthermore, it is an object of this invention to provide an anode assembly for use in monopolar and bipolar diaphragm type electrolytic cells which excells in ease of assembly.

And, it is an object of this invention to provide an anode assembly for electrolytic cells which provides a smaller voltage drop between the anode and the current conductor than is obtainable from normal anode-lead base connections.

BRIEF DESCRIPTION OF THE INVENTION

In accordance with this invention, there is provided an electrode assembly for an electrolytic cell comprising a base plate having attached thereto plural electroconductive spacer bars to which the electrodes are clamped and held in position by two pressure bars and a bolt running parallel to said base plate through holes in the electrode, spacer bar and pressure bar assembly.

Basically, this unitary electrode assembly involves a metallic (preferably steel) base plate or backer plate to which spacer bars of an electrically conductive material such as platinized-titanium, aluminum alloys and preferably copper are attached by welding, tinning, bolting

or by other mechanical means to the steel at predetermined intervals based upon the desired pitch of the anodes. When the spacer bar is constructed from platinized titanium, the use of sealants may be dispensed with as protective means against attack by the corrosive materials which contact it. The spacer bar is disposed in such a manner that the attached anodes will be aligned with abutting edges vertically situated within the cell unit. The spacer bar contains holes through which pass the bolts running parallel to the base plate. The holes through the spacer bars are preferably slotted, at an angle downwardly extending from the vertical bar surface. The number of anodes that may be attached to the spacer bars by pressure bars depends upon the designed height of the cell where the anodes are horizontally attached to the spacer bar in a vertically disposed bank of anodes, or the cell width where the anodes are vertically attached to the spacer bar in a bank extending across the cell.

The pressure bars, one being drilled and countersunk, the other being provided with threaded holes, act, in conjunction with the bolt running through them, the anode and spacer bar, as an electrode clamping device. In the clamped position, the electrical resistance through the anode-spacer bar contact is a function of the pressure developed at the contacting surfaces. Hence, the resistance developed through the clamped connection of anode and spacer bar may be controlled by regulating the pressure applied by the clamping bolts. Consideration must also be given to the thermal expansion of the spacer bar during operation of the cell in which temperatures above 95° C. are common. In practice, the bolts may be of a suitable metal or metal alloy to compensate for the expansion of the spacer bars and pressure bars.

The pressure bars may be made of any suitable material, such as steel. The electrode assembly may be employed in diaphragm type electrolytic cells to produce a desired product such as chlorine, caustic and hydrogen or an alkali metal chlorate.

The electrodes are loosely assembled initially, two at a time, placed on the permanent spacer bar with the bolts in the slotted holes. The bolts are tightened to firmly clamp the anodes to the spacer bar. After the anodes have been installed, a sealant is placed over the connecting members between each electrode.

Any corrosion resistant sealant known to the art may be employed. For example, natural or synthetic rubbers may be employed by themselves, in combination or in conjunction with other resins. Bituminous materials may be employed if desired and the phenol-formaldehyde resins and polyester resins are acceptable sealants. Especially good sealants may be derived from the reaction of a polyhydric alcohol with a Diels-Alder adduct of hexahalocyclopentadiene and an alpha, beta unsaturated dicarboxylic acid, such as are disclosed in U.S. 3,216,884. The sealants employed in this invention may be advantageously highly filled with such materials as sand, SiO_2, graphite particles or other inert materials.

The applicable electrodes in the present invention comprise graphite, metals, metal oxides and combinations thereof. The metallic electrodes comprise an electro-conductive substrate metal with an active surface. By substrate metal it is intended to encompass those metals and metal alloys which become passivated when polarized anodically and remain passive well beyond the anodic potential needed to convert a chloride ion to chlorine. The phenomenon of passivity in this connection is discussed in an article by Greene, appearing in the April 1962 issue of Corrosion—National Association of Corrosion Engineers, pages 136*t* to 142*t*, wherein reference may be made to FIG. 1 which describes a typical active-passive

transition of a metal toward a corrosive medium. The metal substrate employed in the electrodes applicable in this invention will not pass into the transpassive range until a potential is reached which is considerably higher than that needed to produce chlorine from the chloride ion. Hence, the substrate metal remains passive during the operation of the electrolytic cell.

Illustrative of the substrate metals in a generic sense are the "valve" metals (with the exclusion of certain metals which obviously are inapplicable such as aluminum, zirconium, and the like). Titanium, tantalum or niobium are acceptable substrate metals. The titanium employed is normally a commercially pure grade of titanium of intermediate strength. Alloys of titanium may be employed as long as the alloy meets the criterion of passivity set forth in the preceding paragraph. For example, titanium alloys of aluminum, vanadium, palladium, chromium or tin may be employed in which the latter metals are present as less than about 10 percent of the alloy.

The surface of the substrate metal may be made active by various methods. For example, a conductor such as a noble metal (preferably platinum) may be deposited on the surface of the substrate metal by methods known to the art such as electrodeposition. Mixtures of noble metals and platinum may be used to activate the surface of the metal substrate. The preferred surface metal mixture or alloy is one containing more than about 50 percent platinum. Likewise, noble metal oxides may be used alone or in combination with noble metals to form the active electrode surface. By noble metal, it is intended to include the platinum and palladium triads of the Periodic Table with the exclusion of osmium. Thus, ruthenium, rhodium, palladium, irridium and platinum represent noble metals which are especially applicable in their metallic form, alloys thereof and as oxides.

The electrode substrate metal upon which an active surface, as described in the preceding paragraph, is applied need not be homogeneous in cross section. For example, the substrate metal or alloy may be clad upon an electrically conductive core. In this sense, the core may consist of any electrical conductor of which aluminum, steel and especially copper are exemplary. The substrate metal may be clad to the electrically conductive solid core by any means known to the art such as by mechanical coating or with an electrically conductive adhesive material. Likewise, the substrate metal may have a hollow core in which a metal or mixture of metals appear such as sodium, potassium or mixtures thereof. These metals may be liquid at the temperature of cell operation to form a completely encapsulated liquid core of excellent electrical conductivity.

By means of the electrode assembly of the instant invention, graphite anodes no longer need to be handled with assembly jigs and cast in a lead base. Furthermore, the production of graphite anodes with tapered ends which are designed for wedging into slots or holes is avoided. Likewise, the initial gap between the graphite anodes and the cathodes are accurately set within close tolerances for optimum performance of the cell due to the uniform alignment of the electrodes.

Advantages in the electrode assembly of this invention, when employed in a fingered bipolar cell reside in minimized bus bar connections, minimized voltage loss due to bus bar connections and minimized investment for copper used as bus bars.

Additional advantages of bipolar electrolytic cells are that they require less floor space. Consequently, building and piping costs are lower per unit of capacity. The capital investment per unit of production should be less for bipolar cells than for monopolar cells. A number of bipolar cells may be contained in one box. Therefore, the cell containers may cost less than those presently used for monopolar cells even though the materials for their construction are more expensive. Rectifier costs are lower for a number of moderately sized bipolar cells than for high current rated cells. The cost per kilowatt of rectification is higher for low voltages and high amperages than for higher voltages and moderate amperages.

The invention is best understood in all its ramifications by considering the drawings.

FIG. 1 is a top view of the fingered bipolar cell of this invention with the top of the cell removed. A partial section is shown to illustrate the assembly of the electrodes.

FIG. 2, is a side section of FIG. 1.

FIG. 3, is a side section of FIG. 1 taken along view 3—3.

FIG. 4 is a magnified view of the anode-cathode assembly at the top and bottom of the cell, with the cell liquor outlet.

FIGS. 5 and 6 are magnified top views of the anode connection of the backer plate employing platinum-titanium and graphite electrodes, respectively.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIGS. 1 and 2 the electrolytic cell series depicted illustrated the use of graphite anodes **10** of this invention. The spacer bars **11** are attached to the base plates **12**. The pressure bars **13** clamp the graphite anodes **10** perpendicularly to the base plate. Sealant **14** completely seals the spacer bars and pressure bars to form a substantially impervious seal against attack from the anolyte liquor. The cathode fingers **15** project between the anodes. The ends of the base plates **12** are coated with a rubber or plastic lining **16** where they extend to the cell casing **17**. The base plates **12** are supported by support bracket **30** which serves as a guide for the base plate during assembly. Conductors **28** serve to complete the electrical circuit to the cathode screen **15** and as cathode support ribs to prevent collapse of the cathode screen onto base plate **12**. Cell liquor outlets **19** are provided for liquid removal Outlets **18** are provided for removal of the hydrogen gas product of the electrolysis.

The cell casing **17** may be constructed with steel or plastic. The liner **16** for cell casing **17** is coextensive with all exposed internal parts of the casing **17**. The liner **16** may be rubber or a plastic material such as after chlorinated polyvinyl chloride with a chlorine content by weight within the range of from about 60 to about 76 percent. Other acceptable resins such as chlorinated polyesters may be employed. It is desirable to use resins which are highly filled with sand, SiO_2, graphite particles or other inert materials as the cell liner.

The base plates at each end of the cell are rubber or plastic lined independently from the box so that they may be removed readily for rebuilding. A gas-liquid tight junction may be formed between the end base plates and the cell box by any suitable means such as bolting in such manner as to form a sealed joint.

In FIG. 3, the arrangement of the anodes **10** upon the steel back plate **12** is shown. The bolts **21** extend through the anodes **10** and the slotted holes in the spacer bar **11**. Conductors **28** have circulation channels interconnecting the cathode compartments to aid in the flow of catholyte from chamber to chamber. The location of outlet **19** for withdrawal of cell liquors is shown in relationship to the base plate **12** and support bracket **30**. A hydrogen outlet (not shown) is similarly constructed with a duct running upward to a point above the cell liquor level. Chlorine rises in the cell liquor to a common chlorine space above the electrolyte from which it flows to a header for ultimate collection. FIGS. 1 and 3 show only one bi-polar unit but any reasonable number of such unit may be included in a box.

FIG. 4 presents the arrangement of the back plate **12** and its assemblage at the top and bottom. The spacer bar **11** contains slotted holes **20** through which bolts **21** pass to connect the anode **10** to the backplate. An asbestos rope, liner or other functionally equivalent means may be placed in the slotted hole **20** over the bolt **21** to separate the bolt from sealant **14** to make the task of disassembly easier. The entire exposed surface of back

plate **12** and spacer bar **11** is protected from the cell liquors and products by plastic sealant **14** while rubber or plastic liner **16** protects the base plate where it meets the side or bottom of the tank. The cathode support ribs **28** with catholyte flow spaces **34** are connected to the base plate **12** by welding or by any method that will insure adequate strength, electrical conductivity and corrosion resistance toward cathodic activity. The cell liquor outlet **19** and the hydrogen outlet **18** pass through the cell casing **17** at the bottom of the cell. The opening through cell casing **17** is lined with rubber or plastic **16** and a gasket **32** is inserted between the cell liquor withdrawal means where they join. The gasket **32** may be made of gum or soft rubber or other suitable material. FIGS. 5 and 6 present the electrode assembly of the instant invention in conjunction with the use of metal electrodes **23** and graphite anodes **10**, respectively. The spacing bar **11** is attached to the steel base plate **12** by welding, brazing, tinning, bolting or by any method which will assure adequate strength and electrical conductivity. The bolt **21** is passed through the pressure bar **13**, the anodes, the spacing bar **11** and tightened on the pressure bar **13**. The pressure bars may be transported as may the bolt in the assembly. The downflow space **24**, the interelectrode space **27** and the cathode compartment **26** form the cell compartments. The plastic sealant **14** covers the attachment assembly for the electrodes and rubber or plastic **16** lines the base plate where it meets the side of the tank.

To illustrate the application of the anode assembly of this invention with clamped anodes, a comparison of operating conditions of an actual electrolysis is presented in the following examples. The concentration of various solutions in the examples is expressed in grams per liter (g.p.l.).

These examples illustrate the results of the electrolysis of feed brines containing various concentrations of sodium chloride, diminishing concentrations of sodium sulfate beginning with 3.8 percent Na_2SO_4 at 314 grams per liter of sodium chloride and trace amounts of CaO and MgO, initially present in an amount of about 12 parts per million and 7 parts per million, respectively. The relative ratios of these feed brine constituents remained constant as the feed brine was diluted to afford various sodium chloride concentrations.

EXAMPLE I

The following results were obtained during the electrolysis of feed brine containing NaCl in the stated concentration with graphite anodes cast in lead and covered with mastic as is conventional in the art.

TABLE I.—GRAPHITE ANODE—ELECTRICAL CONNECTION CAST IN LEAD 0.9 AMPERE PER SQUARE INCH

Feed brine		Anolyte		Catholyte, g.p.l.		Temp. ° C.	Cell voltage	Anode gas			Percent current efficiency
NaCl, g.p.l.	pH	NaCl, g.p.l.	pH	NaCl	NaOH			CO_2	O_2	CO	
314	7.7	284	1.8	264	48	95	3.2	2.15	.07	--------	95.7
300	7.7	265	1.8	231	78	95	3.2	1.65	.76	--------	95.2
238	7.3	215	1.7	172	64	93	3.3	2.33	1.7	--------	92.3
198	7.7	168	1.7	135	62	92	3.5	3.89	.43	.20	91.2
149	7.5	102	2.6	89	64	97	3.55	9.43	2.32	.40	78.4
158	7.6	108	2.7	40	98	97	3.6	8.91	2.37	.36	88.3
136	7.8	82	2.4	40	80	93	3.65	6.20	2.12	.50	83.5
139	7.6	92	2.1	46	78	94	3.65	8.81	1.62	.55	80.3
121	7.8	75	2.1	43	70	94	3.8	13.15	1.60	.68	73.1
81	7.9	40	1.75	13	44	96	4.3	17.19	1.56	1.07	66.9
81	7.7	41	1.4	9	54	97	4.4	14.26	1.32	1.43	70.6

EXAMPLE II

This example illustrates results compiled in Table II, obtained from the electrolysis of feed brine containing NaCl in the stated concentration with graphite anodes bolted to a copper spacer bar as disclosed in this specification.

TABLE II.—GRAPHITE ANODE—ELECTRICAL CONNECTION BOLTED TO BLADE 0.9 AMPERE PER SQUARE INCH

Feed brine		Anolyte		Catholyte, g.p.l.		Temp. ° C.	Cell voltage	Anode gas			Percent current efficiency.
NaCl, g.p.l.	pH	NaCl, g.p.l.	pH	NaCl	NaOH			CO_2	O_2	CO	
314	7.7	246	1.6	----------	70	96	3.0	2.58	.05	--------	94.8
300	7.7	265	1.6	205	96	95	3.0	1.59	.06	--------	96.8
238	7.3	205	2.35	151	100	95	3.1	3.41	.24	.25	91.8
198	7.7	158	1.7	122	62	92	3.25	4.30	.61	.25	89.9
149	7.5	107	2.0	99	36	95	3.3	6.10	.73	.48	86.3
158	7.6	119	2.1	73	78	96	3.3	6.18	.66	.70	85.0
136	7.8	91	2.0	66	48	93	3.35	5.80	1.12	.44	86.2
139	7.6	109	2.3	73	64	95	3.4	4.95	.54	.41	88.7
121	7.8	86	1.8	53	58	96	3.45	9.66	.49	.40	80.6
81	7.9	50	1.85	21	18	97	3.8	9.59	1.29	.86	78.1
81	7.7	58	1.4	30	37	95	3.75	6.09	.49	.48	8.63

NOTE: Initial feed brine contained 3.8 percent Na_2SO_4. Approximately 0.5 percent CO_2 comes from feed brine

EXAMPLES III AND IV

The following examples illustrate the operation of an electrolytic cell with platinized-titanium anodes (Type B-Englehard Coating) bolted directly to the copper bus as described in this specification. Highly filled polyester resin, described supra, was used to insulate the anode connection from the anolyte.

TABLE III.—PLATINIZED TITANIUM ANODE 0.9 AMPERE PER SQUARE INCH

Feed brine		Anolyte		Catholyte, g.p.l.		Temp.	Cell	Anode gas			Percent current
NaCl, g.p.l.	pH	NaCl, g.p.l.	pH	NaCl	NaOH	° C.	voltage	CO_2	O_2	CO	efficiency
314	6.25	264	2.95	224	58	92	2.9	1.71	.76		98.3
274	7.25	248	2.8	205	78	95	3.0	.65	.24		99.2
231	7.5	201	2.8	145	66	93	3.05	.68	1.59		96.6
211	6.8	165	3.45	125	64	93	3.15	.25	.18		99.6
173	6.5	137	3.8	90	72	96.5	3.2	.57	1.39		97.0
152	6.5	120	3.85	76	66	96	3.3	.39	.94		97.3
124	6.8	86	3.8	52	62	95	3.45	.41	1.84		95.8
140	6.7	105	3.75	65	61	94	3.35	.34	.94		97.9
136	7.1	91	3.7	61	62	93	3.4	.44	1.73		96.5
136	6.7	91	3.5	51	59	93	3.45	.39	1.81		96.2
133	6.6	83	3.7	48	62	95	3.45	.20	1.90		93.8
129	7.2	87	3.7	49	58	96	3.45	.36	1.09		97.8
144	6.8	92	3.4	65	56	96	3.45	.47	1.29		97.4
132	7.2	92	3.7	50	61	97	3.45	.43	1.16		96.9
135	7.3	92	3.6	53	62	96	3.45	.43	1.7		95.8
132	7.2	90	3.9	50	63	96	3.5	.36	1.23		97.3

NOTE: Initial feed brine contains 3.8 percent Na_2SO_3. Source of CO_2 comes from feed brine.

TABLE IV.—PLATINIZED TITANIUM ANODE 0.9 AMPERE PER SQUARE INCH

Feed brine		Anolyte		Catholyte, g.p.l.		Temp.	Cell	Anode gas			Percent current
NaCl, g.p.l.	pH	NaCl, g.p.l.	pH	NaCl	NaOH	° C.	voltage	CO_2	O_2	CO	efficiency
315	7.0	281	3.0	264	43	91	2.85	1.77	.18		99.4
304	7.3	290	4.3	246	43	94	2.75	1.84	.17		99.6
295	7.5	271	4.4	243	41	95	2.75	.38	.23		99.5
298	7.0	275	4.5	245	43	96	2.75	1.23	.19		99.0
185	6.8	165	4.3	138	39	94	2.85	.42	.86		97.8
146	6.5	128	4.2	99	39	95	2.9	.12	1.62		94.4
147	7.4	127	3.7	99	40	95	3.0	.70	.52		98.9
112	6.4	91	3.8	67	37	94	3.1	1.57	.83		98.3
103	7.4	81	3.9	52	40	95	3.2	.71	.75		98.4
81	7.4	56	4.0	22	42	97	3.55	.84	3.0		93.5
81	7.4	48	4.1	19	51	96	3.7	1.02	6.39		87.2
72	7.5	36	4.3	16	52	97	4.4	1.10	6.60		86.7
73	7.7	38	4.1	26	35	98	4.6	1.22	8.45		83.7
79	2.7	36	4.1	22	47	97	4.6	1.84	17.4		69.3

Electrolytic cells equipped with the anode assemblies of this invention may be operated at considerably higher current densities than cells now operating. The anode assembly of this invention may be used in the operation of diaphragm type chlorate cells, chlor-alkali cells, monopolar cells and bipolar cells.

EXAMPLE V

A laboratory size (50 amperes) monopolar type electrolytic cell equipped with a platinized-titanium anode bolted to the bus bar was employed in the electrolysis of sodium chloride brine containing up to 3.8 percent sodium sulfate. An asbestos diaphragm was employed and the cell temperature was maintained at 94°±2° C. The current densities as high as about 260 amperes per square foot were achieved without encountering excessive voltage. The data presented in Table V was taken near the end of the experiments at which time the condition of the diaphragm and depletion of the electrolyte in the cell exaggerated the cell voltage readings and current efficiency.

TABLE V.—EXPERIMENTS IN A LABORATORY SIZE MONOPOLAR TYPE CELL AT CURRENT DENSITIES UP TO 260 AMPERES/SQUARE FOOT

	Anolyte						
Current density, amp./sq.ft.	NaCl concentration, g.p.l.	pH	Catholyte, g.p.l. NaCl	Catholyte, g.p.l. NaOH	Cell voltage	Percent current efficiencies
129.6	98	3.85	59	62	4.15	84.5
259.2	95	4.05	50	90	5.65	89.6
129.6	267	4.1	185	108	3.5	86.8
259.2	264	4.15	198	120	4.6	89.6

With clamped anode assemblies in bipolar electrolytic cells, higher current densities may be employed without encountering excessive voltages. This is because the clamped joint between the anode and the current conductor is a low resistance joint. Likewise, the anode length may be shorter because, by clamping the anodes and sealing them with a plastic sealant as opposed to the conventional mastic or asphalt covering over a poured lead-anode connection provides an anode stub loss of about 1 to 2 inches as opposed to a stub loss of 3 to 4 inches.

Normal current densities of between 125 to 130 amperes per square foot may be increased to as much as 350 amperes per square foot and more with the anode assembly of this invention which provides graphite-copper electrical connection which is superior to a conventional lead-graphite connection.

Having disclosed the invention, it will be apparent that obvious modifications within the scope of the invention may be made by those skilled in the art.

What is claimed is:

1. An electrode assembly for an electrolytic cell comprising a base plate having a plurality of non-detachable electroconductive spacer bars, two electrodes detachably clamped to each spacer bar and held in position by two pressure bars and bolt means positioned parallel to said plate and extending in sequence through holes in a pressure bar, an electrode, a spacer bar, another electrode and another pressure bar.

2. The electrode assembly of claim 1 in which said electrodes are selected from the group consisting of graphite, a metal, a metal oxide and combinations thereof.

3. The electrode assembly of claim 1 in which said base plate is steel, said spacer bar is copper and said pressure bars are steel.

4. The electrode assembly of claim 1 in which the spacer bar, electrode, pressure bar and base plate connections are sealed from attack by the electrolysis products of an electrolytic process by a plastic sealant.

5. An electrolytic cell comprising container means; means for supplying an electric current to the electrodes; and means for introducing reactant and removing prod-

ucts, said electrodes comprising anodes and cathodes separated by a diaphragm, said cathodes defining plural pockets which extend into the spaces between the anodes, said anodes extending from a base plate having a plurality of non-detachable electroconductive spacer bars, said anodes being clamped to said spacer bars by bolt means disposed parallel to the base plate, said bolt means extending in sequence through holes in a pressure bar, an electrode, a spacer bar, another electrode, and another pressure bar.

6. The electrolytic cell of claim **5** in which said means for supplying an electric current to the electrodes comprises a monopolar base plate at one end of the cell, said monopolar base plate being separated and insulated from the cell box by liner means and being connected to a source of electricity.

7. The electrode assembly of claim **5** in which said electrodes are selected from the group consisting of graphite, a metal, a metal oxide and combinations thereof.

8. A diaphragm type electrolytic cell of the fingered bipolar type comprising a plurality of anodes extending from a base plate and a plurality of cathode pockets extending from a juxtaposed base plate to the spaces between the anodes, means for introducing reactant and removing products, means for supplying electrical energy to said electrodes, said base plate having a plurality of non-detachable electroconductive spacer bars, said anodes being clamped to said spacer bars by bolt means disposed parallel to the base plate, said bolt means running in sequence through a pressure bar, an anode, a spacer bar, another anode and another pressure bar.

9. The electrode assembly of claim **8** in which said electrodes are selected from the group consisting of grahpite, a metal, a metal oxide and combinations thereof.

References Cited

UNITED STATES PATENTS

776,490	12/1904	Briggs	204—286
1,815,080	7/1931	Smith	204—254

TA-HSUNG TUNG, Primary Examiner

U.S. Cl. X.R.

204—98. 258. 286, 297

PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,563,878 Dated February 16, 1971

Inventor(s) Morris P. Grotheer

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 20, change "illustrated" to read --- illustrates ---;

Column 5, line 44, change "transported" to read --- transposed ---;

Column 6, Example II, Table II, under "Percent Current Efficiency" change "8.63" to --- 86.3 ---;

Columns 7 and 8, Table III - Footnote, change "Na_2SO_3" to --- Na_2SO_4 ---.

Column 8, line 59, Claim 1, change "said plate" to --- said base plat

Column 8, line 71, Claim 4, change "by the electrolysis" to ---by the electrolyte and electrolysis ---;

Column 10, line 10, change "grahpite" to --- graphite ---.

Signed and sealed this 2nd day of November 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Acting Commissioner of Patent