(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 147 246 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
27.04.2005 Bulletin 2005/17

(21) Application number: **00970713.4**

(22) Date of filing: **10.10.2000**

(51) Int Cl.[7]: **C25C 3/16**

(86) International application number:
PCT/US2000/027936

(87) International publication number:
WO 2001/027353 (19.04.2001 Gazette 2001/16)

(54) CATHODE COLLECTOR BAR WITH SPACER FOR IMPROVED HEAT BALANCE

KATHODENKOLLEKTOR MIT ABSTANDSHALTER FÜR VERBESSERTE WÄRMEBILANZ

BARRE COLLECTRICE DE CATHODE AVEC ELEMENT D'ESPACEMENT PERMETTANT D'AMELIORER LE BILAN THERMIQUE

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
SI

(30) Priority: **13.10.1999 US 416767**
10.04.2000 US 546273

(43) Date of publication of application:
24.10.2001 Bulletin 2001/43

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(56) References cited:
FR-A- 1 161 632
FR-A- 2 351 192
US-A- 3 551 319
US-A- 4 795 540
US-A- 5 976 333

EP 1 147 246 B1

Printed by Jouve, 75001 PARIS (FR)

Description

[0001] This invention relates to electrolytic cells. In one aspect, this invention relates to cathode collector bars of electrolytic reduction smelting cells used in the production of aluminum.

[0002] Aluminum is produced by an electrolytic reduction of alumina in an electrolyte. The aluminum produced commercially by the electrolytic reduction of alumina is referred to as primary aluminum.

[0003] Electrolysis involves an electrochemical oxidation-reduction associated with the decomposition of a compound. An electrical current passes between two electrodes and through molten Na_3AlF_6 cryolite bath containing dissolved alumina. Cryolite electrolyte is composed of a molten Na_3AlF_6 cryolite bath containing alumina and other materials, e.g., such as fluorspar, dissolved in the electrolyte. A metallic constituent of the compound is reduced together with a correspondent oxidation reaction.

[0004] Electrical current is passed between the electrodes from an anode to a cathode to provide electrons at a requisite electromotive force to reduce the metallic constituent which usually is the desired electrolytic product, such as in the electrolytic smelting of aluminum. The electrical energy expended to produce the desired reaction depends on the nature of the compound and the composition of the electrolyte.

[0005] Hall-Heroult aluminum reduction cells are operated at low voltages (e.g. 4-5 volts) and high electrical currents (e.g. 70,000-325,000 amps). The high electrical current enters the reduction cell through the anode structure and then passes through the cryolite bath, through a molten aluminum metal pad, and then enters a carbon cathode block. The electrical current is carried out of the cell by cathode collector bars.

[0006] As the electrolyte is traversed by electric current, alumina is reduced electrolytically to aluminum at the cathode, and carbon is oxidized largely to carbon dioxide at the anode. The aluminum, thus produced, accumulates at the molten aluminum pad and is tapped off periodically. Commercial aluminum reduction cells are operated by maintaining a minimum depth of liquid aluminum in the cell, the surface of which serves as the actual cathode. The minimum aluminum depth is about 5.1 cm (2 inches) and may be 50.8 cm (20 inches).

[0007] The alumina-cryolite bath is maintained on top of the molten aluminum metal pad at a set depth. The current passes through the cryolite bath at a voltage loss directly proportional to the length of the current path, i.e., the interpolar distance gap between the anode and molten aluminum pad. A typical voltage loss is about 0.4 volt per cm (1 volt per inch.) Any increase of the anode to cathode spacing restricts the maximum power efficiency and limits the efficiency of the electrolytic cell operation.

[0008] Much of the voltage drop through an electrolytic cell occurs in the electrolyte and is attributable to electrical resistance of the electrolyte, or electrolytic bath, across the anode-cathode distance. The bath electrical reslstance or voltage drop in conventional Hall-Heroult cells for the electrolytic reduction of alumina dissolved in a molten cryolite bath includes a decomposition potential, i.e., energy used in producing aluminum, and an additional voltage attributable to heat energy generated in the inter-electrode spacing by the bath resistance. This latter heat energy makes up 35 to 45 percent of the total voltage drop across the cell, and in comparative measure, as much as twice the voltage drop attributable to decomposition potential.

[0009] An adverse result from reducing anode-cathode distance is a significant reduction in current efficiency of the cell when the metal produced by electrolysis at the cathode is oxidized by contact with the anode product. For example, in the electrolysis of alumina dissolved in cryolite, aluminum metal produced at the cathode can be oxidized readily back to alumina or aluminum salt by a close proximity to the anodically produced carbon oxide. A reduction in the anode-cathode separation distance provides more contact between anode product and cathode product and significantly accelerates the reoxidation or "back reaction" of reduced metal, thereby decreasing current efficiency.

[0010] The high amperage electrical current passing through the electrolytic cell produces powerful magnetic fields that induce circulation in the molten aluminum pad leading to problems such as reduced electrical efficiency and "back reaction" of the molten aluminum with the electrolyte. The magnetic fields also vary the depths in unequal distance between the molten aluminum pad and the anode. The motion of the metal pad increases, sometimes violently stirring the molten pad and generating vortices, and causing localized electrical shorting.

[0011] Metal pad depth variations restrict the reduction of the anode to cathode gap and produce a loss in current efficiency. Power is lost to the electrolyte interposed between the anode and cathode blocks. Movement of the molten aluminum metal pad also contributes to uneven wear on the carbon cathode blocks and can accelerate cell failure.

[0012] Metal pad turbulence also increases the "back reaction," or reoxidation, of cathodic products, thereby lowering cell efficiency. Metal pad turbulence accelerates distortion and degradation of the cathode bottom liner through attrition and penetration of the cryolite.

[0013] In the conventional cathode today, steel cathode collector bars extend from the external bus bars through each side of the electrolytic cell into the carbon cathode blocks. The steel cathode collector bars are attached to the cathode blocks with cast iron, carbon glue, or rammed carbonaceous paste to facilitate electrical contact between the carbon cathode blocks and the steel cathode collector bars.

[0014] The flow of electrical current through the aluminum pad and the carbon cathode follows the path of least resistance. The electrical resistance in a conventional cathode collector bar is proportional to the length of the current path from the point the electric current enters the cathode collector bar to the nearest external bus. The lower resistance of the current path starting at points on the cathode collector bar closer to the external bus causes the flow of current through the molten aluminum pad and carbon cathode blocks to be skewed in that direction. The horizontal components of the flow of electric current interact with the vertical component of the magnetic field, adversely affecting efficient cell operation.

[0015] Existing Hall-Heroult cell cathode collector bar technology is limited to rolled or cast mild steel sections. The high temperature and aggressive chemical nature of the electrolyte combine to create a harsh operating environment. The high melting point and low cost of steel offset its relatively poor electrical conductivity. In comparison, potential metallic alternatives such as copper or silver have high electrical conductivity but low melting points and high cost. Copper is used in the apparatus and process of the present invention because it provides a preferred combination of electrical conductivity, melting point, and cost. Other high conductivity materials could be used based on their combinations of electrical conductivity, melting point, and cost relative to the aluminum smelting process.

[0016] The electrical conductivity of steel is so poor relative to the aluminum metal pad that the outer third of the collector bar, nearest the side of the pot, carries the majority of the load, thereby creating a very uneven cathode current distribution within each cathode block. Because of the chemical properties, physical properties, and, in particular, the electrical properties of conventional anthracite cathode blocks, the poor electrical conductivity of steel had not presented a severe process limitation until recently.

[0017] Conventional cathodes contained either 100% Gas Calcined Anthracite (GCA) or 100% Electrically Calcined Anthracite (ECA). These cathode blocks had poor thermal shock resistance. These cathode blocks swelled badly under electrolysis conditions, i.e., under the influence of cathodic current, reduced sodium, and dissolved aluminum. These cathode blocks had poor electrical conductivity (relative to graphite). In their favor, these cathode blocks had low erosion or wear rates (relative to graphite).

[0018] To overcome the shortcomings of 100% anthracite cathodes, cathode manufacturers added an increasing proportion of graphite to the raw cathode block mix. A minimum of 30% graphite seems to be sufficient to avoid thermal shock cracking and to provide reasonable electrical properties and sodium resistance in most instances. Further additions up to 100% graphite aggregate or 100% coke aggregate graphitized at 2,000-3,000°C provide preferred operating and productivity conditions.

[0019] As the graphite content or degree of graphitization increases, the rate increases at which the cathode blocks erode or are worn away.

[0020] In pursuit of economies of scale, aluminum smelting pots have increased in size as the operating amperage has increased. As the operating amperage has been increased, the percentage of graphite in cathodes has increased to take advantage of improved electrical properties and maximize production rates. In many cases, this has resulted in a move to graphitized cathode blocks.

[0021] The operation of the pot is most typically terminated when the aluminum metal is contaminated by contact with the steel collector bars. This can happen when the cathode to seam mix joints leak, when the cathode blocks crack or break because of thermal or chemical effects or the combined thermochemical effects, or when erosion of the top surface of the block exposes the collector bar. In the application of higher graphite and graphitized cathode blocks, the dominant failure mode is due to highly localized erosion of the cathode surface, eventually exposing the collector bar to the aluminum metal.

[0022] In a number of pot designs, higher peak erosion rates have been observed for these higher graphite content blocks than for 30% graphite/ECA blocks or 100% ECA blocks. Operating performance is therefore traded for operating life.

[0023] There is a link between the rapid wear rate, the location of the area of maximum wear, and the non-uniformity of the cathode current distribution. The higher graphite content and graphitized cathodes are more electrically conductive and as a result have a much more non-uniform cathode current distribution pattern and hence higher wear rate.

[0024] Accordingly, there is a need to develop and provide a more even cathode current distribution so that the cathode wear rate will be decreased, the pot life will be increased, and the operating benefits of the higher graphite and graphitized cathode blocks can be realized.

[0025] A related objective of the present invention is to provide an electrolytic reduction cell apparatus and method utilizing a novel cathode collector bar, including a solid, ferrous metal spacer for maintaining a controlled heat balance in the pot.

[0026] These and other objects of the present invention will become more apparent from reference to the following detailed description of our invention.

[0027] In accordance with the present invention, there is provided an apparatus and method for production of aluminum. The apparatus of the invention comprises an electrolytic cell for reducing alumina dissolved in a molten salt bath to aluminum metal. An electric current passes between an anode and a cathode through the molten bath, producing aluminum metal adjacent the cathode.

[0028] The electrolytic cell has cell walls including a first cell wall and a second cell wall, an anode, a carbonaceous cathode block separated from the anode, a bus bar external to the first cell wall, and a collector bar connecting the bus bar with the cathode block. The cathode block preferably defines a slot in which the collector bar is seated. The cell walls define a chamber containing a molten salt bath.

[0029] The collector bar includes a ferrous metal body and a copper insert. As used herein, the term "ferrous metal" refers to iron and steel, including mild steel, low carbon steel, and stainless steel. The term "copper" includes alloys of copper with various other metals including silver. For practice of the present invention we prefer relatively pure forms of copper containing at least 99 wt. % copper because of their excellent electrical conductivity.

[0030] The collector bar has a ferrous metal body comprising a solid, ferrous metal spacer having an external end portion connected with the bus bar and an internal end portion spaced inwardly of the first cell wall. The spacer improves heat balance in the cell by preventing excessive heat transfer between the copper insert and the bus bar. The ferrous metal body also includes a ferrous metal sheath integral with the spacer and defining a cavity containing the copper insert. The cavity extends between an external end adjacent the internal end portion of the spacer, and an internal opening. The cavity and the copper insert may be polygonal or circular in transverse cross-section. We prefer a cylindrical copper insert inside a cavity having a circular transverse cross-section.

[0031] The slot in the cathode block preferably contains means for joining the collector bar to the cathode block, preferably an electrically conductive material. This material may be cast iron, carbonaceous glue or rammed carbonaceous paste and is preferably cast iron.

[0032] The cathode assembly of the present invention is useful for producing aluminum by electrolysis. The cathode assembly is spaced downwardly of an anode in a chamber containing a molten salt bath. An electric current passes from the anode to the cathode assembly, reducing alumina dissolved in the molten salt bath to aluminum deposited in a pad above the cathode block. The copper insert in the collector bar distributes electric current more evenly than in prior art cells having collector bars containing only steel or other ferrous metal. The ferrous metal spacer in the collector bar body reduces heat losses, compared with collector bars having a copper insert connected directly to the bus bar.

[0033] Figure 1 is a schematic cross-sectional view of a prior art electrolytic cell for aluminum production.

[0034] Figure 2 is a schematic cross-sectional view of an electrolytic cell for aluminum production in accordance with the present invention.

[0035] Figure 3 is a schematic view of a collector bar in the electrolytic cell of Figure 2.

[0036] Figure 4 is a cross-sectional view taken along the lines 4-4 of Figure 3.

[0037] Figure 5 is a schematic depiction of current paths in a prior art electrolytic cell for aluminum production.

[0038] Figure 6 is a schematic depiction of current paths in an electrolytic cell of the present invention.

[0039] The apparatus and method of the present invention provide a novel collector bar that minimizes horizontal electrical currents while controlling heat losses. The novel collector bar of our invention may be incorporated into existing aluminum production cells having standard carbon cathode blocks.

[0040] Referring now to Figure 1, there is shown a prior art electrolytic cell 2 fox aluminum production, having a pair of conventional cathode collector bars 10. The collector bars 10 have a rectangular transverse cross-section and they are fabricated from mild steel. Electrical current enters the cell through anodes 12, passes through an electrolytic bath 14, and a molten metal pad 16, and then enters a carbon cathode block 20. Current is carried out of the cell by the cathode collector bars 10. As shown in Figure 5, electrical current lines 70 are non-uniformly distributed and concentrated more toward ends of the collector bar closest to an external bus bar (not shown).

[0041] Referring now to Fig. 2, there is shown an electrolytic cell 4 of the present invention. The cell 4 includes a first cell wall 17 and a second wall 18. The cell walls define a chamber 19 lined on its bottom and sides with refractory bricks 21 and containing the molten electrolyte 14. A cathode block 10 has two half-width cathode collector bars 30. Each collector bar 30 extends from a bus bar 46,48 outside the cell walls 17,18, and inwardly toward a center line 50. The collector bars 30 are separated by a gap 58 in the middle of the cell filled by a crushable material or by a piece of carbon or by tamped seam mix or by a mixture of such materials. Preferably, the gap 58 is filled by a mixture of materials.

[0042] The cathode block 20 has an upper surface 22 supporting the metal pad 16 and a lower surface 23 defining a slot or groove 24 extending between opposed lateral ends of the block 20. The steel collector bars 30 are received in the slot 24 and secured there by a layer of electrically conductive material, preferably cast iron, joining the collector bars 30 to the block 20.

[0043] Referring now to Figures 2-4, the collector bars 30 each include a ferrous metal body comprising a solid spacer 32 and a sheath 33 defining a cavity 34. Each spacer 32 has an external end portion 35 connected with a bus bar 46 and an internal end portion 36 spaced inwardly of the external end portion 35. Preferably, the internal end portion 36 is inside the cell wall 17, as shown in Figure 2.

[0044] Referring now to Figures 3 and 4, a cavity or slot 34 is drilled into an internal side 37 of each collector bar 30. The cavities 34 are machined to have a diameter of about 4.1 cm (1.628 inches) so that their cross-sectional area is about 13.42 cm^2 (2.08 in^2), in a collector bar having a transverse cross-sectional area of about 154 cm^2 (24 in^2). The cavities 34 extend longitudinally, between openings in the collector bar internal sides 37 and internal end portions 36 of the spacers 32. The cavities 34 are positioned centrally inside the collector bars 30, to minimize distortion accompanying heating and cooling.

[0045] A copper insert 40 comprising a cylindrical rod is placed inside each cavity 34. The copper insert has a diameter of approximately 4.1 cm (1.625 ± .0025 inches) so that its transverse cross-sectional area is about 13.35 cm^2 (2.07 in^2.) For practice of our invention we prefer copper inserts composed of a high conductivity grade of copper containing about 99.95 - 99.99 wt% copper.

[0046] An air vent 44 is drilled into each collector bar, between the cavity 34 and a top side. The air vent 44 vents air from the cavity 34 when the copper insert 40 is positioned inside. After the insert 40 is in place, the vent 44 is filled with refractory mortar. If sufficient pressure develops in the cavity 34 to expel the mortar, the vent 44 provides a path for pressure relief.

[0047] A steel plug 45 is placed in the cavity 34 to enclose the copper insert 40. A small space 47 between the plug 45 and the insert 40 allows for expansion upon heating to operating temperature. The plug 45 is welded to the internal side 37 of the collector bar 20. In particularly preferred embodiment, the space 47 provides an expansion allowance of about 1.7 cm (0.65 inch) and the steel plug 45 has a length of about 5.1 cm (1 inch.)

[0048] The apparatus and method of our invention redirect current in a Hall-Heroult cell to reduce or eliminate inefficiencies attributable to non-uniform electrical currents and horizontal electrical currents.

[0049] The cathode current path and current distribution are influenced by the differential between electrical conductivity of the aluminum metal pad and the cathode assembly. With a high electrical conductivity differential in favor of the aluminum pad, the preferred current path will be sideways through the metal pad toward a side wall of the pot and then downwardly through the cathode block to the collector bar.

[0050] In Figure 5 there is shown a current gradient 70 in a prior art pot 2 having an anode 12, a molten metal pad 16, a cathode block 20, and a collector bar 10. The highest current concentration is found directly over the steel collector bar 10 close to an outer end 72 of the cathode block 20. The lowest current distribution is found in the middle of the cathode block 20, adjacent an internal end portion of the collector bar 10. Localized wear patterns observed on the cathode block 20 are deepest in the area of highest electrical current density.

[0051] As electrical conductivity of the cathode block 20 increases to reflect a change to higher graphite content or graphitized cathode blocks, the cathode current distribution 70 becomes more concentrated at the outer end 72 of the block. At constant amperage, the localized wear rate will increase near the outer end 72 of the block 20 as the graphite content increases and reaches a maximum for graphitized cathode blocks.

[0052] The apparatus and method of our invention redirect current in a Hall-Heroult cell to reduce inefficiencies attributable to non-uniform and horizontal electric currents. As shown in Figure 6, our cell 2 includes an anode 12, molten metal pad 16, cathode block 20, and a collector bar 30 having a copper insert 40. The current gradient 90 extends from the anode 12 to the metal pad 16 and along the entire length of the cathode block 20. The current distribution pattern 90 is more uniform than the pattern 70 shown in Figure 5. The copper insert 40 increases electrical conductivity of the collector bar 30 by reducing the conductivity differential in favor of the aluminum pad 16, thereby distributing current more evenly across the block 20.

[0053] We have observed that placing a copper insert in a steel collector bar significantly increases its overall electrical conductivity, corresponding to a lower overall resistance in the collector bar. The result is more uniform current distribution in the cathode and reduced localized wear rates.

[0054] The cathode voltage drop is also reduced by up to 50 mV. This voltage drop can be utilized to reduce the cost of electrical power at a constant production rate, or to increase the tonnage of aluminum produced at constant power.

[0055] Ends of the collector bars extending through side walls of the pot act as fins or heat sinks. Integrating copper inserts into the collector bars increases pot heat losses. Accordingly, the length of the copper insert must be carefully controlled to prevent excessive heat losses and adverse pot life effects. Preferably the copper inserts should not extend outside the pot side walls 17,18. We also combine the copper insert collector bar with additional insulation material in the pot to offset the extra heat loss caused by the copper insert.

Claims

1. An electrolytic reduction cell (4) for aluminum production, comprising a cell wall (17,18), a bus bar (46,48) external to said cell wall (17,18), an anode (12), a carbonaceous cathode block (20) separated from said anode (12), and a collector bar (30) connecting said bus bar (46,48) with said cathode block (20), said collector bar (30) comprising:

(a) a ferrous metal body comprising

1) a solid, ferrous metal spacer (32) having an external end portion (35) connected with said bus bar (46,48) and an internal end portion (36) spaced inwardly of said external end portion (35), and

2) a ferrous metal sheath (33) defining a cavity (34), and

(b) a copper insert (40) inside said cavity (34), said copper insert (40) having an external end adjacent said spacer (32), which spacer (32) improves heat balance in the cell by preventing excessive heat transfer between said copper insert (40) and said bus bar (46, 48).

2. A cell according to claim 1, further comprising

(c) a molten salt bath (14) between said anode (12) and said cathode block (20).

3. A cell according to claims 1 or 2, wherein said cathode block (20) defines a slot (24) and said collector bar (30) is seated in said slot (24).

4. A cell according to claim 3, further comprising

(d) means in said slot (24) for joining said collector bar (30) to said cathode block (24).

5. A cell according to claim 4, wherein said means in said slot (24) comprises an electrically conductive material.

6. A cell according to claims 4 or 5, wherein said means in said slot (24) is selected from the group consisting of cast iron, carbonaceous glue, and rammed carbonaceous paste.

7. A cell according to anyone of the preceding claims, wherein said cavity (34) has a polygonal transverse cross-section and said copper insert (40) has a polygonal transverse cross-section.

8. A cell according to anyone of claims 1-6, wherein said cavity has a generally circular transverse cross-section and said copper insert (40) has a generally circular transverse cross-section.

9. A cell according to anyone of the preceding claims, wherein said cathode block (20) comprises 30-100 wt.% graphite or a graphitized cathode block.

10. A cell according to anyone of the preceding claims, wherein said ferrous metal sheath (33) is integral with said spacer (32).

11. A cell according to anyone of the preceding claims, wherein said internal end portion (36) of the spacer (32) is spaced inwardly of said cell wall (14).

12. A cell according to anyone of the preceding claims, further comprising a steel plug (45) enclosing the copper insert (40) in said cavity.

13. A cell according to anyone of the preceding claims, further comprising an expansion allowance space (47) in said cavity (34) between the copper insert (40) and the steel plug (45).

14. A cell according to anyone of the preceding claims, wherein said collector bar (30) further defines an air vent (44) for relieving pressure from said cavity (34).

15. A method for producing aluminum in an electrolytic cell having cell walls defining a chamber containing a molten salt bath, an anode contacting the bath, and a bus bar outside the cell walls, said method comprising

a) providing a cathode assembly comprising

1) a carbonaceous cathode block separated from the anode,
2) a ferrous metal body comprising a solid, ferrous metal spacer having an external end portion connected with said bus bar and an internal end portion spaced inwardly of said external end portion, and a ferrous metal sheath defining a cavity, and
3) a copper insert inside said cavity, said copper insert having an external end adjacent said spacer, and

b) passing an electric current from the anode to the cathode assembly, thereby to produce aluminum in said cell.

16. A method according to claim 15, wherein said ferrous metal sheath is integral with said spacer.

17. A method according to claims 15 or 16, wherein said internal end portion of the spacer is inside said cell walls.

Patentansprüche

1. Elektrolytische Reduktionszelle (4) zur Aluminumherstellung, umfassend eine Zellenwand (17,18), eine Sammelschiene (46,48) außerhalb der Zellenwand (17,18), eine Anode (12), einen Kohlenstoff-Kathodenblock (20), der von der Anode (12) getrennt ist, und eine Kollektorschiene (30), welche die Sammelschiene (46,48) mit dem Kathodenblock (20) verbindet, wobei die Kollektorschiene (30) aufweist:

(a) einen Eisenmetallkörper, umfassend:

1) ein festes Eisenmetall-Distanzstück (32) mit einem äußeren Endabschnitt (35), der mit der Sammelschiene (46,48) verbunden ist, und einen inneren Endabschnitt (36), von dem äußeren Endabschnitt (35) nach innen beabstandet, sowie

2) einen Eisenmetall-Mantel (33), der einen Hohlraum (34) begrenzt, und

(b) einen Kupfereinsatz (40) im Inneren des Hohlraums (34), wobei der Kupfereinsatz (40) ein äußeres, an dem Distanzstück (32) angrenzendes Ende hat, wobei das Distanzstück (32) den Wärmeausgleich in der Zelle verbessert, indem die Übertragung übermäßiger Wärme zwischen dem Kupfereinsatz (40) und der Sammelschiene (46,48) verhindert wird.

2. Zelle nach Anspruch 1, ferner aufweisend:

(c) ein schmelzflüssiges Salzbad (14) zwischen der Anode (12) und dem Kathodenblock (20).

3. Zelle nach Anspruch 1 oder 2, bei welcher der Kathodenblock (20) einen Schlitz (24) begrenzt und die Kollektorschiene (30) in diesem Schlitz (24) sitzt.

4. Zelle nach Anspruch 3, ferner aufweisend:

(d) in diesem Schlitz (24) ein Mittel zum Verbinden der Kollektorschiene (30) mit dem Kathodenblock (24).

5. Zelle nach Anspruch 4, bei welcher das Mittel in dem Schlitz (24) ein elektrisch leitfähiges Material umfasst.

6. Zelle nach Anspruch 4 oder 5, bei welcher das Mittel in dem Schlitz (24) ausgewählt ist aus der Gruppe, bestehend aus Gusseisen, kohlenstoffhaltigem Klebmittel und gestampfter Kohlenstoffpaste.

7. Zelle nach jedem der vorgenannten Ansprüche, bei welcher der Hohlraum (34) einen polygonalen Querschnitt hat und der Kupfereinsatz (40) einen polygonalen Querschnitt hat.

8. Zelle nach jedem der Ansprüche 1 bis 6, bei welcher der Hohlraum einen allgemeinen kreisförmigen Querschnitt hat und der Kupfereinsatz (40) einen allgemeinen kreisförmigen Querschnitt hat.

9. Zelle nach jedem der vorgenannten Ansprüche, bei welcher der Kathodenblock (20) 30% bis 100 Gew. % Graphit aufweist oder ein graphitisierter Kathodenblock ist.

10. Zelle nach jedem der vorgenannten Ansprüche, bei welcher der Eisenmetall-Mantel (33) mit dem Distanzstück (32) einstückig ist.

11. Zelle nach jedem der vorgenannten Ansprüche, bei welcher der innere Endabschnitt (36) des Distanzstücks (32) nach innen von der Zellenwandung (14) beabstandet ist.

12. Zelle nach jedem der vorgenannten Ansprüche, ferner aufweisend ein Stahl-Verschlussstück (45), welches den Kupfereinsatz (40) in dem Hohlraum umgibt.

13. Zelle nach jedem der vorgenannten Ansprüche, ferner aufweisend einen Zwischenraum für den Ausdehnungsausgleich (47) in dem Hohlraum (34) zwischen dem Kupfereinsatz (40) und dem Stahlverschlussstück (45).

14. Zelle nach jedem der vorgenannten Ansprüche, bei welcher die Kollektorschiene (30) ferner einen Luftauslass (44) zum Entspannen des Druckes aus dem Hohlraum (34) begrenzt.

15. Verfahren zum Herstellen von Aluminium in einer Elektrolysezelle mit Zellenwänden, die eine Kammer begrenzen, welche ein schmelzflüssiges Salzbad enthält, eine Anode im Kontakt mit dem Bad und eine Sammelschiene außerhalb der Zellenwände, welches Verfahren umfasst:

(a) Bereitstellen einer Kathodengruppe, aufweisend:

1) einen Kohlenstoff-Kathodenblock, der von der Anode getrennt ist,

2) einen Eisenmetall-Körper, der einen festen Eisenmetallmantel mit einem äußeren Endabschnitt hat, der mit der Sammelschiene und einem inneren Endabschnitt verbunden ist, der nach innen von dem äußeren Endabschnitt beabstandet ist, sowie einen Eisenmetall-Mantel, der einen Hohlraum begrenzt, und

3) einen Kupfereinsatz im Inneren des Hohlraums, wobei der Kupfereinsatz ein äußeres, an dem Distanzstück angrenzendes Ende hat, und

(b) Durchleiten eines elektrischen Stroms von der Anode zu der Kathodengruppe, wodurch in der Zelle Aluminium erzeugt wird.

16. Verfahren nach Anspruch 15, bei welchem der Eisenmetall-Mantel mit dem Distanzstück einstückig ist.

17. Verfahren nach Anspruch 15 oder 16, bei welchem der innere Endabschnitt des Distanzstückes im Inneren der Zellenwände ist.

Revendications

1. Cuve de réduction électrolytique (4) pour la production d'aluminium, comprenant une paroi (17, 18) de cuve, une barre omnibus (46, 48) externe par rapport à ladite paroi (17, 18) de cuve, une anode (12), un bloc cathodique carboné (20) séparé de ladite anode (12), et une barre collectrice (30) reliant ladite barre omnibus (46, 48) audit bloc cathodique (20), ladite barre collectrice (30) comprenant :

(a) un corps en métal ferreux comprenant

1) un élément d'espacement solide en métal ferreux (32) ayant une partie d'extrémité externe (35) reliée à ladite barre omnibus (46, 48) et une partie d'extrémité interne (36) espacée vers l'intérieur de ladite partie d'extrémité externe (35), et
2) une gaine en métal ferreux (33) définissant une cavité (34), et

(b) une âme en cuivre (40) à l'intérieur de ladite cavité (34), ladite âme en cuivre (40) ayant une extrémité externe adjacente audit élément d'espacement (32), lequel élément d'espacement (32) améliore le bilan thermique dans la cuve en empêchant un transfert thermique excessif entre ladite âme en cuivre (40) et ladite barre omnibus (46, 48).

2. Cuve selon la revendication 1, comprenant en outre

(c) un bain de sels fondus (14) entre ladite anode (12) et ledit bloc cathodique (20).

3. Cuve selon les revendications 1 ou 2, dans laquelle ledit bloc cathodique (20) définit une fente (24) et ladite barre collectrice (30) est placée dans ladite fente (24).

4. Cuve selon la revendication 3, comprenant en outre

(d) un moyen dans ladite fente (24) destiné à raccorder ladite barre collectrice (30) audit bloc cathodique (24).

5. Cuve selon la revendication 4, dans laquelle ledit moyen dans ladite fente (24) comprend un matériau électriquement conducteur.

6. Cuve selon les revendications 4 ou 5, dans laquelle ledit moyen dans ladite fente (24) est choisi parmi le groupe constitué de fentes de fer, de colle carbonée, et de pâte carbonée damée.

7. Cuve selon l'une quelconque des revendications précédentes, dans laquelle ladite cavité (34) a une coupe transversale polygonale et ladite âme en cuivre (40) a une coupe transversale polygonale.

8. Cuve selon l'une quelconque des revendications 1 à 6, dans laquelle ladite cavité a une coupe transversale généralement circulaire et ladite âme en cuivre (40) a une coupe transversale généralement circulaire.

9. Cuve selon l'une quelconque des revendications précédentes, dans laquelle ledit bloc cathodique (20) comprend 30 à 100 % en poids de graphite ou un bloc cathodique graphité.

10. Cuve selon l'une quelconque des revendications précédentes, dans laquelle ladite gaine en métal ferreux (33) est solidaire dudit élément d'espacement (32).

11. Cuve selon l'une quelconque des revendications précédentes, dans laquelle ladite partie d'extrémité interne (36) de l'élément d'espacement (32) est espacée vers l'intérieur de ladite paroi (14) de cuve.

12. Cuve selon l'une quelconque des revendications précédentes, comprenant en outre une carotte en acier (45) enfermant l'âme en cuivre (40) dans ladite cavité.

13. Cuve selon l'une quelconque des revendications précédentes, comprenant en outre un espace de tolérance de dilatation (47) dans ladite cavité (34) entre l'âme en cuivre (40) et la carotte en acier (45).

14. Cuve selon l'une quelconque des revendications précédentes, dans laquelle ladite barre collectrice (30) comprend en outre un évent d'aération (44) destiné à évacuer une pression de ladite cavité (34).

15. Procédé destiné à produire de l'aluminium dans une cuve électrolytique ayant des parois de cuve définissant une chambre contenant un bain de sels fondus, une anode en contact avec le bain, et une barre omnibus à l'extérieur des parois de cuve, ledit procédé comprenant les étapes consistant à

a) fournir un ensemble cathodique comprenant

1) un bloc cathodique carboné séparé de l'anode,
2) un corps en métal ferreux comprenant un élément d'espacement solide en métal ferreux ayant une partie d'extrémité externe reliée à ladite barre omnibus et une partie d'extrémité interne espacée vers l'intérieur de ladite partie d'extrémité externe, et une gaine en métal ferreux définissant une

cavité, et
3) une âme en cuivre à l'intérieur de ladite cavité, ladite âme en cuivre ayant une extrémité externe adjacente audit élément d'espacement, et

b) faire passer un courant électrique de l'anode à l'ensemble cathodique, pour produire de ce fait de l'aluminium dans ladite cuve.

16. Procédé selon la revendication 15, dans laquelle ladite gaine en métal ferreux est solidaire dudit élément d'espacement.

17. Procédé selon les revendications 15 ou 16, dans lequel ladite partie d'extrémité interne de l'élément d'espacement est à l'intérieur desdites parois de cuve.

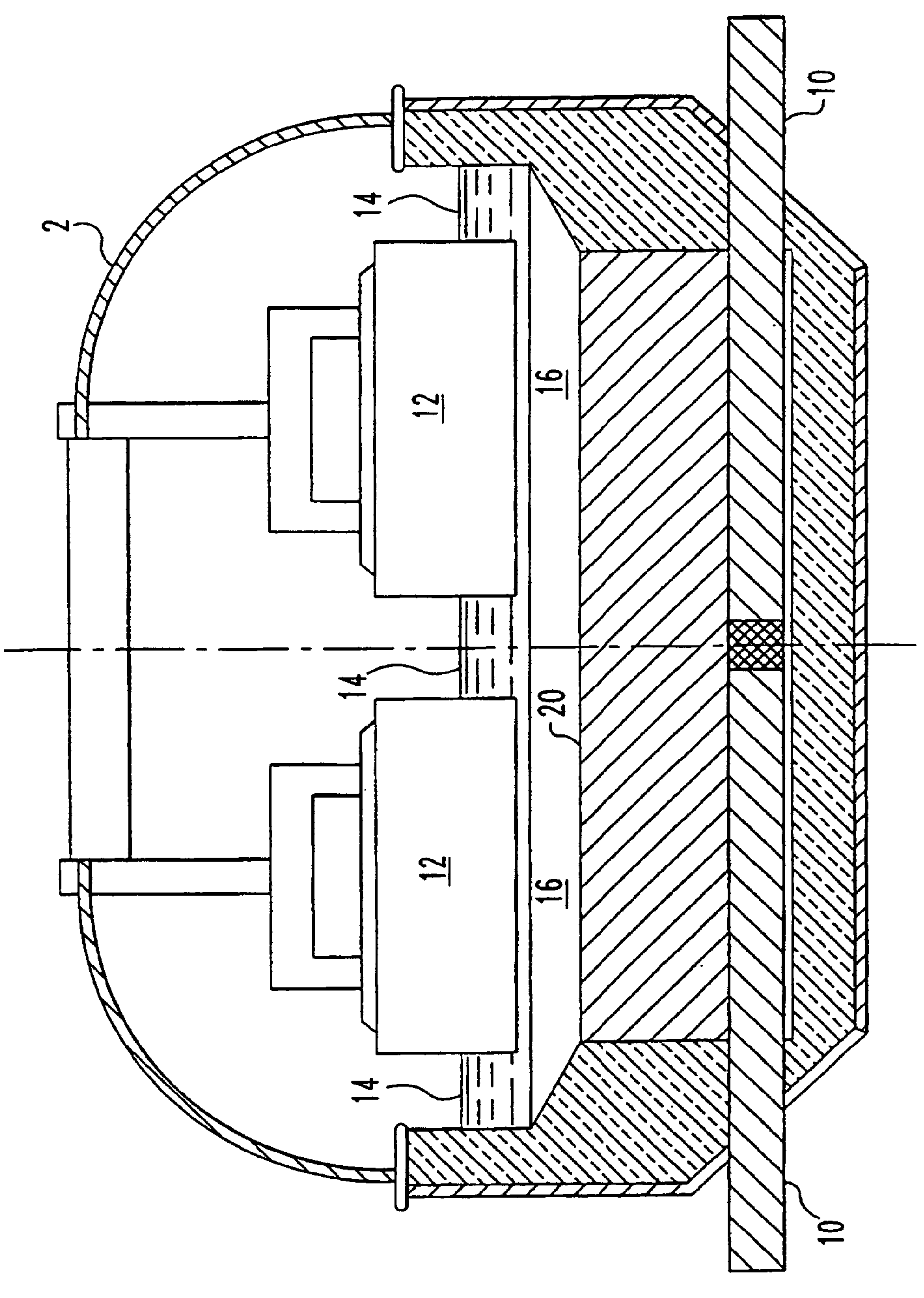

FIG.1

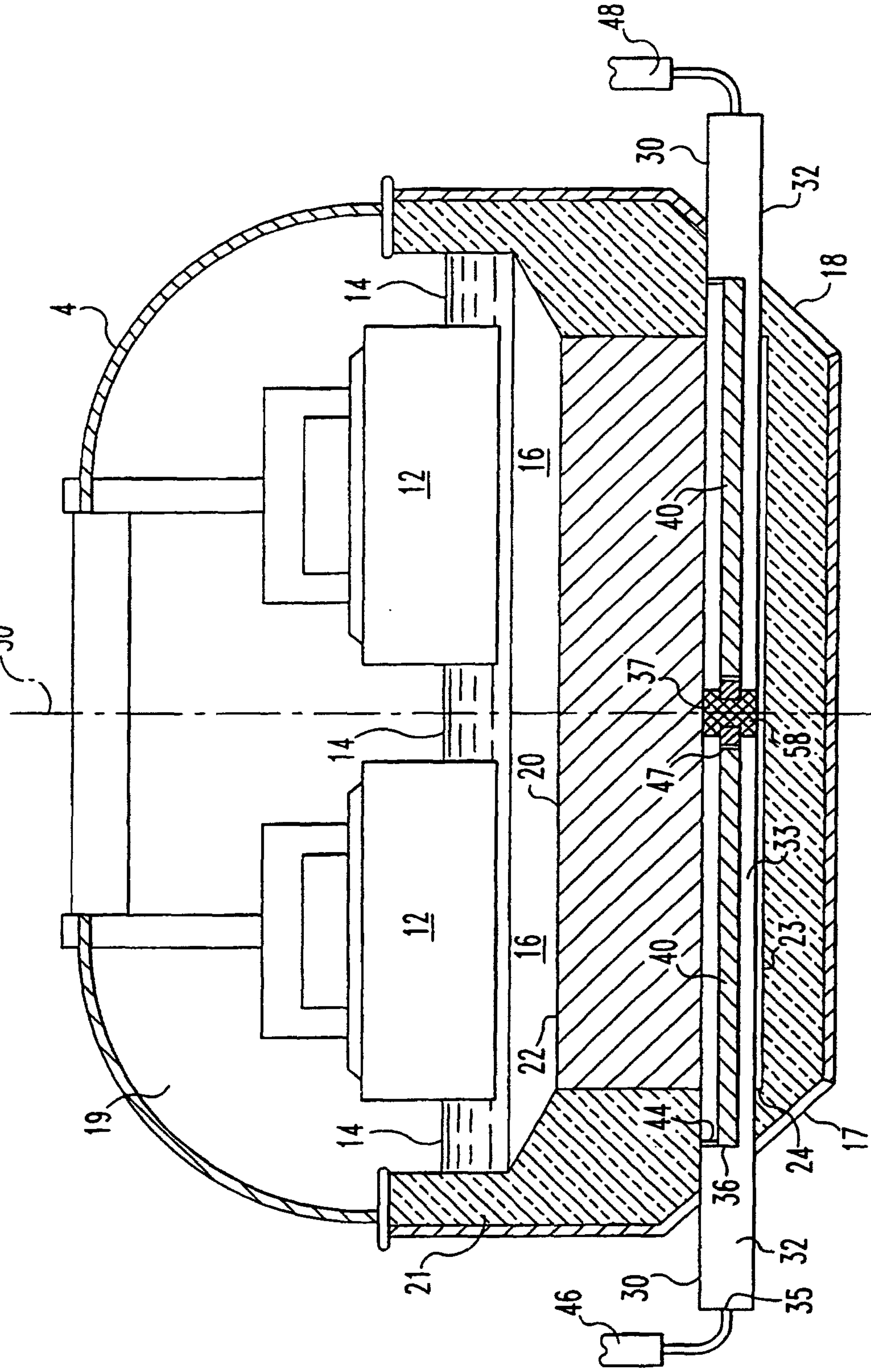

FIG.2

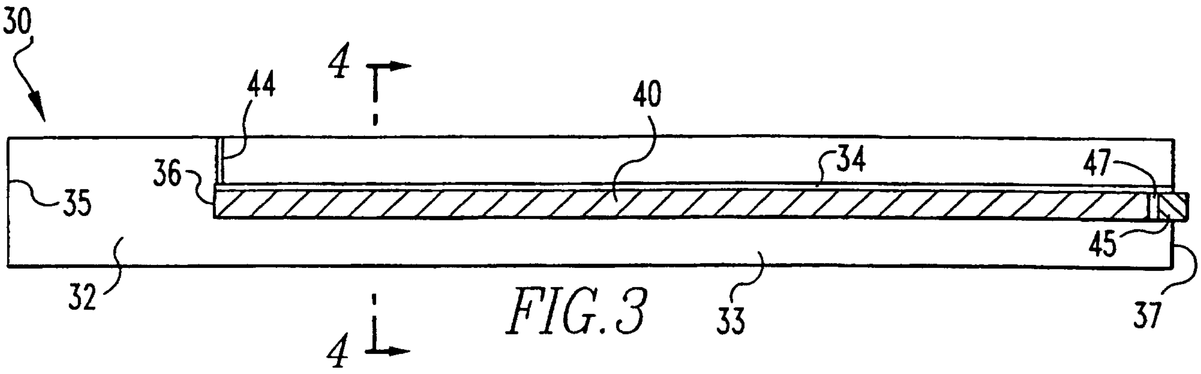

FIG. 3

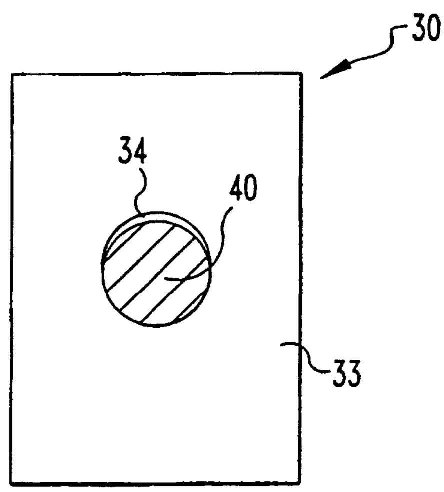

FIG. 4

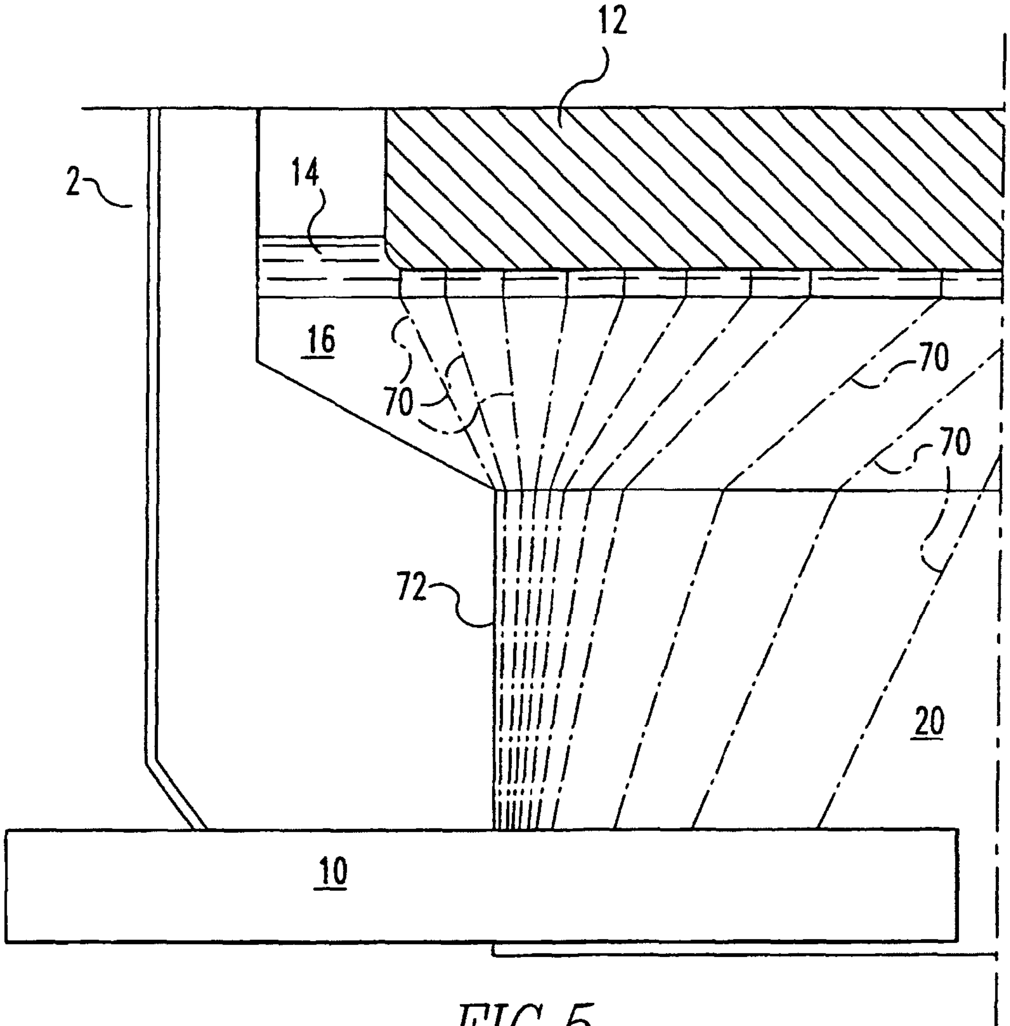

FIG.5

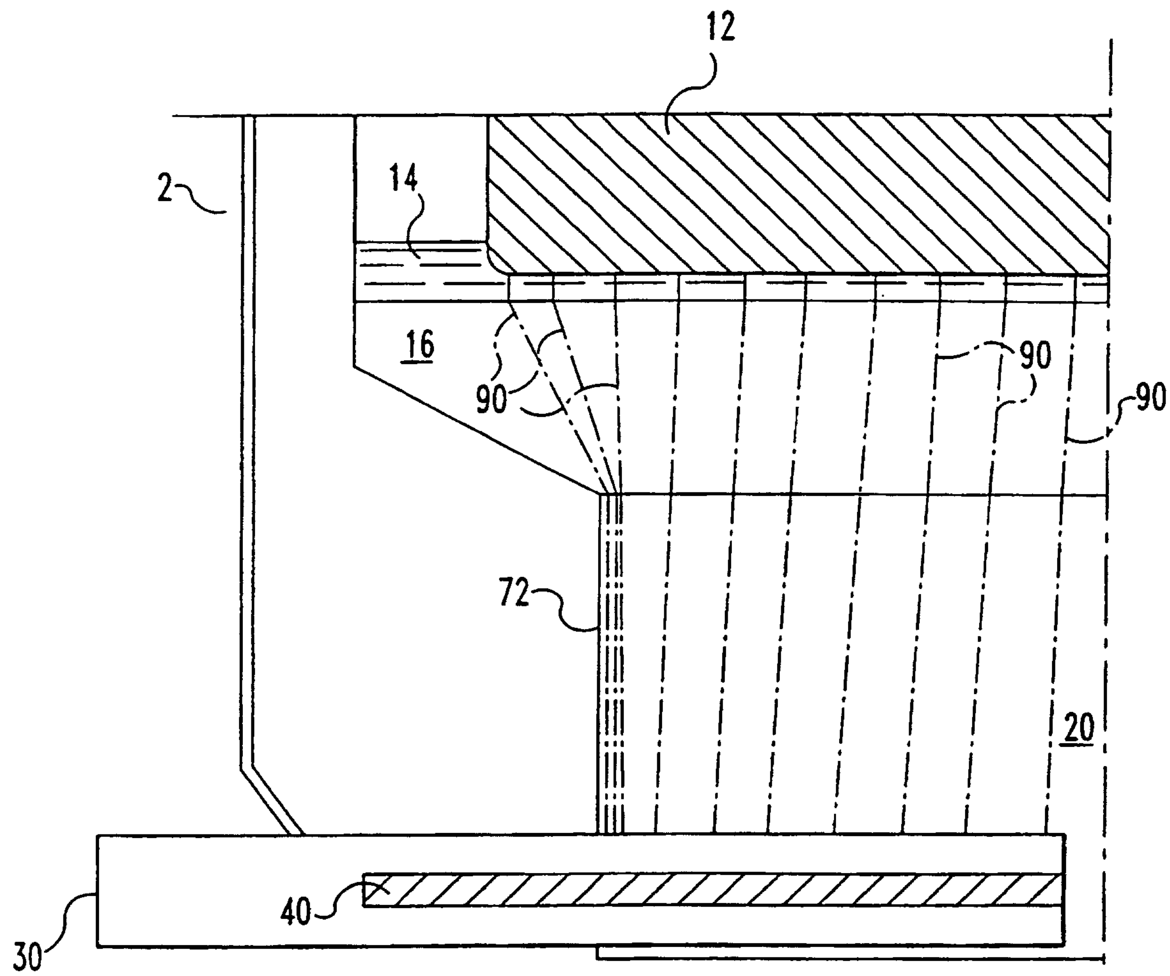

FIG.6