

March 30, 1943.

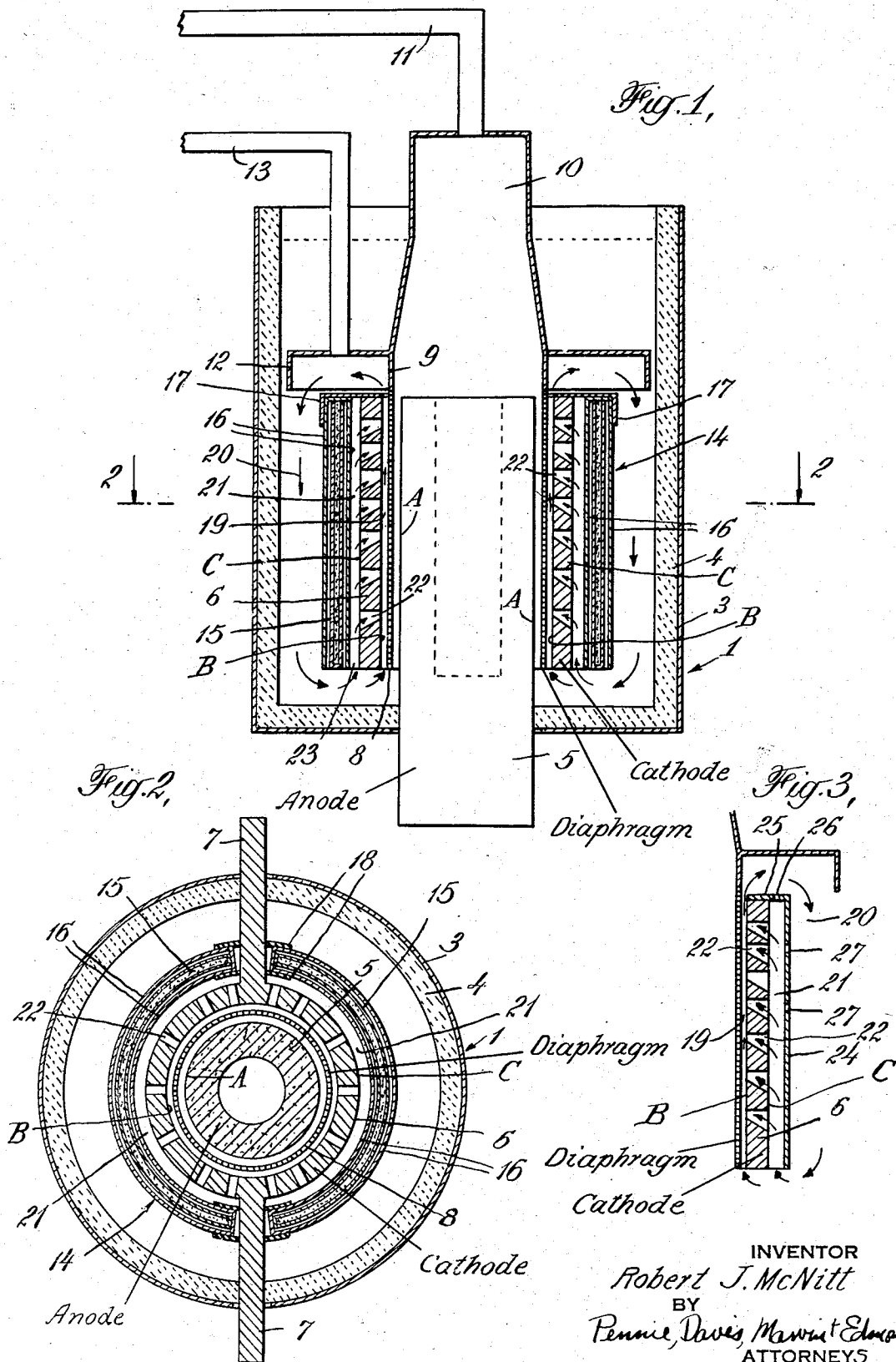
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2,315,443

ELECTROLYTIC CELL FOR FUSED BATHS

Filed Nov. 18, 1939

2 Sheets-Sheet 1



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Fig. 4

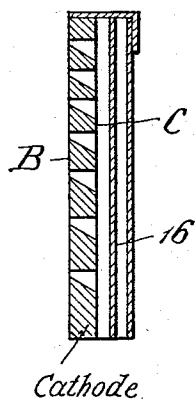


Fig. 5

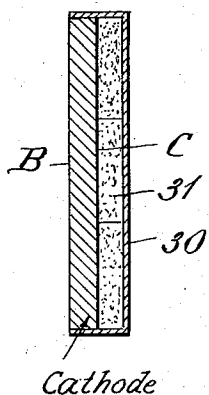


Fig. 6

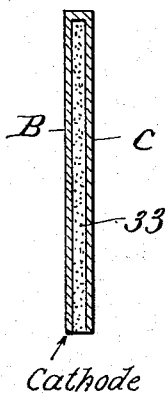


Fig. 7

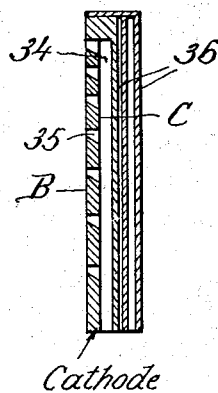
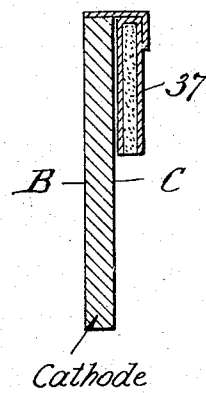


Fig. 8



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ELECTROLYTIC CELL FOR FUSED BATHS

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10 Claims. (Cl. 204—247)

This invention relates to the electrolysis of fused baths and in particular to the production of light metals by the electrolysis of fused mixed baths, wherein the compound of the metal sought is fused with one or more fluxing substances to lower the melting point of the bath. In such electrolytic operations to which this invention pertains, a cathode stream of electrolyte circulates in the bath, flowing upward into the zone of electrolytic action and downward past a surface of the cathode which lies outside of the zone of electrolytic action. This invention has for an object the provision of an improved method of, and apparatus for, effecting an improved circulation of the cathode stream of electrolyte.

In the electrolysis of fused mixed baths, it is important that there shall be adequate circulation of the electrolyte to insure that in all parts of the zone of electrolytic action, the various constituents of the electrolyte shall always be present in suitable proportions.

In small cells satisfactory circulation of the electrolyte is maintained by convection currents therein. Heat liberated by the flow of electric current between the electrodes, raises the temperature and lowers the density of the electrolyte in the zone of electrolytic action. In other parts of the cell, heat departs from the bath causing a fall in temperature and a rise in density. Due to this difference in density circulation of the bath occurs, upward at the active cathode surface, and downward in other parts of the cell.

This circulation has been found inadequate in cells having cathodes of extensive area set close to the anode surface, as is desirable for maximum economy, and it is the aim of my invention to remove this limitation.

This invention aims to improve the circulation of the cathode stream of electrolyte by repressing the flow of heat from the zone of electrolytic action into the downward stream of electrolyte thereby increasing its rapidity of flow. To this end I repress the flow of heat by means of a thermal barrier imposed between the downward stream and the zone of electrolytic action.

The thermal barrier may consist of one or more solid walls or partitions together with one or more liquid or gaseous films or bodies such, for example, as a partition having liquid or gaseous films adjacent thereto, or a partition forming a passage containing a liquid maintained at temperatures intermediate between the temperature

of the upward and downward stream. The thermal barrier may be formed by various combinations of these elements, as demanded by the conditions encountered. A thermal barrier may be placed within the body of the cathode, or between the body of the cathode and the downward stream, or it may be in both positions.

As an example, I shall describe my invention as applied to a cell for the electrolytic production of sodium from a fused bath consisting of sodium chloride, with one or more fluxing agents.

The accompanying drawings illustrate more or less diagrammatically apparatus embodying the invention, in which:

Fig. 1 is a vertical section through an electrolytic cell;

Fig. 2 is a horizontal section taken at line 2—2 of Fig. 1;

Fig. 3 is a fragmentary vertical sectional view of a cathode and thermal barrier, and

Figs. 4, 5, 6 7 and 8 are fragmentary vertical sectional views of modified forms of thermal barriers.

As illustrated in the drawings, the cell comprises a steel shell or containing vessel 3 lined with a refractory 4. A cylindrical graphite anode 5 having an active surface A passes up through the bottom of the shell and is concentric therewith. An annular steel cathode 6 having an active surface B and a less active or inactive surface C is mounted around the anode and supported by two arms 7 which pass through the cell wall and serve to conduct the electric current from the cathode to the outside of the cell. A cylindrical perforated diaphragm 8 is hung concentric with the active cathode and anode surfaces and is supported by a steel collector 9 which is in turn suspended from beams (not shown) which rest on the top of the shell 3. The collector 9 serves to collect and deliver from the cell the products of electrolysis, namely, chlorine gas by way of the dome 10 and duct 11 and liquid sodium by way of hood 12 and duct 13.

Around the outside of the cathode 6, I place a thermal barrier comprising a composite partition 14 having a steel vessel 15, filled with a thermal insulating material, such as diatomaceous earth, and a steel skirt 16 closed at the top suspended from a steel angle ring 17, which in turn rests on the top of the cathode 6. The steel vessel 15 is inserted inside the skirt and is thereby enclosed on the sides and top.

Vessel 15 is closed at the bottom and on all sides, but is open at the top, while skirt 16 is closed against entrance of the molten bath at the

top and on all sides, but is open at the bottom.

In the type of cell shown, I prefer to make the thermal insulating barrier 14 in two sections suspended from the angle ring 17 which may be lowered into position after the fused bath has been prepared around the electrodes. Steel wings 18 serve to guide these sections to their proper positions, and also to close the spaces between the ends of the steel skirts 16 and the cathode arms 7.

The cathode stream of electrolyte comprises an upward stream 19 and a downward stream 20. The upward stream 19 passes between the active surface B of the cathode and the diaphragm 8 in what has been referred to herein as the zone of electrolytic action, and the downward stream 20 passes between the barriers 14 and the refractory lining 4. While there is electrolytic action between the surface A of the anode and the diaphragm, the zone of electrolytic action to which reference is made herein is between the active surface B of the cathode 6 and the diaphragm 8.

The thermal partition 14 taken alone, will effectively check the flow the heat from the upward cathode stream of electrolyte 19 in the zone of electrolytic action, through the cathode body and into the downward stream 20 thus reducing the counter currents in the latter and, by permitting a greater difference in temperature and specific gravity between the rising and falling streams of electrolyte, result in a more effective circulation of replenished bath past the active cathode surface. I may, however, provide a more efficient thermal barrier by spacing the thermal insulating partition 14 a short distance away from the cathode 6, thus forming passages 21 which are connected with the zone of electrolytic action by a plurality of small openings 22 through the cathode. The relatively cool replenished electrolyte entering these passages at the bottom 23, becomes less dense as it absorbs heat through the cathode body 6, and rising in the passage flows through openings 22 into the zone of electrolytic action, taking the place of the electrolyte which has been decomposed by the electric current, and restoring to the electrolyte in the zone of electrolytic action most of the heat which escapes therefrom through the body of the cathode. Moreover, the streams of cool bath flowing up through passages 21 maintain a lower temperature at the surfaces of insulating partition 14 which are adjacent to the cathode than would be possible if the streams were not flowing through passages 21.

I prefer to space the openings 22 more closely together in the upper part of the cathode body and to make the bottom of the openings inclined at an angle greater than 35 degrees with the horizontal to avoid the accumulation of sedimentary matter therein.

By means of the combination of the thermal insulating partition 14 and the auxiliary stream of electrolyte rising in passage 21 and feeding through openings 22 in the cathode into the zone of electrolytic action, I form an effective thermal barrier repressing the flow of heat from the rising stream of electrolyte in the zone of electrolytic action, through the body of the cathode and into the downward flowing stream of electrolyte, and with this improvement it is possible to maintain favorable conditions for electrolysis with more extended cathode surfaces and with a smaller distance between the anode and cathode than has been possible heretofore.

The thermal partition 14 includes a number of gaseous and liquid films which impede the flow of heat. Each of the vertical surfaces of the steel skirt 16, and the exterior surfaces of the vessel 15 have liquid films of electrolyte in contact therewith, and the interior vertical surfaces of the vessel 15 have gaseous films in contact therewith. In certain types of cells requiring a very substantial repression of the flow of heat, the thermal partition 14 as arranged in Fig. 1 is particularly desirable. In cells requiring a lower repression of the flow of heat into the downward stream, I may dispense with one or more of the thermal insulating media comprising the complete partition 14. For example, I may employ vessels 15 in the barrier, with or without the diatomaceous earth, and I may use the skirts 16 alone, omitting the vessels 15 as shown in Fig. 4.

Under certain operating conditions, the simple and effective thermal barrier illustrated in Fig. 3 may be used. This thermal barrier consists of a single wall or partition of sheet steel 24 spaced from the outer surface of the cathode 6 forming the passage 21. This barrier includes the metal wall 24, two liquid films adjacent thereto, and the stream of electrolyte in the passage 21. In this operation, the rising stream of relatively cool electrolyte in passage 21, together with the liquid films and metal, afford ample repression of the flow of heat from the upward cathode stream 19 into the downward stream 20. Adequate circulation can therefore be maintained with this less expensive form of construction.

Instead of using holes 22 in the cathode body I may provide a number of holes 26 to 27 in the roof 25 and upper wall 24 of passage 21, to permit limited circulation of the stream of cool bath in this passage. But this method is much less advantageous than the method in which the stream of bath in passage 21 flows through openings 22 in the cathode body.

There are advantages in combining the thermal insulating partition 14 of Fig. 1 with the form of construction illustrated in Fig. 3 to form a thermal barrier of greater effectiveness.

In other constructions, I may dispense with the passage 21 and the openings 22 and merely fasten a refractory thermal insulator to the inactive side C of the cathode as shown in Fig. 5 in which the iron strap 30 secures the insulation 31 to the cathode. I may also insert thermal insulation 33 in chambers provided in the body of the cathode as shown in Fig. 6. On the other hand, a passage 34, answering the same purpose as passage 21, may be provided in the body of the cathode with openings 35 similar to openings 22 leading to the zone of electrolytic action, and a thermal insulating partition 36 may be inserted between this passage and the downward stream 20 as shown in Fig. 7, if the conditions should be severe.

The thermal barriers illustrated in the drawings extend throughout the length of the cathode and in most operations this is the preferred form of barrier. It is understood, however, that the barriers need not, for all purposes, extend the full length of the cathode, and the invention includes barriers that are relatively short as compared to the cathode. The upper portion of the thermal barrier has a pronounced effect upon the transfer of heat and I may accordingly use relatively short barriers, for example, a barrier 37 which is less than half the length of the cathode as shown in Fig. 8.

I claim:

1. In a cell for the electrolysis of fused mixed baths having a cathode, an anode and a diaphragm between the anode and the cathode, the active surfaces of the cathode and the anode being arranged in upright positions providing a narrow upright space therebetween, an upright space along the inactive side of the cathode connecting both above and below the cathode with the narrow upright space, said cell being arranged to be so operated that a stream of electrolyte circulates in a loop upward in the upright narrow space between the active side of the cathode and the diaphragm and downward in the upright space along the inactive side of the cathode, the improvement which comprises a thermal barrier including a partition arranged between the inactive side of the cathode and the downward stream of electrolyte extending substantially the length of the cathode and so spaced therefrom that a part of the stream of electrolyte flows into the space between the thermal barrier and the cathode, and a plurality of openings in the cathode through which the stream of electrolyte in the space between the thermal barrier and the cathode flows into the upright narrow space between the active surface of the cathode and the diaphragm.

2. A cell for the electrolysis of fused mixed baths which comprises a receptacle for the bath, an upright anode, an upright cathode having a plurality of spaced openings therethrough, an upright diaphragm spaced between the active surfaces of the anode and the cathode, an upright partition extending along the inactive surface of the cathode from the top toward the bottom thereof, an upright space between the cathode and the partition, a member closing the space at the upper parts of the cathode and the partition, a passageway through which the hot cathode stream of electrolyte flowing upward between the cathode and diaphragm flows over the top of the cathode and partition and downward along the partition, and passage means permitting a part of the downward stream to pass into the space between the cathode and the partition and through the openings and another part thereof to pass upward between the cathode and the diaphragm.

3. A cell for the electrolysis of fused mixed baths which comprises an upright anode, an upright cathode, an upright diaphragm spaced between the active surfaces of the anode and the cathode, a plurality of spaced openings in the cathode, a wall spaced from and extending along the inactive surface of the cathode, and an upright thermal barrier comprising a metal plate spaced between the wall and the inactive surface of the cathode extending throughout the greater part of the length of the cathode forming an upright passage along the inactive side of the cathode, and another passage between the thermal barrier and the wall.

4. A cell for the electrolysis of fused mixed baths which comprises an upright anode, an upright cathode, an upright diaphragm spaced between the active surfaces of the anode and the cathode, an upright wall extending along and spaced from the inactive surface of the cathode forming a passageway through which electrolyte flows downward, an upright thermal barrier in the said passageway comprising a metal plate extending from the top of the cathode towards the bottom and spaced from the inactive surface of the cathode, means closing the space between

the top of the metal plate and the cathode, and a plurality of holes in the said means permitting the passage therethrough of a stream of electrolyte rising in the space between the metal plate and the inactive surface of the cathode.

5. A cell for the electrolysis of fused mixed baths which comprises an upright anode, an upright cathode, an upright diaphragm spaced between the active surfaces of the anode and the cathode, an upright thermal barrier mounted near the inactive side of the cathode proportioned and arranged to extend over substantially the entire inactive side of the cathode, an upright wall spaced from the thermal barrier forming a passageway between the wall and the thermal barrier for the downward flow of electrolyte, said thermal barrier comprising a plurality of spaced upright metal plates, and a thermal insulating medium between at least two of the plates, whereby the flow of heat from the cathode into the electrolyte in the passageway is suppressed.

6. A cell for the electrolysis of fused mixed baths which comprises an upright anode, an upright cathode, an upright diaphragm spaced between the active surfaces of the anode and the cathode, an upright passageway between the cathode and the diaphragm in which a stream of electrolyte flows upward, a thermal barrier mounted near the inactive side of the cathode proportioned and arranged to extend over substantially the entire inactive side of the cathode, a passageway for a stream of electrolyte to flow downward from the upright passageway along the side of the thermal barrier opposite the side near the inactive side of the cathode, said thermal barrier comprising a plurality of spaced upright metal plates, a space between at least two of the plates for confining a gas, and another thermal insulating medium enclosed between two of the plates, whereby the flow of heat from the cathode into the electrolyte in the passageway is suppressed.

7. In a cell for the electrolysis of fused baths having an anode, a cathode and a diaphragm arranged in upright positions and so spaced from each other as to form a narrow passageway between the diaphragm and the active surface of the cathode and another passageway along the inactive surface of the cathode and opening means connecting the said passageways both above and below the cathode, whereby the same stream of electrolyte may flow upward in the narrow passageway and downward in the other passageway, the improvement which comprises a thermal barrier mounted near the inactive side of the cathode and between the upward and downward streams which is constructed and arranged to repress the flow of heat from the electrolyte on the active side of the cathode through the cathode to the electrolyte along the inactive side of the cathode.

8. In the electrolytic cell according to claim 7, said thermal barrier comprising a plurality of insulating media including solid and fluid materials.

9. In a cell for the electrolysis of fused baths having a cathode, an anode and a diaphragm arranged in upright positions and so spaced from each other as to form a narrow passageway between the diaphragm and the active surface of the cathode and another passageway along the inactive surface of the cathode and opening means connecting the said passageways both above and below the cathode, whereby the same

stream of electrolyte may flow upward in the narrow passageway and downward in the other passageway, the improvement which comprises a metal partition placed along and spaced from the inactive surface of the cathode and between the upward and downward streams to provide a passage in which molten electrolyte may enter, said partition and molten electrolyte in the passage comprising a thermal barrier which represses the flow of heat through the cathode.

10. In a cell for the electrolysis of fused salt baths having an upright cathode, an upright anode and an upright diaphragm between the anode and the cathode, the active surface of the cathode and the diaphragm being arranged in upright positions providing a narrow upright

space therebetween, an upright wall laterally spaced from the cathode forming an upright space along the inactive side of the cathode connecting both above and below the cathode with the narrow upright space, the improvement which comprises a thermal insulating medium mounted along the cathode and between the active surface of the cathode and the upright space along the inactive surface of the cathode, said thermal insulating medium being adapted to repress the flow of heat from the active cathode surface through the cathode into the electrolyte in the upright space along the inactive surface.

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