

Dec. 9, 1952

H. B. WILLIAMS
CATHODE STRUCTURE
Filed Oct. 8, 1949

2,621,155

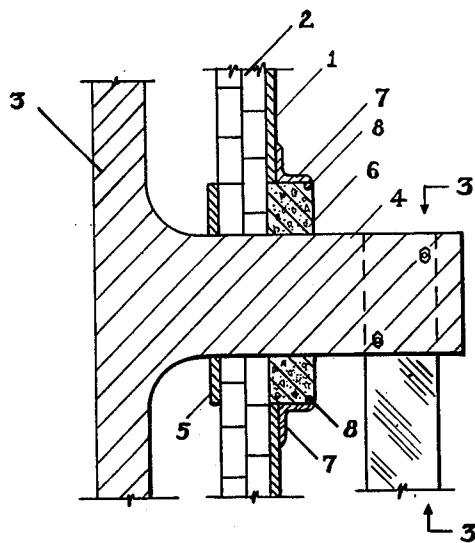


FIG. 1

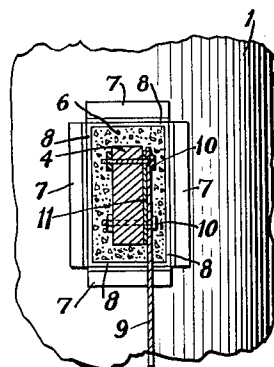


FIG. 3

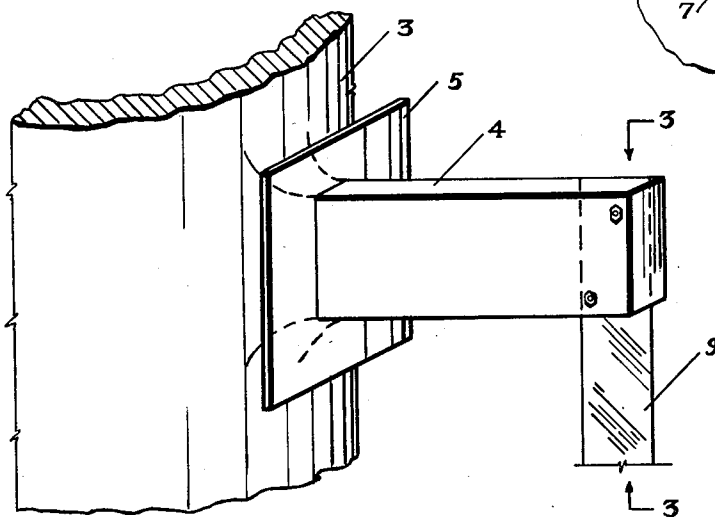


FIG. 2

HERBERT B. WILLIAMS
INVENTOR.

BY *Herbert B. Williams*

ATTORNEY

UNITED STATES PATENT OFFICE

2,621,155

CATHODE STRUCTURE

Herbert B. Williams, Niagara Falls, N. Y., assignor
to E. I. du Pont de Nemours & Company, Wil-
mington, Del., a corporation of Delaware

Application October 8, 1949, Serial No. 120,286

1 Claim. (Cl. 204—243)

1

This invention relates to a cathode structure for an electrolytic cell and more particularly to the cathode structure in a fused salt electrolytic cell.

My invention is particularly adapted for fused salt electrolysis cells such as that described in Downs U. S. P. 1,501,756. This cell has a centrally located cylindrical graphite anode and a coaxial cylindrical annular steel cathode. Two side arms from the cathode project through the cell walls for the purpose of making electrical connection thereto. In cells of this type considerable difficulty is experienced through leakage of the electrolyte through the point where the cathode extends through the cell wall. The cell wall is conventionally constructed of a steel shell lined with refractory brick, jointed by refractory cement. This refractory seal is impervious to the fused salt electrolyte but differential expansion of the steel cathode side arms and the refractory lining causes loosening of the ceramic-to-steel seal, thereby causing leakage along the surface of the cathode arms. Heretofore the only satisfactory method for inhibiting such leakage has been to apply cooling so as to cause freezing of the molten bath along the side wall of the cell. While the resulting layer of solid salt on the interior surface of the ceramic cell lining around the cathode side arms prevents bath leakage to a large degree, it is not entirely satisfactory. The frozen salt does not always completely prevent bath leakage and furthermore this method of preventing leakage requires additional power input, equivalent to the heat removed by cooling.

An object of the present invention is a new and improved electrical connection through the side wall of a fused salt cell to an electrode thereof. A further object is to provide an improved connection for the cathode in a fused salt cell of the type described above. Still other objects will be apparent from the following description of the invention.

In the appended drawings, Figure 1 is a sectional view of a portion of the side wall of a fused salt cell showing a portion of a cathode 3 located therein and electrical connections to the cathode. Figure 2 is a view in perspective of a portion of the cathode 3 of Figure 1. Figure 3 is in part a sectional view in the plane 3—3 indicated in Figures 1 and 2 and in part an elevation of the cell wall exterior.

The drawings illustrate one form of the present invention. The side wall of the electrolytic cell is constructed of a cylindrical steel shell 1 lined with refractory brick 2. Cathode 3 is a vertical

2

cylindrical steel structure having two side arms 4, one of which is shown in the drawings. Cathode arm 4 projects through an opening in the side wall of the cell. As shown in the drawings, cathode arm 4 is of rectangular cross section. The cross-sectional shape of cathode arm 4, however, is immaterial as other shapes, for example, the circular cross-section shown in the above Downs patent, also may be utilized.

A thick steel flange 5 is welded to the cathode arm 4 at such point that plate 5 makes a close fit with the interior surface of the brick lining 2. The width of flange 5 is not less than the distance between cathode arm 4 and the surrounding frame 7, described below. At the point where cathode arm 4 extends through the outside of the cell wall, a refractory ceramic cement 6 is set in place, supported by a frame consisting of angle iron 7 having welded thereto steel rod 8. The frame is welded or otherwise fastened to shell 1. Cement 6, which should have good dielectric properties, serves to electrically insulate the cathode arm 4 from the steel shell 1. The refractory bricks 2 are preferably held together by a refractory ceramic cement and, if desired, such cement may be grouted in between plate 5 and the brickwork. Bus bar 9, which is a conventional copper bus bar, is bolted to the exterior end of cathode arm 4 by conventional means, such as bolts 10. A silver alloy layer 11 is interposed between the bus bar 9 and the cathode neck 4, as described below.

All parts of the electrolytic cell not shown in the drawings or described herein are of conventional design and will be apparent to those familiar with the construction and operation of fused salt electrolytic cells.

With the above described structure, the electrolytic cell may be operated with a relatively high melting fused salt and under conditions such that the fused salt is molten in all parts of the cell, including the interface with the cell wall where the cathode arm 4 projects through the wall, substantially without bath leakage. When the cell is so operated, a relatively large amount of heat is conducted through the side arm 4, and the exterior end of the side arm becomes heated to such extent that if the copper bus bar is merely bolted to the side arm in the conventional manner, oxide formation at the steel-copper interface occurs to such extent as to seriously impair the electrical connection. The above mentioned silver alloy layer interposed between the copper and the steel, in a manner hereinafter described, effectively maintains a substan-

tially perfect electrical connection between the copper and the steel at relatively high temperatures, e. g., temperatures as high as 250° C.

To apply the alloy layer, I first "tin" the surfaces of both the copper bus bar and the steel cathode neck at the point where connection is to be made. The "tinning" may be accomplished by any conventional method. A suitable and preferred method is to heat the copper and steel surfaces, for example, with a blow torch and apply thereto a flux, having the following composition:

	Per cent
Lead -----	27.5
Tin -----	5.2
Ammonium chloride -----	24.7
Zinc chloride -----	41.8

With the surfaces then heated to a temperature above the melting point of the silver alloy, a stick of the alloy is rubbed against the surfaces until both the copper and the steel have received a substantial coating of the silver alloy which may vary from .002 to .005 inch thick. The silver alloy coatings should be made to have substantially smooth, plane surfaces. A convenient method for smoothing the coatings is to wipe them with a cloth, while still molten. If desired, other methods may be used, as by the use of conventional tools or abrasives, after cooling. The copper bus bar is then bolted to the cathode side arm, with the alloy surfaces in contact.

If desired, pure silver, any of the various commercial grades of silver, such as sterling, may be used in place of the above described silver alloy, and such may be applied by any conventional manner. Generally, I prefer to use a silver alloy containing 20 to 50% of silver, and having a melting point between about 300 and 600° C. It is essential that the melting point be not lower than 300° C. to maintain a good electrical connection. For the same reason, the electrical conductivity of the alloy must at least equal that of the copper bus bar. Examples of suitable silver alloys are:

Alloy	A	B
	Per-cent	Per-cent
Silver-----	33.3	30
Tin-----	66.7	21
Bismuth-----		35
Lead-----		14

The above quantities are expressed in percent by weight.

The silver or silver alloy layers may be applied by any conventional method which results in adherence to the iron and copper surfaces. Thus, it may be applied by metal spraying processes or by electroplating. The thickness of the silver or alloy coating may vary from 0.002 inch to as great as about 0.25 inch; but generally there is no advantage in exceeding a thickness of around 0.005 inch.

Various other modifications in the above described structure may be made without departing from the spirit and scope of the present invention. The essential features are a cell wall comprising a steel shell having a refractory ceramic lining, a steel electrode or electrode connector passing through the wall, such steel member being provided with a tightly fitting flange which fits closely against the interior surface of the refractory cell lining. The flange must extend from the steel member for a distance at

least equal to the distance in the same direction, between the steel member and the corresponding edge of the opening in the exterior steel shell. If desired, the flange may have larger dimensions, so as to overlap the shell opening; for example, the flange may extend to twice the above indicated distance.

The opening in the steel shell must be sufficiently large to provide a space between the edges of the opening and the sides of the protruding steel member, so that suitable electrical insulation may be inserted to insulate the steel member from the steel shell. The minimum distance of such spacing will depend on the nature of the insulating material. When the insulation is a refractory cement, I prefer a spacing of at least two inches between the steel member and the shell, e. g., 2 to 6 inches.

To maintain good electrical contact with a copper bus bar or other copper conductor, the steel member and conductor are joined through a layer or layers of silver or silver alloy, which are adherent to both the steel and the copper. The cell lining may be either refractory brick or monolithic refractory cement and an exterior steel shell is not essential. The invention is applicable to either cathode or anode connections through the side wall of a fused salt electrolytic cell. While the invention is particularly useful for cells for the production of sodium or other alkali metal by electrolysis of a molten salt bath comprising an alkali metal chloride, it is not restricted thereto.

My invention makes possible the operation of fused salt cells at relatively high temperatures in the range of 400 to 700° C. and under such conditions that the electrolyte is substantially entirely in the molten state. The herein described construction effectively prevents leakage of the electrolyte at the point where the cathode connections pass through the side walls of the cell. The combination of this non-leaking construction, together with means for maintaining good electrical connection with the bus bar at the high temperatures, thus makes possible cell operation without cooling, with corresponding savings in power input.

I claim:

In a fused salt electrolytic cell adapted to operate at electrolyte temperatures of 400 to 700° C., a side wall comprising a steel shell interiorly lined with a layer of a refractory ceramic material, a steel cathode spaced within the cell away from said side wall and an electrical assembly for conducting current to the cathode, said assembly comprising a steel cathode connector extending from the cathode through the side wall and positioned from said shell by a distance not less than about two inches by means of electrically insulating, refractory cement surrounding said connector and filling the space between the connector and shell, a steel flange fastened to and entirely surrounding said connector and fitted tightly against the interior refractory surface of said side wall, said flange extending outwardly from said connector for a distance, in any direction, not less than the distance in the same direction between the connector and shell, a copper conductor fastened to said steel connector at a point exterior of said shell, and relatively non-corrodible electrically conductive means interposed between said connector and said copper conductor to prevent oxide formation at a steel-copper interface, said electrically conductive means consisting of two adherent coat-

2,621,155

5

ings of a silver alloy, containing 20 to 50% by weight of silver and melting at about 300° to 600° C., applied respectively to the connector and the conductor, each coating being about 0.002-0.005 inch thick.

HERBERT B. WILLIAMS.

REFERENCES CITED

The following references are of record in the file of this patent:

Number
692,688
1,214,808
1,501,756
2,249,765
2,423,714

Number
756,498

6

UNITED STATES PATENTS

Name	Date
Meslans -----	Feb. 4, 1902
McNitt -----	Feb. 6, 1917
Downs -----	July 15, 1924
Hulse -----	July 22, 1941
Leonard -----	July 8, 1947

FOREIGN PATENTS

Country	Date
France -----	Sept. 25, 1933