

Aug. 8, 1933.

L. E. WARD

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ELECTROLYTIC APPARATUS

Filed Sept. 17, 1932

2 Sheets-Sheet 1

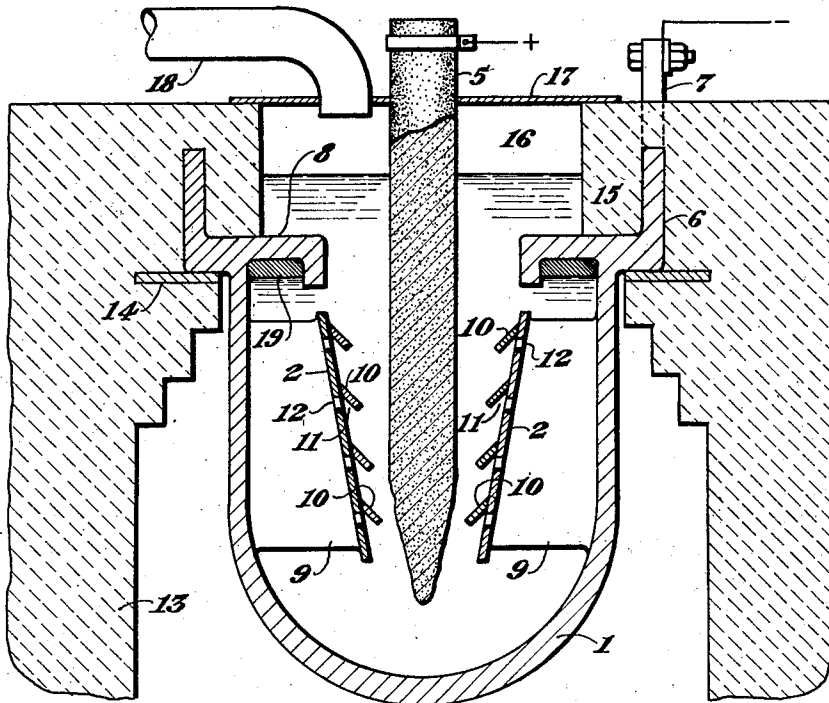


Fig. 1

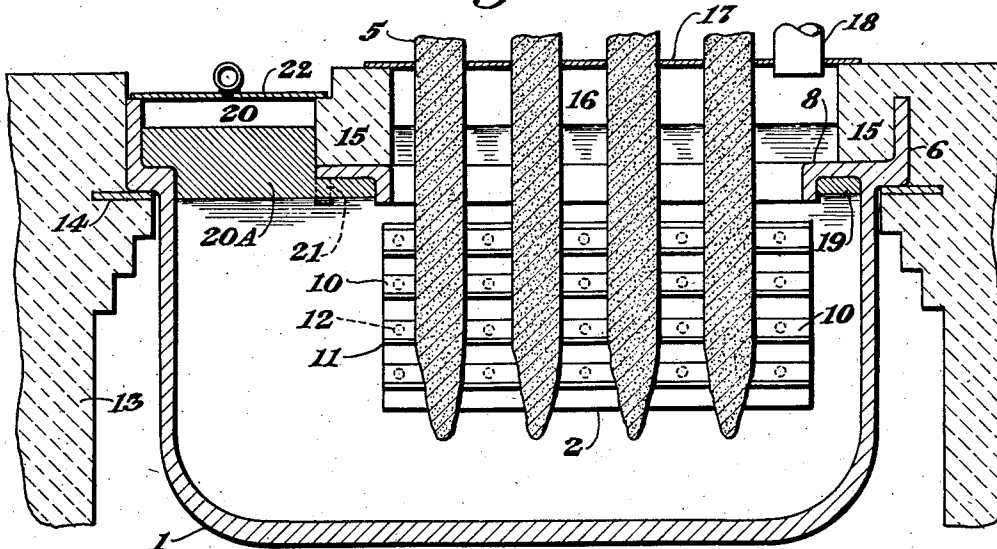


Fig. 2

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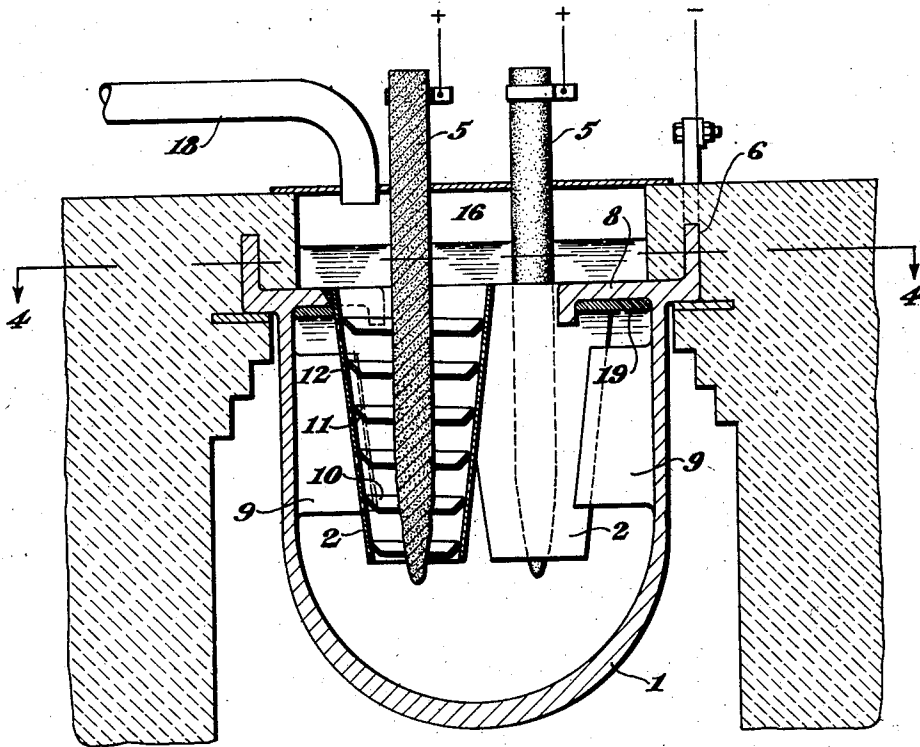


Fig. 3

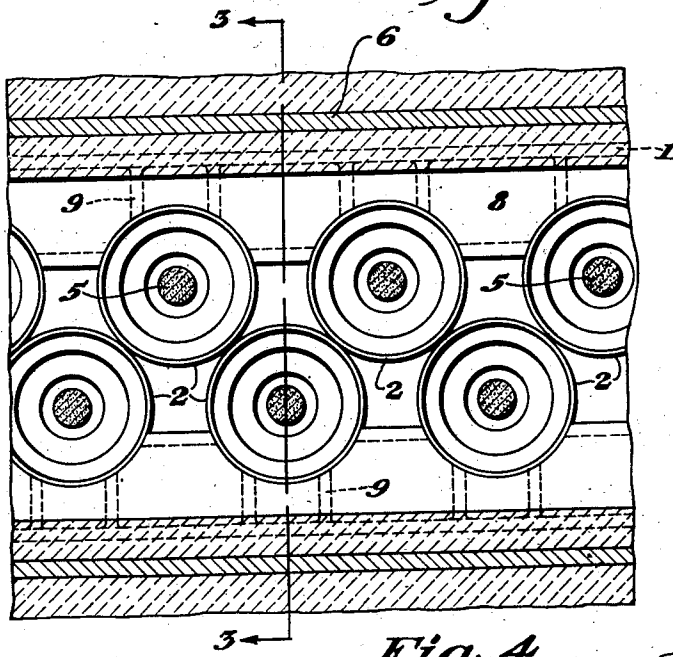


Fig. 4

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ELECTROLYTIC APPARATUS

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12 Claims. (Cl. 204—19)

The invention relates to apparatus for electrolyzing a fused salt bath to produce a metal lighter than the electrolyte, more particularly a bath containing magnesium chloride to produce magnesium.

The products of such electrolysis, e. g. magnesium and chlorine, both rise to the surface of the bath and must be separately collected and removed to prevent recombination thereof. It has been the usual practice to provide an electrolytic apparatus consisting essentially of an iron or steel vessel to contain the electrolyte and to act as cathode, one or more graphitized carbon anodes depending in the bath in the vessel, and a non-conducting partition of refractory material dipping into the bath between the anode and cathode to separate the anode and cathode products at the surface of the bath. This simple form of structure has certain inherent defects which give rise to operating difficulties and also unduly increase the power consumption per unit of product. The refractory partitions are fragile and subject to frequent breakage, necessitating replacement thereof, which interrupts regular operation of the cell. This is especially a serious problem in the larger sizes of cells. Various designs of composite or sectional partitions have been proposed, none of which, however, have succeeded in overcoming the defects of this structural element.

Another disadvantage of the aforesaid cell structure, in which the vessel itself is the cathode, is that the electrode surfaces are of necessity spaced relatively far apart in order to provide for separately taking off the products of the electrolysis at the surface of the bath. It is desirable to bring the electrode surfaces closer together in order to shorten the current path through the bath, thereby reducing the electrical resistance of the cell and consequently the power consumption per unit of product. Various proposals have been made for accomplishing this result, e. g. by inserting a supplemental cathode in the cell between the walls of the vessel and the anode or anodes, but in all such of which I am aware the result has been simply to reduce the available space at the surface of the bath between the active electrodes for separating anode and cathode products, thus making such separation more difficult.

It is an object of the present invention to provide a novel form of cathode which, when incorporated in a cell structure of the type in hand, enables the rapid removal from the active zone of the light metal as it is formed on the cathode, such removal being accomplished to a great extent before the metal rises to the surface of the bath. The metal thus removed is collected by suitable means in the inactive zone between the cathode and the walls of the vessel where it may

be kept out of contact with the gaseous anode products without necessity for providing any separating partition between the active electrodes. My improved cathode, therefore, makes possible dispensing entirely with the use of a fragile partition of non-conducting refractory material between the electrodes. Since with such cathode the removal of the metal product of the electrolysis from the active zone takes place largely below the surface of the bath, the cathode may be advanced more closely to the anode surface than is possible with other types of cathodes heretofore described without loss of current efficiency due to intermixing and recombination of anode and cathode products. Thereby is made possible a reduction of the electrical resistance of the cell and an increase of its energy efficiency. The improvement is set forth in the accompanying drawings and following detailed description illustrating various forms of structure embodying the principle of the invention.

In the drawings:—

Fig. 1 is a transverse section of an electrolytic cell structure for a fused bath in which one embodiment of my improved cathode is shown. Fig. 2 is a longitudinal section of a cell similar to the one shown in Fig. 1, having a plurality of anodes. Fig. 3 is a cross-section of a cell showing a plurality of anodes in parallel rows in which the anodes are shown with associated cathodes individually circumscribing them. Fig. 4 is a partial plan view of the cell shown in Fig. 3.

Referring to Fig. 1 of the drawings, the cell shown comprises an iron or steel vessel 1 to contain a fused salt bath, e. g. containing magnesium chloride, which constitutes the electrolyte, and a cathode structure 2 on either side of a graphitized carbon anode 5. Vessel 1 is provided with an external flange 6, the edge of which is upturned, as shown, forming an L-section. A suitable lug 7 attached to flange 6 forms the negative electrical connection. Vessel 1 is also provided with an inwardly projecting flange 8 having a downturned edge, thus forming an inverted trough. Cathodes 2 are made of a steel or iron plate supported and electrically connected to vessel 1 by lateral brackets 9 having sufficient current carrying capacity. Brackets 9 may be made of steel plate welded to the wall of vessel 1 and to cathode 2. On the inner surface of the cathodes 2 are attached a plurality of strips or bars 10 at an angle with the plate, which may be fastened thereto by welding at one edge of the strips. Strips 10 form with the plate a plurality of inverted troughs 11 ranged one above the other. Troughs 11 are provided with one or more ports 12 through the plate affording communication from the trough to the inactive zone between the cathode and the wall of vessel 1.

Vessel 1 is suspended in a furnace setting 13,

a bearing plate 14 being provided upon which rests the external flange 6 of the vessel. A course of heat-insulating refractory material 15 supported and held in place by flanges 6 and 8 forms a lining for a central anode chamber 16 above cathode 2. Chamber 16 is closed by a cover 17 having a central opening through which anode 5 depends, and a second opening to which is connected an exit duct 18 for gaseous anode products.

To operate the cell, vessel 1 is filled with a molten salt bath containing magnesium chloride to a level approximately as shown in chamber 16, heat being supplied, if necessary, to maintain a suitably elevated temperature, and a direct electric current is passed through the bath between the electrodes. Chlorine is formed at the anode surface and rises through the bath into chamber 16 whence it is led off through duct 18. Magnesium forms on the cathode surface in small droplets which becoming detached rise through the bath and are caught and entrapped by the inverted troughs 11. The metal entrapped in troughs 11 is forced out through ports 12 by the hydrostatic head of the bath into the inactive space back of the cathode, where it is protected from contact with chlorine and rises to accumulate as a liquid mass in the inverted trough 19 under flange 8, whence it may be withdrawn by means shown more particularly in Fig. 2.

Fig. 2 shows in longitudinal section a cell similar to that illustrated by Fig. 1, but employing a plurality of anodes in a row. Like reference characters refer to similar parts as in Fig. 1. The elongated vessel 1 to contain the electrolyte has a row of anodes 5 depending therein, said anodes being flanked on either side by a cathode 2 having on its face a plurality of inverted troughs 11 from which ports 12 give access to the inactive space back of the cathode. Flange 8, which forms the inverted trough 19 for collecting metal rising from the ports 12 of the cathode, is carried around the rim of the vessel at one end and on both sides to a point near the other end, where it bridges across from side to side of the vessel, leaving an open space 20 at the end which forms a metal collecting well. In the bridge section of inverted trough 19 an opening 21 in the side of the trough allows molten metal to flow from the trough into the well 20 where it accumulates in a large body 20a from which it may be removed by dipping with a ladle or by other means. A cover 22 protects the metal in well 20 from the air. The anode chamber 16 is enclosed by the wall of insulation material 15, which in turn is supported by flanges 6 and 8, the chamber being closed by cover plates 17, through which exit pipe 18 for anode gases is taken off. The operation of the cell is as described in the case of Fig. 1. The molten salt bath containing magnesium chloride is maintained at a level about as shown in the drawings. Metal formed on the submerged cathode 2 is first entrapped in troughs 11 as it rises in small globules from the active cathode surface; and thence passes through ports 12, rises through the bath in the inactive zone back of cathode 2, is collected in inverted trough 19, and from the latter is forced by the hydrostatic head of the bath through port 21 into collecting well 20.

For cells of large capacity a plurality of rows of anodes may be used, one arrangement of which, shown in detail in Figs. 3 and 4, provides two parallel rows of anodes disposed in staggered relation to each other, each anode individually circumscribed by a cathode. Fig. 3 is a cross-section

on the line 3—3 of Fig. 4. Fig. 4 is a partial plan view on the line 4—4 of Fig. 3, showing a number of anodes and individual circumscribing cathodes.

In Figs. 3 and 4 a plurality of anodes 5 each circumscribed by a cathode 2 are arranged in two parallel rows running lengthwise in an elongated vessel 1 having an upturned externally flanged rim 6 and an internally projecting flange 8, the latter having a downturned edge forming an inverted trough 19 along the upper edge of the vessel to retain the metal rising thereinto from the ports 12 of the cathodes 2. Cathodes 2 consists of hollow shells with upright side walls, preferably tapered downwardly as shown, having on their inner face a plurality of peripherally disposed inverted troughs 11 ranged one above the other in the manner shown in Figs. 1 and 2. The cathodes 2 may be attached by welding to the flange 8, alternately on opposite sides of vessel 1, the flange being cut out on an arc to give a sufficiently wide bearing surface for welding the cathode thereto, and are additionally supported by brackets 9 connecting to the side wall of vessel 1 through which current is conducted to the cathodes. The inverted troughs 11 on the inner face of cathodes 2 are preferably inclined slightly from the horizontal toward the adjacent side wall of the vessel 1, and a single port 12 located at the high point of the trough serves to deliver the molten metal therefrom into the inactive zone back of the cathode. In the operation of such cell the metal formed at the cathodes, entrapped in troughs 11 and expelled therefrom through ports 12 rises in the inactive space between the cathodes and the wall of the vessel 1 and accumulates in collecting trough 19 under flange 8, whence it is forwarded continuously to a collecting well as shown in Fig. 2.

Other arrangements of apparatus embodying the principle of my invention may be devised, as will readily appear to those versed in the art, and it is understood that the invention comprehends all such equivalent forms of construction. For example, one, two or more rows of anodes may be employed, as desired, in accordance with the size and capacity of the cell. The type of cathode herein described, which is submerged in the bath, may be located in close proximity to the anode to provide a shorter current path than is feasible with forms of construction heretofore known to the art, without sacrifice of yield of light metal product, while it makes possible dispensing entirely with the use of a fragile partition of refractory material for effecting the separation of anode and cathode products. When a downwardly tapering type of cathode is employed, a further advantage accrues, in that the taper of the cathode corresponds more or less to the natural wear of the anode in service. Thereby the anode is caused to wear more uniformly, and at the same time less rapidly, while the tendency to "necking down" and breaking off, which exists when wear is uneven, is largely avoided.

Other modes of applying the principle of my invention may be employed instead of those explained, change being made as regards the apparatus herein disclosed, provided the means stated by any of the following claims or the equivalent of such stated means be employed.

I therefore particularly point out and distinctly claim as my invention:—

1. In an apparatus for electrolyzing a fused bath to produce a metal lighter than the electro-

lyte, a cathode adapted to coact with a vertical anode, said cathode having on its face opposed to such anode a plurality of inverted troughs ranged one above the other and adapted to entrap molten metal rising from the active cathode surface, and means to deliver such entrapped metal to a collecting zone therefor.

2. In an apparatus for electrolyzing a fused bath to produce a metal lighter than the electrolyte, the combination of a metallic vessel to contain such bath, one or more vertical anodes depending therein and a cathode having on its face opposed to such anode or anodes a plurality of inverted troughs ranged one above the other and adapted to entrap molten metal rising from the active cathode surface and ports in said inverted troughs through which to deliver such entrapped metal to a collecting zone therefor.

3. In an apparatus for electrolyzing a fused bath to produce a metal lighter than the electrolyte, the combination of a metallic vessel to contain such bath, a plurality of vertical anodes depending therein in a row, and a cathode submerged in the bath on either side of said row of anodes having on its face opposed to said anodes a plurality of inverted troughs ranged one above the other and adapted to entrap molten metal rising from the active cathode surface and ports in said inverted troughs through which to deliver entrapped metal to a collecting zone therefor.

4. In an apparatus for electrolyzing a fused bath to produce a metal lighter than the electrolyte, a cathode having upright sidewalls adapted substantially to enclose a vertical anode, such cathode having a plurality of inverted troughs ranged one above the other on the inner face thereof adapted to entrap molten metal rising from the active cathode surface and means to deliver such entrapped metal to a collecting zone therefor.

5. In an apparatus for electrolyzing a fused bath to produce a metal lighter than the electrolyte, a cathode having upright sidewalls adapted substantially to enclose a vertical anode, such cathode having a plurality of inverted troughs ranged one above the other on the inner face thereof adapted to entrap molten metal rising from the active surface of the cathode and ports in each trough through which entrapped metal is delivered to a collecting zone.

6. In an apparatus for electrolyzing a fused bath to produce a metal lighter than the electrolyte, a cathode consisting of a hollow metallic shell having a plurality of inverted troughs disposed peripherally on the inner face thereof, and a port through the shell wall in each of said troughs.

7. In an apparatus for electrolyzing a fused bath to produce a metal lighter than the electrolyte, a cathode consisting of a hollow metallic shell having a plurality of peripherally disposed inverted troughs on the inner face thereof, said inverted troughs being inclined slightly from the horizontal, and a port through the shell wall in each trough at the high point thereof.

8. In an apparatus for electrolyzing a fused bath to produce a metal lighter than the electrolyte, a cathode consisting of a hollow metallic shell with downwardly converging walls having a plurality of peripherally disposed inverted

troughs on the inner face thereof, said inverted troughs being inclined slightly from the horizontal, and a port through the shell wall in each trough at the high point thereof.

9. In an apparatus for electrolyzing a fused bath to produce a metal lighter than the electrolyte, the combination of a metallic vessel to contain such bath, one or more vertical anodes depending therein, a cathode in the form of a hollow shell circumscribing each anode in spaced relation therefrom, said cathode having on its inner face a plurality of peripherally disposed inverted troughs adapted to entrap molten metal rising from the active cathode surface and ports through the shell wall in each trough through which such entrapped metal may pass outwardly from said cathode, and means to collect the metal passing through said ports and rising therefrom in the bath.

10. In an apparatus for electrolyzing a fused bath to produce a metal lighter than the electrolyte, the combination of a metallic vessel to contain such bath, one or more vertical anodes depending therein, a cathode in the form of a hollow shell circumscribing each anode in spaced relation therefrom, said cathode having on its inner face a plurality of peripherally disposed inverted troughs inclined slightly from the horizontal and adapted to entrap molten metal rising from the active cathode surface and a port through the shell wall in each trough at the high point thereof permitting such entrapped metal to pass outwardly from said cathode, and means to collect the metal passing through said ports and rising therefrom in the bath.

11. In an apparatus for electrolyzing a fused bath to produce a metal lighter than the electrolyte, the combination of a metallic vessel to contain such bath, one or more vertical anodes depending therein, a cathode in the form of a hollow shell with downwardly converging walls circumscribing each anode in spaced relation therefrom, said cathode having on its inner face a plurality of peripherally disposed inverted troughs inclined slightly from the horizontal and adapted to entrap molten metal rising from the active cathode surface and a port through the shell wall in each trough at the high point thereof permitting such entrapped metal to pass outwardly from said cathode, and means to collect the metal passing through said ports and rising therefrom in the bath.

12. In an apparatus for electrolyzing a fused bath to produce a metal lighter than the electrolyte, the combination of a rectangular metallic vessel to contain such bath, two parallel rows of anodes depending therein in alternate arrangement, a cathode in the form of a hollow shell circumscribing each anode in spaced relation therefrom, said cathode having on its inner face a plurality of peripherally disposed inverted troughs adapted to entrap molten metal rising from the active cathode surface, said troughs being inclined slightly from the horizontal in a direction toward the adjacent sidewall of said vessel, a port through the cathode shell in each trough on the side adjacent to the wall of said vessel, and means to collect the molten metal passing through said ports and rising therefrom in the bath.

LOUIS E. WARD.