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(54) **Apparatus comprising a plurality of electrolytic cells.**

(57) An apparatus which comprises two or more groups of electrolytic cells and a plurality of headers from which different electrolytes may be charged to electrolytic cells in the different groups of cells and a plurality of headers via which different products of electrolysis may be removed from electrolytic cells in the different groups of cells.

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This invention relates to an apparatus comprising a plurality of electrolytic cells.

Electrolytic cells are used to produce a wide variety of chemical products by electrolysis of suitable electrolytes. For example, many electroorganic syntheses are practised industrially but the primary industrial use of electrolytic cells for the production of chemical products is in the electrolysis of aqueous solutions of alkali metal halides. Thus, such solutions are electrolysed on a vast scale throughout the world to produce chlorine, hydrogen and aqueous caustic alkali solutions, eg aqueous sodium chloride solution is electrolysed to produce aqueous sodium hydroxide solution, chlorine, and hydrogen, and aqueous potassium hydroxide solution is electrolysed to produce aqueous potassium hydroxide solution, chlorine and hydrogen. Such solutions are also electrolysed on a large scale to produce aqueous alkali metal chlorate solutions.

Electrolytic cells in which such electrolyses are carried out generally comprise a plurality of anodes and cathodes with each anode generally being separated from the adjacent cathode by a separator which divides the electrolytic cell into a plurality of anode and cathode compartments, although in an electrolytic cell for the production of alkali metal chlorate the cell is undivided. The anode compartments of such a cell are provided with means for feeding electrolyte to the cell, suitably from a common header, and with means for removing products of electrolysis from the cell suitably via a common header or headers. Similarly, the cathode compartments of the cell are provided with means for removing electrolysis products from the cell suitably via a common header or headers, and optionally with means for feeding water or other fluid to the cell, suitably from common headers.

The electrolytic cells may be of the diaphragm or membrane type. In a diaphragm type cell the separators positioned between adjacent anodes and cathodes are microporous and in use the electrolyte passes through the diaphragms from the anode compartments to the cathode compartments of the cell. In a membrane type cell the separators are essentially hydraulically impermeable and in use ionic species are transported across the membranes between the anode compartments and the cathode compartments of the cell.

Where an aqueous alkali metal chloride solution is electrolysed in an electrolytic cell of the diaphragm type the solution is fed to the anode compartments of the cell suitably from a common header, chlorine which is produced in the electrolysis is removed from the anode compartments of the cell via a common header, the alkali metal chloride solution passes through the diaphragms and hydrogen and alkali metal hydroxide produced

by electrolysis are removed from the cathode compartments via a common header or headers, the alkali metal hydroxide being removed in the form of an aqueous solution of alkali metal chloride and alkali metal hydroxide. Where an aqueous alkali metal chloride solution is electrolysed in an electrolytic cell of the membrane type the solution is fed to the anode compartments of the cell suitably from a common header and chlorine produced in the electrolysis and depleted alkali metal chloride solution are removed from the anode compartments via a common header or headers, alkali metal ions are transported across the membranes to the cathode compartments of the cell to which water or dilute aqueous alkali metal hydroxide solution may be fed from a common header, and hydrogen and alkali metal hydroxide solution produced by the reaction of alkali metal ions with water are removed from the cathode compartments of the cell via a common header or headers.

The electrolytic cells may comprise a large number of anodes and cathodes, particularly where the cells are of the filter press type, eg the cells may contain as many as fifty or more anodes and cathodes. The cells may also be of the monopolar or of the bipolar type. In a monopolar type cell a plurality of anodes and cathodes are positioned alternately and a separator, when present, is positioned between each anode and adjacent cathode. A bipolar type cell comprises a plurality of electrodes each having an anode face and a cathode face and a separator, when present, is positioned between an anode face of an electrode and a cathode face of an adjacent electrode.

In the operation of a cell room comprising a plurality of such electrolytic cells it is the practice to charge electrolyte to the cells from a common source and via a common header, and to remove products of electrolysis from the cells via a common header or headers. For example in the electrolysis of aqueous alkali metal chloride solution in a membrane type cell the solution will generally be charged to the anode compartments of each of the electrolytic cells from a common header, and water or aqueous alkali metal hydroxide solution will be charged to the cathode compartments of each of the electrolytic cells from a common header. Similarly, chlorine and depleted alkali metal chloride solution produced in the electrolysis will generally be removed from the anode compartments of the cell via a common header or headers and hydrogen and aqueous alkali metal hydroxide solution produced in the electrolysis will generally be removed from the cathode compartments via a common header or headers for each of these products.

We have realised that this normal arrangement of a cell room comprising a plurality of electrolytic cells severely limits the versatility of operation of

such a cell room. Thus, in such a cell room comprising a plurality of electrolytic cells and also a plurality of headers as described it is possible to electrolyse only one specific electrolyte in the cells in such a cell room, and correspondingly it is possible to produce only one specific product, or specific group of products. For example, in such a cell room it is possible to electrolyse aqueous sodium chloride solution, or aqueous potassium chloride solution, and to produce correspondingly chlorine, hydrogen and aqueous sodium hydroxide solution, or chlorine, hydrogen and aqueous potassium hydroxide solution respectively. It is not possible to electrolyse both of the aforementioned electrolytes in such a cell room at the same time, nor is it possible to produce both of the aforementioned groups of products in a cell room at the same time.

We have also realised that it is a desirable objective to be able to operate such a cell room in a more versatile manner and specifically in such a way that more than one electrolyte may be electrolysed in the same cell room comprising a plurality of electrolytic cells, and in such a way that more than one product or group of products may be produced in the same cell room comprising such a plurality of electrolytic cells. The present invention provides a means by which this objective may be achieved and by means of which the versatility of operation of such a cell room is greatly increased. In particular the manner of operation of such a cell room may be changed readily in order to meet changing requirements for the different products of electrolysis which may be produced in such a cell room.

According to the present invention there is provided an apparatus comprising a plurality of electrolytic cells, a header from which electrolyte may be charged to the electrolytic cells and a header or headers via which a product or products of electrolysis may be removed from the electrolytic cells, and an electrical circuit to which the electrolytic cells are connected and by means of which electrical power may be fed to the electrolytic cells, in which the electrolytic cells are arranged in two or more groups of cells and the apparatus comprises a plurality of headers from which different electrolytes may be charged to electrolytic cells in the different groups of cells, and a plurality of headers via which different products of electrolysis may be removed from specific electrolytic cells in the different groups of cells.

The apparatus may comprise a single electrical circuit to which a plurality of electrolytic cells or even all of the electrolytic cells in the groups of cells are connected. This is of course conventional practice in a cell room which comprises a plurality of electrolytic cells. However, the novelty and in-

ventivity of the present apparatus resides in the arrangement of headers in the apparatus. In conventional practice electrolyte is charged from a single common header to all of the electrolytic cells in a group of cells such that the group of cells may be used for the electrolysis of one electrolyte at any one time, eg it may be used for the electrolysis of aqueous sodium chloride solution, or aqueous potassium chloride solution, but both solutions may not be electrolysed in the group of cells at the same time. In the present apparatus, however, as there are a plurality of headers from which different electrolytes may be charged to specific electrolytic cells or to specific groups of cells it is possible to electrolyse one electrolyte in one group of the cells and a different electrolyte, or different electrolytes, in other cells in a different group or groups of cells. By connecting the cells to an appropriate header, and by changing these connections as desired, it is possible to vary the relative proportions of the different electrolytes which are electrolysed in the groups of electrolytic cells in response to changing commercial requirements. Where two or more different electrolytes are electrolysed in the electrolytic cells it will of course be necessary for the apparatus to comprise a corresponding number of headers from which different electrolytes may be charged to the electrolytic cells and to which different products of electrolysis may be charged to and via which these products may be removed from the cells.

It is possible for two or more than two electrolytes to be electrolysed simultaneously in the apparatus, but generally only two electrolytes will be electrolysed simultaneously, that is the apparatus will generally comprise two groups of cells. By way of example the apparatus will be described with reference to the simultaneous electrolysis of aqueous solutions of sodium chloride and potassium chloride in the apparatus. In this case the electrolytic cells will be connected to an electrical circuit, the apparatus will comprise two headers from one of which aqueous sodium chloride solution may be charged to one group of cells and from the other of which aqueous potassium chloride solution may be charged to the other group of cells. A product or products of electrolysis which are produced during electrolysis in both groups of electrolytic cells, eg chlorine and hydrogen in the case where sodium chloride solutions and potassium chloride solutions are electrolysed, may be passed to a common header or headers for all of the cells but the apparatus will comprise two headers to one of which aqueous sodium hydroxide solution will be passed and to the other of which aqueous potassium hydroxide solution will be passed. By varying the number of cells in the groups of cells connected to the different headers

it is possible to vary considerably the relative proportions of sodium chloride solution and potassium chloride solution which are electrolysed in response to changing commercial requirements.

The electrolytic cells in the apparatus may have any suitable construction as the invention does not reside in the particular type of cells to be used in the apparatus. For example, the cells may be monopolar cells or they may be bipolar cells, and the cells may be fitted with separators positioned between each anode and adjacent cathode in a monopolar cell or between an anode of a bipolar electrode and a cathode of an adjacent bipolar electrode in a bipolar cell.

The nature of the separator, if present, in the electrolytic cells will depend on the nature of the electrolytes which are to be electrolysed. The man skilled in the art will have no difficulty in choosing a suitable separator. Merely by way of example, and where an aqueous alkali metal chloride solution is to be electrolysed, a suitable material for use as a diaphragm in asbestos or microporous sheet of a polymeric material resistant to chemical attack, eg polytetrafluoroethylene, although other materials which may be used include, for example, tetrafluoroethylene-hexafluoropropylene copolymers, vinylidene fluoride polymers and copolymers, and fluorinated ethylene-propylene copolymers. Where such a solution is to be electrolysed a suitable material for use as an ion-exchange membrane is a fluorine-containing polymeric material containing cation-exchange groups, for example, sulphonic acid, carboxylic acid or phosphonic acid groups, or derivatives thereof, or a mixture of two or more such groups.

Suitable cation-exchange membranes are those described, for example, in UK Patents Nos 1184321, 1402920, 1406673, 1455070, 1497748, 1497749, 1518387 and 1531068.

Where aqueous alkali metal chloride solution is to be electrolysed a suitable material for use as an anode is a film-forming metal or an alloy thereof, for example zirconium, niobium, tungsten or tantalum, but preferably of titanium, and the surface of the anode suitably carries a coating of an electro-conducting electrocatalytically active material. The coating may comprise one or more platinum group metals, that is platinum, rhodium, iridium, ruthenium, osmium or palladium, and/or an oxide of one or more of these metals. The coating of platinum group metal and /or oxide may be present in admixture with one or more non-noble metal oxides, particularly one or more film-forming metal oxides, e.g. titanium dioxide. Electro-conducting electrocatalytically active materials for use as anode coatings in an electrolytic cell for the electrolysis of aqueous alkali metal chloride solution, and methods of application of such coatings, are well

known in the art.

Where aqueous alkali metal chloride solution is to be electrolysed a suitable material for use as a cathode is iron or steel or nickel. The cathode may be coated with a material designed to reduce the hydrogen overpotential of the electrolysis.

The electrolytic cells in the group thereof may be substantially the same. However, this is not necessarily so. For example, the nature of the separator in the electrolytic cells may vary depending on the nature of the electrolyte which is to be electrolysed. Thus, where the cells are equipped with ion-exchange membranes the membranes in those cells in which aqueous sodium chloride solution is to be electrolysed may be different from the ion-exchange membranes in those cells in which aqueous potassium chloride solution is to be electrolysed, although some cells may be used to electrolyse different electrolytes.

In order that individual electrolytic cells in the groups thereof may readily be changed in response to changing production requirements and replaced by cells more suitable for satisfying the changing production requirements it is preferred that the cells, and preferably each cell, is provided with means for readily shorting out the cells from the electrical circuit so that it can be removed and replaced by another electrolytic cell. Furthermore, in order to facilitate removal and replacement of electrolytic cells it is preferred that the cells are readily detached from and reattached to the appropriate headers.

It may not be necessary for individual electrolytic cells in the group thereof to be replaced in order to meet changing production requirements. Thus, it is possible that different electrolyses may be carried out in the same electrolytic cell and all that is required when a change is made in the electrolysis which is to be carried out is for the cell to be detached from one header or headers and attached to a different header or headers. It may be necessary also to flush out the cell when the nature of the electrolyte is changed and prior to commencing electrolysis with a different electrolyte.

It can be seen that the apparatus of the present invention is simple in concept but provides substantial benefits in operation, and in particular it provides a plurality of electrolytic cells the use of which may readily be adapted to suit changing production requirements. Thus, the apparatus is readily able to cope, for example, with an increased demand for aqueous potassium hydroxide solution at the expense of aqueous sodium hydroxide solution, and vice versa.

The invention will now be described with reference to the accompanying figure which is a diagrammatic representation of an apparatus compris-

ing a plurality of electrolytic cells, and for the purposes of illustration the apparatus will be described with reference to a group of electrolytic cells in which aqueous sodium chloride solution is electrolysed and with reference to a group of electrolytic cells in which aqueous potassium chloride solution is electrolysed.

The apparatus comprises a plurality of monopolar electrolytic cells (1 to 10) each of which comprises a plurality of anodes and cathodes and in which each anode is separated from an adjacent cathode by a cation-exchange membrane which provide in each of the electrolytic cells a plurality of anode compartments and cathode compartments. Each of the electrolytic cells is connected to a common electrical circuit 11.

The apparatus comprises a plurality of headers 12 to 21, headers 12 to 17 being connected to electrolytic cell 1 by means of lines 22 to 27 respectively and electrolytic cell 6 being connected to headers 16 to 21 by means of lines 28 to 33 respectively. Electrolytic cells 2 to 5 are connected to the headers in the same manner as cell 1 and form with cell 1 a first group of cells, and electrolytic cells 7 to 10 are connected to the headers in the same manner as cell 6 and form with cell 6 a second group of cells.

The headers 12 to 21 served the following functions.

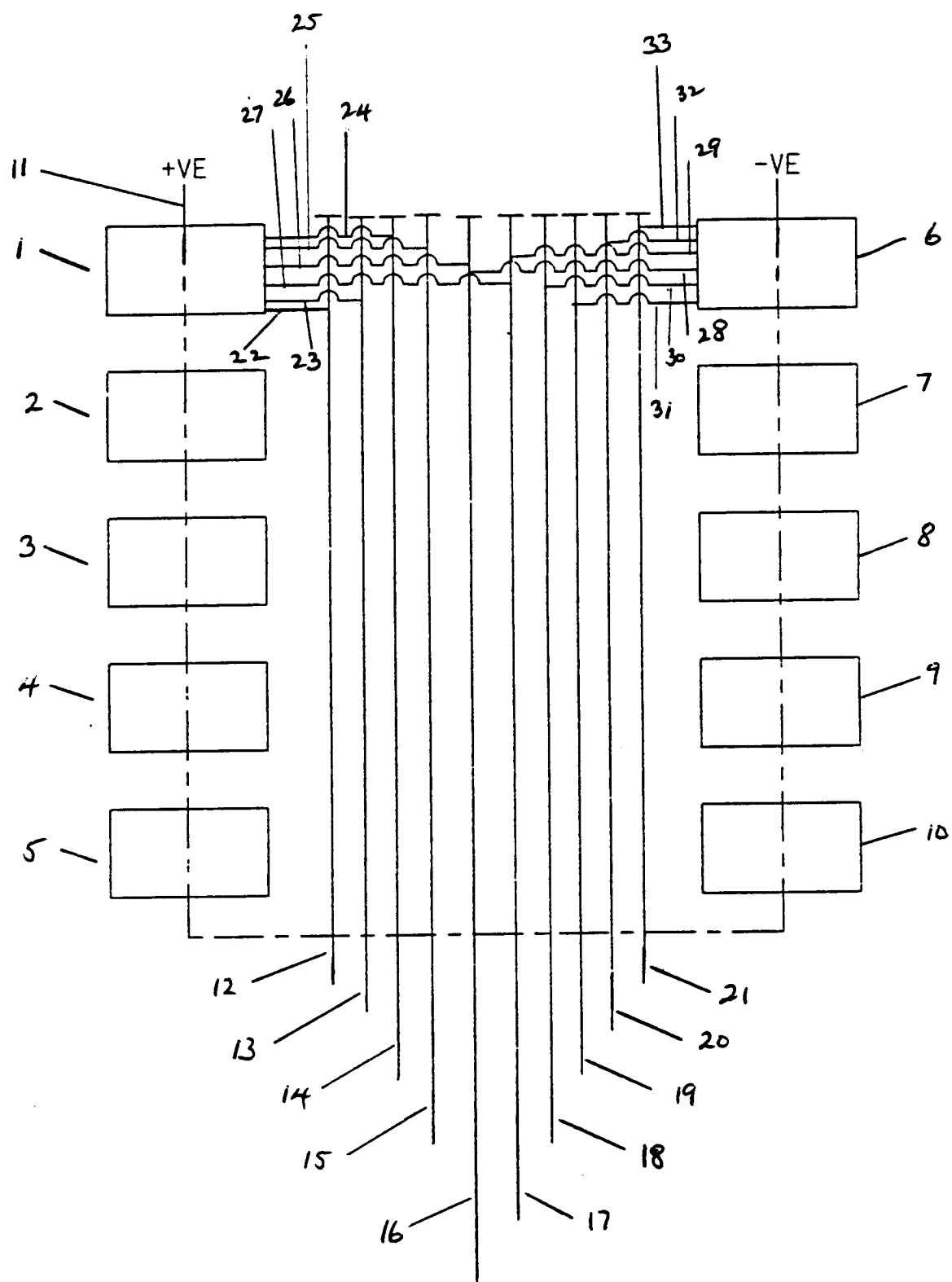
- | | |
|----|-------------------------------|
| 12 | NaCl solution feed |
| 13 | Depleted NaCl solution return |
| 14 | NaOH solution feed |
| 15 | NaOH solution return |
| 16 | Chlorine header |
| 17 | Hydrogen header |
| 18 | KCl solution feed |
| 19 | Depleted KCl solution return |
| 20 | KOH solution feed |
| 21 | KOH solution return |

In operation aqueous NaCl solution and dilute aqueous NaOH solution are charged to electrolytic cell 1 and to cells 2 to 5 from headers 12 and 14 via lines 22 and 24 respectively, and depleted aqueous NaCl solution, aqueous NaOH solution, chlorine and hydrogen are passed to headers 13, 15, 16, 17 via lines 23, 25, 26, 27 respectively. Aqueous KCl solution and dilute aqueous KOH solution are charged to electrolytic cell 6 and to cells 7 to 10 from headers 18 and 20 via lines 30 and 32 respectively, and depleted aqueous KCl solution, aqueous KOH solution, chlorine and hydrogen are passed to headers 19, 21, 16, 17 via lines 31, 33, 28, 29 respectively. It should be noted that the apparatus comprises only one chlorine header and one hydrogen header to which chlorine and hydrogen produced in both the group of electrolytic cells 1 to 5 and in the group of electrolytic cells 6 to 10 is passed.

Should it be required to vary the proportion of aqueous NaCl solution to aqueous KCl solution which is electrolysed, eg to increase the proportion, one or more of the electrolytic cells in the group of cells 6 to 10 may be connected to the headers 12, 14, 13 and 15.

Claims

1. An apparatus comprising a plurality of electrolytic cells, a header from which electrolyte may be charged to the electrolytic cells and a header or headers via which a product or products of electrolysis may be removed from the electrolytic cells, and an electrical circuit to which the electrolytic cells are connected and by means of which electrical power may be fed to the electrolytic cells, in which the electrolytic cells are arranged in two or more groups of cells and the apparatus comprises a plurality of headers from which different electrolytes may be charged to electrolytic cells in the different groups of cells and a plurality of headers via which different products of electrolysis may be removed from electrolytic cells in the different groups of cells.
2. An apparatus as claimed in claim 1 which comprises a plurality of electrolytic cells arranged in two or more groups of cells and a single electrical circuit to which all of the cells in the groups of cells are connected.
3. An apparatus as claimed in claim 1 or claim 2 which comprises two groups of electrolytic cells.
4. An apparatus as claimed in any one of claims 1 to 3 which comprises a common header or headers via which a product or products of electrolysis may be removed from electrolytic cells in more than one group of cells.
5. An apparatus as claimed in any one of claims 1 to 4 in which the electrolytic cells are provided with means for readily shorting out the cells.
6. An apparatus as claimed in any one of claims 1 to 5 substantially as described with reference to the figure.
7. An apparatus as claimed in any one of claims 1 to 6 for use in the electrolysis of aqueous sodium chloride solution and aqueous potassium chloride solution.





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EUROPEAN SEARCH REPORT

Application Number

EP 91 30 4853

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	EP-A-0 135 314 (IMPERIAL CHEMICAL INDUSTRIES PLC) * page 2, line 20 - line 28 ** page 4, line 16 - page 5, line 26; claims 1-8 * - - - - -	1-4	C 25 B 15/08 C 25 B 15/00
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			C 25 B
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of search 03 October 91	Examiner GROSEILLER PH.A.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document			