

June 7, 1960

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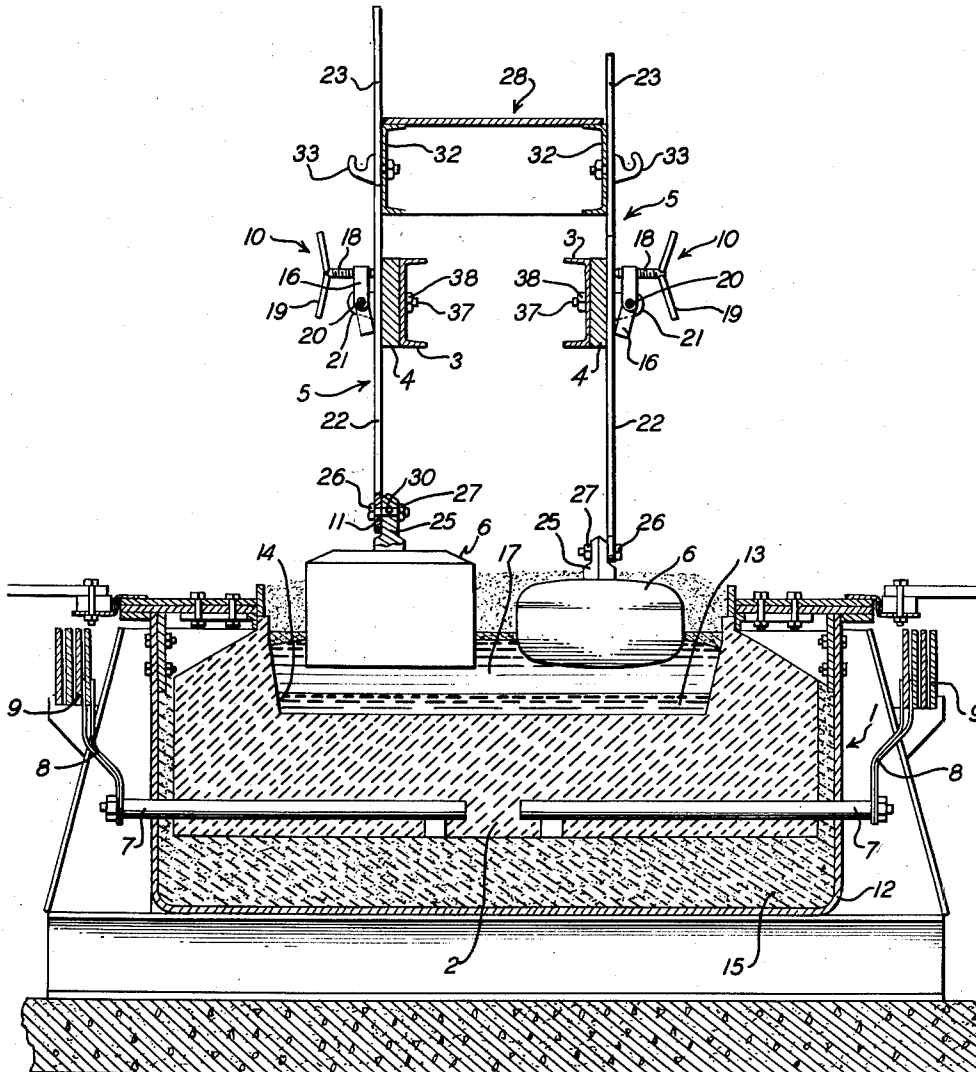
2,939,829

ELECTROLYTIC CELL

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2 Sheets-Sheet 1

Fig. 1.



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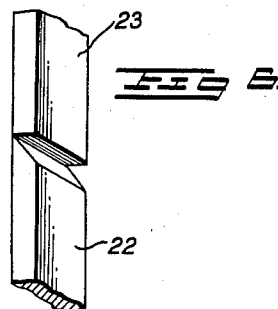
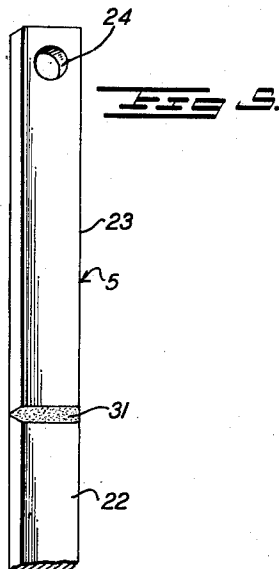
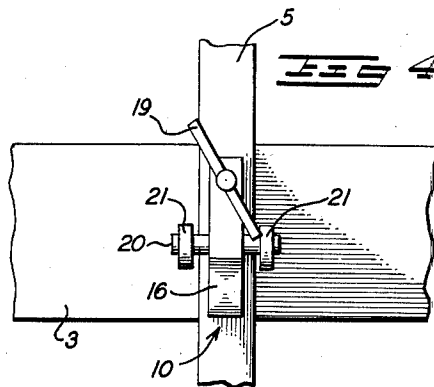
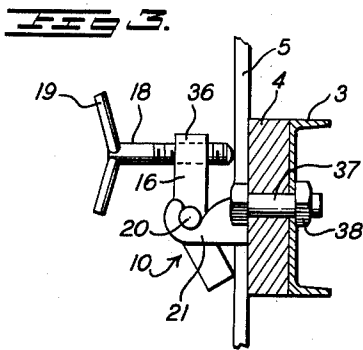
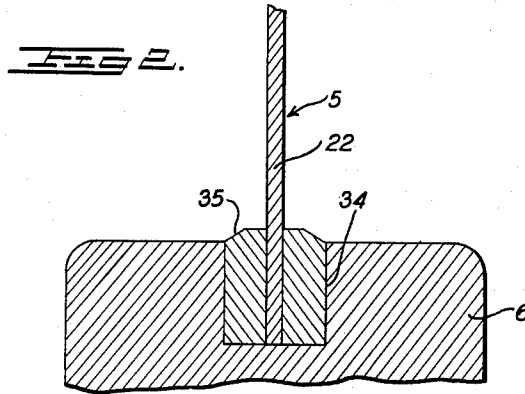
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2 Sheets-Sheet 2



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ELECTROLYTIC CELL

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2 Claims. (Cl. 204-243)

This invention relates to electrolytic cells employing electrodes supported by individual bars of conductor material. More particularly, this invention relates to a novel bar structure for suspending electrodes as employed in electrolytic cells, e.g. suspension of prebake anodes in electrolytic cells for the reduction of aluminum-containing compounds.

Heretofore such electrodes or anodes were suspended from copper bars which in turn were suitably affixed to supporting conductors positioned above the cavity of the electrolytic cell. During operation of such cells the lower portions of the anodes are generally consumed or burned off and the anodes must be lowered in order to have the lower surface thereof in the proper position in the electrolyte. Accordingly, a suitable mechanism is generally provided for lowering and raising the supporting conductors. In order to avoid the necessity of removing and replacing all of the anodes at once they are staggered in their vertical position such that only one or two require replacing at a given time. In view of such staggering it is necessary, when the supporting conductors have reached their lowest position, to be able to maintain the anodes in a fixed position relative to the electrolyte while the supporting conductors are raised to their highest position. After the supporting conductors are raised to their highest position the anodes may be lowered further by lowering the supporting conductors. Accordingly, suitable structural members are provided above and parallel to the supporting conductors. The copper bars are of sufficient length such that the ends of the bars extend to a position above the structural members when the electrode is at its lowest position. Thus when the supporting conductors reach their lowest position, the bars may be affixed to the structural members to maintain them in position. The bars may then be disengaged from the supporting conductors and the supporting conductors moved to their uppermost position. The bars may be again affixed to the supporting conductors and disengaged from the structural members. Lowering of the bars and electrodes may then be resumed by lowering the supporting conductors.

When an anode has been consumed to a point where it needs to be replaced, it is generally necessary to supply a suitable lifting device such as a crane. To facilitate such lifting, an opening is generally provided in the upper end of the copper bars for engagement by a hook of the crane. Accordingly, the copper bars must not only extend to the structural members but must extend somewhat beyond to make possible engaging the crane hook in the opening.

In the past these bars have been fabricated entirely from copper due to the importance of maximum conductivity combined with a sufficiently high melting point to avoid softening at temperatures prevalent in the zone adjacent the electrolytic cell. However, the use of copper for such bars possesses inherent disadvantages with regard to the economics of electrolytic cell operations. Many alumina reduction plants employ more than one

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thousand reduction cells and each cell may use as many as twenty-five or more copper bars. These copper bars must be replaced periodically due to damage from arcing, corrosion and wear. Thus the high cost of copper for these bars is important with regard to both capital and replacement expense.

Accordingly, it is an object of this invention to provide a novel bar structure for the suspension of electrodes in cells which eliminates or substantially reduces the disadvantages of the prior art.

It is a further object of this invention to provide a novel electrolytic cell apparatus characterized by low capital and replacement expense.

It is a further object of this invention to provide a novel electrolytic alumina reduction cell structure characterized by low capital and replacement expense.

It is a still further object of this invention to provide a novel electrode suspension bar for use in combination with an electrolytic cell characterized by low capital and replacement expense.

It is another object of this invention to provide a novel anode assembly for use in combination with an electrolytic cell characterized by low capital and replacement expense.

It is another object of this invention to provide a novel electrode suspension bar for use in combination with an electrolytic cell which overcomes many of the problems present in the use of prior known suspension bars due to the high cost of the conductor material.

Another object of this invention is to provide a novel anode suspension bar for use in combination with an alumina reduction cell which eliminates or substantially reduces the disadvantages of the suspension bars as heretofore known.

Other objects and advantages of this invention will be apparent from the following description taken in conjunction with the accompanying drawings.

This invention relates to an electrode suspension bar for use in combination with an electrolytic cell. This electrode suspension bar comprises a major portion of copper and a minor portion of a metal of lower electrical conductivity than copper, these portions being in abutting high strength bond relationship. This electrode suspension bar is adapted to be affixed to an electrode of the electrolytic cell at the copper end and is provided with an opening in the opposite end.

The accompanying drawings illustrate the presently preferred embodiment of this invention as applied to alumina reduction cells.

Figure 1 is an end elevational view in cross-section, with parts removed for purposes of clarity, of an alumina reduction cell embodying the principles of this invention.

Figure 2 is a fragmentary, cross-sectional illustration of an alternative means for affixing an anode bar to an anode.

Figure 3 is a fragmentary, detail drawing partly in cross-section of a means for affixing the anode suspension bars to the anode support bus conductors when viewed from the end of the cell of Figure 1.

Figure 4 is a fragmentary, detail drawing of the means of Figure 2 for affixing the anode suspension bars to the anode support bus conductors when viewed from the side of the cell of Figure 1.

Figure 5 is a fragmentary, three-dimensional illustration of an anode bar embodying the principles of this invention.

Figure 6 is a fragmentary, three-dimensional drawing illustrating one design for the connection between the steel and copper portions of an anode suspension bar embodying the principles of this invention when viewed prior to welding.

Referring now more particularly to the drawings in

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which the same reference numerals have been applied to corresponding parts, and with particular reference to Figure 1, an alumina reduction cell 1 is shown comprising a carbon lining 2 which defines a cavity 14 adapted to contain a molten aluminum pad 13 and an electrolyte 17 consisting essentially of alumina dissolved in cryolite. Carbon lining 2 is supported by a shell 12 of suitable material such as steel, a layer of insulation 15 being provided between lining 2 and shell 12. This cell further comprises a plurality of carbon anodes 6 suspended in the electrolyte by means of anode suspension bars 5 affixed to anodes 6 by suitable means. One such means is illustrated in Figure 1 wherein anodes 6 are provided with mild steel stubs 25 imbedded therein and anode bars 5 affixed to stubs 25 by bolts 26 and nuts 27, openings 11 and 30 being provided in anode bars 5 and stubs 25, respectively, for the passage of bolts 26.

Another means for affixing bars 5 to anodes 6 is by the use of cast iron as illustrated in Figure 2. This is accomplished by providing a recess 34 in the upper portion of anodes 6 substantially larger than the cross section of anode bars 5. The lower ends of bars 5 are placed in the recess 34 and molten cast iron 35 is poured into the recess 34 around anode bars 5 and allowed to solidify.

Current is delivered to the cell 1 by a suitable anode bus conductor (not shown) through anode support bus conductors 4 and bars 5 to anodes 6. Bus conductors 4 are fabricated from a suitable high electrical conductivity material, e.g. aluminum. Generally bus conductors 4 are reinforced for mechanical strength by structural members 3 of suitable high strength material, e.g. steel. Bus conductors 4 are affixed to structural member 3 by suitable means such as bolts 37 and nuts 38. From anodes 6 the current passes through the electrolyte 17 and molten aluminum 13 to lining 2 and out through contact bars 7 imbedded in lining 2, flexible conductors 8 and cathode bus conductor 9.

Anode suspension bars 5 are affixed to anode support bus conductors 4 by adjustable means such as clamps 10. With reference more particularly to Figures 3 and 4 it will be seen that each clamp 10 comprises an elongated member 16 provided with a threaded opening 36 at one end. A threaded rod 18 having a suitable handle 19 is provided for loosening or tightening clamp 10. Rod 18 is adapted to engage threaded opening 36 whereby turning handle 19 causes rod 18 to move longitudinally through opening 36. Suitable projections 29 are affixed to either side of member 16 midway between the ends of member 16 and are adapted to engage hook members 21 affixed to bus conductors 4 on either side of each anode bar 5. Clamps 10 may be employed to maintain anode bars 5 in contact with bus conductors 4 by engaging projections 29 with hook members 21, while the anode bars 5 are in position, and threading rod members 18 into the threaded openings 36 of members 16 and tightening rod members 18 against anode bars 5.

As the lower portion of the anodes 6 are consumed during reduction operations, the anodes may be lowered by lowering support bus conductors 4 through the use of suitable lowering means (not shown). When conductors 4 have reached their lowest position it is necessary to maintain the anodes 6 in fixed position relative to the electrolyte 17, while anode support bus conductors 4 are raised to their highest position. As previously mentioned this is necessary due to the staggering of the electrodes to avoid the necessity of changing all electrodes at once. In order to maintain the anodes 6 in such a fixed position a suitable superstructure 28 is provided including structural members 32 above conductors 4 and parallel thereto. Suitable hooks members 31 similar to hook members 21 are provided on structural members 32 on either side of anode bars 5. Thus, bars 5 and anodes 6 may be maintained in fixed position by clamping anode bars 5 to structural members 32 by engaging additional

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clamps (not shown), similar to clamps 10, with hooks 33. Clamps 10 may then be removed and bus conductors 4 raised to their highest position. When bus conductors 4 have been raised to their highest position bars 5 may again be clamped to bus conductors 4 by clamps 10 and the clamps clamping bars 5 to structural members 32 may be removed. Anodes 6 may then be further lowered by lowering bus conductors 4.

When an anode 6 is nearly consumed, it may be removed by removing the respective clamp 10 and removing bar 5 supporting the anode. A new anode 6 suspended from a new bar 5 may then be clamped in place by means of clamps 10. Due to the weight of the anodes it is necessary to employ suitable means such as a crane for removing and replacing the anodes and bars. In order to facilitate lifting of bars 5 by crane means it is necessary for the bars to be of sufficient length to extend to a position above structural members 32 when anode 6 is in its lowest position.

With reference more particularly to Figure 5, illustrating an anode suspension bar 5 embodying the principles of this invention, it will be seen that this bar comprises a major portion 22 of copper and a minor portion 23 of a less expensive metal having a lower electrical conductivity than copper, e.g. steel. The major or copper portion 22 is of a length such that it contacts bus conductor 4 even when the anode bar is in its lowest position. That portion 23 of the bar 5 which is above the anode support bus conductor even when the anode bar is in its lowest position does not conduct electric current and thus there is no power loss or loss of operating efficiency resulting from the use of a less expensive lower electrical conductivity metal for portion 23. Bar 5 is provided with an opening 24 near the end opposite the end affixed to the anode to permit lifting bar 5 and anode 6 by crane means. Bar 5 has a sufficient overall length to extend to a position whereby opening 24 is above structural members 32 when the bar is in its lowest position. The two portions of the bar are joined together in abutting high strength bond relationship. The preferred method for achieving such a bond is by inert gas-shielded arc welding to produce a weld 31. That is to say, the method whereby an electric arc surrounded by a protective inert gas shield is employed.

The following are examples of the practice of this invention.

EXAMPLE I

Copper to steel welds were made between short lengths of used 99.88% minimum purity copper anode bars ranging from 7 inches to 8 inches in length, $1\frac{3}{16}$ inch thick x $2\frac{3}{8}$ inches wide, bevelled at one end to a 40 degree angle, and steel sections $\frac{3}{4}$ inch x $2\frac{3}{8}$ inches x 18 inches having square butt ends, as shown in Figure 6 of the drawings. Each end of the bars to be welded was preheated before welding to approximately 1000° F. Welds were made by the inert gas-shielded arc welding process using a consumable 98.9% minimum purity copper filler electrode $\frac{1}{16}$ inch in diameter and a shielding gas consisting of 75% helium and 25% argon. The total gas flow was approximately 60 cubic feet per hour. A welding current of about 300 amperes and an arc voltage of about 28 volts measured between the welding gun and the work was used. D.C. reverse polarity was employed, and a single pass made at a travel speed of 0.5 inch per minute. The finished weld beads were ground flush such that they had the same thickness and width as the copper bars. These samples were divided into six groups of four samples each. The samples in group No. 1 were not heat cycled and mechanical property tests were made at room temperature. Samples of each of the remaining five groups, i.e. 2 through 6, were heat cycled to 200, 300, 400, 500 and 600° F. respectively. Each group of samples was raised to its respective heat temperature in a furnace, held for one-half hour, taken out of the fur-

nace and allowed to air cool. This procedure was repeated ten times. For each group one sample was tensile tested at the maximum heat cycling temperature of the group. Three samples from each group were tensile tested at room temperature. Average mechanical properties for each group of copper to steel weldments obtained in these tests are tabulated in the following table:

Mechanical properties of copper to steel weldments without heat cycling, during and after heat cycling (10 cycles)

Group No.	Max. Temp. During Heat Cycle, ° F.	Properties at Max. Heat Cycle Temp., UTS, p.s.i.	Room Temperature Properties After Heat Cycle.	
			UTS, p.s.i.	Elong., percent in 2.00 in.
1.....	Not Heat-Cycled..		29,920	21.5
2.....	200.....	21,550	27,700	18
3.....	300.....	21,200	28,600	14.5
4.....	400.....	24,050	27,800	20.0
5.....	500.....	19,800	27,900	14.5
6.....	600.....	17,550	26,560	14.5

These tests indicate that the copper to steel weld has bond strength, even when subjected to heat cycling conditions similar to those encountered in service in an alumina reduction cell, such that an anode suspension bar fabricated with a steel top section will function quite satisfactorily.

EXAMPLE II

Forty anode bars embodying the principles of this invention were fabricated from 47 inch long 99.88% minimum purity copper bars, $1\frac{3}{16}$ inch thick by 2 $\frac{3}{8}$ inches wide, bevelled at one end to a 40 degree angle, and steel sections, $\frac{3}{4}$ inch by 2 $\frac{3}{8}$ inches by 15 inches with square butt ends, as shown in Figure 6 of the drawings. Each end of the ends to be welded was preheated before welding to approximately 1000° F. Welds were made by the inert gas-shielded arc welding process using a consumable 99.88% minimum purity copper filler electrode $\frac{1}{16}$ inch in diameter and a shielding gas consisting of 75% helium and 25% argon. The rods were placed in service

in production electrolytic cells and have proved very successful.

While there has been shown and described hereinabove the presently preferred embodiments of this invention, it is to be understood that the invention is not limited thereto and that various changes, alterations and modifications can be made thereto without departing from the spirit and scope thereof as defined in the appended claims, wherein what is claimed is:

1. An electrolytic reduction cell having a lining which defines a cavity adapted to contain an electrolyte, at least one prebake anode and at least one bus conductor positioned above said cavity in combination with at least one anode suspension bar affixed at one end to said anode and adapted to be clamped at a point removed from said anode to said bus conductor, said anode suspension bar comprising a major portion of copper adjacent said anode and a minor portion of steel at the end of said anode suspension bar furthest removed from said anode, said portions being in abutting high strength bond relationship, said minor portion being provided with an opening therein near the end opposite the end of said minor portion in abutting relationship with said major portion.

2. An anode assembly for use in an electrolytic cell comprising a carbon prebake anode and a composite metal bar, said anode being affixed to one end of said bar, said composite metal bar comprising a major portion of copper adjacent said anode and a minor portion of steel at the end of said composite metal bar furthest removed from said anode, said portions being in abutting welded relationship, said composite metal bar being provided with an opening therein near the end opposite the end which is affixed to said anode.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,939,829

June 7, 1960

George Allen

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

Column 2, line 14, for "tof" read -- of --; column 3, line 71, for "hooks members 31" read -- hook members 33 --; column 6, line 25, for "carbon prebake" read -- prebake carbon --.

Signed and sealed this 4th day of April 1961.

(SEAL)

Attest: ERNEST W. SWIDER

~~KARL H. AXLINE~~
XXXXXXXXXXXX
Attesting Officer

ARTHUR W. CROCKER
Acting Commissioner of Patents