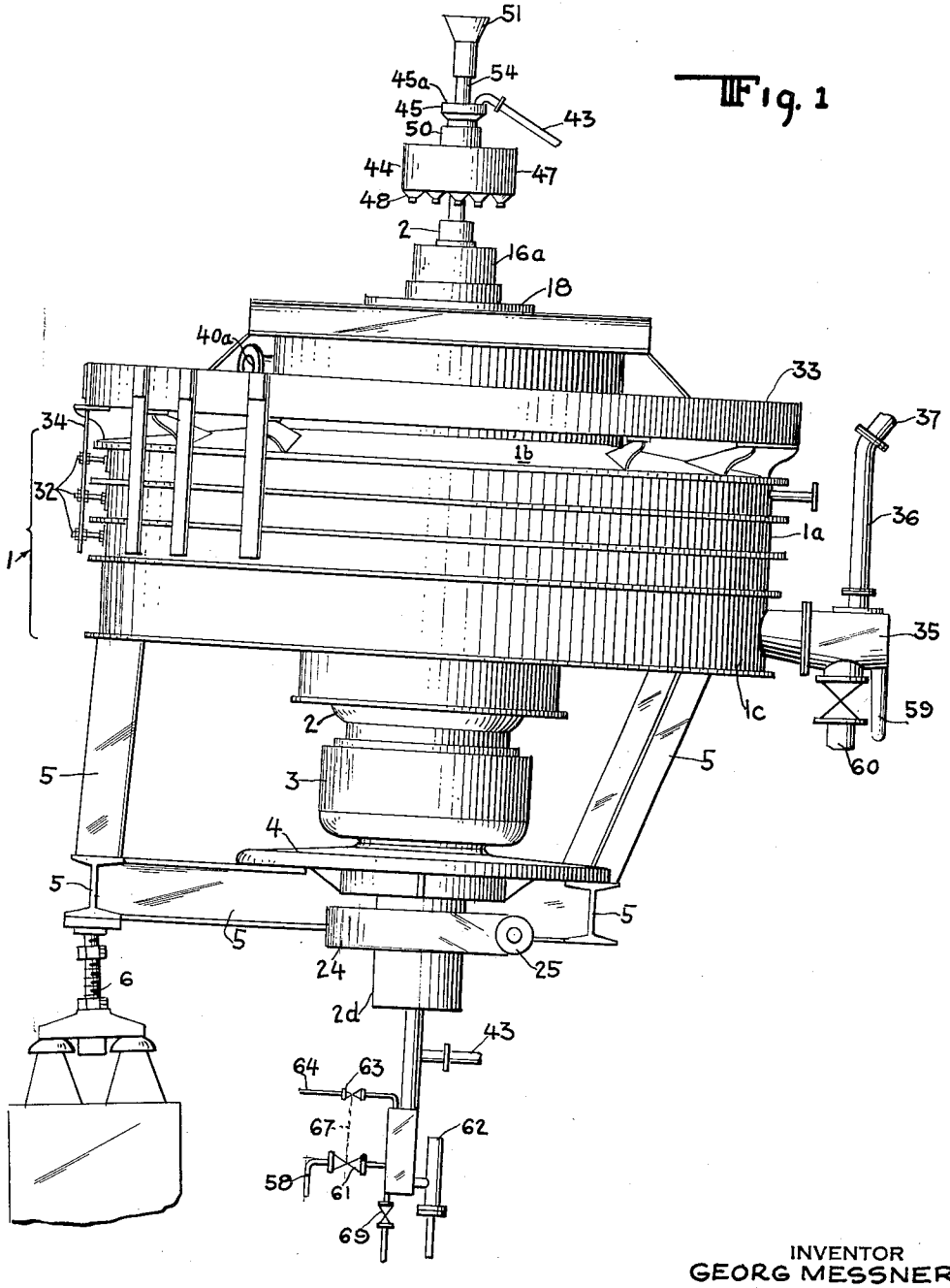
Dec. 11, 1962 G. MESSNER 3,068,165

MERCURY CATHODE ELECTROLYTIC CELL

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Fig. 1



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MERCURY CATHODE ELECTROLYTIC CELL

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Fig. 2

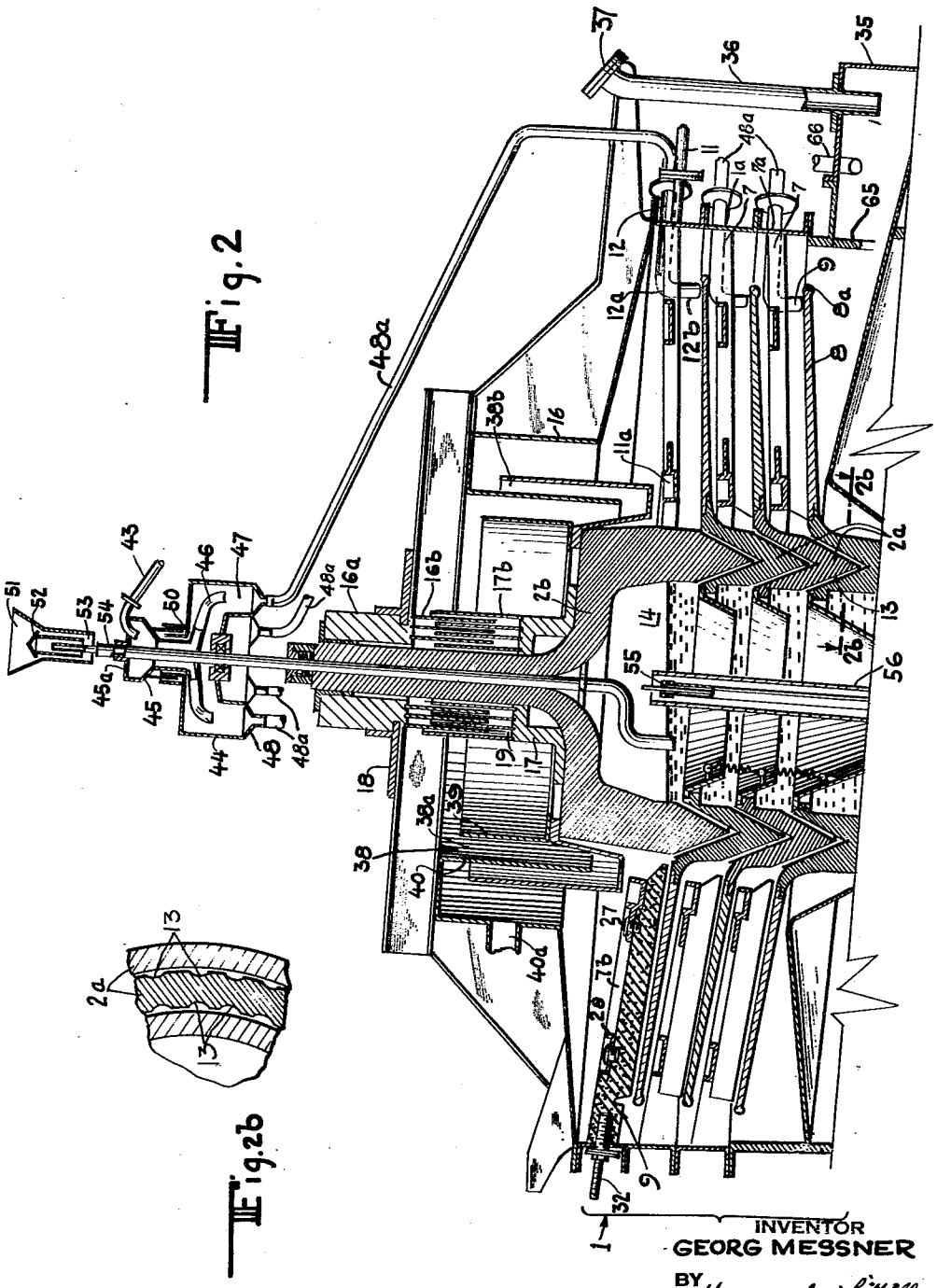


Fig. 2b

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MERCURY CATHODE ELECTROLYTIC CELL

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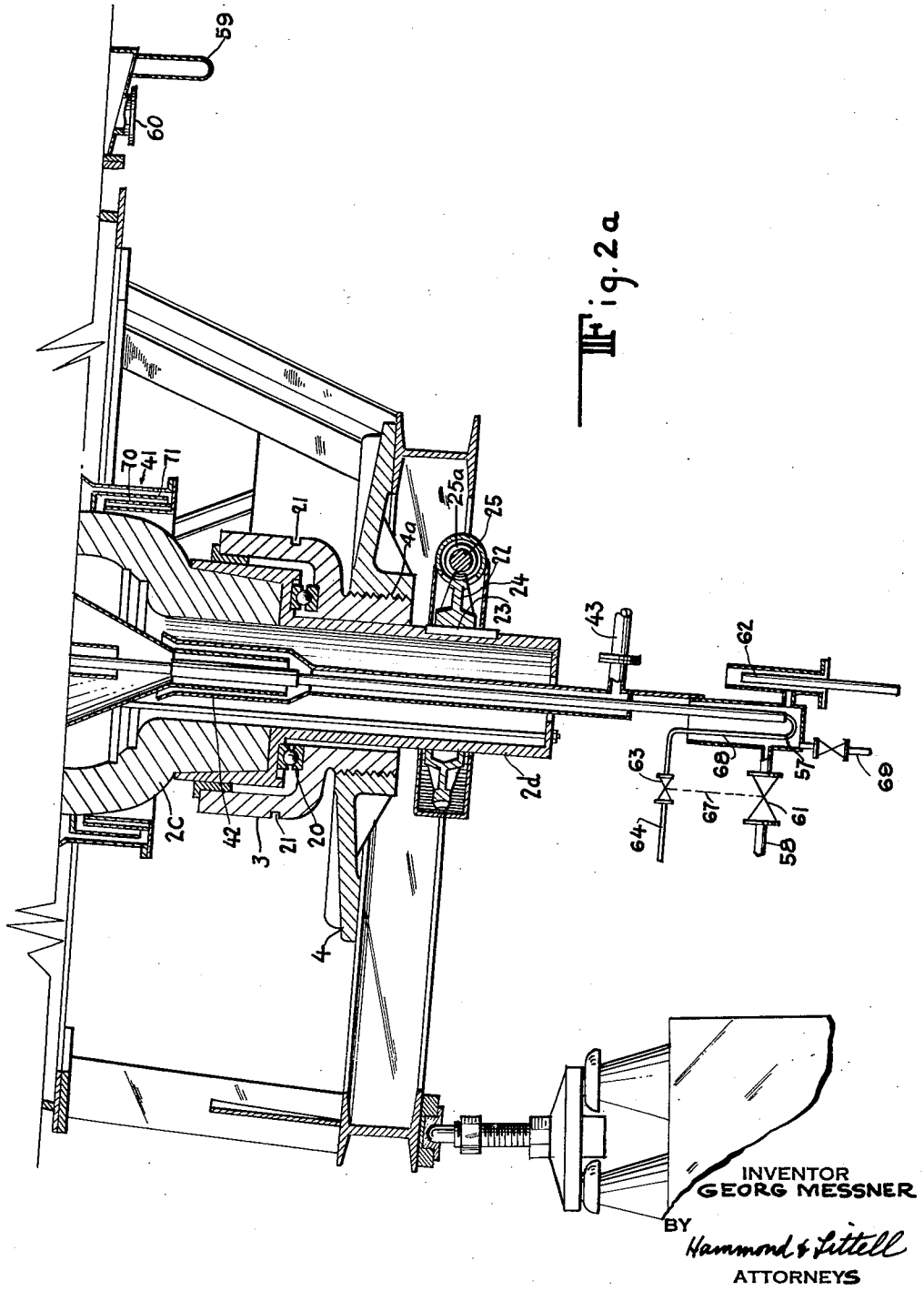


Fig. 2a

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MERCURY CATHODE ELECTROLYTIC CELL

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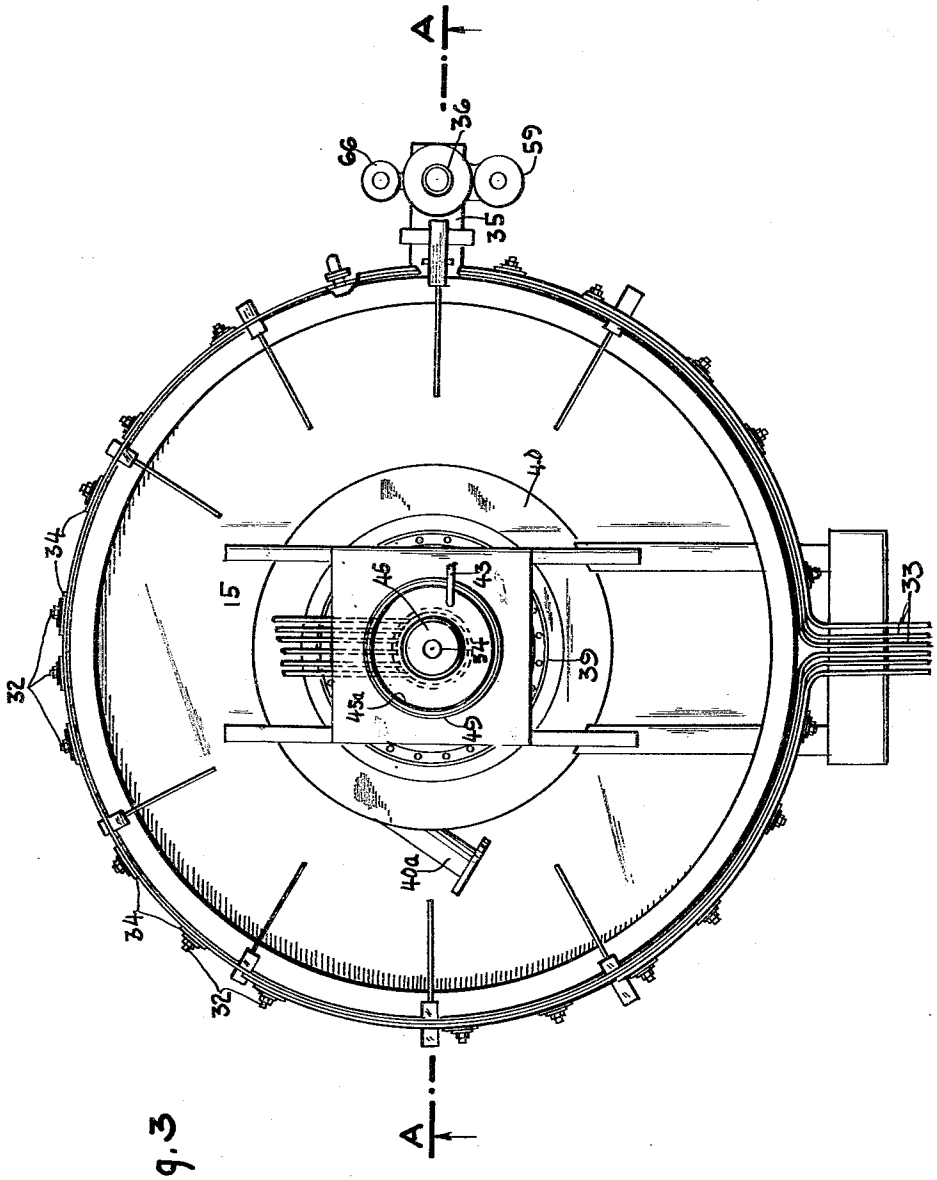


Fig. 3

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MERCURY CATHODE ELECTROLYTIC CELL

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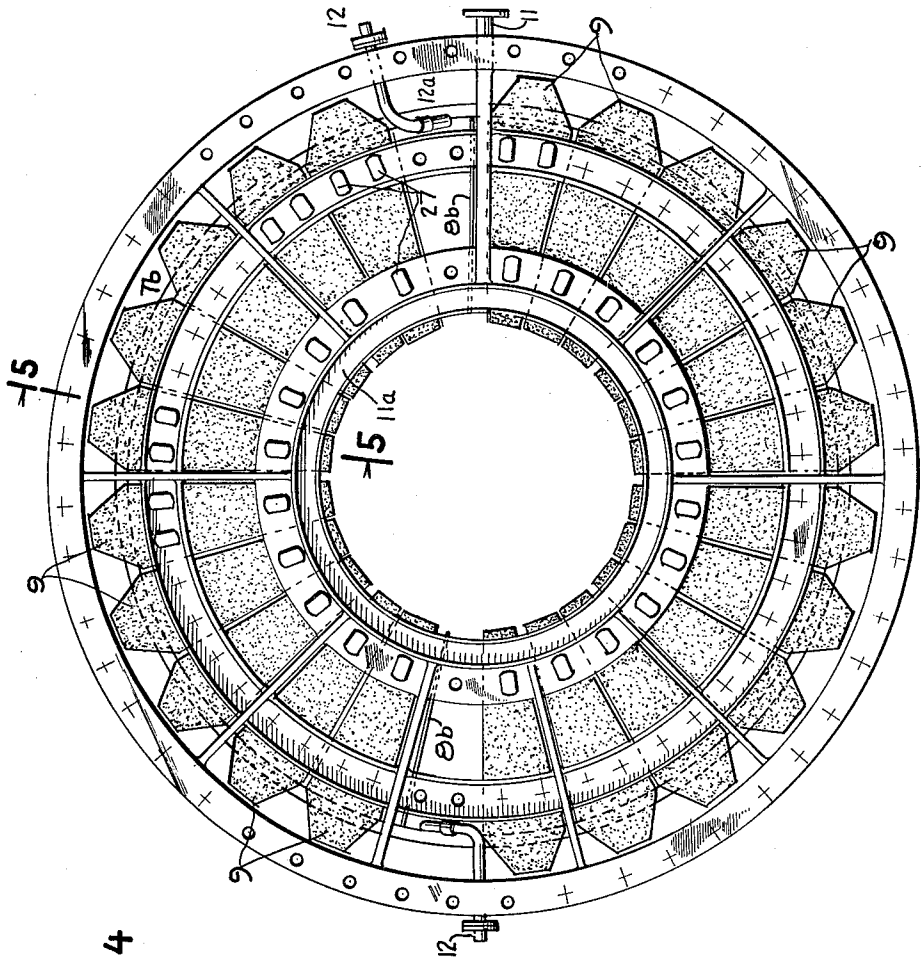


Fig. 4

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MERCURY CATHODE ELECTROLYTIC CELL

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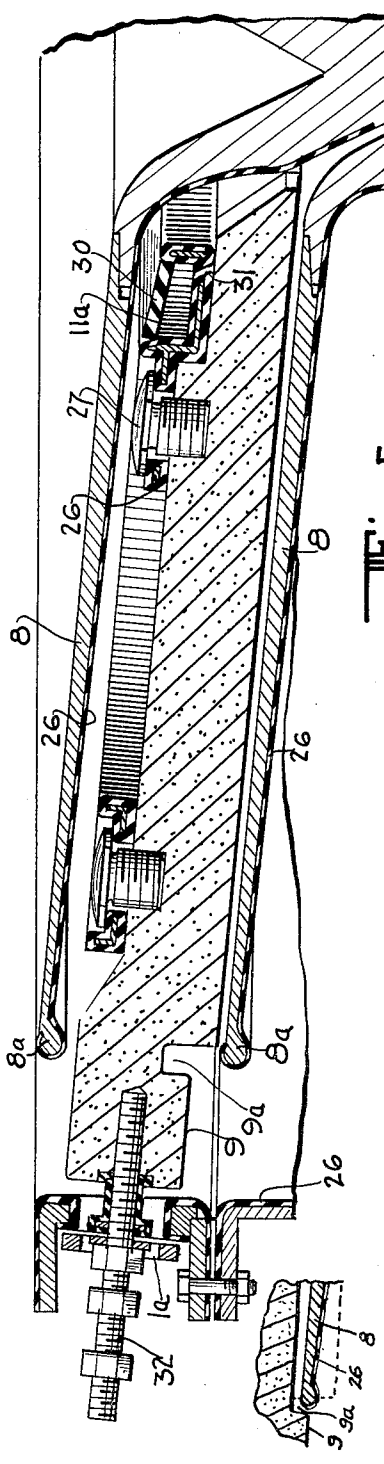


Fig. 5

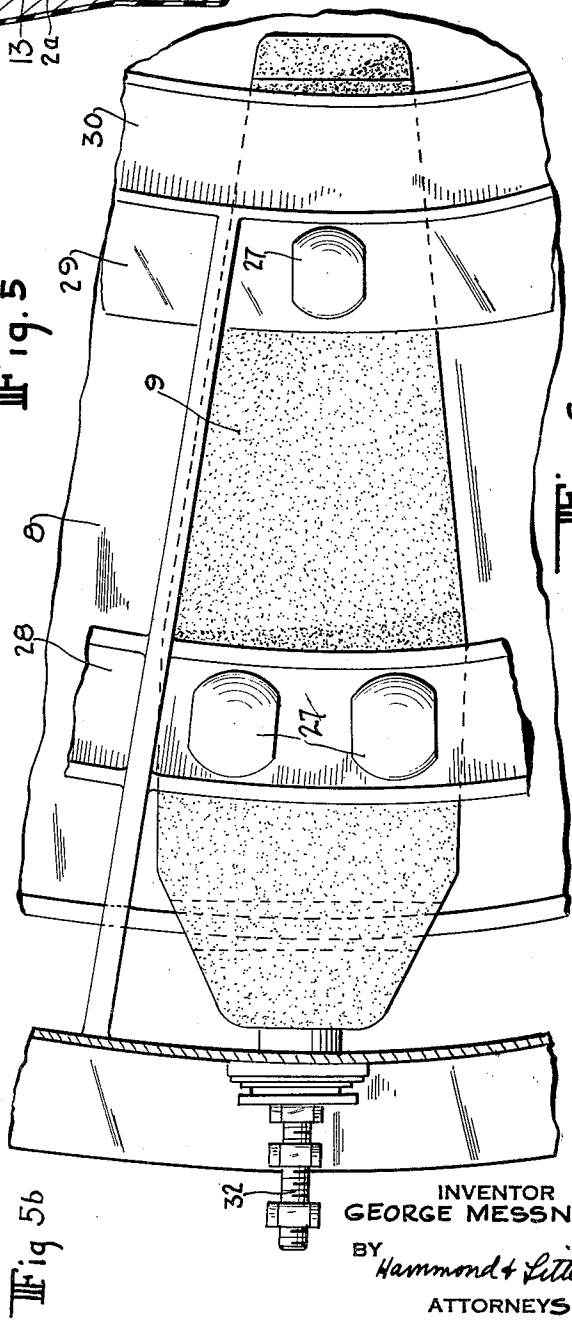


Fig. 6

Fig 5b

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MERCURY CATHODE ELECTROLYTIC CELL

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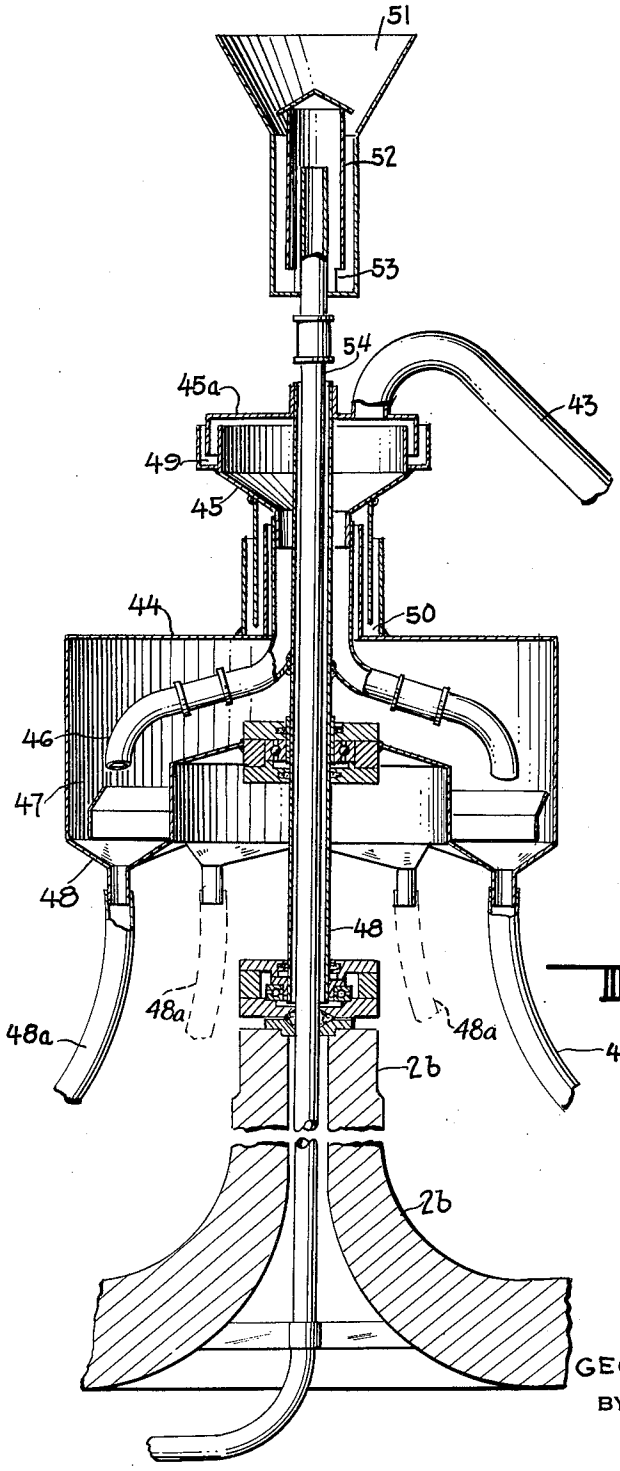


Fig. 7

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MERCURY CATHODE ELECTROLYTIC CELL

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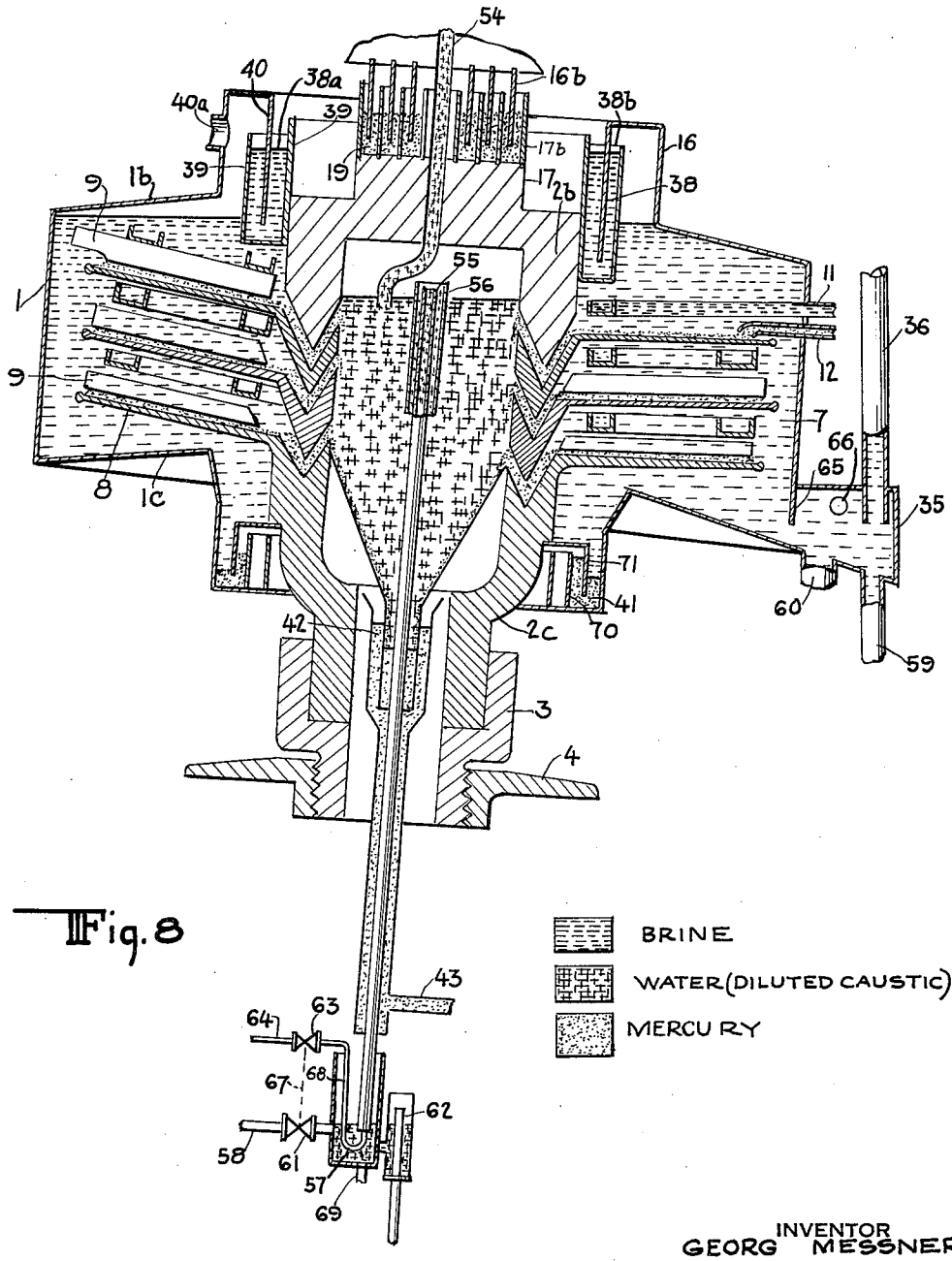


Fig. 8

BRINE

WATER (DILUTED CAUSTIC)

MERCURY

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United States Patent Office

3,068,165

Patented Dec. 11, 1962

3,068,165

MERCURY CATHODE ELECTROLYTIC CELL

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Filed Dec. 1, 1959, Ser. No. 856,500
6 Claims. (Cl. 204—219)

This invention relates to a method and apparatus for the electrolysis of electrolytic solutions making use of a mercury cathode. It more particularly relates to such an electrolytic cell having horizontal mercury cathodes and occupying a relatively small floor space.

The possibility of carrying out electrolysis with a mercury cathode in an electrolytic apparatus requiring as little floor space as possible has been the object of much effort for a long time, especially in the chlorine-alkali industry.

In order to attain the above result, two methods have been proposed so far, one of which consists of increasing the electrode current density, while the other is based upon devices allowing the mercury cathode surface to be kept vertical rather than horizontal. In the former method, a limit seems to have been reached in the maximum utilization of the cathode surface area, since any further increase in current density would cause the cell voltage to reach too high a value.

On the other hand, in the latter method the use of a vertical mercury cathode has also not been found quite satisfactory. This method involves other difficult problems such as, for instance, the provision for a proper adjustment of the graphite anodes. In addition, many cell types, of vertical construction, suffer from the disadvantage of permitting some recombination of alkali with chlorine, so that the cathode must be protected from chlorine attack by a diaphragm, which entails other constructional difficulties as well as an undesired increase in voltage drop.

It is an object of this invention to provide an electrolysis apparatus having a horizontal mercury cathode and occupying a relatively small floor space per cathode area.

A further object is to provide an electrolysis apparatus having a number of superimposed rotating horizontal mercury cathodes.

Another object is to provide a rotating horizontal mercury cathode electrolysis cell having a number of super-imposed electrolysis compartments.

Still another object is to provide a horizontal mercury cathode electrolysis cell having a relatively large vertical dimension and a relatively small cross-sectional area.

A further object is to provide a method for electrolyzing electrolytic solutions with a rotating mercury cathode, whereby recombination of electrolytic products is prevented and proper adjustment of the distance between electrodes is possible.

It is a further object to provide an electrolysis apparatus having a number of parallel electrolysis compartments in which the distance between the anodes and cathodes may be readily adjusted during the operation of the cell.

Another object of my invention is to provide an electrical contact between bus bar elements one of which is stationary and the other rotating.

Another object is to provide a method for cleaning the mercury cathode surfaces of an electrolytic cell.

These and other objects of my invention will become apparent as the description thereof proceeds.

The above advantages may be attained and the disadvantages of prior constructions overcome by the use of an electrolysis apparatus of the mercury cathode type such as described herein which allows a substantial saving in floor space even though keeping the mercury cathode surfaces horizontal or nearly so. This is made

possible by the novel feature of using a plurality of superimposed rotating circular plates to support the mercury. The circular plates may be perfectly flat and horizontal on their upper surface or can be given a slight slope preferably toward the center, so as to assume a hollow conical shape.

FIG. 1 illustrates a side view of the complete cell with some elements removed to facilitate understanding.

FIGS. 2 and 2*a* illustrate a cross sectional view in elevation of the upper and lower portions of a complete cell taken along the line A—A of FIGURE 3.

FIG. 2*b* illustrates a part of the V-shaped connections between the different cathode plate elements in a plan view cross-section taken along the lines 2*b* in FIG. 6.

FIGURE 3 illustrates a plan view of the cell as seen from the top.

FIGURE 4 illustrates a top view of one electrolysis compartment showing the brine and mercury distribution means and the graphite anodes in place.

FIGURE 5 illustrates a cross-sectional side view taken along the line 5—5 of FIGURE 4 of one electrolysis compartment extending from the outer shell to the central shaft.

FIGURE 5*b* represents a partial cross section of FIGURE 5 to illustrate the relative position of anodes and cathodes during the use of the cell.

FIGURE 6 illustrates a more detailed top view of one of the graphite anodes with support means and electrical connections.

FIGURE 7 illustrates a more detailed view in cross-section of the mercury feed and distribution means and the wash water feed means as shown in FIG. 2.

FIGURE 8 illustrates a cross-sectional view of the cell in elevation taken along the lines A—A of FIG. 3, with shading to illustrate the flow of the different fluids through the cell during operation.

The following description is a specific embodiment of my invention given for the purpose of illustration. However, there is no intention of limiting the invention to this particular embodiment.

In FIG. 1, the cell is composed of a cylindrical shell 1 with its axis disposed vertically or it may be slightly inclined from the vertical. Along the axis of shell 1 there is a hollow shaft 2 which protrudes at the top and bottom of the shell. Shaft 2 is supported by bearing support 3, base plate 4 and frame elements 5. The entire frame is supported by adjustable posts 6, preferably three in number so that the cell base may be readily leveled or given the desired inclination. Shaft 2 rotates while shell 1 remains stationary during operation.

Cylindrical shell 1 consists of any desired number of cylindrical chambers 1*a* secured together, one on top of the other, with a top section 1*b* and a bottom section 1*c*. In FIGS. 1 and 2, three chambers 1*a* are illustrated for the purposes of simplicity, but in the operating cells 10 or more chambers 1*a*, one above the other, are used.

Each chamber 1*a* encloses a separate electrolysis compartment 7 (see FIGS. 2 and 2*a*), having a stationary outer wall 7*a*, a stationary frame 7*b* supported therefrom, and a cylindrical metallic plate 8 attached to shaft 2 and rotating therewith, and having a rim 8*a* at its periphery, which plates 8 act as supports for a flowing mercury cathode surface. A plurality of graphite anodes 9 are supported from the stationary anode frame 7*b* above the rotating plate 8 and grouped radially around shaft 2. A brine feed pipe 11 extends through the wall 7*a* of each compartment 7 to a ring distributor 11*a* adjacent to the center of the cell, to feed brine into each compartment of the cell. Mercury feed pipes 12 spaced 180° apart feed mercury to the top of each of the rotating plates 8.

Shaft 2 consists of a number of hollow cylindrical segments 2*a* which are indented on the top and wedge shaped

on the bottom so that any number may be fitted together to form an elongated hollow shaft. There are grooves in the upper side of segments 2*a* (see FIG. 2*b*) so that when two segments 2*a* are fitted together, passages 13 are formed between the electrolysis chamber 7 and the central area 14 of hollow shaft 2. A tapering top shaft section 2*b*, and a tapering bottom shaft section 2*c* are provided for shaft 2.

The cathode current for plates 8 is provided through shaft 2. The electrical current is provided for the shaft through bus bars 15 (see FIG. 3) which are connected to upper cathode connector 16*a* which is stationary and consists of a solid metallic cylinder 16*a* surrounding shaft 2*b*, from which are suspended a number of concentric cylinders 16*b*. The lower cathode connector 17 consists of a solid metallic member 17*a* fixed to shaft 2*a* and having a number of concentric cylinders 17*b* attached to the top and projecting upward to fit within cylinders 16*b*, in a telescoping manner, the outermost cylinder being a 17*b* cylinder. Cathode connector 16*a* is supported by framework 18 attached to shell 1*b*. Cathode connector 17 rotates with shaft 2 while connector 16*a* remains stationary. Cylindrical elements 16*b* and 17*b* are spaced apart and electrical contact is made between the rotating cylinders 17*b* and stationary cylinders 16*b* by mercury introduced between the cylinders in the areas 19 formed by the lower cylinders 17*b*. Thus a fluid, frictionless electrical contact is provided between the moving and stationary cathode connectors.

Shaft base 2*c* fits into shaft drive member 2*d* which rests upon bearing 20 within bearing support 3. Bearing support 3 is held in base plate 4 by a threaded connection 4*a*. Slots 21 in bearing support 3 permit turning of support 3 in the threaded connection to raise or lower the bearing support relative to the base plate 4. Thus entire shaft 2 may be moved upward to adjust the distance between cathode plates 8 and anodes 9 in each electrolysis compartment simultaneously to compensate for erosion of the graphite anodes. Shaft driving member 2*d* is fitted with a gear 22 by keys 23 extending into slots 23*a* and rotates in box 24. Worm gear shaft 25 carries worm 25*a* and is connected to a suitable source of power to turn gear 22 thereby rotating shaft 2.

The cathode plates 8 are attached to shaft section 2*a* and rotate therewith so that an integral unit is formed. These units may be superimposed in any desired number to obtain a plurality of electrolysis compartments. The lower surfaces of plates 8 and the inside of shell 1 are covered with a nonconductive material 26 such as rubber, resistant to the brine solution to be electrolyzed (see FIG. 5) and have a raised rim 8*a* also rubber covered.

Stationary anodes 9 are grouped radially around shaft 2 and are attached by threaded nonconductive bolts 27 to concentric metallic support rings 28 and 29. These support rings are also covered by a non-conductive material. Brine feed pipe 11 feeds brine from each compartment wall 7*a* to a distributor ring 11*a* in each compartment. Ring 11*a* is a trough shaped ring and attached to support ring 29 (see FIG. 5). Brine distributor ring 11*a* is insulated, and closed at the top by a piece of rigid non-conductive material 30. A plurality of feed openings 31 are spaced around the bottom of ring 11*a* to conduct brine into the electrolysis compartments below. It is preferable to have one brine feed opening 31 between each two adjacent anodes 10.

Anodes 9 are provided with electrical contacts 32 at their outer ends. The contacts 32 project through the stationary walls 7*a* of each compartment. The anode current is provided by bus bars 33 which encircle shell 1 at the upper end and by vertical bus bars 34 connected to contacts 32.

As illustrated in FIG. 4, space has been left between the anodes on opposite sides of each compartment to make room for mercury feed pipes 12.

In the operation of the cell, brine is fed to each compartment 7 in shell 1 through brine feed pipes 11.

For every compartment inlet pipe 11 leads to a distribution ring 11*a* provided near the inner circumference of cathode plate 8. This ring has a plurality of openings 31 in its lower side, on the points close to the spaces between the graphite anodes so that brine is distributed along the inner circumference of cathode plates 8 and flows outwardly over the outer edges of rotating plates 8 to the spent brine outlet.

Shaft 2 is rotated at about 10 revolutions per minute.

The new brine is mixed with the partially depleted old brine by rotation of the cathode plates and agitation by the chlorine bubbles.

The brine moves toward the periphery of the rotating plates 8, then flows down the space between the inner wall of shell 1 and the outer edge of plates 8 to outlet box 35 with outlet pipe 36 and leaves by overflow 37 (see FIG. 1). This enables the brine to entrain also the solid particles such as graphite powder, hydroxides (Fe_2O_3), etc. The reason for taking out the depleted brine near the bottom (instead on the brine level) is the possibility of taking off with the outlet brine a big part of the solid impurities of the brine-like graphite powder, iron hydroxide etc., which otherwise would accumulate and deposit on the bottom, especially on top of the mercury seal 41.

A small part of the fresh brine is preferably constantly fed from the brine feed system to hydraulic seal 38 between the rotating part of the cell cover 39 around the rotating cell axle 2 and the stationary part of the cell cover 40. This portion of the brine enters the hydraulic seal at the point 38*a*, passes around the hydraulic seal and leaves on the lowest point 38*b* of the seal inside the cell cover 1*b* and mixes with the brine of the cell. This brine thus flows counter to any possible chlorine diffusion through the seal. In this way it is possible to avoid any escape of free chlorine into the liquid of the external part of this hydraulic seal which could give trouble by corrosion and by its smell. The brine volume in the cell is limited by the cylindrical cell case, the conical cell bottom, the mercury hydraulic seals 41 of the components of the rotating axle and the natural surface of the brine by the accumulated chlorine (partially by the cell cover).

When the electrolysis process gives rise to some gaseous product at the anode, such as chlorine in the electrolysis of sodium chloride brine, these gases pass through the electrolyte until reaching the lower side of the next upper cathode plate 8, along which they flow radially toward the annular space between the electrodes and the shell 1. Then the gaseous products bubble upward through the electrolyte, until reaching the gas dome under shell section 2*b* at the top wherefrom they are conveyed out of the cell through an outlet pipe 40*a*. Seal joint 38 is provided at the points where gas dome section 2*b* and base section 2*c* make contact with the rotating shaft 2.

The main inlet of the mercury to each cathode disk 8 is pipe 12. In the case of large cathode disks a second similar inlet is provided on the opposite side of the disks.

In the operation of the cell, mercury coming from an amalgam decomposer and a mercury pump, not shown, enters the cell (separately for each compartment) through the curved tubes 12 located approximately 180° apart in each compartment and spreads over each cathode disk 8. At the place of entry of every mercury inlet tube 12, the space for one graphite anode is left free for the entry of tube 12 in order to avoid electrical short circuit between cathode and anode by the mercury. Every mercury tube 12 is composed of two parts. The rubber lined iron tube 12*a*, fixed to the outer wall of the cell compartment, consisting of a straight part and a curved part made from one piece of iron tube. The curved part ends at a distance of at least 50 mm. over the upper sur-

face of the cathodic disk, when the anodes are in starting position and an extension piece 12*b* made of a special stiff type of rubber (without metallic reinforcement), is fitted over the curved end of the tube 12*a*.

This rubber tube extension 12*b* is made of a mixture poor in rubber and rich in non-soluble inorganic components such as $BaSO_4$, for example, so that it is easily abraded as long as it has enough contact with the rough upper surface of the continuously rotating cathodic disk 8. By this means, if the cathodic disk is lifted up 1 or 2 mm. in order to compensate for the consumption of the graphite anodes and to maintain the best electrode spacing, the rubber tube extension 12*b* rapidly undergoes abrasion to the extent that it just loses its immediate contact with the rotating cathode disk 8. By the use of this feature smooth and immediate discharge of the entering mercury on the disk surface 8 is assured without danger of dividing it into mercury drops which could be spread in the vicinity of the anodes or could overflow over the brim of the disk. The mercury discharged on the cathode disk 8 then follows the slight inclination of the disk in the direction to its center. In order to avoid formation of a layer of mercury on the disk, which is too thick, a weir 8*b* may be placed along a radius of the disks, made of the same material as the rubber tube 12*b* which discharges the mercury on the disk. This rubber weir will act as a wiper to smooth out the mercury layer and it also undergoes abrasion when the cathode disks are raised for adjustment of the electrode spacing. When new graphite anodes are put into the cell after a period of operation, it is also necessary to replace the rubber tubes 12*b* and rubber weirs for the mercury with new ones. These weirs are not always necessary where conical cathode plates are used and the rotating shaft is slanted, as is more fully described below. Opposite to the mercury inlet the mercury pool has an outlet to the hollow shaft 2. The interior of the hollow shaft can be used for washing the amalgam and, if desired, also for decomposing it by water in the presence of graphite.

In an embodiment of the cell having cathode supports 8 conical, sloping down inwardly toward the center, and shaft 2 inclined from the vertical, a radius of cathode 9 during rotation will pass through a low point where it is substantially horizontal. The mercury is introduced by pipe 12 over this horizontal area and passes across this zone of the cathode disk toward the moving axle. A mercury pool forms on the horizontal area of trays 8 since the mercury feed pipes 12*a* are located over the horizontal portion of these plates and the plates 8 are surrounded by a brim 8*a* of an electrically non-conductive material. The whole plate surface 8 passes under the rows of fixed anodes during a complete revolution so that the amalgam layer, which adheres to the metal plate surface 8 and is enriched with sodium, discharged in the cathodic process, and the sodium enriched amalgam enters the hydraulic seal 13 of each disk and flows into the center of column 2 and through the washing water inside the axle, passes through the mercury seal 42 and leaves the cell by pipe 43 under a static pressure corresponding to the inside level of the mercury in seal 42. The amalgam then flows to an amalgam decomposer, not shown, at a level only a little lower than the inside level of the Hg seal 42. A mercury pump, not shown, pumps the mercury after leaving the decomposer back to the inlet 43 of the mercury distributor 44, from where it flows by gravity through line 48*a* again to the inlets 12 of each cathode disk. The plate surface 8 also passes under the mercury pool during rotation so that the sodium enriched layer of amalgam is diluted and the cathodic process again takes place during the remainder of the rotation of the plate.

The mercury inlet 43 which provides the continuous supply of mercury, feeds into a mercury proportioning device 44 (see FIG. 7). The proportioning device consists of a funnel 45 leading to dual spigots 46. A cover 45*a* is provided. Spigots 46 discharge into reservoir 47 which is circular and has a number of funnel shaped compartments 48 leading from its lower side. Each compartment 48 is connected to an inlet tube 12 to feed mercury to the disk 8 in each electrolysis compartment 7 through conduits 48*a*, connected to inlets 12. For the sake of clarity, only one such conduit is shown in FIG. 2. Reservoir 47 remains stationary during operation of the cell. However, funnel 45 together with spigots 46 are rotated by shaft 48, attached to shaft 2, as shaft 2 rotates. Thus, spigots 46 pass over compartments 48 at equal time intervals, insuring distribution of an equal amount of mercury to each electrolysis compartment 7. Since cover 45*a* and reservoir 47 remain stationary, and part 45 rotates, fluid seals are provided between the moving and stationary parts at 49 and 50.

Washing water passes continuously through the interior of hollow shaft 2. This washing water is in fact not pure water, but a diluted solution of caustic soda (NaOH) in water. Its function is to wash the amalgam, free of NaCl (brine), which should not enter the decomposer and to equilibrate the mercury-hydraulic seals between the cell room interior, containing brine, and the interior of the hollow axle containing the wash water. For this reason the wash "water" is kept at such a NaOH concentration that its density is about the same as the density of the brine in the cell (1.16 corresponding to about 12% NaOH in the wash water). During the operation of the cell a small amount of NaOH is continuously produced in the wash water by decomposition of a small part of the Na-amalgam so that it is not necessary to add NaOH to the wash water. The surplus of NaOH is withdrawn and used for the adjustment of the pH of the brine during its purification. If necessary, the density of the washing solution may be adjusted by adding water.

The wash liquid (wash "water") enters the cell at inlet 51 at the top of the cell and passes through the pipe 54. In order to maintain a constant level of the wash liquid inside the hollow axle, an overflow 55 is provided in the central pipe 56 in the axle 2. The wash liquid flows down from the bottom of pipe 54 to the bottom of the hollow interior of axle 2 and rises through the bottom of pipe 56, between the two pipes 55 and 56 and leaves at the overflow at the top of pipe 55. It then flows through the pipe 55, passes another hydraulic seal 57 (see bottom FIG. 2*a*) and leaves the cell (during the normal operation of the cell) at 58.

The cleaning of graphite powder and other sludge from the cathodic disks 8 is performed by washing the top of the disks with mercury, so that the mercury overflows the outer brims 8*a* of the disks and carries with it the sludge. The wash mercury flows down the cell case, and enters the outlet box 35. Here the mercury is separated from the sludge; the mercury leaves by the hydraulic seal 59 continuously, the sludge is taken away from time to time by the valve 60.

In order to perform this cleaning operation for the mercury-covered cathode disks, valve 61 is closed so that the wash liquid does not leave by 58 but by the higher overflow of the outlet 62. When valve 61 is turned to a closed position, valve 63 is also turned to an open position so that nitrogen under low pressure enters the interior of shaft 2 cell at 64 and pipe 55. The wash liquid in the hollow cell axle is now under an increased pressure of nitrogen gas which is just high enough so that equilibrium between the amalgam coming from the cathodic disks and the wash water is offset and the amalgam can no longer pass mercury seal 13 of each disk 8. At the same time all mercury for each disk is introduced at inlet 12 opposite the brine inlet side. This gives a washing action of the disk zone around the axle, where the dirt to be removed is mainly accumulated. Because there is no passage of Hg through hydraulic seals 13, the mercury overflows the rims of the disks close to the inlets at the brine inlet side, falling

down to the cell bottom and to drain box 35, where it leaves immediately through the mercury seal 59.

This washing mercury contains a certain amount of sodium amalgam because washing is done during cell operation. Because during the described purification of the cathode disks the mercury (amalgam) leaves the cathode disks the mercury (amalgam) leaves the cell by the mercury drain 65, a considerable development of hydrogen gas in the drain box is unavoidable. A gas-shield 65 is provided in order to prevent this hydrogen from entering the main cell room and contaminating the chlorine gas. The gas-shield 65 forces the hydrogen to leave the drain box by the gas outlet 66.

After separation of the dirt the mercury returns by gravity to the Hg-pump and into the cell cycle.

The washing operation takes only a very short time (about 5 to 10 seconds). After this washing operation the valves 61 and 63 are turned by their common axle 67 into the original position, the outlet of the washing liquid is again through 58 (instead of the higher overflow of 62) and the pressurizing nitrogen leaves on the lower end of the thin central pipe 68 so that the conditions of the normal electrolysis operation are restored. The dirt accumulated in the drain box is removed by an opening drain valve 60 briefly.

The outlet 69 on the bottom of the cell serves as drain for mercury, which can accumulate during a long period of operation.

The graphite anodes 9 are suspended on the rubber-lined steel supports (rings) 28 and 29 by screwed glass or porcelain bolts in a fixed manner and cannot be adjusted. The adjustment can be readily accomplished, even during the operation of the cell, by moving the whole cathodic system, i.e. the cathodic disks 8 with their common axle 2, by turning the screwed support 3 so that the thread lifts up the rotating axle 2*d*. Slots 9*a* are provided in anodes 9 (see FIG. 5) in order to permit greater lift during adjustment to compensate for erosion of the anodes. Thus, cathode disk 8 may be lifted as anode 9 erodes up to the top of slot 9*a* until the disk is actually within the end portion of the anode, i.e., the lower surface of disk 8 is substantially even with the remaining lower surface 9*b* of anode 9 (see FIG. 5*b*). During this adjustment a voltmeter is switched on the cell in order to check the decreasing cell tension during the lifting of the cathodes, and to avoid lifting the axle too far which could result in a short circuit between anodes and cathodes.

The cathodic connection 16*a* for the current permits an axial moving of cathodes through a sufficient distance necessary to compensate for the maximum consumption of the graphite anodes.

In the hydraulic seal 38 for the cell top, the cylindrical weir 39 is filled with brine to form the hydraulic seal. The cylindrical pool in weir 39 rotates with shaft 2. Cylindrical separating wall 40 is connected with the non-rotating cover 16 of the cell case. The latter has sufficient clearance in the liquid pool, that it is possible to lift up the cathodic shaft-disk system by about 50 mm. in order to maintain a nearly constant electrode distance between graphite and mercury.

In seal 41, the bottom of the non-rotating cell case 2*c* forms a cylindrical weir 70. The cylindrical separation wall 71 connected with the rotating cathodic shaft 2 is dipped in weir 70. Liquid mercury is used to form the seal. The rotation velocity of the cathodic system is so low (10 per minute) that there is no appreciable centrifugal effect on the sealing brine in seal 38 or on the sealing mercury in seal 41 which could cause escape of the liquids from the weirs.

While I have described my cell specifically as a particular embodiment for the purpose of illustration, there may be variations in structure. For example, shaft 2 may be vertical and plates 8 may be flat. In such a modification, it is necessary to provide a weir 8*b* (see FIG. 4), as stated above, located above plate 8 near mercury inlet 12 and disposed radially from shaft 2 to the brim of plate 8. Weir 8*b*, as previously described, is made of the same erosive material as the tip of mercury inlet 12*a*. The weir is located on the side of inlet 12 that is farthest in the direction of rotation of the plates.

Weir 8*b* is fixed while the plate surface 8 moves tangentially underneath it, and the function of the weir is to allow the mercury stream that flows from the feed pipe 5 to build up a pool of mercury on the plate, which is contained by the brim 8*a* of electrically non-conductive material which surrounds plate 8. As illustrated in FIG. 4 a space is left between anodes in which the mercury pool is maintained. If the plates rotate clockwise, weir 8*a* must be to the side of inlet 12 so that the plate moves into the pool formed by the weir. The plates could, of course, rotate in the opposite direction, in which case the amalgam would be introduced on the opposite side of the weir.

The alkali metal that is discharged upon the amalgamated plate during a complete revolution is dissolved in the mercury pool where fresh mercury is fed from the pipe 12 and forms amalgam which leaves the plate, streaming through drain slots 13 that discharge it into the interior of hollow shaft 2. These discharge drain slots are provided with hydraulic seals. At the same time, a minor part of the amalgam forming pool adheres to the surface of the rotating plate and is able to pass beneath the weir 1 in the form of a thin layer of dilute amalgam. This amalgam layer will act as a cathode, thus gradually increasing its alkali metal concentration throughout a complete revolution until reaching the mercury pool and passing beneath the weir again.

This pool was produced naturally with an inclined shaft and cone-shaped plates as previously described above.

A cell-type conforming to the constructional and operating principles as disclosed above, beside allowing the electrolysis process to be performed as satisfactorily as in any horizontal cell of conventional design, affords the advantages of requiring substantially less floor space and permitting a simpler adjustment of the electrodes spacing. Furthermore, the constructional features as disclosed above make it possible to design cells having a unit production capacity that has never been reached so far.

A horizontal 120,000 amp. cell of conventional design, which produces about 4 short tons of chlorine per day, requires a floor space of about 700 sq. ft. including aisles. A cell of the same capacity but of the type as described and based on this invention would require less than 250 sq. ft. of floor space.

The following specific example of my cell and its operation is recited to enable persons skilled in the art to better understand the invention and it will be understood that there is no intent to limit the invention to the conditions recited.

Example

A cell with 10 cathodic disks, each having an external diameter of the active part of the disk of 2450 mm. (96¼ inches) and an inetrnal diameter of 970 mm. (38¼ inches) that is to say with a total cathodic surface of 38 m.^{3} (410 sq. ft) and the same anodic surface is loaded with 15,000 amps. The distance between cathodes and anodes is 5 mm. (3/16 inch).

The cell has a voltage of 4.05 volts and gives a current yield of 94.5%.

210 U.S. gallons per hour of NaCl-brine with at least 300 gr. of NaCl/liter are fed to the brine inlet pipes 10 of the 10 cell compartments. This brine enters the cell spaces near the cell center through holes 13, is mixed with old brine by the rotation of the cathodes and flows slowly toward the periphery of the cathode disks, down to the brine outlet box 35 and leaves the cell by overflow 36 with a NaCl concentration of approx. 270 gr./liter.

The feed mercury enters the mercury feeder on top of the cell which feeds all the single cathodes 8 by lines 48*a*.

About 460 liters per hour of mercury enter the mercury pool near the external limit of every cathodic disk and leave the cell space as amalgam with approx. 0.15% of sodium, through the mercury seal 13, entering the hollow axle 2 of the cell.

While the introduced mercury goes radially through the mercury pool, the active surface of the cathodic disk passes the mercury pool in a tangential sense due to its own rotation, so that the concentrated sodium amalgam on the active cathode surface of every disk is renewed two times by new Hg or at least by a very diluted sodium amalgam.

The chlorine bubbles formed on the anodes 9 rise until reaching the lower rubber lined sides 26 of the cathodic disks 8, pass to the free brine filled space between the outer cell wall and the rims of cathodic disks 8 and rise finally up to the chlorine collecting space above the level of the brine, from where the chlorine leaves the cell by outlet pipe 40*a*. The chlorine production is 127 lb./hour.

The amalgam, after passing through seal 13, falls down through the washing water in the hollow axle 2 and goes out to the amalgam decomposer. In the decomposer, the amalgam is reacted with water to obtain mercury (or a more dilute amalgam), sodium hydroxide (caustic soda) and hydrogen.

After reaction with water, the mercury is recycled by a pump to the cell feeder. The cell produces 360 lb. of NaOH (calculated as 100%) per hour in the form of a caustic solution of 50–60% NaOH.

The decomposer produces beside of the caustic soda 660 cu. ft. per hour of hydrogen.

While I have recited specific embodiments of my cell, it will be understood that various modifications may be made without departing from the spirit of the disclosure or the scope of the following claims.

This application is a continuation-in-part of my previous application Serial No. 667,165, filed June 21, 1957, now Patent No. 2,951,026.

I claim:

1. In an electrolytic apparatus having a mercury cathode for the electrolysis of electrolytic solutions, a rotating hollow cylindrical shaft disposed substantially vertically, a plurality of circular plates attached to said shaft along its axis, anode frames suspending anodes above each of said plates, said anodes being stationary, disposed radially around said hollow shaft and provided with electrical connections at their peripheral sides, a shell enclosing said shaft, plates and anodes, hydraulic seals at the top and bottom of said shell between said shell and said rotating shaft, means in said shell for introducing an electrolytic solution and mercury onto each of said plates, mercury distribution means for providing equal distribution of mercury to said introducing means, means at the top of said shell for withdrawing gaseous product, means in said shaft for withdrawing amalgam from each of said plates into the hollow center of said shaft, means at the upper end of said shaft for introducing caustic wash water, means for maintaining said wash water at a constant level in said hollow shaft, means in said shaft for withdrawing wash water, means at the lower end of said shaft for withdrawing amalgam, means for introducing an inert gas into said hollow shaft to place a backpressure on said amalgam and cause mercury to overflow said plates and flow towards the botom of said shell, means in said shell for withdrawing spent solution at a point below said plates, comprising an outlet for said spent electrolyte solution, an outlet for mercury, an outlet for evolved gases, and means for preventing evolved gases to enter the electrolysis zone, hydraulic seal means between said rotating shaft and said amalgam withdrawal means, means for raising the lower end of said shaft and decreasing the distance between cathodes and anodes, means for rotating said shaft, support means for said cell, and electrical cathode contact means.

2. In an electrolytic apparatus having a mercury cathode for the electrolysis of electrolytic solutions, a rotating hollow cylindrical shaft disposed substantially vertically, a plurality of circular plates attached to said shaft along its axis, anode frames suspending anodes above each of said plates, said anodes being stationary, disposed radially around said hollow shaft and provided with electrical connections at their peripheral sides, a shell enclosing said shaft, plates and anodes, hydraulic seals at the top and bottom of said shell between said shell and said rotating shaft, means in said shell for introducing an electrolytic solution and mercury onto each of said plates, mercury distribution means for providing equal distribution of mercury to said introducing means, said distribution means comprising a stationary cylindrical case with a mercury compartment and outlet for each mercury conduit to each cathode plate, a mercury discharge tube connected to the rotating shaft to discharge mercury into each said mercury compartment as the tube passes over the compartment, and cover means for said cylindrical case, means at the top of said shell for withdrawing gaseous product, means in said shaft for withdrawing amalgam from each of said plates into the hollow center of said shaft, means at the upper end of said shaft for introducing caustic wash water, means for maintaining said wash water at a constant level in said hollow shaft, means in said shaft for withdrawing wash water, at the lower end of said shaft for withdrawing amalgam, means in said shell for withdrawing spent solution at a point below said plates, hydraulic seal means between said rotating shaft and said amalgam withdrawal means, means for rotating said shaft, support means for said cell, and electrical cathode contact means.

3. In combination with a mercury electrolysis cell having a substantially vertical rotating center shaft, an electrical connection for providing cathode current between a stationary cathode bus bar and said rotating shaft which comprises, a lower conductive cylinder attached to the top of said shaft and oriented axially with said shaft, mercury within said lower cylinder, and an upper concentric conductive cylinder attached to said bus bar, fitting within said lower cylinder and dipping into said mercury so as to form a fluid contact between rotating and stationary members of the electrical contact.

4. In combination with a mercury electrolysis cell having a substantially vertical rotating center shaft, an electrical connection for providing cathode current between a stationary cathode bus bar and said rotating shaft which comprises, a lower solid conductive member attached to the top of said shaft, concentric cylinders attached to the top of said lower member and oriented axially with said shaft, mercury between the walls of said cylinders, an upper stationary solid member making contact with said bus bar and having concentric cylinders depending therefrom, said cylinders being of such a size that they fit within said lower cylinder, said upper cylinders further dipping into said mercury so as to form a fluid contact between rotating and stationary members of the electrical contact.

5. In a mercury electrolysis cell having a substantially horizontal metal cathode support plate and graphite anodes, wherein the mercury is introduced onto said plate at one end thereof and withdrawn at the other end, and the electrolytic solution is introduced at the end of the plate from which mercury leaves, flows countercurrent to said mercury flow and overflows said plate at the end mercury is introduced, a method for cleansing graphite particles from the cathode support plate which comprises, interrupting the normal flow of mercury by placing a backpressure on said mercury at its discharge point thereby preventing its outflow at the mercury outlet and causing it to overflow at the electrolyte outlet for a sufficient time

to carry out graphite particles, releasing said backpressure to permit normal flow of mercury to resume and separating said cleansing mercury from electrolyte.

6. In a mercury electrolysis cell having a substantially horizontal metal cathode support plate and graphite anodes, wherein the mercury is introduced onto said plate at one end thereof and withdrawn at the other end, and the electrolytic solution is introduced at the end of the plate from which mercury leaves, flows countercurrent to said mercury flow and overflows said plate at the end mercury is introduced, a method for cleansing graphite particles from the cathode support plate which comprises stopping the flow of mercury at its inlet, placing a backpressure on said mercury at its outlet to prevent its outflow, introducing cleansing mercury at the electrolyte inlet end of the cell, causing said cleansing mercury to flow concurrent with said electrolyte through said cell and out said electrolyte outlet for a sufficient time to carry out graphite particles, releasing said backpressure and resuming normal flow of mercury and separating said cleansing mercury from electrolyte.

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