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(54) Aluminium electrolytic reduction cells.

(57) In an electrolytic cell of the type in which a molten product metal such as Al is produced by electrolysis of a less dense fused electrolyte, there is provided a displacement block which can be raised or lowered in order to displace the fluid contents of the cell. This may be useful in order to reduce variations in the fused electrolyte surface level, or to tap metal from the cell. The block may be in the electrolysis compartment, in which case it may be an anode or a body of frozen electrolyte, or in a separate metal collection chamber which may be separated from the electrolysis compartment by a metal selective filter.

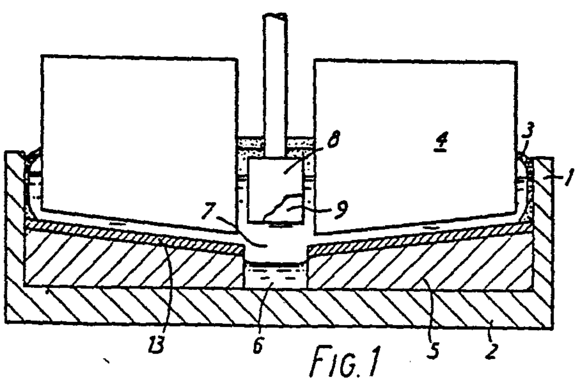

FIG. 1

EP 0 101 153 A2

"IMPROVEMENTS IN ELECTROLYTIC REDUCTION CELLS"

The present invention relates to monopolar or multipolar electrolytic reduction cells for the production of a molten metal product by electrolysis of a molten electrolyte.

In such cells the electrolyte is contained within a generally rectangular refractory lined shell and the cell is provided with one or more suspended anodes. For economic reasons the area occupied by the anode or anodes is a large proportion of the total cell floor area occupied by the electrolyte.

In a conventional electrolytic reduction cell of this general type the cell cathode is a liquid cathode, constituted by a pool of molten metal on the floor of the cell. The depth of this pool progressively increases during the normal cycle of the cell operation and is reduced at intervals when the cell is tapped. The active faces of the anodes are progressively raised to maintain the nominal value of the anode/cathode distance substantially constant and the level of the molten electrolyte in the cell rises and falls substantially in step with the rise and fall of the molten metal level in the metal pool.

Many proposals have been put forward to employ drained cathode structures in electrolytic reduction cells, in which the main body of the product metal is progressively drained from the active cathode surface. In such case the active cathode surface may be constituted by any of the following means:-

1) Solid drained surface (horizontal, vertical, or sloped) composed of plates, tiles or aggregate blocks, e.g. as described in U.S. 3,492,208 or U.S. 3,400,061.

2) Pedestals, e.g. as described in PCT WP 82 01899 or

EP 81 300382.9.

3) Metal retaining containers, e.g. as described in U.S. 4,071,420 or GB 82 17711.

4. Mushroom type projections e.g. as described in U.S. 4,177,128.

5) Metal retained by surface tension in the interstices of metal-wetted packed bed or layer of ceramic shapes e.g. as described in EP 82.303228.9, PCT, WP 81 02170, or FR 2,500,408.

In general, the preferred construction materials are refractory hard metals.

In a drained cathode type cell the product metal may be collected in a collection sump, from which it is conventionally tapped off, usually by siphoning, at extended intervals, for example 24 hour intervals. Alternatively, the metal may be stored among the cathode elements, or below the pedestals.

Where the cell is of the drained cathode type or other similar type, in which there is little or no variation in the level of the active cathode surface at the floor of the cell during normal operation of the cell, there is a relatively large variation in the level of the electrolyte surface, because the electrolyte, displaced by the produced metal, is forced upwardly into the restricted space surrounding the anode or anodes.

Large variations in the level of the electrolyte surface can result in substantial operating problems, which become more severe with increase in the ratio of total anode area to molten electrolyte top surface area. In particular large variations in the level of the electrolyte substantially disturb the heat balance of the cell and result in instability in the layer of frozen electrolyte at the cell walls and in the frozen electrolyte crust. Intermittent impregnation of the crust by the molten electrolyte tends to lead to uncontrolled increase in the crust thickness.

It is an object of the present invention to provide a means of operating an electrolytic reduction cell, in particular an electrolytic reduction cell of the drained cathode type in such a way that the variation in the level of the electrolyte surface is substantially reduced in relation to the rate at which product metal is produced and tapped under conventional practice.

In principle the method of the present invention relies on varying the space available for liquid (in relation to a datum level) in the cell. This may be achieved by raising or lowering a solid block, which is in contact with the molten cell contents to increase or decrease liquid space in line with increase or decrease of liquid metal during the conventional tapping cycle.

One method of carrying out the invention is to arrange for one or more of the cell anodes to be adjustable vertically independently of the remainder of the cell anodes. Just after tapping such anode or anodes are set level with the remaining anodes, but as the cell cycle proceeds such anode or anodes are raised to compensate for the increase of liquid contents of the cell. The electric current carried by the raised anodes decreases as a result of the increase in the anode/cathode distance as compared with that for the remainder of the anodes.

Other alternative arrangements are described with reference to the accompanying drawings in which

Figure 1 is a diagrammatic cross section of a cell equipped with a drained cathode.

Figure 2 is a longitudinal section of a displacement block for use in the construction of Figure 1.

Figure 3 is a diagrammatic representation of an alternative system for controlling cell electrolyte level.

Figure 4 is a longitudinal section through an electrolytic cell equipped with internal electrolyte level control and metal tapping system.

In Figure 1 the reduction cell comprises insulated side walls 1 and floor 2.

The side walls 1 (and end walls) are protected in the conventional manner by a layer 3 of frozen cell electrolyte. Rows of prebake type anodes 4 are arranged at each side of the cell and project to a predetermined depth in the molten cell electrolyte 7. The drained cathode is formed of titanium diboride or other "hard metal" shapes 13 which are supported on carbonaceous cathode blocks 5 and have slightly inclined upper surfaces which slope downwardly to a central trough or sump 6, in which the molten metal product collects and is tapped off periodically.

The trough requires to be of such size to accommodate the metal produced in a normal metal tapping cycle. Since anodes 4 themselves remain at a fixed position in relation to the cathode blocks 5, the electrolyte displaced from the trough 6 by molten metal rises into the space surrounding the anodes.. In order to limit the extent of the change in electrolyte level (which results in progressive change in the level and shape of the protective freeze layer 3) a vertically movable block 8 dips into the electrolyte and is shaped so that it may descend into the trough 6. As metal progressively displaces electrolyte from the trough, the block 8 is raised to lift an increasing portion of the block out of the electrolyte, thus increasing the space available for liquid electrolyte. This system may be employed to compensate in whole or only in part and thus may be employed to maintain the electrolyte level essentially constant or to allow progressive slight increase in electrolyte level during a normal operating cycle.

The trough 6 and co-operating displacement block 8 may be arranged longitudinally of the cell (as shown) or transversely or at one end of the cell (or at both ends for a very large cell). The block 8 is preferably arranged over the sump, but may be at a different location in some instances.

It is convenient to provide a small ancillary section 9 of the displacement block 8 at the siphon tapping location. This can be lifted out of the cell in advance of the tapping operation without causing appreciable disturbance of the electrolyte level.

The displacement block 8 may be formed of carbon (or be constituted by one or more anodes as already explained).

However it is convenient for the displacement block to be formed essentially of a frozen body of electrolyte. As illustrated diagrammatically in Figure 2 a series of metal fins 11 are arranged on one or more hollow supports 10, through which a coolant (air or gas) is passed, thus maintaining a solid mass 12 of frozen electrolyte to cover the fins 11.

In the described embodiment the compensating displacement block is located in the molten electrolyte and is raised or lowered to compensate for the correct change of electrolyte level.

In an alternative system illustrated in Figure 3 the displacement block is located in a vessel outside the electrolysis compartment of the cell. Such a vessel may be inside or outside the steel shell of the cell. In this instance the molten metal collects in a relatively small sump 26 at one end of the cell and this communicates with a separate metal collection chamber 27 via a passage 28.

The level of molten metal in the chamber 27 is controlled by a vertically movable block 29, which may be formed of alumina or other refractory, which is not subject to attack by molten aluminium. The block is withdrawn at a rate set by the metal production rate of the cell, which is essentially constant. This maintains a constant metal level in the chamber 27. Alternatively, the drive system for the block 29 may be controlled by a sensor, which continually senses the metal level in the chamber 27. The rate of upward movement of the block 29 may then be automatically adjusted in order to maintain a substantially constant metal level in the chamber 27. By maintaining a relatively constant metal level in chamber 27, the level of metal in the collection sump 26 and the level of cell electrolyte are also maintained substantially constant.

Although it may not be necessary in every instance, particularly where the passage 28 leads upwardly out of the bottom of a relatively deep sump, in which a substantial head of molten metal is maintained by means of the operation of the block 29 it is preferred that a selective filter of the type described in Europe Patent Specification No. 68782 be interposed between the electrolyte in the cell and the chamber 27 to avoid entry of the cell electrolyte into the chamber. For this purpose the sump 26 may be of small size and be filled with correctly sized balls or fragments of TiB_2 or other "hard metal" refractory, which is resistant to attack by molten aluminium and molten cell electrolyte.

In Figure 3 the cell is provided with a drained cathode structure 35, provided with cathode current collectors (not shown) and conventional overhead anodes 34.

Product metal is drawn off at intervals, such as 24-hour intervals, from the chamber 27 by conventional means, such as siphon tapping. Where the selective filter is present it is preferred to displace the metal from the chamber 27 through a spout 36 into the collection crucible (not shown) by simply driving the displacement block down to the bottom of the chamber. High resistance to the fluid flow through the selective filter prevents re-entry of any substantial amount of metal back into the electrolysis compartment of the cell. It is preferred to maintain an inert gas cover in the upper part of the chamber 27.

Alternatively, the product metal can be drawn off from the collection chamber 27 at much more frequent intervals, for example every 15 minutes. This has several advantages. The metal collection chamber can be made comparatively small and can conveniently be fitted within the steel shell of the cell. For example, if a cell which produces 1 to 2 tons of metal per day is tapped every 15 minutes, the yield is only 10 - 20 kg per tapping. The storage capacity for such yield is easily accommodated in a transfer tube in which the displacement lock travels.

Another advantage is that the metal can be tapped into a molten metal pipeline as described in European Specification 68782. The electrical insulation between the cells which are interconnected by the molten metal pipeline can be maintained by activating the displacement blocks in different cells in sequence, so that at any one time only one cell would be being tapped and in electrical contact with the molten metal pipeline. This arrangement can be used as the basis for a completely automatic metal tapping system.

Figure 4 shows an alternative system in which the metal collection vessel is placed with its lower end in the sump 26, rather than merely communicating with the sump by means of a passage 28 as shown in Figure 3. In Figures 3 and 4, like numerals denote like parts.

In Figure 4, a metal transfer spout 36 leads to a collection vessel 37 which may be either a collection crucible or a molten metal pipeline.

A metal selective filter 25 is provided across an entry point at the bottom of the metal collection vessel. Alternatively, this filter could have been provided in the sump 26. For frequent or automatic tapping, a metal selective filter is not essential, although it is preferred to avoid the risk of entry of electrolyte into the metal collection chamber. Any form of restricted orifice can be used at the entrance 25 to the metal collection chamber to ensure that lowering of the displacement block 29 drives molten metal into the tapping system and not back into the cell. Preferably, more than one metal collection chamber is used for each cell. Then, if one metal collection chamber accidentally becomes blocked or otherwise ceases to function, it can simply be lifted out of the sump, without the need to interrupt operation of the cell, and replaced after repair.

C L A I M S

1. A method of operating an electrolytic reduction cell of the type in which a molten product metal is produced by electrolysis of a fused electrolyte which is less dense than the molten product metal, characterized by providing a displacement block in contact with the molten cell contents and raising or lowering the block to increase or decrease the liquid space in the cell, so as to reduce variation in the level of the electrolyte surface in relation to the rate at which product metal is produced and tapped.

2. A method as claimed in claim 1, in which the cell is of the drained cathode type.

3. A method as claimed in claim 1 or claim 2, wherein the displacement block is raised or lowered in contact with the cell electrolyte.

4. A method as claimed in any one of claims 1 to 3, wherein the cell includes anodes suspended in the electrolyte, and one or more of the anodes is adjustable vertically to act as the displacement block.

5. A method as claimed in any one of claims 1 to 3, wherein the displacement block consists of a hollow cooled support surrounded by a mass of frozen electrolyte.

6. A method as claimed in any one of claims 2 to 5, wherein the cell is provided with a sump for collection of product metal, and the displacement block is positioned over the sump.

7. A method as claimed in claim 1 or claim 2, wherein the displacement block is located in a vessel outside the elctrolysis compartment of the cell.

8. A method as claimed in claim 7, wherein the displacement block is located in contact with product metal in a separate metal collection chamber.

9. A method as claimed in claim 8, wherein the metal collection chamber is in communication with the electrolysis compartment of the cell via a selective filter which permits the passage of molten product metal but not of fused electrolyte.

10. A method as claimed in claim 9, wherein product metal is tapped from the metal collection chamber by lowering the displacement block therein.

11. An electrolytic reduction cell of the type in which a molten product metal is produced by electrolysis of a fused electolyte which is less dense than the molten product metal and comprising an electrolysis compartment and a separate metal collection chamber, characterized in that there is provided a displacement block in contact with molten metal in the metal collection chamber, and means for raising or lowering the block.

12. A cell as claimed in claim 11, wherein the electrolysis compartment is of the drained cathode type having a sump for molten product metal.

13. A cell as claimed in claim 12, wherein the metal collection chamber is in communication with the electrolysis compartment via a selective filter which permits passage of molten product metal but not of fused electrolyte.

14. A cell as claimed in any one of claims 11 to 13, wherein the means for raising or lowering the displacement block are operable to tap product metal from the metal collection chamber.

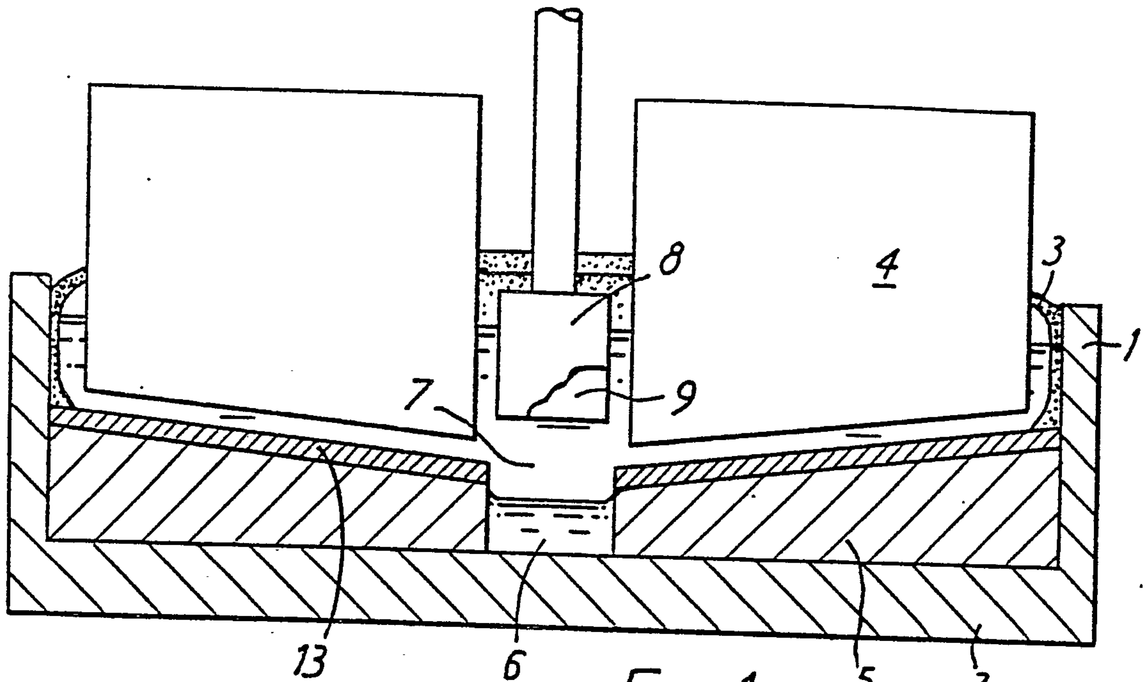

FIG.1

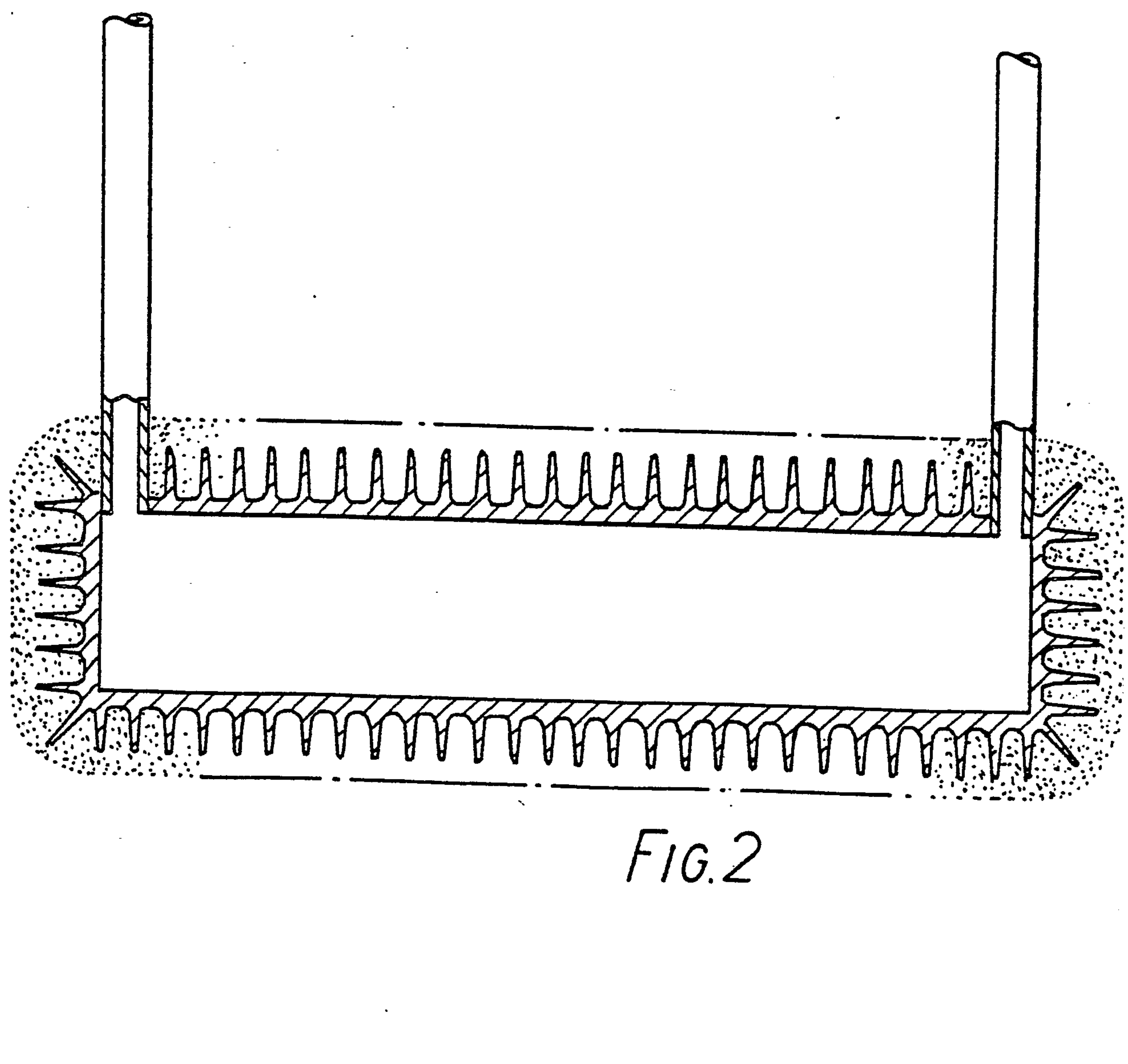

FIG.2

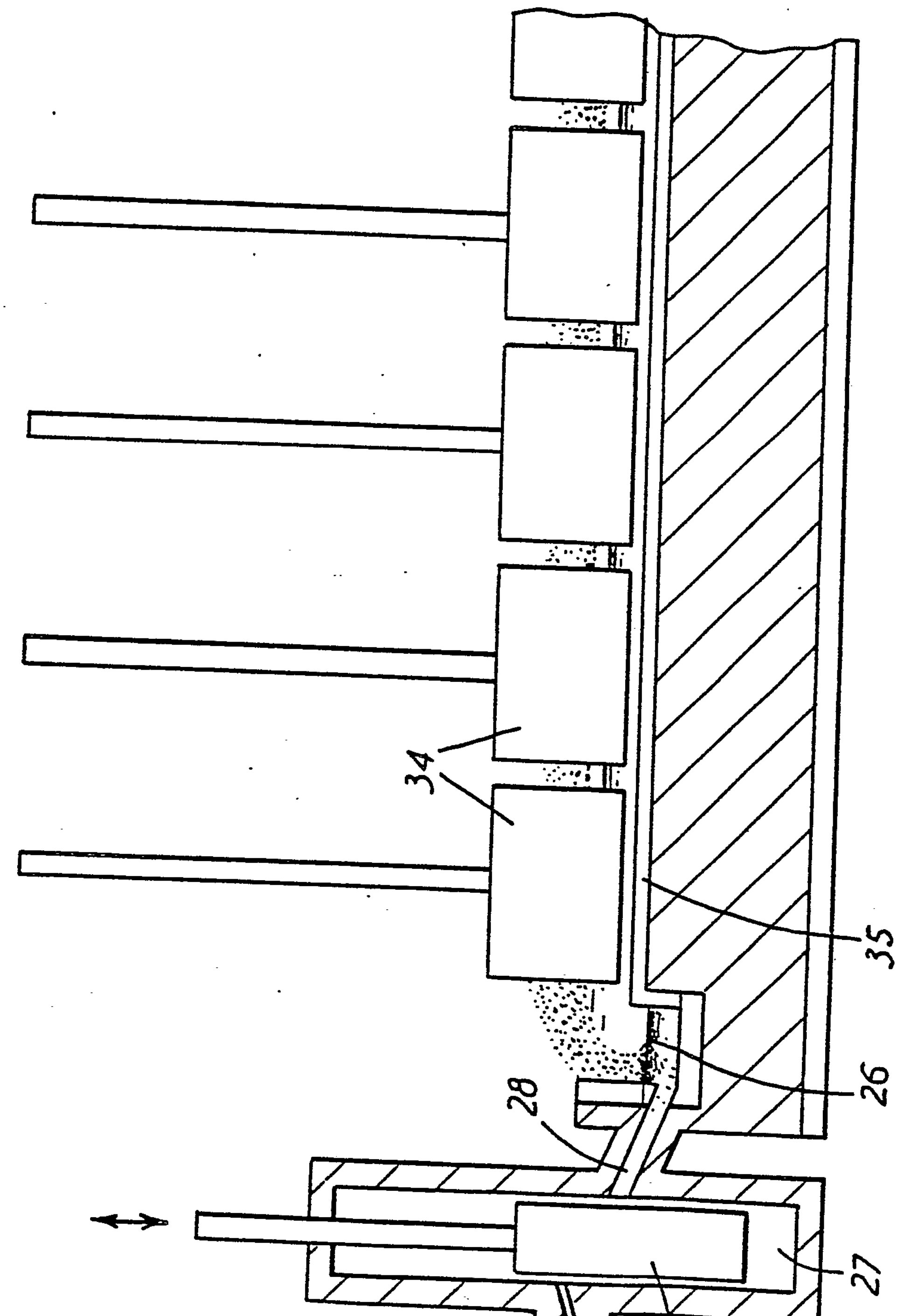

FIG. 3

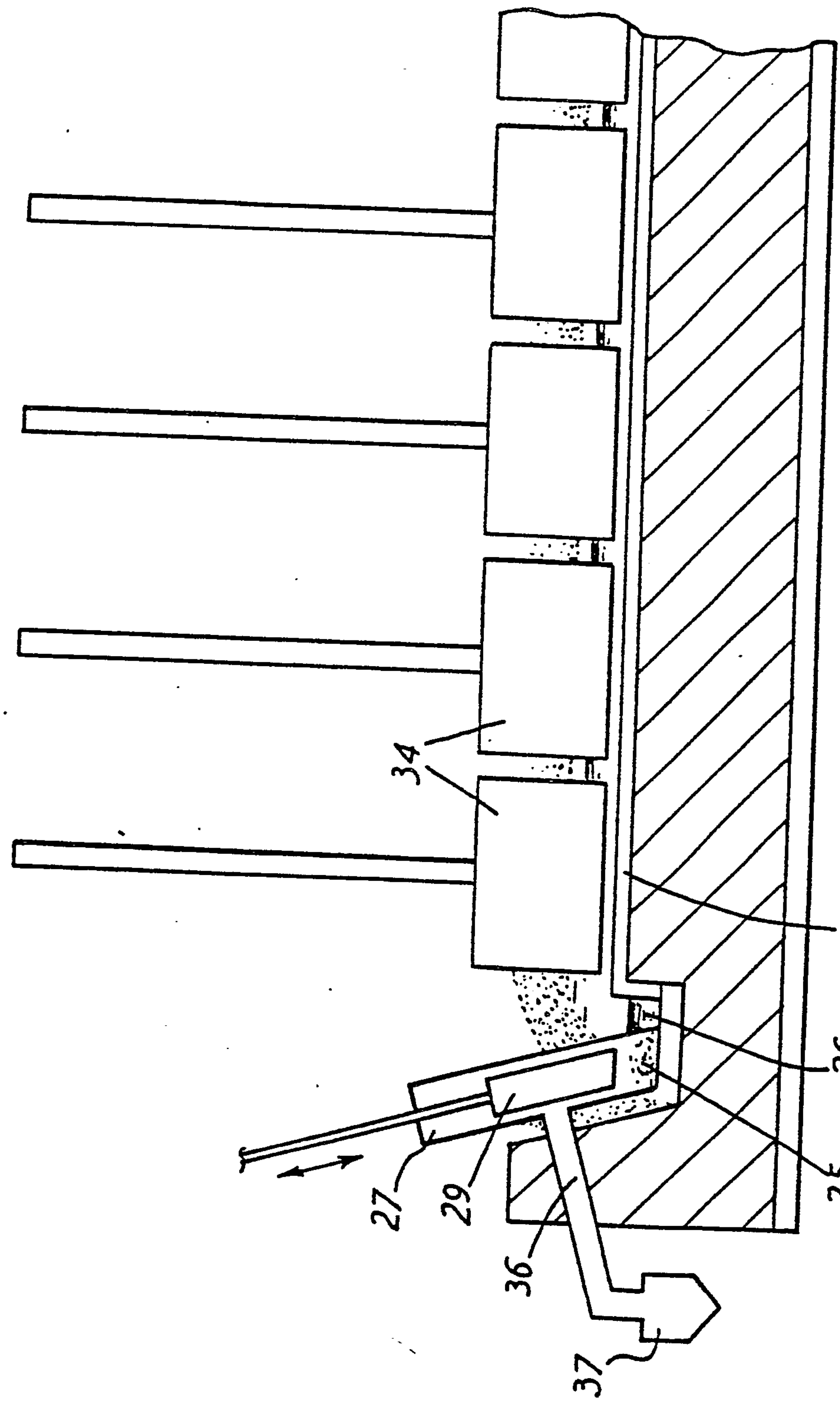

FIG.4