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(72) Inventor: **Fabian, Peter**
63571 Gelnhausen (DE)

(74) Representative: **Reitstötter - Kinzebach**
Patentanwälte
Sternwartstrasse 4
81679 München (DE)

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(71) Applicant: **De Nora Deutschland GmbH**
63517 Rodenbach (DE)

(54) **Hydrodynamic means for electrochemical cells**

(57) The present invention is directed to hydrodynamic means to be installed in existing electrochemical cells wherein the electrodes are connected to the back-walls by means of rows of studs or ribs or other types of elongated supports and gaseous products are generated. The means of the invention consist of flat strips or folded strips which are inserted between each contiguous couple of studs or ribs or other types of elongated supports and allow for the separation between the ascending mixed phase comprising the generated gas and the degassed downcoming electrolyte. This separation greatly improves the overall internal recirculation, thus eliminating dead areas where the concentration of

the electrolyte may change and/or gas bubbles may be entrapped, both situations leading to decay of performances. The means of the invention comprise optional diverting baffles in their upper section to facilitate the separation of the gas phase from the electrolyte. In addition, the means of the invention may be provided with side lips whose elastic deformation permits the easy and firm insertion within the existing rows of studs or ribs or other types of elongated support. The material of construction may be any metal or plastic material characterized by chemical resistance to the cell environment and by a proper combination of stiffness and elasticity as required for securely fixing in place the means.

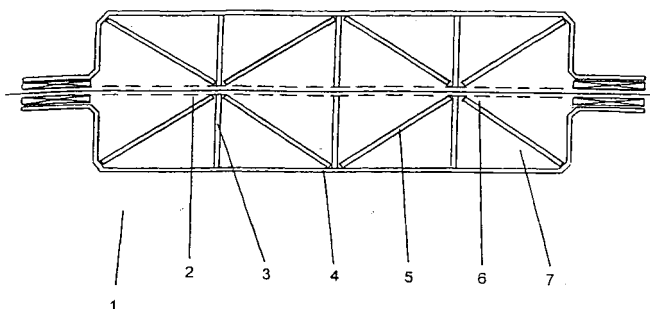


FIG. 2

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Description

STATE OF THE ART

[0001] The present invention is directed to hydrodynamic means suitable for installation in existing electrochemical cells wherein the electrodes are connected to the backwalls by means of elongated supports, such as ribs or the like, and gaseous products are generated. Typical processes characterized by the formation of gaseous products are the well known chlor-alkali electrolysis, hydrochloric acid solution electrolysis and water electrolysis, only to mention those which are particularly important from an industrial point of view. In all these processes the internal recirculation of the electrolytes plays an extremely important role in preventing the formation of dead areas wherein bubbles may be entrapped and the concentration of the electrolyte may change, both factors leading to an increase of cell voltage with the associated worsening of the consumption of electric energy. In addition, when the cells are divided into separate compartments by means of ion exchange membranes, as it happens in all updated processes, the mentioned dead areas cause a rather quick decay of both performance and mechanical characteristics, which in turn impose the shutdown of the cells for providing with the installation of new membranes.

[0002] The patent literature discloses a number of electrolytic cells equipped with internal hydrodynamic means such as baffles or channels primarily directed to separate the ascending flow of the mixed phase comprising the generated gas and the liquid electrolyte from the downcoming flow of liquid electrolyte which has been degassed in the top section of the cell: the difference of density between mixed and degassed phases is the driving force which induces the internal recirculation known as natural or gas lift recirculation. It is immediately evident that the recirculation attains the maximal value when the mentioned difference of density is also maximal, as it happens when the downcoming electrolyte flow is substantially free of gas. This result is strictly tied to the most efficient separation between the ascending and downcoming flows and to the quick coalescence of the gas bubbles, especially the tiny bubbles, in the upper section of the cell: as for the latter point, the resulting buoyancy effect exhibited by the large size bubbles leads to a very effective degassing, while only the few survived tiny bubbles remain entrained in the liquid phase and conveyed towards the lower section of the cell.

[0003] Patent literature discloses a number of devices directed to facilitate the coalescence of bubbles: the common point for all disclosures is represented by a restriction of the cross section available for the ascending mixed phase flow localized in the very top section of the cell.

[0004] Patent Application DE-A 198 50 071 is here assumed as one of the most representative documents

wherein the mentioned hydrodynamic means and the device for the coalescence of the tiny bubbles are disclosed: in particular, the hydrodynamic means are obtained by folding a metal sheet in a zig-zag or wave-like shape followed by fixing the wave, such as by welding, to the backwall of each compartment of the cell. The electrodes represented by foraminous sheets are then connected, again by welding, to the apexes of the zig-zag structure whereby the zig-zag structure also functions as current distributor from the backwall to the electrodes. The space limited by the backwall and the internal surface of the zig-zag structure is only available for the downcoming flow of degassed electrolyte, whereas the mixed gas—electrolyte phase is totally confined in the space defined by the process-side surface of the zig-zag structure and the electrode. In addition the upper edge of the wave-like section is provided with a protruding baffle which is directed to restrict the cross section for the passage of the mixed phase, thus facilitating the coalescence of the smaller size bubbles.

[0005] The efficiency of the claimed means and device has been demonstrated on the field by the operation of industrial size cells: the results of the tests show that the recirculation rate is greatly increased while the pressure pulsations caused by bubbles being entrained in the downcoming liquid phase are strongly reduced. In addition the service life of the delicate ion exchange membranes is substantially improved.

[0006] However, the means and devices disclosed in DE_A 198 50 071, in view of their rather complicated geometry, can only be used for the construction of new cells, whereas their installation on existing cells is practically impossible and in any case extremely expensive, as it would require the almost total destruction of the cell.

OBJECTS OF THE INVENTION

[0007] Hence, it is the scope of the present invention to overcome the mentioned difficulties and to allow an easy and cheap retrofitting of existing cells with hydrodynamic means and coalescence devices characterized by a modified design, while keeping the same efficiency of the means and devices disclosed in DE-A 198 50 071.

[0008] It is therefore an object of the present invention to disclose hydrodynamic means suitable for installation in existing cells of the type equipped with electrodes supported by rows of studs, or ribs or other elongated profiles during the operations of substitution of new electrodes in place of the exhausted electrodes by using simplified procedures which do not require complicated and expensive mechanical modifications and welding steps.

[0009] It is a further object of the invention to disclose hydrodynamic means consisting of flat strips or folded strips having a L or Z or C or trapezoidal shape, said flat strips or folded strips being characterized by a certain degree of elasticity which facilitates the insertion be-

tween each couple of rows of studs or ribs or any other type of elongated profiles by simply pressing them with the optional cooperation of the new electrode sheets.

[0010] It is another object of the invention to disclose hydrodynamic means consisting of flat strips or folded strips having a L or Z or C or trapezoidal shape, said flat strips or folded strips being further provided with side lips characterized by elasticity such to allow for the facile insertion and firmly fixing in place between each contiguous couple of rows of studs, or ribs, or any other type of elongated profile thus eliminating the need of cooperation of the electrode sheets.

[0011] It is another object of the invention to disclose hydrodynamic means of the type mentioned above wherein the upper edge is extended by means of a protruding baffle directed to reduce the cross section of the passage available for the flow of the gas-electrolyte mixed phase in order to improve the coalescence of the bubbles.

[0012] It is a final object of the invention to disclose hydrodynamic means, such as the types mentioned above, which are manufactured by using metals or plastic materials provided with chemical inertia, elasticity and low tendency to creep relaxation under the electrolysis conditions.

DESCRIPTION OF THE INVENTION

[0013] In the following description reference is made to some preferred embodiments but it has to be understood that various other modifications of the devices of the invention may be made without departing from the spirit or scope thereof and therefore such modifications are not intended to limit the invention thereto.

[0014] The invention will now be described by making reference to the following figures, wherein:

- figure 1 shows the top view of a cross section of an existing cell comprising two half shells, each one provided with vertical ribs supporting the electrode sheets and provided with apertures (not shown) to allow transversal mixing of the electrolytes;
- figure 2 represents the top view of a cross section of the same cell of figure 1, with the strip-shaped hydrodynamic means of the invention inserted in a zig-zag configuration between the rows of vertical ribs;
- figure 3 is the side view of a cross section of the same cell of figure 2 with the arrows indicating the separated ascending and descending flows of the internal recirculation generated by the hydrodynamic means;
- figure 4 shows another embodiment of the cell of figure 2 where the hydrodynamic means have a curved cross section;
- figure 5 schematizes a cross section similar to that of figure 2, with L-shaped folded strips in-

figure 6

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figure 7

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figure 8

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figure 9

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figure 10

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serted between the rows of ribs to form a saw tooth pattern wherein the apertures of all ribs of each are obstructed;

represents another embodiment of the invention similar to that of figure 2 with the Z-shaped folded strips inserted between the rows of ribs, again forming a saw tooth pattern where the apertures of all ribs are obstructed;

represents a further embodiment of the invention similar to that of figure 2 with trapezoidal folded strips inserted between the rows of ribs;

shows the top view of a cross section of a preferred embodiment of the trapezoidal folded strips of figure 7 provided with side lips directed to facilitate the retention between the rows of ribs during the construction;

shows a cross section similar to that of figure 7 where the trapezoidal folded strips are further provided on the upper edge with a protruding baffle directed to reduce the cross section of the passage available for the gas-electrolyte mixed phase for the improved coalescence of the dispersed bubbles;

schematizes a side view of a cross section of the embodiment of figure 9.

[0015] Figure 1 shows the top view cross section of an existing cell 1 where the electrodes 2 are supported by rows of studs or ribs 3 or other similar elongated profiles fixed, e. g. by welding, on the backwall 4. The ribs are generally provided with perforations (not shown in the figure) to allow for a certain transversal mixing of the electrolytes such as to avoid the formation of areas with different concentration. As it is known to the experts of the field, the catalytic activity of the electrodes is tied to the presence of a thin coating film containing certain elements such as the platinum group metals: during the electrolysis the mechanical stresses caused by the detachment of gas bubbles and/or chemical attack, when anomalous conditions appear in the cell, induce a slow consumption of the film until its residual traces left on the surface of the electrodes are unable to support the electrolysis process. At this point the cell is disassembled and the half shells are subjected to reactivation, which generally comprises the detachment of the worn-out electrodes 2 followed by fixing, for example by welding, of new electrodes. Once the worn-out electrodes have been detached and before the new electrodes are installed, the space between the rows of supporting studs or ribs or other elongated profiles becomes accessible and the hydrodynamic means of the invention can be inserted between the rows. The embodiment sketched in figure 2 (top view cross section) and 3 (side view cross section) represents the simplest realization

of the invention with the hydrodynamic means consisting of flat strips 5 which are inserted between said rows to form a zig-zag pattern. In such a way the space defined by the electrodes 2, the ribs 3 and the backwall 4 is divided in two regions 6 and 7, respectively dedicated to the ascending flow 8 of gas-electrolyte mixed phase and to the down coming flow of electrolyte 9 separated from the gas bubbles in the upper section 10 of the cell. The strips have a width slightly greater than the diagonal of each space between two contiguous rows of ribs and are kept in position thanks to their elasticity and the pressing action of the new electrodes which are fastened by a suitable jig before being welded to the top of the ribs. As the strips are kept in their position only by the mechanical restraint against the corners defined respectively by the couples electrodes/ribs and backwall/ribs, they may be manufactured with plastic materials, in addition to the currently used metals, provided that the selected plastic materials be chemically resistant to the electrolysis environment and to the creep relaxation at the temperature of operation. Fluorinated materials such as polyvinylidenefluoride, perfluorinated alkoxyethylene copolymers, polychlorotrifluoroethylene are particularly suitable. With the zig-zag pattern of figure 2 the perforations of the ribs, which remain unobstructed, allow the transversal mixing alternately of the ascending mixed phase and of the downcoming degassed electrolyte.

[0016] The hydrodynamic means may also be shaped in the form of curved strips 11 as shown in figure 4: the insertion procedure and the mechanical behaviour remain the same discussed in the case of the preceding figure 2. However, the unobstructed perforations of the ribs only allow the transversal mixing of the degassed electrolyte.

[0017] The plain strips of figure 2 may be folded to obtain an L-shaped section 12 as shown in figure 5: these strips are advantageously inserted between the rows of ribs to form a saw tooth pattern characterized in that the shorter length of the L obstructs the perforations of the ribs so that no transversal mixing is allowed: in this case a more effective motion of both the mixed phase and the degassed electrolyte is generated: however it is required the distribution of the electrolyte in the lower section of the cell be highly uniform. A quite similar result is obtained when the hydrodynamic means are given the Z shape 13 sketched in figure 6 by suitably folding the strips. In both cases of L and Z shapes an additional advantage derives from the ability of the strip to remain in position after insertion without the need of the pressing by the electrodes thanks to the forcing action against the contiguous rows of ribs due to the intrinsic elasticity of the structure: as it is clear, this peculiarity leads to a simplified procedure of production of the modified cells.

[0018] A further design suitable for the hydrodynamic means of the invention is represented by the use of trapezoidal or C-shaped folded strips 14 (figure 7, only the

trapezoidal strips shown), which are characterized by a behaviour quite similar to that discussed before in the case of the strips of figure 5 and figure 6.

[0019] If desired, it is possible to reinforce the ability of remaining in position between the rows by providing the strips with side lips 15 whose elastic reaction against the ribs guarantees a totally firm retention in place without any need of cooperation of the electrodes (figure 8).

[0020] The trapezoidal and C-shaped means represent a two-fold advantageous design solution.

[0021] First, the trapezoidal and C-shaped strips may be easily equipped on the upper edge with protruding baffles 16 (figure 9: top view of the cross section, figure 10: side view of a cross section), which are aimed to restrict the passage of the gas-electrolyte mixed phase in the very top section of the cell: the increase of the linear velocity of the mixed phase enhances the coalescence of the gas bubbles, in particular the tiny bubbles, greatly facilitating the degassing of the electrolyte and, as a consequence, the internal recirculation. The baffles may be integral with the body of the strip thus avoiding time consuming and expensive procedures of welding or gluing by means of proper stamping of suitably cut flat strips.

[0022] In the second place the regions dedicated to the ascending gas-electrolyte mixed phase and to the downcoming degassed electrolyte do not have necessarily the same cross section as is the case for the means of figures 2, 5 and 6, but on the contrary their ratio may be adjusted so that the linear velocity in the two regions is optimized for the best degassing and recirculation.

[0023] Obviously the hydrodynamic means and the procedure of insertion and fixing described for the case of the retrofitting of existing cells during the reactivation of the catalytic activity can also be employed for the construction of new cells.

[0024] As stated before, various modifications of the hydrodynamic means of the invention may be devised without, however, departing from the spirit or scope thereof and it is to be understood that the invention is intended to be limited only as defined in the appended claims.

Claims

1. Hydrodynamic means directed to establish or improve in gas evolving electrochemical cells the internal recirculation of both the gas-electrolyte mixed phase and the degassed electrolyte, comprising two half shells, at least one of said half shells including a backwall, rows of studs or ribs or other types of elongated profiles supporting the electrodes **characterized in that** the hydrodynamic means are inserted between each contiguous couple of rows and have the form of flat strips or folded strips with a L- or Z- or C- shaped or trapezoidal

cross section.

2. The hydrodynamic means of claim 1 **characterized by** dividing the space defined by the backwall, the electrodes and the rows in two separate regions directed to the ascending flow of gas-electrolyte mixed phase and to the downcoming flow of degassed electrolyte. 5
3. The hydrodynamic means of claim 1 or 2 **characterized in that** the ribs or other elongated profiles are provided with perforations for the transversal mixing of the electrolyte. 10
4. The hydrodynamic means of claim 3 **characterized in that** said perforations are at least in part obstructed by said folded strips. 15
5. The hydrodynamic means of anyone of the preceding claims **characterized by** being kept in place under the effect of the pressing action of the electrodes. 20
6. The hydrodynamic means of anyone of claims 1 to 4 **characterized by** being kept in position under the effect of their structural elasticity. 25
7. The hydrodynamic means of anyone of claims 1 to 4 **characterized by** being kept in position under the effect of the elastic restraint of side lips. 30
8. The hydrodynamic means of claim 2 **characterized in that** said regions have substantially equivalent cross section of passage for said mixed phase and said degassed electrolyte. 35
9. The hydrodynamic means of claim 2 **characterized in that** said regions formed by said C-shaped or trapezoidal folded strips have an adjustable ratio of cross section of passage for said mixed phase and said degassed electrolyte 40
10. The hydrodynamic means of claim 1 **characterized in that** said C-shaped or trapezoidal folded strips are provided with protruding baffles on their upper edge. 45
11. The hydrodynamic means of claim 10 **characterized in that** said baffles are integral parts of said C-shaped or trapezoidal folded strips. 50
12. The hydrodynamic means of anyone of the preceding claims 1 **characterized in that** said plain strips or folded strips are manufactured with metals or plastic materials. 55
13. The hydrodynamic means of claim 12 **characterized in that** said plastic materials are fluorinated

polymers.

14. The hydrodynamic means of claim 13 **characterized in that** said fluorinated polymers are selected from the group of polyvinylidenefluoride, perfluorinated alkoxyethylene copolymers, polychlorotrifluoroethylene.
15. Method of installation of the hydrodynamic means of anyone of claims 1-14 **characterized in that** said flat strips or folded strips are inserted between each contiguous couple of rows during the reactivation of the electrochemical cells.
16. An electrochemical cell comprising the hydrodynamic means of anyone of claims 1-14.
17. The electrochemical cell of claim 16 **characterized in that** it is a cell suitable for chlor-alkali electrolysis.
18. The cell of claim 16 **characterized in that** it is a cell suitable for the electrolysis of hydrochloric acid solutions.

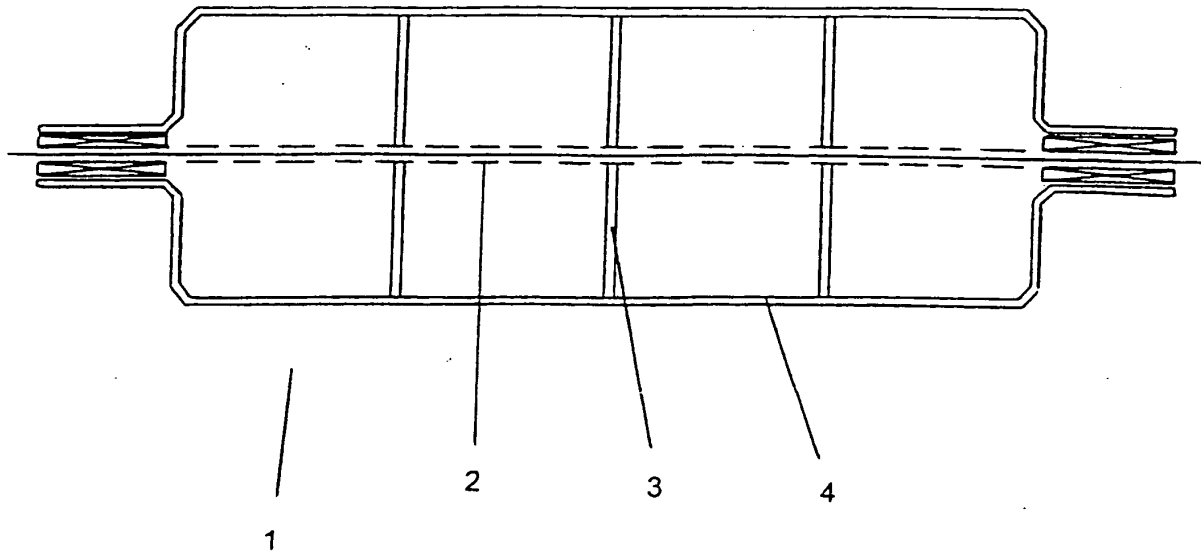


FIG. 1

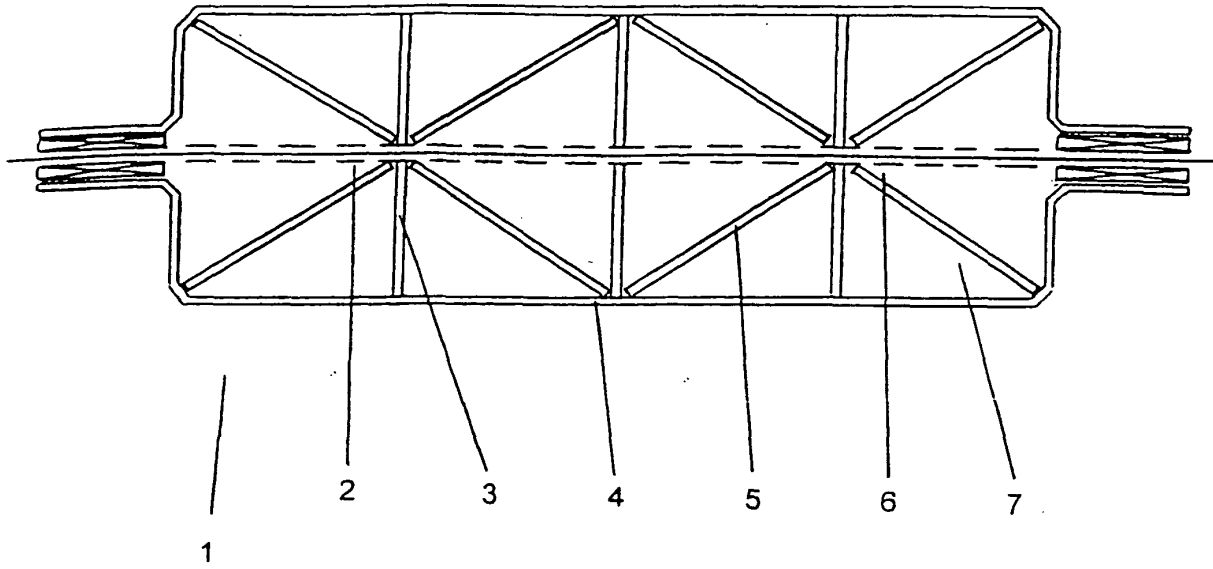


FIG. 2

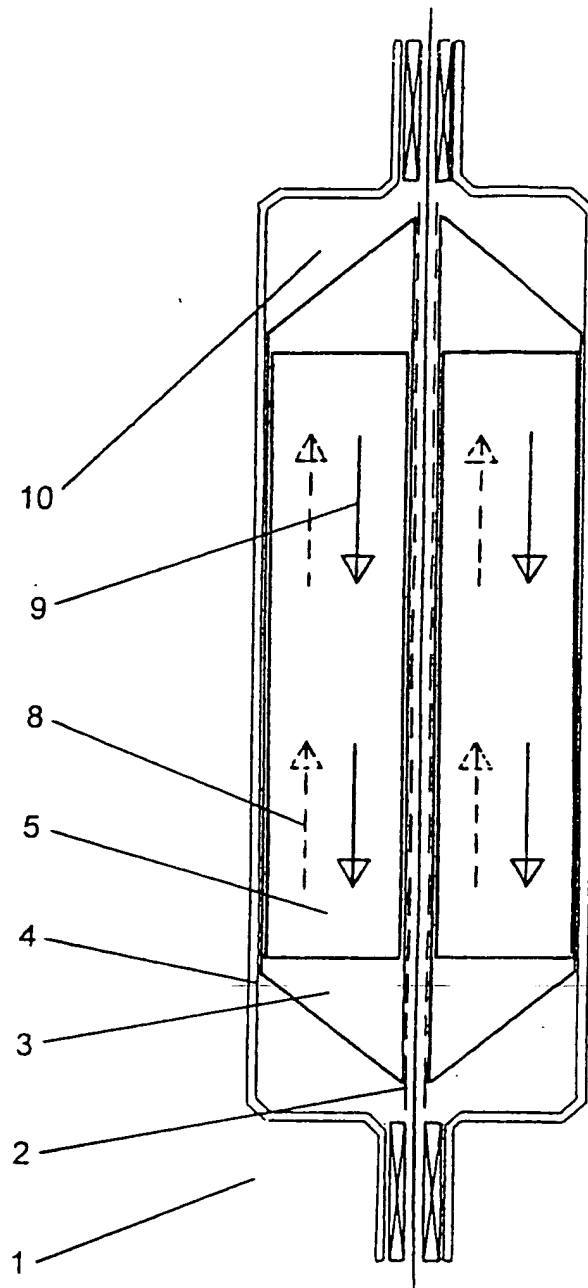


FIG. 3

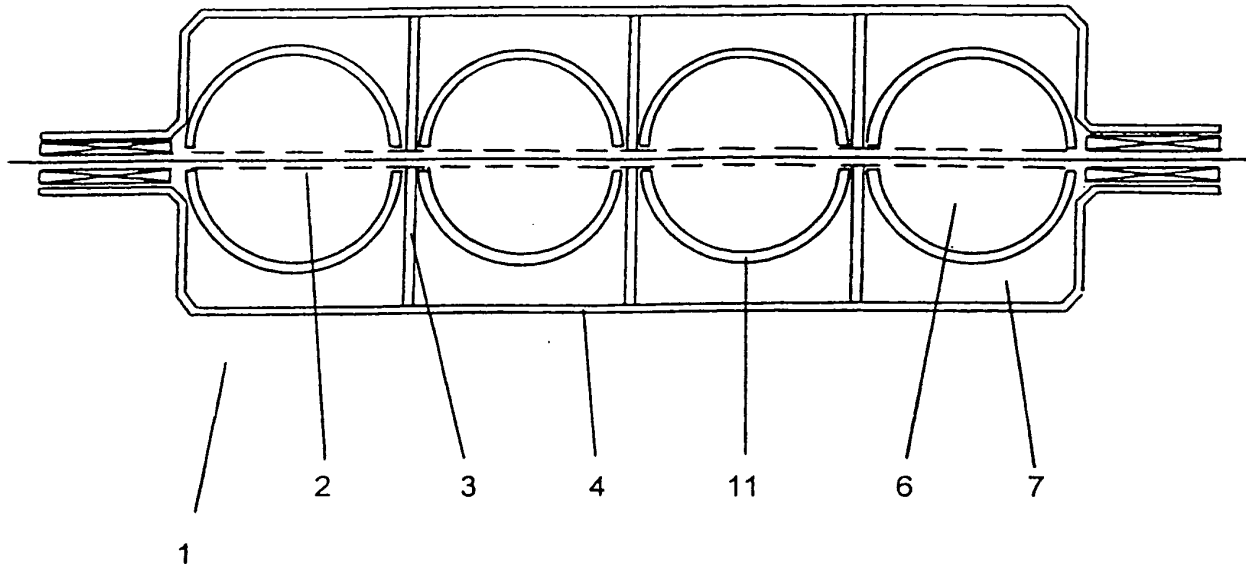


FIG. 4

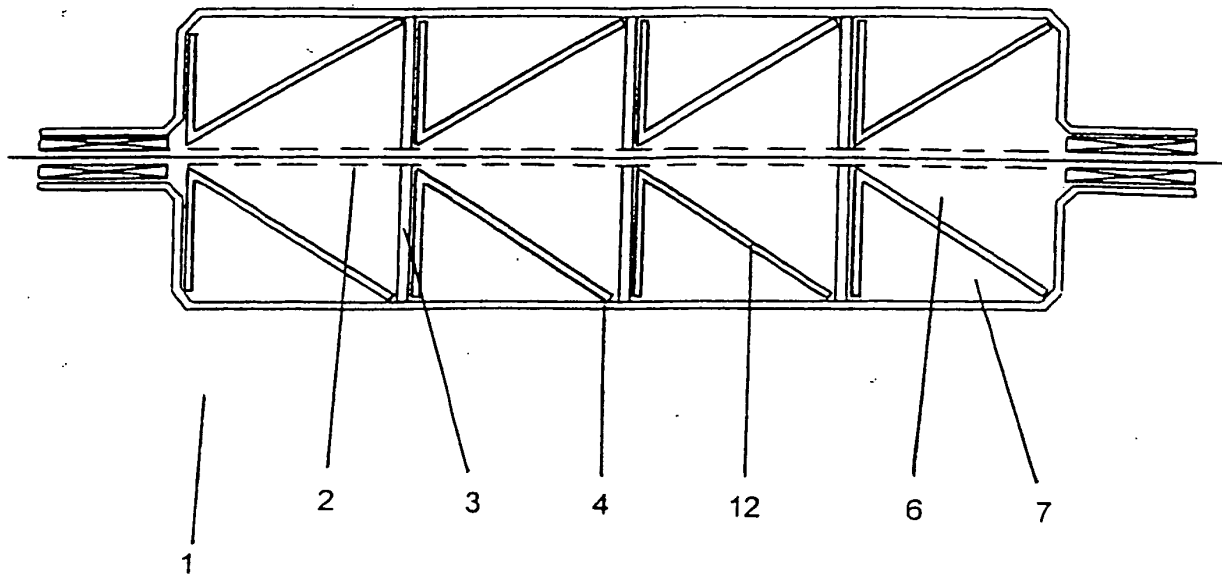


FIG. 5

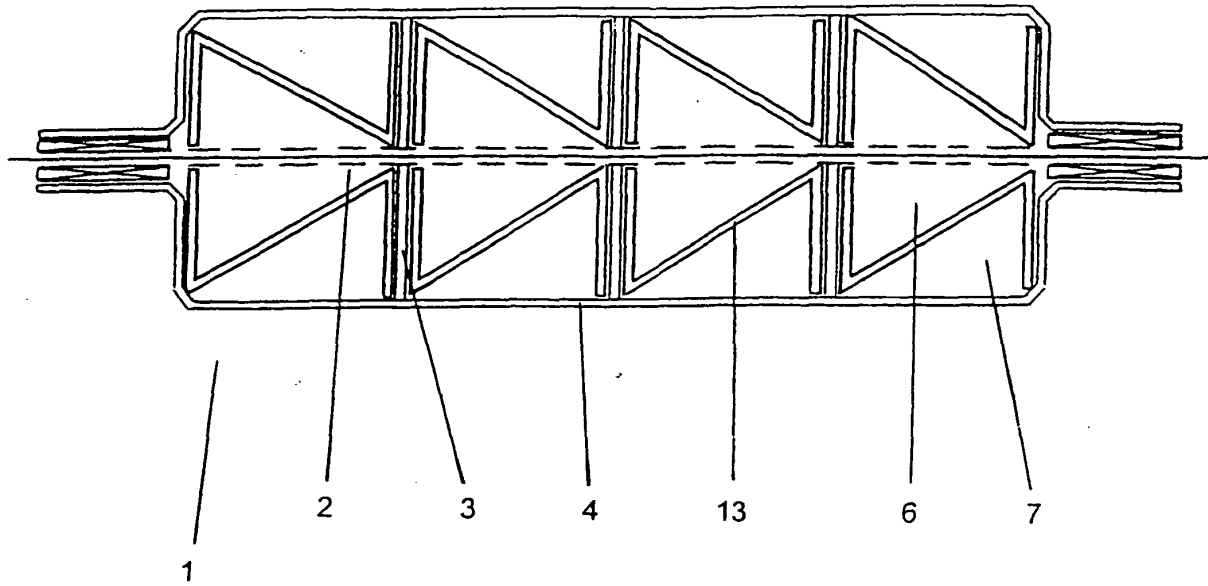


FIG. 6

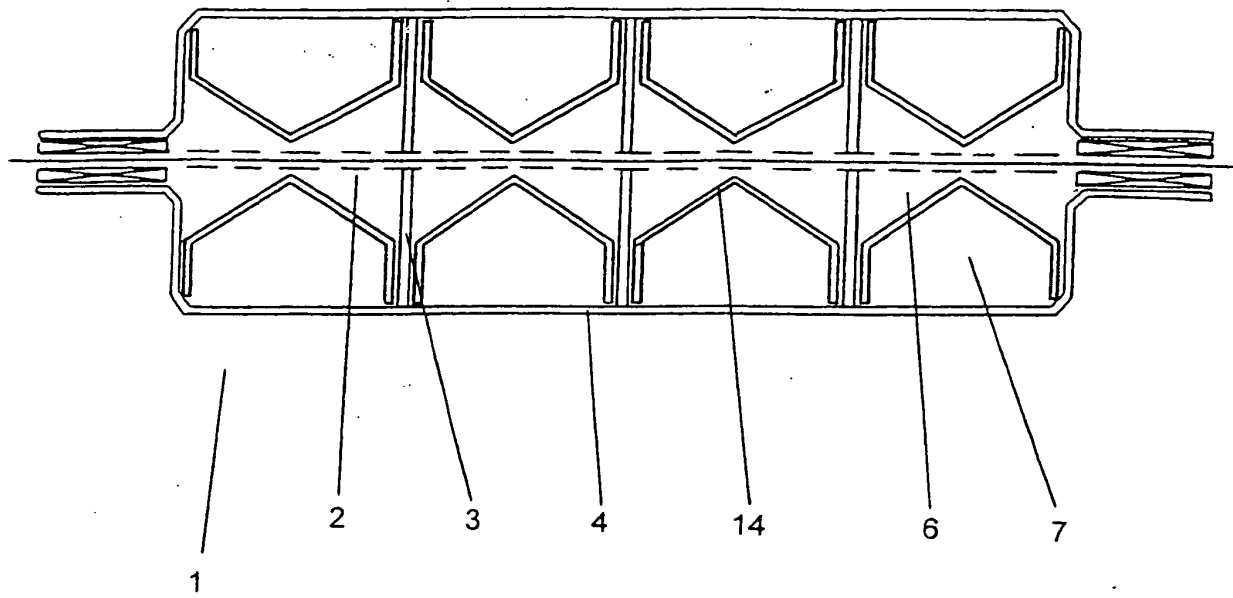


FIG. 7

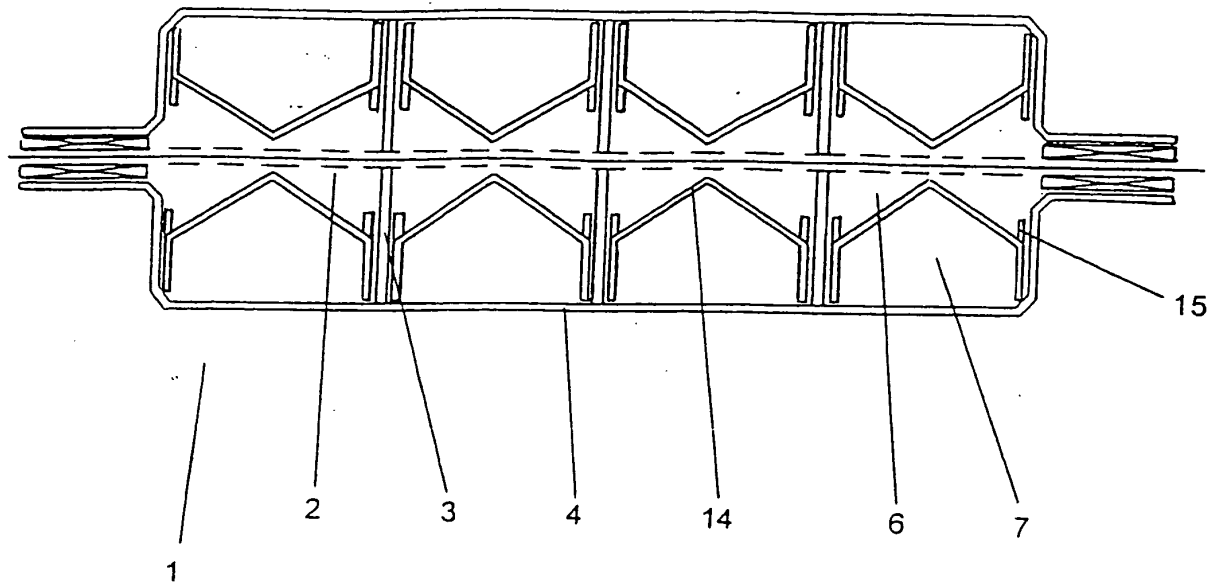


FIG. 8

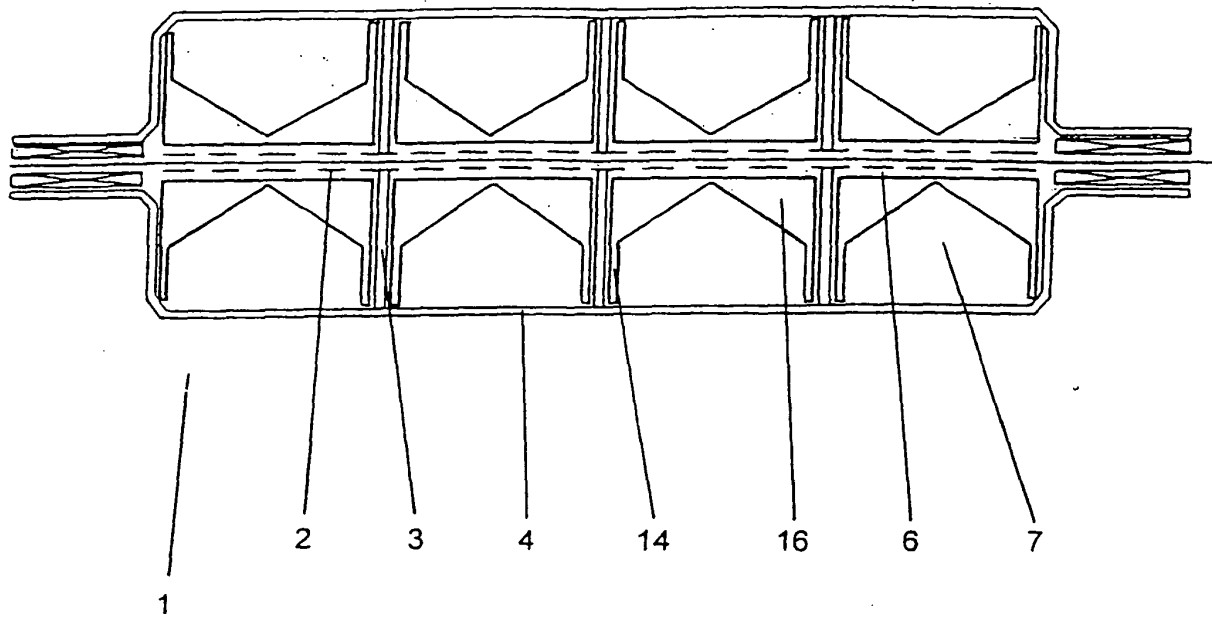


FIG. 9

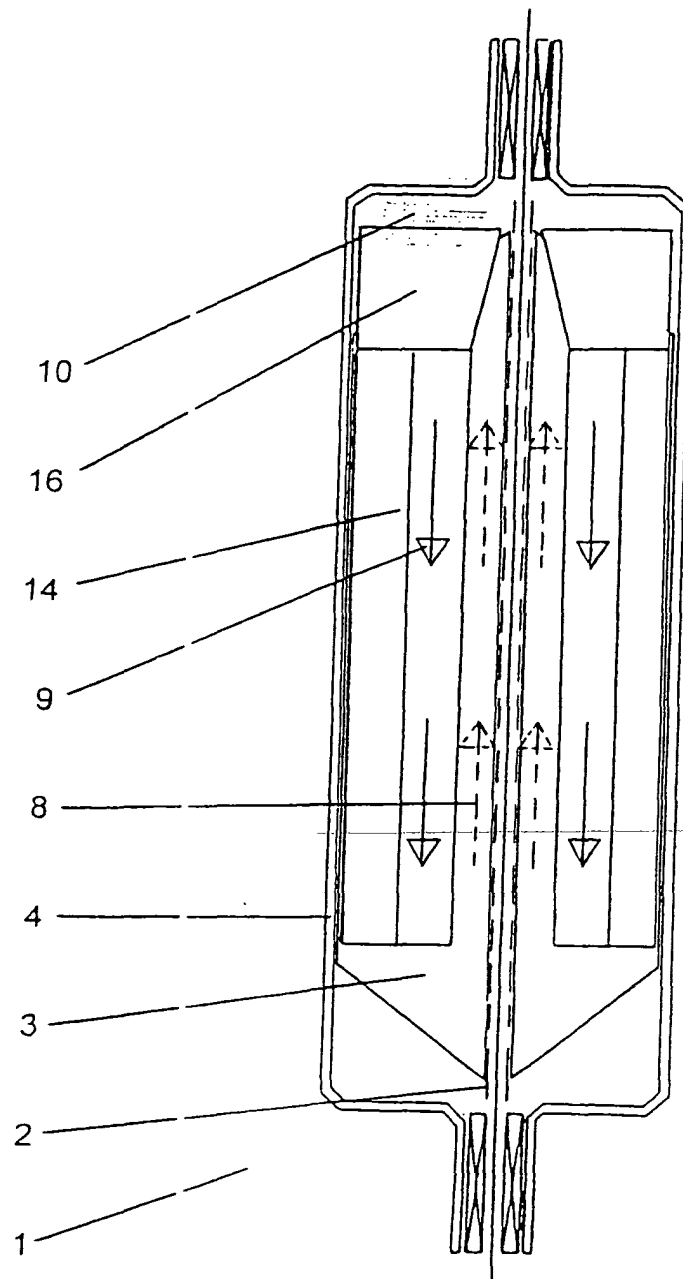


FIG. 10