

Complete Specification No. 139827, dated 3rd December, 1973. Application and Provisional Specification No. 2089/1972, dated 8th December, 1972. Acceptance of the Complete Specification advertised on 7th August, 1976.

Index at acceptance—70B[LVIII(5)]

International classification—B01 K 3/02

PROVISIONAL SPECIFICATION

“AN ANODE ASSEMBLY FOR MERCURY TYPE CHLOR-ALKALI CELLS”

COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH, RAJI MARG, NEW DELHI-1, INDIA, AN INDIAN REGISTERED BODY INCORPORATED UNDER THE REGISTRATION OF SOCIETIES ACT (ACT XXI OF 1860).

The following specification describes the nature of this invention:—

This is an invention by RAMASWAMY THANGAPPAN NADAR, Scientist, HANADY VENKATKRISHNA UDUPA, Director, BABU RAM YADAV, Senior Scientific Assistant and PERUMAL SUBBIAH, Junior Scientific Assistant, all of Central Electrochemical Research Institute, Karaikudi-3 Tamil Nadu, India, all Indians.

This invention relates to a titanium substrate insoluble anode assembly for mercury type chlor-alkali cells.

Hitherto it is known to employ graphite, and to a limited extent graphite substrate lead dioxide, magnetite, platinum etc. as anodes in mercury cells used for the electrolysis of aqueous solutions of alkali metal halides. Graphite, when used as anodes in the electrolysis of brine solution to chlorine-caustic soda, chlorate, perchlorate of sodium etc., gets disintegrated in the course of the cell operation and hence the dimensions get altered resulting in larger inter-electrode distance, less pure anode gas, increased power consumption, frequent cell interruptions and down times for maintenance and the employment of more labour. Graphite substrate with massive lead dioxide coatings could not successfully withstand the strains of handling and the high temperature involved in the cell operation is detrimental to the anode. They could not withstand current reversals and amalgam dips in mercury cells. While using substrate like graphite, there is also a limitation to the shapes and configurations that could be provided. Whenever the lead dioxide coating is damaged, disintegration of graphite starts. Magnetite anode structures are very massive; they possess poor mechanical strength; they are not easily machinable. And so, such electrodes are not used in mercury cells for chlor-alkali, though they find some limited use in other electrolysis.

The object of this invention is to obviate these disadvantages by making the substrate out of corrosion resistant titanium or other valve metals like tantalum, tungsten or an alloy of the valve metals in various shapes and configurations to suit a particular cell shape and size, the current being uniformly distributed to the entire base by means of copper or aluminium core clad with titanium or other valve metal and the surface of the base being activated by depositing a metallic or semi-conductive coating.

To these ends, the invention broadly consists in the preparation of anode assemblies illustrated in Figs. 1 to 5 of accompanying drawings) out of a valve metal or an alloy of valve metals such as titanium, zirconium, niobium, tantalum, tungsten, especially titanium which are resistant to corrosion in aqueous electrolytes, especially in the electrolysis of saturated brine to chlorine-alkali, in the form of expanded sheet (figs. 1, 2 and 4) perforated sheet (fig. 5) or square, rectangular, cylindrical bars (fig. 3) shaped to square, rectangular or other shaped base to suit a particular cell shape and configuration, the current being uniformly distributed to the entire base by means of a number of horizontal copper or aluminium core clad

with titanium or other valve metal in conjunction with vertical copper or aluminium cores clad with a valve metal sheet, and the surface of the electrode base being activated by thermally depositing a metallic or semi-conductive coating. The copper or aluminium cores (A) which are tightly fitted into copper coated sleeves (B) of titanium or other valve metal by means of white metal composition, carry the current and distributes uniformly to the entire surface of the anode structure avoiding undue voltage drop in the bulk of the base metal. The edges of the base are welded with strips (C) to provide additional reinforcement to the anode structure. The activation of the surface of the anode is done in accordance with the procedures described in Indian Patent No. 134375 wherein a metallic or semi-conductive coating is provided by depositing platinum or a combination of platinum group metals like rhodium, iridium, ruthenium, osmium and palladium or a combination of the oxides of one or more of platinum group metals and a film forming metal like titanium, zirconium, niobium, tantalum or tungsten, the deposition being effected by thermal decomposition of a paste, a mixture of the various compounds supported in an organic vehicle required to supply the metal or the metal oxide, painted over the polished and etched surface of the substrate and baked at temperatures between 300 and 650 °C in an atmosphere of either limited supply of forced circulation of air.

The following typical examples are given to illustrate the invention.

Example I

A titanium expanded sheet of geometrical area 140cm² was provided with a vertical copper core enclosed in a titanium sleeve the inner surface of which was coated with copper. The copper core was tightly fixed into the titanium tube by introducing a pinch of ammonium chloride followed by molten white metal composition. The core was joined to the expanded sheet by welding (as in figs. 1, 2 and 4). A mixed oxide coating of ruthenium and titanium was given to the surface of the electrode structure from a chelate containing the compounds of both the metals (as described in Indian Patent 134375) and its performance as anode in brine electrolysis in mercury cell for caustic soda-chlorine⁻ was as follows :

Geometrical area of the anode facing the cathode	. =140 cm ²
Details of expanded titanium sheet :	
Thickness of sheet	. =1 mm
Strand width	. =1.5 mm
Diagonal distance of the diamond shaped mesh	. =6 mm × 18 mm
Actual area of the anode	. =Nearly 40% of Geometrical area.
Inter-electrode distance	. =4 mm

Price : TWO RUPEES.

Concentration of NaCl in brine feed	=300—310 g/l
pH of feed brine	=3—4
Temperature of electrolysis	=70 °C
Amalgam concentration	=0.22% sodium
Current efficiency based on NaOH production	97%
Current efficiency based on Cl ₂ production	96%
Chlorine purity	99%

Current passed (amps)	Anode current density based on geometrical area (kA/m ²)	Cell voltage (volts)	
		With copper core	Without copper core
28	2	3.3	3.4
42	3	3.35	3.45
56	4	3.4	3.55
70	5	3.5	3.7
84	6	3.6	3.8
98	7	3.75	3.95
112	8	3.85	4.05
126	9	3.9	4.15
140	10	4.05	4.45

Example II

The copper core in the anode assembly mentioned in Example I was replaced by aluminium core which was pre-coated with copper. The performance of this anode was same as in Example I, except the voltage characteristics which is given below :

Anode current density (kA/m ²)	Cell voltage (volts)	
	With aluminium core	Without aluminium core
2	3.34	3.40
3	3.42	3.45
4	3.47	3.55
5	3.63	3.70
7	3.87	3.95
10	4.25	4.45

Example III

A titanium substrate of 1 mm thick was provided with 3.5 mm perforations at a triangular pitch of 4.5 mm (as in fig. 5). This was coated with mixed oxide coating as in example I. The operating characteristics of the anode in brine electrolysis in mercury cell were as follows :

Geometrical area of the anode	36 cm ²
Actual area of the anode : Nearly	60% of the Geometrical area.
Concentration of NaCl in feed brine	300—310 g/l
pH of the feed brine	3—4
Temperature of electrolysis	80 °C
Amalgam concentration	0.25% sodium.
Current efficiency on the basis of NaOH production	97%
Current efficiency based on chlorine production	96%
Chlorine gas purity	99.1%

Current passed (amps)	Current density based on geometrical area (kA/m ²)	Cell voltage (volts)	
		Inter-electrode distance 4 mm	Inter-electrode distance : 2mm.
7.2	2	3.35	3.25
10.8	3	3.47	3.35
14.4	4	3.55	3.40
18.0	5	3.65	3.45

Example IV

A perforated titanium plate of 40 cm² coated with compounds of platinum and titanium as described in Indian Patent 134375 was used as anode in the oxidation of sodium chloride to sodium chlorate. A current efficiency of 93% was obtained at a current density of 1.6 kA/m²; the electrolyte being a mixture containing 274 g/l of NaCl and 92 g/l of NaClO₃ and the electrolyte pH and temperature being 6.7 and 65°C respectively. The inter-electrode distance was 0.7 cm and the cell voltage was 3.4 volts.

A tantalum electrode coated with compounds of platinum and iridium gave a current efficiency 83% while using the same as anode for oxidising sodium chlorate to sodium perchlorate at a current density of 2.5 kA/m², the electrolyte being a solution containing 610 g/l of sodium chlorate. The pH and temperature of the electrolyte were maintained at 6.7—7 and 50°C respectively. The inter-electrode distance was 0.7 cm and the cell voltage was 4.3 volts.

The following are among the main advantages of the invention :

1. Anode assemblies described above keep constant inter-electrode distance and hence the cell voltage remains constant throughout the period of the active coating life and the cell interruptions and down times are minimum.

2. Anodes of any shape and size could be made to suit a particular cell shape and size. Different anode configurations are possible with such base metal assemblies. This will lead to savings in metal as well as power due to lower cell voltages.

3. These anodes are light; possess good mechanical strength; and could withstand the temperatures that normally prevail in aqueous electrolysis. This will help using automatic devices to lower or raise the anode assembly.

4. As the substrate metal is not at all attacked during its use, the same anode structure could be used for recoating again and again and hence the anode structure lasts for indefinite period.

5. The voltage drop in the anode structure is minimised due to welded structure and incorporation of suitably clad copper or aluminium core.

6. Anodes of similar shapes and configurations could also be made out of other valve metals like tantalum, tungsten etc., and their alloys.

7. These anode assemblies could also be used in the electrolytic production of chlorate, perchlorate, hypochlorite of sodium and the like products, in sea water electrolysis, in electro-dialysis, in electro-winning and refining, in certain plating operations, in organic reactions, in cathodic protection and in other similar operations.

Dated this 2nd day of December, 1972.

Sd./-

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COMPLETE SPECIFICATION

AN ANODE ASSEMBLY FOR MERCURY TYPE CHLORALKALI CELLS

COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH, RAJ MARG, NEW DELHI-I, INDIA, AN
INDIAN, REGISTERED BODY INCORPORATED UNDER THE REGISTRATION OF SOCIETIES ACT (ACT XXI
OF 1860)

The following specification particularly describes and ascertains the nature of this invention and the manner in which it is to be performed:—

This is an invention by Ramaswamy Thangappan Nadar, Scientist, Handady Venkatakrishna Udupa, Director, Babu Ram Yadav, Senior Scientific Assistant and Perumal Subbiah, Junior Scientific Assistant all of the Central Electrochemical Research Institute Karaikudi-3, all Indian citizens.

This invention relates to an anode assembly for mercury type chlor-alkali cells and has particular reference to the design and preparation of insoluble anode assembly for mercury type chlor-alkali cells wherein a perforated or foraminous plate (of titanium or other valve metals like tantalum, tungsten or an alloy of valve metals which are resistant to corrosion under the conditions prevailing in brine electrolysis) is welded to horizontal parallel bar/bars (of copper or aluminium of cross section square, rectangular or circular and clad with titanium or other valve metals), which in turn are welded to vertical stem/stems (copper or aluminium cored tubes of titanium or other valve metals) to distribute the current uniformly over the entire base, the surface of the base being activated by depositing a metallic or semi-conductive coating.

Titanium, tantalum, zirconium, niobium and tungsten are known as 'valve metals' as their oxides have the typical rectifying action. Throughout this specification, by the expression 'valve metals' we mean the above metals.

Similarly, by the expression 'platinum group metals' we mean the metals platinum, iridium, ruthenium, rhodium, osmium and palladium throughout this specification.

By 'insoluble anode' we mean that there is no change in the dimensions of the anode with time and as such there is no dissolution or disintegration of the anode structure during electrolysis.

Hitherto it is known to employ graphite as anode in mercury cells used for the electrolysis of aqueous solutions of alkali metal halides. The anodes are graphite slabs or blocks, the lower faces of which are grooved and slotted or drilled to facilitate the discharge of chloride gas bubbles. Each anode is supported by one or two stems of graphite, graphite with copper core or copper itself protected with porcelain or PVC sleeves. The anode stems are screwed into the anode plate. Obviously there are a number of disadvantages while using graphite as anodes in mercury cells for caustic soda and chlorine. For instance, these anodes get disintegrated in the course of the cell operation and hence the dimensions get altered resulting in larger inter-electrode distance, less pure anode gas, increased power consumption, frequent cell interruptions and down times for the maintenance and the employment of more labour. Other disadvantages and limitations arise from the shape of anode itself. Although holes and grooves are provided in the anode plate for the efficient removal of the chlorine gas from the lower working surface of the anode, there is a resistance to the passage of current due to bubble effect. Gas bubbles accumulate under the anode and form local gas cushion which shields a considerable portion of the anode area leading to an increase of the effective resistance of the layer of electrolyte between the electrodes owing to non-uniform distribution of the current over the electrolyte cross section and to an increase of anodic polarisation owing to the increased current density

at the anode surface, which is not shielded by the gas. As operating current density is increased, more densely packed chlorine bubbles are formed and available anode surface for electrolysis is considerably reduced. If inter-electrode distance is reduced beyond 3 mm, accumulated chlorine bubbles react with sodium amalgam and thus reduce the current efficiency. A further disadvantage is due to anode material itself. The specific resistance of graphite is nearly 500 times more than that of copper. There is a gradual increase in voltage as wear decreases the anode cross section. There is appreciable contact resistance between copper to graphite and graphite to graphite depending upon the state of surfaces and pressure between the two surface materials.

Recently a substitute for graphite anode (in the electrolysis of brine for caustic soda and chlorine) has been developed which is made of titanium or other valve metals (like tantalum, tungsten or an alloy of valve metals), its surface being activated with platinum, a combination of platinum group metals like rhodium, iridium, ruthenium, osmium and palladium or a combination of the oxides of one or more of platinum group metals and a film forming metal like titanium, zirconium, niobium, tantalum and tungsten as described in Indian Patent 134375.

Therefore the object of this invention is to obviate these disadvantages by making an anode assembly which consists of perforated or foraminous plate (of titanium or other valve metals like tantalum, tungsten or an alloy of valve metals) to which horizontal parallel bar/bars (of copper or aluminium of cross section square, rectangular or circular and clad with titanium or other valve metals) are attached (by welding) in conjunction with vertical stem/stems (copper or aluminium cored tubes of titanium or other valve metals) to distribute the current uniformly over the entire base, the surface of the base being activated by depositing a metallic or semi-conductive coating as described in Indian Patent 134375.

The new principle underlying the invention is the design and preparation of the anode assemblies out of a valve metal or an alloy of valve metals such as titanium, zirconium, niobium, tantalum, tungsten, especially titanium, which are resistant to corrosion in aqueous electrolytes, especially in the electrolysis of saturated brine to chlorine-alkali in mercury cell, in the form of expanded sheet, perforated sheet, or square, rectangular, cylindrical bars shaped to square, rectangular or other shaped base to suit a particular cell shape and configuration, the current being uniformly distributed to the entire base by means of horizontal parallel bar/bars (of copper or aluminium of cross section square, rectangular or circular and clad with titanium or other valve metals) in conjunction with vertical stem/stems (copper or aluminium bars clad with titanium or other valve metals) and the surface of the electrode being activated by thermally depositing a metallic or semiconductive coating.

According to the present invention, there is provided an anode assembly of the type having an anode base, horizontal current distributors and anode stems for mercury cells in the electrolysis of alkali metal halide solutions and characterised in that it comprises

- (a) a horizontal perforated or foraminous base and the surface of the base being activated by

depositing a metallic or semi-conductive coating ;

- (b) horizontal current distributors in the form of bar/bars of square, rectangular or circular cross section made out of copper or aluminium and enclosed inside the fluidtight titanium or other valve metal casing using white metal and welded to upper surface of the anode base ; and
- (c) vertical anode stem/stems made out of titanium tubes fitted inside with copper or aluminium cores by means of white metal and welded to the horizontal current distributor.

The edges of the base are welded with strips to provide additional reinforcement to the anode structure. These anode assemblies keep constant inter-electrode distance and hence the cell voltage remains constant throughout the period of the life of active coating and the cell interruptions and down times are minimum. Perforated or foraminous anode base made of expanded sheet or bars structure allows easier chlorine bubbles release resulting in higher critical current density and reduced cell voltage. Also on the perforated metallic anode base very fine chlorine bubbles are formed hence inter-electrode distance can be reduced smaller than with graphite anodes without resulting the reaction of chlorine bubble with sodium amalgam. The voltage drop in the anode structure due to poor conductivity of titanium (i.e., specific resistance of titanium at the temperature prevailing in the cell is about 62×10^{-6} ohms-cm) is reduced to a minimum by the use of horizontal parallel bars of good conducting metals like copper or aluminium clad with titanium or other valve metals. These bars distribute the current uniformly over the entire base. Anode of any shape and size could be made to suit a particular cell shape and size. This leads to savings in metal as well as power due to lower cell voltages. These anodes are light; possess good mechanical strength; are easily machinable and withstand the temperatures that normally prevail in aqueous electrolysis particularly in the electrolysis of saturated brine in mercury cells. As the substrate metal is not at all attacked during its use the same anode structure is used for recoating again and again and hence the anode structure lasts longer. The contact resistances are minimised due to contact points being metallic.

A perforated titanium sheet anode structure installed in a laboratory mercury chlor-alkali cell has registered a cell voltage of 3.6 volts at an inter-electrode distance of 3 mm and at a current density of 5 kA/m² during its operation for 18 months, the cell being operated for nearly 7 hours a day. The cell temperature was 60°C. A titanium anode of 140 cm² geometric area made out of expanded titanium sheet and provided with current conducting copper core showed cell voltages of 3.3 to 4.05 V at current densities of 2 to 10 kA/m², for the saturated brine electrolysis in mercury cell, the inter-electrode distance being 4 mm and the electrolysis temperature 70°C. The total weight, including copper or aluminium core, of one square metre of this type of anode structure is 25 to 35 kg only compared to 150 to 2000 kg of graphite. While recoating the worn-out anode, the weight loss of anode due to the removal of the oxide layer was found to be 2.4 to 4.2 mg/cm² of the geometric area of the anode. This being very small compared to the weight of 4.5 gm or 9 gm per cm² of anode made of 1 mm or 2 mm thick titanium sheet respectively; the same structure was used again and again for coating with active material.

To these ends, the invention broadly consists in the preparation of anode assemblies out of a valve metal or an alloy of valve metals such as titanium, zirconium, niobium, tantalum, tungsten, especially titanium, which are resistant to corrosion in aqueous electrolytes, especially in the electrolysis of saturated brine to chlorine-alkali, in the form of expanded sheet (figs. 1, 2 & 4) perforated sheet (fig. 5) or square, rectangular, cylindrical bars (figs. 3) shaped to square, rectangular or other

shaped base to suit a particular cell shape and configuration, the current being uniformly distributed to the entire base by means of a number of horizontal copper or aluminium core clad with titanium or other valve metal (figs. 1, 2, 3, 4 and 5) in conjunction with vertical copper or aluminium cores clad with a valve-metalsheet, and the surface of the electrode being activated by thermally depositing a metallic or semi-conductive coating. The copper or aluminium cores (A) which are tightly fitted into copper coated sleeves (B) of titanium or other valve metal by means of white metal composition carry the current and distribute uniformly to the surface of the anode structure avoiding undue voltage drop in the bulk of the base metal. The edges of the base are welded with strips (C) to provide additional reinforcement to the anode structure. The activation of the surface of the anode is done in accordance with the procedures described in Indian Patent No. 124375, wherein a metallic or semi-conductive coating is provided by depositing platinum, iridium, ruthenium, osmium and palladium or a combination of platinum group metals like rhodium, iridium-ruthenium, osmium and palladium or a combination of the oxides of one or more of platinum group metals and, a film forming metallike titanium, zirconium, niobium tantalum or tungsten, the deposition being effected by thermal decomposition of a paste, a mixture of the various compounds supported in an organic vehicle required to supply the metal or the metal oxide painted over the polished and etched surface of the substrate and baked at temperatures between 300 and 650 °C in an atmosphere of either limited supply or forced circulation of air.

The following typical examples are given to illustrate the invention with the help of drawings accompanying the provisional specification wherein Figs. 1 to 5 illustrate the anode assemblies.

Example I

A titanium expanded sheet of geometrical area of 140 cm² was provided with a vertical copper core enclosed in a titanium sleeve the inner surface of which was coated with copper. The copper core was tightly fixed into the titanium tube by introducing a pinch of ammonium chloride followed by molten white metal composition. The core was joined to the expanded sheet by welding (as in figs. 1, 2 and 4). A mixed oxide coating of ruthenium and titanium was given to the surface of the electrode structure from a chelate containing the compounds of both the metals (as described in Indian Patent No. 134375) and its performance as anode in brine electrolysis in mercury cell for caustic soda-chlorine was as follows.

Geometrical area of the anode facing the cathode	140 cm ²
Details of expanded titanium sheet :	
Thickness of sheet	1 mm
Strand width	1.5 mm
Diagonal distance of the diamond shaped mesh	6 mm × 18 mm
Actual area of the anode	nearly 40% of geometrical area
Inter-electrode distance	4 mm
Concentration of NaCl in brine feed	300-310 g/l
pH of feed brine	3-4
Temperature of electrolysis	70°C
Amalgam concentration	0.22% sodium
Current efficiency based on NaOH production	97%
Current efficiency based on Cl ₂ production	96%
Chlorine purity	99%

Current passed (A)	Anode current density based on geometrical area (kA/sq. m.)	Cell voltage (volts)	
		With copper core	Without copper core
28	2	3.3	3.4
42	3	3.35	3.45
56	4	3.4	3.55
70	5	3.5	3.7
84	6	3.6	3.8
98	7	3.75	3.95
112	8	3.85	4.05
126	9	3.9	4.15
140	10	4.05	4.45

Example II

The copper core in the anode assembly mentioned in Example I was replaced by aluminium core which was precoated with copper. The performance of this anode was same as in Example I, except the voltage characteristics which is given below :

Anode current density (kA/sq.m)	Cell voltage (volts)	
	With aluminium core	Without aluminium core
2	3.34	3.40
3	3.42	3.45
4	3.47	3.55
5	3.63	3.70
7	3.87	3.95
10	4.25	4.45

Example III

A titanium substrate of 1 mm thick was provided with 3.5 mm perforations at a triangular pitch of 4.5 mm (as in fig. 5). This was coated with mixed oxide coating as in Example I. The operating characteristics of the anode in brine electrolysis in mercury cell were as follow :

Geometrical area of the anode	36cm ²
Actual area of the anode	Nearly 60% of the geometrical area
Concentration of NaCl in feed brine	300-310 g/l
pH of the feed brine	3-4
Temperature of electrolysis	80 °C
Amalgam concentration	0.25% sodium
Current efficiency based on NaOH production	97%
Current efficiency based on chlorine production	96%
Chlorine gas purity	99.1%

Current passed (A)	Current density based on geometrical area (kA/sq.m)	Cell voltage (volts)	
		Inter-electrode distance 4 mm	Inter-electrode distance 2 mm
7.2	2	3.35	3.25
10.8	3	3.47	3.35
14.4	4	3.55	3.40
18.0	5	3.65	3.45

Example IV

A perforated titanium plate of 40 cm² coated with compounds of platinum and titanium as described in Indian Patent No. 134375 was used as anode in the oxidation of sodium chloride to sodium chlorate. A current efficiency of 93% was obtained at a current density of 1.6 kA/m² the electrolyte being a mixture containing 274 g/l of NaCl and 92 g/l of NaClO₃ and the electrolyte pH and temperature being 6.7 and 65 °C respectively. The inter-electrode distance was 0.7 cm and the cell voltage was 3.4 volts.

Example V

A tantalum electrode coated with compounds of platinum and iridium gave a current efficiency of 83% while using the same as anode for oxidising sodium chlorate to sodium perchlorate at a current density of 2.5 kA/m², the electrolyte being a solution containing 610 g/l of sodium chlorate. The pH and temperature of the electrolyte were maintained at 6.7-7 and 50 °C respectively. The inter-electrode distance was 0.7 cm and the cell voltage was 4.3 volts.

The advantages of the invention are :

1. Anode assembly described above keeps constant inter-electrode distance and hence the cell voltage remains constant throughout the period of the active coating life and the interruptions and down times are minimum.
2. The voltage drop due to bubble effect is minimised because of perforated or foraminous anode base.
3. Anode assembly of any shape and size could be made to suit a particular cell shape and size. Different anode configurations are possible with such base metal assemblies. This will lead to savings in metal as well as power due to lower cell voltages.
4. These anode assemblies are light, possess good mechanical strength and could withstand the temperatures that normally prevail in aqueous electrolytes. This will help using automatic devices to lower or raise the anode assembly.
5. As the substrate metal is not at all attacked during its use, the same anode structure could be used for re-coating again and again and hence the anode structure lasts for indefinite period.
6. The voltage drop in the anode structure minimised due to horizontal bars.

WE CLAIM :

1. An anode assembly of the type having an anode base, horizontal current distributors and anode stems

for mercury cells in the electrolysis of alkali metal halide solutions and characterised in that it comprises

- (a) horizontal perforated or foraminous base and the surface of the base being activated by depositing metallic or semi-conductive coating.
- (b) horizontal current distributors in the form of bar/bars of square, rectangular or circular cross section made out of copper or aluminium and enclosed inside the fluid-tight titanium or other valve metal casing using white metal and welded to upper surface of the anode base, and
- (c) vertical anode stem/stems made out of titanium tubes fitted inside with copper or aluminium cores by means of white metal, and welded to the horizontal current distributor.

2. An anode assembly as claimed in claim 1, wherein the edges of the base are welded with strips to provide additional reinforcement to the anode structure.

3. An anode assembly of the type having an anode base, horizontal current distributors and anode stems for mercury cells in the electrolysis of alkali metal halide solutions substantially as hereinbefore described.

Dated this 22nd day of November, 1973.

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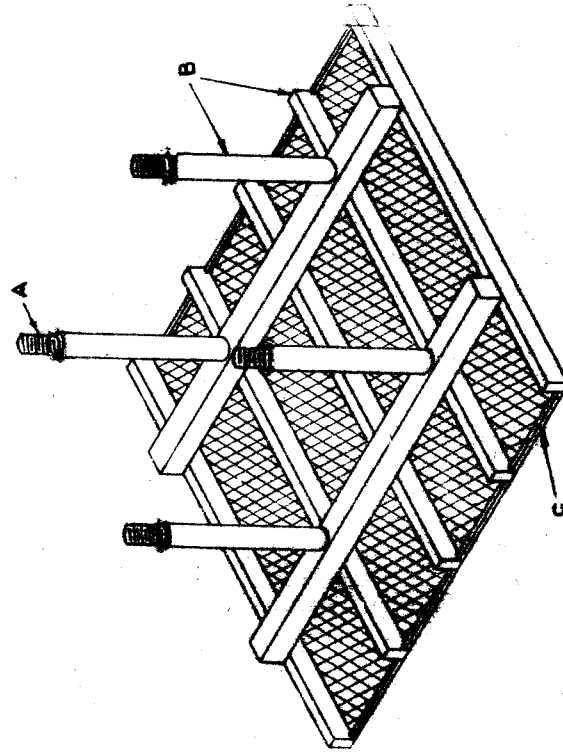


FIG. 1

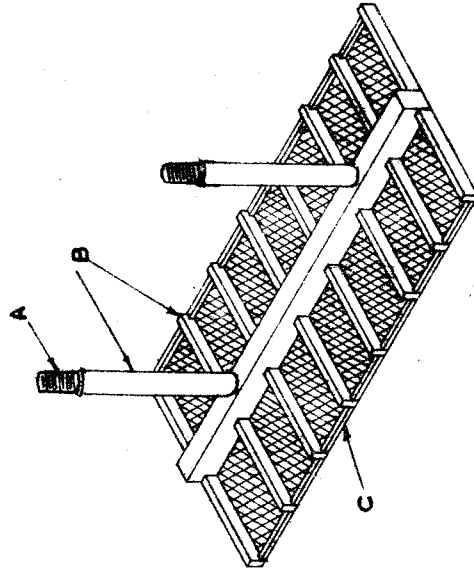


FIG. 2

ORIGINAL

8 DEC 1972

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2039

No. 139827

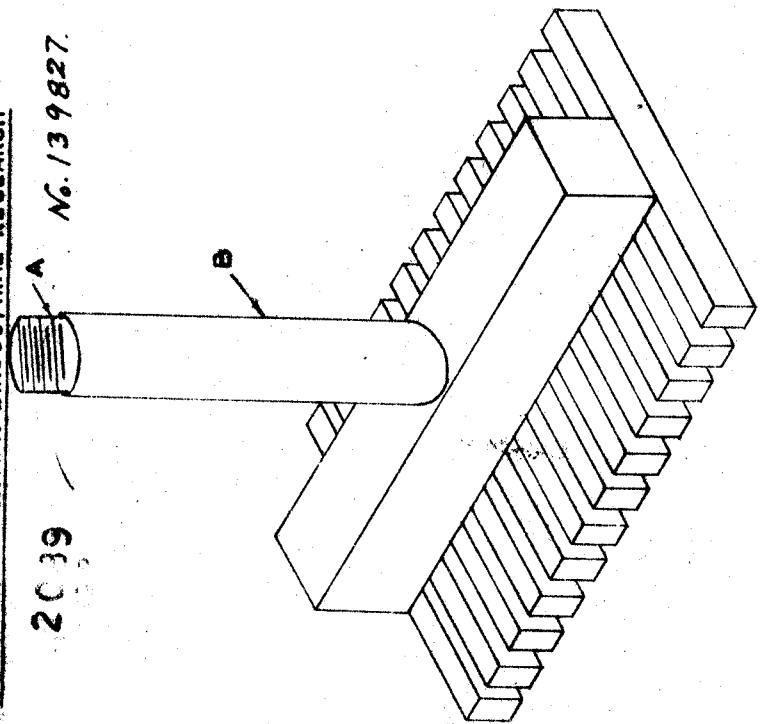


FIG. 3

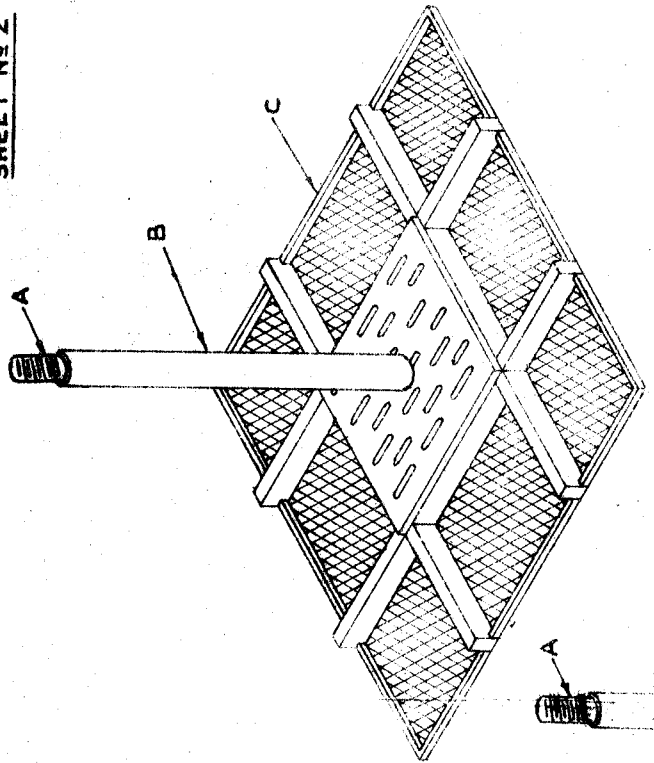


FIG. 4

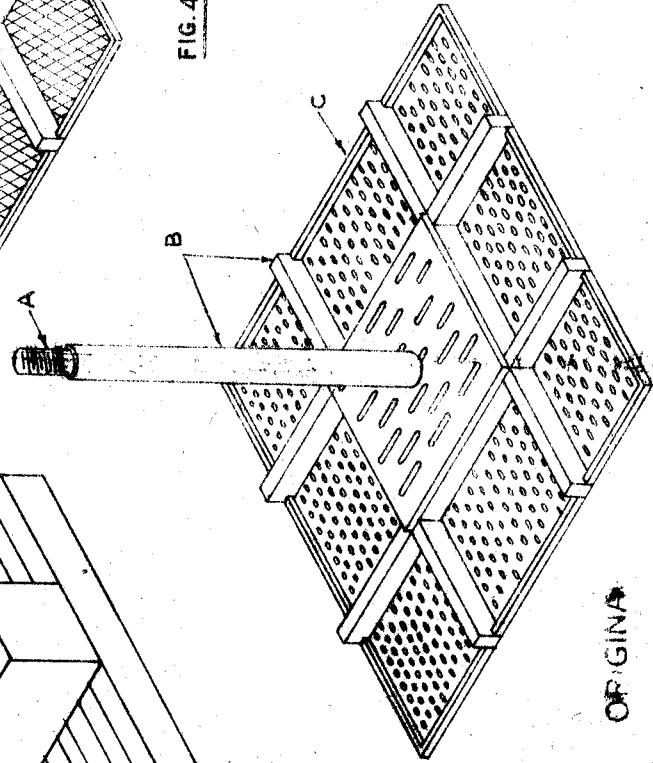


FIG. 5

ORIGINAL

DEC 1972

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