Jan. 12, 1954 C. C. SILSBY, JR 2,666,028

ELECTROLYTIC CELL FOR THE ELECTROLYSIS OF BRINE

Filed July 1, 1950 2 Sheets-Sheet 1

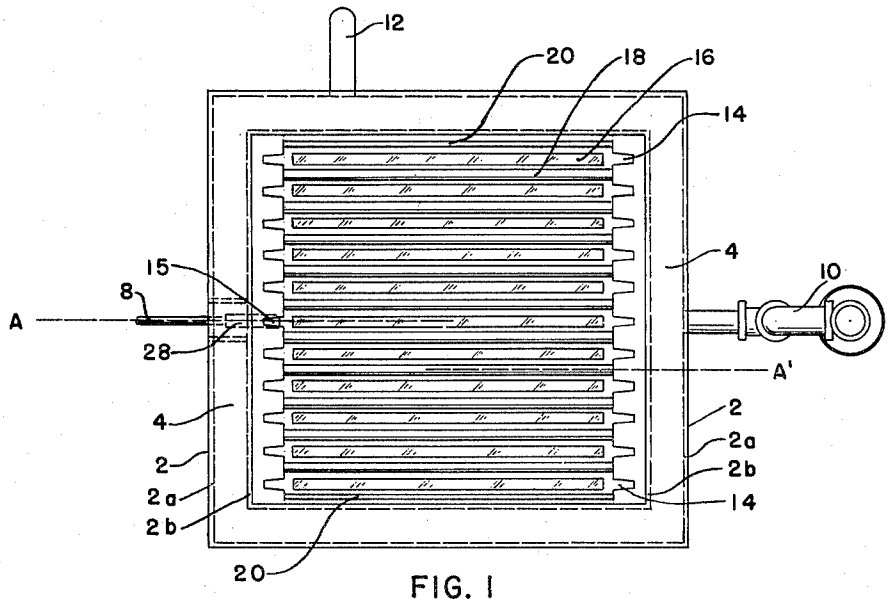


FIG. 1

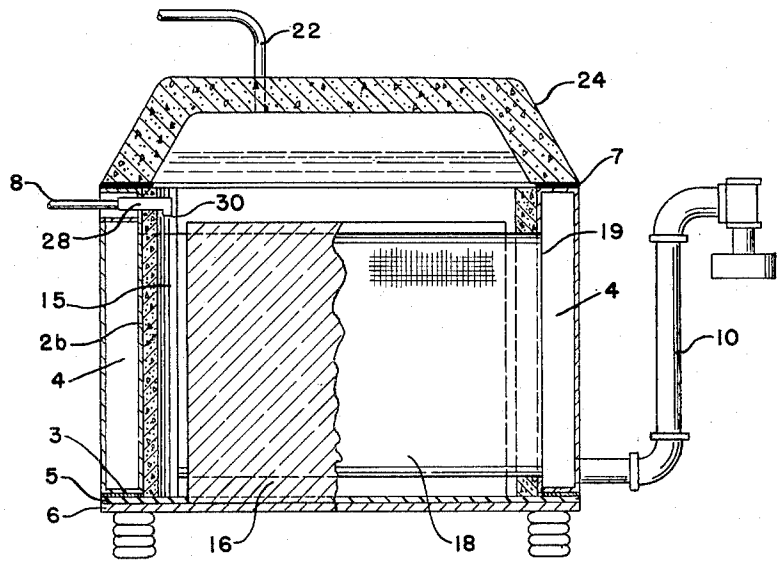


FIG. 2

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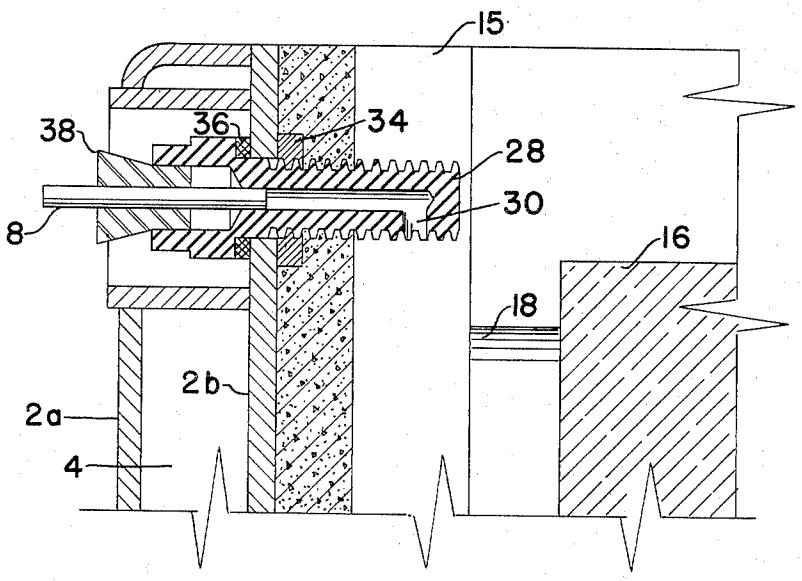


FIG. 3

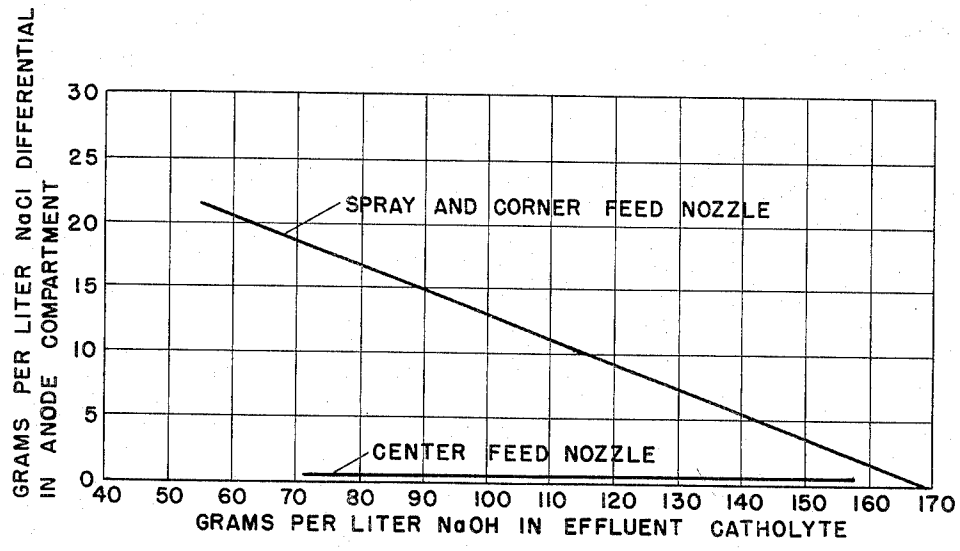


FIG. 4

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ELECTROLYTIC CELL FOR THE ELECTROLYSIS OF BRINE

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3 Claims. (Cl. 204—266)

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This invention relates to electrolytic cells for the electrolysis of sodium chloride brine, and more particularly relates to cells having a combination of elements which increases the efficiency of the electrolytic process. Moreover, the invention is directed to an improvement in the construction and operation of that type of electrolytic cell for the electrolysis of sodium chloride brine characterized by having rows of diaphragm-covered, hollow, foraminous, metallic cathodes and rows of carbon anodes, juxtaposed alternately within a containing vessel.

In such cells the problem of providing adequate circulation of anolyte to maintain uniform chloride ion concentration throughout the anode compartment during the operation of the cell is difficult of solution. In the regions of the anode compartment where the chloride ion concentration is relatively low, electrolysis efficiency is materially reduced and excessive anode erosion results in need for frequent and costly repairs.

In order to maintain uniform chloride ion concentration throughout the anode compartment, it has heretofore been proposed to maintain the brine in the cell in some sort of gross movement, it having been early recognized that where little or no circulation occurs, except that due to the evolution of the anode gas, the portion of the brine closest to an electrolytic element soon becomes impoverished of the ion sought to be recovered in molecular form from the solution whereby, no matter how efficiently it may otherwise be designed, the cell fails to convert any more than a fraction of the ions in the solution to the desired molecular form.

It has also been recognized by prior art investigators that both for efficient electrolysis and economical operation, it is desirable to locate the electrolytic elements of an electrolytic cell, i. e., the anodes and the cathodes, in as close proximity to each other as constructional considerations permit. Thus, the resistance of the anolyte liquor to the passage of electric current therethrough is reduced and the efficiency of the electrolytic process accordingly increased. Further, it is important to place as many anodes and cathodes in a given cell container or can, and at such close proximity as possible, in order to conserve the cost of both the can structure and the floor space occupied by the entire cell. In particular, the saving of floor space is a vital consideration when a battery of several hundred such cells is set up.

However, the design of cells in which a relatively large number of electrolytic elements are

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combined, especially where such elements are of substantially rectangular cross-section, gives rise to problems of impoverishment of electrolyte from the solutions unless some provision is made in the cell for relatively rapid movement of solution past the electrolytic elements, and unless provision is made to distribute the brine feed stream efficiently within the cell in order that relatively concentrated brine be in contact with the elements at all times.

It has been taught to provide a space or aisle dividing the anolyte chamber in half from one end to the other, which space is unoccupied by electrolytic elements and thus provides a non-electrolytically active area for the downward movement of anolyte. However, from the standpoint of efficiency of electrolysis of brine, this circulation space is purely wasted, and it is apparent that such design of a cell is undesirable in that a large area of the cell, which otherwise could be used for active work, is lost. In addition, by locating the so-called circulation area in the center of the cell, the warmest portion of the cell is devoted to downward circulation, which circulation accordingly must take place against normal convection currents.

In the design and operation of cells of the type under discussion, there is also the problem of initially filling the cell can with sodium chloride brine during the critical start-up period; subsequently in the operation of the cells, the brine feed problem remains to a lesser extent. In general, it has heretofore been proposed at the start-up of the cell when the anode compartment is being filled, to introduce the brine feed stream at the base of the anode compartment by means of a suitable conduit entering through the cell top in order that the feed stream, during the period when the cathodes are not surrounded and protected by the body of anolyte, shall not impinge upon the cathode diaphragms, since so directing the feed stream may result in erosion and ultimately in destruction of the diaphragms. After the anode compartment has been filled with brine and the brine level therein brought to a level above the tops of the anodes, some means of continuing feed of brine to such cells have been suggested, such as sprays or the like, but commonly the brine feed stream has been so directed as to oppose the natural circulation in the cell, whereby poor circulation of brine produces regions of low chloride ion concentration and excessive anode erosion necessarily results.

An object of the present invention is to provide means for effecting uniform distribution of

chloride ions throughout the anode compartment of an electrolytic cell for the electrolysis of sodium chloride brine.

Another object of the invention is to provide a brine stream feed distributor by means of which the numerous manipulations encountered during the start-up period of operation of the cell are eliminated.

A further object is the provision of instrumentalities for continued feed of brine to a cell during electrolysis, which feed means enhances optimum distribution in the anode compartment of ions to be electrolyzed.

These and other objects will be apparent to those skilled in the art from the description of an embodiment of the invention hereinbelow.

Referring now to the drawings,

Fig. 1 is a top-plan view of an electrolytic cell for the electrolysis of sodium chloride brine with the cover removed, showing the arrangement of anodes and cathodes therein,

Fig. 2 is a partial vertical section taken on the line A—A' of Fig. 1, parts being shown diagrammatically,

Fig. 3 is a fragmentary detail of the structure of Fig. 2, enlarged for clarity, and

Fig. 4 is a graph of curves obtained by plotting the maximum differential of chloride ion concentration within the anode compartment against the NaOH concentration in the catholyte (which is a measure of the brine feed rate to the cell) when the brine feed distributor is located as shown in Fig. 1, compared with the maximum chloride ion differential for the same brine feed rates when brine is fed to the same cell in the conventional manner at a corner thereof either by a feed device which feeds above the tops of the anodes but below the anolyte level or sprays the brine above the anolyte level from the roof of the anode compartment, to substantially the same position and so directed as not to oppose natural circulation of the anolyte.

In the cell structure, the cell can **2** comprises outer walls **2***a* and inner walls **2***b*; these walls, with can bottom **3**, form chamber **4** for the collection of catholyte solution and cathode gas evolved in cathode tubes **18** and half-cathodes **20**. Channels **14** are formed in walls **2***b* on the anolyte side thereof, opposite the vertical end surfaces of anodes **16**. The walls **2***b*, where exposed to anolyte, are overlaid with a chemically inert layer insuring electrical inertness of these surfaces.

Anodes **16** are mounted in base member **6** by any suitable means insuring electric connection therewith. Thus, they may be secured in suitable slots, not shown, in member **6**. Member **6** is attached to a suitable source of potential and is overlaid with a chemically inert, non-conducting coating **5**, such as bitumen or the like, between the anodes, and between the cell can and the base **6**. Thus, electrolysis at the base of the cell and corrosion of the base by anolyte are prevented. Cathode tubes **18** extend from end wall to end wall of the cell and communicate with chamber **4** through openings **19** as shown in Fig. 2; at the two ends of the cell can are half-cathodes **20** which also communicate with the chamber **4**. Cell cover **24** rests upon the upper enclosing member of chamber **4** and is provided with a coating of suitable inert sealant material **7** to insure isolation of the anolyte compartment from the atmosphere.

In accordance with the present invention, the brine feed is preferably directed downwardly in

a channel **14** which is situated near the center of the bank of anodes and cathodes and most suitably in the center channel **15** equidistant from the ends of the cell. Though the channel **15** acts substantially as a pipe or conduit to lead entering brine substantially entirely to the bottom of the cell before it is distributed to any extent throughout the anode compartment, it has been found generally unnecessary to enclose the channel **15** at its anode end-facing side in order to gain the full advantages of this proposal, though that expedient may be resorted to if desired.

Brine feed nozzle **28** may be brought to the preferred position at the top of the channel **15** located centrally between the end walls by any convenient means. Thus, brine feed line **8** may be directed into a nozzle **28**, as shown in Fig. 3, in which case the brine feed line may be held in place by a flexible member **38**, such as a rubber stopper, inserted in an extension of nozzle **28**; nozzle **28** then penetrates chamber **4** and inner wall **2***b* and is attached thereto by means of nut **34** and gasket **36**.

In the operation of the cell of Figs. 1–3, a sodium chloride brine stream is fed to the cell through line **8**, passing through nozzle **28** and through opening **30** into a channel **15**. During the start-up period of the operation of the cell, the rate of feed of the brine into the anode compartment may be at substantially any desired rate since the danger of directing the stream of brine against the diaphragm covering the cathode tubes is substantially precluded. The brine level is brought to a point somewhat above the upper surface of the anodes, suitably more than 1 inch and preferably about 1 to 4 inches above the anodes, and an electric current passed through the cell by means of electric connections not shown. Chlorine gas forms at the surfaces of the anodes **16**, rises along the anodes and is exhausted from the cell through vent **22**. The rising chlorine, as well as the heat generated by electrolysis, causes upward movement of the anolyte in the electrolytically active region of the cell compartment, accompanied by further circulation of the anolyte downwardly in electrolytically inert channels **14**.

Although the precise manner in which the feed nozzle **28** and channels **14** co-act with other elements in the operation of the cell to give uniform chloride ion concentration throughout the anode compartment is not completely understood, there is evidence that the feed stream entering through nozzle **28** and flowing downwardly through channel **15** into which it is directed, is dispersed laterally to a limited extent upon impact with the base of the cell, is further dispersed in its passage upward between anodes and cathodes in the central portion of the cell, and finally, is rapidly and uniformly distributed laterally throughout the body of anolyte maintained above the anodes and cathodes, in part apparently because of the agitation effected by the evolved anodic gas. In this connection, it has been found that the anolyte level is preferably maintained well above the tops of the electrode elements of the cell to aid in insuring uniform chloride ion distribution in the anolyte compartment, and cooperates with the feature of introducing the feed stream at a locus of the character of that shown in Fig. 1.

Concurrently with the evolution of chlorine from the anodes, anolyte percolates through the porous cathode diaphragm of the metallic cathode members **18** where it forms caustic soda and

hydrogen. The caustic solution and hydrogen escape from cathodes 18 into chamber 4 via openings 19; the catholyte solution ultimately leaves the cell through take-off conduit 10, here shown at the side of the cell opposite the side at which the brine feed stream is introduced into the anode compartment. However, the catholyte take-off conduit may conveniently be located otherwise than as shown without detrimental effect upon the advantages provided by the present invention. Hydrogen may be suitably removed as through hydrogen outlet 12.

The advantages of the present invention over cells of conventional design is shown in Fig. 4 of the drawings, wherein the maximum differential of the chloride ion concentration adjacent the point of entry of feed to the cell and in the anolyte at maximum distance from the point of entry of the feed stream into the anode compartment is plotted as ordinates against NaOH concentration in the catholyte, which is inversely proportional to the rate at which the brine is fed to the cell, as abscissa. One curve is a plot of the chloride ion concentration when the brine feed stream is fed to the anolyte compartment of a cell equipped with channels 14, both by means of feeding slightly below the anolyte level at a corner of the cell and by a spray nozzle depending from the top of the cell and impinging its spray upon the surface of the anolyte; the other curve is a plot of this difference in chloride ion concentration against rate of anolyte feed, where the feed stream is continuous and is directed downwardly in the channel 15, approximately midway between the ends of the anolyte compartment. It can be seen that where the feed procedure of the present invention is employed, a substantially constant and small differential in the chloride ion concentration is maintained over a wide range of feed flow rates between the brine entering the anode compartment and the chloride ion concentration at a maximum distance from this point. In contrast, a cell operating according to prior art procedure has wide differences throughout the anode compartment in brine concentration. In the cell of this invention, anode consumption, chlorate formation, and thus cell efficiency are considerably advantageously affected over prior art practice, especial improvement being noticeable at higher rates of brine feed, but substantial and desirable advantages being obtained at brine feed rates which produce a sodium hydroxide concentration in the catholyte of 130 grams per liter and higher.

While there have been described in detail certain forms of the invention and embodiments of its practice, the invention is not to be understood as being limited to the detailed disclosure as it is realized that changes within the scope of the invention are possible, and it is further intended that each step in the following claims shall refer to all equivalent steps for accomplishing the same result in substantially the same or equivalent manner, it being intended to cover this invention broadly in whatever form its principle may be utilized.

What is claimed is:

1. In an electrolytic cell for the electrolysis of brine, said cell having a base member, a frame mounted on said base, said frame having side walls and vertical hollow end sections, said end sections having inner and outer end walls, said walls forming a liquid-containing vessel with said base, regularly spaced anodes mounted in said base parallel to said side walls and vertically disposed within said vessel, hollow foraminous-diaphragm covered cathodes interposed between said anodes and communicating with said hollow end sections through said inner end walls, the improvement which includes an electrically-insulating liquid-impervious material overlaying the areas of said inner end walls exposed to anolyte in said vessel, a vertical channel in said electrically insulating material situated substantially equidistant from said side walls of said frame and extending substantially from top to bottom of an inner end wall, and a conduit situated near the top of and opening into said channel for introducing brine into said vessel.

2. In an electrolytic cell for the electrolysis of brine, said cell having a base member, a frame mounted on said base, said frame having side walls and vertical hollow end sections, said end sections having inner and outer end walls, said walls forming a liquid-containing vessel with said base, regularly spaced anodes mounted in said base parallel to said side walls and vertically disposed within said vessel, hollow foraminous-diaphragm covered cathodes interposed between said anodes and communicating with said hollow end sections through said inner end walls, the improvement which includes an electrically-insulating liquid-impervious material overlaying the areas of said inner end walls exposed to anolyte in said vessel, a plurality of open vertical channels in said electrically-insulating material substantially coextensive vertically with an inner end wall, one of said channels being substantially equidistant from said side walls, and a conduit situated near the top of and opening downwardly into said channel equidistant from said side walls for introducing brine into said vessel.

3. In an electrolytic cell for the electrolysis of brine, said cell having a base member, a frame mounted on said base, said frame having side walls and vertical hollow end sections, said end sections having inner and outer end walls, said walls forming a liquid-containing vessel with said base, regularly spaced anodes mounted in said base parallel to said side walls and vertically disposed within said vessel, hollow foraminous-diaphragm covered cathodes interposed between said anodes and communicating with said hollow end sections through said inner end walls, the improvement which includes an electrically-insulating liquid-impervious material overlaying the areas of said inner end walls exposed to anolyte in said vessel, a plurality of U-shaped vertical channels open toward said anodes and situated in said electrically-insulating material of each of said inner end walls, said channels being substantially coextensive vertically with an inner end wall, one of said channels being substantially equidistant from said side walls, and a conduit for introducing brine into said vessel, said conduit being situated near the top of and opening downwardly into said channel equidistant from said side walls.

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