May 25, 1971 J. R. PETERSON 3,580,835

ELECTROLYTIC REDUCTION CELL

Filed Feb. 24, 1969 6 Sheets-Sheet 1

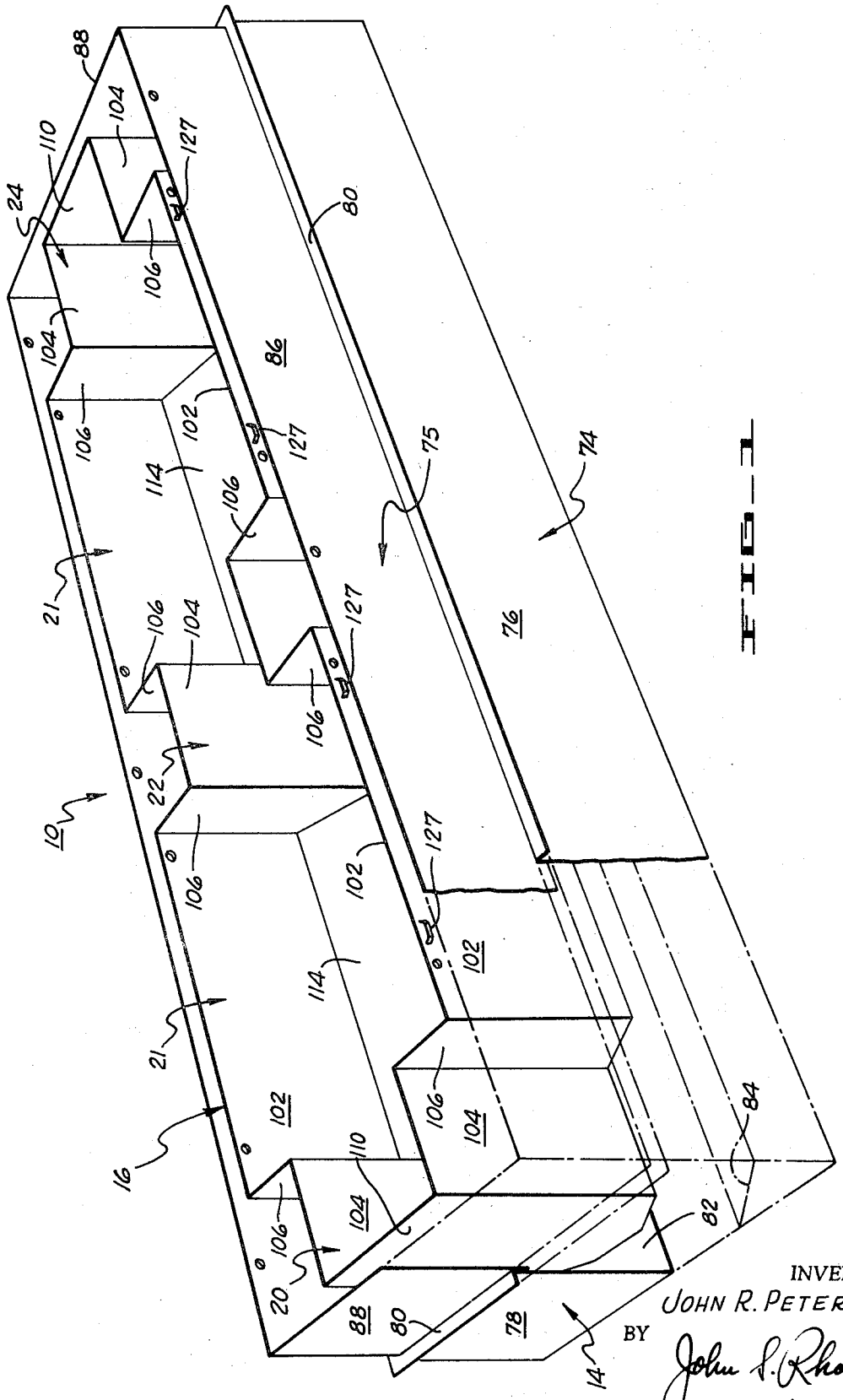


FIG. 1

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ELECTROLYTIC REDUCTION CELL

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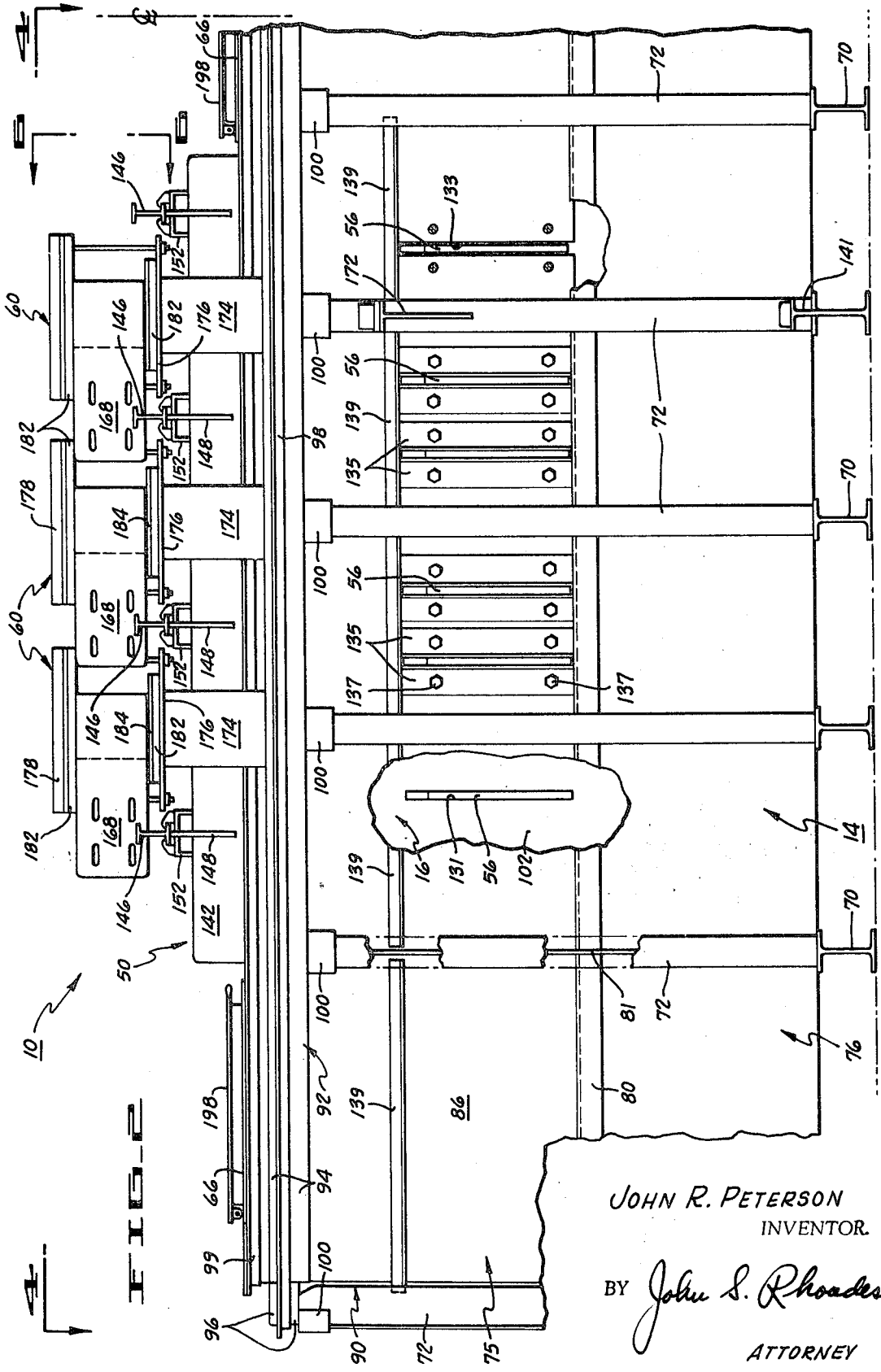


FIG. 2

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ELECTROLYTIC REDUCTION CELL

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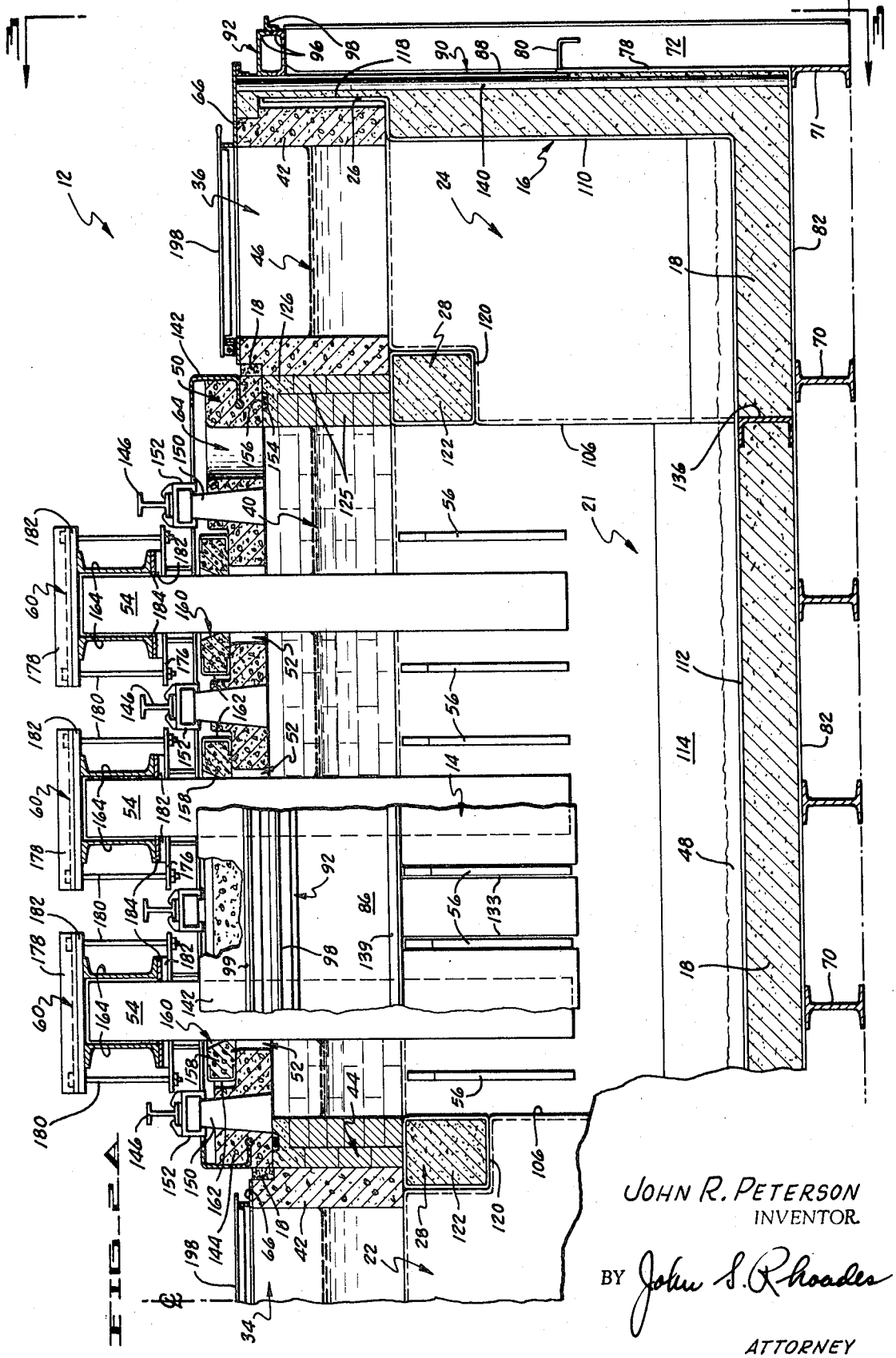


FIG. 4

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ELECTROLYTIC REDUCTION CELL

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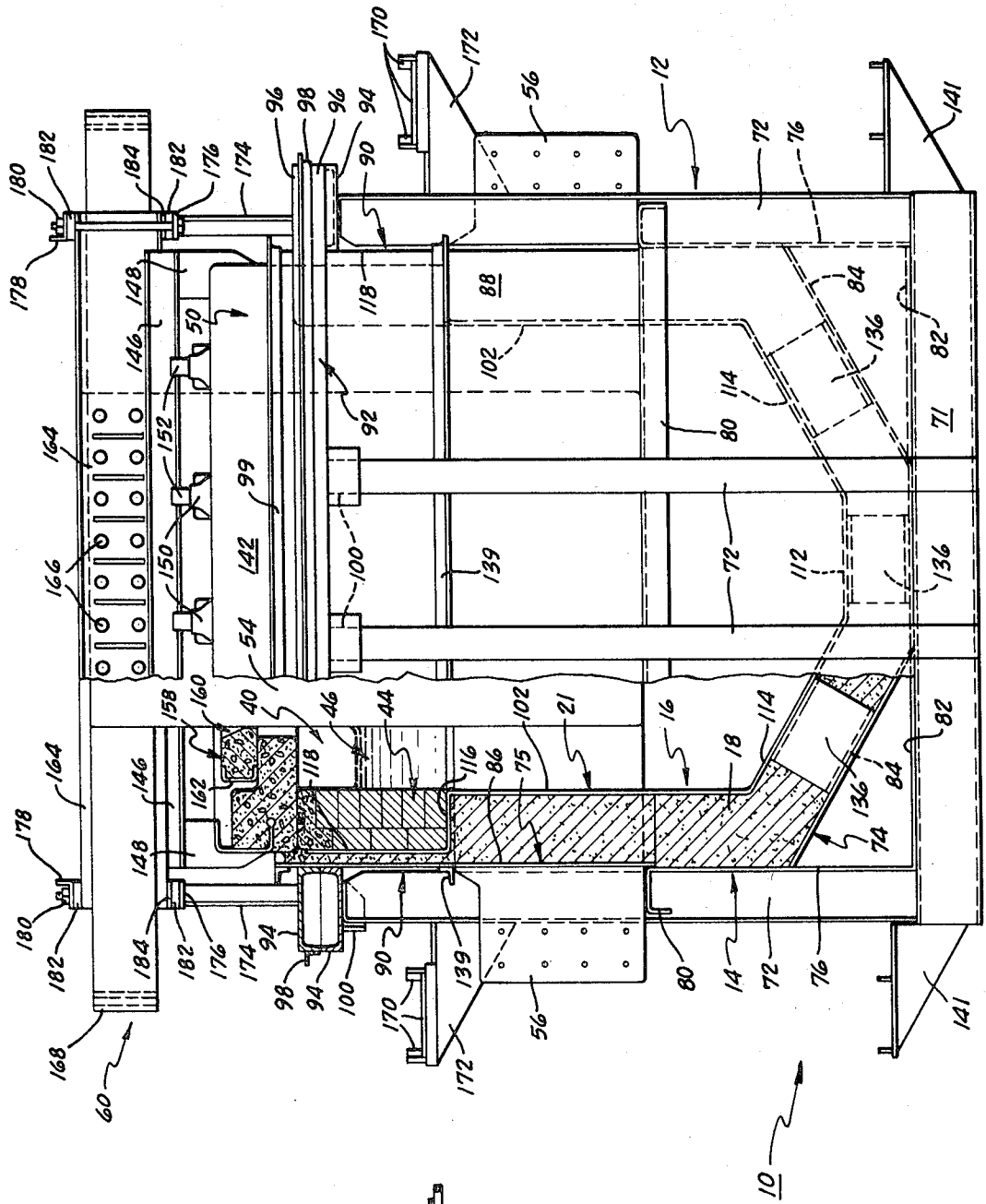


FIG. 4

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ELECTROLYTIC REDUCTION CELL

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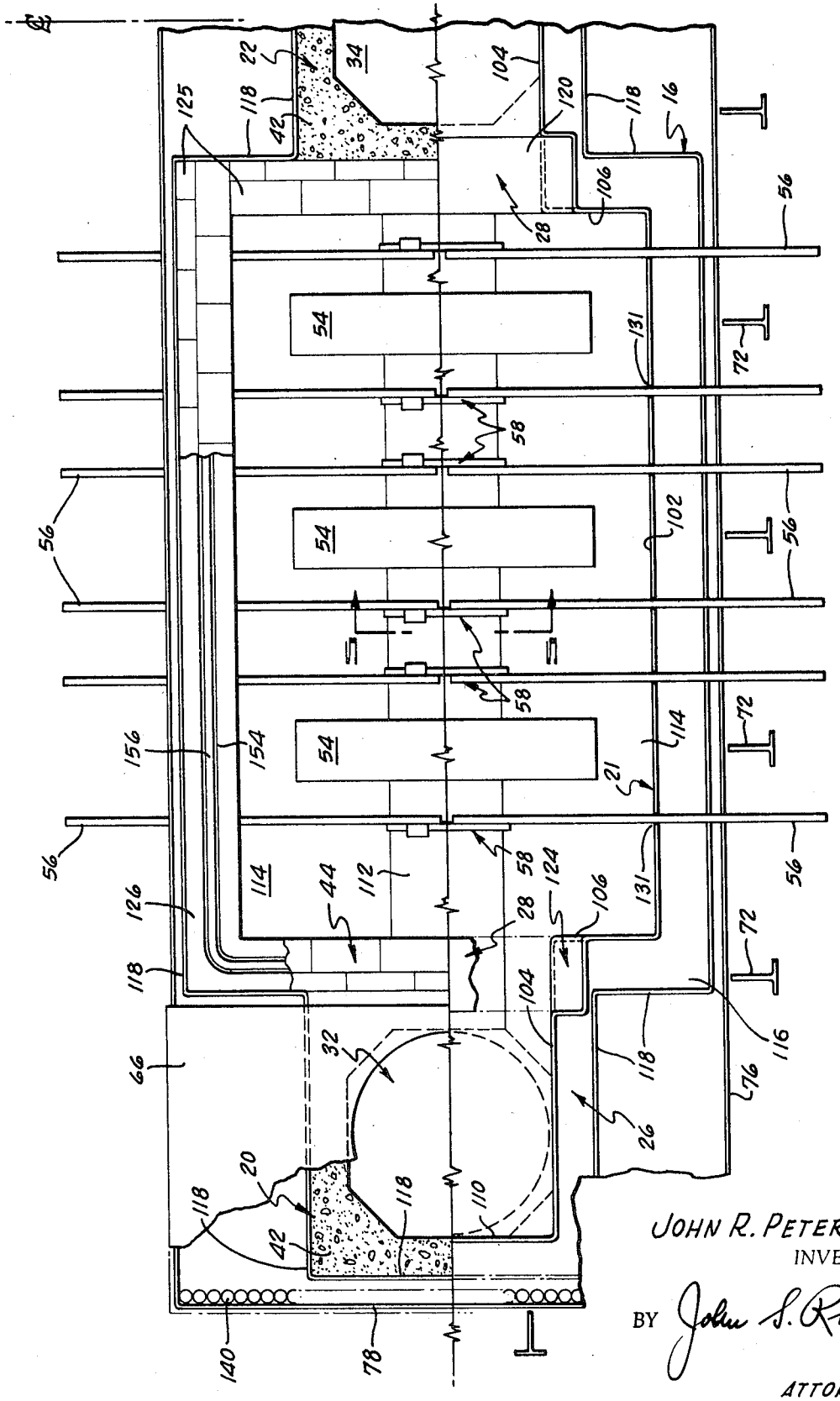


FIG. 4

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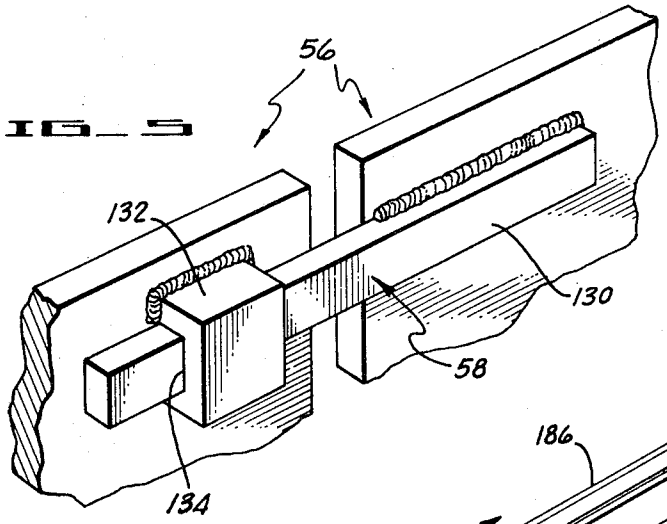
ATTORNEY

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ELECTROLYTIC REDUCTION CELL

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FIG_5



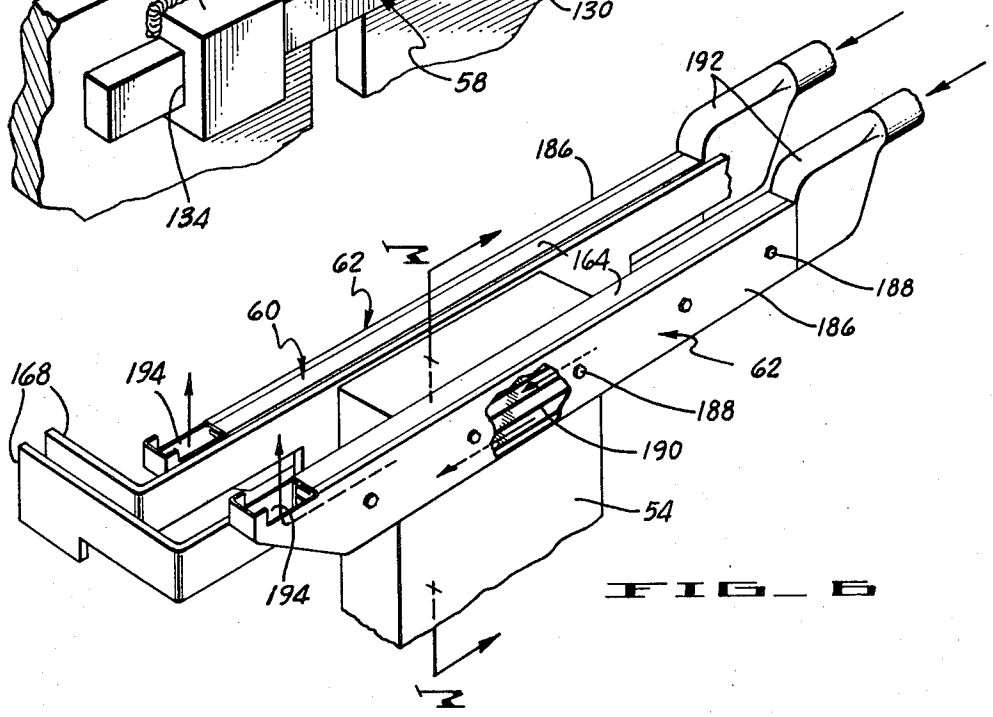


FIG_6

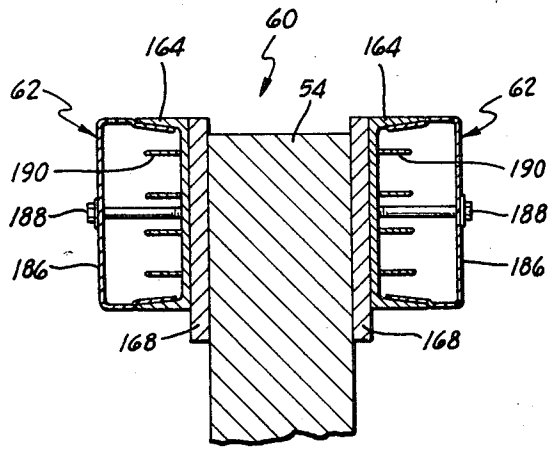


FIG_7

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United States Patent Office 3,580,835
Patented May 25, 1971

3,580,835

ELECTROLYTIC REDUCTION CELL

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Filed Feb. 24, 1969, Ser. No. 801,454
Int. Cl. C22d 3/02, 3/08
U.S. Cl. 204—243 23 Claims

ABSTRACT OF THE DISCLOSURE

Improved electrolytic reduction cell for producing molten magnesium metal and the like and made up of uniquely and removably arranged outer and inner shells having a mass of thermally resistant material interposed therebetween and wherein the interior of the cell is divided in an improved fashion into feed and electrolytic chambers.

BACKGROUND OF THE INVENTION

This invention relates to an electrolytic reduction cell for producing magnesium metal. More particularly, it relates to an improved electroyltic reduction cell provided with means for holding a fused electrolytic bath containing magnesium chloride of a density less than the magnesium metal produced from the bath and provided with further means for dividing the cell into an electroytic chamber and a feed chamber in such a unique fashion that the electrolytic bath can be periodically replenished without at the same time interfering with the normal production of magnesium metal and appropriate collection of chlorine gas liberated from the bath during operation of the cell.

In the past, electrolytic cells have been provided for producing magnesium from a fused electrolytic bath containing magnesium chloride and having a density less than the magnesium metal liberated from the bath, as exemplified by the U.S. Pat. 2,880,151 to Dean et al. granted on Mar. 31, 1959, and U.S. Pat. 2,950,236 to Dean et al. granted on Aug. 23, 1960. One of the principal deficiencies of prior electrolytic cells for producing magnesium was that the cell's structure did not lend itself to ready servicing of the cell during the use thereof. The cell structure was also such that it did not effectively separate the electrolytic chamber from the feed chamber, thus often necessitating the use of an anhydrous feed for the cell, which is difficult and costly to obtain.

SUMMARY OF THE INSTANT INVENTION

The primary purpose of the instant invention is to provide an improved electrolytic cell adapted to hold a fused electrolytic bath containing magnesium chloride of less density than the magnesium metal produced from the bath and having unique means for effectively dividing the cell into an electrolytic chamber and a feed chamber in order that the fused electrolytic bath can be periodically replenished through the feed chamber by an appropriate feed mechanism without at the same time interfering with the production of magnesium metal and anhydrous chlorine liberated from the fused electrolytic bath in the electrolytic chamber of the cell during the operation thereof.

BRIEF DESCRIPTION OF THE INVENTION

Wtih reference to the accompanying drawings,

FIG. 1 is is a simplified diagrammatic and perspective view of a preferred embodiment of the cell of the instant invention;

FIGS. 2 and 2A when taken together constitute an overall side elevational view, with parts broken away and parts shown in section of the cell of the instant invention;

FIG. 3 is an end elevational view taken along line 3—3 of FIG. 2A, with parts added and other parts broken away;

FIG. 4 is a top plan view taken along line 4—4 of FIG. 2, with parts broken away;

FIG. 5 is an enlarged framgmentary view taken from a position along line 5—5 of FIG. 4.

FIG. 6 is an enlarged fragmentary prespective view taken from a view point generally in the area of line 6—6 in FIG. 2; and

FIG. 7 is an enlarged cross sectional view taken along line 7—7 of FIG. 6.

With further reference to the drawings and particularly FIGS 1–4 thereof, a preferred embodiment of an improved electrolytic reduction cell **10** for producing magnesium metal and the anhydrous baseous chlorine incidental thereto in accordance with the instant invention, generally comprises an open-ended grid-like framework **12** of receptacle-like configuration. An open-ended overall outer metal shell **14** is disposed within the framework **12** and an inner open-ended overall metal shell **16** of roughly H-shaped configuration in plan view is removably disposed within and in spaced relation to the outer shell **14**. A uniformly compacted mass of thermal resistant particulate material **18** preferably powdered alumina can be advantageouly interposed between and fill the cavity between the shells **14** and **16**. The segments for the overall shells **14** and **16** and framework **12** on each side of a centerline of the cell as well as their associated parts have a like configuration and structure; therefore, a description of one side of the cell will suffice for both.

Since the alumina **18** is relatively incompressible and since there is a tendency of the inner shell **16** to thermally expand relative to the outer shell **14**, suitable resilient means such as tubes **140** can be disposed between the inner and outer shells **16** and **14** so as to compensate for the relative thermal expansion between the shells, thereby preventing fracture of either one of the shells **14** and **16** during operation of the cell **10**.

Each of the inner and outer shell segments is preferably made up of weldably interconnected plates of a suitable grade of steel. As indicated in FIGS. 1 and 3–4, the inner shell **16** is comprised of a pair of longitudinally spaced segments or portions **21** that terminate at each end in reduced end sections **20** and **24**. The intermediately disposed end or web portion **22** of the inner H-shaped shell **16** is connected to adjacent enlarged portions **21** and the inner shell **16** is flanged outwardly and upwardly at the upper end thereof in the manner illustrated at **26** in FIGS. 2A, 3 and 4.

As indicated in FIGS. 2, 2A, and 4, spaced divider elements **28** are disposed within the overall inner shell **16** adjacent the upper end thereof and extend in a direction generally transverse of the longitudinal axis of the cell **10**. The longitudinal ends of each one of the divider elements **28** are connected to and supported by opposed ledges **124** provided in opposed sidewall portions of the inner shell **16** at a reduced end portion **20** or **22** or **24**, as the case may be. As will become more apparent hereinafter, the dividing elements **28** advantageously divide the opening of the overall inner shell **16** in to a plurality of feed chambers **32**, **34** and **36** and two electrolytic chambers **40** and **40**. These chambers **32**, **34**, **36**, and **40**–**40** of the inner shell **16** beneath or below the four divider elements **28** and above the bottom of the inner shell **16** are in direct open intercommunication with each other. The flange **26** at the top of the inner shell **16** in conjunction with the four dividing elements **28** supports a series of two upstanding refractory liners **42** and another series of two upstanding referactory liners **44** in interposed relation to the series of three liners **42**. A liner **42** circumscribes each of the feed chambers **32**, **34** and **36** at the upper portions thereof and a liner **44** circumscribes

each of the electrolytic chambers **40** at the upper portions thereof.

During operation of the electrolytic cell **10**, the overall inner shell **16** is adapted to receive a predetermined amount of a fused electrolytic bath **46**, containing magnesium chloride and having a density less than the magnesium metal liberated from the bath. By virtue of the liberated magnesium metal **48** being of greater density that the bath, it settles out at the bottom of the inner shell **16** where it collects and can be removed in a suitable manner such as by valved piping (not shown) connected to the bottom of the inner shell **14** as indicated in FIG. 2A. The normal surface level of the bath **46** during operation of the cell is preferably disposed between the top and bottom edges of the refractory liners **42** and **44**. Each one of the pair of electrolytic chambers **40** is covered at the top thereof and at a distance above the normal surface level of the electrolytic bath **46** by a refractory lined closure element **50**.

Each one of the pair of closure elements **50** includes a series of three longitudinally spaced apertures **52** for slidably receiving carbon anodes **54** of generally rectangular shape in transverse cross section. At least one opening **64**, see FIG. 2A, is provided in each of the covers **50** for exhausting the gaseous chlorine liberated from above the surface level of the electrolytic bath **46** in the electrolytic chamber **40** associated therewith when the cell **10** is being operated. Similarly, the open ends of each one of the reduced portions **20**, **22**, **24** of the inner shell **16** is covered by an apertured cover plate **66**, thereby enclosing the associated feed chambers **32**, **34**, **36** at a distance above the normal surface level of the electrolyte **46** disposed therein. Each one of two series of six pairs of cathodes **56** is connected to the inner and outer shells **14** and **16** and disposed in either one of the enlagred portions **21** of the inner shell **16**. Each one of several pairs of cathodes **56** in chambers **40** are connected to the inner and outer shells **14** and **16** as well as being disposed along the longitudinal axis of the cell **10** in spaced relation to each other. They are also disposed in a direction transverse to the longitudinal axis of the cell **10** in such fashion that the inner ends of a given pair of aligned cathodes **56** are slightly spaced from each other while being disposed within the opening of the inner shell **16** at an enlarged portion **21** thereof. As indicated in FIGS. 3 and 5, the spaced inner ends of a given pair of aligned cathodes **56** are interconnected by a device **58**. The outer ends of a given pair of aligned cathodes **56** extend outwardly of the outer shell **14** for electrical connection to a D.C. source (not shown).

A support assembly **60** attached to the upper end of each one of the three anodes **54** associated with one of the pair of cover elements **50** and is connected to the upper end of the framework **12** for slidably disposing each one of the three anodes **54** within their associated apertures **52** and in spaced and operative relation to adjacent pairs of spaced cathodes **56**. Each support assembly **60** can be used to effect electrical connection of its associated anode **54** to a D.C. source (not shown). A water cooling device **62**, see FIG. 6, may be attached to an opposed side of a support assembly **60**, to maintain the anode **54** at a desired temperature level during operation of the cell **10**.

The open-ended grid-like framework **12** is generally comprised of a plurality of spaced I-shaped beams **70**, a pair of spaced channel-shaped beams **71**, and a plurality of upstanding spaced T-shaped elements **72**. The series of spaced I-shaped beams **70** and channel-shaped beams **71** form the bottom of the framework **12**. The upstanding T-shaped elements **72** form the opposed end and sidewalls of the framework **12** and are disposed about the sidewall perimeter of the cell **10**. The lower ends of certain ones of the T-shaped elements **72** at the opposed sidewalls of the framework **12** are connected to the upper flanged end portions of the I-shaped beams **70**, as indicated in FIG. 3.

On the other hand, as depicted in FIGS. 1–2, other spaced T-shaped beams **72** are disposed at the end sidewalls of the framework **12** and are somewhat longer than the first mentioned T-shaped beams **72** on the opposed sidewalls thereof. These other spaced T-shaped beams **72** are connected at their lower ends to intermediate portions on the back side of the web of either one of the pair of the channel-shaped beams **71**. As indicated in FIG. 2, by virtue of the other T-shaped end sidewall beams **72** being somewhat longer than the first mentioned opposed sidewall beams **72**, the upper ends of the end sidewall beams **72** of the framework **12** extend somewhat above the upper ends of the sidewall beams **72** thereof, the purpose of which will be set forth more fully hereinafter.

With reference particularly to FIGS. 1 and 3, it will be observed that the upwardly opening outer shell **14** is generally comprised of telescopically-connected lower and upper sections **74** and **75** disposed within the upwardly facing recess of the framework **12**. The lower section **74** includes a series of interconnected steel plates arranged to form a shallow upstanding box-like structure. The lower portion of shell **14** also includes opposed side plates **76** extending the full length of the framework **12** between the end sidewall beams **72** thereof and further includes end plates **78** extending the width of the framework between the inwardly disposed free edges of the web portions of the oppose sidewall beams **72**.

The side and end plates **76** and **78** of the lower section **74** are of the same height and the upper edges of all the side and end plates **76** an **78** include a common interconnected flange **80** of angle-shaped configuration that extends in an outward and downward direction about the sidewall perimeter of the framework **12**. The flange **80** extends laterally outward a distance shorter than the depth of the web portion of a given beam **72** of the framework **12** as illustrated in FIG. 2. At the point where the flange **80** intersects the web portion of a given beam **72**, it is provided with recesses, only one of which is indicated at **81** in FIG. 2, so that the web portion of a given beam **72** can be freely inserted and anchored therein. The common flange **80** at the top of the side and end plates **76** and **78** not only reinforces the same but also facilitates telescoping connection of the upper section **75** to the lower section **74**, as will be subsequently described.

A bottom plate **82** extends freely between and is connected to the lower aligned edges of the side and end plates **76** and **78** and is further connected to the top of the beams **70** and **71** forming the bottom of the framework **12**. The side and end plates **76** and **78** are connected to the inner free ends of the web portions of the upstanding end and sidewall beams **72** of the framework adjacent the bottom thereof. Thus, the side, end and bottom walls **76**, **78** and **82** of the lower section **74** of the inner shell **14** in being connected to the beams **70**, **71** and **72** of the framework **12** holds the beams thereof in spaced relation while further rigidifying the framework **12**.

A pair of plates **84** at their longitudinal ends extend fully between and are connected at one extremity to the opposed inside surface portions of the end plates **78** of the lower section of shell **14** at each end thereof in such fashion that the plates are inclined in a downward and inward direction at the bottom of the lower section **74** of the inner shell **14**. At the same time the opposed longitudinal edges of each one of the pair of plates **84** are connected to spaced intermediate surface portions of a side plate **76** and the bottom plate **82** in order to provide the bottom of the lower section **74** with a configuration that is roughly V-shaped in transverse cross-section. The V-shaped bottom of the lower section **74** of the outer shell **14** not only facilitates centering of the inner shell **16** relative to the outer shell **14** during assembly of the inner shell into the cavity of the outer shell, but also provides for uniform compaction of the mass of powdered alumina **18** disposed between the shells **14** and **16**. Reinforcing elements, not shown, can be provided to

extend between and be connected to a plate **84** and the underlying end portion of the bottom plate **82**.

The upper section **75** of a segment of the outer metal shell **14** is made up of opposed side plates **86** of a length somewhat less than the end plates **78** of the lower section **74** but of a height corresponding to the height of the side plates **76** of the lower section **74**. The side and end plates **86** and **88** of the upper section **75** are interconnected together in a suitable manner, such as by welding, to form a tubular upper section that is adapted to overlappingly engage the upper edge of the lower section **76** about the periphery of the cell as illustrated in FIG. 1.

By virtue of the side and end plates **86** and **88** being of a length somewhat shorter than the corresponding plates on the lower section **74** of the outer shell **14**, the outer surface portions of the upper section **75** freely fit between the surrounding and adjacent free edges of the webs of the beams **72** of the framework **12**, as indicated by the clearance space at **90** in FIGS. 2–2A and 3.

The top of the upper section **75** of the overall outer shell **14** is reinforced by a surrounding box beam assembly **92** connected thereto. The box beam assembly **92** is comprised of four channel-shaped elements **94** and **96** respectively. Each one of the four channel-shaped elements **94** of one series of such elements is of a length corresponding to the length of the opposed side plates **86** of the upper section **75** of the outer shell **14**.

Each one of the four channel-shaped elements **96** of the second series is of a smaller configuration in transverse cross section than the channel-shaped elements **94** of the first series. The four channel-shaped elements are also arranged in two pairs in a corresponding fashion so as to form two smaller box beam sections. Each one of the two smaller box beam sections is of a length longer than the length of an end plate **88** of the upper section **75** of the outer shell **14**. As indicated in FIGS. 2–2A and 3, the two larger box beam sections comprised of the first series of four channel-shaped elements **94** are affixed to outside surface portions of opposed side plates **86** of the upper section **75** of the outer shell **14** adjacent the top edge thereof. The smaller two box beam sections made up of the four channel-shaped elements **96** of the second series are affixed to outside surface portions of the end plates **88** of the upper section of the outer shell adjacent the top edge thereof in such fashion that the upwardly facing back sides of the top webs of the elements **94** in the smaller box beam sections are disposed in planar alignment with the upwardly facing back sides of the top webs of the elements **94** in the two larger box beam sections. At the same time the longitudinal ends of either one of the smaller box beam sections overlap and are connected to adjacent longitudinal ends of the two larger box beam sections of elements **94**, thereby forming a rigidfied beam assembly **92**, as indicated in FIGS. 2–2A and 3. If desired, a series of four angle-shaped reinforcing elements **98** may be disposed about and affixed to the outer peripheral surface portions of the box beam assembly **92**, as illustrated in FIGS. 2–2A and 3. Finally, a plurality of four interconnected angle-shaped elements **99** may be affixed to the outside of the top edge of the upper section **75** of the outer shell **14** above the box beam assembly **92** for reinforcing the upper edge thereof.

Channel-shaped shoe elements **100** corresponding to the number of the beams **72** of the framework **12** are advantageously affixed to preselected surface portions of the downwardly facing side of the web of the lower beams **94** and **96** of beam assembly **92** in spaced relation to each other in such a fashion that any one of the relatively spaced elements **100** of the series thereof is disposed in alignment with the upper end of its associated beam **72** of the framework **12**. In effecting assembly of the upper section **75** of the outer shell **14** to both the lower section **74** thereof and the upstanding beams **72** of the framework **12**, the affixed shoe elements **100** are adapted to be aligned with and overlap the upper ends of their associated beams **72** in such a manner that the upper longitudinal end faces of the beams **72** abuttingly engage the downwardly facing web portions of the beams **94** and **96** making up the beam assembly **92**. The abutting engagement between the downwardly facing web portions of the beams **94** and **96** and the upper ends of the beams **72** is enhanced by the influence of gravity acting on the overall mass of the upper section **75** of the outer shell **14**.

As depicted in FIGS. 2, 2A and 3, shoe elements **100** in overlappingly engaging the upper ends of their associated beams **72** cooperate with these beams during use of the cell **10** to hold outside surface portions of the upper section **74** in spaced relation to the adjacent free edges of the webs of the beams **72** of the framework **12**, by the clearance space **90**. At the same time, the abutting engagement of the upper longitudinal end faces of the beams **72** with the downwardly facing web portions of the box beam assembly **92** precisely limits the overlapping telescoping engagement of the upper edge of the lower shell segment **74** with the lower edge of the upper shell segment **75**, as shown in FIGS. 2–2A and 3.

As indicated in FIGS. 2–2A and 4, each main segment of inner shell **16** is comprised of side plates **102** that form the opposed sidewalls of the longitudinally spaced enlarged portions **21** or legs of the roughly H-shaped overall inner shell **16**. Similarly, pairs of side plates **104** of smaller overall size than the plates **102** form the opposed sidewalls of the reduced portions **20**, **22** and **24** of the inner shell **16**. Each one of the smaller side plates **104** is offset laterally inward of an adjacent sidewall **102** relative to the longitudinal axis of the cell **10**. The opposed sidewalls **102** of each one of the pair of enlarged portions **21** and the opposed sidewalls **104** of each one of the reduced portions **20**, **22** and **24** are interconnected by shouldered walls **106** that extend in a direction transversely of the longitudinal axis of the cell **10** and are spaced longitudinally therealong in such fashion that any one shouldered wall **106** of a given pair of transversely aligned walls **106** is interconnected at its opposed side edges to the adjacent longitudinal side edges of adjoining and laterally offset sidewalls **102** and **104** on either side of the longitudinal axis of the cell **10** as best shown in FIG. 1.

The outermost longitudinal side edges of the opposed sidewalls **104** of the reduced end portions **20** and **24** at either longitudinal end of the inner shell **16** are interconnected by an end plate **110** that forms a longitudinal end wall thereof. The upper edges of the interconnected side, shouldered and end walls **102** and **104**, **106** and **110** making up the inner shell **16** are all aligned as evident from an inspection of FIG. 1.

The overall bottom of the inner shell **16** in transverse cross-section advantageously has an approximate shallow V-shaped configuration similar to the bottom of the outer shell **14**. To this end, the lowermost edges of the beveled end walls **110** thereof are interconnected by a centrally disposed bottommost plate **112**. The lower beveled edges of each one of the pair of end walls **110** extending between the lowermost edge of each one of the pair of end walls **110** and an opposed side edge thereof are inclined in a direction upwardly and outwardly of their associated lowermost edge on either side of the longitudinal axis of the cell **10**. Similarly, the lower edges of each pair of transversely aligned shouldered walls **106** of the four pairs thereof are laterally offset outwardly of the lower beveled edges of the end plates **110** and are beveled in similar fashion on either side of the longitudinal axis of the cell **10**. By virtue of the lower edges of the opposed sidewalls **102** of an enlarged portion **21** of the shell **16** being aligned with the outermost lower ends of the shouldered walls **106**, the height of each one of the opposed sidewalls **102** of the shell **16** is less than the height of each one of the opposed sidewalls **104** of the reduced

portions 20, 22 and 24 thereof. The bottom of the segment of the inner shell 16 includes a pair of inclined plates 114 secured to bottom plate 112. Each plate 114 is comprised of a pair of spaced intermediate enlarged portions and a series of three interposed reduced portions one of which is disposed intermediately of the enlarged portions of a plate 114 and the other two of which are disposed at the outer ends of the enlarged portions thereof. A given plate 114 is of an overall length corresponding to the length of the inner shell 16 between the end walls 110 thereof. The reduced and enlarged portions of the given plate 114 are disposed in alignment with their associated reduced and enlarged portions 20, 22 and 24 and 21 and 21 of the inner shell. Thus, as indicated in FIGS. 1, 2A and 3–4, when each one of the pair of plates 114 is connected to the associated lower side edges of opposed sidewalls 102 and 104, the lower beveled edges of the shouldered and end walls 106 and 110 and to an adjacent longitudinal side edge of the bottom plate 112, the bottom of the inner shell 16 is fully closed off.

Each divider element 28 is generally comprised of a tubular steel sleeve 120 of rectangular shape in transverse section and a baked carbon or graphite block 122 disposed within the opening of the sleeve 120 and extending between the ends thereof. Sleeve 120 can be perforated to facilitate the evaporation of moisture from the carbon block 122 disposed therewithin. One of the purposes of the sleeve is to shield the carbon block 122 during initial heating of the cell 10, particularly prior to the feeding of an electrolytic bath thereto, so as to prevent oxidation thereof.

The top of the inner shell 16 is outwardly flanged at 26 so as to include an upstanding flange 118 interconnecting shoulder 116. Flange 118 and shoulder 116 extend fully about the upper periphery of the inner shell. The shoulder 116 is cut away at various points along the cell periphery so as to define upwardly-facing ledges 124 in the areas of mergence of the main cell segments and the intermediate and end projections 32, 34 and 36. Each transversely aligned pair of ledges 124 is adapted to engage the ends of a divider 28 in order to support the divider 28 disposed therebetween so that its top surface is aligned with the shoulder 116.

The refractory liner 44 circumscribing the top of the inner shell 16 at each one of the enlarged portions 21 thereof is carried by portions of the shoulder 116 and the top surface portions of an adjacent pair of dividers 28 at the longitudinal ends of each one of the enlarged portions 21. As indicated in FIGS. 2A, 3 and 4, the liner 44 is comprised of a plurality of suitably arranged bricks 125 of an appropriate refractory material. By applying a suitable coating to the exposed faces of the bricks, the inner shell 16 can in effect be made impervious to the electrolytic bath 46 and to the chlorine liberated at the surface level thereof.

The upper edge of the inner row of bricks 125 is offset upwardly of the upper edge of the outer row of bricks 125 in each one of the liners 44, as shown in FIGS. 2A, 3 and 4. A strip of refractory material 126 is cast about the offset top edges of the inner and outer rows of bricks 125, thereby locking the strip 126 to the bricks and forming the top edge of a liner 44 to which the cover 50 is sealably connected for closing off the top of an associated electrolytic chamber 40. The combined weight of the cover 50 and the liner 44 in each one of the pair of enlarged portions 21 effectively counteracts the bubbling action of the electrolytic bath 46, thereby maintaining the seal connection between the liner 44 and associated portions of the flange 26 and adjacent pair of dividers 28.

The refractory liner 42 for each one of the reduced portions 20, 22 and 24 of the inner shell 16 at the top thereof is comprised of a suitable refractory material cast-in-place in conventional fashion. The refractory liner 42 for each one of the longitudinal reduced end portions 20 and 24 is carried by the outer end portions of the shoulder 116 of the flange 26 and a top surface portion of an endmost divider 28 associated therewith as illustrated in FIGS. 2A and 4. Similarly, the refractory liner 42 for the intermediate reduced portion 22 is carried by opposed intermediate portions of the shoulder 116 of the flange 26 and top surface portions of the adjacent pair of dividers 28 associated therewith. Each reduced end portion 20 or 24 of the cast-in-place liners 42 is confined by portions of the flange 26 and by a divider 28 and adjacent end portions of a liner 44 associated therewith. The intermediately disposed liner 42 in being cast-in-place is confined by opposed portions of the flange 26 and by adjacent pairs of dividers 28 and adjacent end portions of the liners 44. The top of each liner 42 extends above the top edges of both the upstanding flange 118 and the pair of refractory liners 44, as illustrated in FIG. 2 and since these liners form extensions of the dividers 28, they act in conjunction with dividers 28 to effectively separate the upper portions of the feed chambers 32, 34 and 36 from the upper portions of the electrolytic chambers 40 and 40. The liners 42 and 44 also effectively prevent corrosive attack of the electrolytic bath 46 at the top of the inner metal shell 16 when the cell 10 is operating.

A series of pairs of opposed elongated slots 131 (see FIG. 2) are provided on opposed sidewalls 102 in each of the enlarged portions 21 of the inner shell 16 and these slots 131 in conjunction with the slots 133 in outer shell 14 receive the cathode plates 56. As noted above, the inner ends of a pair of cathodes 56 are slightly spaced from each other and they are spliced together by splicing bar assembly 58. Splicing bar assembly 58 can include a grooved block 132 with the groove 134 of the block 132 slidably reeciving the splice bar 130. One end of the bar is affixed to one of the cathode plates 56 and the block is affixed to the opposing cathode plate 56 to complete the circuit therebetween.

The lower offset upper edge of the cathodes 56 is adapted to contact the bottom of the slotted openings 133 in shell 14 when the upper section 75 of the outer shell 14 is telescopingly connected to the lower section 74 thereof and with the beam assembly 92 being in abutting engagement with the upper ends of the beams 72 of the framework 12, as aforedescribed. In order to assure proper abutting engagement of the bottom of an inverted slot 133 with a given cathode 56, the width of slot 133 is slightly greater than the thickness of the given cathode 56 and the depth of a slot 133 is slightly greater than the height at the lower offset upper edge thereof.

The outer end of a cathode plate 56 is electrically connected by a plurality of lead-in bus-bar strap elements (not shown) to a bus-bar terminal bracket 141 affixed to opposed sides of the framework 12 at the lower longitudinal ends of a given pair of beams 70 thereof. To facilitate connection of a lead-in strap element (not shown) to the outer end of a cathode 56, the cathode includes a series of apertures as depicted in FIG. 3.

Legs 136 affixed to the outside surface portions of the bottom plates 112, 114 and 114 of the inner shell 16 act when the inner shell 16 is lowered by a hoist or the like into the upwardly facing open cavity of the lower section 74 of the outer shell 14 to maintain the inner and outer shells 14 and 16 in the proper centered and spaced relationship to each other. After lowering of the inner shell 16 into the lower section of the outer shell 14, the upper section 75 of the outer shell 14, by the action of a hoist or the like, is connected to the upper ends of the beams 72 of the framework 12 and the lower section 74 thereof in such manner that the inverted U-shaped slots 133 of the upper section 74 of the outer shell 14 freely pass over their associated cathode plates. With reference to FIG. 1, a series of holes or bail elements 127 only some of which are shown are provided about the top edge of the inner shell 16 for facilitating attachment of a cable rig, not shown, in suitable manner in order to effect hoisting of the inner shell into and out of the upwardly facing cavity of the lower section 74 of the

outer shell **14**. Similarly, a series of holes are provided about the top edge of the upper section **74** of the outer shell **14** for facilitating attachment of a cable rig (also not shown) in order to effect hoisting of the upper section **75** into and out of connection with the lower section **74** of the outer shell **14** and the beams **72** of the framework **12**.

After assembly of the upper section **75** of the outer shell **14** to the cell **10**, each slot **133** is sealed from the atmosphere by angular flange sealing elements **135** (see FIG. 2). A given pair of angular flange elements **135** are connected to outside surface portions of an opposed sidewall **86** of the upper section **75** and disposed on opposed sides of an outer apertured end of a cathode **56**. One leg section of each sealing element **135** includes openings for receiving cap screw assemblies **137** in order to effect attachment of the element **135** to the outside of an opposed sidewall **86** of the upper section **75**. In effecting attachment of one leg section of each element **135** to the opposed sidewall **86** of the upper section **75**, the other leg section thereof is disposed in sealing engagement with one side of a given cathode **56** at the outer end thereof. The sealing of slots **133** prevents leakage of the powdered alumina **18** disposed in the space between the shells **14** and **16**. If desired, the slots **133** can be made long enough so that reinforcing bars **139** can be sandwiched in between the tops of cathode plates **56** and the bottom of the inverted slots **133** in the manner illustrated in FIG. 2.

When the inner shell **16** is disposed within and in spaced relation to shell **14** as aforedescribed, powdered alumina **18** is added to the space between the shells **14** and **16** in a suitable manner and compacted. By virtue of the approximate V-shaped bottoms of the shells **14** and **16**, the alumina **18**, under the influence of gravity, is sufficiently and uniformly compacted to a desired mass and density between the shells **14** and **16** in an appropriate fashion. During operation of the cell **10** at an elevated temperature level, the inner shell **16** tends to expand relative to the outer shell **14**, particularly along the longitudinal axis of the cell **10**. Since the compacted alumina filler **18** is relatively incompressible, this expansion of shell **16** could cause rupture of either shell **14** or **16** unless compensated for. This compensation is effected by the use of resilient upstanding tubes **140** disposed adjacent end walls of shells **14** and **16**, as depicted in FIGS. 2A and 4.

Each of the covers **50** includes inwardly directed flange elements anchored in the cast-in-place refractory portions of the covers. A plurality of I-beams **146** extend crosswise to and are connected to the cover **50** by means of brackets **148**.

Each cover **50** is provided with a series of support blocks **150** which have a frusto-conically shaped bottom and a cylindrically shaped top. Clips **152**, portions of which engage beams **146** and other portions of which engage support blocks **150**, are used to secure the blocks **150** to beams **146**.

The cover **50** is completed by means of a cast-in-place refractory **144**. The refractory wall **144** is disposed within the confines of the opening delineated by the peripheral flange **142** in such fashion that the castable refractory material of the wall **144** is cast about all the blocks **150** between the ends thereof and about the lower flanged ends of the surrounding channel-shaped elements **142**, as illustrated in FIG. 1. In casting the wall **144** appropriate removable cores (not shown) are employed to locate and define a series of three apertures **52** for receiving the three anodes **54**, as well as to locate and define at least one opening **64** for exhausting the chlorine which is liberated from the bath **46** during operation of the cell **10**.

A cover **50** is hoisted by the usual means onto the top of the cell **10** and into nesting and sealing engagement with the upper surface of the strip **126** of the refractory liner **44** of its associated enlarged portion **21** of the inner shell **16**. If desired, a circumscribing rectangular groove **154** can be formed in the top of the strip **126** and a surrounding length of compressible asbestos rope **156** or the like disposed in the groove **154**. The rope **156** acts to also sealably connect a cover **50** to the top strip **126** of the associated liner **44**. As depicted in FIGS. 2A and 3, each one of the covers **50** may be further sealably connected to the associated refractory strip **126** by packing alumina **18** between the outer periphery of a cover **50** and the top peripheral edge portions of the outer shell **16** and between the adjacent recessed top edge portions of the refractory liners **42** of the adjoining reduced portions **20** and **22** or **22** and **24**, as the case may be.

A series of apertured sealing blocks **158** are associated with each aperture **52** of the pair of covers **50**. Each sealing block **158** is comprised of a castable refractory wall having an upwardly and outwardly flared opening **160** for sealably receiving an anode **54**. The opening **160** is smaller than an aperture **52** of a cover **50**. A sealing block **158** is reinforced by means of interconnected braces **162** connected to the outer periphery of the castable wall thereof. In overall size each block **158** is smaller than the upwardly facing counterbore of its associated aperture **52** of a given cover **50** and it is adapted to be sealably and slidably disposed against the shoulder defining the bottom of the counterbore thereof, as depicted in FIGS. 2A–3.

The support assembly **60** for each anode **54** includes opposed channels **164** and a pair of bus-bar elements **168**. The bus-bar elements **168** are interposed between the upper end of an anode **54** and the back sides of the webs of the channels **164**. Bolt-nut assemblies **166** pass through aligned apertures in the channels **164**, the interposed bus-bar elements **168** and an anode **54**, thereby clampingly assembling channels **164** and bus-bar elements **168** to the anode **54**. In connecting the pair of channel-shaped elements to an anode **54**, the upper flanges thereof are offset upwardly of the top of the anode **54** and bus-bar elements **168**, as indicated in FIG. 2A. The bus bars **168** are longer than the channel-shaped elements **164** and extend beyond the opposed sides of the framework **12**, as indicated in FIG. 3.

Channel-shaped legs **174** are connected in depending fashion to the longitudinal ends of each pair of channel-shaped elements **164** of a support assembly **60** and the upper end of each leg **174** includes a flange **176**. An angle-shaped strap element **178** extends across the top flanges of a pair of channel-shaped elements **164** at either longitudinal end thereof. A strap element **178** and a depending leg **174** are clampingly connected to the flanges at either longitudinal end of a pair of channel-shaped elements **164** by a pair of bolt-nut assemblies **180** passing through aligned apertures in the outer ends of both the strap element **178** and the upper flange **176** of the leg **178**. In clampingly connecting a pair of the legs **174** to the longitudinal ends of a pair of channel-shaped elements **164** of a support assembly **60**, the lower end of the legs are aligned with opposed longitudinally extending sides of the framework **12** of the cell **10** at the top of the box beam assembly **92**. Thus a given support assembly **60** and an anode **54** after attachment to the support assembly **60** can be hoisted as a unit to the top of a cover **50** for connection thereto in such manner that the lower free end of the anode **54** is lowered through the aligned apertures **160** and **52** of a sealing block **158** and the cover **50** and into the electrolytic chamber **40** disposed beneath the cover until the lower ends of the legs **174** of the given support assembly **60** abuttingly engage the top of the box beam assembly **92**. At this time the lower end of the anode **54** is disposed between adjacent pairs of cathodes **56** in spaced and operative relation thereto as depicted in FIG. 4. By virtue of a given support assembly **60** having its spaced legs **174** in nesting engagement with the box beam assembly **92** and by virtue of the anode **54** being disposed freely in an aperture **52** of a cover **50**, the anode **54** is free to move relative to the cell **10** during operation thereof, thereby preventing breakage of the anode **54**.

The longitudinal ends of bus elements **168** associated with a support assembly **60** are connected to a D.C. source (not shown). A plurality of bus-bar terminal brackets **172** are connected to beams **72** intermediate the ends thereof on opposed sides of the framework **12**. The longitudinal ends of bus-bar elements **168** of a support assembly **60** are electrically connected to a pair of brackets **172** by a pair of lead-in strap elements (not shown). Brackets **172** are electrically insulated from the framework **12** and the cathodes **56** by a series of insulating strips **170**. Since the pair of legs **174** of a support assembly **60** are electrically connected to the framework **12**, a pair of strips **182** are used to electrically insulate a leg **174** from its associated support assembly **60** at either end thereof. One of the insulating strips **182** is interposed between the strap **178** and the top of the upper flanges of the channel-shaped elements **164** of a support assembly **60** at either end thereof as indicated in FIGS. 2–2A and 3. The other strip **182** is interposed between the flange **176** and the bottom of the lower flanges of the channel-shaped beams **164** of the support assembly **60** at either end thereof. If desired, a spacer element **184** can be interposed between the bottom flanges of a pair of channel-shaped elements **164** and the associated insulating strip **182** adjacent the upper flange **176** of the leg **174**. The brackets **172** in being affixed to the beams **72** on opposed sides of the framework **12** are advantageously spaced relative to the outer ends of the cathodes **56** so as not to interfere with the connection and disconnnection of the outer and inner shells **14** and **16** of the cell **10** to the framework **12** thereof as indicated in FIGS. 2–3.

In order to prevent excessive burning of the anodes **54** during operation of the cell **10**, a water cooling device **62** or the like can be affixed to at least one of the channel-shaped elements **164** of the support assembly **60**. With reference to FIGS. 6–7, the cooling device generally comprises a channel-shaped cover **186** of a longer length than the channel-shaped elements **164**. The flanged ends of the cover **186** are indented inwardly and downwardly to facilitate their attachment to the flanged ends of an associated channel-shaped element **164**. Appropriate bolt assemblies **188** securely attach the cover **186** to the associated channel-shaped element **164**. The longitudinal ends of cover **186** include appropriate inlet and outlet fittings **192** and **194** for connection to an external water source, not shown. To facilitate extraction of heat from an anode **54**, a series of spaced fins **190** can be affixed to the outwardly facing surface of a web of a given channel-shaped element **164** of a support assembly **60**, as shown in FIGS. 6–7.

Feed chambers **32**, **34** and **36** are covered by an apertured plate **66** that extends between the upper edges of the outer shell **16** and the adjacent side portions of a cover **50** or adjoining covers **50**, as the case may be, in the manner shown in FIGS. 2–2A and 4. A cover **198** can be hingedly connected to the plate **66**, thereby covering the aperture thereof.

In an operative embodiment of the cell **10** of the instant invention, the cell **10** with the anodes **54** initially removed can be heated up to an operating temperature on the order of 1300 to 1500° F. Then the fused electrolytic bath **46**, containing magnesium chloride and having a density less than the magnesium metal produced thereby, can be added to the heated cell **10**. One suitable electrolyte that can be used is that set forth in the U.S. Pat. 2,950,236 to Dean et al. granted on Aug. 23, 1960. Appropriate gas-type and electrical heaters, not shown, can then be inserted through the openings of the feed chambers **32**, **35** and **36** and the apertures **52** of both cover elements **50**. When the cell **10** is brought up to an operating temperature and after adding the electrolyte **46** until its surface level is between the top and bottom of the refractory liners **42** and **44** in the manner shown in FIG. 1, the cell **10**, by virtue of the powdered alumina **18**, can be maintained at an optimum operating temperature of about 1400° F. by merely having the heaters, not shown, disposed in the openings of the feed chambers **32**, **34** and **36**, thereby keeping the electrolyte **46** in the molten state. At this time, the anodes **54** and their associated support assemblies **60** are connected to the cell **10**. After connection of the anodes **54**, the D.C. source, not shown, is connected to the cell **10**, and the heaters removed. Then the cell **10** will continue to operate to produce magnesium that settles to the bottom of the inner shell **16** and liberates gaseous chlorine from the bath **46** at the top of the electrolytic chambers **40** and **40**. The gaseous chlorine is removed through the opening **64** for subsequent processing, and the magnesium metal is removed periodically from the feed chambers **32**, **34** and **36** in an appropriate manner, for example, by piping, not shown, connected to the bottom of the inner shell **16**. The feed chambers **32**, **34**, **36**, by virtue of the dividers **28** and refractory liners **42** and **42**, enable the electrolytic bath **46** to be replenished during operation of the cell without interfering with the electrolytic bath producing chlorine and magnesium metal in the electrolytic chambers **40**. In replenishing the bath **46** with a magnesium chloride feed, it may even be hydrated since the bath **46** in being at an elevated temperature during operation of the cell **10** will effect dehydration of the magnesium chloride feed before it circulates to the electrolytic chambers **40**.

By virtue of the cell **10** of the instant invention being constructed in the manner aforedescribed, access to selected interior portions of the cell **10** may be readily obtained for normally servicing certain parts thereof, such as repair or replacement. The powdered alumina **18** disposed in the space between the shells **14** and **16** may be selectively removed by an appropriate suction device (not shown) in vacuum cleaner fashion thereby enabling access into the space between the shells. If it is desired to remove one or more support assemblies **60** with their anodes **54**, the bus-bars **168** associated with the anodes **54** are disconnected from their associated bus-bar terminals **172**, thereby electrically disconnecting anodes **54** from the D.C. source (not shown). During removal of the support assemblies **60** with their anodes **54**, the bath **46** within the inner shell **16** may be maintained at operating temperature by auxiliary gas heaters (not shown) wherein the gas heaters (not shown) are inserted through an anode opening **52** or a feed opening **32** or **34** or **36** in a cover **198** of the inner shell **16**.

If it is necessary to remove the upper section **75** of the outer shell **16** in order to service the cell **10**, a substantial part of the powdered alumina **18** must be removed as well as all the support assemblies **60** with their anodes **54**. After withdrawing the angular members **135** from engagement with their associated cathode element **56** by loosening of the cap screw assemblies **137** in conventional fashion, the upper section **75** of the outer shell **14** can be disconnected from the lower section thereof and the beams **72** of the framework **12** by a suitable hoist connected to the holes at the top of the upper section **75** thereof.

The inner shell **16** after removal of the upper section **75** of the outer shell **14** can be disconnected from the lower section **74** of the outer shell **14** by use of a suitable grapple device having hooks insertable in the holes at the top thereof. Prior to hoisting the inner shell **16** out of the outer shell, the auxiliary gas heaters (not shown) are withdrawn from the inner shell **16**. At the same time, the cathodes **56** are disconnected from their associated bus-bar terminals **141**, thereby electrically disconnecting the cathodes **56** from the D.C. source (not shown). Thus, except for removal of the inner shell **16**, the overall cell may be serviced without interfering with the operation thereof.

Depending upon the capacity of the cell **10**, it should be understood that only one anode and cathode may be required as well as only one feed chamber and one electrolytic chamber wherein the chambers are partially separated by a divider. Further, the anodes and cathodes could be cylindrical instead of rectangular as shown. Although the refractory liner **44** is comprised of refractory bricks **125**, the liner **44** could be comprised of a suitable cast-in-place refractory material. It is to be understood that even

though the cell **10** of the instant invention has been described with reference to use of an electrolytic bath having less density than the magnesium metal produced, it is not to be limited thereto. By virtue of the grid-like framework **12**, the cell **10** can be constructed above or below a floor level. Depending upon the construction of the outer shell **14** for a given installation of cell **10**, the outer shell may be made sufficiently strong enough to obviate the use of a separate framework **12** for supporting the same.

The removable filler is preferably powdered alumina **18**, but it is to be understood that any suitable filler material can be used, for example, a granular material or a fluid material or even a solid material such as magnesia brick. Regardless of the removable filler material used, it should have sufficient strength to withstand the forces exerted thereon during operation of the cell **10** and the elevated temperatures at which the cell **10** is operated.

A preferred embodiment of the cell of the instant invention which is made up of readily removable and replaceable parts has been specifically illustrated and described, and it will be understood that the invention is not to be limited thereto, as many variations will be apparent to those skilled in the art and the invention is to be given its broadest interpretation within the terms of the following claims, wherein:

What is claimed is:

1. An electrolytic cell for producing magnesium metal and the like, said cell comprising a pair of open ended shells one of which is nested within and at least partially spaced from the other, and means for telescopingly connecting the upper section of the outermost shell to the lower section thereof, said inner shell comprising a bottom and upstanding sidewalls for holding the electrolyte, and containing at least one anode and at least one cathode.

2. An electrolytic cell as set forth in claim **1**, including means interposed between said inner and outer shells and compensating for the thermal expansion of the inner shell relative to the outermost shell so as to prevent fracture of either one of the shells.

3. An electrolytic cell as set forth in claim **1** in which said shells are comprised of a ferrous metal.

4. An electrolytic cell as set forth in claim **1**, wherein the walls of said shells are provided with sealable openings for receiving at least one cathode element.

5. An electrolytic cell as set forth in claim **1**, wherein the cathode element comprises segments connected together so as to maintain alignment of said cathode element segments during operation of said cell.

6. An electrolytic cell as set forth in claim **1** in which the top of said inner shell is provided with a sealable cover means.

7. An electrolytic cell as set forth in claim **1** including divider means extending between and connected to opposite sidewall portions at the upper part of said inner shell, said divider means acting in conjunction with the electrolyte in the cell in order to isolate gases generated during operation of the cell from an electrolyte feeder opening.

8. An electrolytic cell as set forth in claim **1**, including a removable cover provided for floatably and sealably suspending the anode within the inner shell.

9. An electrolytic cell as set forth in claim **1**, including means for cooling the anode.

10. An electrolytic cell as set forth in claim **1**, including stop means on the upper section of said outermost shell for limiting the telescoping connection between the upper and lower sections of said outermost shell.

11. An electrolytic cell as set forth in claim **1**, in which one of the shells is provided with fixed leg means attached to the bottom thereof for engaging the associated portion of the other shell so as to maintain the shells in spaced relation to each other.

12. An electrolytic cell as set forth in claim **1** including a filler material disposed in the spaces between the shells.

13. An electrolytic cell as set forth in calim **12** in which said filler material is powdered alumina.

14. An electrolytic cell for producing magnesium metal and the like, said cell comprising a pair of open ended shells one of which is removably nested within and at least partially spaced from the other, the upper section of the outermost shell being telescopingly connected to the lower section thereof to provide ready access to the inner shell during removal of the inner shell from or installation of the same within the outer shell and filler material removably disposed in spaces between said shells.

15. A cell as set forth in claim **14** wherein the bottom portions of the said shells have converging sidewall portions for facilitating the settling of the filler material in the spaces between the respective shells.

16. A cell as set forth in claim **14** including leg elements on one of the shells and engageable with the other shell for holding at least portions of the shells in spaced relation to each other.

17. A cell as set forth in claim **14** wherein the top sections of the shells are provided with sealable openings for receiving at least one cathode element.

18. A cell as set forth in claim **17** wherein the opening in the upper section of the outer shell is in the form of a downwardly opening slot.

19. A cell as set forth in claim **14** including divider means extending between and connected to opposite side wall portions of the upper part of the inner shell, said divider means acting in conjunction with the electrolyte in the cell during its operation to isolate gases generated during said operation from an electrolyte feeder opening.

20. A cell as set forth in claim **14** including an anode and cooling means for the anode.

21. An electrolytic cell as set forth in claim **14** wherein the filler material is powdered alumina.

22. A cell as set forth in claim **14** including means interposed between said shells for compensating for the thermal expansion of the inner shell relative to the other shell so as to prevent fracture of either one of the shells.

23. A cell as set forth in claim **14** wherein the inner shell is of a greater height than the lower section of the outermost shell and said inner shell being provided with means engageable with a hoisting device.

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