Dec. 1, 1970 V. J. REILLY 3,544,444

FUSED SALT ELECTROLYSIS CELL HAVING ANODE WITH TAPERED WELL THEREIN

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FIG. 2

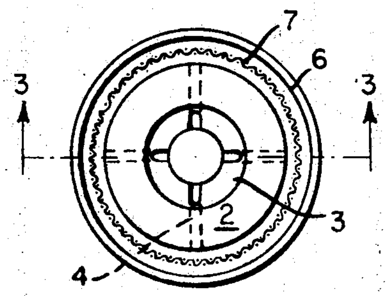


FIG. 1

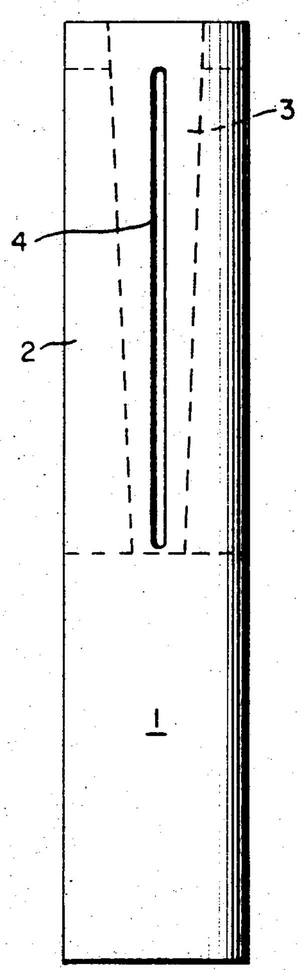
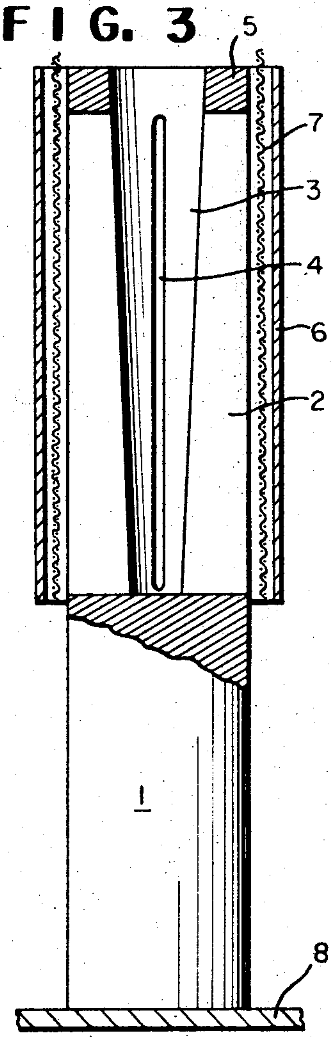


FIG. 3



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1

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FUSED SALT ELECTROLYSIS CELL HAVING ANODE WITH TAPERED WELL THEREIN

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U.S. Cl. 204—243 8 Claims

ABSTRACT OF THE DISCLOSURE

A fused salt electrolysis cell, particularly for the production of metallic sodium, having a vertical anode surrounded by a cathode, which anode is provided with a tapered well in the top thereof extending longitudinally through the center of the anode in the portion thereof opposite the electrolysis zone, which well, in conjunction with perforations, preferably vertical slots, provided in the anode wall, assures circulation of electrolyte from the well into the electrolysis zone. By having the anode well tapered from its top towards its bottom, i.e., towards the end of the anode where it is connected with the power source, the anode resistance in the cell is desirably reduced without adversely affecting electrolyte circulation.

BACKGROUND OF THE INVENTION

Sodium is produced commercially by the electrolysis of a fused electrolyte comprising sodium chloride in cells which are basically similar in design to the Downs cell described in Downs U.S. Pat. 1,501,756. Such cells employ bottom-mounted vertical graphite anodes each surrounded by a metal cathode, the two electrodes thus defining an annular electrolysis zone. A foraminous diaphragm is inserted in the electrolysis zone to separate the electrolysis products. Chlorine produced at the anode is removed from the upper part of the cell through a gas dome positioned above the anode. Sodium produced at the cathode rises into a collecting manifold from which it is removed through a vertical pipe communicating with the exterior of the cell.

A factor affecting the economical operation of Downs type cells is the cell resistance, and it is evident that by keeping the resistance as low as possible the cell voltage drop and power costs will be reduced. In order to reduce the anode resistance, and thereby reduce the overall cell resistance, the anodes are made as large as possible with respect to the other cell parts. However, there is a limit to the size of anodes which can be used because of the adverse effect of excessively large anodes on electrolyte circulation. Good electrolyte circulation, particularly in the electrolysis zone, is essential for economical performance of the cell. To facilitate such circulation, it has been common practice to employ anodes provided with cylindrical wells in their centers, which wells communicate with the electrolysis zone through slots or holes provided in the anode wall. Such wells and slots permit circulation of electrolyte through the anode well into the electrolysis zone, thereby increasing the overall performance of the cell.

The benefits derived from employing anodes provided with wells in conjunction with perforations in the anode wall whereby electrolyte circulation is enhanced, have long been recognized. Combinations of such anode wells and slots are disclosed in U.S. Pats. 2,194,443, 2,390,548, 2,414,831, 2,755,244 and 2,921,894. As shown in such patents, the well in the anode has always been of cylindrical design and in the center of the anode. Various types of perforations communicating with such a well have been proposed, although vertical slots appear generally to be preferred.

2

While the provision of wells in the anodes, in conjunction with the above-mentioned slots, is advantageous from the standpoint of improving circulation of the electrolyte, use of such wells has the distinct disadvantage of increasing the anode resistance. In the past, the advantage in improved circulation has been regarded as offsetting the disadvantage of increased anode resistance resulting from the provision of anode wells. Thus, the use of anodes with wells of cylindrical design therein opposite the electrolysis zone together with slots in the anode wall has become more or less common practice. It has now been found that a significant reduction in the anode resistance, compared with the resistance of similar anodes provided with wells of the previous cylindrical design, can be obtained by employing anodes having a well of improved design described below. Furthermore, such reduction in the resistance can be achieved without adversely affecting electrolyte circulation.

SUMMARY OF THE INVENTION

The invention relates to a Downs type cell for the production of alkali metals by the electrolysis of fused alkali metal halide electrolytes, particularly for the production of sodium and chlorine by the electrolysis of a fused electrolyte comprising sodium chloride. Such cells comprising a bottom-mounted vertical anode, generally cylindrical in shape, surrounded by a cathode, which is usually supported by side arms extending through the side walls of the cell, a foraminous diaphragm positioned between the electrodes, and means for separately removing the electrolysis products from the upper part of the cell. Such cells may contain a single pair of electrodes, i.e., an anode-cathode pair, or an assembly of several such pairs, generally four. The invention contemplates the use in such a cell of an anode having a tapered well in the top thereof extending longitudinally through the center of the anode in that portion thereof opposite the electrolysis zone, which well is in open communication with the electrolysis zone through perforations, preferably slots, in the anode wall which permit effective circulation of electrolyte from the well into the electrolysis zone. The taper of the anode well is essentially from its top to its bottom, i.e., towards the end of the anode that is connected with the power source. Since the anode customarily rises vertically from the bottom of the cell where contact with the power source is effected, the well will be in the upper portion of the anode and will taper towards its bottom, i.e., the diameter of the well will be greater at the top than at the bottom. It has been found that anodes with such tapered wells which communicate through perforations in the anode wall with the electrolysis zone to permit the desired circulation of electrolyte exhibit a substantially lower resistance in the cell than do otherwise similar anodes having wells of the conventional cylindrical design. Furthermore, the tapered design of the anode well does not significantly reduce electrolyte circulation.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view in elevation of an anode having a tapered well therein in accordance with the invention.

FIG. 2 is a plan view of the anode of FIG. 1 shown with a surrounding cathode and an annular diaphragm positioned between the anode and the cathode.

FIG. 3 is a vertical cross-section of the structure of FIG. 2.

In the drawing, **1** is a bottom-mounted vertical cylindrical graphite anode whose upper part **2** is provided with a tapered well **3** which is in open communication through vertical slots **4** with the electrolysis zone between portion **2** of the anode and cathode **6**. Four such slots are shown, each extending vertically from the bottom of well **3** and terminating a little short of the top of the anode so as to leave a solid collar **5** which is desirable to impart greater strength but is not essential for the functioning of the anode. Anode **1** is mounted at the bottom of the cell (not shown) so as to form intimate contact with a metal conductive member **8** which is connected with the power source.

Shown surrounding top portion **2** of anode **1** is a cylindrical metal cathode **6** which is generally supported by cathode arms (not shown) extending through the cell walls (not shown) where contact with the power source is made. An annular foraminous diaphragm **7**, usually a steel wire screen, is positioned in the electrolysis zone, i.e., the zone between cathode **6** and the upper portion **2** of the anode. Diaphragm **7** is usually rigidly fastened to a removable product collector assembly (not shown) from which it is suspended in the position indicated in the drawing. It will be noted that well **3** in the anode is generally opposite the electrolysis zone and is substantially coextensive in vertical length therewith.

DESCRIPTION OF PREFERRED EMBODIMENTS

The preferred design of the well in the anode together with the preferred type of perforations for providing communication between the well and electrolysis zone is that shown in the drawing. Thus, in the preferred embodiment of the invention, the electrolysis zone is approximately coextensive in length with the upper part of the anode whereby the well in the anode will be approximately substantially coextensive in length with and generally opposite the electrolysis zone. As indicated in the drawing, well **3** in the anode will have a diameter at its top which is about twice its diameter at its bottom, with the diameter at the top being approximately half the diameter of the anode. In the preferred embodiment illustrated in the drawing, electrolyte communication between well **3** and the electrolysis zone is provided by four slots **4** equally spaced radially about the circumference of the upper portion **2** of the anode. Depending upon the width of such slots, more or fewer than four slots, e.g., from 2 to 8 equally spaced about anode portion **2**, may be employed, but usually four positioned as indicated with each having a width equal to from about 5 to 20%, preferably 8 to 12%, of the top diameter of the anode well, are generally adequate.

Desirably, tapered well **3** will be no larger than is necessary to provide, in conjunction with slots **4**, efficient circulation of electrolyte from the well into the electrolysis zone, otherwise, the electrical resistance of the anode in the cell will be undesirably increased. In general, the diameter of the well at its top will be equal to from 30 to 80%, preferably 40 to 60%, of the diameter of the anode. In order to permit a significant reduction in the anode resistance while still permitting realization of effective circulation of the electrolyte, the diameter of the well at its bottom should generally be no greater than 70% of the diameter of the well at its top. In general, the diameter of the well at its bottom will be equal to from 0 to 70% of the diameter at its top; most preferably, it will be equal to from 30 to 60% of the diameter at the top. Thus, the general shape of the well may be that of an inverted cone but preferably will be that of an inverted truncated cone, the latter being generally preferred as indicated.

The perforations in the anode wall providing communication between the well and the electrolysis zone may be in the form of several holes running transversely through the walls of the anode. Such holes, when employed, should be distributed more or less uniformly over that portion of the anode which together with the cathode defines the electrolysis zone, e.g., that portion of the anode which is generally coextensive with slots **4** in the drawing. Instead of transverse holes, sloping holes may also be employed. However, the preferred type of perforations are those in the form of vertical slots such as slots **4** in the drawing. The number thereof and their width should be sufficient to insure the desired electrolyte circulation and they should be uniformly spaced about the anode.

With respect to the tapered well in the upper part of the anode, the sides thereof are preferably straight with the taper thereof being downward as indicated previously. However, tapered wells with side walls that are somewhat curved, either inwardly or outwardly, can be used, although they are not as advantageous as the preferred straight sided tapered wells. As indicated in the drawing, the tapered well should be in the center of the anode and symmetrical with respect to the longitudinal axis of the anode, otherwise distribution of the current flow to the active anode surfaces will not be uniform.

Six Downs type sodium cells, constituting a "Test Group," were provided with anodes of the design indicated in the drawing. Each anode included a tapered well centered in approximately its upper half so as to be opposite and approximately coextensive in length with the electrolysis zone. The top diameter of the wells was one-half the diameter of the anodes, while the bottom diameter of the wells was one-half their top diameter. Each anode was also provided with four vertical circulation slots positioned as shown in the drawing, the width of each slot being about 20% of the diameter of the bottom of the anode well and about 10% of the diameter of the top of the anode well. Nine other Downs type cells, constituting a "Reference Group," were provided with anodes having anode wells therein which were of the conventional cylindrical design with a top and bottom diameter equal to the top diameter of the wells of the anodes in the cell of the Test Group. Except for the design of the anode wells in the anodes employed, the cells of the Test Group and those of the Reference Group were the same.

The cells of each of the above groups were operated to produce sodium and chlorine over periods of time ranging from about 9.5 to 20.8 months and the statistical values for power consumptions (kilowatt-hrs., D.C.) per 100 lbs. of sodium produced (average life-to-date) were determined. The average power consumption per 100 lbs. of sodium produced in the Test Group of cells was 423.4 kilowatt hours, weighted for the age of the cells, whereas the corresponding value for the Reference Group of cells was 426.4 kilowatt hours.

The power consumption values reported above correspond to a reduction of about 0.06 volt in favor of the cells of the Test Group, i.e., the cells with tapered anode wells. The lower power consumption in the cells of the Test Group resulted from a reduction of the resistance of the anodes having tapered wells. The difference in power consumption found is significant and distinctly advantageous, since it is worth about 1.5 cents per 100 pounds of sodium with power at 0.5 cent per kilowatt hour.

Further advantages result from the use of anodes with tapered wells, in that the voltage on such cells does not rise as rapidly with age, as with cells with cylindrical-well anodes. This results from the fact that, as the anodes wear, the cross-sectional area of a tapered-well anode reduces proportionally less than that of a corresponding cylindrical-well anode. Thus, with anodes with dimensions in the preferred ranges, a new tapered-well anode has about 25% more cross-sectional area than the corresponding cylindrical-well anode near the base of the electrolysis zone.

However, near the end of the useful life of such anodes, the tapered-well anode has about 50% more cross-sectional area. This is important since power loss in older cells dictates the current load they may carry, as well as the age at which they must be retired. In terms of voltage reduction near the end of the useful life of the cells, the tapered-well has an advantage of about 0.1–0.15 volt. The net effect of the reduced average voltage, and the greater reduction in voltage with older cells, is an increase in current capacity of about 2–3%. A given investment in electrolytic cells and associated facilities can thereby produce 2–3% more sodium.

I claim:

1. In a fused salt electrolysis cell having a vertically positioned cylindrical anode and a surrounding cylindrical cathode defining an electrolysis zone therebetween, the improvement wherein said anode has a tapered well in the top thereof extending longitudinally through the center of said anode in the portion thereof opposite said electrolysis zone, the taper of said well being substantial and being essentially uniform from its top to its bottom, which well is in open communication with perforations provided in the anode wall for circulation of electrolyte from said well into said electrolysis zone.

2. A fused salt electrolysis cell in accordance with claim **1**, wherein the anode is cylindrical and the diameter of the anode well at its top is equal to 30 to 80% of the diameter of the anode, and the diameter of the anode well at its bottom is no greater than 70% of the diameter of said well at its top.

3. A fused salt electrolysis cell in accordance with claim **2**, wherein the diameter of the anode well at its top is equal to 40 to 60% of the diameter of the anode, and the diameter of said well at its bottom is equal to 30 to 60% of the diameter of said well at its top.

4. A fused salt electrolysis cell in accordance with claim **2**, wherein the diameter of the anode well at its top is about one-half the diameter of the anode, and the diameter of said well at its bottom is about one-half the diameter of said well at its top.

5. A fused salt electrolysis cell in accordance with claim **1**, wherein the perforations in the anode wall are a plurality of vertical slots equally spaced around the anode with each slot having a width equal to about 5 to 20% of the diameter of the anode well at its top.

6. A fused salt electrolysis cell in accordance with claim **2**, wherein the perforations in the anode wall are a plurality of vertical slots equally spaced around the anode with each slot having a width equal to about 5 to 20% of the diameter of the anode well at its top.

7. A fused salt electrolysis cell in accordance with claim **3**, wherein the perforations in the anode wall are a plurality of vertical slots equally spaced around the anode with each slot having a width equal to about 5 to 20% of the diameter of the anode well at its top.

8. A fused salt electrolysis cell in accordance with claim **4**, wherein the perforations in the anode wall consist of four vertical slots equally spaced around the anode and generally coextensive in vertical length with the length of the anode well, each of said slots being of a width equal to about 8 to 12% of the diameter of said anode well at its top.

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204—284, 272