Sept. 13, 1955 E. A. ZDANSKY 2,717,872

PRESSURE ELECTROLYZERS

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Fig. 2

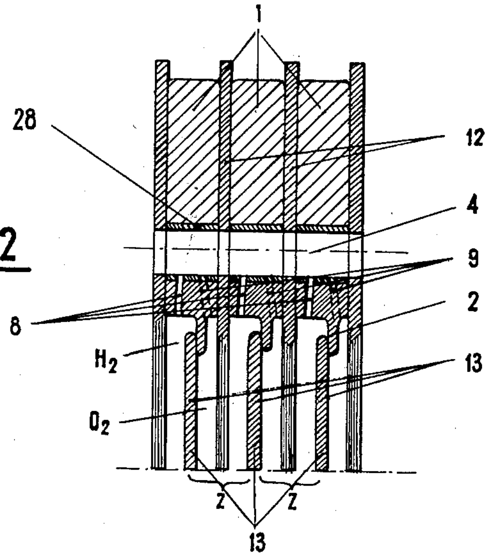

Fig. 1

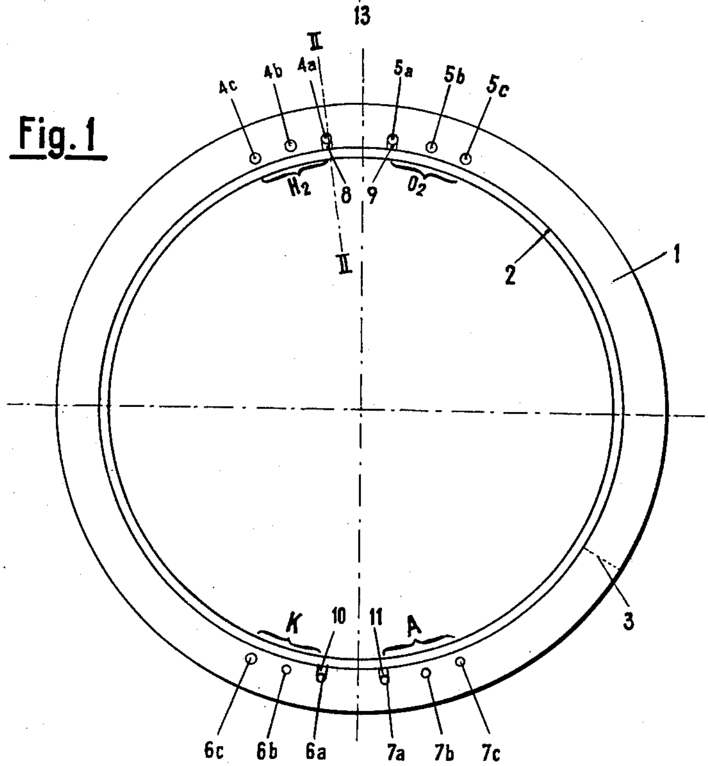

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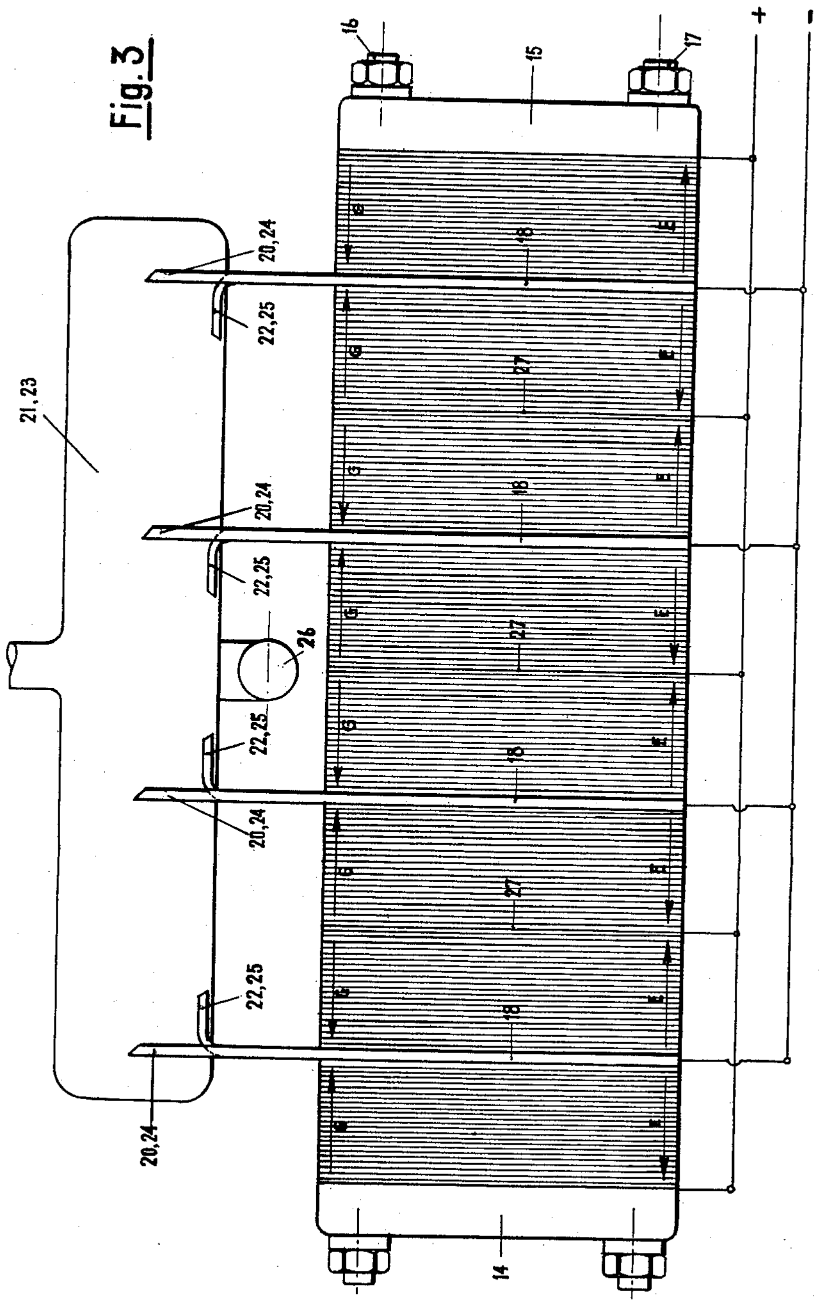
Fig. 3



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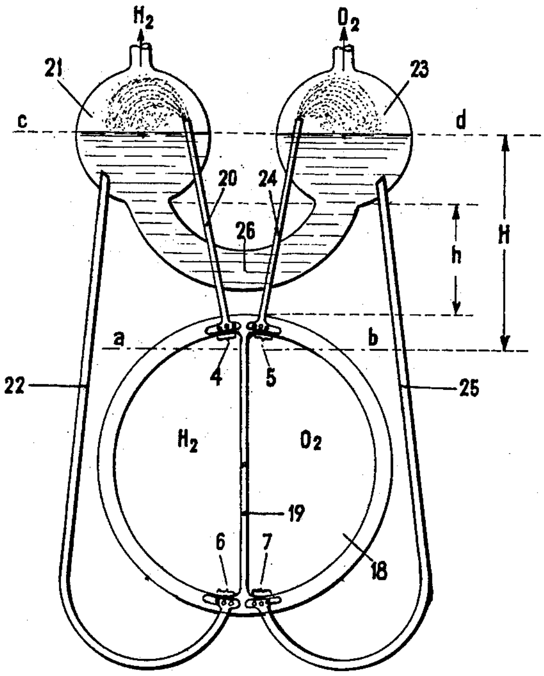

Fig. 4

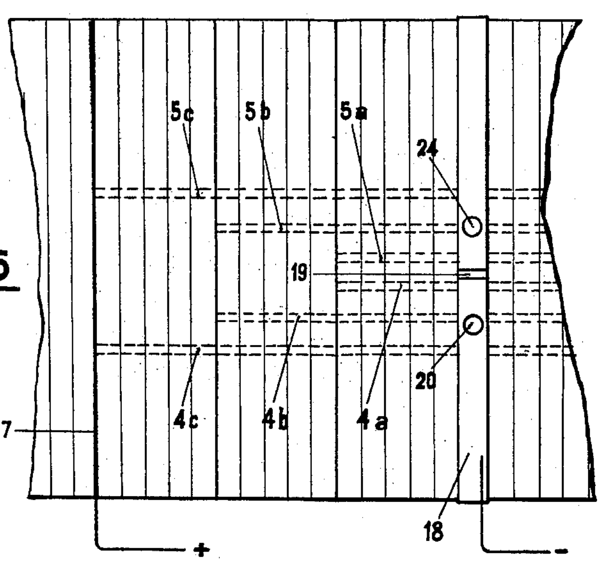

Fig. 5

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PRESSURE ELECTROLYZERS

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Claims priority, application Switzerland August 12, 1950

5 Claims. (Cl. 204—256)

This invention relates to pressure electrolyzers.

Pressure electrolyzers constructed along filter press principles, as compared with electrolytic cells working under atmospheric pressure, make it possible to decrease the width of the individual cells, because both the dimensions of the individual gas bubbles and the total volume of the bubbles are by the increased pressure reduced to a fraction of the volume occupied at atmospheric pressure, so that the space available for the electrolyte is much less restricted by the formation of the gas. The cell frames therefor can be made in the form of flat, sheet metal rings of about 6 to 10 millimeters thickness and can be connected in series by tie rods to form an elongated column. The bipolar electrodes and diaphragms may be carried by the cell frames. The advantage is that the radially-acting pressure component is taken up by the annular sheet metal cell frames at the inner edges thereof. The cell frames are made sufficiently wide so as to form a pressure vessel of considerable wall-thickness capable of reliably resisting the required pressure.

An object of the present invention is to provide pressure electrolyzers and to form therein this kind of the conduits required for each individual cell, for discharging the gases produced in the electrolytic process and returning the electrolyte carried over in such gases and deposited in the usual gas separators. There are required, in all, four such conduits for each cell, namely one gas-discharge conduit each for hydrogen and oxygen respectively, and one return conduit each for the catholyte and the anolyte respectively. It has already been suggested, to increase the width of the cell frames within sectors of about 30°, by appropriate lugs or by extension of sufficient segments of material, and to provide within such widened portions suitable apertures to form the necessary conduits. This arrangement obviates the necessity of introducing into each cell, four pressure-resisting conduits.

The invention proposes to subdivide each of these conduits into a plurality of cooperating ducts formed by narrow channels arranged in parallel in a common, annular zone of the cell frames and thus avoids the necessity for widening broadening portions of the cell frames. It is thus possible to make the annular cell frames of uniform width so that they may be shaped from finished, if necessary suitably profiled, flat strip or sheet material requiring only rounding at the edges and butt-welding at the joints. The required passages to form the ducts are then formed in the cell frames by punching or shaping. Each cell frame is provided with a radially inwardly directed extension for securing thereto, by electric spot- or seam-welding, a thin plate acting as a bipolar electrode. The structure results in very considerable simplification in manufacture, economy in labour and prevents waste of material.

A necessary condition for making the pressure-loaded, annular cell frame of uniform width or radial thickness without reducing its static strength by the conduits formed therein, is the subdivision of these conduits into respectively separate groups of mutually parallel cooperating ducts arranged in the same annular zone of the cell frame. These groups of ducts are suitably situated as close as possible to the inner edges of the annular sheet metal frames since the inner fibres of the frames experience the least tensile stresses responsive to the applied pressure. To obviate corrosion, the individual ducts are internally lined with small-bore nickel tubes. The packing gaskets or diaphragms which are interposed between the individual annular cell frames must of course be provided with corresponding ducts and so fitted that these ducts exactly coincide with the ducts in the cell frames.

The system of ducts provided by the invention reduces perceptibly the inevitable electrolytic shunt currents between individual cells and groups of cells. This is of particular importance in the case of pressure electrolyzers with relatively narrow cells and consequently short shunt paths; it being only necessary to connect to each cell one cooperating duct of each group of ducts forming the respective conduit, and if the individual cooperating ducts of a conduit are each connected with a separate group of directly consecutive cells and at the same time led (from their point of connection with a common pipe or receiver leading to the gas separator) only as far as the last cell of the particular, connected group of cells, the resulting total conduit cross-section decreases from the cell group next adjacent to the common receiver pipe until at the most remote cell group the total cross-section is only the sum of the cross-sections of the cooperating ducts forming the respective conduits for hydrogen, oxygen, catholyte and anolyte. The intensity of the electrolytic shunt current decreases correspondingly.

It is already usual, in water electrolyzers working under atmospheric pressure, to provide an intermediate chamber in the middle of the column of cells, which is divided into two compartments, into one of which are led the hydrogen and catholyte return conduits from the cells, and into the other, the corresponding oxygen and anolyte return conduits. The first compartment is then connected at the top with the mixture pipe leading to the hydrogen gas separator, and at the bottom with the return pipe for the catholyte from the associated gas separator. The second compartment is similarly connected on top with the mixture pipe leading to the oxygen gas separator and at the bottom with the return pipe for the anolyte from this gas separator. It has now been found advantageous, in water electrolyzers according to this invention, to provide several, instead of only one, such intermediate chambers, dividing the column of cells into a number of main groups, each group comprising a number of cell subgroups corresponding to the number of cooperating ducts in each conduit group and each group connected to the cooperating conduit ducts in the manner above described. Each of these intermediate chambers thus receives all the cooperating conduit ducts of the adjacent main cell groups on either side thereof. The arrangement makes it possible to appreciably reduce the duct lengths and to make the ducts of correspondingly smaller cross-section without unduly increasing the flow velocities therein. Smaller duct cross-sections, however, not only ensure a reduction in the intensity of the electrolytic shunt currents, but also an increase in the static compression strength of the annular cell frames through which the ducts pass. In order to obviate shunt currents within the gas separators, the intermediate chamber are maintained at the same potential.

A further means of ensuring rapid electrolyte circulation even when using relatively narrow ducts is to provide for a correspondingly high hydrostatic head therein. It has been usual in the past to arrange the gas separators into which the electrolyte is carried over by the discharged gases on the principle of the so-called "mammoth pump," hardly 30 centimetres above the upper edge of the cell column. Experiments have, however, shown that in the case of a pressure electrolyzer, owing to the smaller volumes of gas exerting the pumping effect, a considerably higher head is required; and it has, therefore, been found suitable, in electrolyzers according to the invention, to arrange the gas separators at least 500 millimetres above the upper edge of the cell column. The returning electrolyte is thus put under a hydrostatic head of about 700–900 millimetres water and more, and the necessary quantities of electrolyte can therefore be passed through a system of relatively narrow ducts with a suitable flow velocity.

The invention will be better understood from the following description and the accompanying drawings.

Figure 1 of the drawings is a plan view of a single annular cell frame, a plurality of such frames forming the cell column of the electrolyzer;

Figure 2 is a cross-section through the edges of three cells of a cell column formed by the cell frames of Fig. 1 with welded-on electrode plates and intermediate diaphragms also acting as packings or gaskets;

Figure 3 is a general, diagrammatic view of a complete electrolyzer;

Figure 4 is a diagrammatic section through an intermediate chamber as shown in Figure 3; and

Figure 5 is a diagrammatic plan view of a main cell group connected to such an intermediate chamber, showing the subdivision into cell sub-groups connected to the individual cooperating conduit-forming ducts.

As will be seen from Figure 1, each cell frame is a flat metallic ring, e. g., an iron ring **1** of uniform width or radial thickness, with a flange **2** extending radially inwardly therefrom. The frame ring can be made directly from suitably profiled strip material by suitable forming and welding at **3**. Each of the four conduit systems H_2, O_2, K and A for respectively leading off the hydrogen and oxygen and returning the catholyte and anolyte, comprises three cooperating ducts as indicated respectively at *4a, b, c, 5a, b, c* and *6a, b, c, 7a, b, c*. These ducts are disposed parallel to each other in a common annular portion of the frame ring **1**. Since each cell requires to be connected to only one each of these cooperating ducts, radial passages **8**, **9**, **10** and **11** are provided only for one of the ducts in the frame ring, e. g., for the ducts **4***a*, **5***a*, **6***a* and **7***a*, connecting the internal spaces of the cell associated with the corresponding frame ring to the conduits which cooperate with these ducts.

The construction of the cells is shown by Figure 2, representing on a larger scale, a partial section through two consecutive cells along the line II—II (Figure 1). Between the three ringlike cell frames **1** are disposed the diaphragms **12**, the sides of which are suitably impregnated so that they may also act as insulating and sealing intermediate elements. The radially inwardly directed flange **2** of each cell frame carries a thin disc **13**, intimately secured thereto or connected therewith, e. g., by welding, and acting as a bipolar electrode. The difference in axial thickness between the frame strips **1** and the electrode plates **13**, provides the free gas and electrolyte spaces of the individual cells Z. The portion of the cell space to the right of the diaphragm **12**, is connected with the radial passages **8**, leading from this cell space to the cooperating duct **4** by which the hydrogen escapes. The cooperating ducts are lined with nickel bushings and if desired, also with insulating sleeves **28**. The other cell spaces are connected with the radial passages **9**, shown in broken lines, leading to the component ducts **5**, which are not visible in Figure 2 being in back of the ducts **4**, and are used to lead off the oxygen.

As will be seen from Figure 3, the whole cell assembly, held together between two heavy end plates **14**, **15** by correspondingly strong tie-rods **16**, **17**, is subdivided by a number of intermediate chambers **18**, into main cell groups, each of which has a separate electrolyte circuit; each of these intermdiate chambers **18** being connected by a separate piping system with the gas separators disposed above the structure.

A diagrammatic section through such an intermediate chamber **18** is shown in Figure 4. As will be seen, the chamber is divided by a partition **19** to form two spaces H_2 and O_2, each of which is filled with electrolyte up to about the level *a–b*; the compartment H_2 containing the catholyte, and the compartment O_2, the anolyte. The compartment H_2 is connected to the hydrogen escape conduit formed by the cooperating ducts *4a, 4b, 4c* of the corresponding cell main group. The corresponding connecting passages are not visible in the drawing. This receiver space is also connected by the mixture pipe **20** with the hydrogen gas separator **21** for passing to the separator the gas-electrolyte mixture from the cells. The electrolyte carried along with the gas collects inside the gas separator **21** and fills the latter approximately to the level *c–d*. From the gas separator **21**, the electrolyte flows through the catholyte return pipe **22**, back into the compartment H_2, to the bottom of which is connected the return conduit comprising all cooperating catholyte return ducts **6***a*, **6***b*, **6***c*. In a similar manner the compartment O_2 is connected with the oxygen gas separator **23** through the pipe **24** and the anolyte return pipe **25**. The two gas separators **21**, **23** are made to intercommunicate by means of a V-tube **26** which to some extent equalizes by diffusion the concentration of the anolyte and catholyte.

Figure 5 shows a plan view of such a cell main group enclosed between an intermediate chamber **18**, and an intermediate plate **27**, with the gas escape conduits comprising respectively the cooperating ducts *4a, 4b, 4c* and *5a, 5b, 5c* shown in broken lines. As will be seen, the cooperating ducts **4***a*, **5***a* extend only through the first five cells. These are connected by corresponding radial passages (**8**, **9**—see Figure 2) with such five cells. The cooperating ducts **4***b* and **5***b* extend through the first ten cells and are connected by corresponding radial passages with the sixth to tenth cells. Finally, the cooperating ducts **4***c* and **5***c* extend through the whole cell main group and are connected with the eleventh to the sixteenth cells. The first to fifth, sixth to tenth, and eleventh to fifteenth cells of the cell main group thus form respectively separate cell sub-groups, each subgroup intercommunicating with the others through the medium of its cooperating duct. Since the shunt current for each cell corresponds to the total cross-section of the gas and electrolyte conduits in parallel with the particular cell, this shunt current decreases stepwise from one cell group to the next.

In actual practice, however, it is usual to provide more than 5 cells in a sub-group, e. g., 25 cells. The corresponding main cell group will then comprise 75 cells. As the circuit diagram in Figure 3 shows, the cell assembly is divided into 8 main groups, each main group having a separate current circuit. Two such main groups are connected on each side to a common intermediate chamber **18**.

If the main group consists of 75 cells, and assuming a cell voltage of about 2 volts, the tension in the circuit will be 150 volts. The complete structure will then contain 75×8, i. e. 600 cells.

The intermediate chambers **18** carry the same, preferably negative voltage, while the partition electrodes **27** carry the positive voltage. Figure 3 also shows the direction of circulation. The gas-electrolyte mixture flows from both cell groups to the intermediate chamber in the direction of the arrows G, while the electrolyte coming from the intermediate chamber flows back into the individual cell sub-groups in the direction of the arrows E.

The arrangement according to the invention permits the use of relatively short horizontal passages in spite of the great number of cells, and the ducts offer less flow resistance to the circulation of the gases and liquids in spite of their exceptionally small cross-sections, so that a sufficient and continuous circulation is assured even with cooperating ducts of only 10–20 mm. diameter.

In order to further accelerate the electrolyte circulation as well as to further reduce friction occurring in the cooperating ducts, the gas separators **21**, **23** (see Figure 4) are positioned at a level *"h"* spaced 60 centimetres above the upper edge of the cell structure. The hydrostatic pressure of the electrolyte returning from the gas separators to the cells through the reflux pipes **22**, **25**, is in this manner, as shown in Fig. 4, raised to the relatively high value "H" corresponding to the difference between the levels *a–b* and *c–d*.

I claim:

1. In an electrolyzer apparatus, in combination, an assembly of disc-shaped juxtaposed axially aligned electrolytic cells composed of a plurality of subgroups of cells each comprising a plurality of said cells, each cell having two separate chambers; a collecting member arranged at one end of said group of cells and having two separate chambers; and a plurality of pairs of inlet and outlet conduits, each pair connecting each chamber of the cells of only one of said subgroups to said collecting member with the chambers of each cell communicating with a different chamber of said collecting member.

2. In an electrolyzer apparatus, in combination, an assembly of disc-shaped juxtaposed axially aligned electrolytic cells, said cells being arranged in at least two groups of cells, each group being composed of a plurality of subgroups of cells each comprising a plurality of said cells; a collecting member arranged between said groups of cells; and a plurality of pairs of inlet and outlet conduits, each pair connecting the cells of only one of said subgroups to said collecting member.

3. In an electrolyzer apparatus, in combination, an assembly of disc-shaped juxtaposed axially aligned electrolytic cells, said cells being arranged in at least two groups of cells, each group being composed of a plurality of subgroups of cells each comprising a plurality of said cells, each cell having two separate chambers; a collecting member arranged between said groups of cells and having two separate chambers; and a plurality of pairs of inlet and outlet conduits, each pair connecting each chamber of the cells of only one of said subgroups to said collecting member with the chambers of each cell communicating with a different chamber of said collecting member.

4. In an electrolyzer apparatus, in combination, a plurality of juxtaposed annular frame members; disc-shaped bipolar electrode members attached to each frame member and extending across the space defined by the inner surface thereof, said electrode members defining with said frame members an assembly of disc-shaped electrolytic cells arranged along the axis of said frame members, said assembly of cells being composed of a plurality of subgroups of cells each comprising a plurality of said cells; a collecting member arranged at one end of said assembly of cells; and a plurality of pairs of inlet and outlet conduits, each pair connecting the cells of only one of said subgroups to said collecting member.

5. In an electrolyzer apparatus, in combination, a plurality of juxtaposed annular frame members; disc-shaped bipolar electrode members attached to each frame member and extending across the space defined by the inner surface thereof, said electrode members defining with said frame members an assembly of disc-shaped electrolytic cells arranged along the axis of said frame members, said assembly of cells being arranged in at least two groups, each group being composed of a plurality of subgroups of cells each comprising a plurality of said cells; a collecting member arranged between said groups of cells; and a plurality of pairs of inlet and outlet conduits formed in said frame members, each pair connecting the cells of only one of said subgroups to said collecting member.

References Cited in the file of this patent

UNITED STATES PATENTS

1,211,687	Dohmen	Jan. 9, 1917
1,273,357	Gougnard	July 23, 1918
1,448,037	Pechkranz	Mar. 13, 1923
1,799,116	Noeggerath	Mar. 31, 1931
2,075,688	Zdansky	Mar. 30, 1937

FOREIGN PATENTS

421,310	Great Britain	Dec. 18, 1934