Aug. 19, 1958 M. P. NEIPERT ET AL 2,848,408

FLUID OUTPUT END APPARATUS FOR A MERCURY CATHODE ELECTROLYTIC CELL

Filed Nov. 5, 1957 4 Sheets-Sheet 1

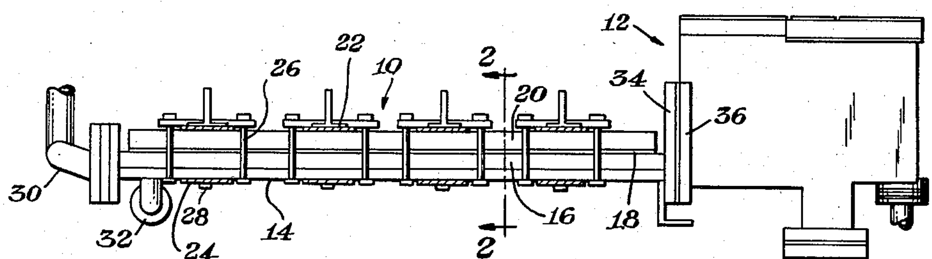

Fig. 1

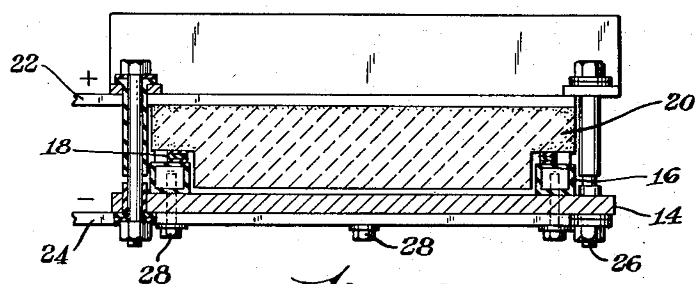

Fig. 2

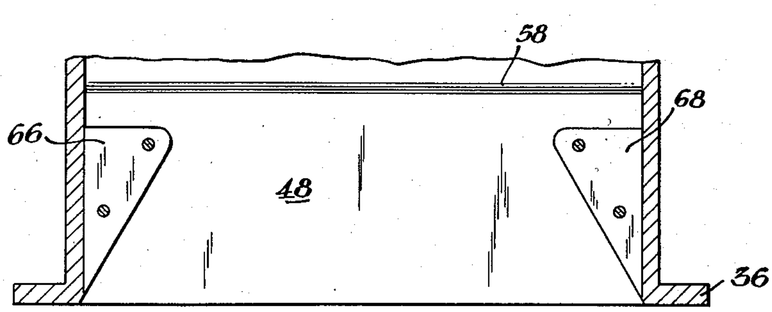

Fig. 6

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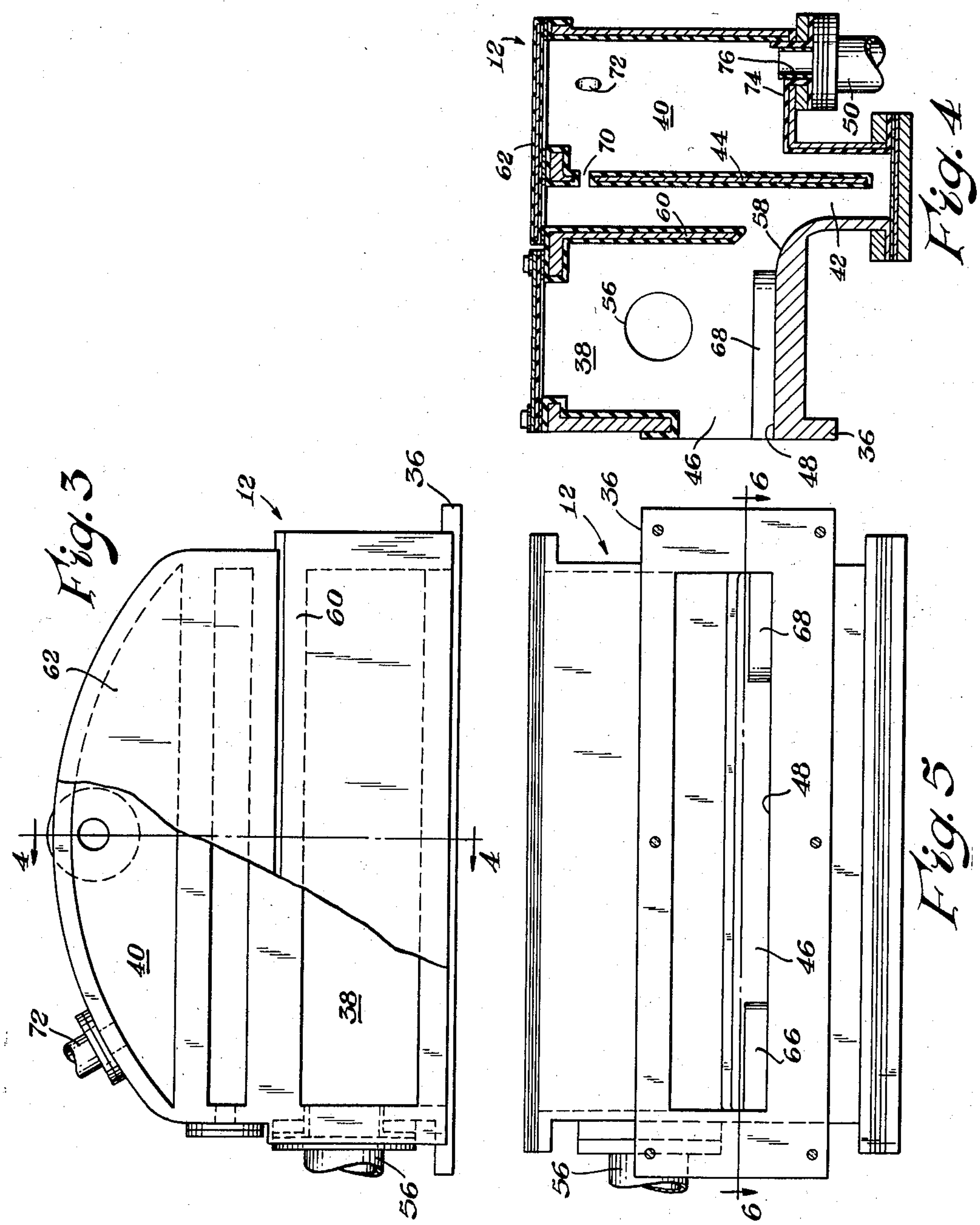
FLUID OUTPUT END APPARATUS FOR A MERCURY CATHODE ELECTROLYTIC CELL

Filed Nov. 5, 1957 4 Sheets-Sheet 2



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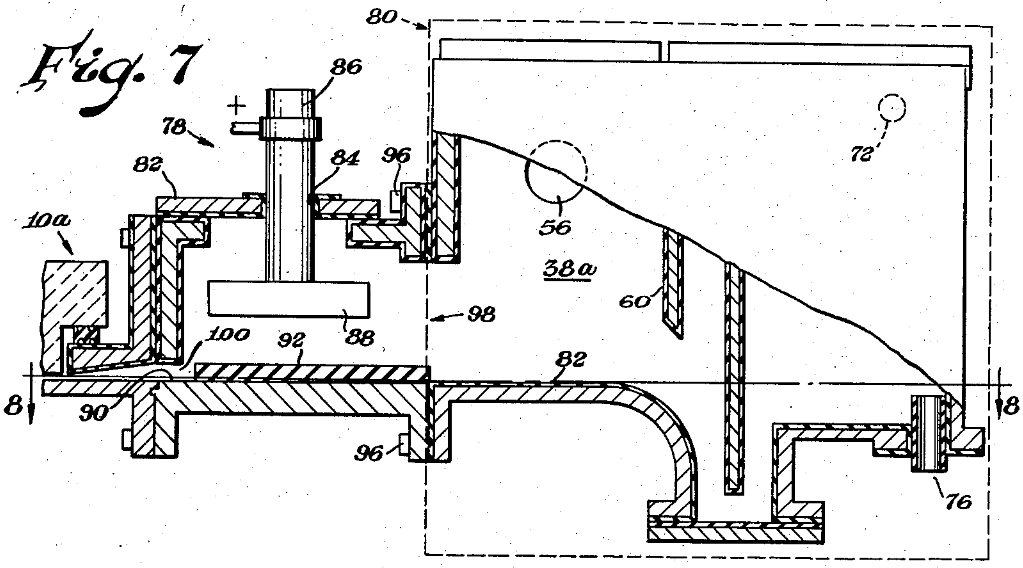

Fig. 7

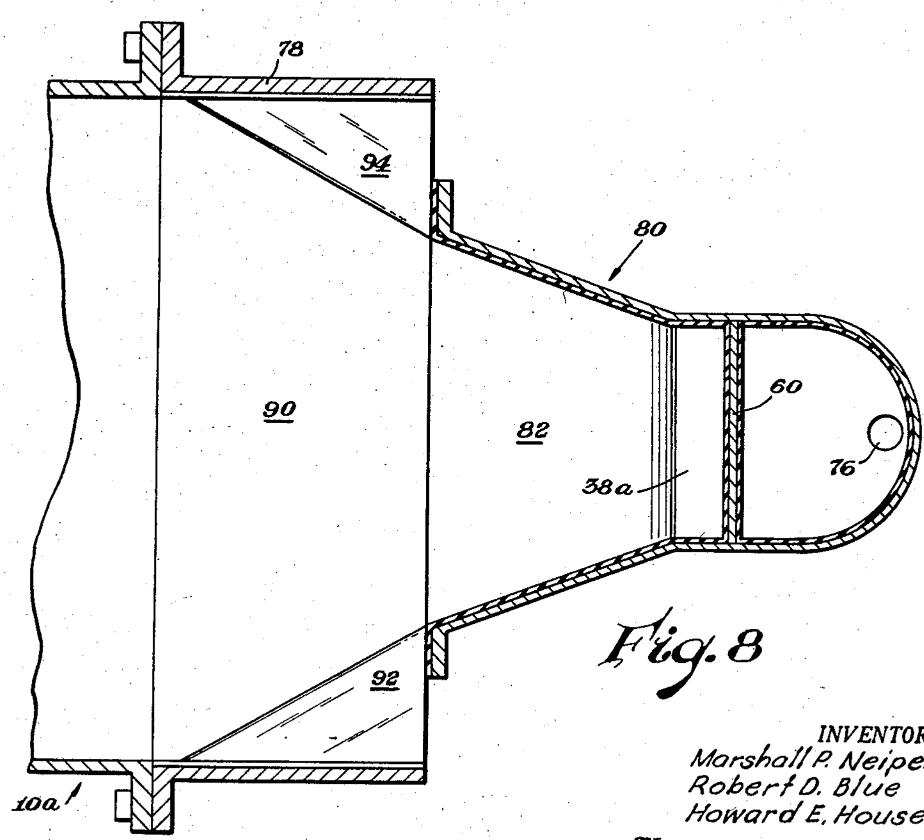

Fig. 8

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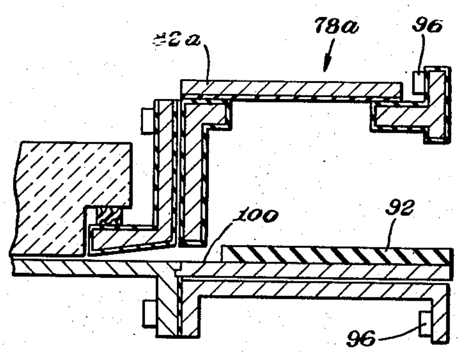

Fig. 9

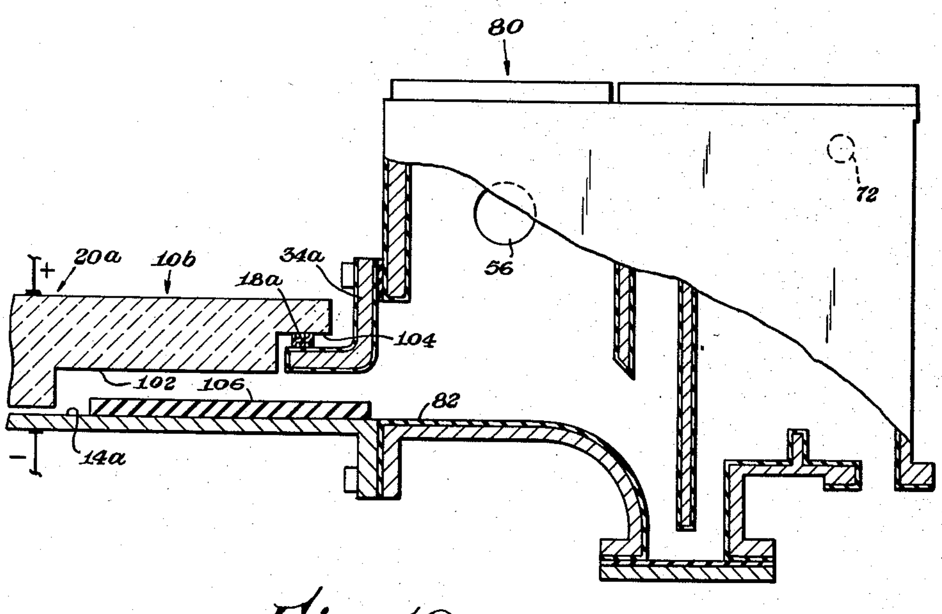

Fig. 10

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FLUID OUTPUT END APPARATUS FOR A MERCURY CATHODE ELECTROLYTIC CELL

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Application November 5, 1957, Serial No. 696,012

8 Claims. (Cl. 204—219)

This invention relates to mercury-cathode electrolytic cell assemblies, and particularly to output end structures for such cells.

This is a continuation in part of applicants' copending application Serial No. 451,611, entitled "End Box for a Mercury Cathode Electrolytic Cell," filed August 23, 1954.

A conventional mercury cell usually consists of a long narrow trough with a mercury cathode at the bottom and graphite anodes suspended from a rubber lined cover. Feed brine flows slowly through the cell with very low turbulence. On electrolyzing a strong alkali metal brine, the cation, e. g. sodium, migrates to the cathode and form an amalgam with the mercury. The chlorine ions move to the anode, where they are converted into chlorine gas, which is drawn off from the cell. The brine and mercury amalgam flow into an end box associated with the cell and are separated before the mercury amalgam is passed through a denuding chamber where it is reacted with water to produce sodium hydroxide solution and hydrogen.

Because both the brine and the mercury flow at slow rates in conventional mercury-cathode electrolytic cells, the end box usually comprises a simple box like stilling chamber wherein the heavy mercury is withdrawn from the lower portion and the brine passes through an outlet in the upper portion thereof. To avoid attack by the chlorine-containing brine on the iron or steel of the end box, the inner surface of the end box is covered with rubber or some other material which is not attacked by the brine.

While such end boxes suffice for use with mercury-cathode electrolytic cells in which the brine and mercury flow at low velocities and turbulence, they are somewhat less than satisfactory when used in conjunction with the high brine turbulence (or high velocity) slot-type electrolytic cells which have been recently developed. (See, for instance, Canadian Patent No. 476,519.) In such cells the mercury flows over a steel cathode at a high velocity and in a thin film. The flow of mercury is aided by the brine flow, which is flowing at high velocity or high turbulence through the space, usually a small fraction of an inch, which separates the mercury from the anode of the cell.

When the brine, chlorine and amalgam pass from the cell into the end box there is a tendency for mercury to become entrained in the brine. The entrained mercury dissolves in chlorinated brine and is unrecoverable in systems where the depleted brine is circulated into underground salt domes for resaturation, causing a serious economic loss.

The high velocity and turbulence of the brine and mercury also contribute to the entrainment of brine in the mercury which is objectionable in cell operation since it would increase the chloride content of the caustic.

A principal object of this invention is to provide improved means for preventing entrainment of mercury amalgam in brine as the cell fluids leave the cell.

Another object of this invention is to provide an improved end box which is particularly adapted for use with slot-type electrolytic cells.

In an end box in accordance with the present invention the mercury flows into the brine and amalgam receiving chamber over a steel bottom surface rather than a rubber covered surface. The width of the flow channel over which the liquid cathode material flows as it enters the end box is made progressively smaller as the liquid cathode material travels into the end box. The steel bottom surface replaces the rubber covered lower surface of the conventional end box structure, and is used because the cathode material wets the steel surface and sharply reduces the tendency of the cathode material to become entrained in the brine. Restricting the width of the mercury channel causes the cathode material layer, usually mercury, to deepen sufficiently to form a moving film or sheet constantly covering the entire steel surface, thus preventing the formation of hydrogen and the eating away of the steel surface which would occur if the steel were exposed to the chlorinated brine.

A mercury trap is provided between the brine and mercury receiving portion of the end box and a mercury washing chamber of the box where water greatly dilutes any traces of brine which may have become entrained with the mercury. A baffle plate separates the main brine and amalgam receiving chamber of the end box from the part of the end box which is above the intake portion of the mercury trap. The greater part of the chlorine gas in the brine is removed while the brine is in the part of the end box which is between the baffle plate and the electrolyzer.

The top of the end box above the mercury trap intake may be opened during operation to facilitate the removal of any accumulation of mercury butter which is near the intake of the trap.

The portion of the end box in which the amalgam layer is thickened and restricted in width may be termed a mercury brake. The mercury brake may be a part of the output end of the cell or an intermediate structure disposed between the output end of the cell and an end box.

The invention, as well as additional objects and advantages thereof, will best be understood by reading the following detailed description when taken in connection with the accompanying drawings, in which:

Fig. 1 is a side elevational view of a slot type mercury-cathode electrolytic cell and end box in accordance with the invention;

Fig. 2 is a transverse sectional view of the electrolytic cell shown in Fig. 1;

Fig. 3 is a top view, partly broken away and in section, of an end box made in accordance with this invention;

Fig. 4 is a side elevational view, in section, taken along the line 4—4 of Fig. 3;

Fig. 5 is an elevational view of the brine and amalgam input end of the end box shown in Figs. 3 and 4;

Fig. 6 is a fragmentary sectional plan view, taken along the lines 6—6 of Fig. 5;

Fig. 7 is a side elevational view, in section, of a mercury brake structure disposed between an electrolytic cell and an end box;

Fig. 8 is a view taken along the line 8—8 of Fig. 7;

Fig. 9 is a side elevational view, in section, of an alternative embodiment of mercury brake structure adapted to be inserted between the output end of a cell and an end box, and

Fig. 10 is a fragmentary side elevational view, in section, of a mercury brake structure included as an end part of an electrolytic cell.

Referring to Figs. 1 and 2, there is shown a slot-type mercury-cathode electrolytic cell **10** having an end box **12** attached thereto. The cell **10** comprises a cathode base plate **14**, an electrode separator frame **16**, a deformable gasket **18**, and a monolithic graphite anode **20**. The electrodes are separated by the frame **16**, which is secured to the cathode base plate, and the gasket **18** which is disposed between the frame **18** and the anode **14**. Power is applied to the anode **20** through the positive bus bars **22** and to the cathode baseplate **14** by means of the negative bus bars **24**. The positive bus bars **22** are clamped against the anode **20** by the bolts **26** and the negative bus bars **24** are secured to the cathode base plate **14** by screws **28**. A brine inlet **30** and a mercury inlet **32** are provided near the end of the cell **10** which is remote from the end box **12**. A flange **34** at the end box end of the cell **10** is utilized in attaching the end box **12** to the electrolytic cell **10**. A detailed description of such a cell may be found in applicants' co-pending application, Serial No. 451,612, filed August 23, 1954, entitled "Liquid Cathode Electrolytic Cell."

The end box **12** is a box-like structure having a flange **36** by which it is attached to the flange **34** on the output end of the electrolytic cell **10**. Referring to Figs. 3, 4, 5, and 6, the interior of the end box **12** is divided into two compartments, a brine, chlorine and amalgam receiving compartment **38** and an amalgam washing compartment **40**, which are joined by a trap **42** which projects downwardly from the bottom of the end box **12**. The compartments are separated by a partition **44**. The bottom of the partition **44** which separates the two compartments extends into and is a part of the trap **42**. Referring especially to Figs. 4 and 5, the end box has a fluid entry slot **46** which is rectangular in shape and is framed by the mounting flange **36** and through which the brine, chlorine, and amalgam enter the first compartment **38** of the end box. The bottom of the slot **46** is aligned with the surface **48** of the bottom of the interior of the end box **42**. The bottom of the end box is made of bare steel, while the top and sides of the end box are made of rubber covered steel or of some metal which is covered by a material which protects the metal from attack by the chlorine or brine.

A chlorine and brine outlet **56** is provided in a side wall of the first or fluid entry compartment **38**, while the amalgam leaves the end box **12** through an amalgam outlet **50** in the second or amalgam washing compartment **40**.

The bottom of the first or brine, chlorine and amalgam receiving compartment **38**, into which the liquid and gas output of the electrolytic cell flow, is flat for a substantial part of the length of the compartment **38**, but curves downwardly near the edge **58** of the trap **42**.

Two hard rubber or rubber covered blocks **66**, **68** are secured to the bottom surface **48** of the fluid entry compartment **38**. The blocks **66**, **68** extend obliquely inwardly from the end of the end box **12** which abuts against the electrolytic cell **10** to or near to, the point where the bottom surface **48** curves downwardly into the trap **42**.

A baffle plate partition **60** of rubber covered steel extends downwardly from the top of the end box **12** almost to the bottom thereof in the region of the trap **42**. That part **62** of the top of the end box **12** which extends from the baffle plate **60** to the back end over the amalgam washing chamber or compartment **40** of the end box **12** is attached to the end box **12** in a readily removable manner, while the remainder of the top of the end box is clamped and sealed to the walls of the end box in a gas-tight manner.

The amalgam washing compartment **40** is connected to the fluid entry or intake compartment **38** through an aperture or apertures **70** near the top of the partition **44** as well as by the trap **42**. A vent aperture **72** is provided near the top of the amalgam washing compartment **40**. The aperture **72** is above the liquid level of either compartment. The height of the surface **74** of the bottom of the interior of the amalgam washing compartment **40**, over which the amalgam passes, is as high as the surface **48** of the bottom of the first or fluid entry compartment **38** in order that the amalgam level in the fluid entry compartment **38** will substantially cover the curved bottom surface or spillway going into the trap **42**.

When the end box **12** is attached to the electrolytic cell **10** by the mounting flanges **34**, **36**, the bottom surface **48** of the fluid entry channel or slot **46** abuts against and is aligned with the top surface of the cathode base plate **14** to form a continuation thereof.

The operation of the end box **12**, which separates the brine, chlorine, and amalgam, is as follows: The amalgam, brine, and chlorine passes from the electrolytic cell **10** into the end box **12** at high velocity. However, due to the large volume of the end box **12** as compared with the volume between the anode and cathode of the electrolytic cell **10**, the velocity of the fluid entering the end box **12** rapidly decreases.

The chlorine gas rises through the brine and leaves the end box **12** through the brine and chlorine outlet **56**. Because the baffle plate **60** extends downwardly almost to the level of the amalgam and because it is located remotely from the fluid entry end of the end box **12**, the brine which passes under the baffle plate **60** is substantially free of chlorine. That is, practically all of the chlorine in the brine bubbles out before the brine passes beyond the baffle plate **60**.

Upon entering the end box **12** the mercury-sodium amalgam flows along the steel surface **48**, through the trap **42**, and into the amalgam washing chamber or compartment **40**. The steel bottom surface **48** of the end box **12** was found to be necessary to prevent the thin mercury film which enters the end box **12** from the electrolytic cell **10** from breaking up into droplets which tend to become entrained in the brine. It was found that the mercury would cling to steel, thus keeping the amalgam in the form of a film which then passes into the trap **42**. The thin film of mercury which flows over the steel surface **48** tends, because of surface tension or some other property of the mercury, to leave bare spots of steel exposed to the brine. To prevent the exposure of the bare steel to chlorinated brine, the obliquely disposed rubber blocks **66**, **68**, on the steel surface **48** gradually restrict the width of the channel **46** and thus cause the thickness of the mercury film to be increased to thereby slow down the velocity of the film and insure that the mercury film completely covers the bottom of the channel **46** under all conditions of operation of the end box. The flow channel and blocks become, in effect, a mercury brake.

While the blocks **66**, **68** (referring especially to Fig. 6) are indicated as extending inwardly from the sides of the end box **12**, blocks of any shape could be used if the remainder of the bottom of the end box **12** not used as an amalgam channel were protected, as by a rubber covering for example, from exposure to the brine. The blocks **66**, **68** extend to the edge **58** of the curved spillway part of the steel bottom surface **48** which is below the amalgam level at the edge of the trap **42**. The amalgam flows through the washing compartment **40** where any brine which is entrained with the amalgam is removed and diluted in the water contained in the compartment. The bottom **74** of the amalgam washing compartment, as well as the sides and top thereof are lined with rubber or other suitable material which is not attacked by brine, chlorine, or mercury amalgam. The amalgam outlet **50** is disposed in the bottom of the amalgam washing compartment. The height of the amalgam outlet may be raised or lowered by means of an adjustable insert sleeve **76** to control the mercury amalgam level in the end box **12**.

Any chlorine which remains in the brine between the baffle plate **60** and the partition **44** as well as any mercury vapors remaining there, pass into the amalgam washing compartment 40 through the aperture 70 in the partition 44 and are vented through the aperture 72 in the wall of the end box 12.

The removable part 62 of the top of the end box 12 facilitates both the removal of mercury butter which collects at the trap 42 and the cleaning of the amalgam washing compartment 40. Due to the slight amount of chlorine which is present in the brine which rises above the trap 42, the top part 62 may be removed, if desired, during operation of the cell 10 in order to clean the trap 42.

Referring now to Figs. 7 and 8, it may be seen that a mercury brake structure, indicated generally by the numeral 78, may be disposed between the cell 10*a* and the end box assembly, enclosed in broken lines and indicated generally by the numeral 80. The end box assembly 80 is of the same general construction as the end box 12 shown in Fig. 4, except that the bottom of the amalgam receiving compartment 38*a* has a rubber covering 82 rather than bare steel as in the end box 12 of Fig. 4. Also, the end box 80 contains no blocks 66, 68 (as in Fig. 4) to progressively restrict the width of the amalgam flow in the end box.

The mercury brake structure 78 comprises a box-like housing which includes a cover plate 82 having an aperture 84 through which extends an anode supporting rod 86 of electrically conductive material. An anode 88 (of graphite, for example) is secured to the lower end of the rod 86 and is spaced from the steel amalgam flow surface 90 of the structure 78 by a distance several times that of the anode-cathode separation of the cell 10*a*.

As shown in Fig. 8, the brake structure 78 is at least as wide as the width of the cell 10*a*. The steel amalgam flow surface 90 of the structure 78 is co-planar with respect to the amalgam flow surface of the cell 10*a* and with respect to the rubber covered flow surface 82 of the end box 80. While the amalgam flow surface 90 of the structure 78 is as wide as the amalgam flow surface of the cell 10*a* at the cell side of the structure 78, blocks 92, 94 of the type designated by the numerals 66, 68 in Figs. 4, 5, and 6, are secured to the flow surface 90.

The output end of the structure 78 is coupled to the input end of the end box 80 by bolts 96. The opening 98 in the output end of the structure 78 is several times as large as the opening 100 in the input end of the structure 78.

In operation the brine and amalgam leaving the cell 10*a* enter the mercury braking structure 78 through the opening 100. The brine velocity decreases at it enters the larger volume of the structure 78, and accordingly the brine exerts less influence on the amalgam which flows along the surface 90. The blocks 92, 94 restrict the width of the amalgam flow channel and cause the depth of the amalgam stream to increase and its velocity to decrease sufficiently to permit the amalgam stream to flow over the rubber covered surface 82 without breaking into discrete droplets which become entrained in the brine.

The mercury braking structure 78*a* shown in Fig. 9 is similar to that shown in Figs. 7 and 8 except that the cover 82*a* has no aperture and not anode is disposed within the structure. While the inclusion of an anode 88 as in Figs. 7 and 8 does permit the structure 78 to function as an electrolytic cell in addition to being an amalgam braking device, such a cell is inefficient as compared to the slot type cell 10*a* with which the structure 78 is associated.

Though not shown in Fig. 9, an end box 80 is coupled during operation, as shown in Figs. 7 and 8, to the output end of the structure 78.

Referring now to Fig. 10, it may be seen that the output end of the cell 10*b* may be altered to permit the inclusion of the amalgam braking structure within the cell proper.

The inwardly extending part of the flange 34*a* is raised considerably above its normal level for use in a slot type high velocity electrolytic cell. The spacing between the lower surface of the inwardly extending part of the flange 34*a* and the upper surface of the cathode base plate 14*a* may be, for example, two inches as compared with a typical separation of about one eighth inch in a slot type high velocity cell.

The output end of the anode 20*a* contains a cut away part 102 in addition to the shouldered part 104 which rests on the gasket 18*a*. The cut away part 102 extends along the entire width of the flow path through the cell and for perhaps a foot (depending on cell design dimensions along the length of the anode 10*b*). The anode 10*b* at the cut away part 102 is, for example, about two inches thinner than the part of the anode which is closely spaced from the cathode base plate.

A pair of blocks 106 corresponding to the blocks 66, 68 in Figs. 4, 5, and 6, are secured to the cathode base plate and disposed in the same relative configuration along the amalgam flow channel as are the blocks 66, 68 shown in Figs. 4, 5, and 6.

The length of the blocks 106 may vary from several inches to a foot or more, depending on the degree of braking of the amalgam velocity which is desired. The height of the blocks 106 need be only slightly higher than the anticipated depth of the amalgam stream. Thus, a block height of the order of one-eighth inch is approaching the lower limit of height for the blocks, but in practice a block thickness of about one-half inch is often used.

The operation of the mercury braking structure of Fig. 10 is similar to the structure 78 in Fig. 7. The cut away part 102 of the anode 10*b* provides a large volume into which high velocity brine stream may rush prior to its entry into the end box 80, thus permitting a reduction in the brine velocity even before it leaves the cell 10*b*.

Thus, it may be seen that the braking and thickening of the amalgam stream at the output end of a high velocity slot type electrolytic cell may take place either in the end box, in a structure disposed between the cell and end box, or at the output end section of the cell.

We claim:

1. In a mercury cathode electrolytic cell in which brine and mercury amalgam cathode material flows, at an output end, from a slot between the planar surface of a cathode base and an anode spaced above said cathode base, an end box including a fluid entry compartment having side walls, an entry end wall secured to said output end of said cell, said entry end wall having a fluid entry slot therein, a steel mercury amalgam flow surface extending inwardly from said fluid entry slot and extending between the side walls, means secured to said flow surface and extending centrally thereof at an acute angle from said side walls for restricting the width of the surface over which mercury amalgam material may flow during operation of the cell, said flow surface being substantially aligned with the planar surface of the cathode base of said cell from the inlet slot past the centrally extending means for restricting the width of the surface, a strap having an inlet side and an outlet side disposed beyond said centrally extending means for withdrawing amalgam from said fluid entry compartment, and brine removal means disposed in at least one of said side walls above the amalgam inlet side of said trap.

2. In a high velocity mercury cathode electrolytic cell in which brine and mercury amalgam cathode material flows, at an output end, from a slot between the planar surface of a cathode base and an anode spaced above said cathode base, an end box including a fluid entry compartment having side walls and a top which are covered with a material which is resistant to attack by chlorinated brine, an entry end wall secured to said output end of said cell, said entry end wall having a fluid entry slot therein, a steel mercury amalgam flow surface extending inwardly from said fluid entry slot and extending be-

tween the side walls, block means secured to said flow surface and extending centrally thereof at an acute angle from said side walls for gradually restricting the width of the surface over which mercury amalgam material may flow during operation of the cell, said flow surface being substantially aligned with the planar surface of the cathode base of said cell from the inlet slot past the centrally extending means for restricting the width of the surface, the flow surface then curving downwardly, at a similar radius of curvature across the width of the surface, a trap having an inlet side and an outlet side disposed beyond said downwardly curving part of said amalgam surface for withdrawing amalgam from said fluid entry compartment, and brine removal means disposed in at least one of said side walls above the inlet side of said trap.

3. An end box in accordance with claim 2, wherein said block means comprises a pair of triangular shaped blocks each having generally flat bottom and edge surfaces and being shaped as a right triangle, one of the triangles being disposed with its base along each side wall with the smaller acute angle of the triangular block facing the entry end wall.

4. In a high velocity mercury cathode electrolytic cell in which brine and mercury amalgam cathode material flows, at an output end, from a slot between the planar surface of a cathode base and an anode spaced above said cathode base, an end box including a fluid entry compartment having side walls, an entry end wall secured to said output end of said cell, said entry end wall having a fluid entry slot therein, a steel mercury amalgam flow surface extending inwardly from said fluid entry slot and extending between the side walls, means secured to said flow surface and extending centrally thereof at an acute angle from said side walls for restricting the width of the surface over which mercury amalgam material may flow, said flow surface being substantially aligned with the planar surface of the cathode base of said cell from the inlet slot past the centrally extending means for restricting the width of the surface, the flow surface then curving downwardly, at a similar radius of curvature across the width of the surface, and an amalgam washing compartment, said washing compartment and said fluid entry compartment being joined, a trap having an inlet side and an outlet side, said inlet side being disposed below said downwardly curving part of said amalgam surface for withdrawing amalgam from said fluid entry compartment, the outlet side of said trap opening into said washing compartment, brine removal means disposed in at least one of said side walls above the amalgam level of said compartment, and amalgam removing outlet means in said washing compartment.

5. In a mercury cathode electrolytic cell in which brine and mercury amalgam cathode material flows, at an output end, from a slot between the planar surface of a cathode base and an anode spaced above said cathode base, an amalgam braking structure including a fluid entry compartment having side walls, an entry end wall secured to said output end of said cell, said entry end wall having a fluid entry slot therein, a steel mercury amalgam flow surface extending inwardly from said fluid entry slot and extending between the side walls, means secured to said flow surface and extending centrally thereof at an acute angle from said side walls for restricting the width of the surface over which mercury amalgam material may flow during operation of the cell, said flow surface being substantially aligned with the planar surface of the cathode base of said cell from the inlet slot past the centrally extending means for restricting the width of the surface, and a fluid outlet slot.

6. Apparatus in accordance with claim 5, wherein an anode electrode is disposed in said fluid entry compartment.

7. In a high velocity mercury cathode electrolytic cell in which brine and mercury amalgam cathode material flows, at an output end and between side walls, from a slot between the planar surface of a cathode base and an anode spaced above said cathode base, an amalgam braking structure disposed within said cell adjacent to said output end of the cell, comprising a fluid entry compartment having a top and side walls, said top being spaced from said cathode by a distance which is several times the anode-cathode separation in a high velocity slot type cell and said side walls being the side walls of the cell, a steel mercury amalgam flow surface extending toward the output end of the cell and extending between the side walls, and means secured to said flow surface and extending centrally thereof at an acute angle from said side walls for restricting the width of the surface over which mercury amalgam material may flow during operation of the cell, said flow surface being substantially aligned with the planar surface of the cathode base of said cell from the inlet slot past the centrally extending means for restricting the width of the surface.

8. An amalgam braking structure for use in a high velocity slot-type electrolytic cell series having a closely spaced anode-steel cathode flow surface, comprising a fluid entry chamber having a top, side walls, a steel amalgam flow channel, said steel flow channel being separated from said top by several times the spacing between the closely spaced anode and steel cathode flow surface, and means secured to said flow channel and extending centrally thereof at an acute angle from said side walls for restricting the width of the channel over which the amalgam may flow.

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UNITED STATES PATENT OFFICE
Certificate of Correction

Patent No. 2,848,408 August 19, 1958

Marshall P. Neipert et al.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 28, for "form" read —forms—; column 5, line 49, for "at" read —as—; line 61, for "not" read —no—; column 6, line 60, for "strap" read —trap—.

Signed and sealed this 28th day of April 1959.

[SEAL]

Attest:
T. B. MORROW,
Attesting Officer.

ROBERT C. WATSON,
Commissioner of Patents.