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[54] **CONVEYANCE OF ELECTRODES FOR ELECTROLYTIC CELLS IN ELECTROREFINING**

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[51] **Int. Cl.** **B66b 17/00**

[58] **Field of Search** 214/89; 134/76, 77, 62, 134/104, 133

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[57] **ABSTRACT**

In electrolytic refining of copper and other nonferrous metals in which anodes and cathodes are both supplied in the form of sheets each having a pair of lugs or requivalent means projecting laterally from its top so as to be conveyed in a suspended manner, a pair of overhead rails are mounted on a bridge having a vertical aperture therethrough and spanning an array of open-top electrtolytic cells, and which is itself movable in both directions along a pair of elevated rails. A traveling hoist movable in both directions along the overhead rails is equipped with means for picking up, through the aperture in the bridge, a complete set of alternating anode and cathode sheets from a truck on floor-level rails extending along-side the array of electrolytic cells. The set of anode and cathode sheets can then be deposited into any desired one of the electrolytic cells by virtue of the combined motion of the hoist along the overhead rails and of the bridge along the elevated rails.

11 Claims, 4 Drawing Figures

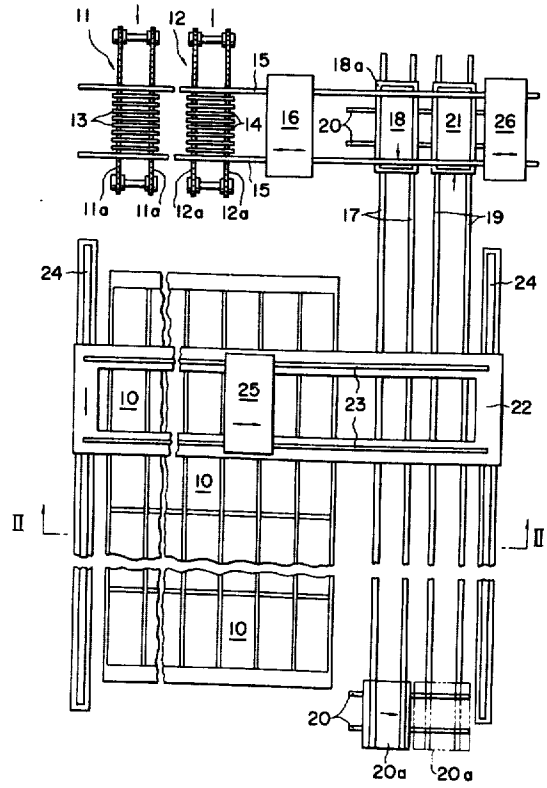

FIG. 1

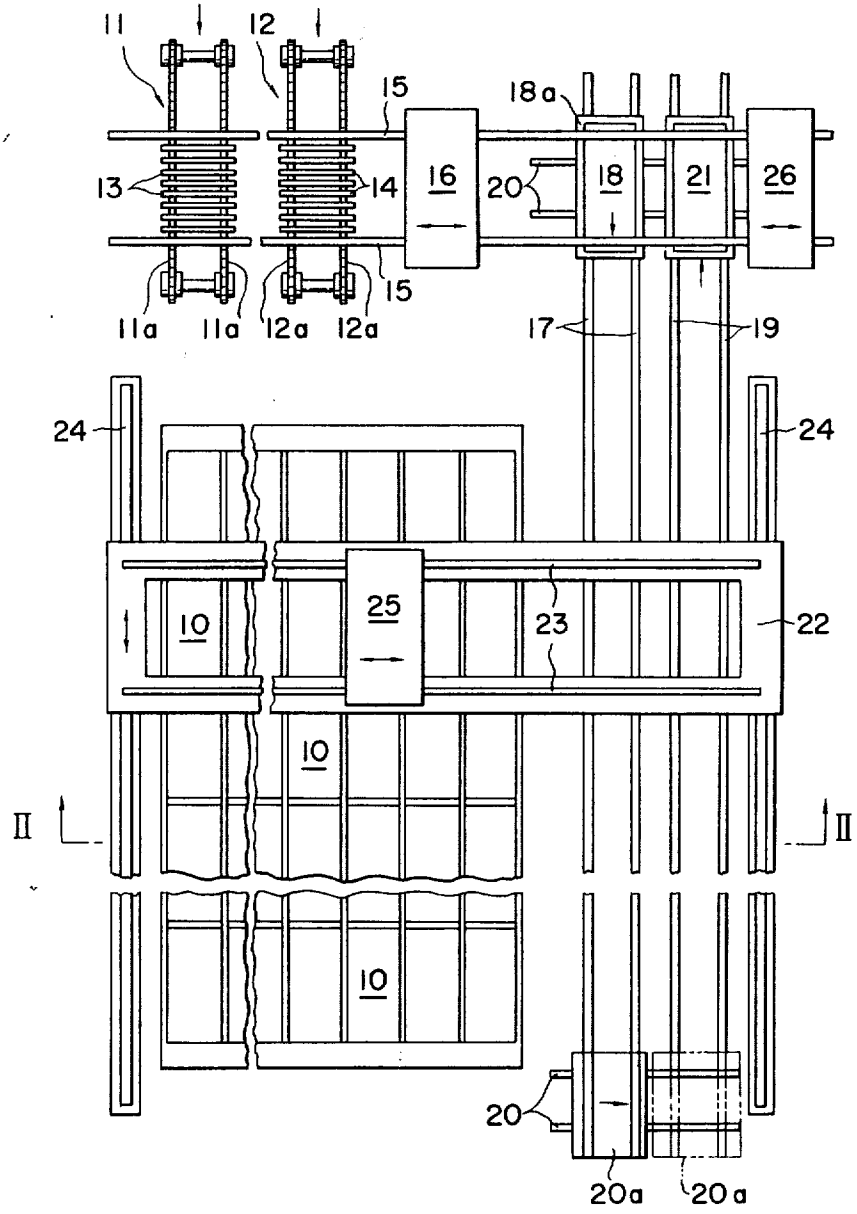
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FIG. 2

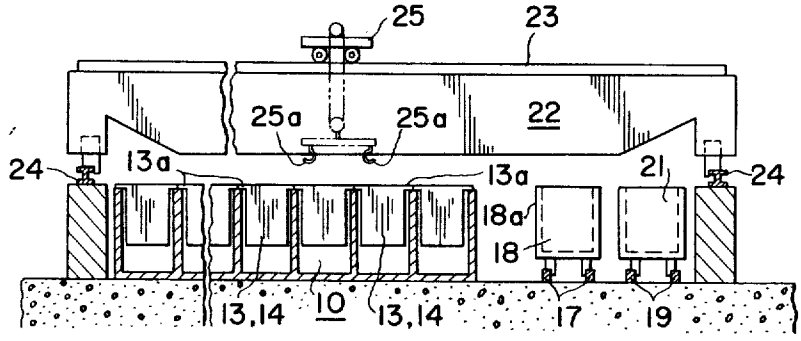


FIG. 3

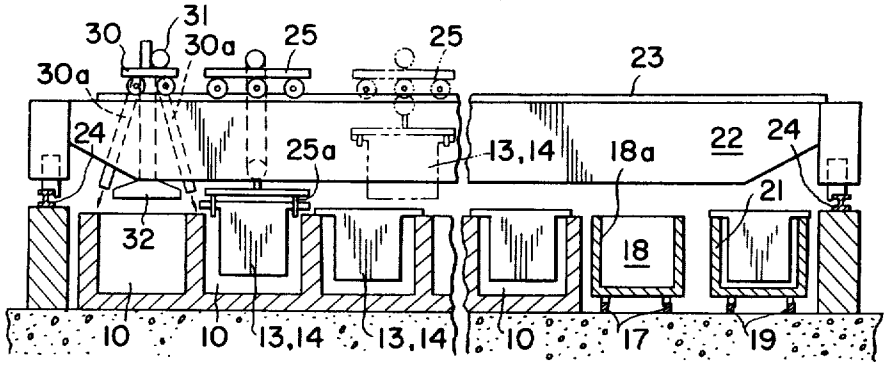
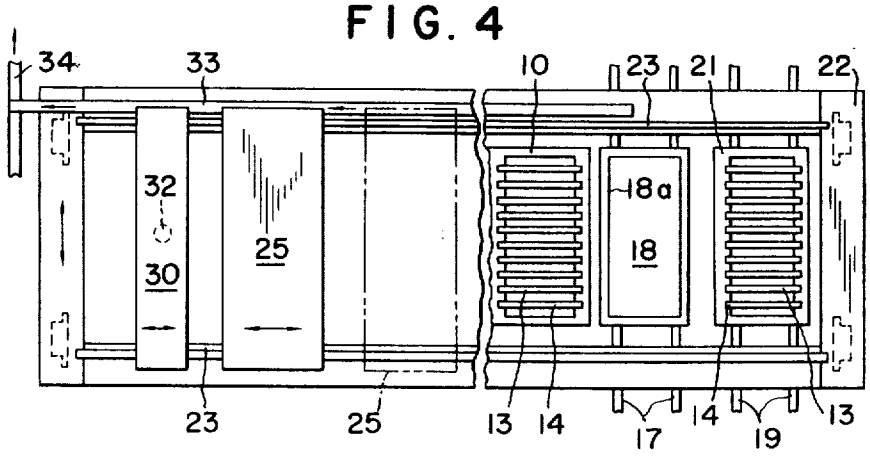


FIG. 4



CONVEYANCE OF ELECTRODES FOR ELECTROLYTIC CELLS IN ELECTROREFINING

BACKGROUND OF THE INVENTION

This invention relates generally to material handling and in particular to a method and a system for conveyance of successive sets of anodes and cathodes into and out of an array of open-top cells in electrolytic refining of copper, lead, tin and other nonferrous metals.

It is well known that for electrolytic refining of the listed metals on an industrial level, anodes and cathodes in the form of sheets must ordinarily be arranged alternately at specified spacings in each of a plurality of electrolytic cells containing the necessary electrolyte therein. Heretofore, for thus introducing the anode and cathode sheets into each electrolytic cell, a prescribed number of the anode sheets have first been arranged at constant spacings in the cell, and a corresponding number of the cathode sheets have then been conveyed by an overhead crane to be carefully unloaded in the spacings between the anode sheets with the aid of manual readjustment by several skilled workmen. However, so small are the spacings between the anode and cathode sheets, and so thin and pliable are the cathode sheets, that it involves a highly troublesome and timeconsuming procedure for the workmen on their insecure foothold to arrange the anode and cathode sheets in each cell at the exact spacings required.

Moreover, since the overhead crane carrying the anode and cathode sheets is required to travel back and forth over the workmen, it becomes necessary that rails or like supporting structures for the crane be mounted sufficiently high within the building of the refining plant. This objective can be accomplished only by the expenditure of considerable costs for reinforcement of the refining plant building to a sufficient degree to withstand the full load of the running crane.

SUMMARY OF THE INVENTION

In view of the above described difficulties accompanying the prior art, it is an object of this invention to provide novel and improved method and system for conveyance of anodes and cathodes into and out of electrolytic cells in electrolytic refining of metals, such that the entire process of the conveyance of the electrodes can be fully automated.

Another object of the invention is to provide a method of the above stated nature, wherein a traveling bridge with large inertial mass movable across the electrolytic cells is retained directly above a specific row of cells until exchange of anode and cathode sheets in all the cells of that row has been completed and only a hoist movable on said bridge and having low inertial mass is reciprocatingly moved along the length of the bridge for the exchange of the sheets in that row, whereby inertial effect on the positioning of the sheets is lessened with resultant correct positioning thereof.

Still another object of the invention is to provide a method and a system whereby the anodes and cathodes can be automatically introduced into each electrolytic cell in their exact relative positions, without the necessity of manual readjustment.

A further object of the invention is to provide a method and a system wherein the cathodes, which usually are in the form of extremely thin sheets, are conveyed to a desired electrolytic cell in combination with the anodes, in such a manner that the possbility of deformation of the cathodes during the process of conveyance is minimized.

A still further object of the invention is to provide a system wherein no structures are employed which must be mounted unduly high above the floor level, thereby economically utilizing the overhead space within the building of the tank house and further significantly reducing the costs for its construction.

A further object of the invention is to provide a system including means for automatic removal of slime formed at the bottom of each electrolytic cell as a result of the refining process.

A still further object of the invention is to provide a system which is simple and inexpensive in construction but which contributes greatly toward the increase in the productivity of refined metals.

According to this invention, in one aspect thereof, there is provided a method of conveying anode and cathode sheets into and out of an array of open-top electrolytic cells mounted on a floor and including a series of parallel rows of cells, wherein the anode and cathode sheets are each provided with a pair of lugs or the like so as to be supported vertically in a suspended manner throughout the entire process of conveyance and the method comprises the steps of providing a traveling bridge spanning the array of cells in a direction parallel to said series of rows and movable transversely of the rows; conveying fresh anode and cathode sheets as vertically suspended and alternately arranged successive sets of anode and cathode sheets along a conveying path transverse to the series of rows to the adjacency of said array of electrolytic cells at a position in alignment with a selected row of cells; moving said bridge to a position in alignment with the selected row of cells in the second series; moving a traveling hoist on the bridge along the length thereof to a starting position directly above said fresh set of sheets which have been conveyed to the starting position; moving the hoist reciprocally between the starting position and each of the positions of all the cells of said selected row to carry fresh sets of sheets successively into all the cells of said selected row and to carry used sets of sheets in the cells to the starting position successively on the way back of the hoist to the starting position for exchange of the sets in the cells; maintaining the bridge in said position alignment with the selected row until the exchange of the sets in all the cells in the selected row has been completed; and moving the bridge to another position in alignment with another selected row of cells to repeat the above mentioned operation.

According to this invention, in another aspect thereof, there is provided a conveying system in an electrolytic metal refining plant, for conveyance of anode and cathode sheets into and out of an array of open-top electrolytic cells mounted on a floor and including a series of parallel rows of cells, wherein the anode and cathode sheets are each provided with a pair of lugs or the like so as to be supported vertically in a suspended manner throughout the entire process of conveyance, and the system comprises: means for conveying the anode and cathode sheets as a vertically suspended and alternately arranged set of anode and cathode sheets along a conveying path parallel to the series of rows to the adjacency of the array of electrolytic cells; a pair of spaced apart rail means parallel to the conveying path with the array of electrolytic cells and

the conveying path interposed therebetween; a traveling bridge riding on said spaced apart rail means so as to be movable in both directions along the same and spanning the array and the conveying path in a direction parallel to series of rows at a height close to the top of the array; and a traveling hoist movable on the bridge along the length of the same, said hoist including means for picking up a set of alternating anode and cathode sheets from the conveying means and then lowering the set into a desired one of the electrolytic cells in such a manner that the anode and cathode sheets are released in the desired electrolytic cell with their relative positions unchanged.

The features which are believed to be novel and characteristic of this invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and mode of operation, together with the further objects and advantages thereof, will be best understood from the following description taken in conjunction with the accompanying drawings which illustrate, by way of example only, some preferred embodiments of the invention, and in which like reference numerals denote like parts of the several views.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partly broken-away to plan view showing the entire arrangement of a system for conveyance of electrodes into and out of an array of electrolytic cells in accordance with the principles of this invention;

FIG. 2 is a partly broken-away vertical sectional view taken along the plane of line II—II in FIG. 1 as viewed in the direction of the arrows;

FIG. 3 is a view similar to FIG. 2 but showing another preferred embodiment of the invention; and

FIG. 4 is a partly broken-away top plan view of the arrangement of FIG. 3.

DETAILED DESCRIPTION

A first preferred embodiment of this invention will now be described in detail with reference to FIGS. 1 and 2. The reference numeral 10 in these figures generally designates a plurality of open-top electrolytic cells containing an electrolyte the nature of which is dictated by a particular metal to be refined therein, the electrolytic cells 10 being arrayed in columns and rows on the floor of the refining plant.

First and second chain conveyors 11 and 12 are disposed in parallel spaced relationship to each other on one side of the array of electrolytic cells 10. Each of these first and second chain conveyors 11 and 12 consists essentially of a pair of parallel spaced endless chains 11a and 12a extending horizontally at a suitable height above the refining plant floor. The first chain conveyor 11 is adapted to support vertically a prescribed number of anode sheets 13 of a desired impure metal such as blister copper in side-by-side relationship and at prescribed spacings from one to the next. For being thus supported by the first chain conveyor 11, each of the anode sheets 13 has a pair of lugs 13a projecting laterally from its top, as seen in FIG. 2, which lugs are adapted to rest on the respective chains of the first conveyor. Ordinarily, the anode sheets 13 may be cast into the desired shape and size in a separate casting plant and may then be shipped to the refining plant, where they are transported one by one by the first chain conveyor 11 to the position illustrated in FIG. 1. The motion of the first chain conveyor 11 stops temporarily when the prescribed number of the anode sheets 13 to be accommodated in a single electrolytic cell have thus been arranged in position in the manner previously set forth.

The second chain conveyor 12 is likewise adapted to support vertically a prescribed number of cathode sheets 14 or starting sheets, in side-by-side relationship and at prescribed spacings from one to the next. Although not clearly seen in the drawings, it is assumed that each of the cathode sheets 14 has a tubular ribbon affixed to its top to receive a crossbar therethrough, and both ends of the crossbar project laterally from the ribbon so as to rest on the respective chains 12*a* of the second chain conveyor 12. After having been made flat by a prior art finishing process, the cathode sheets 14 are successively transported by the second chain conveyor 12 to the position of FIG. 1, and the second chain conveyor comes to a temporary stop when the prescribed number of the cathode sheets to be accomodated in a single electrolytic cell in combination with the prescribed number of the anode sheets 13 have been arranged in position in the above mentioned manner.

A pair of overhead rails 15 extend horizontally above the first and second chain conveyors 11 and 12 at right angles thereto. A traveling hoist 16 supported by these overhead rails 15 so as to be capable of moving in both directions thereon has first and second sets of paired hooks, not shown, which are movable up and down independently to engage the lugs 13*a* of the anode sheets 13 and the lateral projections of the crossbars on the cathode sheets 14, respectively. Thus, when the hoist 16 is located above the first chain conveyor 11, the first set of paired hooks only are caused to descend therefrom to receive the anode sheets 13 and to lift them up from the first chain conveyor. When the hoist 16 is succeedingly brought to a position above the second chain conveyor 12, the second set of paired hooks are caused to descend in their turn to receive the cathode sheets 14 and to lift them up from the second chain conveyor, with the result that the anode and the cathode sheets are suspended in alternate disposition under the hoist 16. The hoist 16 is then caused to run further to the right, as seen in FIG. 1, on the rails 15.

A pair of rails 17 are laid on the refining plant floor at right angles to the pair of overhead rails 15 so as to extend alongside the array of electrolytic cells 10. An open-top truck 18 movable on these rails 17 is equipped with upright means 18*a* for receiving the complete set of anode and cathode sheets 13 and 14 from the hoist 16 by engaging their lugs and lateral crossbar projections as the first and second sets of paired hooks are caused to descend by the hoist 16. It will therefore be understood that the anode and cathode sheets 13 and 14 are held vertically within the truck 18 is alternating, parallel relationship with the required spacings therebetween.

If desired, another pair of rails 19 can be laid on the refining plant floor parallel to the pair of rails 17, and pairs of turnover rails 20 with a transverse transfer carriage 20*a* thereon may be provided adjacent both extremities of the rails 17 and 19, respectively, so that the truck 18 as well as another truck 21 of identical construction is enabled to shift from one to the other. The trucks 18 and 21 will thus move along the complete loop formed by the parallel pairs of rails 17 and 19 and

the turnover rails **20**, for purposes hereinafter made apparent.

A movable bridge **22** extends horizontally across the array of electrolytic cells **10** and the parallel pairs of rails **17** and **19** to support thereon a pair of overhead rails **23**. As best shown in FIG. **2**, the bridge **22** is itself movably mounted on a pair of elevated rails **24** at both extremities thereof, the elevated rails **24** being disposed in height substantially flush with the top of the electrolytic cells **10**. The bridge **22** is thus made movable in the longitudinal direction of the array of electrolytic cells **10** at a height close to the top of the cells.

A traveling hoist **25** is supported on the overhead rails **23** so as to be movable in the transverse direction of the array of electrolytic cells **10**. Like the aforementioned hoist **16** on the overhead rails **15**, this hoist **25** is equipped with a plurality of paired hooks **25***a* which are simultaneously movable up and down through an aperture in the movable bridge **22** to receive the complete set of anode and cathode sheets **13** and **14** from the open-top truck **18** or **21** by engaging their lugs and lateral crossbar projections when the truck is brought to a position under the movable bridge. The hoist **25** can then carry the anode and cathode sheets **13** and **14** over to a desired one of the electrolytic cells **10**, and as the anode and cathode sheets are succeedingly lowered by the paired hooks **25***a* of the hoist **25**, their lugs and lateral crossbar projections will come to rest on bus bars (not shown) lying along the respective lateral edges of the desired cell, in such a manner that the hooks **25***a* are now free to move up by leaving the anode and cathode sheets within the cell. It will be apparent that the anode and cathode sheets **13** and **14** thus loaded into the desired electrolytic cell are likewise held vertically in alternating, parallel relationship with the required spacings therebetween. It will also be appreciated that thanks to the combined motion of the hoist **25** along the overhead rails **23** and of the overhead rails **23** along the elevated rails **24**, the complete set of anode and cathode sheets **13** and **14** can be charged into, and removed from, any desired one of the array of electrolytic cells **10**.

The process of electrolysis in each of the cells **10** proceeds in accordance with the prior art, with the substantial transfer of the desired metal from the anode sheets **13** to the cathode sheets **14**. The ultimate results will be the deposit of the pure metal on the cathode sheets **14** and the formation of a slime at the cell bottom containing the various insoluble inpurities liberated from the anode sheets **13**.

Upon completion of this electrolytic process in any of the cells **10**, the hoist **25** is brought into vertical registration with that particular cell in the manner previously set forth, and its paired hooks are operated to lift out of the cell the residue anode sheets and the cathode sheets having the pure metal deposited thereon. The hoist **25** is then caused to move to the right, as viewed in FIG. **1**, along the overhead rails **23** and to lower the used anode and cathode sheets onto, say, the truck **18** which has been held standing by on the rails **17** after having previously given the complate set of fresh anode and cathode sheets **13** and **14** over to the hoist **25**.

Upon reception of the used anode and cathode sheets from the hoist **25**, the truck **18** is caused to travel along the rails **17** in a direction away from the overhead rails **15** to shift to the rails **19** via the turnover rails **20** and then to travel toward the other extremity of the rails **19**. As the loaded truck **18** is thus brought to the position where the rails **19** intersect with the turnover rails **20** and therefore with the overhead rails **15**, the used anode and cathode sheets are taken over by another traveling hoist **26** on the overhead rails **15**, which hoist is identical in construction to the first mentioned hoist **16**, and are thereby transported to a desired location for further processing.

The thus unloaded truck **18** is then caused to travel along the turnover rails **20** back to the position illustrated in FIG. **1**, ready to receive the next set of fresh anode and cathode sheets **13** and **14** from the hoist **16** on the overhead rails **15** in the above described manner. It will be apparent that the above explained procedure can be greatly facilitated by the provision of the second truck **21** movable along the rails **17** and **19**, the operation of which second truck follows suit after that of the first truck **18**.

Although not shown in the drawings, it is assumed that the trucks **18** and **21** are each equipped with a drive mechanism of any known or suitable construction to be driven along the rails **17**, **19** and **20** and with a control mechanism of any known or suitable organization to control the operation of the drive mechanism in relation with the operation of the hoists **16**, **25** and **26**. Likewise, the hoists **16** and **26** are assumed to be equipped with their own drive mechanisms, while the hoist **16** is assumed to be further equipped with a control mechanism to control the operation of its drive mechanism in relation with the operation of the first and second chain conveyors **11** and **12**. The hoist **25** and the apertured bridge **22** are also assumed to be equipped with their own drive mechanisms and with control mechanisms to control the operation of the respective drive mechanisms in relation with the progress of the electrolytic processes in the respective cells **10**. In this manner the entire operation of the system shown in FIGS. **1** and **2** can be performed fully automatically in accordance with a predetermined program.

Illustrated in FIGS. **3** and **4** is another preferred embodiment of the invention, in which a truck **30** is movably supported on the overhead rails **23** on the bridge **22** in addition to the aforesaid hoist **25**. With a view to removal of the slime formed at the bottom of each of the electrolytic cells **10** as a result of the refining operation, the truck **30** is equipped with a suction pump **31** and a vertically extensible suction conduit **32** having ports at their respective lower ends in communication with the suction pump **31**. The suction conduit **32** is further movable horizontally along the truck **30**, for purposes hereinafter made apparent. On both sides of the suction conduits **32** there are provided a pair of hot water ejectors **30***a*.

For the discharge of the slime removed from the bottom of each electrolytic cell **10** by the suction conduit **32**, a trough **33** is formed in the upper surface of the bridge **22** so as to be in communication with another trough **34** provided immovably alongside the course of reciprocation of the bridge. Other details of construction are substantially as above described in connection with the preceding embodiment of the invention.

The operation of this second embodiment is also substantially identical with that of the preceding embodiment. However, while the hoist **25** is in operation to carry the set of used anode and cathode sheets **13** and **14** away from one of the electrolytic cells **10** into one of the trucks **18** and **21** and to bring a set of fresh anode

and cathode sheets back from the other of the trucks **18** and **21**, the truck **30** on the overhead rails **23** is caused to travel to its position in registration with the emptied electrolytic cell. The suction conduit **32** of the truck **30** is then extended downwardly close to the bottom of the cell, and with the suction pump **31** in operation, the port at the lower end of the suction conduit is caused to move from one end to the other of the cell. The slime thus removed by suction from the bottom of the cell is directed into the trough **33** and thence into the trough **34**, for discharge in any convenient manner. The ejectors **30***a* operate to eject hot water downwardly against the upper edges of the cells, which tend to be stained by the electrolyte, to keep the edges clean.

According to this method of slime removal, most of the electrolyte can be left in each of the cells, so that the process of electrolysis with a fresh set of anode and cathode sheets can be resumed only by a slight replenishing of the electrolyte into the cell. It is also noteworthy that the array of electrolytic cells **10** need not be mounted on any elevated level as is the case where the slime is removed by gravity through the bottoms of the cells.

While the various objects of the invention, either explicitly stated or otherwise set forth, are believed to be fully accomplished by the preferred embodiments herein disclosed, it will also be appreciated that such specifically recited embodiments are susceptible to various modifications or changes within the usual knowledge of those skilled in the art.

What we claim is:

1. A method of conveying anode and cathode sheets into and out of an array of open-top electrolytic cells mounted on a floor and including a series of parallel rows of cells, wherein said anode and cathode sheets are each provided with a pair of lugs or the like so as to be supported vertically in a suspended manner throughout the entire process of conveyance, said method comprising the steps of:

providing a traveling bridge spanning said array of cells in a direction parallel to said series of rows and movable transversely of said rows;

conveying fresh anode and cathode sheets as vertically suspended and alternately arranged successive sets of anode and cathode sheets along a conveying path transverse to said series of rows to the adjacency of said array of electrolytic cells at a position in alignment with a selected row of cells;

moving said bridge to a position in alignment with said selected row of cells;

moving a traveling hoist on said bridge along the length thereof to a starting position directly above said fresh set of sheets which have been conveyed to said starting position;

moving said hoist reciprocally between said starting position and each of the positions of all the cells of said selected row to carry fresh sets of sheets successively into all the cells of said selected row and to carry used sets of sheets in the cells to said starting position successively on the way back of said hoist to the starting position for exchange of the sets in the cells;

maintaining said bridge in said position in alignment with said selected row until the exchange of the sets in all the cells in said selected row has been completed; and

moving said bridge to another position in alignment with another selected row of cells to repeat the above mentioned operation.

2. The method as recited in claim **1**, wherein said anode sheets are successively fed by first conveyor means in a vertically suspended, parallel spaced manner and said cathode sheets are successively fed by second conveyor means in parallel to said first conveyor means in a vertically suspended, parallel space manner, and wherein a second traveling hoist is moved across said first and second conveyor means to pick up said anode and cathode sheets in a manner such that said anode and cathode sheets are in alternate disposition with spacings therebetween, said second traveling hoist transferring said anode and cathode sheets to said conveying path.

3. A conveying system in an electrolytic metal refining plant, for conveyance of anode and cathode sheets into and out of an array of open-top electrolytic cells mounted on a floor and including a series of parallel rows of cells, wherein said anode and cathode sheets are each provided with a pair of lugs or the like so as to be supported vertically in a suspended manner throughout the entire process of conveyance, said system comprising:

means for conveying said anode and cathode sheets as a vertically suspended and alternately arranged set of anode and cathode sheets along a conveying path parallel to said series of rows to the adjacency of said array of electrolytic cells;

a pair of spaced apart rail means parallel to said conveying path with said array of electrolytic cells and said conveying path interposed therebetween;

a traveling bridge riding on said spaced apart rail means so as to be movable in both directions along the same and spanning said array and said conveying path in a direction parallel to said series of rows at a height close to the top of said array; and

a traveling hoist movable on said bridge along the length of the same, said hoist including means for picking up a set of alternating anode and cathode sheets from said conveying means and then lowering the set into a desired one of said electrolytic cells in such a manner that said anode and cathode sheets are released in the desired electrolytic cell with their relative positions unchanged.

4. The system as recited in claim **3**, further including:

first conveyor means for successively conveying said anode sheets to the adjacency of said array of electrolytic cells in a vertically suspended, parallel spaced manner;

second conveyor means extending parallel to said first conveyor means for successively conveying said cathode sheets to the adjacency of said array of electrolytic cells in a vertically suspended, parallel spaced manner;

overhead rail means extending at right angles to said first and second conveyor means; and

a second traveling hoist supported on said overhead rail means so as to be movable in both directions along the same, and including means for successively picking up said anode and cathode sheets from said first and second conveyor means in a manner such that said anode and cathode sheets are in alternate disposition with spacings therebetween, said second hoist operating to carry said

picked up anode and cathode sheets to transfer the same to said conveying means.

5. The system as recited in claim 3, wherein said means for conveying said anode and cathode sheets is an open-top truck and said conveying path is floor-level rail means for supporting and guiding said truck.

6. The system as recited in claim 3, further including rail means mounted on said bridge for supporting and guiding said first traveling hosit.

7. The system as recited in claim 5, further including second floor-level rail means extending parallel to said first mentioned floor-level rail means, turnover, means interconnecting said first and second floor-level rail means at both extremities thereof to form a substantially complete loop, and at least one other open-top truck movable in said one direction along said first and second floor-level rail means, said other truck being identical in construction to the first mentioned truck.

8. The system as recited in claim 7, further including a third traveling hoist supported on said first overhead rail means so as to be movable in both directions along the same, said third hoist including means for picking up a complete set of used anode and cathode sheets from the successive open-top trucks for transportation in a direction away from said first and second conveyor means.

9. The system as recited in claim 4, wherein said first and second conveyor means are each in the form of a chain conveyor comprising a pair of parallel spaced endless chains adapted to engage said lugs of said anode and cathode sheets.

10. The system as recited in claim 3, further including a truck movable along the length of said bridge, suction conduit means extensible downwardly from said truck and having a suction inlet at its lower end, and means mounted on said truck for creating a desired degree of vacuum in said suction conduit means, whereby slime at the bottom of each of said electrolytic cells can be removed by suction exerted through said inlet of said suction conduit means.

11. The system as recited in claim 10, further including trough means formed on said bridge for the discharge of the slime removed through said suction conduit means.

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