

Jan. 4, 1938.

E. SORESENSEN

2,104,678

ELECTROLYTIC CELL

Original Filed Oct. 1, 1935

3 Sheets-Sheet 1

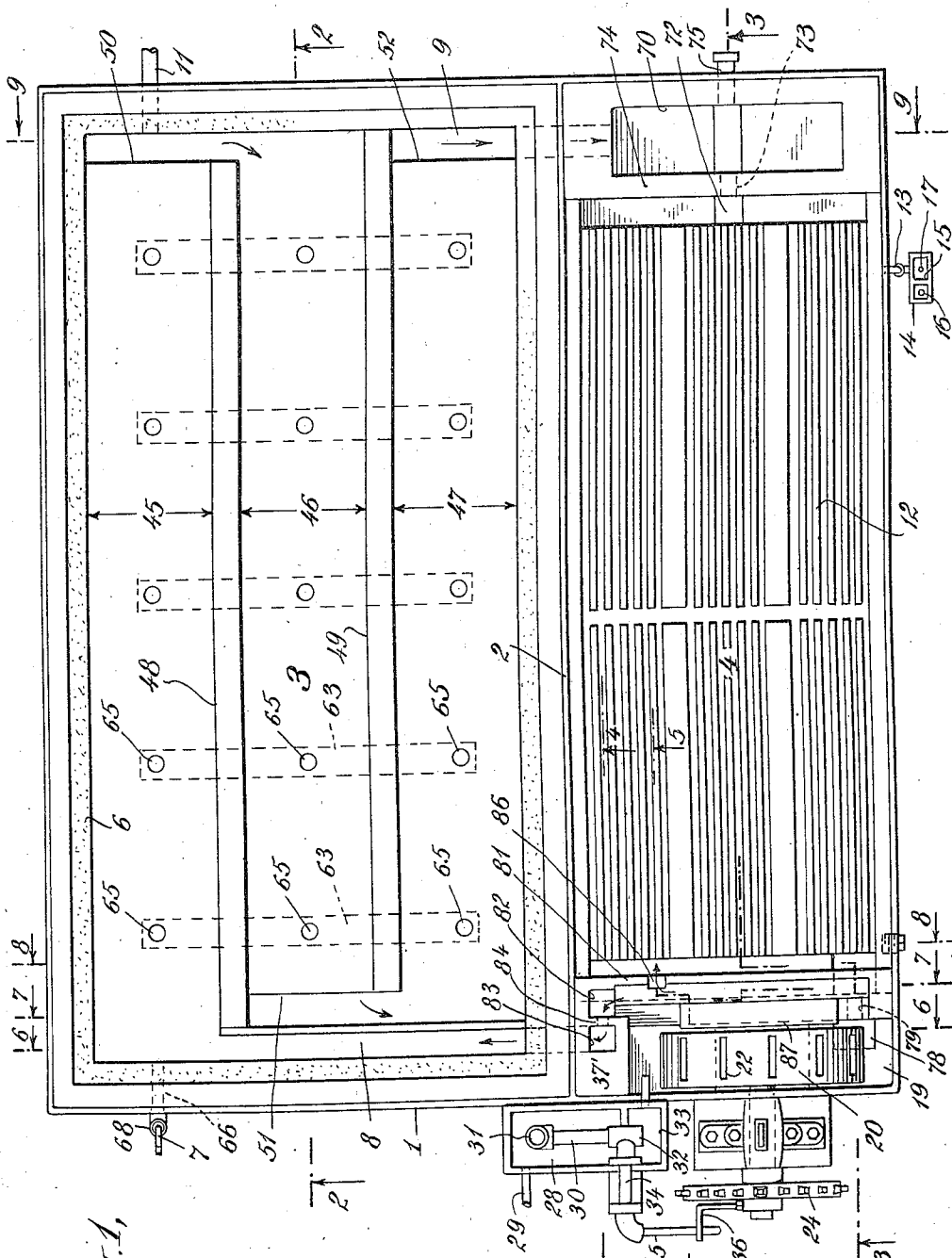


Fig. 1,

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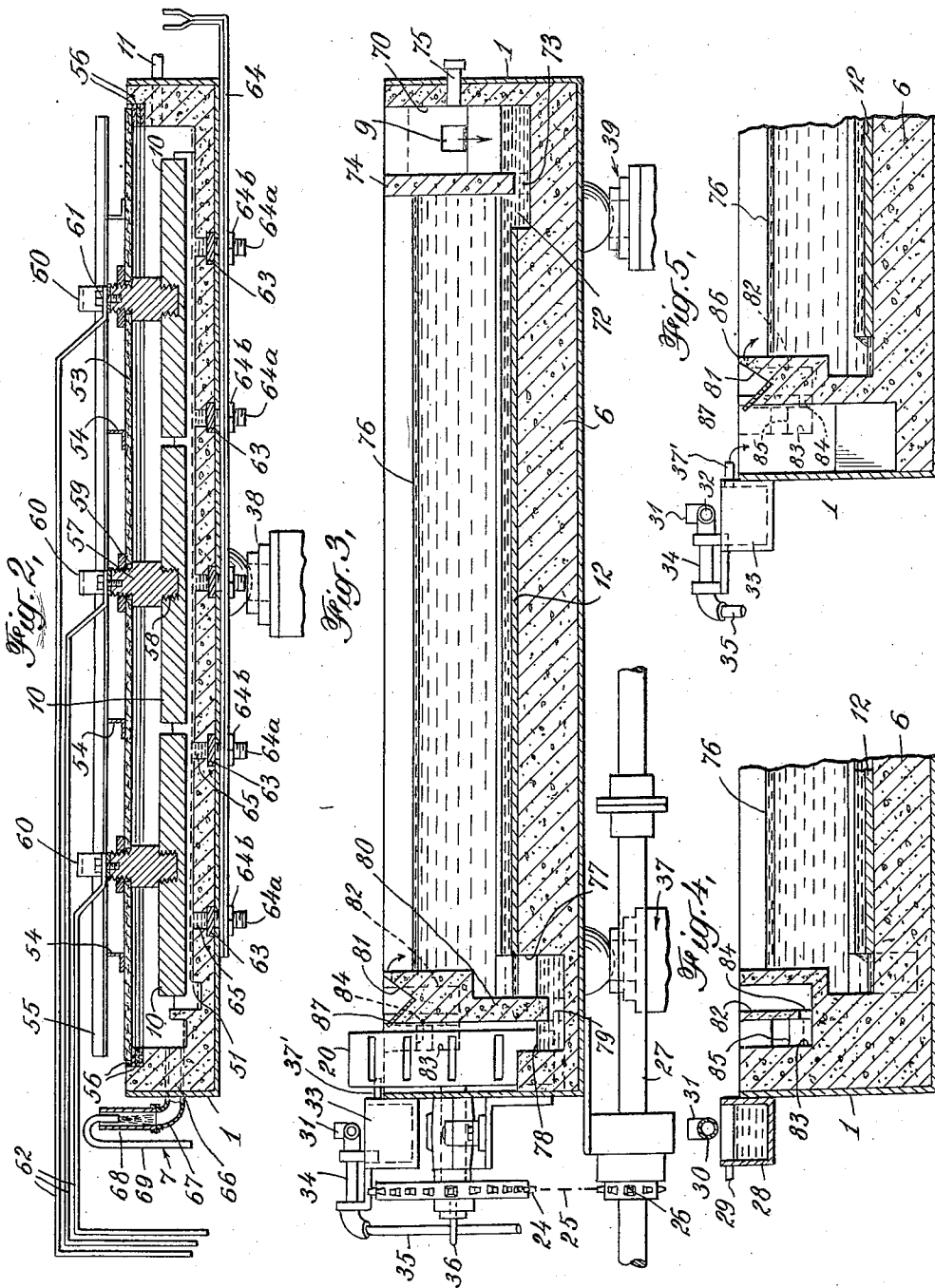
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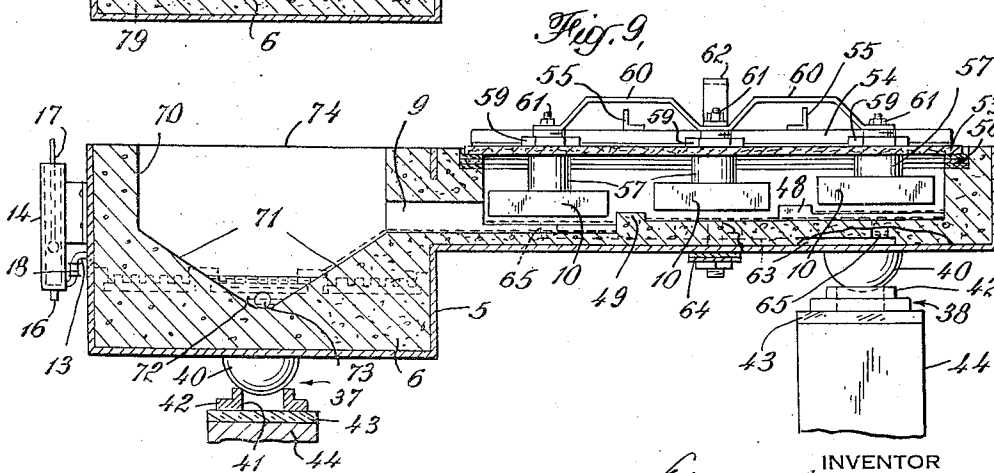
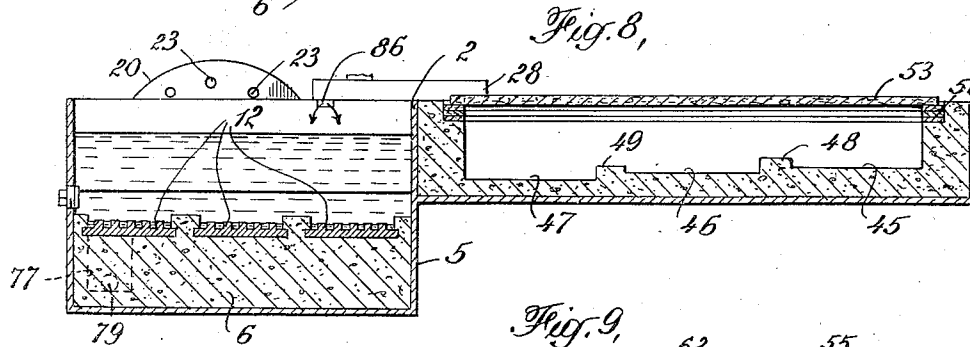
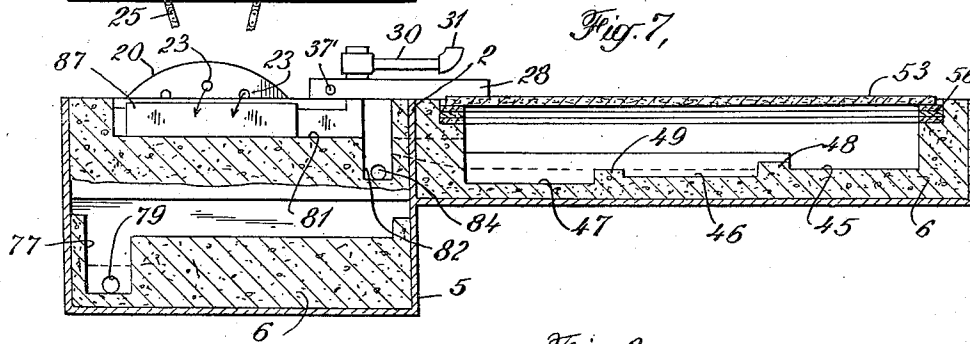
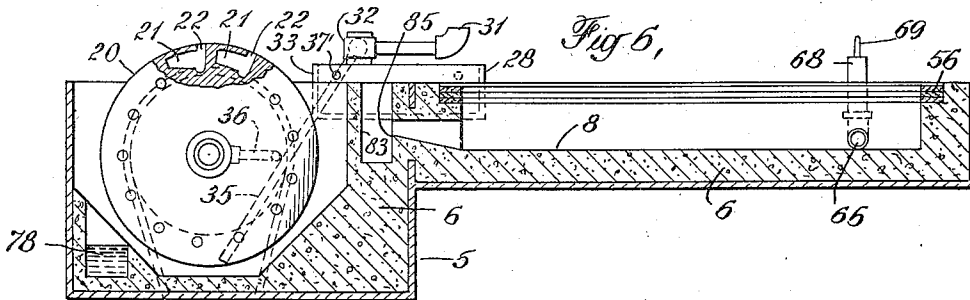
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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

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ELECTROLYTIC CELL

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Original application October 1, 1935, Serial No.
43,027. Divided and this application May 23,
1936, Serial No. 81,344

4 Claims. (Cl. 204—58)

This application is a division of my copending application Serial No. 43,027 filed October 1, 1935.

The invention relates to electrolytic cells for producing chlorine and sodium hydroxide from brine. Such a cell is disclosed in my prior Patent #1,613,966, issued January 11, 1927. The cell of the present application, in general construction and operation, is similar to the cell of my prior patent, but embodies certain improvements hereinafter described and claimed.

The cell disclosed in the above-mentioned patent comprises a casing having a longitudinal partition which divides the cell into a decomposing compartment and an oxidizing compartment. Brine, to be treated, enters the decomposing compartment, the floor of which is covered with a slowly moving layer of mercury which constitutes a cathode. Graphite plates located above the mercury constitute the anode. Electric current passing between the graphite plates and the mercury liberates chlorine from the brine and the mercury forms an amalgam with the sodium of the brine. The amalgam flows out of the decomposing compartment into the oxidizing compartment where it passes over notched graphite plates. Measured quantities of water are fed into the oxidizing compartment. By the action set up in the oxidizing compartment the amalgam is decomposed and the sodium reacts with the water to form sodium hydroxide solution. The mercury thus freed of its sodium then enters a pump chamber in which a rotary pump lifts the mercury and returns it to the decomposing compartment.

This application is directed particularly to the anode and cover assembly of the decomposing compartment, the object being to improve the construction and functioning of that part of the apparatus.

An electrolytic cell embodying the invention is shown in the accompanying drawings, but it is to be understood that the anode and cover assembly comprehended by this invention may be used with cells differing very materially from the one illustrated. The particular cell shown in the drawings is an improvement upon the cell shown in my prior patent above referred to not only with respect to the cover and anode assembly herein claimed, but also as to certain other features disclosed but not claimed herein but claimed in my parent application Serial No. 43,027, above referred to, and in other divisions of the apparent application, Serial No. 86,725, filed June 23, 1936; Serial No. 93,580, filed July 31, 1936 and Serial No. 97,884, filed Aug. 26, 1936.

In the drawings:

Figure 1 is a plan view of the cell with the cover and the anode assembly of the decomposing compartment removed to expose to view the interior construction of this compartment;

Fig. 2 is a longitudinal section through the decomposing compartment taken on the line 2—2 of Fig. 1. In this view the cover and the anode assembly are in place;

Fig. 3 is a longitudinal section through the oxidizing compartment taken on the line 3—3 of Fig. 1;

Fig. 4 is a detailed sectional view of one end of the oxidizing compartment taken on the line 4—4 of Fig. 1;

Fig. 5 is a sectional view similar to Fig. 4 taken on the line 5—5 of Fig. 1;

Fig. 6 is a transverse section taken on the line 6—6 of Fig. 1;

Fig. 7 is a transverse section taken just to the rear of the section of Fig. 6, i. e., on the line 7—7 of Fig. 1;

Fig. 8 is a transverse section taken just to the rear of the section of Fig. 7, i. e., on the line 8—8 of Fig. 1, and

Fig. 9 is a transverse section taken on the line 9—9 of Fig. 1.

The improved cell has an external metal casing 1 which is generally rectangular in shape as shown in Fig. 1. It is divided into two compartments by a longitudinal partition 2. One of these compartments, designated 3, is the decomposing compartment and the other one designated 4 is the oxidizing compartment. As best shown in Figs. 6 to 9, inclusive, that part of the metal casing which houses the oxidizing compartment projects downwardly to a lower level than the part of the casing which houses the decomposing compartment. This is indicated at 5 in Figs. 6 to 9. The metal casing is lined along the inside walls and over the bottom with concrete 6 and is properly molded to form the various passages and seals hereinafter described.

Brine to be treated enters the decomposing compartment through an inlet 7 (Figs. 1 and 2). The mercury enters the decomposing compartment from the oxidizing compartment at 8. The mercury passes in a thin layer over the bottom of the decomposing compartment in the manner to be hereinafter described and is discharged through the passage 9 (Figs. 1 and 9) into the oxidizing compartment. The mercury in the decomposing compartment forms the cathode of an electric circuit, the anode being graphite plates 10 supported with their lower faces just above

the surface of the mercury. As the mercury passes through the decomposing compartment it forms an amalgam with the sodium of the brine, and the spent brine together with the liberated chlorine is discharged through an outlet 11 located at the proper elevation to maintain the desired depth of brine within the decomposing compartment.

In the oxidizing cell the mercury amalgam passes over the notched graphite plates 12. Measured quantities of water are fed into this compartment by means to be hereinafter described to maintain in this compartment a predetermined density and to compensate for the water consumed in the displacement action. The displacement action which takes place in this cell frees the amalgam of its sodium and causes the sodium to unite with the water to form sodium hydroxide solution. The sodium hydroxide solution is withdrawn from the oxidizing compartment through a pipe 13 (Figs. 1 and 9) which discharges into the lower end of receptacle 14. This receptacle has a vertical partition 15 dividing it into two compartments. The sodium hydroxide solution enters the bottom of the right hand compartment (as viewed in Fig. 1) and flows over the upper edge of the partition 15 into the left hand compartment. It is then discharged through an outlet pipe 16 in the bottom of the left hand compartment. In the right hand compartment there may be located a hydrometer 17 (Fig. 9) by which the density of the sodium hydroxide solution may be measured. The level of the sodium hydroxide solution in the oxidizing compartment is determined by the elevation of the upper edge of the partition 15. Therefore, the level of the sodium hydroxide solution in the oxidizing compartment may be varied, if desired, by raising or lowering the receptacle 14 and thereby raising or lowering the elevation of the upper edge of the partition 15. This may be effected by providing the pipe 13 with a removable section 18 which may be replaced by a longer or shorter section.

The mercury freed of its sodium passes into a pump well, 19. A rotary pump 20 lifts the mercury from the well and discharges it at a higher elevation where it flows into the passage 8 of the decomposing compartment thereby completing the cycle. The pump has a series of peripheral pockets 21 (Fig. 6) to which the mercury is admitted through peripheral openings 22. It is discharged from these pockets through openings 23 (Figs. 7 and 8) in the lateral wall of the pump. It is then caught in the manner hereinafter to be described and passed on to the decomposing compartment. The mercury pump is operated by a sprocket wheel 24 connected by means of a chain 25 (Fig. 6) to a sprocket wheel 26 (Fig. 3) on a drive shaft 27 driven in any suitable manner.

The water to be supplied to the oxidizing compartment first enters a receptacle 28 through a pipe 29. A pipe 30 having an elbow 31 at its outer end, which forms a small bucket, is oscillated so that it dips down into the water in the receptacle 28 and then as the pipe rises the water flows through the pipe and is discharged from the inner end 32 of the pipe into another compartment 33 of the receptacle 28. The pipe 30 is mounted on a horizontal shaft 34 to the outer end of which is connected an arm 35. This arm is engaged and deflected by a projection 36 associated with the sprocket wheel 24 so that every time the sprocket wheel makes one revolu-

tion the pipe 30 is lifted to scoop up a small portion of water and dump it in the compartment 33. From the compartment 33 the water passes through a pipe 37 directly into the pump well 19. The pump picks up both the mercury and the water and the manner in which the water and mercury are separated so that the water is delivered to oxidizing compartment and the mercury delivered to the decomposing compartment will be hereinafter described.

As thus far described the electrolytic cell is substantially the same in construction and operation as the cell disclosed in my prior patent above referred to with the exception that in the cell of the prior patent the water, after being scooped up by the oscillating pipe, is delivered directly into the oxidizing compartment, whereas in the improved cell of this application the water is delivered into the well of the mercury pump. The differences in construction and operation which characterize the improved cell will now be described.

The container or casing 1 may be made of any suitable metal but it is preferably made of steel. The use of steel instead of cast iron greatly reduces its cost. Convenient and inexpensive manufacture is made possible by maintaining straight lines throughout its construction. The casing is shaped to conform with the mercury flow arrangement.

A three point support is used for the cell in order to maintain even bearing and to facilitate leveling of the cell should this become necessary. The three supports are shown at 37, 38 and 39 in Figs. 2, 3 and 9. As best shown in Fig. 9 each support comprise a hemisphere 40, preferably made of metal, the flat side of which is secured to the bottom of the casing 1 and the curved surface of which rests in the opening 41 of a metallic member 42 which might conveniently be a pipe flange. The member 42 rests on a glass insulating plate 43 which in turn is supported on top of the cell leg 44. The three point support insures that the cell will be firm and steady notwithstanding any irregularities in the floor. If it is desired to level the cell this may be done by replacing the pipe flange 42 or the glass plate 43 with a thinner or thicker one at any of the three supports where it is desired to make the adjustment.

The decomposing compartment 3 is constructed in such a manner as to provide and maintain a continuous, undivided flow of a uniformly thin layer of mercury through the compartment at a suitable distance from the anodes and in conformity with their area. The floor of the decomposing compartment is divided into three adjacent channels 45, 46 and 47 (Fig. 1) by a pair of longitudinally extending ribs 48 and 49. These ribs may be molded from the concrete which lines the casing of the decomposing compartment, as best shown in Figs. 7, 8 and 9. The outermost channel 45 communicates with the transverse passage 8 through which the mercury enters the decomposing compartment. The channels 45 and 46 communicate with each other at the right hand end of the cell, as viewed in Fig. 1, and the channels 46 and 47 communicate with each other at the left hand of the cell, as viewed in this figure. The right hand end of the channel 47 communicates with the passage 9 through which the mercury leaves the decomposing compartment. The mercury, therefore, follows a tortuous passage as follows: From the entrance passage 8 it passes to the right (as

viewed in Fig. 1) through the channel 45, then to the left through channel 46, and then to the right through channel 47 and is then conducted by the passage 9 into the oxidizing compartment. The floors of the channels 45, 46 and 47 are level in both directions which necessitates a slight head of mercury at the inlet of the first channel in order to obtain a flow of mercury through the compartment. By using level instead of pitched floors the amount of mercury which it is necessary to use may be greatly decreased and still maintain flow of a continuous undivided and uniformly thin layer of mercury through the combined lengths of the channels.

By reference to Figs. 7, 8 and 9 it will be seen that the channel 46 is at a lower level than the channel 45, and the channel 47 is at a lower level than the channel 46. At the right hand end of the channel 45 (as viewed in Fig. 1) there is a step or drop 50 where the mercury and amalgam cascades to the level of the middle channel 46. There is a similar drop 51 at the left hand end of channel 46 where the mercury and amalgam cascades to the level of channel 47. A third drop 52 is located at the right hand end of channel 47 where the mercury and amalgam cascades to the level of the passage 9. These steps, or drops, facilitate the flow of the mercury and decrease the total amount of mercury necessary for operation of the cell. They also cause an efficient mixing of the amalgam with the free mercury. This mixing of the amalgam and the free mercury is further promoted by the change in direction of flow as the mercury and amalgam pass from one channel to the next.

It will be noted that the mercury is not subdivided at the entrance end of the decomposing compartment into several parallel streams which flow in the same direction through the decomposing compartment as in the cell disclosed in my prior patent, but there is one undivided stream which follows a tortuous path through the decomposing compartment. This makes it possible to eliminate the dams which have sometimes been found necessary at the outlets of the channels when the mercury is subdivided and flows through the channels in the same direction. When the mercury is thus divided between a plurality of channels the mercury has insufficient flow through any one of the channels to maintain a uniform and continuous layer of mercury over the channel floors unless dams are used. Moreover, the flow of the mercury in that type of cell is not positive in action because deposition of graphite and other impurities cause scum formation at the inlet to the channels thus causing uneven distribution of the mercury between the channels and thus results in too much mercury flow through certain channels while too little flows through others. Positive and uniform flow of the mercury is obtained by the channels communicating in series rather than in parallel. In the improved cell herein disclosed the rate of flow of the mercury through the decomposing compartment is controlled by the amount in excess of that necessary to cover the floor of the channels of the decomposing compartment and the slotted graphite plates of the oxidizing compartment.

The anodes do not rest upon projections on the floor of the decomposing compartment as in the cell of my prior patent, but are rigidly fastened to, and suspended from, the cover of the decomposing compartment and form a unit therewith. The cover of the decomposing compartment is

shown at 53 (Fig. 2). It may be made of light material, such as impregnated fibre. Inasmuch as the cover is called upon to support the anodes, it is preferably reinforced by transversely extending angle irons 54 and longitudinally extending angle irons 55. The cover 53 is supported at its edges on the concrete walls of the cell by means of fibre strips 56. As the anodes wear down, the fibre strips 56 may be removed one at a time, thus lowering the anodes and restoring the proper spacing between them and the mercury cathode. Each graphite anode 10 is rigidly secured to the cover 53 by a graphite lead 57 threaded at both ends. The lower end of the lead 57 is screwed into the anode 10, as shown at 58 and the upper end of the lead passes through an opening in the cover 53 and is clamped to the cover by a fibre nut 59. In the particular cell shown in the drawings there are three anode plates in each channel thus making nine all together. The three anode plates of each transverse row are electrically connected by means of a metallic conducting strip 60 (Figs. 2 and 9) which is secured to the graphite leads 57 by means of stud bolts 61. Three bus bars 62 conduct current to the three transverse rows of anodes.

The cover and anode assembly may be easily removed as a unit when it is desired to clean the cell. The cover is much lighter than the concrete covers heretofore used thus facilitating its removal. Due to the fact that all joints in the cover assembly prevent substantial infiltration of air it is possible to produce higher concentration chlorine gas.

Current is supplied to the mercury cathode in the decomposing compartment as follows: Embedded in the concrete floor of the decomposing compartment are a series of transversely extending metal bars or strips 63 (Figs. 1 and 2). These are supplied with current by a bus bar 64. Bolt terminals 64a are screwed and welded to the transverse bars 63 and extend through the metal container and are secured to the bus bar 64 by means of nuts 64b. Over each metal bar 63 the concrete floor is provided with a series of holes 65 by means of which the mercury makes contact with the bar. The path of the current is therefore from the bus bar 64 to the bolts 64a, to the transverse bars 63, then to the mercury cathode, through the brine to the graphite anodes 10, then through the leads 57 and connecting strips 60 to the bus bars 62.

The improved brine inlet comprises a hard rubber pipe 66 (Fig. 2) having an elbow 67 which supports a piece of glass tubing 68 in a vertical position. The glass tube extends upwardly to a point above the level of the brine in the decomposing compartment. Brine is fed continuously into the glass tube 68 by a small glass pipe 69 communicating with the brine supply pipe. This arrangement serves the purpose of sealing the brine inlet thus preventing air from entering the cell. It also minimizes electric current leakage as the brine is caused to fall through the air for a short distance in a somewhat dispersed column as it leaves the discharge end of the small glass pipe 69.

After the mercury leaves the decomposing compartment and before it enters the oxidizing compartment it forms a seal and thereby prevents brine from passing from the decomposing compartment to the oxidizing compartment. This seal is therefore called the "brine seal" and is constructed as follows: At the right hand end of the oxidizing compartment 4 (as viewed in Fig. 1)

there is a pit or well 70 molded in the concrete lining. In plan view this well is relatively narrow longitudinally of the cell and is relatively long transversely of the cell. The bottom of the well is tapered to form a V as shown at 71 in Fig. 9, the taper being in such a direction that the mercury passing from the decomposing compartment through the passage 9 will flow down one of the arms of the V.

The well 70 forms one of the chambers of the brine seal, the other chamber, shown at 72 (Figs. 1 and 3) being a pit located in the floor of the oxidizing compartment. The bottom of the well 70 communicates with the pit 72 through an opening 73 extending through the wall 74 that separates the well 70 from the oxidizing compartment. It is obvious from this arrangement that a body of mercury will be maintained in the chambers 70 and 72 of the seal at a constant level. As the mercury is continuously fed into the well 70 it is continuously discharged from the pit 72 into the oxidizing compartment. The body of mercury maintained in this manner by the seal chambers 70 and 72 prevents any brine from entering the oxidizing compartment.

It will be noted that the mercury enters the well 70 in the lengthwise direction of the well but in a direction transverse to the axis of the opening 73. The mercury thus passing into the well 70, down one side of the V-shaped bottom and partly up its other side has its velocity spent. This prevents brine from being entrained with the mercury as it passes into the oxidizing compartment thus maintaining purity of the sodium hydroxide solution produced in the oxidizing compartment. The well 70 also serves as a concentration point for any broken up or dispersed mercury as well as any precipitated graphite from the anodes. This concentrated material can be easily removed during operation of the cell which greatly lengthens the time of operation possible between wash-ups. It is important to concentrate and remove the dispersed or broken up mercury for otherwise it will pass into the oxidizing compartment through the seal and may entrain some of the brine. Furthermore, any dispersed mercury which finds its way into the oxidizing compartment will remain in suspension in the sodium hydroxide solution and pass off with it thereby causing a continuous loss of mercury. The outer wall of the well 70 has a normally closed pipe 75 extending through it which communicates with the interior of the well and affords a convenient outlet for the wash water during wash-ups. Moreover, by discharging the wash water through the pipe 75 it is prevented from entering the oxidizing compartment.

In the oxidizing compartment hydrogen gas is liberated when the sodium is freed from the amalgam and unites with water to form sodium hydroxide solution. In order to prevent entrainment of caustic by the hydrogen gas thus liberated, an oil layer 76 (Fig. 3) is formed by floating on the surface of the caustic liquor an oil which is completely inert toward the caustic. Prevention of entrainment of caustic by the hydrogen gas which is liberated to the cell room atmosphere is an important consideration from a health standpoint. It also decreases the loss of caustic.

In passing from the oxidizing compartment into the pump well, the mercury forms a second seal called the "caustic seal" because it prevents caustic from passing along with the mercury to the pump well. This seal comprises a pit 77 molded

in the concrete floor of the oxidizing compartment and a pit 78 molded in the concrete floor of the pump well (Figs. 3 and 5). Communication between these two pits is established by a passage 79 in the wall 80 which separates the oxidizing compartment from the pump well. The body of mercury maintained in the chambers 77 and 78 at a constant level constitutes a seal similar to the one previously described. As the mercury is continuously fed into the compartment 77 it is continuously discharged from the compartment 78 into the well of the mercury pump but no caustic can pass into the pump well.

As previously stated the rotary mercury pump 20 picks up the mercury in the pump well and also the water which has been fed to the pump well by the water bucket 31 already described. The mercury and water, discharged through the lateral openings 23 in the side wall of the pump, falls into a transverse trough 81 (Figs. 1, 3, 5 and 7) which conducts them to a third mercury seal called the "water seal" because it prevents the water from passing along with the mercury into the decomposing compartment. This seal is formed by pits 82 and 83 molded in the concrete and a connecting passage 84 which places the bottom of these pits in communication (Figs. 1, 3, 4, 5, 6 and 7). As the mercury is continuously fed into the pit 82 it is continuously discharged over the edge 85 of the pit 83 (Fig. 6) and then passes into the transverse passage 8 which conducts the mercury to the first channel 45 of the decomposing compartment. The water held back by the seal 82-83-84 and which floats on top of the mercury as it passes through the trough 81 is conducted through a short passage 86 and discharged directly into the oxidizing compartment (Figs. 1 and 8).

The trough 81 is so arranged as to minimize splash of the mercury as it is discharged from the pump 20. Splashing of the mercury at this point would be harmful as it would cause breaking up or dispersing of the mercury or would also augment vaporization. Prevention of vaporization of the mercury is very important from a health standpoint. A spill plate 87 (Figs. 1 and 3) extends from the bottom of the trough 81 to a point closely adjacent the discharge outlets 23 of the pump to prevent spill of the mercury back into the pump well. The water in the trough 81 (supplied by the oscillating bucket 31 to the pump well and delivered by the pump to the trough 81) acts as a cushion for the falling mercury. It also acts as a wash and a submerging cover for the mercury during its travel to the water seal 82-83-84.

As previously described the oscillating water bucket 31 supplies a uniform and measured quantity of water to the oxidizing compartment. As the water is first delivered to the pump well it keeps the mercury in the pump well and in the pockets of the pump covered with water and thereby prevents vaporization of the mercury and the consequent contamination of the room atmosphere.

I claim:

1. An electrolytic cell having a decomposing compartment and an oxidizing compartment through which mercury may be circulated, a removable cover for the decomposing compartment made of light fibrous material, a plurality of metallic reinforcing bars strengthening said cover, and a plurality of anodes rigidly secured to the cover and supported solely thereby and removable with the cover as a unit.

2. An electrolytic cell having a decomposing compartment and an oxidizing compartment through which mercury may be circulated, a removable cover for the decomposing compartment made of light fibrous material, reinforcing means associated with the cover adapted to resist bending thereof, and a plurality of anodes rigidly secured to the cover and supported solely thereby and removable with the reinforced cover as a unit.
3. An electrolytic cell having a decomposing compartment and an oxidizing compartment through which mercury may be circulated, a removable cover for the decomposing compartment made of light fibrous material, metallic reinforcing bars strengthening said cover some of which extend longitudinally of the cover and others transversely thereof, and a plurality of anodes

rigidly secured to the cover and supported solely thereby and removable with the reinforced cover as a unit.

4. An electrolytic cell having a decomposing compartment and an oxidizing compartment through which mercury may be circulated, a removable cover for the decomposing compartment made of light fibrous material, a reinforcement strengthening the cover comprising one set of angle irons extending across the top of the cover and a second set of angle irons superposed on the first set and extending at right angles thereto, and a plurality of anodes rigidly secured to the cover and supported solely thereby and removable with the reinforced cover as a unit.

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