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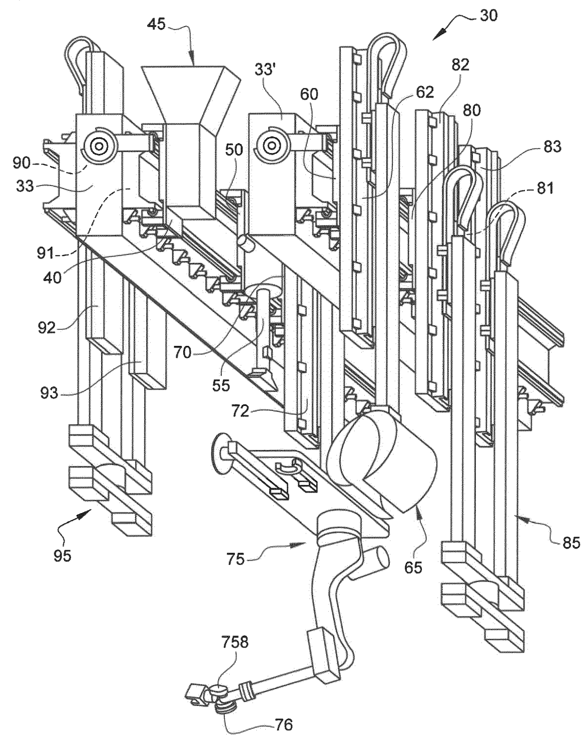
(54) ANODE SERVICING ASSEMBLY FOR AN ALUMINIUM ELECTROLYSIS PLANT, AND METHODS FOR OPERATING THE SAME

(57) An anode servicing assembly (30, 35) for an aluminium electrolysis plant, said aluminium electrolysis plant comprising at least one line (L1, L2) of electrolysis cells (C1-Cn, C'1-C'n) connected in series, each cell having a plurality of anode assemblies (5) connected to an anode beam,
said anode servicing assembly comprising:
- an elongated body (31),
- running means adapted to allow movement of said elongated body along a running direction, substantially parallel to main axis of said line (L1, L2),
- an anode servicing machine (32) mounted on said elongated body, said anode servicing machine comprising
o at least two operating devices (45, 55, 65, 75, 85, 95), each adapted to fulfil at least one specific function different from cell lifting and anode beam raising,
o at least two support assemblies (40, 50, 60, 62, 70, 72, 80, 81, 82, 83, 90, 91, 92, 93), each adapted to support a respective operating device with respect to said elongated body,

said operating devices (45, 55, 65, 75, 85, 95) being movable independently the one with respect to the other, along at least one of a longitudinal axis (L31) of said elongated body (31) and a vertical axis (ZZ).

Fig. 7



EP 4 293 141 A1

Description

Technical field of the invention

[0001] The invention relates to the field of fused salt electrolysis, and more precisely to anodes for use in the Hall-Héroult process for making aluminium by fused salt electrolysis and to the methods for replacing anode assemblies. Carbon anodes are consumed in the course of the electrolysis process; they need to be replaced regularly. The invention relates to a device for replacing anode assemblies in electrolytic cells that is used in conjunction with a dedicated overhead crane, forming with the latter a system for replacing anode assemblies and for carrying out certain maintenance operations related to the replacement of anode assemblies.

Prior art

[0002] The Hall-Heroult process is the only continuous industrial process for producing metallic aluminium from aluminium oxide. Aluminium oxide (Al_2O_3) is dissolved in a molten cryolite (Na_3AlF_6) based electrolyte. The dissolved alumina is electrochemically decomposed with the aid of a consumable anode at a temperature that is typically comprised between 950 °C and 970 °C in an electrolytic cell. The typically rectangular electrolytic cell (also called "pot") used for all modern Hall-Héroult cells typically comprises a steel shell (so-called potshell), the base of which contains a thermally insulating lining that includes refractory bricks and supports heat, and an array of transversely positioned cathode blocks usually made from graphite, anthracite or a mixture of both. These blocks are jointed to each other and each one has an embedded metal bar or bars for connection to the negative side of a DC power source. The sidewall is also sealed to carbonaceous lining base with carbonaceous material making a leakproof container for the liquid aluminium produced, and the less dense electrolyte containing the dissolved alumina. An electrically isolated superstructure is fixed on the top of the steel pot shell, and this is designed to contain consumable materials (alumina and aluminium fluoride) hoppers, breakers and feeders. The superstructure supports a height adjustable aluminium busbar (also called "anode beam") to which the anodes are clamped, and enable enclosing the atmosphere so that emissions can be collected and appropriately treated.

[0003] Anodes in the Hall-Heroult process are usually prebaked cuboids made from a carbonaceous material. The anodes are fixedly connected to so-called anode hangers.

[0004] The latter serve two different purposes, namely to keep the carbon anodes at a predetermined distance from the cathode, and to carry the electrical current from the anode beam down to the carbon anodes. Anode hangers are fixed to the overhanging anode beam in a detachable manner using a system comprising hooks and clamps. Anode hangers comprise an upper part called "anode rod", which is connected to the anode beam, and a lower part, called "anode yoke". The anode yoke has a number of legs each of which terminates in a cylindrical stub that is embedded in pre-formed stub holes of the carbon anodes and is fixed with cast iron acting as temperature-resistant, electrically conductive contact element. This process is called "rodding". The assembly formed by a carbon anode fixed to its anode hanger is called an "anode assembly".

[0005] The plurality of anodes supported by the adjustable anode beam and which are usually in two rows are immersed into the molten salt electrolyte to the required height above the liquid aluminium cathode. Anodes and cathodes are connected to external busbar circuitry to enable electrical current through the cell at a controller determined voltage that is invariably somewhere between 3.8 V and 5 V. This arrangement combined with the electrical energy provided enables electrochemical decomposition of the ionic species arising from dissolving the aluminium oxide in the molten fluoride-based solvent. The aluminium containing cationic species formed from the alumina dissolution are electrochemically reduced at the metal pad surface to liquid aluminium. Simultaneously the oxy-anions formed from alumina are reactively oxidised to carbon monoxide and more dominantly to carbon dioxide at the carbon-anode interface. The resulting metallic aluminium is not miscible with the liquid electrolyte, has a higher density than the liquid electrolyte and will thus accumulate as a liquid metal pad on the cathode surface from where it needs to be removed from time to time, usually by suction into a crucible (so-called "tapping" procedure), said crucible being typically carried by a vehicle moving on the ground floor or by an overhead crane.

[0006] Because of the electrochemical consumption of the carbon, each anode assembly has a finite life. Furthermore in order to maintain metal quality, and thus ensure no metallic part of the anode assembly comes into contact with the electrolyte, only approximately 80% of each anode is consumed electrochemically and chemically before it is considered to be a "spent anode assembly", thus needing replacement. Depending on the design and dimensions of the carbon block, the anode assembly, usually has an operating lifetime between 18 to 30 days. Knowing that a modern electrolysis cell typically comprises between 16 and 40 anodes, the replacement of an anode or a pair of anodes occurs between 24 and 48 hours in each pot and more often every 32 hours. In order to minimize the disturbance to the operating cell condition the replacement of all spent anode assemblies are scheduled at a regular interval such that each is changed once in the operating life cycle. Hence depending on the number of anodes and their size, typically, the replacement of an anode or anode pair will occur at intervals somewhere between once every approximately 24 to 48 hours for each cell.

[0007] Together with liquid metal tapping, anode change is the most frequent periodic maintenance operation in the Hall-Heroult process, which is, as such, a continuous process. Anode change is carried out by replacing a spent anode assembly by a new anode assembly. The spent anode assemblies are transported to a dedicated workshop in the plant, where the remains of the spent carbon anode are removed from the anode yokes, and the anode hangers of the spent anode assemblies, are cleaned and reused in new anode assemblies; new carbon anodes are fixed to the anode yoke, thereby creating a "new anode assembly".

[0008] The present technology and work practices associated with removing a spent anode assembly and replacing it with a new anode assembly has numerous manual labour intensive steps that not only lead to excessive harmful emissions, but are also wasteful of the stored energy as well as introducing performance harming disturbances, and presenting a health hazard to workers.

[0009] The said cathode blocks that form the bottom of the electrolytic cell undergo a series of very slow degradation steps, limiting their lifetime to typically between five to eight years. On failure the superstructure is removed and the spent potshell is lifted using a heavy overhead crane (so-called "Cathode Transport Crane", abridged CTC), enabling a replacement pre-lined pot shell to be positioned, ready for commissioning. Said cathode transport crane needs to have a very high lifting power, typically of more than 200 tonnes.

[0010] Electrical energy is a major operational cost in the Hall-Heroult process, and two of the contributors to the energy wastage, cell heat loss and lowering of current efficiency, are magnified by the present procedure and equipment used to enable anode changing. Unnecessary heat loss occurs through wastage of the energy content of the anode cover material used for the spent anode, while a high radiant heat loss occurs during the extended duration of cavity cleaning that becomes necessary from secondary effects of the Jack hammering of the anode cover sealing crust. There are inevitable spillages of anode cover material lumps into the electrolyte arising from the jack-hammering which leads to metal pad turbulence that harms current efficiency.

[0011] Besides carbon dioxide, gaseous emissions of the Hall-Heroult electrolytic process also comprise fine particulate condensed fluoride arising from the electrolyte as well as hydrogen fluoride, originating from impurities in the smelter grade alumina that also dissolve in the electrolytic bath, and minor amounts of SO_2 originating from impurities in the anode carbon. These are noxious to workers and to the environment. Therefore, since the 1970s, gaseous emissions of Hall-Heroult cells are no longer released into the environment but undergo purification. More precisely, gaseous emissions from electrolytic pots are collected using protection devices such as hooding systems and are treated in gas treatment stations to remove fluorine compounds and other noxious compounds before releasing the collected air into the environment. The prior art work practice for replacing spent anodes results in some of these harmful chemicals escaping into the working environment.

[0012] In practice, the hooding system at the level of the electrolytic cell comprises an arrangement of movable hood panels, which are typically disposed on an elongated frame which extends substantially parallel to each of the two parallel lines of anodes. This frame supports two fixed end walls, located at the opposite extremities of the anodes line, and facing the front side of the anodes, several panels (so-called "hood panels") are provided between these end walls. These hood panels are typically shaped such as to ensure an optimal protection and tightness. They also act as heat shields, thereby limiting thermal losses of the electrolytic cell and protecting the workers. For maintenance, the hood panels can be removed, as needed, to gain access to the anode hangers.

[0013] Nowadays anode assembly replacement (this operation is more conventionally called "anode change", and this expression will be used in the following) is usually carried out using a so-called pot tending machine and a floor operator. During anode change, a number of individual operations need to be carried out, starting with the removal of at least one of the pot hood panels (and more frequently, of two adjacent hood panels) in order to access to the anode assembly to be removed. The removal of the anode assembly is also done by the pot tending machine which is controlled by an operator. The preparatory operation prior to this is to break the solidified electrolyte/vapours/alumina crust used to conserve heat and prevent air access to the anode carbon surface that is not immersed in the electrolyte. The actual removal operation of the spent anode assembly involves unfastening the clamps by which the anode rod is fixed to the height adjustable anode beam, vertical lifting of the spent anode assembly, and positioning of the removed anode assembly on the floor level (usually in a pallet). Good work practice usually then requires cleaning the cavity of the crust of solidified electrolyte that has entered the electrolyte by using a cavity scoop. Then the new anode assembly is inserted into the cavity, fixed to the anode beam and precisely positioned; in particular, the anode bottom needs to be positioned at a given height for accurate control of the anode-cathode distance. Then the hood panel/s is/are put in place (possibly after having been inspected, or another hood panel in good condition is used).

[0014] This procedure invariably takes between ten and twenty minutes. As noxious gases may escape from the pot when the hood is open, it is desirable to minimize both the time during which the hood is open and the presence of a floor operator.

[0015] Pot tending machines (PTM) have been available for many years, manufactured by ECL (Fives group) or Noell-NKM (REEL group). Their basic function is to carry the anode assembly during an operation known as anode beam raising. Since the carbon anodes are gradually consumed during the electrolysis process, the anode beam, which is holding all the anodes in position, has to be lowered gradually in order to maintain a constant anode-cathode distance. Eventually, the position of the anode beam reaches a physical lower limit. At this point, the anode beam has to be raised by use of a special anode-beam raising equipment (ABRE) carried by the pot-tending machine. During this process, the anode rods remain in electrical contact with the anode-beam although they are mechanically disconnected (anode connectors loosened) from the anode beam while the anode beam is raised sliding against the anode rods to maintain the electrical contact. The anodes are hold in position by said ABRE, which presses the anode rods against the anode beam to maintain the electrical contact.

[0016] Modern pot tending machines have several additional functions. They can be combined with the overhead travelling crane (also called bridge crane), and a cabin for the PTM operator. They can also be used for carrying the crucible during the tapping procedure. The lifting power of modern pot tending machines is usually in excess of 25 metric tons, and more frequently in excess of 35 or 40 metric tons, especially when they are designed for tapping.

[0017] Anode changing devices also exist mounted on dedicated ground vehicles; these are usually specifically designed trucks. Such anode changing vehicles are offered for sale by GLAMA company, as well as by HENCON and TECHMO. They may be too large to be usable in potlines having a very small distance between two neighboring electrolysis cells. Furthermore and more generally, it may be undesirable to use vehicles at the floor level between the electrolysis cells, and as a matter of policy, it may be deemed even more undesirable to use long metallic tools extending horizontally at the floor level between the electrolysis cells and the potroom building, as this implies electrical hazards.

[0018] Pot tending machines integrated on an overhead crane are designed to avoid such electrical hazards. Pot tending machines that carry out specific tasks in the anode assembly replacement process in Hall-Heroult cells have been described in a large number of patent publications. These machines may have a variable degree of automatization. WO 2004/079046 and US 8,888,156 describe handling grippers for gripping anode rods prior to their transportation by a crane. WO 2004/101853 describes a tool for unlocking and locking the clamps by which the anode rod is fixed to the anode beam. US 8,066,856 describes a pneumatic impact generator that may improve the electrical contact between the anode rod and the anode beam when mounting the new anode assembly. WO 2005/095676 describes a service module for anode changing equipped with different tools that can be mounted on an overhead crane; this movable service module comprises a cabin for the operator. WO 2006/010816 and US 2007/0205104 describe further tools for such service modules. US 8,273,223 describes tools for handling hood panels. WO 2010/079266 describes a service module equipped with a crust shovel for cleaning the cavity during anode change; WO 2011/130892 and US 2012/0234690 disclose other designs for crust shovels. US 2008/0251392 describes a method for changing an anode, comprising a step of positioning the anode assembly replacing a spent anode assembly that can be automatized. WO 2006/030092 describes another such method that includes a device for measuring the vertical distances travelled by the tool using electromagnetic or acoustic waves. WO 2016/128631 and FR 3 032 457 disclose a pot tending machine comprising two separate service modules that can carry out different functions in parallel, which speeds up the anode changing process. All the patents mentioned in this paragraph are assigned to E.C.L.

[0019] These prior art pot tending machines aim at simplifying the work of the floor operator by reducing the number of individual tasks he has to carry out, such as handling the hood panels, assisting in the accurate positioning of the anode, cleaning the cavity. Some of these machines may be able to replace the floor operator and are only controlled by the PTM operator from the cabin. Such machines have been described for example in the publication "Electrolysis pots anode changing automation: impact on process and safety performance" by N. Dupas, Light Metals 2009 (TMS), p. 515-518, and in WO 2015/132479 (E.C.L.) that describes an automatic pot tending machine for anode change including multiple tools and a hood panel storage element. The publication "New ECL embedded service robot: Towards an automated, efficient and green smelter" by J. Guérin and A.G. Hequet, published in 2015 in Light Metals (TMS), p. 695-697 announces even a fully automatic anode change robot that no longer requires a crane operator. This new robot comprises a telescopic mast fixed to the overhead travelling crane, said mast bearing a plurality of individual tools, each being dedicated to an individual task.

[0020] This system has a number of shortcomings. First of all, whether or not there is a floor operator, it is desirable to shorten the time interval during which the hood is open, in order to minimize the release of noxious gases into the atmosphere which would otherwise be sucked into the exhaust gas purification system. Secondly, the existing automatic or semi-automatic anode changing machines, while they do simplify the work of operators, take longer than conventional methods for changing an anode. And thirdly, all existing automatic or semi-automatic anode changing machines depend on the availability of an overhead travelling crane. Knowing that these cranes may be required to carry out other tasks unrelated to anode changing, it is particularly undesirable to increase the total period of time that is required for changing an anode, even if the floor operator is no longer necessary: it is the crane time available for changing anodes that may be a limiting factor if the crane is needed elsewhere in the potline.

[0021] The present inventors, while acknowledging that it is desirable to move towards a fully automatized anode changing process, have tried to overcome these shortcomings of prior art anode changing robots.

Object of the invention

[0022] The present invention presents a new anode servicing assembly for an aluminium electrolysis plant capable of changing anodes. Changing anodes is a rather complex procedure, referring to a certain number of individual operations, such as removing (and replacing) hood panels, unlocking (and locking) anode hooks, removing (and replacing) the anode assembly, vacuum cleaning, and so on. The term "servicing" as used herein refers to general servicing operations, and according to the invention, the anode servicing assembly can carry out one or more task related to anode change, and possibly additional task not related to anode change. Said anode servicing assembly comprises a crane beam and a specific servicing machine; said servicing machine comprises movable operating devices. The latter are capable of carrying out one or more individual operations carried out on individual anode assemblies (such as locking and unlocking anode hooks, and lifting used anode assemblies), and/or one or more individual operations carried out in relation with the change of individual anode assemblies (such as opening and closing anode hoods, and vacuum cleaning in the vicinity of the anode in the pot).

[0023] According to the invention, the problem is solved by two independent means that can be combined.

[0024] According to a first aspect of the invention, the anode servicing assembly is based on an additional, independent crane beam, adapted to move on the rails of the existing overhead travelling crane and/or on the rails of the existing pot tending machine (which may be all the same rails), but that is much lighter than conventional pot tending machines, because of dedicated, independent tools instead of complex multifunction service modules. As a consequence, a lifting force of less than about 20 tons, and preferably less than about 10 tons is sufficient for an anode servicing assembly according to the invention.

[0025] Furthermore, the inventors have recognized that prior art anode change robots tend to be rather slow, because their tools are all mounted on one or two service modules, each of which service modules can carry out only one function at a given time. As a consequence, these individual tools cannot operate fully independently one from the other.

[0026] According to a second aspect of the invention, the anode servicing assembly according to the invention comprises a plurality of independent tools, each of which is mounted on a separate service module. This allows a total independence of the different tools, each of which is dedicated to a given function. This total independence may allow, in certain cases, that two or more tools are carrying out movements simultaneously, and may allow, in certain cases, that two or more tools are carrying out different functions simultaneously.

[0027] A first object of the invention is an anode servicing assembly for an aluminium electrolysis plant, said aluminium electrolysis plant comprising at least one line (L1, L2) of electrolysis cells (C1-Cn, C'1-C'n) connected in series, each cell being connected to a cathodic busbar and each cell having a plurality of anode assemblies connected to an anode beam,

said anode servicing assembly being intended to be provided on at least one line of said plant, said anode servicing assembly comprising:

- an elongated body such as a beam,
- running means adapted to allow movement of said elongated body along a running direction, substantially parallel to main axis of said line (L1, L2),
- an anode servicing machine mounted on said elongated body, said anode servicing machine comprising
  - ◦ at least two operating devices, each adapted to fulfil at least one specific anode servicing function, said anode servicing function being different from cell lifting and anode beam lifting,
  - ◦ at least two support assemblies, each adapted to support a respective operating device with respect to said elongated body,

said operating devices being movable independently the one with respect to the other, along at least one of

- a longitudinal axis of said elongated body and
- a vertical axis.

[0028] According to other aspects of the invention, at least one support assembly comprises at least one carrier movable with respect to said elongated body along said longitudinal axis (L31) of said body, said respective operating device being fixed with respect to said carrier, at least in translation.

[0029] According to another aspect, at least one support assembly comprises at least one carrier movable with respect to said elongated body along said longitudinal axis of said elongated body, as well as at least one drive member provided with driving means, adapted to move said operating device with respect to said carrier along said vertical axis (ZZ).

[0030] Furthermore, at least one support assembly can comprise two carriers as well as two drive members, said driving means being adapted to move one single operating device with respect to said carriers along said vertical axis.

[0031] Said elongated body can comprise at least one, and in particular at least two parallel rails, at least one rail being provided with at least one track for translation motion of at least one carrier.

[0032] Said specific anode servicing function(s) is (are) advantageously chosen amongst: lifting a new anode, vacuum cleaning anode cover material surrounding and/or covering an anode, sawing solid crust material surrounding an anode, lifting of the spent anode, placing the new anode at specific height, adding anode cover material on and around an anode, recording images representative of the position and the shape of an anode, moving a hood panel giving access to an anode, and moving back the hood panels after completing the anode change.

[0033] It is possible, and advantageous, to design the devices such that the lifting power of each operating device is inferior to 20 metric tons, preferably less than 15 metric tons, and even more preferably less than 10 metric tons.

[0034] According to an embodiment, an anode servicing assembly according to the invention comprises at least two so-called lifting operating devices, each being adapted for lifting a respective anode assembly.

[0035] According to another embodiment, it may comprise (or further comprise) a so-called multi use operating device, said multi use operating device being provided with a head, said head being adapted to cooperate with

- tools detachably fixed on a distinct operating device
  and/or
- tools detachably fixed on said multi use operating device.

[0036] A second object of the invention is an aluminium electrolysis plant comprising at least one line of electrolysis cells of substantially rectangular shape, said plant further comprising means for electrically connecting said cells in series and means for connecting the cathodic busbar of a cell to the anode beam of a downstream cell,

said plant comprising at least one heavy lifting assembly, and/or at least one pot tending assembly (25),

- said heavy lifting assembly, if present, comprising an elongated body such as a beam, running means adapted to allow movement of said elongated body along a running direction, substantially parallel to main axis of said line, as well as a heavy lifting machine mounted on said elongated body and adapted to fulfil at least one function of a so-called heavy lifting type, which includes lifting of superstructures and pot shells with failed or new linings,
- said pot tending assembly, if present, comprising an elongated body such as a beam, running means adapted to allow movement of said elongated body along a running direction, substantially parallel to main axis of said line, as well as a pot tending machine mounted on said elongated body and adapted to fulfil at least one function of a so-called main type which includes raising of anode beams and tapping,
  characterized in that said line of said plant further comprises at least one anode servicing assembly according to any of the embodiments and variants of the present invention,
- said anode servicing assembly comprising a body, running means adapted to allow movement of said body along said running direction, as well as an anode servicing machine mounted on said body and adapted to fulfil at least one specific anode servicing function,

and further characterised in that
at least one of the functions of said heavy lifting type, and/or at least one of the functions of said main type, is distinct from said anode servicing functions,
whereas at least one of the specific anode servicing functions is distinct from said heavy lifting type, and from functions of said main type, and in particular distinct from lifting cells, raising anode beams and tapping.

[0037] This plant may further comprise at least one common running path usable by running means of said anode servicing assembly, adapted to cooperate with running means of the heavy lifting assembly and/or with the running means of said pot tending assembly, in particular two common running paths, provided on either side of said cells, with reference to transversal axis of said line.

[0038] A third object of the invention is a method of operating an anode servicing assembly according to the present invention, said anode servicing assembly being in particular part of an aluminium electrolysis plant according to the invention, said operating method comprising:

- picking up a so-called replacement anode assembly, with a first lifting operating device of said anode servicing assembly, said replacement anode assembly being intended to replace a so-called spent anode assembly;
- moving said anode servicing assembly, the latter carrying said replacement anode assembly, close to said spent anode assembly;
- picking up said spent anode assembly with a second lifting operating device of said anode servicing assembly;

- placing replacement anode assembly at the original location of spent anode assembly,

said operating method advantageously further comprising

- analysing the shape of spent anode, so as to determine height position of replacement anode, and/or
- vacuum cleaning material surrounding spent anode assembly, stocking at least part of said material and pouring at least part of said stocked material around replacement anode assembly.

[0039] Said operating method can further comprise:

- positioning said heavy lifting assembly or said pot trending assembly above one given cell, or between two neighbouring cells, of said plant, as well as
- positioning a first anode servicing assembly above a first cell, located on a first side of said given cell or said two neighbouring cells, with respect to said main axis, and/ or
- positioning a second anode servicing assembly above a second cell, located on a second side of said given cell or said neighbouring cells, with respect to said main axis.

[0040] Said operating method advantageously further comprises:

- carrying out at least one specific anode servicing function on said first cell, and/or
- carrying out at least one specific anode servicing on said second cell.

[0041] Yet another object of the present invention is a method for making aluminium by the Hall-Héroult electrolysis process, characterized in that said method is carried out in an aluminium electrolysis plant according to the invention.

Figures

[0042]

Figures 1 to 18 represent an embodiment of the present invention; they do not limit the scope of the invention.

Figure 1 is a schematic view, showing the global arrangement of a series of cells in an electrolysis plant according to the invention.

Figure 2 shows a schematic transverse cross-sectional view of an electrolytic cell which belongs to plant of figure 1.

Figures 3 shows a schematic transverse cross-sectional view of plant of figure 1, illustrating more particularly a pot tending machine (PTM) facing a cell of said plant.

Figures 4 shows a schematic transverse cross-sectional views of plant of figure 1, illustrating more particularly an anode servicing assembly facing a cell of said plant.

Figures 5 and 6 are schematic views analogous to figure 1, showing two stages of a monitoring process of said plant, according to the invention.

Figure 7 is a perspective view, showing more in detail an anode servicing assembly which equips the plant of above figures.

Figure 8 is a perspective view showing in particular a carrier, which is part of the anode servicing assembly of figure 7, as well as rails on which said carrier is mounted.

Figure 9 is a perspective view showing carrier of figure 8, as well as a platform cooperating with said carrier.

Figure 10 is a perspective view showing a first operating step of an anode servicing assembly, wherein the position of an anode rod is captured by a camera.

Figure 11 is a perspective view showing another operating step of this anode servicing assembly, wherein the position of a lifted anode is captured by a camera.

Figure 12 is a perspective view showing another operating step of this anode servicing assembly, wherein hood panels of the pot shell are removed.

Figure 13 is a perspective view showing another operating step of this anode servicing assembly, wherein material surrounding an anode intended to be replaced is vacuum cleaned.

Figure 14 is a perspective view showing another operating step of this anode servicing assembly, wherein crust surrounding anode of figure 13 is broken.

Figure 15 is a perspective view showing another operating step of this anode servicing assembly, wherein anode of figure 13 is lifted.

Figure 16 is a perspective view showing another operating step of this anode servicing assembly, wherein shape of lifted anode of figure 15 is captured.

Figure 17 is a perspective view showing another operating step of this anode servicing assembly, wherein a replacement anode is put in place, instead of anode of figures 13 to 16.
Figure 18 is a perspective view showing another operating step of this anode servicing assembly, wherein some material is poured around replacement anode of figure 17.

Detailed description

[0043] The following reference numbers are used in the figures:

1	Electrolytic cell (prior art)	2	Sidewalls of potshell
4	Bottom of potshell	3	Lining
5	Anode assembly	6	Anode rod of 5
7	Anode of 5	5U	Spent Anode assembly
6U	Anode rod of 5U	7U	Anode of 5U
8	Cathode block	9	Cathode collector bar
10	Anode frame	11	Electrolytic bath
12	Liquid aluminium pad	13	Hood panel
14	Clamps	15	Anode assembly
16,16’	Sheds (building)	17,18	Side walls of shed
19	Top wall of sheds	20,21	Running paths
25	Pot tending machine (PTM)	26	Body of 25
27	Lifting machine of PTM	L31	Main axis of body 31
30	First anode servicing assembly	31	Body of 30
32	Anode servicing machine	33,33’	Rails of 32
34,34’	Tracks of rails	35	Second anode servicing assembly
40	Carrier for 45	41,42	Sidewalls of potshell
45	Hopper	50	Carrier for 55
55	Crust breaker	60	Carrier for 65
62	Platform for 65	65	Bucket shovel
70	Carrier for 75	72	Platform for 75
75	Multi-tool robot	750	Deck of 75
752	Proximal arm of 75	753	Intermediate arm of 75
754	Distal arm of 75	756	Rotator of 75
758	Head of 75	76	Camera of 75
77-79	Tools of 75	80,81	Carriers for 85
82,83	Platforms for 85	85	Lifting robot
90,91	Carriers for 95	92,93	Platforms for 95
95	Lifting robot		
C1-Cn ; C’1-C’n ; Ci ; Ci ; Cj ; C’j		Electrolytic cells	
L1,L2	Lines of electrolytic cells	ZZ	Vertical axis
XX	Main axis of cell line	YY	Transverse axis of cell line

[0044] The present invention is directed to the arrangement of a plant, also called aluminium smelting plant or aluminium smelter, using the Hall-Heroult process. This plant comprises a plurality of electrolysis cells (potline) connected in series. The Hall-Heroult process as such, the way to operate the latter, as well as the general structure of above electrolysis cells are known to a person skilled in the art and will not be described here. In the present description, the terms "upper" and "lower" refer to mechanical elements in use, with respect to a horizontal working surface. Moreover, unless otherwise specifically mentioned, "conductive" means "electrically conductive".

[0045] As schematically shown on figure 1, the aluminium smelter of the invention comprises a plurality of electrolytic cells, typically arranged along two parallel lines L1 and L2, each of which comprises n cells, i.e. C1 to Cn and C'1 to C'n. The electrolysis current therefore passes in a cascade fashion from one cell to the next cell, along arrow DC. The number of cells in a series is typically comprised between 50 and over 250, even over 400 in the most recent smelters, but this figure is not substantial for the present invention.

[0046] The electrolytic cells are rectangular shaped and are arranged transversally (side by side), in reference of the line they constitute. In other words, the main dimension, or length, of each cell is substantially orthogonal to the main direction of the line, i.e. the circulation direction of current. The large sides of two adjacent cells are parallel. The electrolytic cells, or pots, can implement various technological variants that do not form a part of the present invention; such pots are known to a person skilled in the art. On the figure 1, only the contour of the external metal (steel) shell, or "potshell", of the cells is shown.

[0047] The general structure of a Hall-Heroult electrolysis pot is known *per* se and will not be explained here in detail. It is sufficient to explain, in particular in relation with Figure 2, that a typical cell **1** includes a potshell comprising a first longitudinal sidewall **2,** a second longitudinal sidewall **2',** first and second transversal end walls (not visible on figure 1) and a bottom **4.** The potshell walls define a space lined on its bottom and sides with refractory materials **3** (maintaining the thermal balance during the electrolysis process) along with the cathode blocks **8,** thereby defining a volume containing the molten metal and electrolyte. The side lining **3** comprises a layer of carbonaceous material (not shown on the figures) protected in steady state operation by solid electrolyte in contact with molten liquid material.

[0048] Said cathode blocks **8** comprise one or more cathode collector bars **9.** They protrude out of the potshell. Several anode assemblies **5** are also provided, each comprising an anode rod **6** and an anode **7.** Electrical current enters the cell through anodes **7** (suspended above the cell by anode rods **6** attached to an aluminium beam called anode beam, which is supported by the cell superstructure **10**), passes through the molten electrolytic bath **11** and the molten aluminium pad **12,** and then enters the carbon cathode block **8.** The current is carried out of the cell by the cathode collector bar **9** connected to the cathode busbar not shown on figure 2. The cell **1** is closed by a set of hood panels **13.** In a way known as such, clamps **14,** which are schematically represented, ensure removable fixing of anode rods to anode beam.

[0049] Typically, all the cells of the plant have the same structure. Two sheds **16,16'** are also provided, each covering a respective line. On figure 1, these sheds are illustrated in phantom lines. As shown on figures 3 and 4, said shed **16,16'** comprises sidewalls **17,18** as well as top walls **19.** The shed **16,16'** can be open or closed, at one or both longitudinal ends. With reference to these figures, each cell is arranged so as to leave running paths **20, 21** on internal faces of side walls **17,18** of said shed **16,16'.** These paths allow the displacement of anode servicing assemblies along main axis of each line, as will be explained here after. Each path is provided with appropriate means, such as rails, for cooperating with complementary means of anode servicing assembly, such as wheels.

[0050] The combination, according to the invention, between a heavy lifting assembly (often designated as a cathode transport crane, abridged CTC) and/or a pot tending assembly (abridged PTM) on the one hand, and at least one anode servicing assembly on the other hand, will now be described. In particular, the anode servicing assembly advantageously uses the same running paths as the heavy lifting assembly and/or the pot tending assembly. When the heavy lifting machine is not needed, it does not stay in the line but (usually) in the pot repair area (not shown on the figures), from where it is moved into the pot line with a transboarding machine (not shown on the figures) generally located in the central passage.

[0051] This description is made, first with reference to figures 3 to 6 which are schematic. The structure of these anode servicing assemblies will be described more in detail with reference to figures 7 and following.

[0052] A plant according to the invention is provided with a pot tending assembly **25,** schematically shown on figure 3. The latter comprises an elongated body **26,** such as a beam, which is equipped with above-mentioned complementarity means, so as to run along above-described paths. Moreover said pot tending assembly is provided with a so called pot tending machine **27.** In a way known as such, this lifting machine is adapted to carry out the function of raising an anode beam. In this respect, the lifting power of this lifting machine is sufficient to fulfil this lifting. Typically this lifting machine is not adapted to fulfil some other functions, such as replacing a spent anode assembly by a new anode assembly; adding a specific anode changing machine to the pot tending machine is possible, but will add unnecessary cost, and will not provide sufficient flexibility of use.

[0053] A plant according to the invention is usually also provided with a heavy lifting assembly (not shown on the figures), which comprises an elongated body, such as a beam, which is equipped with above-mentioned complementarity means, so as to run along above-described paths. Moreover said heavy lifting assembly is provided with a so called heavy lifting machine which, in a way known as such, is adapted to carry out the function of lifting a potshell and lifting a superstructure. In this respect, the lifting power of this lifting machine is sufficient to fulfil this lifting. Typically this heavy lifting machine is not adapted to fulfil some other functions, such as pot tending functions (such as raising anode beams) or anode servicing functions.

[0054] A plant according to the invention is also provided with at least one so called anode servicing assembly. In the present embodiment as will be explained more in detail, two anode servicing assemblies **30,35** are provided. Each anode servicing assembly, schematically shown on figure 4, comprises an elongated body **31,** such as a beam, which is equipped with above-mentioned complementarity means, so as to run along above described paths. Moreover said anode servicing assembly **30,35** is provided with a so called anode servicing machine **32.** The present invention is directed to said anode servicing assembly **30,35,** and to said anode servicing machine **32.**

[0055] This machine **32** is provided with several operating devices, which will be described more in detail hereafter. These operating devices are adapted to carry out a specific anode servicing function, such as replacing a spent anode assembly by a new anode assembly. These operating devices are not adapted to carry out the lifting of a cell or the raising of an anode beam. In this respect, the lifting power of each operating device is not sufficient to fulfil this lifting. Typically the lifting power of each of those operating devices is inferior to 20 metric tons, and can be inferior to 10 metric tons. This will simplify its structure.

[0056] In other words, the heavy lifting machine is adapted to fulfil certain functions, such as lifting a whole cell, and a superstructure which cannot be fulfilled by the anode servicing machine **32** because the latter does not have enough lifting power. Likewise, the pot tending machine is adapted to fulfil certain pot tending operations, which cannot be carried out by the anode servicing machine **32** because the latter does not have enough lifting power. Moreover the anode servicing machine **32** is adapted to fulfil at least one so called distinctive function, such as automatically (i.e. without a human operator) replacing a spent anode assembly, which cannot be fulfilled automatically by a pot tending machine. On the other hand, the heavy lifting machine of the heavy lifting assembly is not adapted to replace a spent anode assembly by a new one, because it is lacking specific tools.

[0057] An operating method of the global plant according to the invention will now be described, with reference to figures 5 and 6. These do not however illustrate the operation of the anode servicing assembly **30** or **35,** which will be described with reference to figures 10 to 18.

[0058] It is advantageous to provide each line of the plant with a plurality of anode servicing assemblies, depending of the number of cells to be served. On figures 5 and 6, a first anode servicing assembly **30, 30'** and a second anode servicing assembly **35, 35'** are shown to allow changing anodes simultaneously on different cells of the same line of cells.

[0059] With reference to figure 5, let us suppose that the pot tending assembly **25, 25'** faces one first given cell Ci, C'i located close to the rectifier end of the line on said figure. As a variant, said pot tending assembly may be positioned between two neighboring cells. In particular, this pot tending assembly may carry out a first type of operation on said cell(s), such as a lifting of the latter. In this respect all the other cells may be dealt by the two anode servicing assemblies. Indeed top cells C1 to Ci-1, C'1 to C'i-1 may be dealt by first anode servicing assembly **35,35',** whereas bottom cells Ci+1 to Cn, C'i+1 to C'n may be dealt by second anode servicing assembly **30,30'.**

[0060] With reference to figure 6, let us suppose now that pot tending assembly **25,25'** has moved from its position of figure 5, so as to face one second given cell Cj, C'j located close to the non-rectifier end of the line on said figure. According to the invention all the other cells still may be dealt by the two anode servicing assemblies. Indeed top cells C1 to Cj-1 C'1 to C'j-1 may be dealt by first anode servicing assembly **35,35',** whereas bottom cells Cj+1 to Cn, C'j+1 to C'n may be dealt by second anode servicing assembly **30,30'.**

[0061] Within the meaning of the invention, the first and second anode servicing assemblies **30, 30', 35 35'** may carry out servicing operations on cells, which may be the same servicing operations or different servicing operations. In particular, they may proceed to the change of the spent anode, so as to replace it by a new one. With reference to figures 7 to 18, one constructive embodiment of an anode servicing machine, capable of such a replacement, will now be given.

[0062] An overall view of anode servicing machine **30** according to an advantageous embodiment is given on Figure 7. Elongated body **31** of said anode servicing machine **30** comprises in particular two parallel rails **33,33',** extending along transversal axis YY. As a consequence, this axis is coincident with a so-called main axis L31 of elongated body **31,** which is shown in particular on figure 8.

[0063] As shown on figure 8, each rail **33,33'** has opposite top and bottom walls, as well as opposite inner and outer walls. So-called inner wall of one rail faces the other rail. Tracks **34, 34', 34"** are provided on at least one side wall of at least one rail. Said track, the structure of which is of any appropriate type, permits the displacement of carriers which will be described here under. In the illustrated example, both inner and outer walls of first rail are provided with respective tracks, whereas outer wall of second rail is provided with a respective track.

[0064] Back to figure 7, each track **34,34',34"** cooperates with at least one carrier **40,50,60,70,80,81,90,91** which is mounted on this track. Said carrier is mobile on said track, along main axis L31 of the elongated body **31.** To this end, said carrier is equipped with appropriate running means, such as rolling means. Each carrier **40,50,60,70,80,81,90,91** is adapted to support one or more operating devices **45,55,65,75,85,95.** In the example of figure 7, two carriers **90,91** are provided on outer wall of first rail **33,** three more carriers **40,50,70** are provided on inner wall of first rail **33,** whereas three further more carriers **60,80,81** are provided on outer wall of second rail **33'.**

[0065] Said carriers may cooperate with the above-mentioned operating devices, in two distinct modes. In a first mode, one carrier may directly form a support assembly for a respective operating device. In other words, it means that a given operating device is immobilized, at least in translation, with respect to said carrier. In the present embodiment, this applies for two carriers **40,50** which respectively support a hopper **45** and a nozzle **55,** the functions of which will be detailed hereafter.

[0066] In this first mode, said operating devices **45,55** are independently movable, along only longitudinal axis L31 of the elongated body **31.**

[0067] In a second mode, some carriers may support operating devices while allowing a further displacement of the latter. In this respect an intermediate platform is fixed on said carrier, said platform permitting the movement of device along the vertical axis ZZ; this axis is shown on Figure 9. To this end said platform is equipped with appropriate driving means, such as a servo motor. A support assembly, within the meaning of the invention, is then formed by said carrier and said platform.

[0068] According to a first possibility of said second mode, single carrier **60** cooperates with single platform **62** which in turn supports an operating device, which is a bucket shovel **65.** In a similar manner, single carrier **70** cooperates with single platform **72** which in turn supports an operating device, which is a first robot **75,** the structure of which will be described in further detail below.

[0069] According to a second possibility of said second mode, two different carriers may be provided for one single operating device, in particular in case the latter is heavy and or has great dimensions. As shown on figure 7 two carriers **80** and **81** support two respective platforms **82** and **83,** on which a first lifting robot **85** is mounted. In addition, two more carriers **90** and **91** support two respective platforms **92** and **93,** on which a second lifting robot **95** is mounted. Lifting robots **85** and **95** are typically adapted to lift an anode, in a way known as such.

[0070] In this second mode, said operating devices **65, 75, 85, 95** are independently movable, along not only longitudinal axis L31 of the elongated body **31,** but also vertical axis ZZ.

[0071] The functions of these mechanical elements will become clear, at reading the description of the following example of an operating method according to the present invention. This example is given with reference to further figures 10 to 17. On the latter, all the mechanical elements of the anode servicing assembly according to the invention are not illustrated, for sake of clarity. In particular, these figures 10 to 17 show only one **33** of the two rails, which form the elongated body.

[0072] These figures also illustrate robot **75,** in further detail. With reference in particular to Figure 12 this robot **75** first comprises, starting from platform **72,** a deck **750** which is pivotably mounted on this platform around a vertical axis. Furthermore three successive arms are provided, namely a proximal arm **752** pivotably mounted on deck **750** around horizontal axis A752, an intermediate arm 753 pivotably mounted on arm **752** around horizontal axis A753, as well as a distal arm 754 pivotably mounted on arm **753** around horizontal axis A754. A rotator **756** is further pivotably mounted on distal arm around longitudinal axis L754 of said arm.

[0073] Said rotator is provided with a multi-use head **758,** which is pivotably mounted around horizontal axis A758. As illustrated in particular on figures 13 and 14, this head is adapted to detachably receive specific tools **77, 78** and **79** which will be further described. In particular these tools may be detachably fixed on platform **72.** Moreover, this head **758** is provided with a camera **76,** which is of any appropriate type, in particular of the 3D type. Contrary to tools **77** to **79,** this camera is preferably attached to this head in a permanent way.

[0074] Let us suppose that one anode assembly of a cell needs to be replaced, which is called here after "spent anode assembly". The latter is referenced **5U,** whereas its rod and its anode are respectively noted **6U** and **7U.** This task will be carried out either by first or second anode servicing assembly.

[0075] Let suppose that the chosen anode servicing assembly is the one referenced **30.** The latter first picks up a so-called replacement anode assembly, intended to replace above-mentioned spent anode assembly. In this respect Figure 10 illustrates end cell C1, as well as a group RG of replacement anode assemblies which are gathered in the vicinity of this cell C1. Then said anode servicing assembly **30** moves to the group of replacement anode assemblies, by running along paths **20, 21** which are shown on figures 3 and 4. Figure 10 shows rail **33** of anode servicing assembly **30,** one **20** of these running paths, as well as robots **75** and **85.**

[0076] Let us note **5R** the chosen replacement anode assembly, as well as **6R** and **7R** respectively its rod and its anode. The 3-D camera **76** first localizes the position of the replacement anode rod **6R** (see capture **76A).** Then the lifting robot **85** is moved so as, first to pick up the replacement anode assembly, and then lift this picked up assembly as shown on Figure 11 (see arrow L1). Once this replacement anode assembly has been lifted, the 3-D camera determines the position of this replacement anode (see capture **76B).** After this determination step the anode servicing assembly **30,** which carries the replacement anode assembly **5R,** is driven back along the paths (see arrow F30 on this figure 11) until it reaches the location of the spent anode.

[0077] Robot **75** is then moved, so as to equip its head **758** with a U shaped gripper **77** (see figure 12). This gripper **77,** which is detachably fixed on platform **72** (see in particular Figure 14 which shows this gripper on this platform), is adapted to cooperate with the hood panels 13. As shown on figure 12, each anode assembly of a given cell is associated with two adjacent hoods panels, i.e. it is necessary to remove two adjacent hood panels to access to a given anode assembly. In particular the spent anode assembly **5U** is associated with hood panels **13A** and **13B.** The camera **76** first localizes right hood panel **13A,** and thereafter gripper **77** lifts said hood panel and places it onto neighboring hood noted **13C** as shown on this figure 12. The same operation (not shown on this figure 12) is carried out on the left hood panel **13B,** which is localized, gripped and then placed onto neighboring hood panel **13D.**

[0078] Robot **75** is then moved, so as to release back the gripper **77** on platform. Head **758** is then equipped with above described nozzle **55.** This nozzle makes it possible to aspirate hot material (crushed bath and alumina mixture) called hereafter ACRM (Anode Cover Recycled Material), from the vicinity of spent anode along arrow F55. This step is illustrated on figure 13. Said nozzle is then placed back on its carrier **50.**

[0079] Thereafter said robot **75** further moves, so that its head might be equipped with a crust saw **78,** which is detachably supported by platform **72** (see also Figure 13 showing this saw mounted on this platform). The crust around spent anode is then broken, typically around four sides of said spent anode (see figure 14 with lines F78 showing the motion of the saw **78).** So as to avoid any undue damage, the 3-D camera had previously determined the position of the neighboring anodes, namely those which are on either side of spent anode. Said crust saw 78 is then placed back on its platform **72.**

[0080] Afterwards the position of the anode rod **6U** of spent anode assembly **5U** is checked, using said 3-D camera **76.** This step, which is not shown on the figures, is analogous to above described step carried out on replacement anode assembly **5R.** Then the other lifting robot **95** is lowered, so as to come in the vicinity of spent anode assembly. Clamp **14** is unlocked, using an appropriate screw tool **96** which is provided on said lifting robot **95.** Then the latter lifts then said spent anode, as shown by arrow L2 on Figure 15.

[0081] 3-D camera **76** determines then the position of this spent anode, as shown on Figure 16 (see capture **76C).** Said figure 16 illustrates, on the one hand lifting robot **85** and replacement anode assembly **5R,** on the other hand lifting robot **95** and spent anode assembly **5U.** It shall be noted that providing two distinct lifting robots **85, 95** brings about specific advantages. Indeed it makes it possible to operate two anode assemblies at the same time, without moving anode servicing assembly between spent anode assembly and the group of replacement anode assemblies. This makes it possible to save time, for what concerns the global processing of the plant.

[0082] Said camera **76** also checks the shape of spent anode assembly **5U** as well as the position of the pot opening **PO,** created by the removal of hood panels **13A** and **13B.** On figure 17, only first removed panel **13A** is illustrated above panel **13C,** bearing in mind that other removed panel **13B** is placed above panel **13D.** Replacement anode assembly **5R** is then put in place, into the above-mentioned pot opening. This step is illustrated on Figure 17, the arrow D showing the downwards motion of both robot **85** and replacement anode assembly **5R.** The final position of said replacement anode is adjusted on the basis of images, which have been captured by the above camera 76 as above described. Clamp **14R** is locked by a tool **86,** analogous to that **96,** which is provided on robot **85.**

[0083] As shown on Figure 18 multi use head **758** of robot **75** grasps then the above described nozzle **55.** The latter contains a quantity of recycled hot ACRM, which is poured at the vicinity of replacement anode along arrow f55. Moreover, some cold ACRM is further poured on top of above poured ACRM, until right thickness is reached (said step is not illustrated). This further quantity of ACRM is fed to nozzle **55,** from hopper **45.**

[0084] As final steps, which are also not illustrated, multi-use head of robot **75** places back hood panels **13A** and **13B** in their original position, so as to close pot opening PO. Camera **76** checks then that the new anode is situated at the right height. As a further checking step, multi-use head grasp tool **79,** which is adapted to measure the current intensity and to determine proper anode settings.

[0085] It should be noted that the embodiment of the anode servicing assembly according to the invention which comprises a camera configured to determine and control the anode height is particularly advantageous. Prior art devices use either external reference systems or laser height measurement devices.

Claims

1. An anode servicing assembly (30, 35) for an aluminium electrolysis plant, said aluminium electrolysis plant comprising at least one line (L1, L2) of electrolysis cells (C1-Cn, C'1-C'n) connected in series, each cell being connected to a cathodic busbar and each cell having a plurality of anode assemblies (5) connected to an anode beam,

said anode servicing assembly comprising:

- an elongated body (31) such as a beam,
- running means adapted to allow movement of said elongated body along a running direction, substantially parallel to main axis of said line (L1, L2),

- an anode servicing machine (32) mounted on said elongated body, said anode servicing machine comprising

  ◦ at least two operating devices (45, 55, 65, 75, 85, 95), each adapted to fulfil at least one specific anode servicing function, said anode servicing function being different from cell lifting and anode beam raising,
  ◦ at least two support assemblies (40, 50, 60, 62, 70, 72, 80, 81, 82, 83, 90, 91, 92, 93), each adapted to support a respective operating device with respect to said elongated body,

said operating devices (45, 55, 65, 75, 85, 95) being movable independently the one with respect to the other, along at least one of

- a longitudinal axis (L31) of said elongated body (31) and
- a vertical axis (ZZ).

2. An anode servicing assembly according to preceding claim, wherein at least one support assembly comprises at least one carrier (40, 50) movable with respect to said elongated body along said longitudinal axis (L31) of said body, said respective operating device (45, 55) being fixed with respect to said carrier, at least in translation.

3. An anode servicing assembly according to claim 1 or 2, wherein at least one support assembly comprises at least one carrier (60, 70, 80, 81, 90, 91) movable with respect to said elongated body along said longitudinal axis of said elongated body, as well as at least one drive member (62, 72, 82, 83, 92, 93) provided with driving means, adapted to move said operating device with respect to said carrier along said vertical axis (ZZ).

4. An anode servicing assembly according to claim 3, wherein at least one support assembly comprises two carriers (80, 81, 90, 91) as well as two drive members (82, 83, 92, 93), said driving means being adapted to move one single operating device with respect to said carriers along said vertical axis.

5. An anode servicing assembly according to any above claims, wherein said elongated body (31) comprises at least one, and in particular at least two parallel rails (33, 33’), at least one rail being provided with at least one track (34, 34’, 34") for translation motion of at least one carrier.

6. An anode servicing assembly according to any preceding claims, wherein at least one specific anode servicing function(s) is (are) chosen amongst: lifting a new anode, vacuum cleaning anode cover material surrounding and/or covering an anode, sawing solid crust material surrounding an anode, lifting of the spent anode, placing the new anode at specific height, adding anode cover material on and around an anode, recording images representative of the position and the shape of an anode, moving a hood panel giving access to an anode, and moving back the hood panels after completing the anode change.

7. An anode servicing assembly according to any preceding claims, wherein the lifting power of each operating device is inferior to 20 metric tons, preferably less than 15 metric tons, and even more preferably less than 10 metric tons.

8. An anode servicing assembly according to claim 6 or 7, comprising at least two so-called lifting operating devices (85, 95), each being adapted for lifting a respective anode assembly (6, 106).

9. An anode servicing assembly according to claim 6 to 8, comprising a so-called multi use operating device (75), said multi use operating device being provided with a head (758), said head being adapted to cooperate with

   - tools (55) detachably fixed on a distinct operating device
   and/or
   - tools (77 - 79) detachably fixed on said multi use operating device.

10. An aluminium electrolysis plant comprising at least one line of electrolysis cells of substantially rectangular shape, said plant further comprising means for electrically connecting said cells in series and means for connecting the cathodic busbar of a cell to the anode beam of a downstream cell,

    said plant comprising at least one heavy lifting assembly, and/or at least one pot tending assembly (25),

- said heavy lifting assembly, if present, comprising an elongated body such as a beam, running means adapted to allow movement of said elongated body along a running direction, substantially parallel to main axis of said line, as well as a heavy lifting machine (27) mounted on said elongated body and adapted to fulfil at least one function of a so-called heavy lifting type which includes lifting of pre-lined pot shells, potshells with failed linings and superstructures.
- said pot tending assembly (25), if present, comprising an elongated body such as a beam, running means adapted to allow movement of said elongated body along a running direction, substantially parallel to main axis of said line, as well as a pot tending machine (27) mounted on said elongated body and adapted to fulfil at least one function of a so-called main type which includes raising of anode beams and tapping,
characterized in that said line of said plant further comprises at least one anode servicing assembly (30, 35) according to any of above claims,
- said anode servicing assembly (30,35) comprising a body (31), running means adapted to allow movement of said body along said running direction, as well as an anode servicing machine (32) mounted on said body and adapted to fulfil at least one specific anode servicing function,

and further **characterised in that**
at least one of the functions of said heavy lifting type, and/or at least of the functions of said main type, is distinct from said specific anode servicing functions,
whereas at least one of the specific anode servicing functions is distinct from functions of said heavy lifting type and from functions of said main type, and in particular distinct from lifting cells, raising anode beams and tapping.

11. An aluminium electrolysis plant according to claim 10, comprising at least one common running path (20, 21) adapted to cooperate with running means of said anode servicing assembly (30, 35), and with running means of said heavy lifting assembly and/or said pot tending assembly, and comprising in particular two common running paths, provided on either side of said cells, with reference to transversal axis of said line.

12. A method of operating an anode servicing assembly (30, 35) according to any of claims 1 to 9, said anode servicing assembly being in particular part of an aluminium electrolysis plant according to any of claims 10 to 11, said operating method comprising the following specific functions:

- picking up a so-called replacement anode assembly (5R), with a first lifting operating device (85) of said anode servicing assembly, said replacement anode assembly being intended to replace a so-called spent anode assembly (5U);
- moving said anode servicing assembly, the latter carrying said replacement anode assembly, close to said spent anode assembly;
- picking up said spent anode assembly with a second lifting operating device (95) of said anode servicing assembly;
- placing replacement anode assembly at the original location of spent anode assembly,

said operating method advantageously further comprising

- analysing the shape of spent anode, so as to determine height position of replacement anode
and/or
- vacuum cleaning material surrounding spent anode assembly, stocking at least part of said material and pouring at least part of said stocked material around replacement anode assembly.

13. Method of operating a plant according to any of claims 10 to 11, comprising:

- positioning said heavy lifting assembly or said pot tending assembly(25) above one given cell, or between two neighbouring cells, of said plant, as well as
- positioning a first anode servicing assembly (30) above a first cell, located on a first side of said given cell or said two neighbouring cells, with respect to said main axis, and or
- positioning a second anode servicing assembly (35) above a second cell, located on a second side of said given cell or said neighbouring cells, with respect to said main axis,

said operating method advantageously further comprising

- carrying out at least one specific anode servicing function on said first cell, and/or

- carrying out at least one specific anode servicing function on said second cell.

14. A method for making aluminium by the Hall-Heroult electrolysis process, **characterized in that** said method is carried out in an aluminium electrolysis plant according to any of claims 10 to 11.

Fig. 1

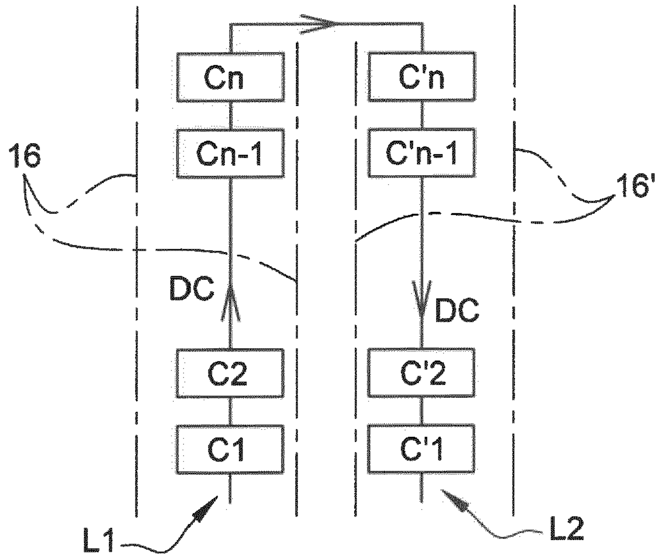

Cn
C'n
Cn-1
C'n-1
16
16'
DC
DC
C2
C'2
C1
C'1
L1
L2

Fig. 2

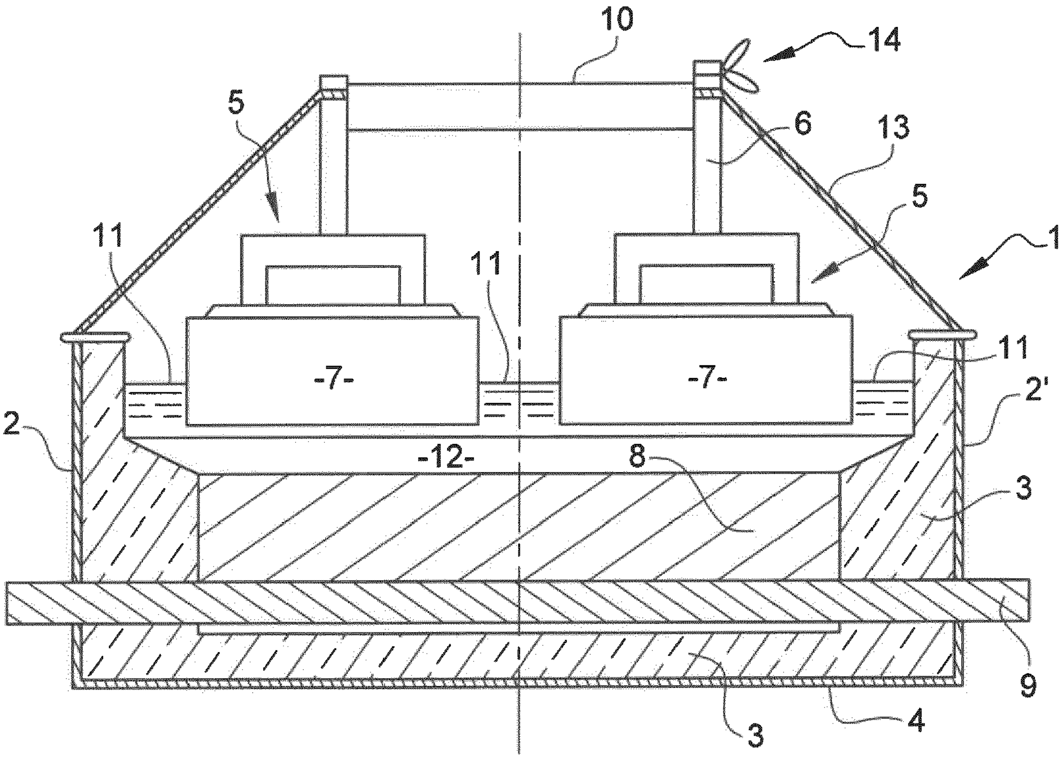

10
14
5
6
13
5
1
11
11
11
-7-
-7-
2
2'
-12-
8
3
9
3
4

Fig. 3

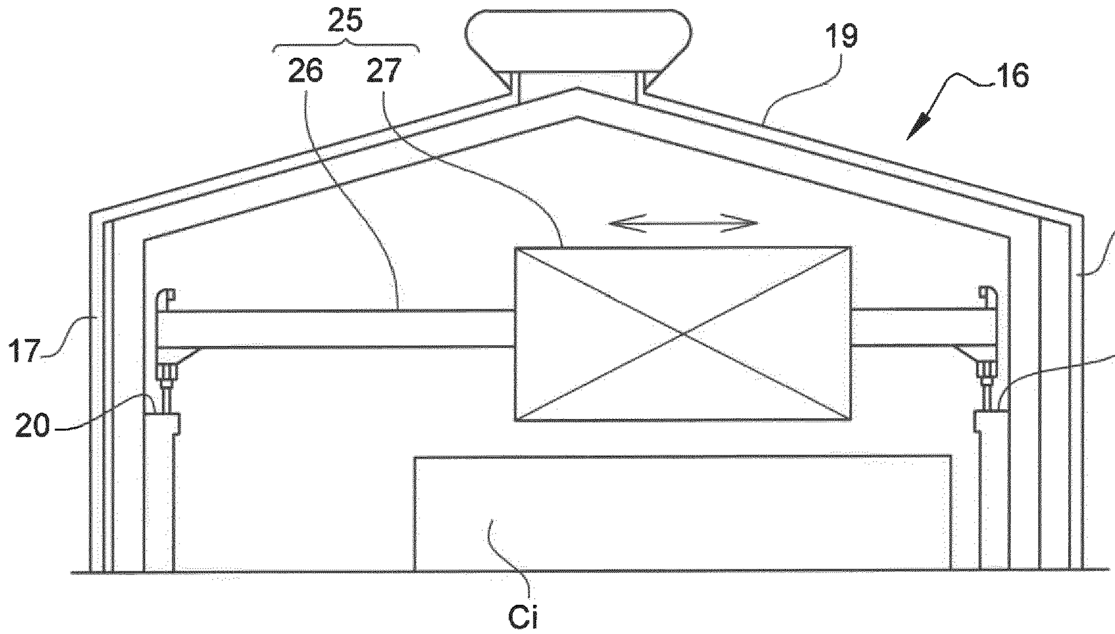


Fig. 4

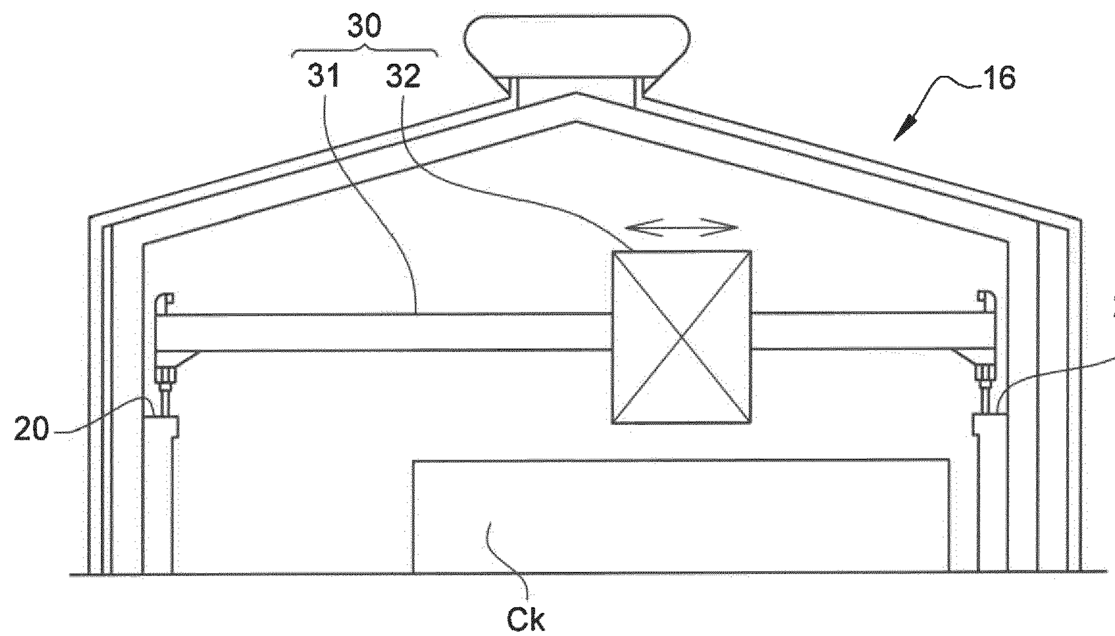


Fig. 5

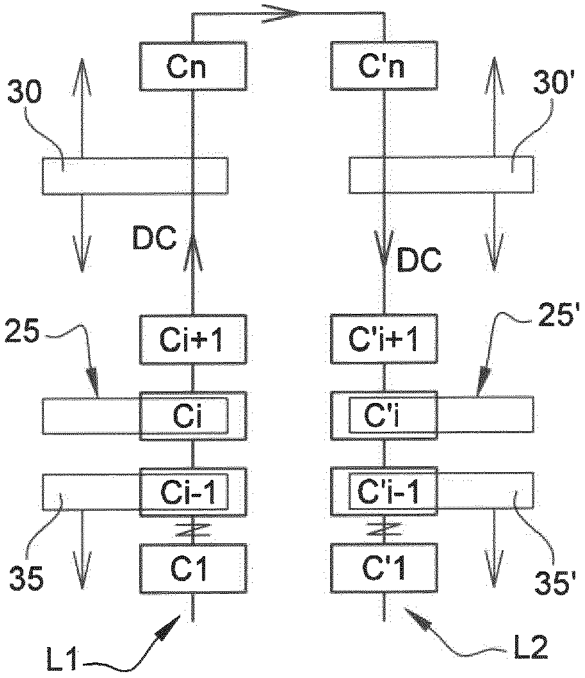
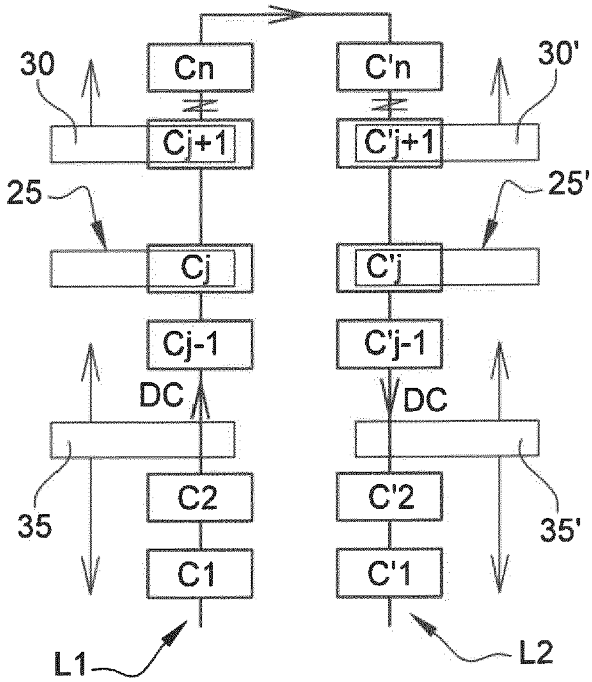


Fig. 6



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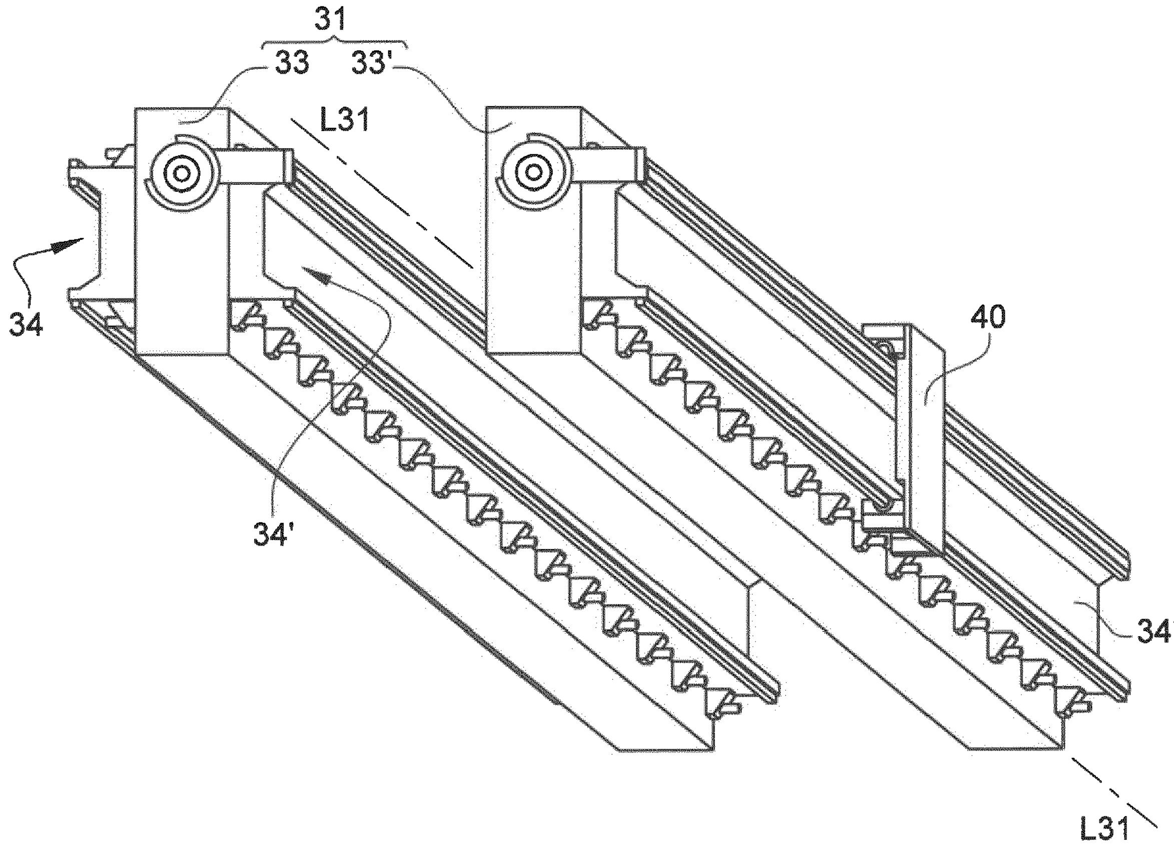

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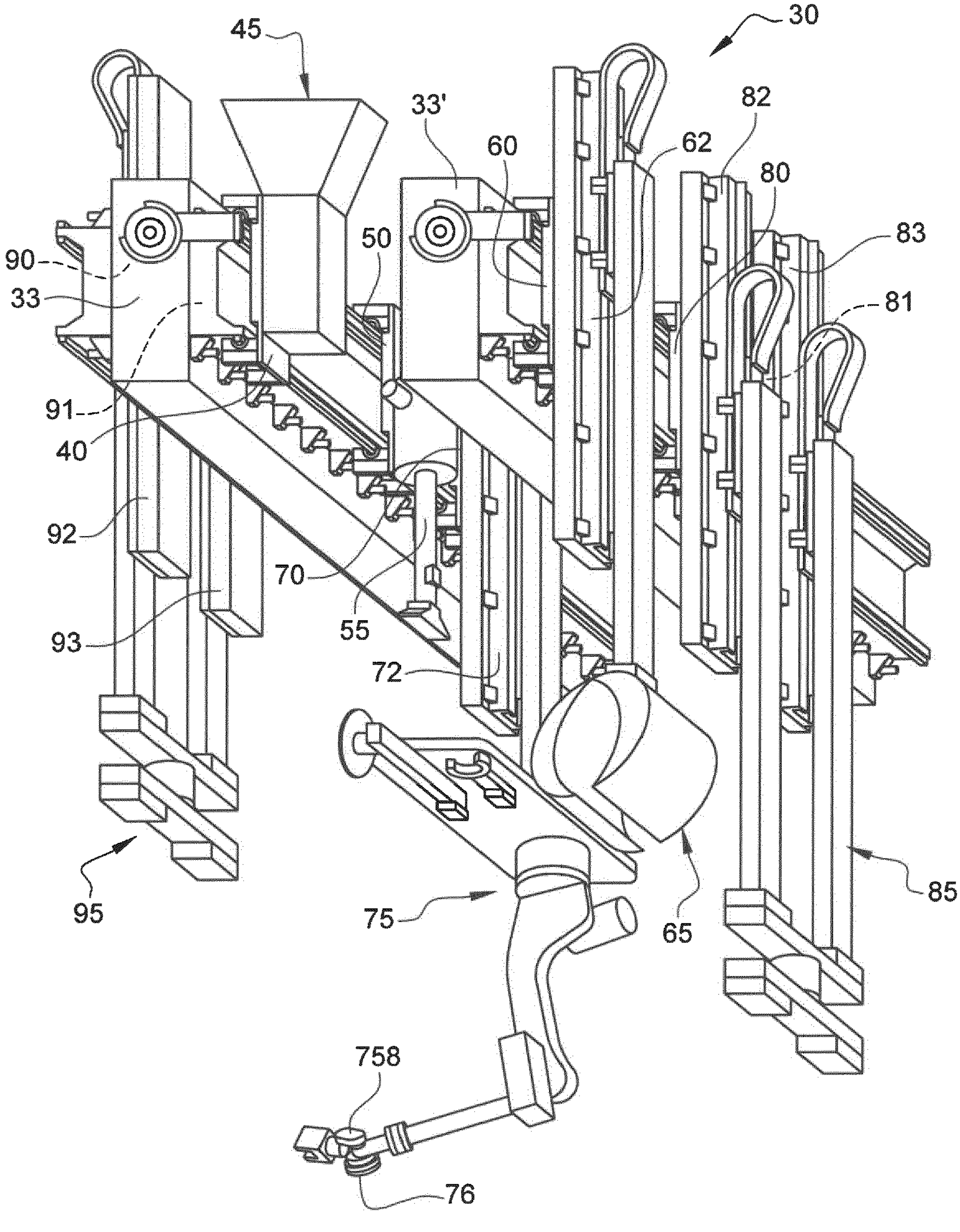
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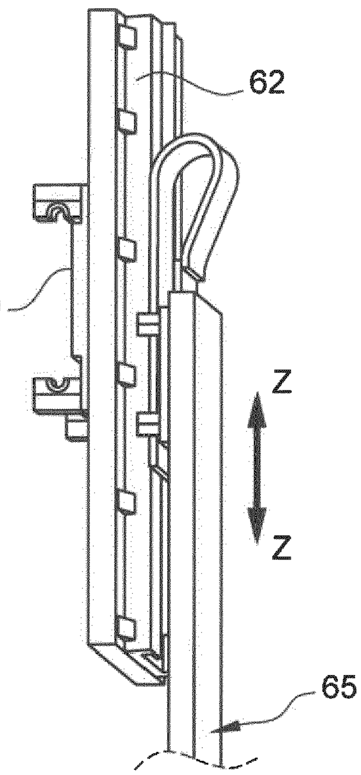
Fig. 9



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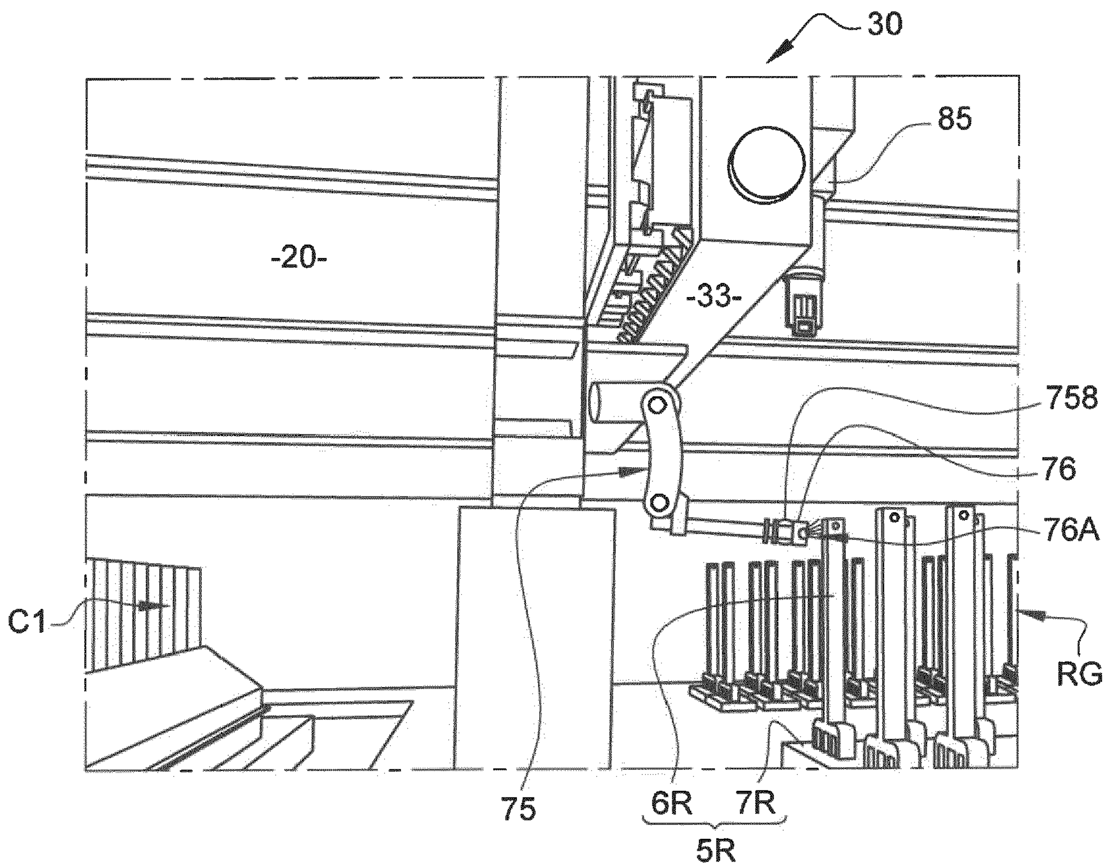

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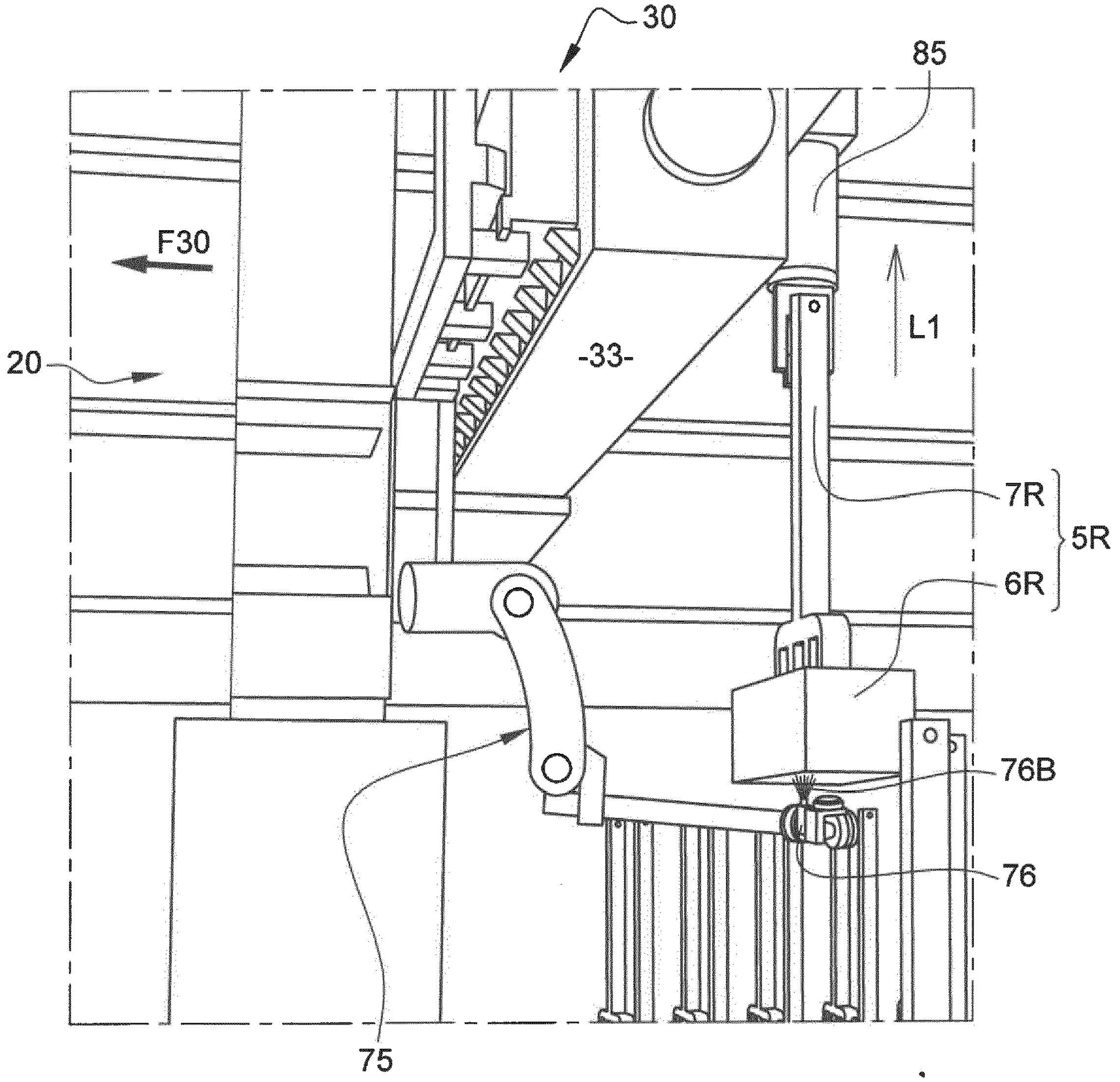

Fig. 12

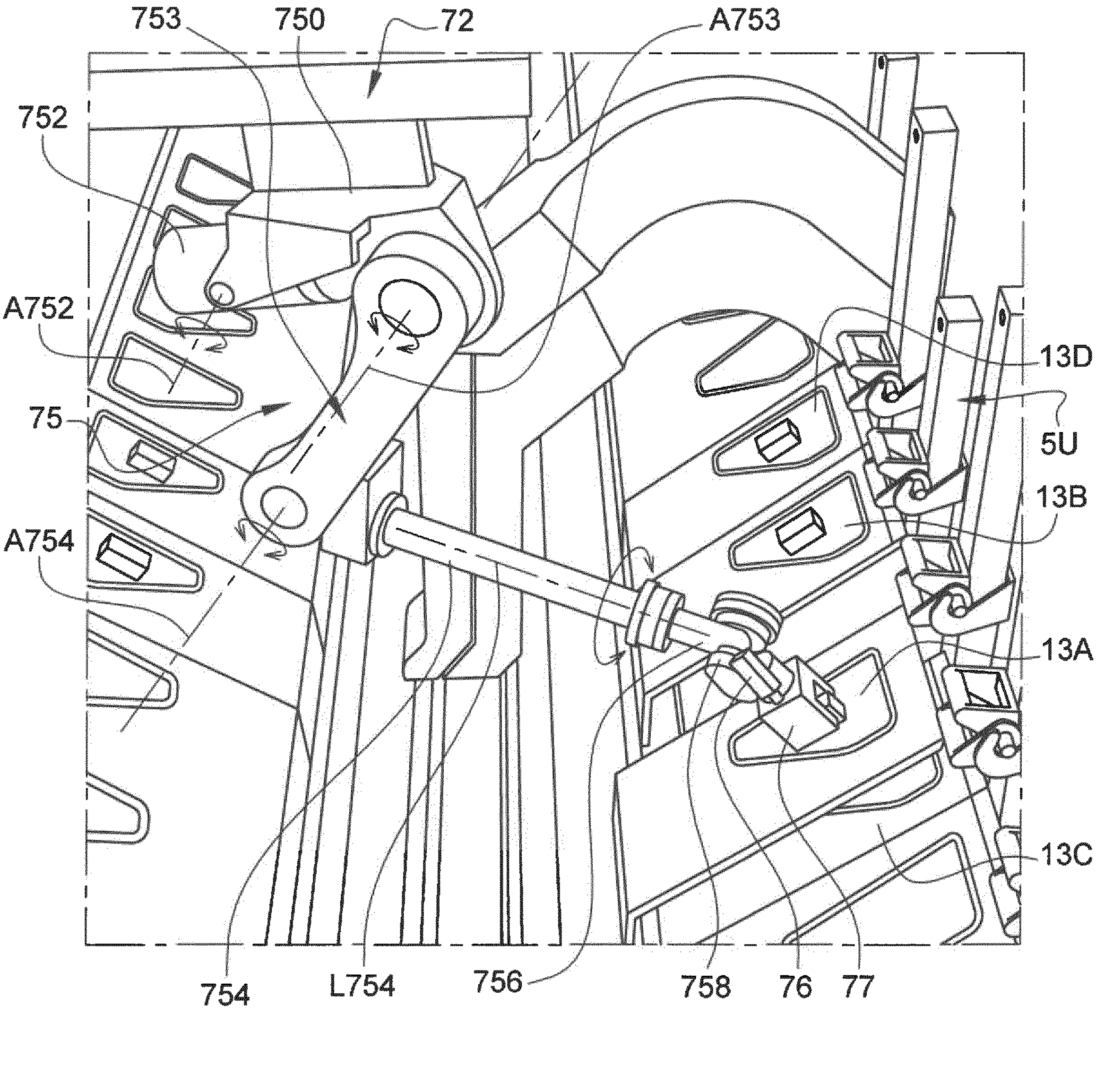
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Fig. 13

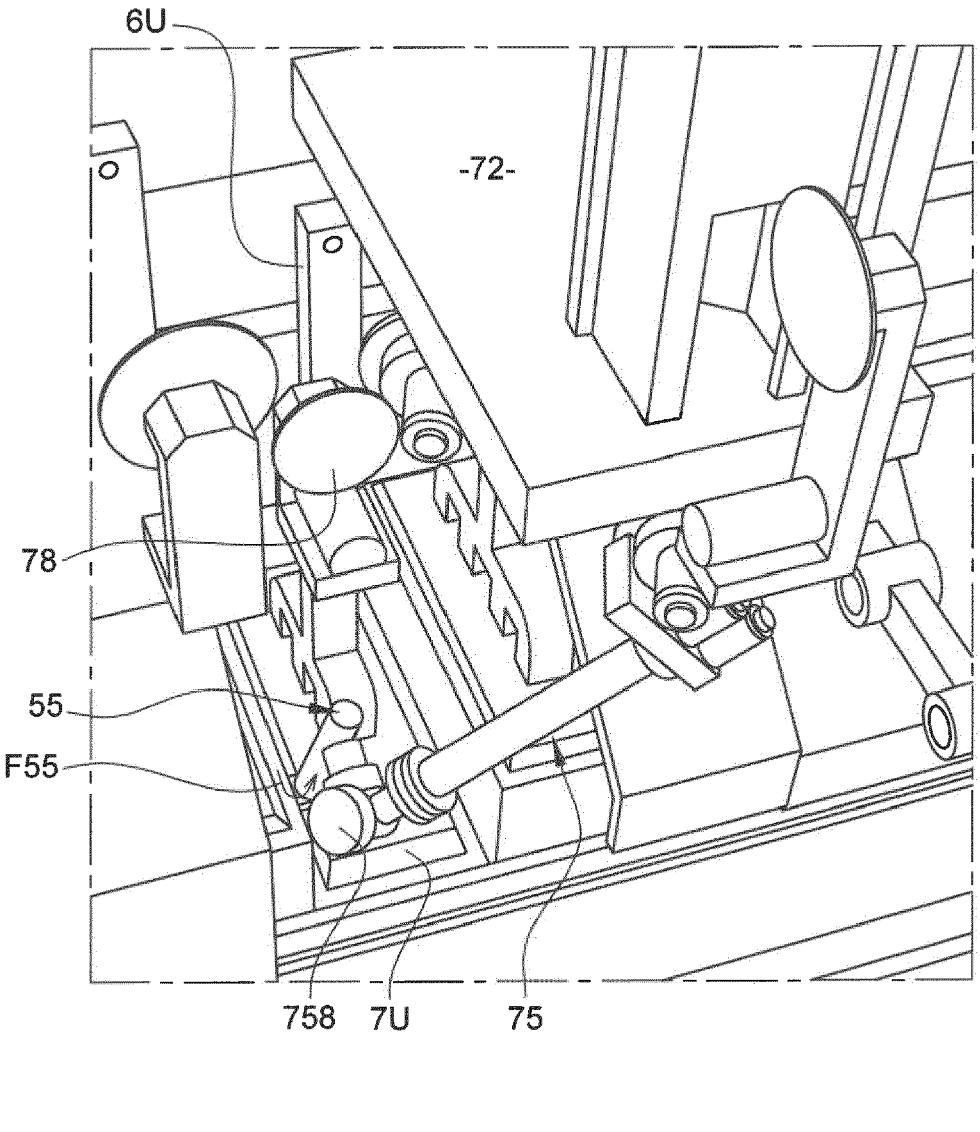


Fig. 14

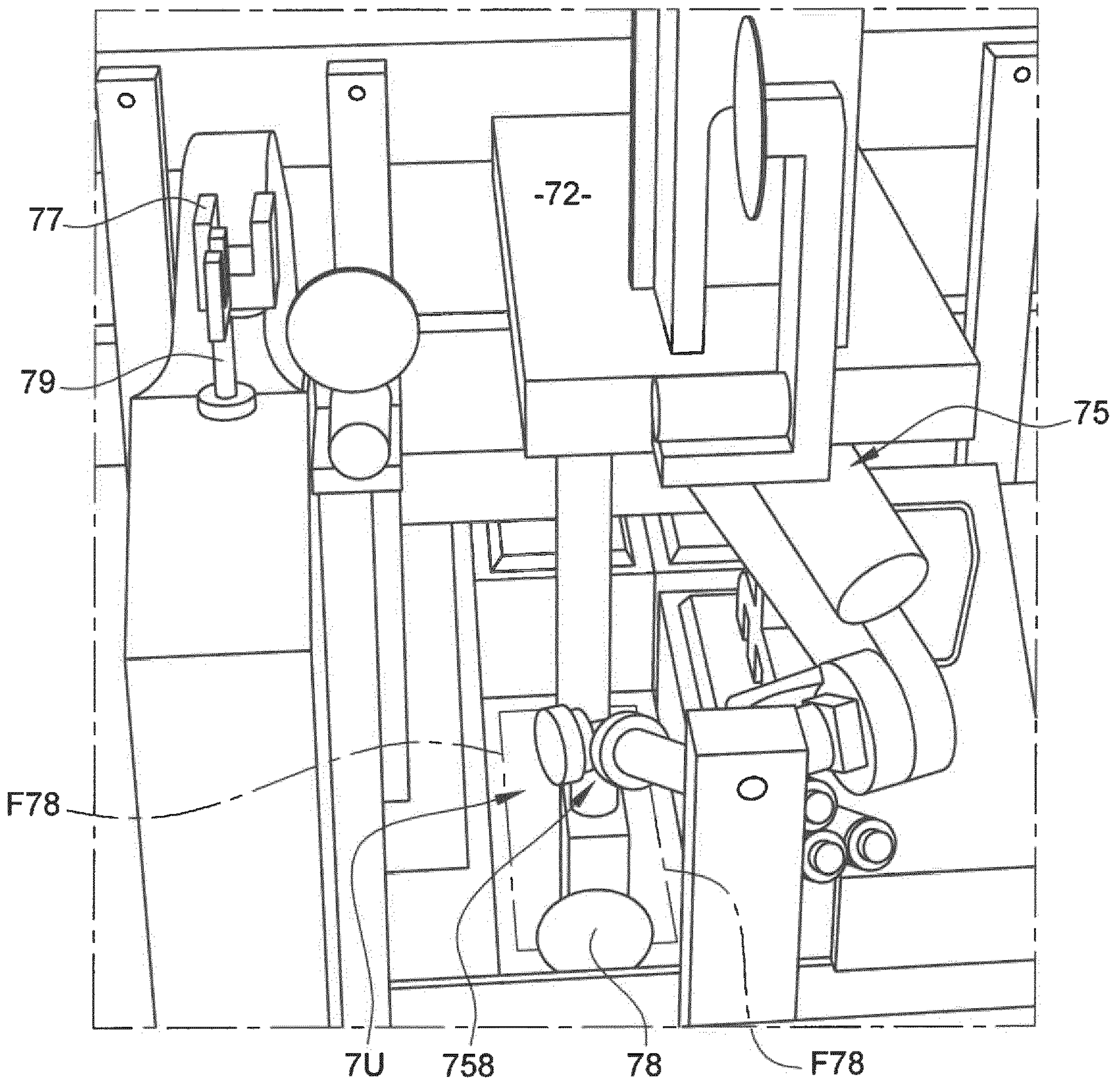


Fig. 15

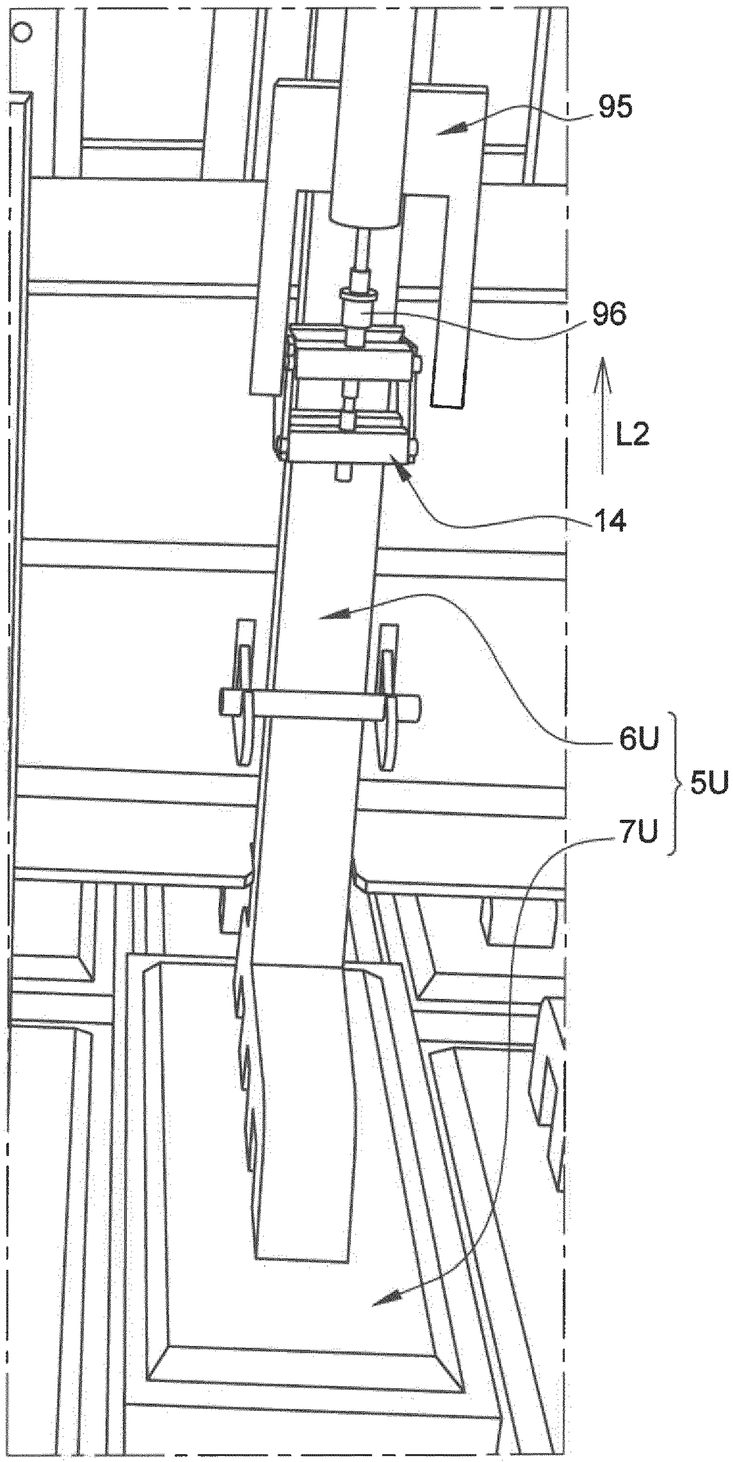


Fig. 16

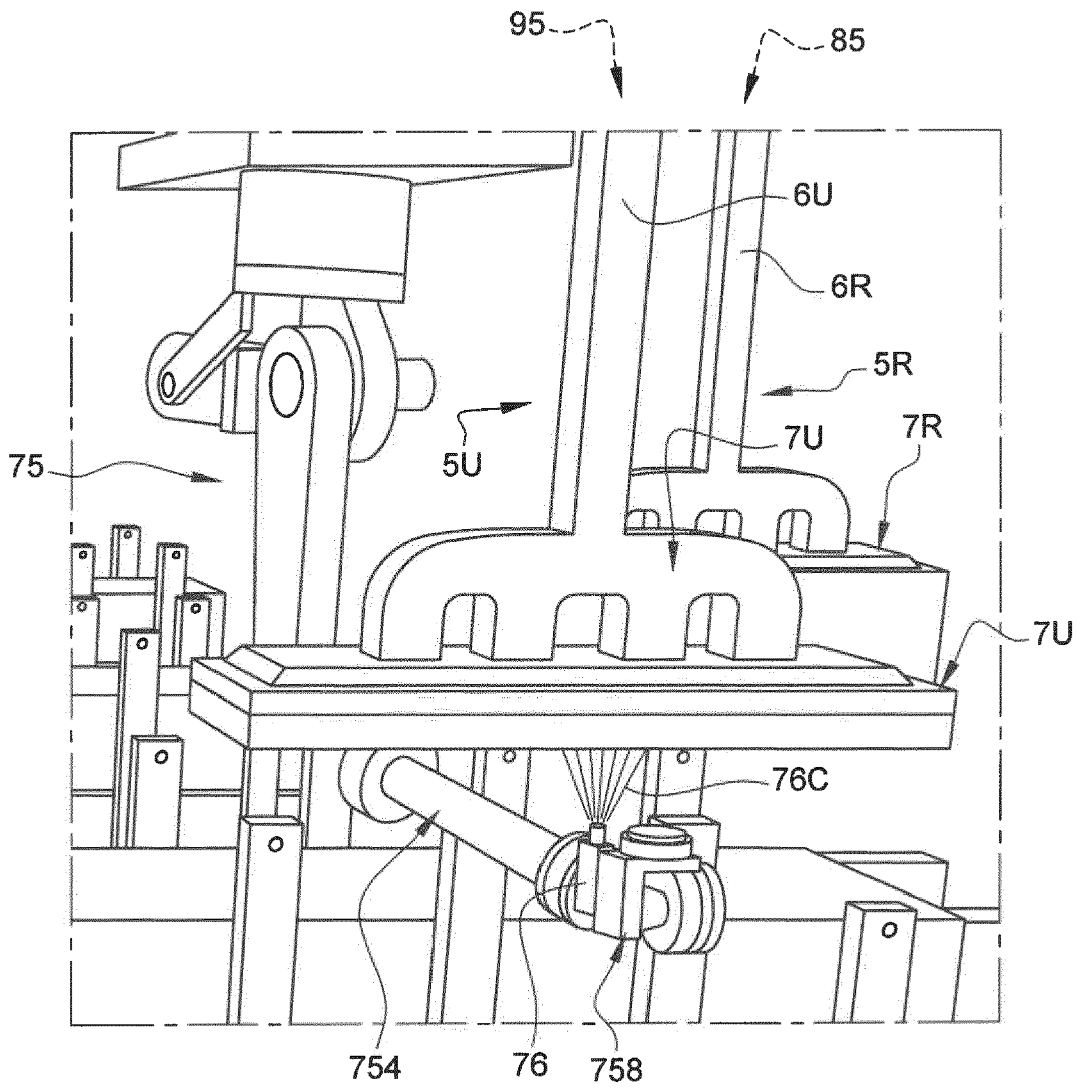


Fig. 17

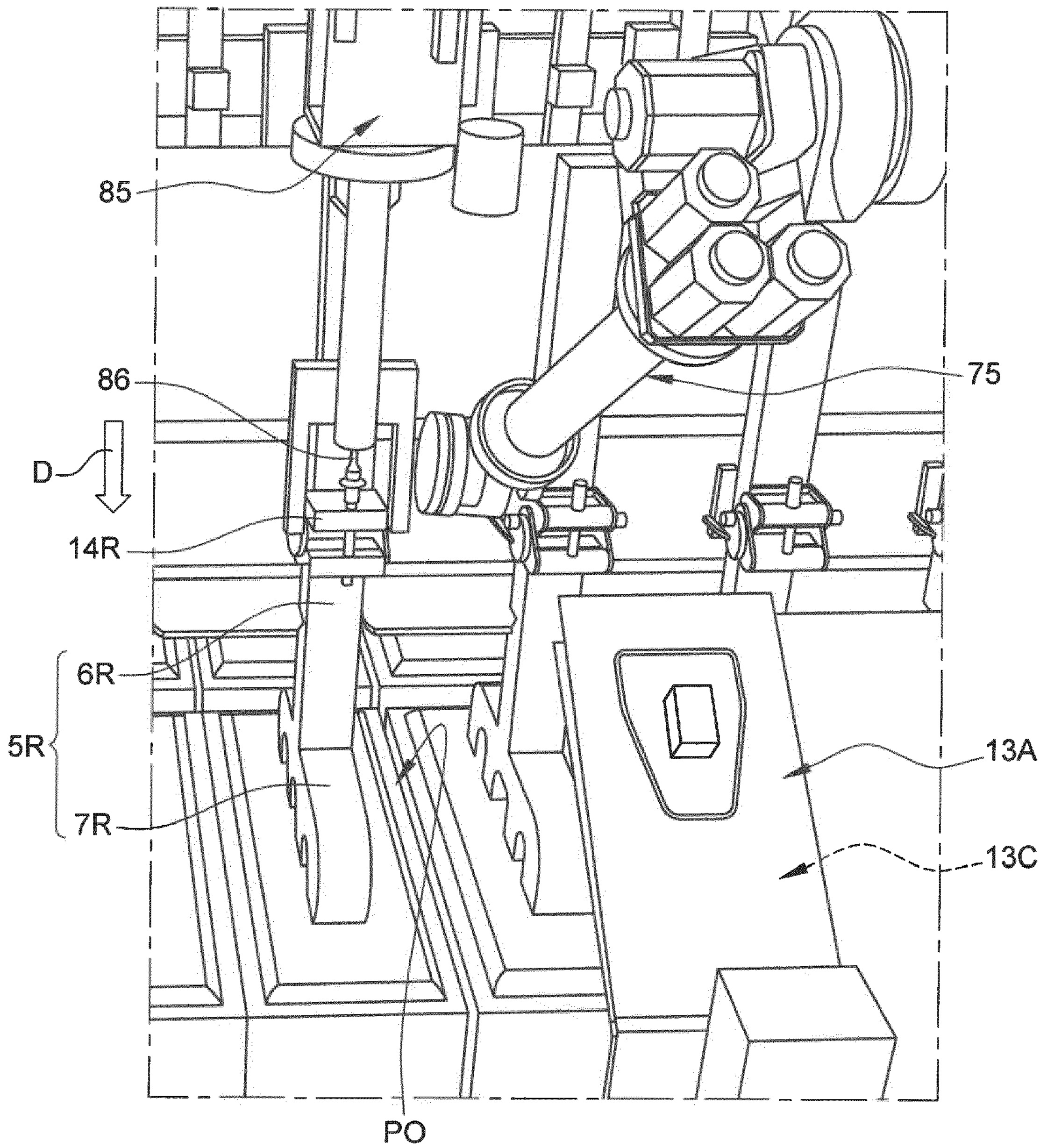
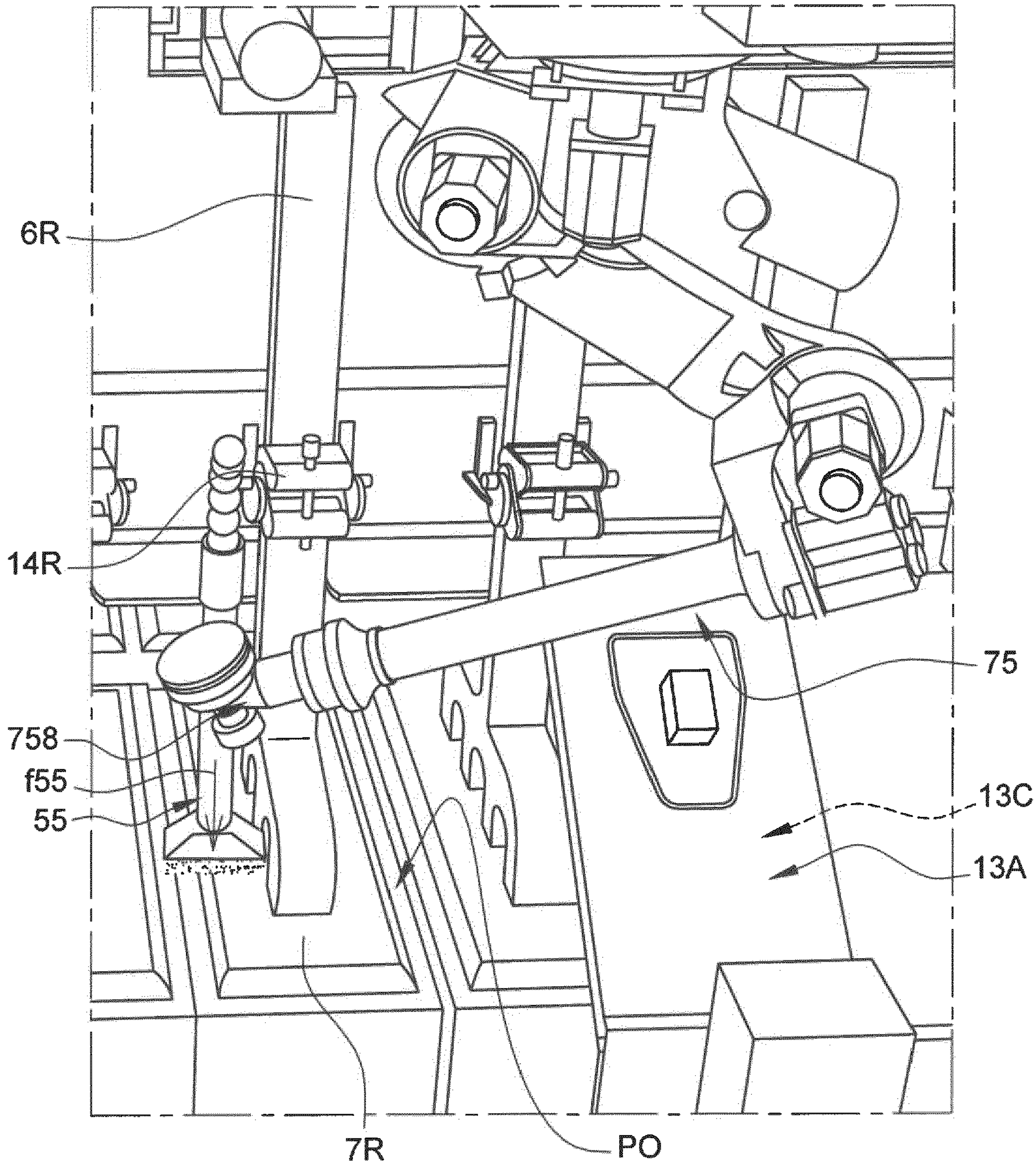


Fig. 18



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EUROPEAN SEARCH REPORT

Application Number
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	19 January 2023	Leu, Oana

1

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