ELECTROLYTIC CELL

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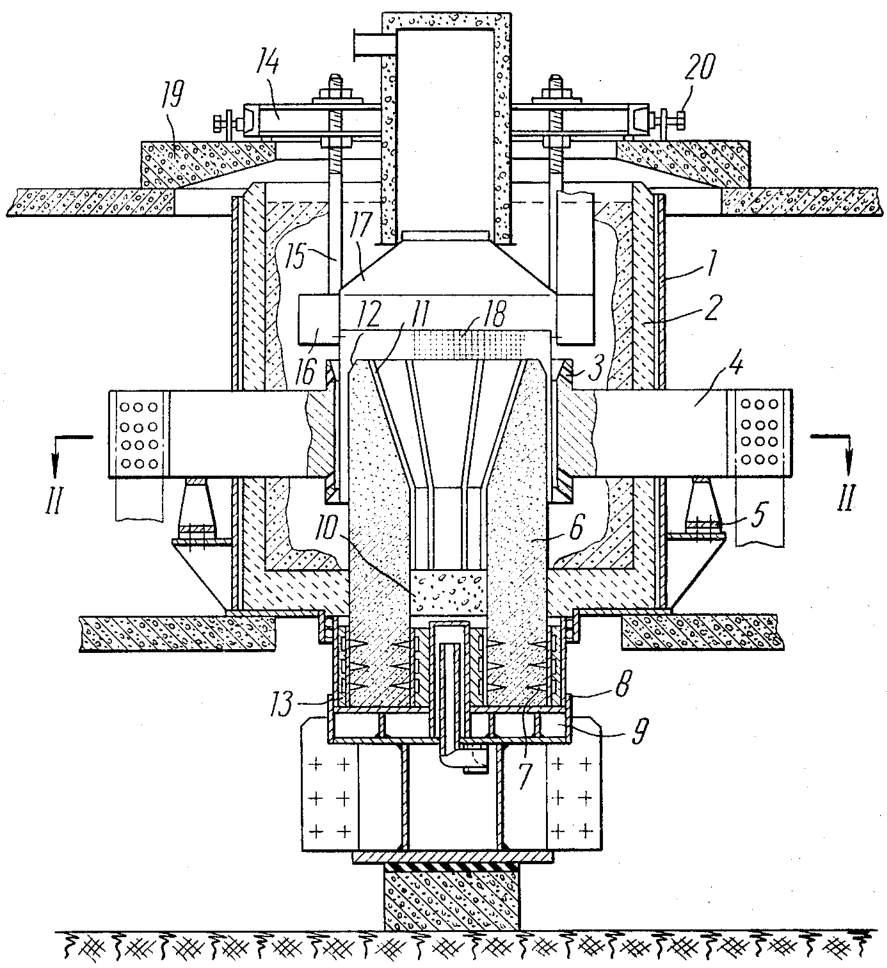

FIG. 1

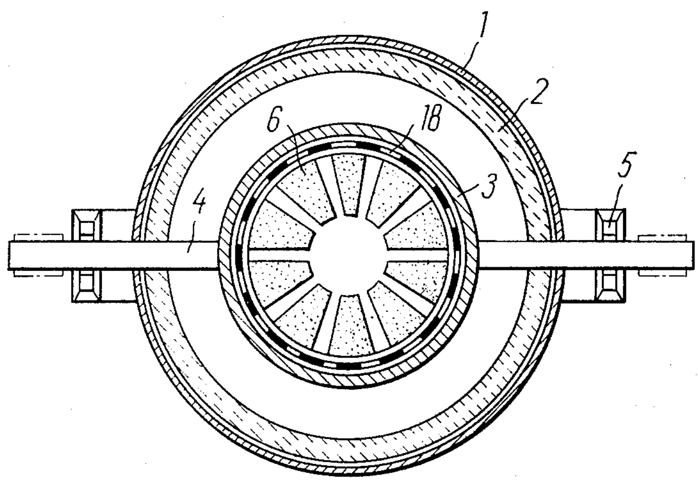

FIG. 2

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ELECTROLYTIC CELL

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ABSTRACT OF THE DISCLOSURE

An electrolytic cell comprises a hollow annular anode assembled from a plurality of spaced circumferentially arranged bars, the anode defining a cavity in which an anode cooler penetrates. The anode is surrounded by a closed cathode and the anode cathode and anode cooler are incorporated in a lined tank, the dimensions of the anode and the lined tank, the lining thickness and the cooler parameters being selected so as to constantly maintain in the course of electrolytic cell operation a heat insulating garnissage layer at least on the entire inner surface of the tank.

This invention relates to cells for the production of sodium by the electrolysis of sodium chloride in a fused bath of halide electrolytes.

In the known electrolytic cells of this type, provision is made for a refractory brick-lined tank which houses an anode assembled from bars and a cathode that surrounds the anode assembly (cf. Alabishev et al., Sodium and Potassium, Goskhimizdat, 1959). Disposed in the interelectrode gap is a screen diaphragm affixed to a dome which is located above the anode and cathode and serving for collecting and discharging the sodium and chlorine liberated when the fused salt bath undergoes electrolysis in the course of cell operation.

In the operation of the above cells, the principal disadvantage stems from the fact that the temperature of the electrolyte rises above the permissible level, thereby causing an interruption or even complete termination of the process of sodium and chlorine liberation.

This temperature elevation occurs due to inadequate elimination of the excessive heat evolved as a result of the gradual destruction of the anode and due to an increasing interelectrode gap, the latter factor being ultimately responsible for a limited life of the cell.

In the electrolytic cells of the known types, care is taken to control the electrolyte temperature and eliminate excessive heat. It is known to employ to this end detachable heat-insulating shields mounted on the electrolytic cell jacket or water-cooled contact plates at the bottom ends of the anode.

However, practical experience has shown the above measures to be inadequate, as the detachable heat-insulating shields mounted on the jacket are inconvenient in service and do not render it possible to vary uniformly the elimination of heat, while the water-cooled anode contact plates are of low efficiency because the heat transfer from the graphite bars to these plates is poor.

Another adverse factor responsible for a decreased yield of the electrolysis products is the onset of unwanted eddies in the electrolyte, the most pronounced deleterious effect being produced by the eddies arising in the vicinity of the upper butt ends of the anode graphite bars and obstructing the inflow of the electrolyte into the central channel of the anode.

In the known electrolytic cells no provision is made for eliminating the above eddies in the electroyte.

The known electrolytic cells for the production of sodium also suffer from the disadvantage in that the working face of the anode assembly must be machined to obtain the desired dimensions. The machining of graphite rods involves the removal of the surface layer obtained in the course of manufacturing and graphitizing the graphite rods and results in a shorter anode life as well as in a rapid increase of the interpole gap. In view of the necessity for machining, transporting and mounting heavy large-size anode assemblies, the cost of anode assemblies is increased and they are prone to breakage at various steps of machining, transportation and mounting.

It is also inexpedient to use refractory brick or heat-resisting concrete for sealing the central part of the anode assembly in the lining of the hearth of the known electrolytic cells as the above materials have a coefficient of thermal expansion which differs markedly from that of graphite, so that considerable pressure exerted on the anode bars due to thermal expansion may cause their failure.

It is an object of the present invention to eliminate the aforementioned disadvantages.

It is the principal object of the present invention to provide an electrolytic cell that will maintain the temperature of the electrolyte close to the electrolyte melting point throughout the run, will eliminate metallization of the lining by providing the conditions that are conducive to the establishment of steady thermal equilibrium, and will ensure the optimum rate of electrolyte circulation with concomitant minimum loss of the metal due to electrochemical dissolution of the metal and current losses, metal losses being likewise minimized thanks to losses occurring as a result of the interaction of electrolysis products with the anode, which incorporates a more efficient cooling system and ensures a longer electrolytic cell life.

This object has been accomplished in an electrolytic cell intended primarily for the production of sodium and chlorine from molten halide electrolytes, in which a bar anode assembly and a closed cathode surrounding the anode are disposed in a tank, wherein, according to the invention, the dimensions of the tank and anode, the thickness of lining and the parameters of the anode cooler are selected so as to render it possible to maintain in the bath, in the course of cell operation, adequate surface conditions (garnissage), at least over the entire surface of the bath walls.

In the electrolytic cell, provision may be made for a hollow anode with a cooler disposed in the anode cavity, the anode being sealed from the top with graphite-filled concrete whose coefficient of thermal expansion is close to that of the anode bars.

Use can likewise be made of anode bars which are trapezoidal in the cross-section and chamfered on the outside and inside in the top part.

Presented hereinbelow by way of illustration is a description of the exemplary embodiment of the present electrolytic cell with appended drawings, wherein:

FIG. 1 is a longitudinal section of the electrolytic cell; and

FIG. 2 is a sectional view of the electrolytic cell taken along line II—II of FIG. 1.

The electrolytic cell comprises a tank **1** formed by a cylindrical steel shell (FIGS. 1 and 2) lined with fireclay brick **2**. Mounted in the electrolytic cell tank is a cathode which consists of perforated steel cylinder **3** held in place by two steel plates **4** welded to it, the plates passing through the side walls of the tank and resting on brackets **5**.

The anode is constituted of prismatic graphite bars **6**, which are trapezoidal in cross section. Graphite is formed into this shape in the course of manufacturing the bars so as to preserve a firm, unmachined layer on the working surface of the anode bars.

The bars are disposed within the cathode at equal distances from it and form a hollow annular anode having appropriate clearances between adjoining bars. Screws **7** are screwed into the bottom of the bars. Bars **6** of the anode assembly rest on contactor unit **8**, in which provision is made for cooler **9**, which partly protrudes into the anode cavity and is sealed with concrete layer **10** containing a graphite filler and having a coefficient of thermal expansion that is nearly equal to that of bars **6** of the anode assembly. In each bar **6**, the top has an inner chamfer **11** and an outer chamfer **12**.

In the anode bar assembly, the inner chamfers form an expansion in the upper part of the anode chamber, while the outer chamfers are instrumental in inscreasing the distance between the anode and cathode. In the cathode, provision is also made for top and bottom chamfers on the cathode side facing the anode. The space between cooler **9** and the wall of contact unit **8** is sealed with cast lead **13**, whereas the internal space extending from the lead casting to the level of the electrolytic cell hearth is sealed with cast concrete **10**.

Suspended from frame **14** of the electrolytic cell bv means of steel ties **15** is an annular trough **16**, which mounts diffuser **17**. Cylindrical screen **18** rigidly affixed to annular trough **16** is disposed in the space between the anode and cathode. The screen separates the anolyte from the catholyte layer, thereby preventing contact between the sodium and chlorine.

Top plate **19** of the electrolytic cell is furnished with a mechanism for centering screen **18** in the interelectrode gap in the course of cell operation. The anode bars are shaped to the desired form at the manufacturing plant by a process involving extrusion through a die of an appropriate section, so that the users of anode bars may dispense with machine tools for machining the surface of anode bars and have the advantage of employing the anode bars with the most dense layer of the working surface left intact, which fact results in longer anode life.

The bars are mounted in the electrolytic cell consecutively one after another, the cathode of the cell serving as a templet to which the anode bars are adjusted via spacers that determine the interelectrode gap.

The wall thickness, inside diameter and height of the cell shaft should be estimated on the basis of optimum results of the electrolytic cell operation when the current efficiency amounts to 80%.

These results are obtained when the following ratio holds:

$$\frac{D-0.163H}{\sqrt{I}} > 1.35\times 10^{-2}$$

where:

D is the diameter of electrolytic cell shaft, in meters;
H is the height of electrolytic cell shaft, in meters;
I is the cell load, in amperes.

The thickness of the electrolytic cell walls is selected to conform with the load applied to the given cell.

The electrolytic cell of the present type operates as follows.

The cell bath contains a molten electrolyte which fills the cell shaft almost to the top. The bath dimensions, lining thickness and the parameters of the cooler disposed within the anode bottom are selected so as to constantly provide, in the course of electrolytic cell operation, garnissage over the entire surface of the side walls of the shaft and a crust on the electrolyte surface. The crust and garnissage are heat-insulating layers that have the property of varying automatically their thickness in response to an increase or decrease in the amount of excessive heat in the electrolytic cell, thereby ensuring a corresponding increase or decrease in the amount of the heat eliminated from the electrolytic cell when the temperature of the electrolyte experiences a slight variation.

Direct current flowing through the electrolytic cell enters the anode via lead layer **13** cast to fill the space between cooler **9** and the wall of contact unit **8**.

Thanks to the provision of screws **7** in the bottom part of anode bars **6**, the voltage drop across the contact is reduced to a minimum.

The anode of the present electrolytic cell is made hollow and houses in the bottom part a cooler intended for eliminating the excessive heat. In the bottom part, the anode cavity is sealed together with the cooler by graphite-filled concrete whose coefficient of thermal expansion is close to that of graphite. Current supply to the cathode is effected via plates **4** welded to it.

In the course of electrolysis, sodium is liberated at the cathode, while chlorine is liberated at the anode. To separate the products of electrolysis, provision is made for screen **18** disposed in the interelectrode gap. The sodium floats up to the surface of the electrolyte and collects in annular trough **16**, from whence it is directed by a riser into a sodium collector.

Diffuser **17** directs the chlorine into a chlorine chamber, from whence the chlorine leaves the cell via a chlorine pipeline.

The electrolyte is maintained at a temperature of approximately 600° C. in the course of electrolytic cell operation. When the temperature in the cell becomes excessive, garnissage on the shaft side walls and the crust on the electrolyte surface become thinner, this process resulting in the appearance of free-from-crust areas on the electrolyte surface or, in the limiting case, in the complete freedom of the electrolyte surface from the crust. Crust thinning is conducive to an increased heat transfer to the ambient medium.

The desired gap between the anode and the cathode faces is obtained due to the fact that the anode bars of trapezoidal cross-section are assembled to form the anode by a technique involving the use of temporary spacers between the bars being assembled and the cathode face. Anode bars **6** having been sealed in contact unit **8** and in the hearth of the electrolytic cell shaft, the spacers employed for assembling the anode are removed so that the anode of the desired diameter disposed at a pre-determined gap from the cathode is obtained.

As no machining is required to obtain the desired dimensions of the anode working face, recourse may be had to anode bars, in which the facets that form the working face of the anode undergo no machining and retain the characteristics conferred on them by moulding and graphitizing in the course of manufacture. Preservation of the external layer of the anode bars makes it possible to obtain the anode face noted for its durability under service conditions, which fact accounts for longer life of the electrolytic cells of the present type due to lower wear of the anode face.

In the upper end of the anode provision is made for inner and outer chamfers which are instrumental in diminishing the surface of the top butt ends of the anode bars which cause the onset of deleterious eddies in the electrolyte. Due to the chamfers, electrolyte flow into the central channel of the anode is more steady and no eddies arrise. The outer chamfers provide for an increased volume of the space between the anode and screen (diaphragm) at the upper end of the anode thereby reducing the pressure of chlorine bubbles and decreasing the extent to which chlorine penetrates through the screen into the cathode chamber. Moreover, the presence of the outer chamfers on the top ends of the anode bars facilitates the insertion of a screen into the interelectrode gap in the course of cathode dome replacement.

Heating causes no deterioration of the anode bars because use is made of graphite-filled concrete to seal the anode bars in the hearth, the coefficient of thermal expansion of this sealing material being close to that of graphite.

To attain a more efficient heat elimination from the anode, use is made of the cooler disposed in the anode cavity.

The cathode-to-screen voltage drop is maintained in the 1.5 to 2.2 v. range to obtain the maximum current efficiency; voltage drop control is effected by means of the screen centering mechanism.

Although the present invention has been described with reference to a preferred embodiment thereof, it will be readily understood by those skilled in the art that various alterations can be resorted to without deviating from the spirit and scope of the invention.

We claim:

1. An electrolytic cell for the production of sodium and chlorine from fused halide electrolytes, which comprises a hollow annular anode assembled from a plurality of circumferentially arranged bars; a closed cathode surrounding said anode; an anode cooler at least partly inserted into said anode; and a lined tank incorporating said anode, said cathode, and said anode cooler, the dimensions of said anode and said lined tank, lining thickness and cooler parameters being selected so as to constantly maintain, in the course of electrolytic cell operation, a heat insulating garnissage layer at least on the entire inner surface of the tank.

2. An electrolytic cell according to claim **1**, in which said anode has a cavity incorporating said cooler sealed from the top with graphite-filled concrete, whose coefficient of thermal expansion is approximately equal to that of the anode bars.

3. An electrolytic cell according to claim **2**, wherein the bars from which said anode is assembled are trapezoidal in cross-section and are furnished with outer and inner chamfers in the upper part thereof.

4. An electrolytic cell according to claim **1** wherein said anode bars are graphite.

References Cited

UNITED STATES PATENTS

2,213,073	8/1940	McNitt	204—243 XR
2,390,114	12/1945	McNitt	204—68
2,990,347	6/1961	Blosser	204—246 XR
3,334,040	8/1967	Conrad et al.	204—294 XR

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