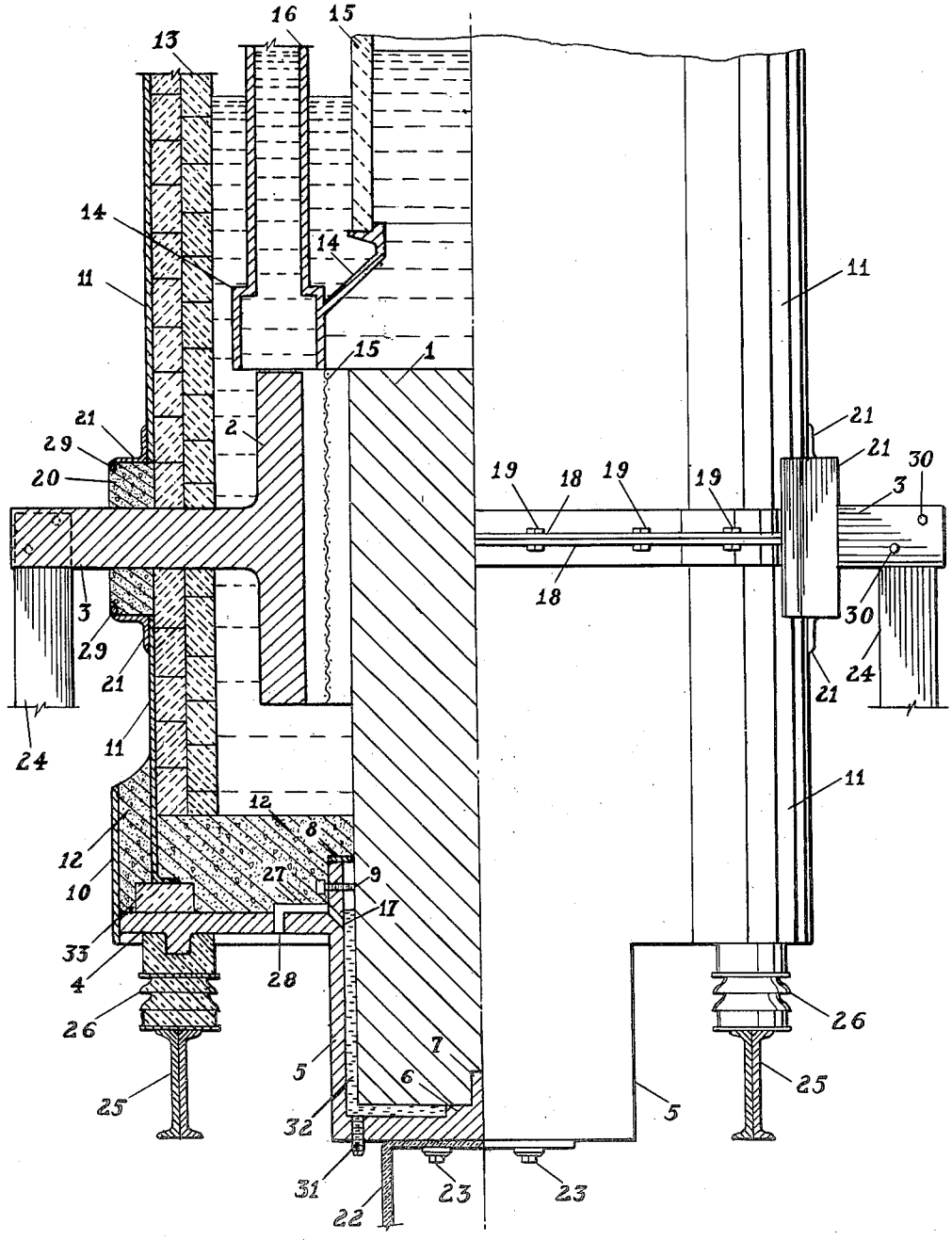
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ELECTROLYTIC CELL

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ELECTROLYTIC CELL

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This invention relates to electrolytic cells for fused salt electrolysis, for example, cells for the electrolysis of a molten salt to produce an alkali metal and more particularly to the construction of such cells with particular reference to means for mounting anodes therein and electrically connecting the anodes to their source of electrical current.

A well-known type of electrolytic cell for the electrolysis of a molten salt electrolyte to produce alkali metals, for example, sodium is described in Downs, U. S. P. 1,501,756. One modification of this cell is shown in Hardy et al., U. S. P. 2,194,443. In this type of cell a graphite anode is used which extends through the bottom of the cell and there is attached to a source of electrical current, while the connection to the cathode is made through the side of the cell. In this mode of construction, such as shown for example, in the above mentioned Hardy et al. patent, it is necessary to carefully seal the anode to prevent leakage of electrolyte and such sealing has been a difficult problem because of unequal expansion and contraction of several parts of the cell when changes of temperature occur.

It is also necessary to insulate the anode from the steel shell that forms side walls of the cell. In the cells heretofore known, the steel bottom is joined to the side wall and hence the anode must be insulated from the bottom plate of the cell. Without such insulation, even though the cathode is insulated from the steel side wall, leakage of sodium spilled from the receiver and other accidents often occur which permit electric current to flow between the steel side walls and cathode. Therefore, for efficient operation and safety to operating personnel, it is necessary that the steel side walls be "neutral," i. e., not electrically connected to either anode or cathode.

There has also been a problem in make the electrical connections to the portion of the anode projecting from the cell bottom. The anode conducts considerable heat from the cell and to such an extent that it is impractical to attach a copper connection directly to the graphite, as in such case oxidation of the copper causes considerable resistance to the flow of electrical current between the copper and the graphite. It has been necessary to fasten heavy iron or steel plates or the like to the graphite and attach the copper to the iron or steel some distance from the graphite. With such arrangements, a perfect electrical connection between the graphite and steel is difficult to maintain. The bolts holding the steel and graphite parts together, originally drawn tight, expand more than the graphite when heated during cell operation, loosening the connection. Cooling the steel parts by flowing water through channels in the steel parts only partially corrects this condition,

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as the differential expansion still occurs during variations in temperature, stretching the bolts or crushing the graphite sufficiently to loosen the connection, thereby increasing electrical resistance at the graphite to steel contact.

It is also necessary to cool the cell bottom to reduce oxidation of the protruding portion of the graphite and to inhibit leakage of electrolyte. Cooling inhibits leakage by freezing a portion of the electrolyte in the cell bottom to solid form, the frozen layer cooperating with the refractory seal to provide a barrier against leakage. Such cooling, while necessary for the reasons stated, is objectionable because of the energy thus withdrawn from the cell in the form of heat, thus decreasing the overall efficiency of the cell.

An object of the present invention is to provide a new and improved electrolytic cell for fused salt electrolysis. A further object is a new and improved mode of mounting graphite anodes in fused salt cells. A further object is to obtain an improved electrical connection between the anode and the source of electrical supply and particularly between the graphite and an iron or steel member which is connected in turn to a copper conductor, while maintaining the anode out of electrical contact with the side walls of the cell. Another object is to eliminate or decrease cooling the cell bottom. Still other objects will be apparent from the following description.

These objects are attained by a cell construction in which the graphite anode is entirely enclosed within the cell and is electrically connected to a steel base plate or cell bottom which, in turn, is insulated from ground and from the cell side walls and is connected to an electrical source.

The appended drawing shows, partly in vertical cross-section and partly in elevation, one embodiment of the present invention. The drawing shows the lower portion of a fused salt electrolysis cell. The cell as shown by the drawing is cylindrical in shape having a centrally located vertical graphite anode 1 surrounded by an annular steel cathode 2 which is supported by two cathode arms 3. The anode is supported by base plate 4 which is a circular steel plate horizontally disposed and has formed therein anode socket 5. The base plate 4 and anode socket 5 may be a single, integral casting or the socket and base plate may be separately formed and welded together. At its periphery, plate 4 is provded with an upstanding flange 10. Base plate 4 is supported by beams 25 and insulators 26, which insulate the base plate and anode from ground.

Anode 1 is centered in socket 5 and has a smaller diameter thereof, leaving a narrow annular space between the anode and the near wall

of the socket. Boss or projection 6 on the interior bottom wall of socket 5, upon which the base of the anode rests, insures that there will be an open space between the remaining bottom floor of the socket and the bottom of the anode. This space and also the annular space around the stem of the anode inside socket 5 are filled with a metal 32 which is introduced in the molten state or melted in place and which preferably is a metal or alloy which will be liquid at the temperature of the lower portion of the anode during normal cell operation. A vent channel communicating with the anode socket 5, serves to permit contraction and expansion of the molten metal with changes of temperature. The vent channel is formed by a hole 17 drilled in the upper side wall of socket 5, leading to channel 27 in the refractory 12, channel 27 in turn communicating with an opening 28 in base plate 4. Preferably, the amount of molten metal is sufficient to rise slightly above the vent hole 17 during cell operation. Annular refractory plate 8 surrounds the anode and covers the space filled with molten metal. The space between the molten metal and plate 8 is filled with a refractory insulation, e. g., asbestos. The tapered pin 7 on boss 6 cooperating with a corresponding hole drilled in the end of the anode holds the bottom end of the anode in its proper position. Three or more set screws 9 are provided to adjust and hold the anode in a vertical position.

Socket 5 preferably is provided with a drainage hole closed with plug 31. This is useful in disassembling the cell. The metal may be drained while in the molten state. Then, after the cell has been emptied and cooled, the anode is easily lifted from the socket.

The side walls of the cell are formed by a cylindrical steel shell 11 which is open at both ends and is provided with two suitable openings to receive cathode arms 3. The diameter of shell 11 is less than the diameter of plate 4 so that when shell 11 is centered with the anode there is an annular space between the shell and flange 10. In constructing the cell three or more insulating refractory bricks 33 are placed on plate 4 to support shell 11. A refractory, insulating cement 12 is then placed in the annular space between shell 11 and the anode and in the annular space between shell 11 and flange 10. The layer of refractory cement 12 is sufficiently thick to cover the top of the anode socket 5 and plate 6. After the refractory cement has set, the shell 11 is lined with refractory brick 13 or other suitable refractory in the conventional manner; and during this operation cathode 2 is installed in the usual and conventional manner. In order to install the cathode with the arms 3 projecting through the sides of the cell, the shell 11 is formed in two halves, which are fastened together by conventional means, e. g., flanges 18 and bolts 19, after the cathode has been set in place. Cathode arms 3 are sealed by refractory, insulating cement 20 held in place by flanges 21, or by other suitable means. Flanges 21 preferably are provided with projections 29, which conveniently may be formed by welding on steel rods. The cell is completed by adding the remaining conventional elements, those shown in the drawing being the collector ring and dome support assembly 14, diaphragm 15 supported by the collector ring assembly, gas collecting dome 15 and riser pipe 16 which serves to lead molten alkali metal to the cell receiver, not shown.

Electric bus bar 22 is fastened to the base of anode socket 5 by means of bolts 23. Bus bars 24 are fastened to cathode arms 3 by means of bolts 30.

If desired, the cell may be provided with conventional cooling means, not shown, e. g. cooling water channels in base plate 4 or elsewhere. The sole purpose of such cooling is to adjust electrolyte temperature to an optimum point and it is unnecessary when such temperature adjustment is made by regulating the electric current.

The metal in the socket 5 may be lead, tin, an alloy of either or both, or any other metal or alloy which is a good electrical conductor and which may conveniently be introduced in the molten state or melted in place. Preferably this metal is a low melting alloy such as Woods' metal, which will be molten at the lowest temperature encountered in the socket during cell operation. That temperature usually will vary 100 to 200° C. below the electrolyte temperature. In any event the metal preferably should have a melting point lower than 350° C. The following table shows a number of low melting alloys suitable for this purpose (% is percentage by weight):

Melting Point	Lead	Tin	Bismuth	Cadmium	Antimony
°C.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
65.5	25	12.5	50	12.5	
90	40		52	8	
96	32	15	53		
250	85				15
275	67	33			
180		68		32	
180	33	67			
145	32	50		18	

It will be apparent to those skilled in the art of constructing fused salt electrolysis cells that many modifications in the above described apparatus may be made without departing from the spirit and scope of the present invention. For example, in place of the described anode socket other equivalent means, for example, a relatively shallow depression in base plate 4, may be utilized to hold a quantity of molten metal in contact with the lower end of the anode.

This mode of construction also may be used to hold a plurality of anodes set in a common cell base. The horizontal cross-sectional shape of the cell may be rectangular, circular or oval as desired, utilizing a base plate of corresponding shape. The distance between flange 10 and shell 11 may be varied considerably; but this distance, in combination with the material selected as refractory seal to fill that space, must be such that flange 10 is electrically insulated from shell 11. This is an important feature of the invention. Also, other means may be employed to insulate the base plate from the shell.

The present invention provides a means for establishing a substantially perfect electrical connection between the graphite anode and the steel cell bottom. The excellence of the contact is independent of temperature at the junction, as no oxidation can there occur and the contact is not varied by unequal expansion and contraction of the steel and graphite with changes in temperature. These results, furthermore, are accomplished without causing electrical connection between the cell bottom and the steel side walls, thus retaining the advantageous features of prior art cells. The construction utilized

herein also insures against electrolyte leakage, as it eliminates the problem of sealing an anode projecting through the base of a cell. The invention further eliminates the necessity of cooling the cell bottom, thus saving energy and an increasing overall cell efficiency.

A further advantage is that a cell of large size, constructed according to this invention, may be bodily lifted and moved from its place in a bank of cells, facilitating the rapid replacement of worn-out cells. Heretofore, because of the necessity of providing exterior supports for the refractory seal and the anode, the cells have had to be dismantled in situ; and new cells likewise were built in place in the cell bank.

A still further advantage is that the present construction is more compact than that in which the anode protrudes through the cell bottom, occupying less vertical space. This provides a greater vertical space inside the cell, permitting the use of a longer cathode, utilizing a greater length of the anode for effective electrolysis, thus increasing cell capacity.

We claim:

1. A fused salt electrolysis cell comprising a circular, horizontally disposed steel base plate, an anode-receiving steel socket set in said plate and extending below the bottom side thereof, a cylindrical graphite anode set in said socket and electrically connected thereto by means of a molten metal seal, said anode extending upwardly into a zone of electrolysis, an annular steel cathode in said zone and surrounding said anode, a cylindrical, refractory-lined, steel shell having a diameter less than that of said plate, and surrounding said cathode, the lower edge of said shell being spaced above the top of said plate, said plate having at its periphery an upstanding steel flange extending above the bottom of said shell, a refractory insulating seal in the annular space between said flange and the lower part of said shell, and a copper conductor fastened to the exterior of said anode socket.

2. A fused salt electrolysis cell having refractory-lined, steel side walls and a steel bottom, a graphite anode wholly enclosed within the cell and set in a socket formed in said bottom, a molten metal in said socket serving to maintain said anode in electrical contact with said bottom, said bottom being insulated from said side walls and from ground, and a layer of refractory material covering said socket and completely surrounding and tightly embracing said anode above said molten metal so as to prevent contact of electrolyte with said molten metal.

3. A fused salt electrolysis cell having a refractory-lined, steel shell which forms the cell side walls, a horizontally disposed steel base plate forming the cell bottom and insulated from ground, said plate extending laterally beyond the side walls, spaced below the lower edge of said shell, and having an upstanding flange, spaced from, and extending above the bottom edge of, said shell, a refractory insulating seal in the space between said flange and shell, a vertically disposed graphite anode entirely within the cell, and resting in a steel socket formed in said base plate, a molten metal in said socket serving as electrical connection between the anode and said base plate, a refractory cement laid to cover said base plate and extending upward to completely surround and tightly embrace said anode at a height above said socket, so as to prevent contact of electrolyte with said molten metal, an electrical connection to said base plate; and a steel cathode operatively associated with said anode and having electrical connection means extending laterally through the cell walls.

4. A fused salt electrolytic cell having a vertical, cylindrical graphite anode surrounded by an annular steel cathode, cell side walls consisting of a refractory-lined, cylindrical steel shell, electrical connectors extending from said cathode through said shell, a circular, horizontally disposed base plate insulated from ground, an anode receiving socket in said base plate, the lower end of said anode being set in said socket, means for holding said anode erect in said socket, said socket containing molten metal serving to electrically connect said anode to said base plate, a layer of refractory, insulating cement laid to cover said base plate and of a thickness sufficiently great to completely surround and tightly embrace said anode at a height above said socket, so as to prevent contact of electrolyte with said molten metal and said base plate, said base plate having a diameter greater than that of said cylindrical shell and being spaced from the bottom edge thereof; an upstanding steel flange at the periphery of said base plate and extending above the bottom edge of said shell; a refractory insulating seal in the annular space between said flange and the exterior wall of said shell and a copper bus bar electrically connected to said base plate.

5. A fused salt electrolytic cell comprising a steel base plate insulated from ground, a steel anode-receiving socket set in said base plate, a graphite anode set in said socket and extending upwardly into the electrolysis zone of the cell, said socket containing molten metal serving to electrically connect said anode to said base plate, a layer of refractory, insulating cement laid to cover said base plate and of a thickness sufficiently great to completely surround and tightly embrace said anode at a height above said socket, so as to prevent contact of electrolyte with said molten metal and said base plate, cell side walls constructed of a refractory-lined steel shell, a steel cathode located in the electrolysis zone and a steel electrical connection therefor extending through a side wall of said shell, said shell extending downwardly from said cathode connection toward, but spaced from, said base plate, a steel flange attached to said base plate and extending upwardly to a height between the bottom of said cell and said cathode connection and spaced away from said shell, and a refractory insulating seal in the space between said shell and flange.

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