Aug. 24, 1948. K. E. STUART 2,447,547

ELECTROLYTIC ALKALI CHLORINE CELLS

Filed June 2, 1945 5 Sheets-Sheet 1

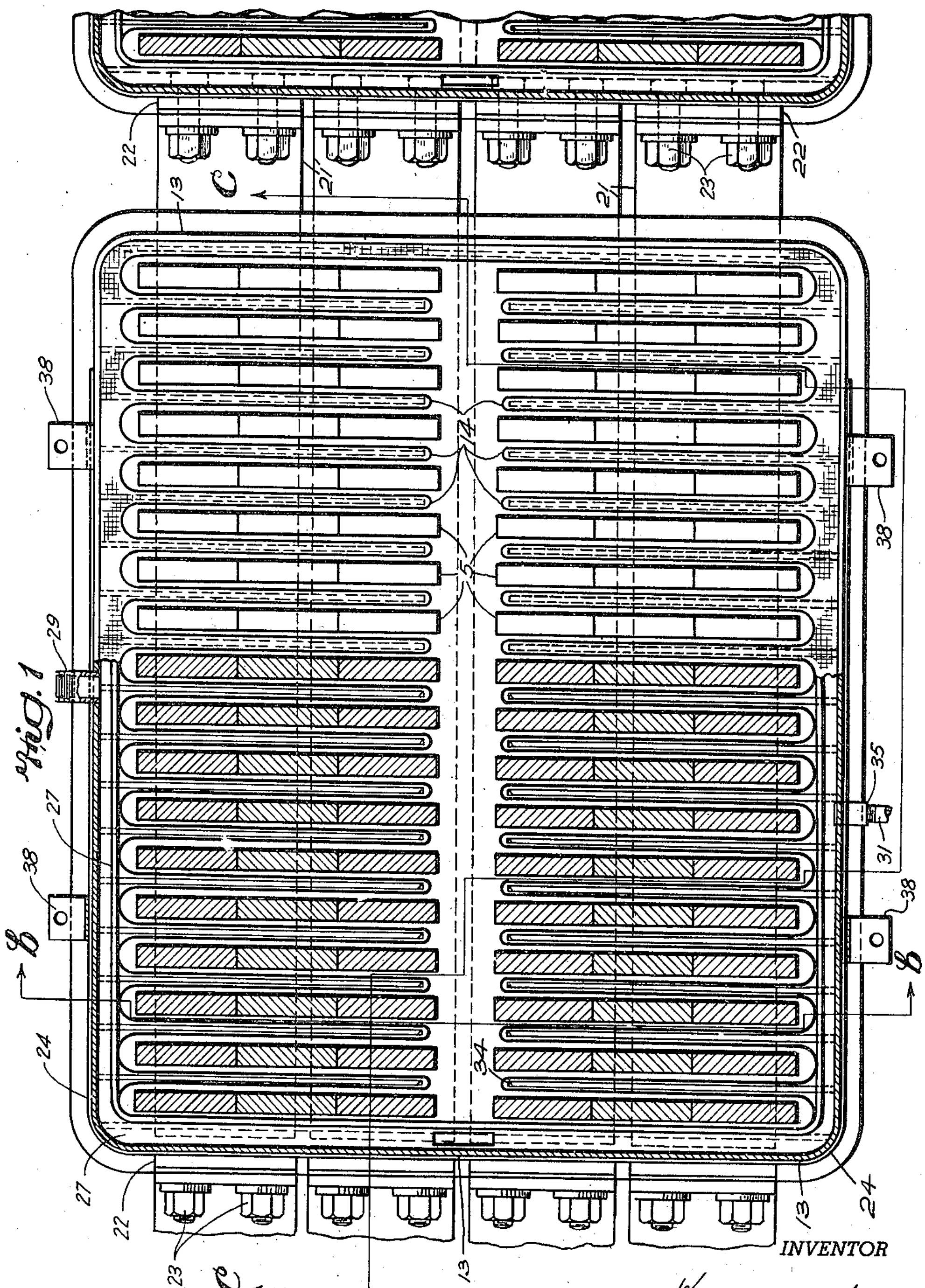

Fig. 1

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ELECTROLYTIC ALKALI CHLORINE CELLS

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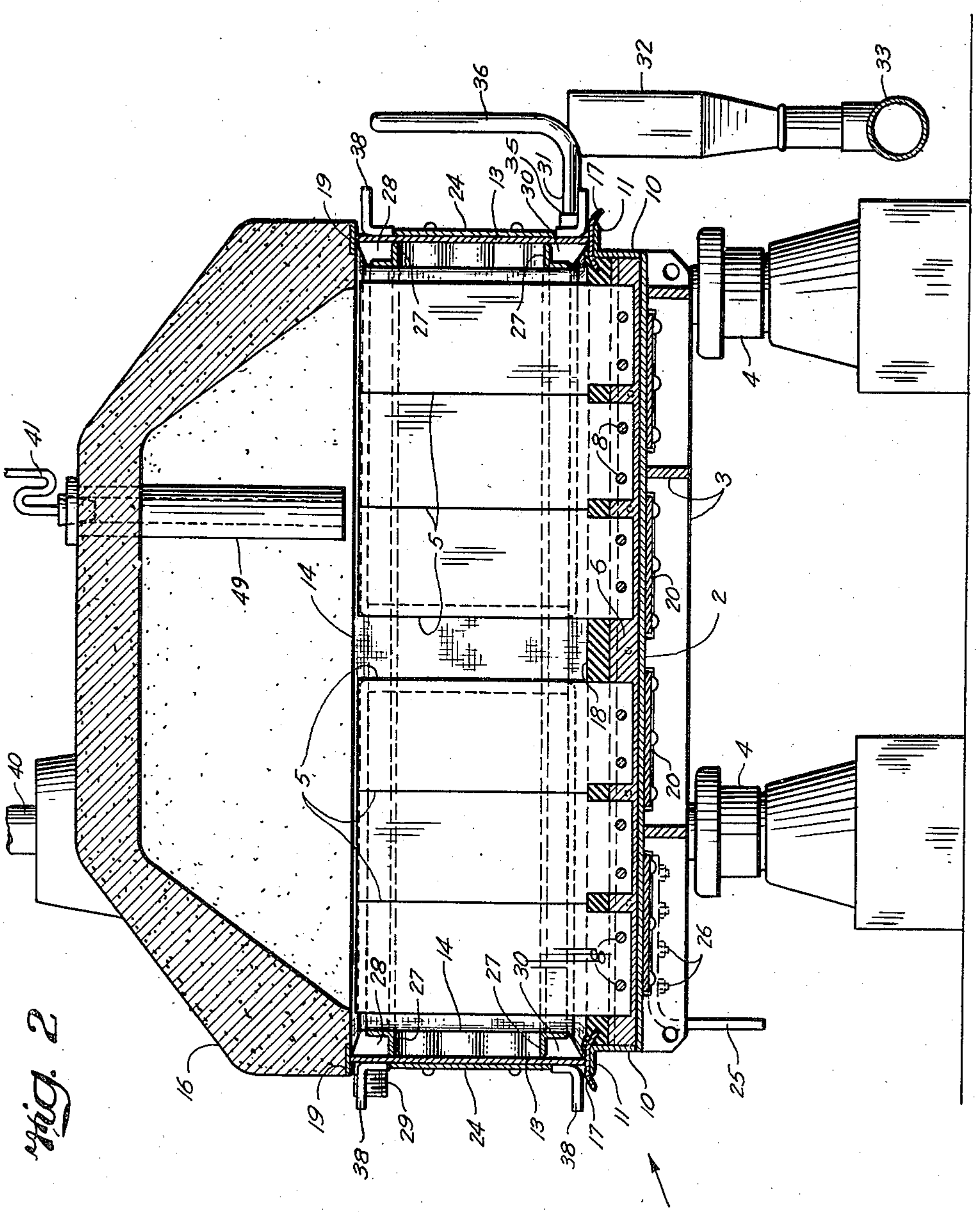

Fig. 2

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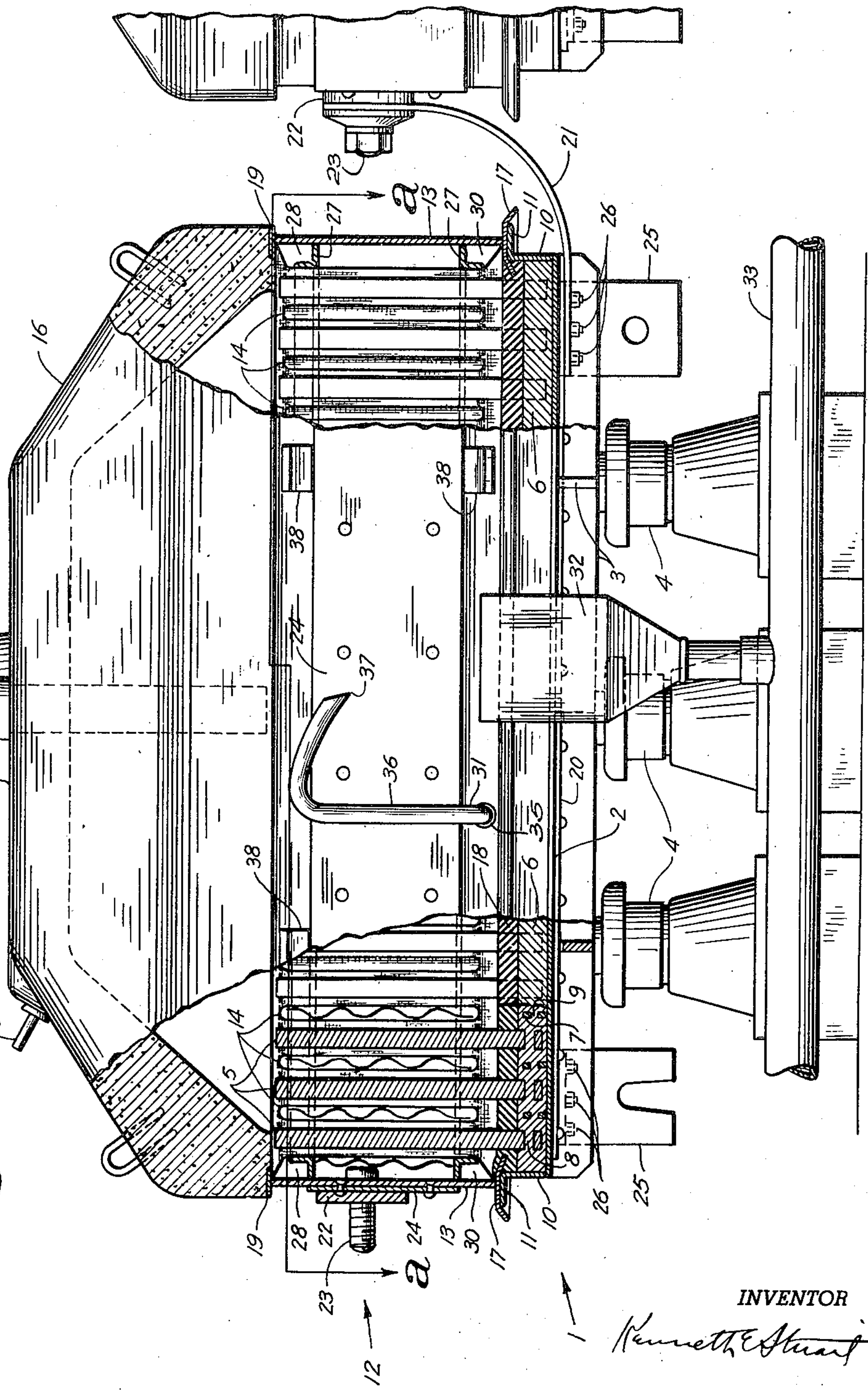
Fig. 3



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ELECTROLYTIC ALKALI CHLORINE CELLS

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Fig. 5

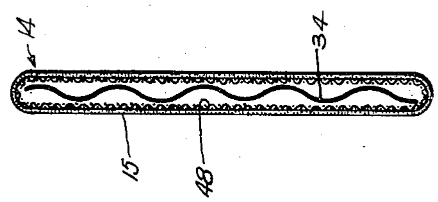
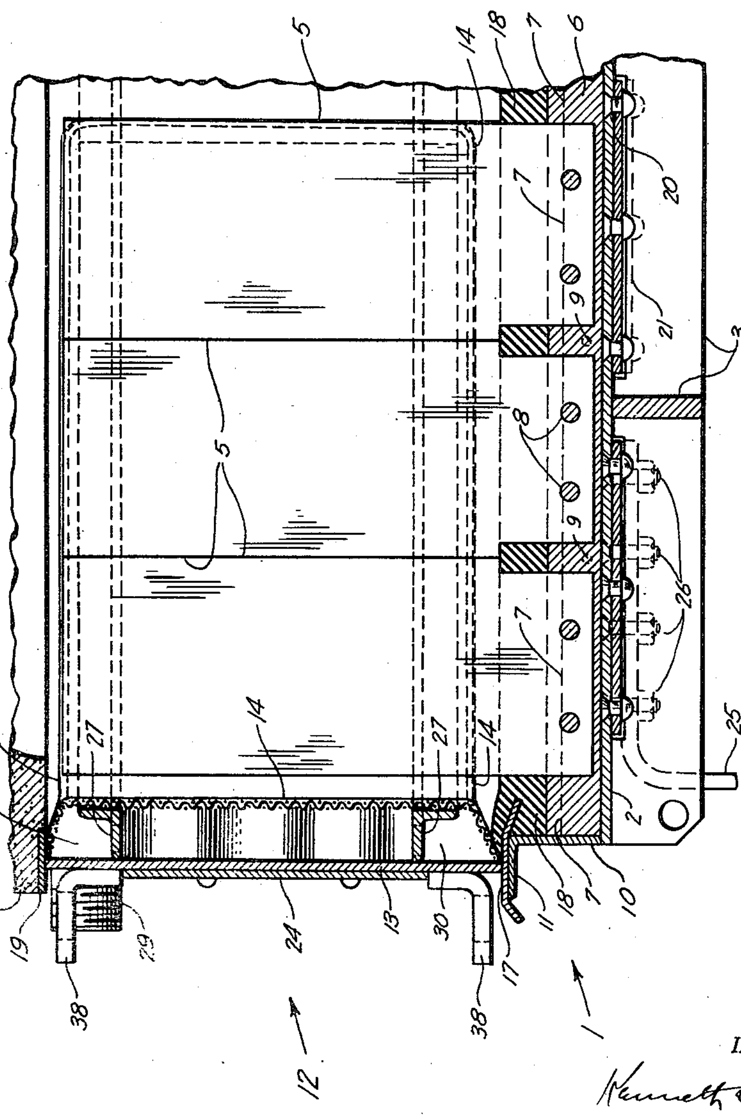


Fig. 4



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ELECTROLYTIC ALKALI CHLORINE CELLS

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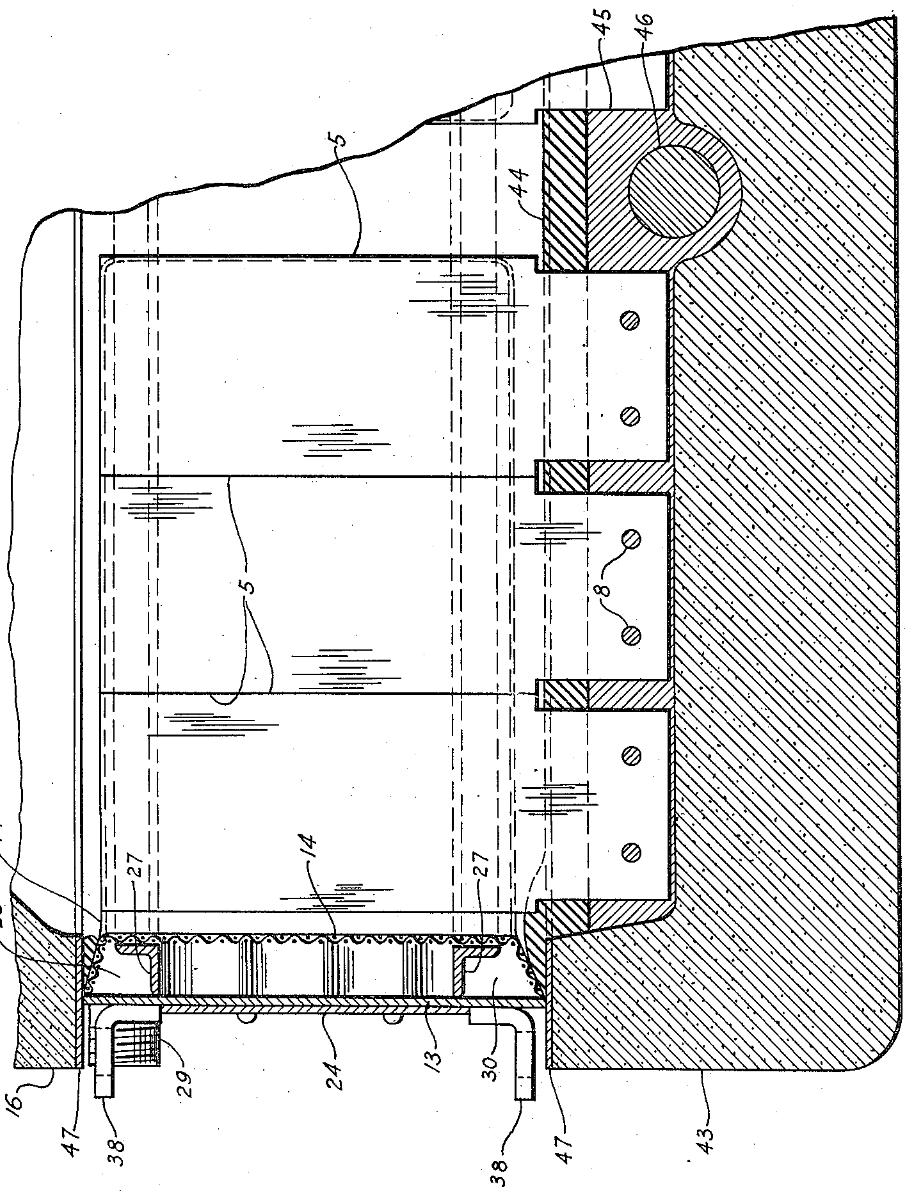

Fig. 6

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Patented Aug. 24, 1948

2,447,547

UNITED STATES PATENT OFFICE

2,447,547

ELECTROLYTIC ALKALI CHLORINE CELL

Kenneth E. Stuart, Niagara Falls, N. Y., assignor to Hooker Electrochemical Company, Niagara Falls, N. Y., a corporation of New York

Application June 2, 1945, Serial No. 597,259

5 Claims. (Cl. 204—266)

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This application is a continuation-in-part of application Serial No. 444,771, filed May 28, 1942, now abandoned.

My invention relates more particularly to an improvement upon the cell described in Patent No. 1,866,065, granted to me July 5, 1932. One object of my invention is to increase the electrode surface of the cell per unit of floor space occupied. Another object of my invention is to simplify the construction of the cathode assembly. Another object of my invention is to provide improved means for forming a liquid-tight joint between the liquid-retaining enclosing wall of the cathode assembly and the liquid-retaining bottom closure member of the cell. Another object of my invention is to protect the bottom closure member against electrolysis which would otherwise be liable to result from accidental minor leaks through said joint, when the bottom closure member is of metal. Still another object of my invention is to provide an improved means for forming a liquid-tight joint between the liquid-retaining enclosing wall of the cathode assembly and the non-conducting cover member of the cell. A further object of my invention is to eliminate certain imperforate cathodic metal surfaces which are liable to become exposed to electrolytic action within the cell and thus cause formation of chlorates, with loss of current efficiency.

Referring to the drawings:

Fig. 1 is a plan view of the cell, with the gas collecting cover member removed, and partly in section along line *a—a* of Fig. 3, showing the cathodic and anodic electrodes, and their spacing with respect to each other.

Fig. 2 is an end elevation of the cell, in section along line *b—b* of Fig. 1.

Fig. 3 is a side elevation of the cell, partly in section along line *c—c* of Fig. 1.

Fig. 4 is an elevation of a portion of the cell, in section along line *b—b* of Fig. 1, but to an enlarged scale.

Fig. 5 is a sectional elevation through one of the cathodic electrodes, to the scale of Fig. 4.

Fig. 6 is an elevation of a portion of the cell, corresponding to Fig. 4, but showing the bottom closure member as constructed of non-conducting material, such as concrete.

Referring to Figures 1, 2 and 3, **1** is the anode assembly, including a bottom closure plate **2**, which in this case is rectangular in plan and constructed of metal, and preferably of steel, and adapted to carry the cell current. Plate **2** is stiffened by ribs **3**, **3** which rest upon non-con-

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ducting members **4**, **4**, and supports the anodic electrodes, comprising rows of upright, elongated, chlorine-resistant anodes **5**, **5**. Anodes **5** are of graphite in the form of flat-sided blades, and have their lower ends conductively affixed to plate **2**, preferably by embedding these ends in a slab **6**, of low melting metal, such as lead, which is anchored to plate **2**. The ends of the anodes are embedded in slab **6** by supporting the anodes above the plate, preferably with a slight clearance between, and pouring molten lead around the ends of the anodes. Lead slab **6** may be anchored to plate **2** by solder, or by means of fins **7**, or both. Fins **7** are preferably welded to plate **2** and extend between the rows of anodes. Holes **8**, **8** are drilled through the ends of anodic electrodes **5**, below the level to which the lead is to be poured. Holes **9**, **9** are similarly drilled through fins **7**. The molten lead flowing through holes **8** and **9** anchor anodic electrodes **5**, **5** to plate **2** firmly and conductively. This method of affixing the anodic electrodes to the metal closing plate is disclosed and claimed in co-pending application Serial No. 389,033, filed April 17, 1941, now Patent No. 2,370,087.

Plate **2** is provided with a rim **10**, which may serve as a retaining wall for the molten lead when it is poured in for the purpose of anchoring the anodic electrodes. Rim **10** is preferably of angle section, one leg being welded to plate **2**, perpendicularly with respect thereto, and the other leg forming flange **11**, upon which cathode assembly **12** is supported.

Cathode assembly **12** comprises a foraminous structure enclosed in upright liquid-retaining wall **13**. Wall **13** is constructed of metal plate and its upper and lower rims lie in normally horizontal boundary planes. In horizontal or plan view wall **13** conforms in shape with flange **11**, so that it is adapted to rest thereon and form a liquid-tight closure therewith. The foraminous structure comprises a series of thin hollow, upright, flat-sided, elongated, parallel, horizontally aligned cathodic electrodes **14**, arranged in two banks, projecting inwardly from opposite sides of wall **13**, and alternating with anodic electrodes **5**, as clearly illustrated in Fig. 1. Cathodic electrodes **14** are supported and reinforced by structure to be described in detail later. A cross-section of one of the cathodic electrodes is illustrated in Fig. 5, in which **48** is the wall, of woven-wire screen, which constitutes the active electrode surface, and **34** a corrugated inner plate. Wire screen **48** is covered by permeable, chlorine resistant diaphragm **15**. This diaphragm is preferably of asbestos fiber and formed in accordance with the process of U. S. Patent No. 1,865,152, granted to me July 28, 1932, and therefore seamless over the entire foraminous cathode structure of the cell.

Surmounting the cathode assembly, conforming with enclosing walls 13 and resting thereon is the chlorine gas collecting cover or cell top 16, which may be of concrete, as shown in the drawings.

Unlike the cell of Patent No. 1,866,065, above referred to, the enclosing frame of which is of channel section, enclosing walls 13 are flangeless. This is an important feature of the present invention, as the space between the flanges of the earlier cell, which in that construction is outside the cell, may by omission of the flanges be made available for housing of electrodes, without any increase in floor space occupied. In the cell of the patent, the anode assembly includes a bottom member of concrete, and the joint between flange of the cathode enclosing frame and concrete bottom member is rendered liquid-tight by means of rope type gasket of circular cross-section, in accordance with Patent No. 2,208,778, granted to me July 23, 1940. This in theory gives line contact between the flange and gasket, which however, under the weight of the superposed structure, becomes surface contact, the surface being about one quarter of an inch wide. In the present invention I obtain substantially the same effect by cementing gasket 17, of resilient, non-conducting sheet material, upon the surface of flange 11. The edge of enclosing wall 13 is then caused to rest directly upon gasket 17, and since the thickness of this wall is about one quarter of an inch, the intensity of pressure is the same as before, and the joint equally effective.

The metal parts of the cathodic assembly, if of iron, are unaffected by electrolysis, but the metal of bottom plate 2 and rim 10 are anodic. There is no known metal but platinum that will withstand wet nascent chlorine, and electrolyte leaking past gasket 17 would, if allowed to flow down over rim 10, cut the metal away almost as if the the electrolyte were a strong acid. As no gasket joint is at all times absolutely perfect, it is very important to guard against contact between flange 11 and any electrolyte that may accidentally leak past gasket 17. For this purpose, I extend gasket 17 outwardly a short distance beyond the edge of flange 11. The overhanging part of gasket 17 is then caused to sag and forms a natural drip rim, causing any leaking electrolyte to drip directly to the floor instead of flowing downward over the surface of flange 11 and rim 10.

It is of course also necessary to protect lead slab 6 and the inner surface of rim 10 against electrolysis. This is accomplished by carrying rim 10 above the level of the lead slab and filling in all the space enclosed by rim 10 above the lead and between anodic electrodes 5 with a layer of impervious, non-conducting, chlorine-resistant material, such as bitumen, as indicated at 18. Layer 18 is applied in a fluid condition, either while molten or in a solvent. The fluid bitumen may be poured in until it fills the space within rim 10 level full. Gasket 17 preferably extends beyond flange 11 inwardly as well as outwardly. The inwardly overhanging part of gasket 17 may then be pressed downward into the fluid bitumen until the latter flows over its upper surface. The edge of the gasket is thus embedded in the bitumen and an excellent seal secured. Gasket 17

may be of rubber or of any good, resilient, non-conducting rubber substitute. If the solvent for the bitumen is also a solvent or softening agent for the material of the gasket, a perfect bond is secured. If desired, the bitumen may be poured in while in a molten condition to a level just below gasket 17, and another layer of bitumen in a solvent may then be poured in, making a bond with both the first layer of bitumen and the gasket. If the gasket is of a material incapable of withstanding the temperature of molten bitumen, it is thus protected against injury.

The joint between enclosing wall 13 and cover 16 may be made in a similar manner by cementing gasket 19 to the under surface of the rim of cover 16.

It should be noted that although flange 11 projects beyond walls 13, it projects much less far than the flange of a standard channel of a height equal to that of enclosing wall 13. Hence the floor space occupied by the cell is more effectively utilized when the enclosing wall of the cathode assembly is flangeless, as in my present cell.

By reference to Figs. 1 and 2, it will be seen that the use of a steel bottom plate 2 lends itself to a very simple bus bar connection to the anode assembly, consisting of four flat bus bars 20, extending longitudinally of the cell in a direction generally parallel to the rows of anodic electrodes, and bolted and soldered to the outer surface of plate 2, opposite the ends of these electrodes. Bus bars 20 preferably extend from end to end of the cell. At one end they are overlapped by bus bars 21, which are bolted and soldered to bus bars 20, curve upward beyond the cell preferably in a sweep of large radius and are bolted to plate 22, upon the vertical face of the cathode enclosing wall 13 of the next cell of the series, by means of bolts 23. Bus bars 21 should be of soft annealed copper or laminated, for flexibility. Bus bars 24 carry the current around the side walls 13 and are riveted and soldered thereto. Lugs 25 are affixed to the bottom of plate 2, by bolts 26. Lugs 25 serve for connection of "jumper switches" (not shown), by means of which any particular cell of the series may be short-circuited when necessary for diaphragm or anode renewal. This type of bus bar connection between cells is very economical of floor space.

By reference to Fig. 1, it will also be seen that, while, as before, the electrodes are divided into two banks with a clearance between, which is important for circulation of electrolyte, the corresponding electrodes are opposite each other, instead of being staggered, as in the original cell. While the staggered arrangement is advantageous under most circumstances, when economy of floor space is a prime consideration it may be dispensed with. In this way longitudinal space equal to half the distance between corresponding electrodes is gained.

By the use of the type of bus bar connection between cells just described and the saving in flange space and that due to dispensing with the staggered arrangement of the two banks of electrodes, I am able to gain sufficient space to increase the number of electrodes in each bank from fifteen to eighteen, or one fifth, upon the same center to center distance between cells.

Similarly, by the saving in flange space at each side of the cell I am able to increase the total width of the graphite anode blades by one sixth.

It should also be noted that by dispensing with the outward flanges of enclosing wall 13, the cell design is freed from the limitations of standard channel sections. This makes it possible to utilize one sixth more of the height of the standard graphite anode blades.

The combined effect of the increase in number, width and height of electrodes is an increase of more than sixty per cent in total electrode surface, without any increase in floor space occupied; a very important result, especially when it is realized that this is by comparison with a cell which is itself extremely economical of floor space.

When the walls of the enclosing frame are of flangeless plate, as in the present case, it may be desirable to provide means for stiffening these walls. This object is accomplished by means of members 27. These extend horizontally around walls 13. In order that members 27 may have a maximum sectional moment of inertia, they are preferably of angle section, with the edge of one leg welded to the adjacent wall 13 and the other leg inside and parallel to this wall. The space within the legs of the upper angle 27 is thus left open, to form passage 28 for flow of hydrogen to exit 29 similarly, the space within the legs of lower angle 27 forms passage 30 for flow of the liquid product of electrolysis to effluent pipe 31, whence it falls by gravity into funnel 32 to be carried away by header pipe 33. Members 34 are provided, for reinforcing cathodic electrodes 14 against collapsing pressure.

Effluent pipe 31 is connected to passage 30 through a threaded opening at 35 and swings upon the thread. From this opening it projects outwardly, then bends upwardly to vertical leg 36. At the top of leg 36 it bends horizontally and describes an arc about opening 35, finally ending in spout 37, which is adapted to deliver into funnel 32. The liquid product of electrolysis fills passage 30 inside wall 13 to a level just short of passage 28 and must not be allowed to encroach upon passage 28, for otherwise the hydrogen exit would be obstructed. The radius of the arc described by effluent pipe 31 about opening 35 is therefore made such that in any position of the pipe passage 28 cannot be obstructed.

Lugs 38 are provided for lifting the cathode assembly as for diaphragm renewal.

Brine is supplied to the cell preferably at a constant rate through flow controlling restriction 39, in accordance with U. S. Patent No. 2,183,-299, granted to me Dec. 12, 1939. The brine is supplied preferably at a temperature of 60° to 90° C. and saturated at that temperature in accordance with the process of U. S. Patent No. 2,173,986, granted to me Sept. 26, 1939. Chlorine is discharged from cover 16 through pipe 40. The electrolyte level within the cell is shown by the liquid column in manometer 41, with reference to the lower end of vertical pipe 49, to the upper end of which the manometer is connected, the manometer reading corresponding to the pressure built up in pipe 49 by chlorine evolved upon anodes 5 and trapped in the pipe under the hydrostatic head corresponding to the depth of submergence of the open lower end of the pipe.

An important advantage of the flangeless construction of walls 13 about which nothing has heretofore been said is as follows: when the walls are of flanged channel section, the foraminous border of the cathodic electrode structure is welded to the edges formed by the flat surfaces of the flanges with the web of the channel. Since the gasket could not make a liquid-tight joint with the foraminous border, and since there is some variation in the forming of the channel frame, the gasket is necessarily caused to bear upon the surface of the flange at a short distance from the edge, where the foraminous border, and hence the diaphragm, begins. Between the edge and the bearing area there therefore exists a narrow strip of surface extending around the cell which is imperforate and not covered by the diaphragm. It is necessary to protect this surface against electrolysis by the use of putty, as caustic soda would otherwise be formed upon it and this would come into contact with chlorine and be converted to sodium chlorate, an undesired current wasting by-product. But putty is not a reliable protection for this surface. It sometimes fails, and when this occurs there results a contamination of the product and loss of current efficiency in the cell. By the use of the flangeless construction of the present invention, however, the foraminous cathode border is carried to the edge of wall 13 where this edge rests upon the gasket, and no marginal surfaces are left to be covered by putty where chlorate might otherwise be formed and current wasted.

While I have described the novel cathode structure of my cell in connection with a novel type of metal bottom closure, I do not wish to be limited to this combination, as my cathode may be used in combination with the concrete bottom closure member of Patent No. 1,866,065. This is illustrated in Fig. 6, in which the cathode is that described above, and the reference figures likewise the same, insofar as they apply to the cathode. In this case, however, the bottom closure member 43 is adapted to be constructed of concrete or other non-conducting material. 45 is a slab of low melting metal, corresponding to slab 6 and 44 a layer of bituminous material corresponding to layer 18. Bottom closure member 43 being massive, its rim requires no flange, since it is itself broad enough to provide a gasket seat. The same is true of the rim of cover 16. Gaskets 47, which are of the flat sheet type, are therefore cemented directly to the rims of the top and bottom closure members. Since concrete is non-conducting, gaskets 47 do not need to project outwardly of the bottom closure rim to form a drip rim. Current is supplied to slab 45 through bus bar 46, embedded therein.

When my improved cathode is used in combination with a concrete bottom closure there is still a substantial increase in electrode area per unit of floor space, and the other advantages enumerated above are the same as when it is used in combination with a metal bottom closure.

I claim as my invention:

1. In an electrolytic alkali chlorine cell comprising a cathode assembly including a foraminous metal structure and cathodic electrodes housed in an upright, liquid-retaining metal wall; an anode assembly co-operative therewith, including upright anodic electrodes having their lower ends embedded in a slab of low melting metal; a top closure member for said retaining wall; and a bottom closure member for said retaining wall and support for said cathode and anode assemblies, said bottom closure member being provided with an upturned border and said upturned border having a normally horizontal flat face around its upper rim, said slab being protected against anodic electrolysis by a layer of impervious, electrically non-conducting pressure-plastic material extending around and between the lower ends of said anodic electrodes to

said bottom closure upturned border and making a sealing bond therewith: the improvement which consists in that said retaining wall is of thin plate; that the lower edge of said retaining wall plate lies in a flat boundary plane; that the lower border of the foraminous structure is continuous and conductively joined to the inner face of the retaining wall plate, flush with the lower edge thereof, leaving said edge exposed to form a gasket bearing surface of a width limited by the thickness of said retaining wall plate; that the flat face of the bottom closure upturned border conforms with the lower rim of the retaining wall in plan view and extends inwardly and outwardly thereof; and that said face is provided with a flat gasket of impervious, resilient material, the lower edge of said retaining wall plate resting upon said gasket and making a normally liquid-tight closure therewith under the weight of the superstructure.

2. In an electrolytic alkali chlorine cell as described in claim 1, the further improvement which consists in that the upper edge of said retaining wall plate likewise lies in a flat boundary plane; that the upper border of the foraminous structure is likewise continuous and conductively joined to the inner face of the retaining wall plate, flush with the upper edge thereof, leaving said edge exposed to form a gasket bearing surface of a width limited by the thickness of said retaining wall plate; that said top closure member is provided beneath with a flat normally horizontal gasket bearing surface conforming in plan view with the upper rim of said retaining wall and extending inwardly and outwardly thereof; and that said top closure gasket bearing surface is provided with a flat gasket of impervious, resilient material, affixed thereto and resting upon the upper edge of said retaining wall plate.

3. In an electrolytic alkali chlorine cell as described in claim 1, the further improvement which consists in that the upper edge of said retaining wall likewise lies in a flat boundary plane; that the upper border of the foraminous structure is likewise continuous; that the borders of the foraminous structure are spread vertically; that the upper border of the foraminous structure is likewise conductively joined to the inner surface of the retaining wall plate, flush with the upper edge thereof, leaving said edge exposed to form a gasket bearing surface of a width limited by the thickness of said retaining wall plate; that said top closure member is provided beneath with a flat normally horizontal gasket bearing surface conforming in plan view with the upper rim of said retaining wall and extending inwardly and outwardly thereof; and that said top closure gasket bearing surface is provided with a flat gasket of impervious, resilient material affixed thereto, resting upon the upper edge of said retaining wall plate.

4. In an electrolytic alkali chlorine cell comprising a cathode assembly including a foraminous metal structure and cathodic electrodes housed in an upright liquid retaining metal wall; an anode assembly co-operative therewith including upright anodic electrodes having their

lower ends embedded in a slab of low melting metal; a top closure member for said retaining wall, and a bottom closure member for said retaining wall and support for said cathode and anode assemblies comprising a flat metal plate beneath said retaining wall extending completely across from side to side thereof and having its upper surface affixed to said slab, said bottom plate being also provided with an upturned border and said upturned border being provided with an outwardly extending flat flange around its upper rim; the improvement which consists in that said retaining wall is of thin plate; that the lower edge of said retaining wall plate lies in a flat boundary plane; that the lower border of the foraminous structure is continuous and conductively joined to the inner surface of the retaining wall plate, flush with the lower edge thereof, leaving said edge exposed to form a gasket bearing surface of a width limited by the thickness of said retaining wall plate; that the flange of the bottom closure member conforms with the lower rim of the retaining wall in plan view and extends inwardly and outwardly thereof; that the flange is provided with a flat gasket of impervious, resilient, electrically non-conducting material; and that the edge of the retaining wall plate resting upon said gasket makes a normally liquid-tight closure therewith under the weight of the superstructure; said slab, bottom plate and upturned border being protected against anodic electrolysis by a layer of impervious, electrically non-conducting pressure plastic material extending around and between the lower ends of said anodic electrodes to said gasket and making a sealing bond therewith.

5. In an electrolytic alkali chlorine cell as described in claim 4, the improvement as claimed therein, in which said gasket extends inwardly of said flange and is embedded in said layer.

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