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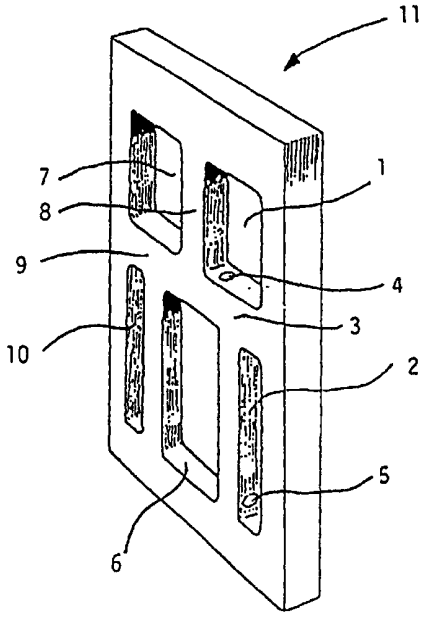
(54) Title: A CELL ELEMENT FOR USE IN A DEVICE FOR CARRYING OUT AN ELECTROLYTIC PROCESS, A DEVICE TO BE USED FOR THAT PURPOSE AS WELL AS A METHOD FOR CARRYING OUT SUCH AN ELECTROLYTIC PROCESS



(57) Abstract: The present invention relates to a cell element for use in a device for subjecting a chloride compound to an electrolytic process, wherein several electrolytic cells are electrically connected in series, said cells consisting of said cell element, a bipolar electrode and a diaphragm or a semi-permeable membrane, wherein said cell element includes an electrolyte space and an electrode space. The invention is characterized in that the electrolyte space and the electrode space are in direct communication with each other, wherein the electrolyte space is subdivided into a first and a second electrolyte chamber by a dividing element.

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Title: A cell element for use in a device for carrying out an electrolytic process, a device to be used for that purpose as well as a method for carrying out such an electrolytic process.

The present invention relates to a cell element for use in a device for subjecting a chloride compound to an electrolytic process, in which device several electrolytic cells are electrically connected in series, said cells consisting of said cell element, a bipolar electrode and a diaphragm or a semi-permeable membrane, wherein said cell element includes an electrolyte space and an electrode space. The present invention furthermore relates to a method for subjecting a chloride compound to an electrolytic process, wherein several electrolytic cells are electrically connected in series, said cells consisting of a cell element, which includes an electrolyte space and an electrode space, a bipolar electrode and a diaphragm or a semi-permeable membrane, which cells are surrounded by an encasing comprising two end plates. The present invention furthermore relates to a method for subjecting a chloride compound to an electrolytic process in an electrolysis device.

The cell element as referred to in the introduction is known per se from the previously filed European patent application no. 0 958 407 in the name of the present applicant. The cell element that is used therein is characterized in that the cathode space is in direct communication with the catholyte space, which catholyte space also functions as an outlet for hydrogen gas, and in that the anode space is in direct communication with the anolyte space, which anolyte space functions as an outlet for chlorine gas, whereby there is no communication between the catholyte space and the anolyte space. A construction of this kind ensures that the hydrogen gas which is produced at the cathode during the electrolytic process can exit the cathode space via the opening present at the upper side thereof. The hydrogen gas which is thus transported from the cathode space to the catholyte space, which hydrogen gas accumulates in the space present above the surface of the catholyte fluid, ensures that "fresh" catholyte is drawn into the cathode space via an opening present at the bottom side. This process is sometimes referred to as the "bubble pump". In the cathode space the fresh catholyte material thus supplied is subsequently converted into hydrogen gas, which gas exits the cathode space via the opening present at the upper side. The use of two

openings ensures that there will be a continuous supply of fresh starting material in the catholyte space and a continuous discharge of reaction products. A construction of this kind is also used with the anode space and with the anolyte space. Said European patent application no. 0 958 407 can furthermore be considered as a further development of European patent no. 0 427 340 as granted to the present applicants.

German Offenlegungsschrift no. 36 03 254 furthermore relates to a cell frame which is composed of a cathode gas part and an anode gas part, which parts are in communication with the electrolytic cell part via a communication opening.

The object of the electrochemical cell that is known from US patent no. 4,371,433 is to minimize or prevent shunt current flow via the electrolyte, parallel to the actual electrolytic process between the cathode and the anode. According to said US patent specification this objective is accomplished by an interruption of the flow of conductive fluid (electrolyte) between the electrode space and the other compartments by means of a free fall of the fluid to a significantly lower fluid level. For the present invention, on the other hand, a pump system is not required for realising the increased potential pressure so as to enable said free fall.

British patent specification no. 761,823 relates to a bipolar electrolyser, wherein external pumps are used for forcing the electrolytes over a "high" threshold into the practically empty degassing chambers, so that an interruption is provided between the electrode space and the other compartments.

The present inventors have carried out extensive research with a view to improving the prior art electrolysers, in particular the cell element to be used therein. It has been found that during the electrolytic process the concentration of chloride compound of the aqueous flow of saturated brine solution that is supplied to one of the end sides of the encasing decreases in the direction of the location where the chlorine gas that has formed during the electrolytic process is discharged. This means that the concentration of chloride compound of a brine solution that is measured at the end side of the encasing where the discharge of the chlorine gas takes place, lies far below the saturation concentration. Such a decrease is the natural result of the formation of chlorine gas. Since the concentration of chloride compound

becomes lower and lower in the direction of the end side where the discharge of the chlorine gas takes place, this will have an adverse effect on the overall efficiency of the electrolyser.

The object of the present invention is thus to provide a cell element as well as a device and a method for subjecting a chloride compound to an electrolytic process, wherein the efficiency has been enhanced in comparison with the prior art devices.

Another object of the present invention is to provide a cell element, a device as well as a method for subjecting a chloride compound to an electrolytic process, wherein a durable construction is obtained without complex adaptations being required.

Another object of the present invention is moreover to provide a cell element, a device as well as a method for subjecting a chloride compound to an electrolytic process, wherein leakage of the electrolyte from the electrolytic cell is prevented. In addition it is desirable to use an electrolysis device which does not require the use of separate degassing tubes, as is already known from European patent no. 0 427 340.

According to the present invention, the cell element referred to in the introduction is characterized in that the electrolyte space and the electrode space are in direct communication with each other, wherein the electrolyte space is subdivided into a first and a second electrolyte chamber by a dividing element.

The use of such a dividing element leads to separate fluid flows being created within the device for carrying out the electrolysis, which separate fluid flows preferably contain a maximum concentration of chloride compound.

In a special embodiment of the present cell element, the dividing element is preferably integrally formed with the cell element.

Such an integral construction of the dividing element reduces the risk of leakage to a significant degree. Moreover, a cell element of this kind can readily be manufactured by means of an injection moulding process, so that there is no need to use additional connecting structures.

The electrolyte space of the present cell element can in particular be considered as an anolyte space, which anolyte space is subdivided into a first and a second anolyte chamber by means of an anolyte

dividing element, wherein in a special embodiment the volume of the first anolyte chamber is preferably equal to or larger than the volume of the second anolyte chamber.

The anolyte space functions to discharge the chlorine gas, so that it is desirable in view of the high concentration of chloride compound in the electrolytic cell that the volume of the first anolyte chamber is larger than the volume of the second anolyte chamber. The first anolyte chamber primarily functions to discharge chlorine gas, whilst the second anolyte chamber in particular comprises aqueous fluid flows.

In addition, the electrolyte space of the present cell element is preferably also a catholyte space, which catholyte space is subdivided into a first and a second catholyte chamber by means of a catholyte dividing element, wherein the volume of the first catholyte chamber is preferably equal to or larger than the volume of the second catholyte chamber.

The catholyte space functions to discharge hydrogen gas, wherein said first catholyte space may be considered to be a chamber in which the hydrogen gas is collected, whilst the second catholyte chamber can be considered to be a chamber in which the aqueous fluid flows are present.

It is furthermore preferred to form the cell element in one piece, so that dimensional stability is ensured. Thus, possible stresses will not lead to leakage, which is one of the objectives of the present invention. In addition to that , such cell elements are easy to manufacture, and that with great precision. It is in particular preferable for the cell element to have a rectangular geometry, wherein the part that forms the anolyte space and the part that forms the catholyte space have a P-shaped structure, wherein the two P-shaped structures are present in the cell element, being separated from each other by an intermediate member and by the space of the bipolar electrode. Thus the desired bubble pump function can be achieved with a small amount of fluid in the anolyte space and in the catholyte space. In particular, both the anolyte space and the catholyte space have a P-shaped geometry, which P-shaped geometry is made up of an intermediate member that forms part of the first anolyte space or catholyte space and the space of the bipolar electrode.

In a special embodiment of the present invention the bipolar electrode is preferably integrated in a cell element, wherein it

is in particular preferable that the intermediate member includes a discharge channel for direct communication between the electrolyte space and the electrode space, which discharge channel forms a connection between the electrode space and the first electrolyte chamber, with no connection being present between the catholyte space and the anolyte space.

Such a special embodiment of the present cell element makes it possible to interconnect two separate cell elements in a sandwich construction, wherein a diaphragm or a semi-permeable membrane is disposed between two respective cell elements. Moreover, such a diaphragm or semi-permeable membrane additionally functions as a gasket, thus minimizing the risk of leakage. For more detailed information with regard to such a construction reference is made to the accompanying figures.

In a special embodiment the present cell element includes a recess into which the bipolar electrode can be placed, which recess is provided with corrugations all around.

The use of corrugations ensures that the bipolar is properly sealed in the recess of a cell element, thus preventing leakage of the fluid in the cathode space to the anode space and vice versa. Preferably, such corrugations are also present on the cell element so as to ensure the fixation and sealing of the diaphragm or semi-permeable membrane with respect to the cell element.

The present invention furthermore relates to a device for subjecting a chloride compound to an electrolytic process, wherein several electrolytic cells are electrically connected in series, said cells consisting of a cell element, which includes an electrolyte space and an electrode space, a bipolar electrode and a diaphragm or a semi-permeable membrane, wherein said cell elements are surrounded by an encasing comprising two end plates, which device is according to the invention characterized in that one or more of the above-described cell elements are used.

In such a device it is in particular preferable to connect the electrolytic cells in series in such a manner that alternately a cathode space and an anode space are provided.

In the present invention, in order to achieve a high concentration of chloride compound in the aqueous fluid flows, the dividing elements of the series-connected electrolytic cells preferably form a division plate extending along the length of the device, wherein both the

catholyte space and the anolyte space extending along the length of the device can be considered as a succession of first and second catholyte and anolyte spaces, respectively, which are separated from each other by a catholyte dividing element and an anolyte dividing element, respectively.

Maintaining a high concentration of chloride compound in the aqueous flows of the present invention is in particular realised in that a metering element is disposed near the end side of the encasing, where the discharge of the chlorine gas that has formed during the electrolytic process takes place, in which metering element the aqueous flow in the electrolytic cell is enriched with chloride compound.

In specific embodiments it is preferable to position the metering element within the encasing. With such an embodiment a device is obtained wherein no external discharge and supply pipes are needed, so that a compact arrangement can be obtained, with this exception that a supply element for the chloride compound is required.

In a special embodiment it is preferable to position the metering element outside the encasing, however.

According to such a construction the aqueous fluid flow must be led to an external metering element, in which metering element the incoming aqueous flow is enriched with chloride compound. Then the aqueous flow that has been enriched with chloride compound is returned to the device, thus realising the desired high concentration of chloride compound.

The present invention furthermore relates to a method for subjecting a chloride compound to an electrolytic process in an electrolysis device, which method is according to the present invention characterized in that said electrolytic process is carried out in the aforesaid device.

The method according to the present invention is further characterized in that the electrolytic cells are electrically connected in series in such a manner that a fluid flow of the aqueous solution of the chloride compound takes place both in the first and in the second electrolyte chamber, with said flows taking place in opposite directions.

According to such a method, at one end side of the encasing there will be generated a flow in the direction of the other end side, where the chlorine gas is discharged. At the former end side enrichment with chloride compound will take place, after which the aqueous

solution containing the enhanced concentration will flow in the direction of the end side. Thus a continuous flow of aqueous solution containing a maximum chloride concentration is ensured, which significantly enhances the efficiency of the present invention in comparison with the prior art devices.

The present invention will be discussed in more detail hereafter with reference to a number of drawings, whereby it should be noted, however, that the present invention is by no means limited so such special drawings.

Figure 1 is a schematic representation of a special embodiment of the present cell element.

Figure 2 is a special embodiment of the present invention, in which the cell element according to Figure 1 is incorporated.

Figure 3 is a special embodiment of the present cell element.

Figure 4 is a special embodiment of the present cell element.

In Figure 1 the present cell element is indicated by numeral 11. The present cell element 11 comprises a first anolyte chamber 1, a second anolyte chamber 2, a first catholyte chamber 7, a second catholyte chamber 10, with the anolyte dividing element being indicated by numeral 3 and the catholyte dividing element being indicated at 9. Second anolyte chamber 2 comprises an opening 5, so that the second anolyte chamber communicates with electrode space 6, in which a bipolar electrode (not shown) can be placed. As a result of the electrolytic process that takes place in electrode space 6, chlorine gas (not shown) is formed, which chlorine gas moves to first anolyte chamber 1 via opening 4. Figure 1 clearly shows that first anolyte chamber 1 is separated from first catholyte chamber 7 by means of an intermediate member 8.

In Figure 2 the present device is indicated by numeral 12. The cell element that is schematically shown in Figure 1 is incorporated in device 12, whereby bipolar electrode 18 can be considered to be a negative electrode 16 and a positive electrode 17. Electrolysis device 12 can be considered to be a number of series-connected cell elements 23, 11, 14, 24, with a diaphragm or semi-permeable membrane 19 being disposed between cell elements 14 and 24. A similar construction is used between cell element 11 and cell element 23. In Figure 2 the

direction of flow of the aqueous solution in the first anolyte spaces 1 and the second anolyte spaces 2 is schematically indicated by means of arrows. The aqueous solution is thus capable of enhancing its concentration of chloride compound by flowing past an amount of chloride compound 22 at end side 15. The chloride compound 22 is supplied to end side 15 via supply element 20, which supply element 20 includes a conical member 21. Metering preferably takes place at a variably reduced pressure, in particular in combination with variable heating. According to such an embodiment, a maximum concentration of chloride compound is ensured in each cell element 24, 14, 11, 23, so that the output of chlorine gas is maximized. For a better understanding of the parts of the electrolysis device 12 that is shown in Figure 2, reference is made to European patent application no. 0 958 407 filed in the name of the present applicant, which document may be considered to be incorporated herein.

It should be understood that the present device 12 is by no means limited to the specific number of cell elements used therein.

Figure 3 shows a special cell element according to the present invention, wherein the bipolar electrode 35 is integrated in cell element 30. Cell element 30 comprises a first anolyte chamber 31 and a second anolyte chamber 32, as well as a first catholyte chamber 33 and a second catholyte chamber 34. The gas that has formed upon electrolysis is carried from electrode space 38, in which bipolar electrode 35 is disposed, into first catholyte chamber 33 via discharge channel 36. A similar construction is used in electrode space 38, which is disposed to the rear of bipolar electrode 35, wherein the gas that has formed in said electrode space 38 is carried to first anolyte chamber 31 via the discharge channel 39 that is present at the rear side. It should be understood that the cell element as shown in Figure 3 is in particular suitable for use in the electrolysis device 12 that is shown in Figure 2.

The cell element 40 that is shown in Figure 4 is in fact similar to the cell element 30 that is shown in Figure 3, with bipolar electrode 45 being integrated in cell element 40. Cell element 40 comprises a first anolyte chamber 41 and a second anolyte chamber 42, as well as a first catholyte chamber 43 and second catholyte chamber 44. The gas that is formed upon electrolysis is carried from electrode space 48, in which bipolar electrode 45 is disposed, into first catholyte chamber 43 via discharge channel 46. A similar construction is used in electrode space

48, which is disposed to the rear of bipolar electrode 45, wherein the gas that has formed in said electrode space 48 is carried to first anolyte chamber 41 via the discharge channel 49 that is present on the rear side. It should be understood that the cell element that is shown in Figure 4 is in particular suitable for use in the electrolysis device 12 that is shown in Figure 2. Cell element 40 is different from cell element 30 in that the second electrolyte chamber 42, 44 is disposed under rather than beside electrode space 48. Thus it is possible to realise a relatively smaller electrolyte chamber 42, 44 while using the same dimension of cell element 40, so that a relatively larger electrode space 48 will be obtained, which results in a higher cell output. Although the present inventors do not wish to be bound by any theory, it is probable that cell element 40 exhibits an improved behaviour in comparison with cell element 30, because it applies that the lower the specific mass of anolyte, the better the result and thus the better the cell supply.

CLAIMS

1. A cell element for use in a device for subjecting a chloride compound to an electrolytic process, wherein several electrolytic cells are electrically connected in series, said cells consisting of said cell element, a bipolar electrode and a diaphragm or a semi-permeable membrane, wherein said cell element includes an electrolyte space and an electrode space, characterized in that the electrolyte space and the electrode space are in direct communication with each other, wherein the electrolyte space is subdivided into a first and a second electrolyte chamber by a dividing element.

2. A cell element according to claim 1, characterized in that said dividing element is integrally formed with said cell element.

3. A cell element according to claims 1 - 2, characterized in that electrolyte space is an anolyte space, which anolyte space is subdivided into a first and a second anolyte chamber by means of an anolyte dividing element.

4. A cell element according to claim 3, characterized in that the volume of the first anolyte chamber is equal to or larger than the volume of the second anolyte chamber.

5. A cell element according to claims 1 - 2, characterized in that the electrolyte space is a catholyte space, which catholyte space is subdivided into a first and a second catholyte chamber by means of a catholyte dividing element.

6. A cell element according to claim 5, characterized in that the volume of the first catholyte chamber is equal to or larger than the volume of the second catholyte chamber.

7. A cell element according to claims 1 - 6, characterized in that both the anolyte space and the catholyte space have a P-shaped geometry, which P-shaped geometry is made up of an intermediate member that forms part of the first anolyte and catholyte spaces, respectively.

8. A cell element according to claims 1 - 6, characterized in that said electrode space extends the entire width of the cell element, said electrode space forming a division between the first anolyte and catholyte chambers on the one hand and the second anolyte and catholyte chambers on the other hand.

9. A cell element according to claims 1 - 8, characterized in that said bipolar electrode is integrated in the cell element.

10. A cell element according to claims 7 - 9, characterized in that the intermediate member includes a discharge channel for enabling direct communication between the electrolyte space and the electrode space, which discharge channel forms a connection between the electrode space and the first electrolyte chamber, with no connection being present between the catholyte space and the anolyte space.

11. A cell element according to claims 1 - 10, characterized in that the cell element includes a recess into which the bipolar electrode can be placed, which recess is provided with corrugations all around.

12. A device for subjecting a chloride compound to an electrolytic process, wherein several electrolytic cells are electrically connected in series, said cells consisting of a cell element, which includes an electrolyte space and an electrode space, a bipolar electrode and a diaphragm or a semi-permeable membrane, wherein said cell elements are surrounded by an encasing comprising two end plates, characterized in that the device comprises one or more cell elements according to claims 1 - 11.

13. A device according to claim 12, characterized in that the electrolytic cells are connected in series in such a manner that alternately a cathode space and an anode space is provided.

14. A device according to claims 11 - 13, characterized in that the dividing elements of the series-connected electrolytic cells preferably form a division plate extending along the length of the device, wherein both the catholyte space and the anolyte space extending along the length of the device can be considered as a succession of first and second catholyte and anolyte spaces, respectively, which are separated from each other by a catholyte dividing element and an anolyte dividing element, respectively.

15. A device according to claims 12 - 14, characterized in that a metering element is disposed near the end side of the encasing, where the discharge of the chlorine gas that has formed during the electrolytic process takes place, in which metering element the aqueous flow in the electrolytic cell is enriched with chloride compound.

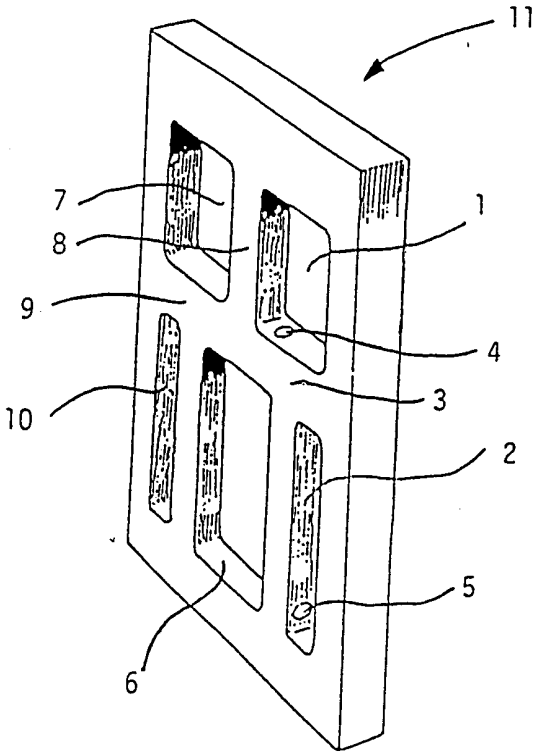
16. A device according to claim 15, characterized in that said metering element is disposed within the encasing.

17. A device according to claim 15, characterized in that said metering element is disposed outside the encasing.

18. A method for subjecting a chloride compound to an electrolytic process in an electrolysis device, characterized in that said electrolysis is carried out in the device according to claims 12 - 17.

19. A method according to claim 18, characterized in that the electrolytic cells are electrically connected in series in such a manner that a fluid flow of the aqueous solution of the chloride compound takes place both in the first and in the second electrolyte chamber, with said flows taking place in opposite directions.

FIGURE 1



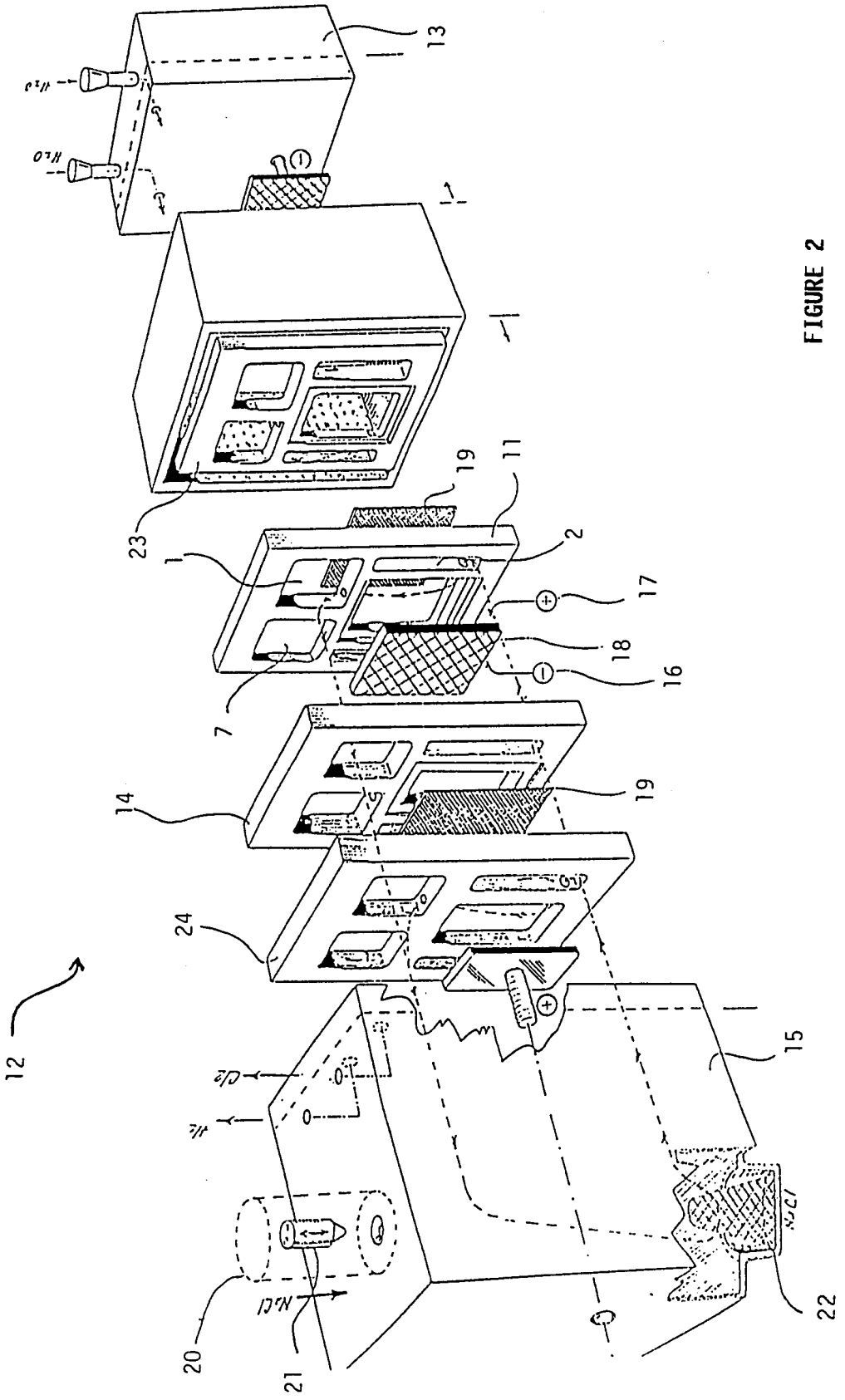


FIGURE 2

FIGURE 3

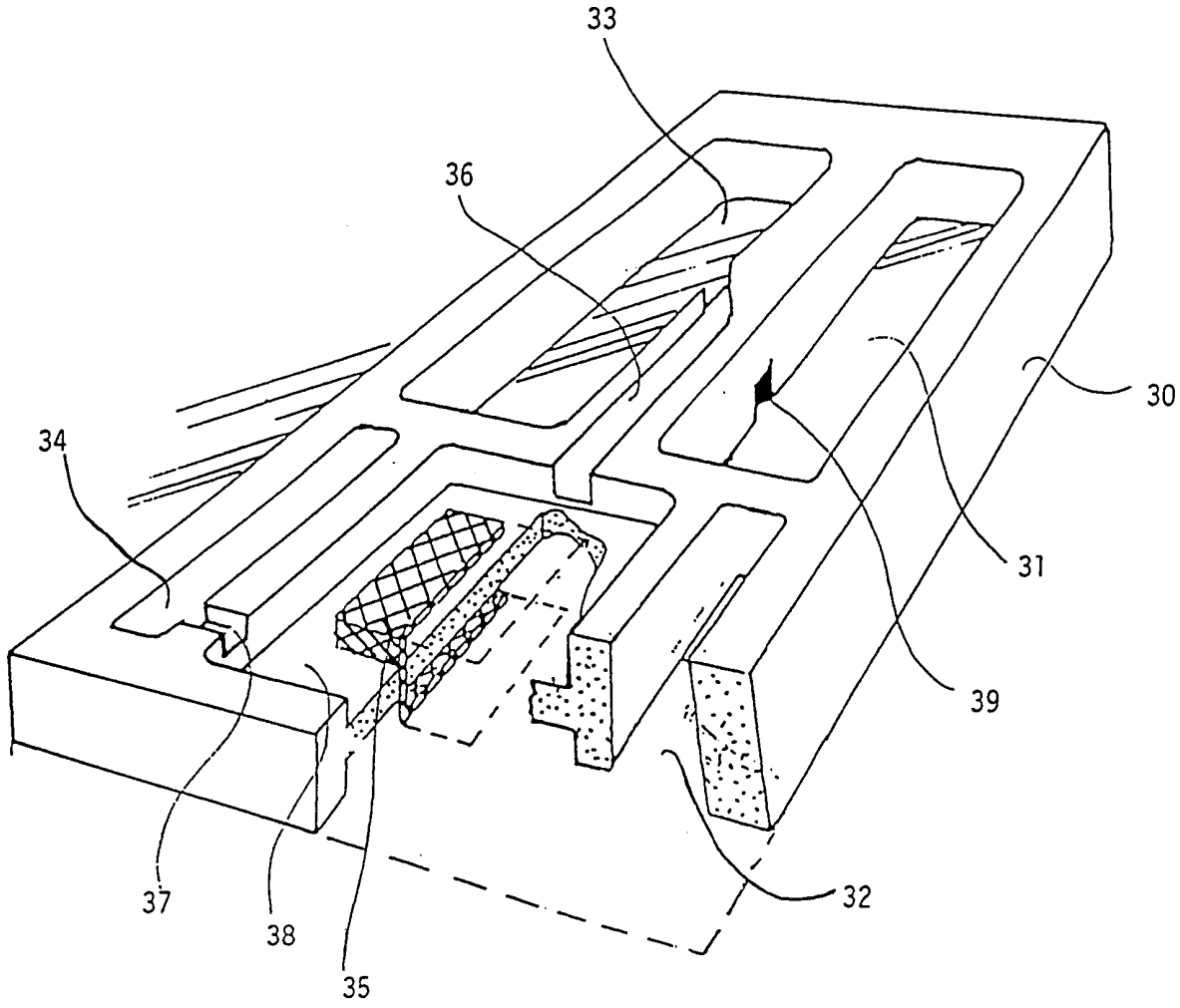


FIGURE 4