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(57) **ABSTRACT**

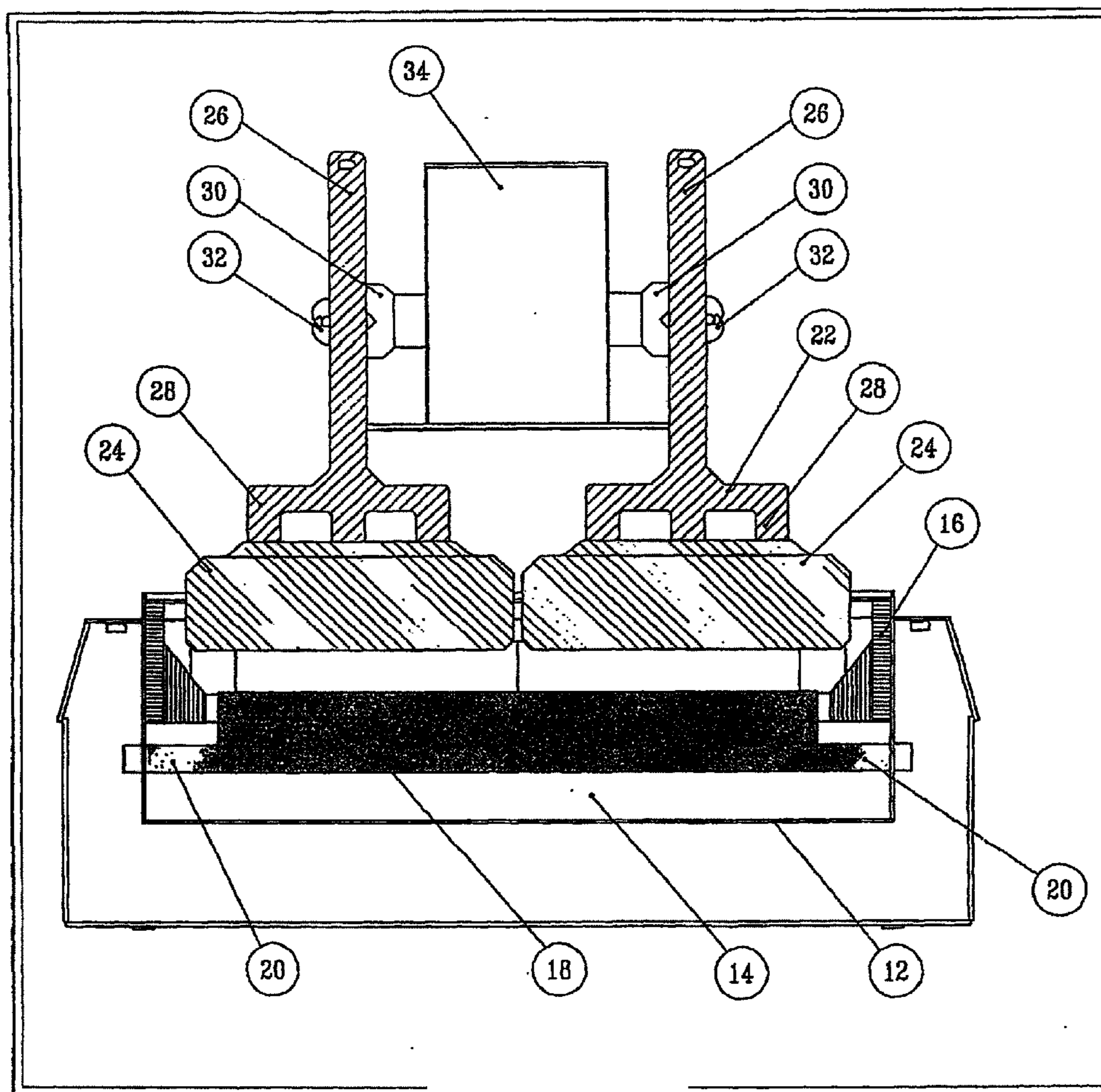
**Related U.S. Application Data**

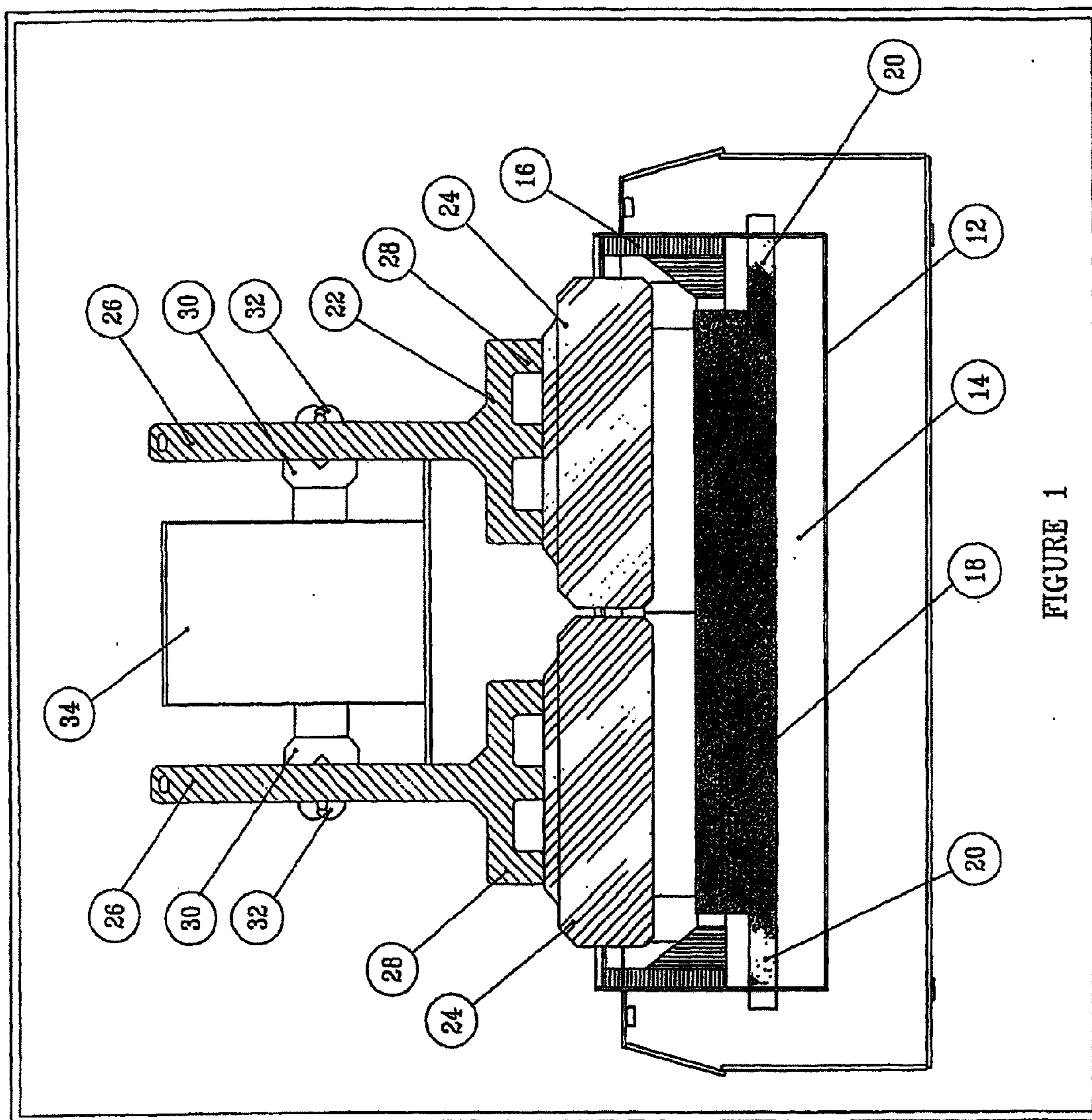
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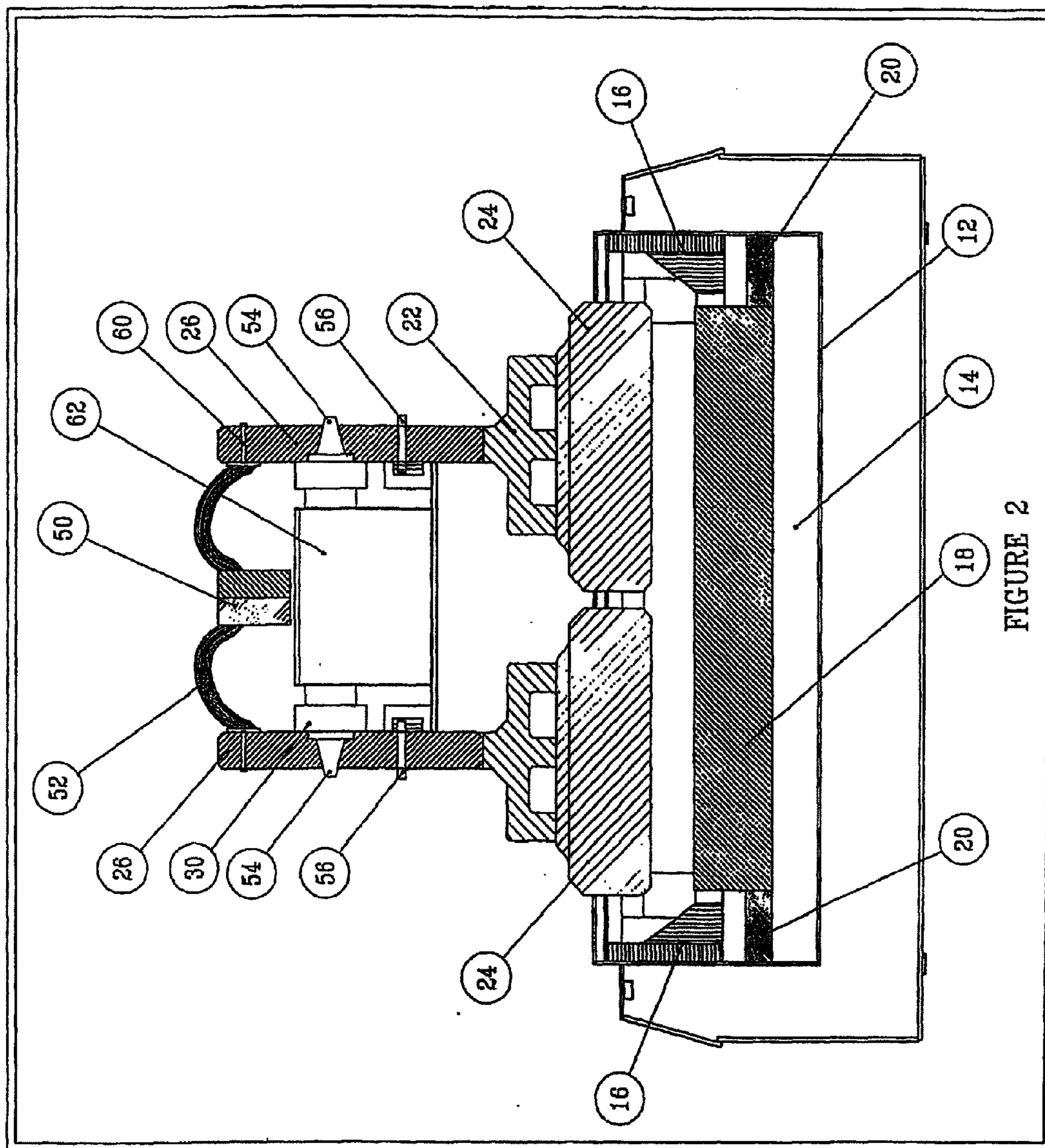
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An apparatus for supporting anodes above a cathode in an electrolysis cell comprising a superstructure, an anode beam to which a plurality of individual anodes 24 are attached, each anode having an anode stem 26 for attachment to the anode beam by a main clamp 54, the anode beam being adjustably mounted to the superstructure, an auxiliary clamp 56 for each anode stem 26, and at least one electrical beam 50 supported by the superstructure, the electrical beam 50 having connectors 52 providing electrical connection between the electrical beam 50 and the anode stems 26.







**ANODE SUPPORT APPARATUS**

[0001] This application is a continuation of and claims priority from PCT/AU2006/000383 published in English on Sep. 28, 2006 as WO 2006/099672 and from AU 2005901488 filed Mar. 24, 2005, the entire contents of each are incorporated herein by reference.

[0002] This invention relates to an apparatus and method for supporting anodes in an electrolysis cell producing for example aluminium, and in particular an apparatus and method for adjusting the position of these anodes in a cell.

[0003] The electrolysis of alumina to produce aluminium by the Hall-Heroult process is well known and involves an electrochemical reaction. This process includes an electrolytic cell comprising an electrolytic tank having a plurality of cathodes and anodes. The aluminium oxide is supplied to a cryolite based bath in which the aluminium oxide is dissolved. The electrolytic process is most effective at bath temperatures between 940° C. and 970° C. The anodes comprise carbonaceous anode blocks and aluminium stems which provide the mechanical and electrical link to the anode beam from which the anodes are suspended. The anodes are partially immersed in the electrolyte to provide an anode-cathode separation distance through which an electrical current passes. During the electrolytic process, aluminium is produced at the cathode and forms a molten aluminium layer on top of the cathode with the cryolite bath floating on the top of the aluminium layer. For efficient operation of the electrolytic cell, the anode-cathode gap should be set and maintained, either at a predetermined optimum distance or within an optimum range. If the anode-cathode gap is too large, this causes a significant voltage drop between the electrodes resulting in an unwanted increased power generation in the electrolyte. If the gap is too small the electrolytic process becomes unstable and inefficient.

[0004] With conventional carbon anodes, the anode blocks are continuously consumed during the electrochemical reaction producing mainly CO<sub>2</sub> gases. As a consequence of the continuous consumption of the anodes the anode-cathode gap increases over time. In order to maintain the gap distance, the cell voltage is continuously monitored and the position of the anodes periodically reset to maintain the optimum anode-cathode gap.

[0005] Due to the continuous consumption, the anodes have a limited lifetime of about four weeks after which they have to be replaced by new anodes. It would be appreciated by those skilled in the art that changing more than one of all the anodes in an electrolytic cell in a short period of time will lead to severe interference with the chemical and thermal processes. Therefore, it is common practice to change only one anode per day in a given cell so that each anode of that cell has a different age between zero and approximately 28 days.

[0006] In a conventional electrolytic cell design, the movable anode support, called an anode beam, is supported by the superstructure. The anodes are clamped directly to this anode beam which provides mechanical support and supplies electrical current to the anodes. Conventionally a single clamp per anode is used for both, mechanical fixation and electrical contact of the anode stem with the anode beam. The distance between the anodes and the aluminium

layer on top of the cathode is then adjusted by raising and lowering the whole anode beam. Hence during the operational life of the anodes, there is a need to raise and lower the anode beam to maintain the anode-cathode gap within optimum ranges.

[0007] Due to the consumption of the anodes, the downward movement of the anode beam prevails and ranges at about 15 to 20 mm per day. As a result of the downward movement the anode beam will reach its lowest possible position on the superstructure after two to three weeks and must then be raised with the help of an auxiliary anode raising beam which is temporarily positioned on top of the cell superstructure. This anode raising beam is equipped with devices which hold the anodes in place while the anode clamps are manually opened by operators to allow the anode beam to move back to its upper position. When the anode beam has reached its upper position, all the anode clamps have to be closed again by the operators.

[0008] These clamping devices also exert a high lateral pressure on the anode stems to maintain electrical contact between the anode stems and anode beam while the anode beam is travelling upward sliding along the anode stems. The process of raising the anodes poses a significant safety risk as the pressure exerted on the anode stems can drop resulting in a loss of the electrical contact between the anode stems and anode beam. In such a situation, dangerous electrical arcs develop until the substitution of the aluminium smelting plant trips due to the open electrical circuit. In such an instance, the operators executing the anode beam raising are at risk of burn injuries.

[0009] Accordingly, it is an object of the present invention to provide an apparatus for raising the anode beam automatically without human interaction which addresses one or more of the problems with the existing arrangements.

**SUMMARY**

[0010] In one aspect of the invention, there is provided: an apparatus for supporting anodes above a cathode in an electrolysis cell including a superstructure, an anode beam to which a plurality of individual anodes are attached each anode having a respective anode stem for attachment to the anode beam by a main clamp, the anode beam being adjustably mounted to the superstructure, an auxiliary clamp for each anode stem, and at least one electrical beam supported by the superstructure, the electrical beam having connectors providing electrical connection between the electrical beam and the anode stems.

[0011] In a preferred form of this aspect of the invention, the auxiliary clamps are fixed in position relative to the superstructure.

[0012] Unlike all commonly known cell technologies, the anode beam of this invention is only a mechanical fixation for the anode stems to provide vertical movements of the anodes for the control of the anode-cathode distance. The anode beam no longer carries out the task of conducting electricity to the anodes. This task is provided by the at least one electrical beam preferably fixed at the centre top of the cell superstructure and a plurality of flexibles. These flexibles preferably are made of a multitude of aluminium foils which are welded to the electrical beam and attached by way of bolted or clamped connections to the top of the anode stems.

[0013] In this way, the task of mechanical fixation and adjustment of the height of the anodes can be maintained separate to the electrical connection to the anode stems. Hence, an uninterrupted electrical contact is provided to the electrical beam while a safer fixation of the anode stems is provided to the movable anode beam.

[0014] In a second aspect, the invention provides an apparatus for adjusting the distance between the anodes and cathode of electrolysis cells including an anode beam to which a plurality of individual anodes are attached by respective anode stems, the anode stem of each anode being maintained in position relative to the anode beam by a main clamp, an auxiliary clamp for each anode stem, and a means to control the operation of the main and auxiliary clamps to allow engagement and disengagement of the clamps.

[0015] The apparatus may further be provided with a superstructure. The auxiliary clamp is preferably secured to the superstructure to support the auxiliary clamp during anode beam raising.

[0016] In a preferred form of the first and second aspects of the invention, the engaging and disengaging of the main and auxiliary clamps are controlled by a process control computer. The disconnecting and reconnecting of the electrical flexibles necessary for the operation of anode change are done by specialized tools attached to the manipulator cranes. The electrical flex connection will only be opened to execute the anode change at the end of the useful life of the anode block.

[0017] In this invention, the operation of raising the anode beam is no longer done with an auxiliary raising beam holding the anodes in place as described above. Instead, the two sets of clamps are used for this operation. In order to raise the anode beam, the process control computer will close the auxiliary clamps to maintain the present positions of the anodes while disengaging the main clamps. When the main clamps of all anodes of the cell are in an open position, the anode beam can be raised freely. There is no need to maintain an electrical contact between anode beam and anode stems by applying pressure on the stems since the electrical conduction remains uninterrupted through the continuous flexible-stem connection.

[0018] Accordingly to a third aspect of the invention, there is provided a method of raising an anode beam in an electrolysis cell described above including the steps of: engaging the auxiliary clamps to maintain the position of the anodes relative to the superstructure, disengaging the main clamps, moving the anode beam, reengaging the main clamps, and disengaging the auxiliary clamps.

[0019] With this invention, it is possible to perform automated anode beam raising on a much more frequent basis (e.g. every one to two days) than with a conventional anode beam arrangement where the labour intensive beam raising occurs every two to three weeks. For this reason, the overall anode beam travel distance can be reduced significantly.

#### DESCRIPTION OF THE DRAWINGS

[0020] FIG. 1 is a sectional view of an electrolysis cell and conventional anode support of the prior art, and

[0021] FIG. 2 is a sectional view of an electrolysis cell and anode support according to an embodiment of the invention.

#### DETAILED DESCRIPTION

[0022] The electrolysis cell of the prior art includes a steel outer shell 12 having a bottom refractory lining 14 and sidewall refractory lining 16. The bottom refractory lining supports a cathode 18 having steel collector bars 20 for conducting electricity to busbars (not shown) on the outside of the steel shell 12. An anode assembly comprising an anode block 24 connected to an anode stem 26 via a steel yoke 22 and stubs 28 is shown. The anode stem 26 is both mechanically and electrically connected to an anode beam 30 by a clamping arrangement 32 fixed to the anode beam. Mechanical drive trains (not shown) are provided to raise and lower the anode beams in order to vary the anode-cathode gap (in reality the gap between anodes immersed in the electrolyte and the liquid aluminium layer on top of the cathode) to a desired distance.

[0023] The design of the anode raising and lowering equipment is based on the assumption that all anodes will be consumed at a constant rate and so generally, all of the anodes in the cell can be raised or lowered concurrently to maintain the gap within the optimum range. Inside the cell superstructure, a number of alumina hoppers (34) is provided to supply alumina to point feeders (not shown) which are generally positioned between the pairs of anodes.

[0024] Such anode beam systems rely on a clamp connection providing sufficient mechanical pressure to maintain the anode stems in a fixed position relative to the anode beam with this same connection providing the electrical connection between the anode beam and the anode stems. Therefore such a system comprises both the electrical connection function and the mechanical fixation function. Furthermore, the removal and addition of the anodes is provided by a crane which is positioned above the electrolytic cell. Because of the design of the cell superstructure, the crane must necessarily be much higher in order to clear the superstructure.

[0025] While the details of a conventional electrolysis cell are those shown in FIG. 1 the embodiment of this invention is shown in FIG. 2. For ease of understanding, structures in the embodiment of the invention which are similar to a conventional electrolysis cell have been given identical numbering. The anode support structure in accordance with the invention includes an electrical beam 50 which is preferably fixed in position and connected to anode stems 26 by electrical connectors referred to as flexibles 52. These flexibles 52 maintain the electrical connection to the anode stems while giving the stems the ability to move relative to the electrical beam 50. The flexibles 52 are generally formed from a plurality of aluminium sheets shaped into a laminar block of aluminium with the laminar structure extending in the direction of current flow. One end of the flexibles is welded to the electrical beam 50 while the other end is connected to the top of the anode stems by way of a bolted or clamped connection 60.

[0026] The anode supporting structure comprises a main clamp 54 attached to the vertically movable anode beam 30 and an auxiliary clamp 56 fixed to the cell superstructure base plate 58. The anode beam is moved by a mechanical drive train (not shown) which is similar to that of a conventional anode support structure. There is one main clamp 54 and one auxiliary clamp 56 for each anode stem 26. The main clamp 54 of all anodes of a cell are continuously

engaged except for during the operation of raising the anode beam. A control means such as pneumatic cylinders or electrical motors is provided to operate the engagement and disengagement actions of the main clamps **54** and auxiliary clamps **56**.

[0027] An alumina hopper **62**, smaller than the prior art hopper, is also provided in the superstructure between the anode beams **30**.

[0028] In order to raise the anode beam the auxiliary clamps **56** of all anodes in a given cell are closed by the process control computer. Subsequently the main clamps **54** are opened so that the mechanical drive train can lift the anode beam **30** freely with the anodes being held in their position by the auxiliary clamps **56** and the electrical connection, provided by the flexibles **52** is uninterrupted. Once the anode beam has reached its upper position the main clamps **54** are closed followed by the opening or disengaging of the auxiliary clamps **56**. The whole operation of disengaging and reengaging the clamps as well as raising the anode beam is fully automated and requires no operator intervention.

1. An apparatus for supporting anodes above a cathode in an electrolysis cell including:

- a. a superstructure, an anode beam to which a plurality of individual anodes are attached, each anode having an anode stem for attachment to the anode beam by a main clamp, the anode beam being adjustably mounted to the superstructure,
- b. an auxiliary clamp for each anode stem, and at least one electrical beam supported by the superstructure, the electrical beam having connectors providing electrical connection between the electrical beam and the anode stems.

2. The apparatus of claim 1 wherein the auxiliary clamps are fixed in position relative to the superstructure.

3. The apparatus of claim 1, wherein the at least one electrical beam is fixed at the centre top of the cell superstructure and a plurality of flexibles.

4. The apparatus of claim 3, wherein the flexibles are made of a multitude of aluminium foils which are welded to the electrical beam and attached by way of bolted or clamped connections to the top of the anode stems.

5. An apparatus for adjusting the distance between the anodes and cathode of electrolysis cells including an anode beam to which a plurality of individual anodes are attached by respective anode stems, the anode stem of each anode being maintained in position relative to the anode beam by a main clamp, an auxiliary clamp for each anode stem, and a means to control the operation of the main and auxiliary clamps to allow engagement and disengagement of the clamps.

6. The apparatus of claim 5 being further provided with a superstructure, the auxiliary clamp being secured to the superstructure to support the auxiliary clamp during anode beam raising.

7. The apparatus of claim 5, wherein the engaging and disengaging of the main and auxiliary clamps is controlled by a process control computer.

8. The apparatus of claim 7, wherein the process controller will only allow disengaging of the main clamps when the auxiliary clamps are closed.

9. A method of raising an anode beam in an electrolysis cell described above including the steps of:

- a. engaging the auxiliary clamps to maintain the position of the anodes relative to the superstructure,
- b. disengaging the main clamps,
- c. moving the anode beam,
- d. reengaging the main clamps, and
- e. disengaging the auxiliary clamps.

10. The method of claim 9 wherein the main clamps are only disengaged when the auxiliary clamps are engaged.

11. The method of claim 9 wherein the auxiliary clamps can only be disengaged when the main clamps are engaged.

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