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F. W. WRIGGE ET AL  
ELECTROLYTIC CELL CATHODE BOTTOM WITH VERTICALLY  
INSERTED CURRENT CONDUCTORS

3,470,083

Filed Oct. 27, 1964

4 Sheets-Sheet 1

FIG. 1

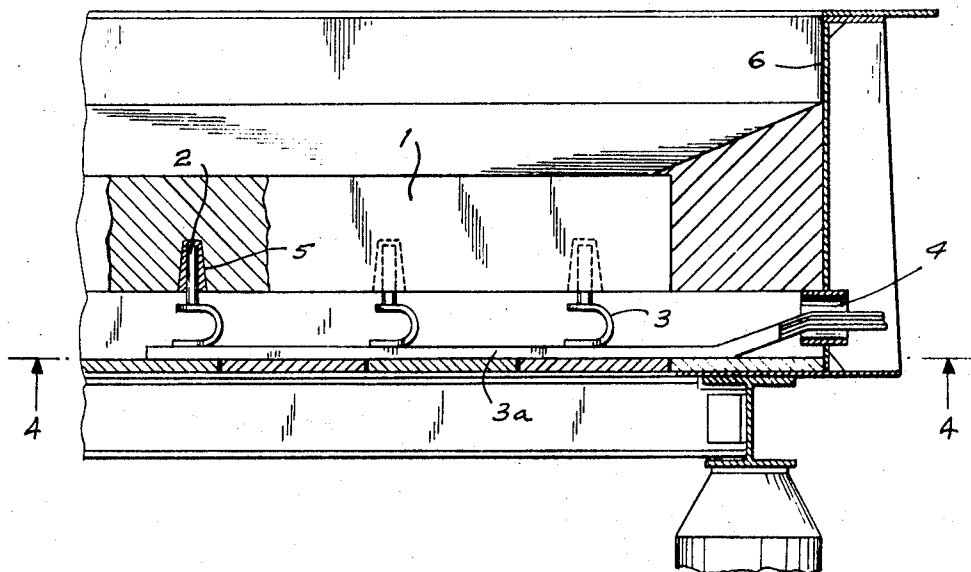
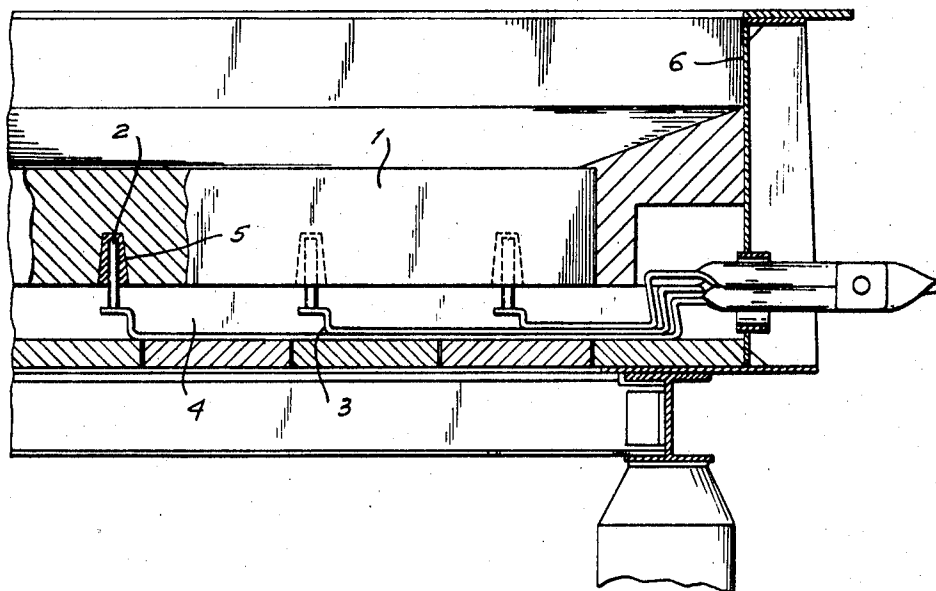


FIG. 2



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**FIG. 3**

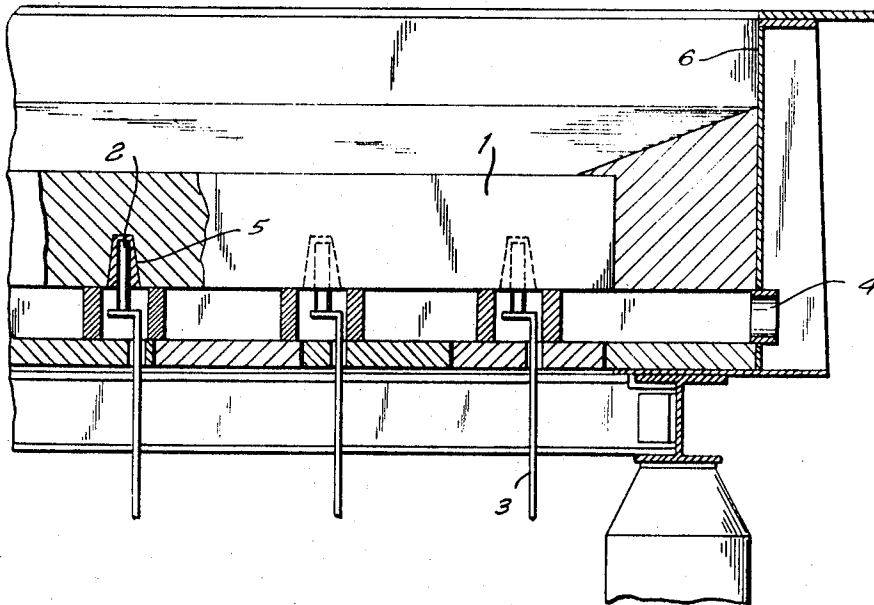
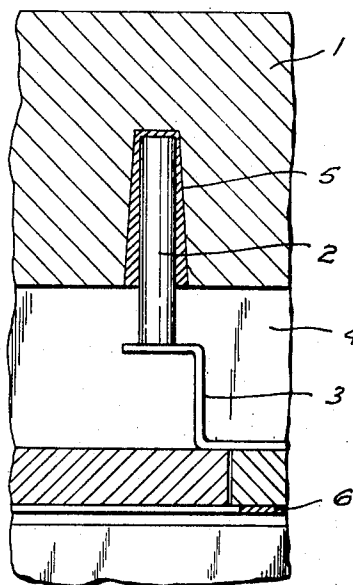


**FIG. 7**



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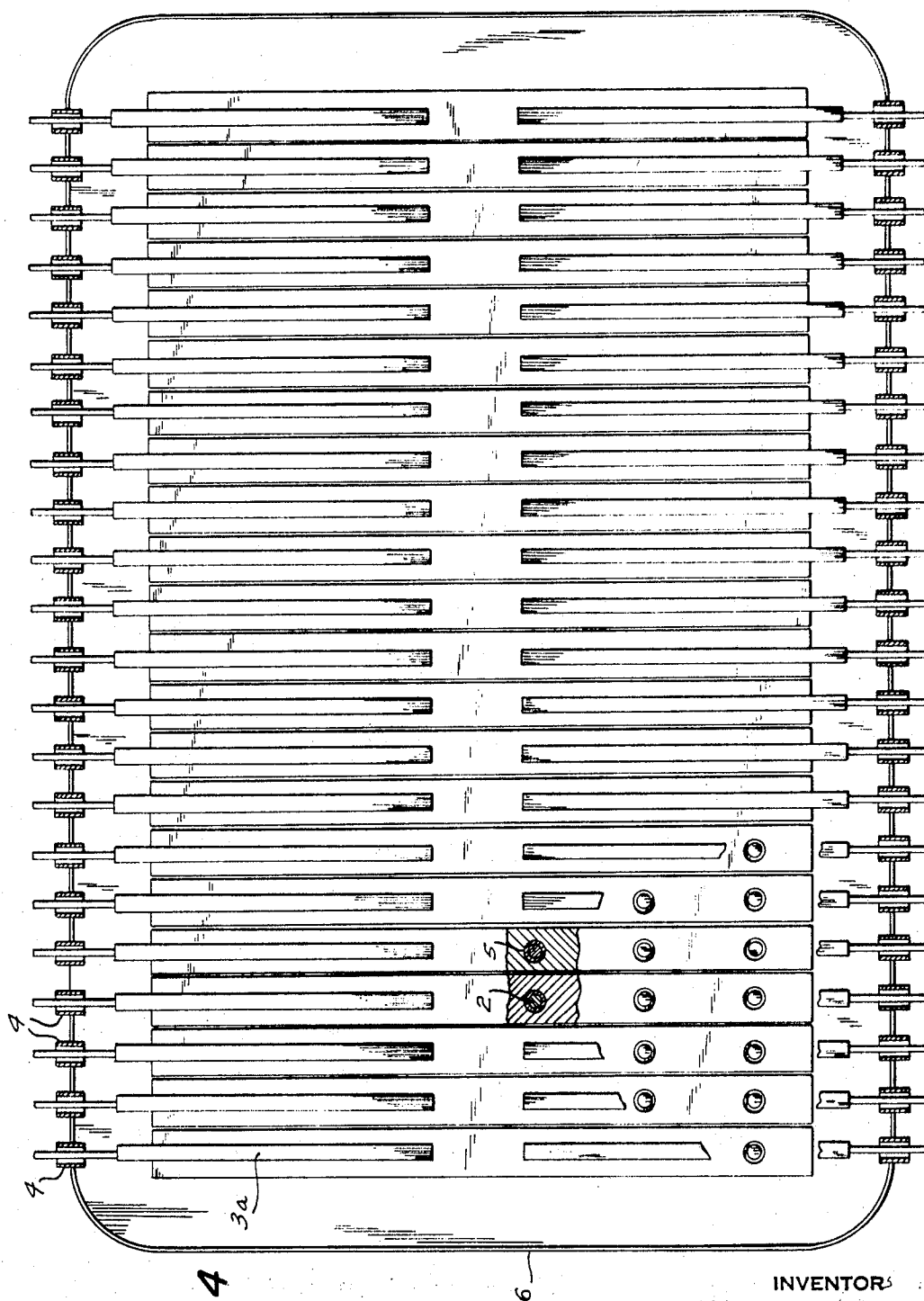


FIG. 4

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FIG. 5

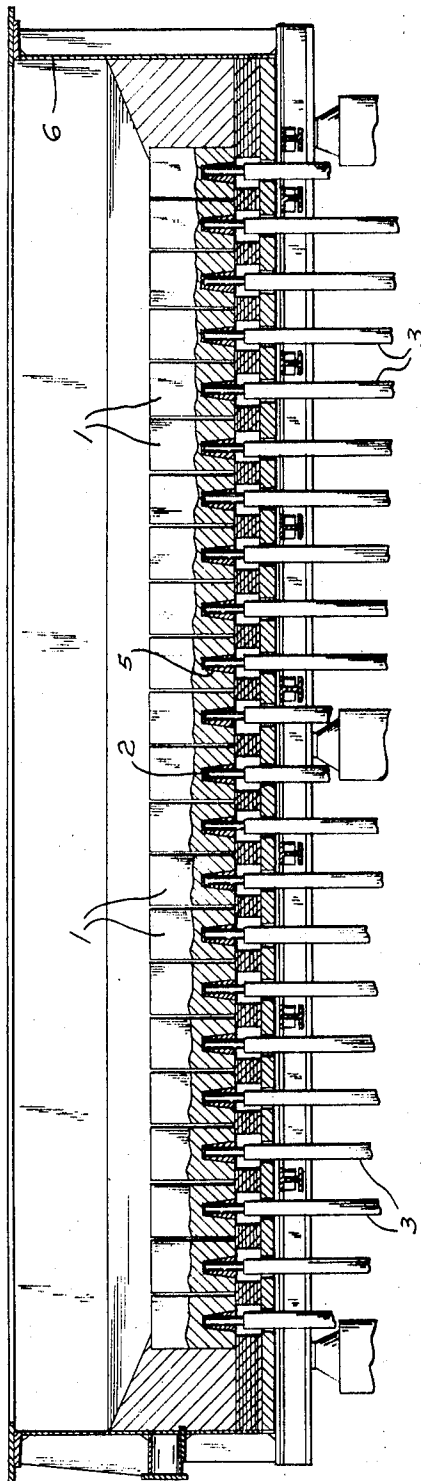
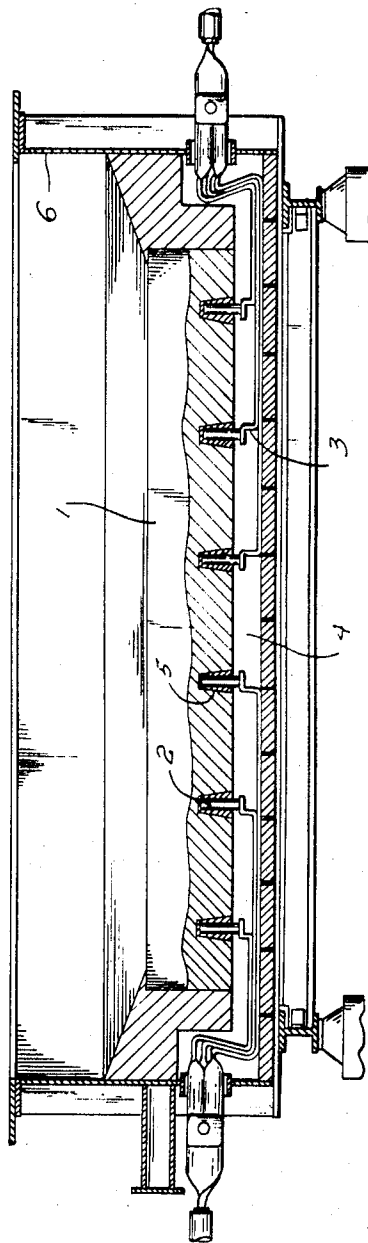


FIG. 6



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3,470,083

## ELECTROLYTIC CELL CATHODE BOTTOM WITH VERTICALLY INSERTED CURRENT CONDUCTOR

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V 24,909, Patent 1,187,809

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10 Claims

The present invention relates to an electrolytic cell and, more particularly, to an electrolytic cell for recovery of a metal from a molten electrolyte containing the same, particularly for the recovery of aluminum in a cell having a bottom-forming cathode of carbonaceous material.

The structure of the cathode has always found great attention in the arrangements for electrolytic recovery of metals from molten electrolyte, particularly for the recovery of aluminum because the useful life span of the electrolytic cell depends on the durability of the cathode.

In the beginning of the aluminum recovery by means of electrolytic cells, the cathode-forming carbon bottom of the electrolytic cell rested on a cast iron plate and current conduction to the cathode was improved by expending bolts which were screwed into the carbon plate, dove-tail ribs or similar devices which extended from the cast iron plate into the carbon electrode. However, with progressively increasing size of the cells, this cathode structure was found to be less and less satisfactory. It was replaced with bottom forming cathodes of preburned carbon blocks or stamped carbonaceous masses whereby, in the case of preburned carbon blocks, the joints were between the individual blocks were filled with stamped carbonaceous mass. Current was introduced by means of steel rods of various dimensions and arrangements.

The large cells which are presently generally used for the electrolytic recovery of aluminum generally include a bottom forming cathode consisting of preburned rectangular carbon blocks in the lower face of which, in preformed grooves, iron rails are located and the remainder of the groove is then filled with stamped or compressed carbonaceous mass. The joints between the individual carbon blocks are also filled with carbonaceous mass which is either stamped or poured into the joints.

Upon starting operation of a thus formed electrolytic cell, the cathode has to be heated as evenly as possible so as to be burned into a unitary carbon block. Only after such unitary carbon block has been formed can the cell be placed into operation, i.e. molten electrolyte poured onto the bottom forming carbon block cathode. It is a prerequisite for the burning of the cathode that by coating of the stamped carbonaceous mass a highly conductive connection is formed between the carbon block and the current conducting iron rails so that the transfer resistance will be as small as possible. On the other hand, due to the firm adherence of the carbon to the iron rails and to the very different heat expansion of the two materials, i.e. the carbon and the iron, considerable mechanical stresses will occur which lead to the formation of transverse cracks in the carbon blocks.

It has been tried to counteract this mechanical destruction of the cathode in various manners. The shape and position of the iron rails was varied in all possible direc-

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tions. However, in the case of large cells requiring current of for instance 100,000 amperes, the cross sections are so large that the shape of the rail is without any substantial influence. Furthermore, it has been tried to counteract the heat stresses by subdividing the preburned carbon bottom into a plurality of blocks and thereby to increase the amount of joint filling carbonaceous mass having a greater extensibility.

By electric heating of the iron rails, maximum expansion of the same was tried to be caused prior to the coking of the joint filling mass in order to prevent in this manner a mechanical destruction of the carbon body. The composition of the joint filling carbonaceous masses as well as of the preburned carbon bodies was also subject of special attention. Finally, it was proposed to discontinue the iron rails in the center of the carbon blocks or to try to introduce current only through laterally arranged nipples although by preceeding in this manner the voltage losses were increased and the current distribution in the cathode became unfavorable.

However, all of these efforts were not fully successful because the basic difficulty which was caused by the difference in the heat expansion of the current conducting iron rail or the like on the one hand and the carbon block on the other hand could not be avoided. Furthermore, the difficulty arose that the temperature gradient within the cathode caused in addition to longitudinal and transverse expansion of the iron rails also an upward arching of the same. Thus, the by far largest number of cathodes is already mechanically damaged prior to starting operation of the cell by the formation of more or less fine expansion cracks in the joints between the individual preburned carbon bodies or even within the individual preburned carbon bodies. During operation of the cell, these cracks will be filled with solidified molten electrolyte and thereby the effectiveness of the cell will be reduced. If it happens that molten electrolyte or aluminum reaches the insulating material beneath the cathode, then the reactions of the various materials will cause increase in volume thereof which will support the destructive thermal forces.

It is therefore an object of the present invention to overcome the above discussed difficulties and disadvantages in the arrangements for current supply to carbon cathodes of electrolytic cells of the type described.

It is another object of the present invention to provide in a simple and economical manner a current supply for the carbonaceous cathodes of such electrolytic cells substantially without causing heat stresses and the damage caused by the same.

Other objects and advantages of the present invention will become apparent from a further reading of the description and of the appended claims.

With the above and other objects in view, the present invention contemplates in an electrolytic cell for recovery of a metal from a molten electrolyte containing the same, in combination, a vessel adapted to hold molten electrolyte the vessel having a bottom formed of a substantially horizontally extending carbonaceous cathode plate having an upper face adapted to contact the molten electrolyte and a lower face, a plurality of current conducting nipples having upper and lower portions and extending spaced from each other with their upper portions into the cathode plate through said lower face thereof, and current supply means operatively connected to the lower portions, respectively, of the nipples spaced from the cathode plate.

Thus, the difficulties and disadvantages in the prior art structure of electrolytic cells for the recovery of metals from molten electrolyte, particularly for the recovery of aluminum are avoided according to the present invention by providing a plurality of nipples which extend, spaced from each other, upwardly into the carbon cathode, whereby the current supply means such as bus bars or iron rails which supply current to the nipples are located outside of and spaced from the cathode. In this manner it is achieved that current will be conducted with very little resistance from the nipple into the carbon cathode, due to the greater heat expansion of the nipple and the consequent firm contact between the upper nipple portion and the surrounding portion of the carbon cathode. On the other hand, in view of the relatively small diameter of the nipple, this pressure exerted by the nipple against the surrounding portion of the carbon cathode will not suffice for mechanical destruction or damage of the carbon cathode, particularly if the nipple is of circular cross section so that a notch effect will be avoided. Due to arrangement of the bus bars spaced from the highly heated cathode, the heat expansion which will cause upward arching of the bus bars is considerably less than in prior art structures. Thereby, the damage to the cathode during the first heating of the same is avoided and increase in the volume of the cathode by penetration of cracks therein with molten electrolyte or metal will not take place. The end result is a considerably prolonged useful life span of the cell.

The nipples preferably extend perpendicular to the horizontally extending carbon cathode, i.e. in vertical direction from the lower face of the carbon cathode towards the molten electrolyte on top thereof. However, in most cases it will be preferred to have the nipples terminate within the center portion of the cathode and not to extend to the upper face thereof so that contact between molten electrolyte and the nipple will be avoided. In order to further counteract any heat stresses which still might occur, it is provided according to the present invention that the space which separates the cathode from the bus bars is formed as a cooling channel or is filled with heat insulating material. Aluminum oxide has been found to be particularly suitable as such heat insulating material which can be blown into the space or cooling channel between the lower face of the cathode and the bus bars.

The nipples may be made of iron or iron alloys or other electrically highly conductive materials, which, however, must have a high melting point, higher than 1,100° C. Non-iron materials which may be successfully used for forming the nipples thereof include titanium borides and carbides.

The bus bars may be made of iron or iron alloys or of other materials which possess an even better electric conductivity and which may have a lower melting point than iron. Since according to the present invention the bus bars are located outside the cathode and are not in contact with the same and are not subjected to such very high heat stresses, it is possible to form the bus bars for instance of copper or of aluminum alloys of suitable composition, for instance of iron-containing aluminum alloys, providing that the material of which the bus bars are formed has a melting point which is at least as high as about 600° C.

It is further provided according to the present invention that the nipples are surrounded in the cathode with material which is stamped or poured around the nipples, for instance a carbonaceous mass which is capable of coking may be used to fill the space between the nipple and the surrounding cathode portion, or a metal such as iron may be poured into this space.

As a stamping mass, i.e. as a carbonaceous mass which can be used to form a firm contact between the nipple and the surrounding portion of the carbon cathode may be used a mixture of about 30–35% pitch coke, between 45 and 50% broken coke and between 25 and 15% pitch.

As pointed out further above, and as illustrated in the drawing, it is advantageous to terminate the cathode nip-

ples, particularly if the same are formed of iron, within the carbon blocks and spaced from the upper face of the carbon cathode so that contact between liquid aluminum and iron nipple portions and dissolution of the iron nipple portions will be avoided. However, if the nipples are formed of material which is resistant to liquid aluminum, such as titanium carbides or titanium borides, then the nipples may extend throughout the entire thickness of the carbon cathode into direct contact with the aluminum at the upper face of the carbon cathode since thereby the conductivity and the passage of current through the cathode into the molten electrolyte will be improved.

The bus bars which supply current to the nipples may extend horizontally or vertically downward. Thus, the bus bars may extend through the side wall or through the bottom wall of the outer shell of the cell.

It is of particular advantage if the current conducting members for each nipple are at least partially flexible. Either the entire current conducting element may be flexible, for instance in the shape of bands, strips or the like, or a rigid bus bar may be used as the main portion of the current conductive element and only the contact between this bus bar and the individual nipples is then provided by a flexible metal band, strip or the like.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

FIG. 1 is a fragmentary vertical cross section of a cell according to the present invention showing a rigid bus bar and a flexible metal strip connection between the rigid bus bar and the individual nipples;

FIG. 2 is a fragmentary elevational cross sectional view of another embodiment of the present invention according to which the entire current conducting element for each nipple consists of a flexible strip which extends horizontally through the outer lateral shell of the cell.

FIG. 3 is a fragmentary elevational cross sectional view somewhat similar to that of FIG. 2, however, showing individual current conducting elements which extend vertically downwardly through the outer bottom of the cell.

FIG. 4 is a transverse sectional plan view taken in the plane which includes the lower faces of the bus bars along line 4–4 in FIG. 1 in the direction of the arrows and illustrating the entire cross section of the cell;

FIG. 5 is a transverse sectional elevation of the structure shown in FIG. 3 showing the entire cross section of the cell;

FIG. 6 shows the entire cross section of the cell of which a part is shown in FIG. 2; and

FIG. 7 is an enlargement of part of the structure shown in FIG. 2.

Referring now to the drawings, it will be seen that cathode 1 extends horizontally along the bottom of the respective cell and is formed in conventional manner of a carbonaceous mass by stamping, pouring and subsequent burning or of preburned carbon blocks. The nipples are indicated by reference numeral 2 and it is apparent from the drawing that a considerable number of nipples of relative small diameter are arranged spaced from each other whereby the distance between the individual nipples will be so chosen as to achieve any desired current density at the corresponding portion of the cathode. The current conducting members 3 are located outside of and spaced from cathode 1. Between the current conducting members 3 and cathode 1 a free space 4 is formed which may be either used as a cooling channel or which may be filled with heat insulating material, and aluminum oxide has been found particularly suitable as a heat insulating material which may be blown into space 4. Nipples 2 may be

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formed of iron or iron alloys or other electrically highly conductive materials which possess a sufficiently high melting point, preferably higher than 1,100° C. The current conducting members 3 may be formed of iron or iron alloys or of other and even more highly conductive materials which have a lower melting point. It is possible to form current conducting members 3 of materials having a lower melting point down to about 600° C. because of the current conducting members 3 are located outside of the cathode and thus will not be exposed to the higher temperatures prevailing in the cathode.

Nipples 2 are stamped into cathode 1 or surrounded by a poured material indicated by reference numeral 5. The surrounding layer 5 may consist either of a carbonaceous mass for instance of the composition described above which is stamped about the nipples, or may be a solidified poured metal having a sufficiently high melting point, for instance iron.

The only difference between the embodiments of FIG. 2 and FIG. 3 will be found in the manner in which the current conducting members 3 are arranged within the outer shell of the electrolytic cell. According to FIG. 2, the current conducting members extend horizontally and pass through the side wall of the shell 6, while according to FIG. 3 the current conducting members extend vertically downwardly and pass through the bottom of shell 6.

The current conducting elements are either completely or partially of flexible construction. As shown in FIG. 1 the major portion of the current conducting element consists of a rigid bus bar and a flexible strip or band connects the bus bar with the respective nipple. According to FIGS. 2, 3 and 7, the entire current conducting member 3 is formed of flexible bands, strips or the like. The flexible portions of the current conducting members 3 serve for evening out the heat stresses since the flexible portions are capable of absorbing the occurring heat expansions of the current conducting members. It is immediately apparent that whatever heat expansion of the current supplying members 3 including bus bars 3a will occur, will be without any effect on carbon cathode 1.

As illustrated, nipples 2 terminate within the interior of cathode 1, about in the center portion of the same or even somewhat below. However, as pointed out above, it is also possible to extend the nipples throughout the entire thickness of the cathode so that the same will come into contact with molten aluminum at the upper face of the cathode, provided that the nipples are formed of a material which will not be affected by the molten aluminum.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of electrolytic cells differing from the types described above.

While the invention has been illustrated and described as embodied in an electrolytic cell for the production of aluminum from molten electrolyte, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. In an electrolytic cell for recovery of a metal from a molten electrolyte containing the same, in combination, a vessel adapted to hold molten electrolyte, said vessel having a bottom formed of a substantially horizontally

extending carbonaceous cathode plate having an upper face adapted to contact the molten electrolyte or molten metal electrolytically separated therefrom, and a lower face; a plurality of current conducting nipples extending spaced from each other in substantially vertical direction through said lower face of said cathode plate into the latter, each of said nipples having a lower end and an upper free end downwardly spaced from said upper face of said cathode plate and completely separated from said top face by an uninterrupted portion of said cathode plate so as to be out of direct contact with said electrolyte; and current supply means spaced from said cathode plate and electrically connected to said lower end of each nipple.

2. In an electrolytic cell as defined in claim 1, said vessel having a free space beneath said cathode plate, and said current supply means extending into said space in engagement with said nipples but spaced from said cathode plate.

3. In an electrolytic cell as defined in claim 1, said vessel having a free space beneath said cathode plate, and said current supply means extending into said space in engagement with said nipples but spaced from said cathode plate; and a heat insulating material substantially filling said free space.

4. In an electrolytic cell as defined in claim 1, said vessel having a free space beneath said cathode plate, and said current supply means extending into said space in engagement with said nipples but spaced from said cathode plate; and aluminum oxide as a heat insulating material substantially filling said free space.

5. In electrolytic cell as defined in claim 1, wherein said plurality of current conducting nipples are formed of an electrically conductive material having a melting point of at least 1100° C.

6. In electrolytic cell as defined in claim 1, wherein said current supply means have a melting point of at least 600° C.

7. In electrolytic cell as defined in claim 1, and including a current conducting binder material interposed between and firmly connecting said nipples, respectively, and said cathode plate.

8. In electrolytic cell as defined in claim 1, wherein said plurality of current conductive nipples are formed of an electrically conductive material selected from the group consisting of iron, titanium carbide and titanium boride.

9. In an electrolytic cell for recovery of a metal from a molten electrolyte containing the same, in combination, a vessel adapted to hold molten electrolyte said vessel having a bottom formed of a substantially horizontally extending carbonaceous cathode plate having an upper face adapted to contact the molten electrolyte or molten metal electrolytically separated therefrom, and a lower face; a plurality of current conducting nipples having upper and lower portions and extending, without contacting said molten electrolyte in substantially vertical direction spaced from each other and from the upper face of said cathode plate, with their upper portions into the interior of said cathode plate through said lower face thereof with portions of said cathode plate interposed between said nipples and the molten electrolyte or molten metal a current conducting binder material interposed between said firmly connecting said nipples, respectively, and said cathode plate; and current supply means operatively connected to said lower portions, respectively, of said nipples spaced from said cathode plate said current supply means including substantially horizontally extending bus bars and resilient conductors connecting said bus bars to the lower portions of said nipples, respectively.

10. In an electrolytic cell for recovery of a metal from a molten electrolyte containing the same, in combination, a vessel adapted to hold molten electrolyte said vessel having a bottom formed of a substantially horizontally extending carbonaceous cathode plate having an upper face adapted to contact the molten electrolyte or molten metal electrolytically separated therefrom, and a lower face; a

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plurality of current conducting nipples having upper and lower portions and extending, without contacting said molten electrolyte in substantially vertical direction spaced from each other and from the upper face of said cathode plate, with their upper portions into the interior of said cathode plate through said lower face thereof with portions of said cathode plate interposed between said nipples and the molten electrolyte or molten metal a current conducting binder material interposed between and firmly connecting said nipples, respectively, and said cathode plate; and current supply means operatively connected to said lower portions, respectively, of said nipples spaced from said cathode plate said current supply means including substantially vertically expanded bus bars and resilient conductors connecting said bus bars to the lower portions of said nipples, respectively.

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## References Cited

## UNITED STATES PATENTS

|           |        |         |         |   |
|-----------|--------|---------|---------|---|
| 1,757,695 | 5/1930 | Westly  | 204—280 | X |
| 2,939,829 | 6/1960 | Allen   | 204—243 |   |
| 3,028,324 | 4/1962 | Ransley | 204—243 |   |
| 3,179,736 | 4/1965 | Ramsey  | 13—25   |   |

## FOREIGN PATENTS

|           |        |          |
|-----------|--------|----------|
| 1,089,980 | 3/1961 | Germany. |
|-----------|--------|----------|

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U.S. Cl. X.R.

204—67, 286