Sept. 19, 1972 R. B. MacMULLIN ET AL 3,692,660

ELECTROLYTIC CELL

Filed Sept. 25, 1970 2 Sheets-Sheet 1

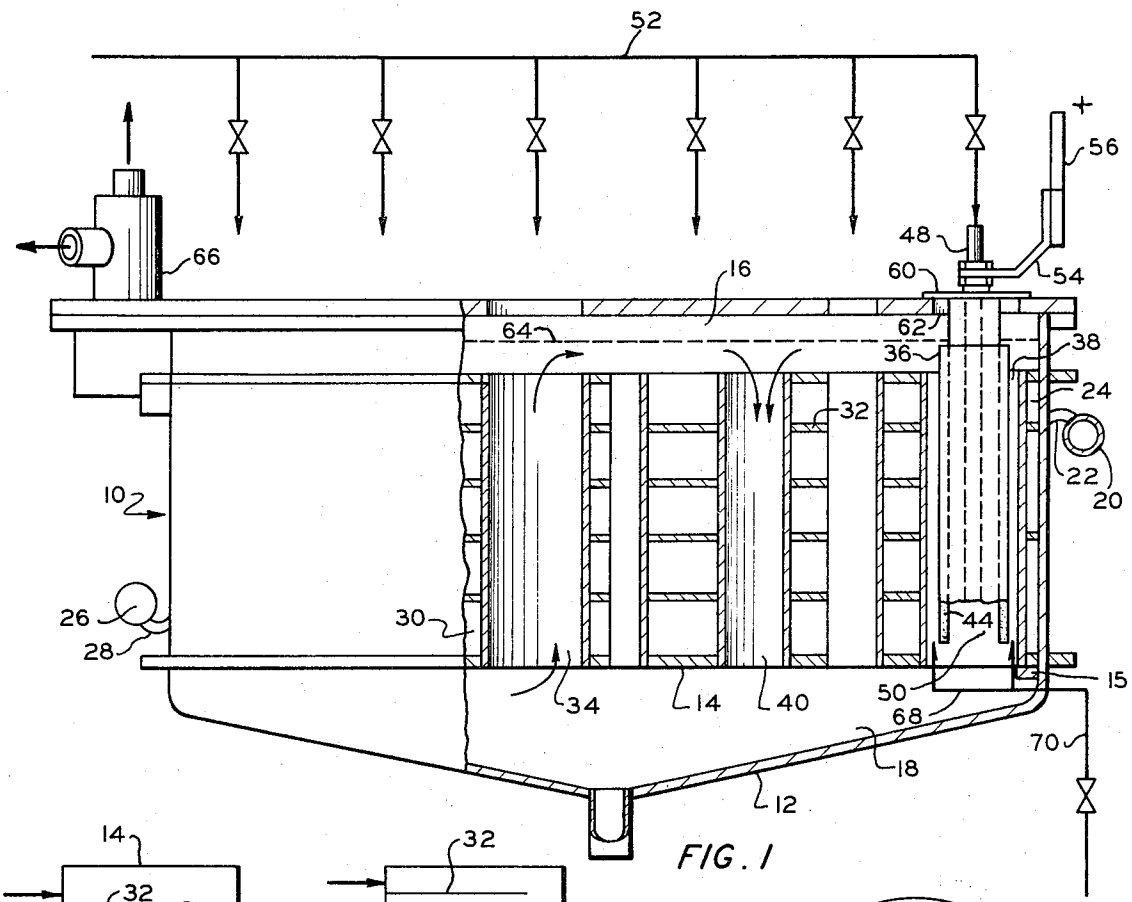


FIG. 1

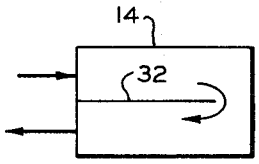


FIG. 5

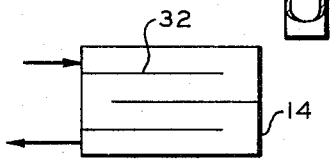


FIG. 6

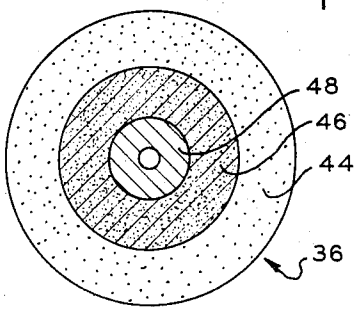


FIG. 10

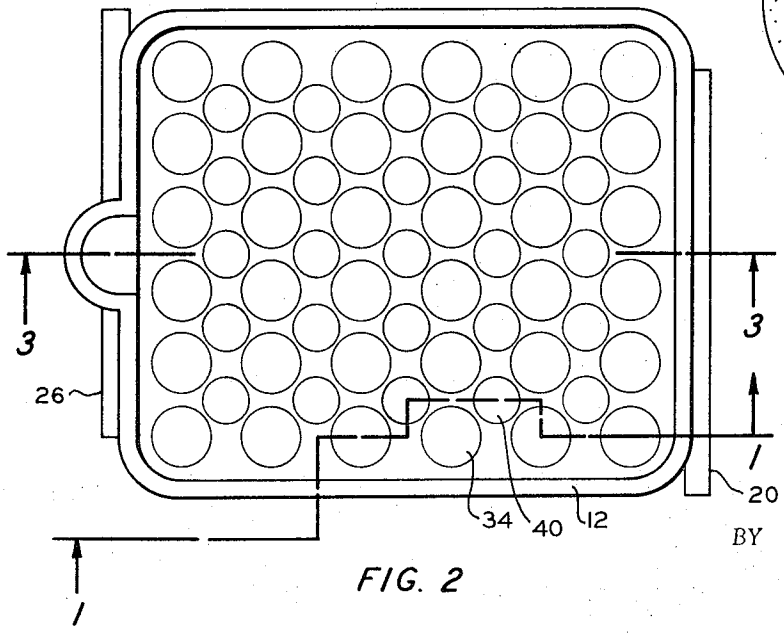


FIG. 2

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ELECTROLYTIC CELL

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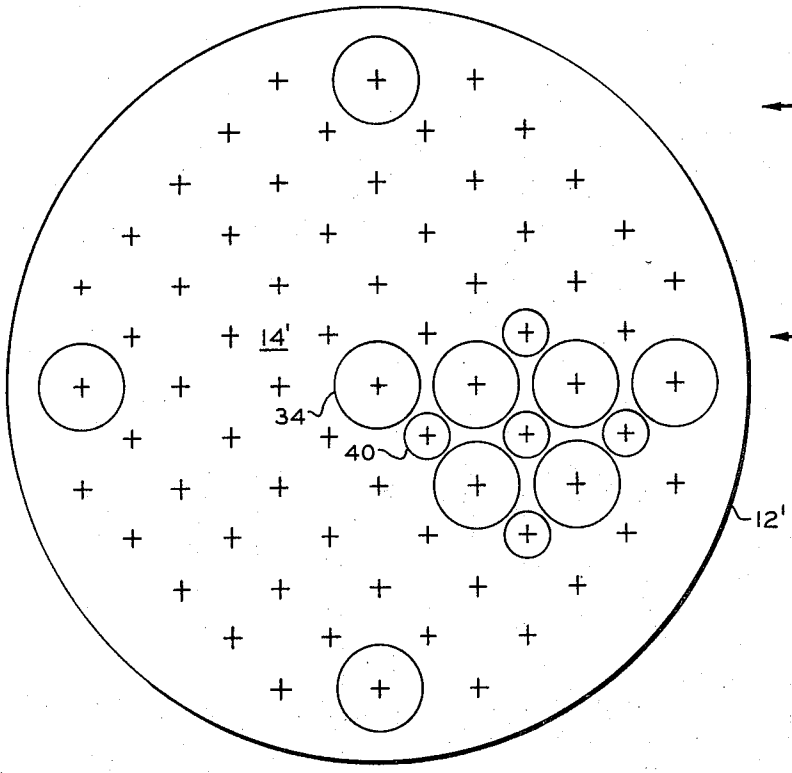


FIG. 4

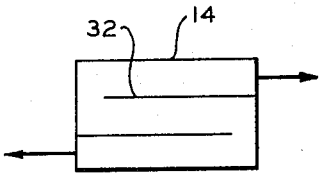


FIG. 7

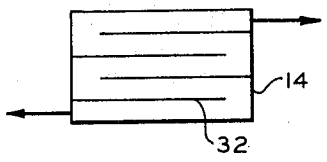


FIG. 8

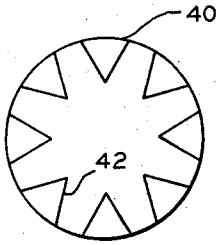


FIG. 9

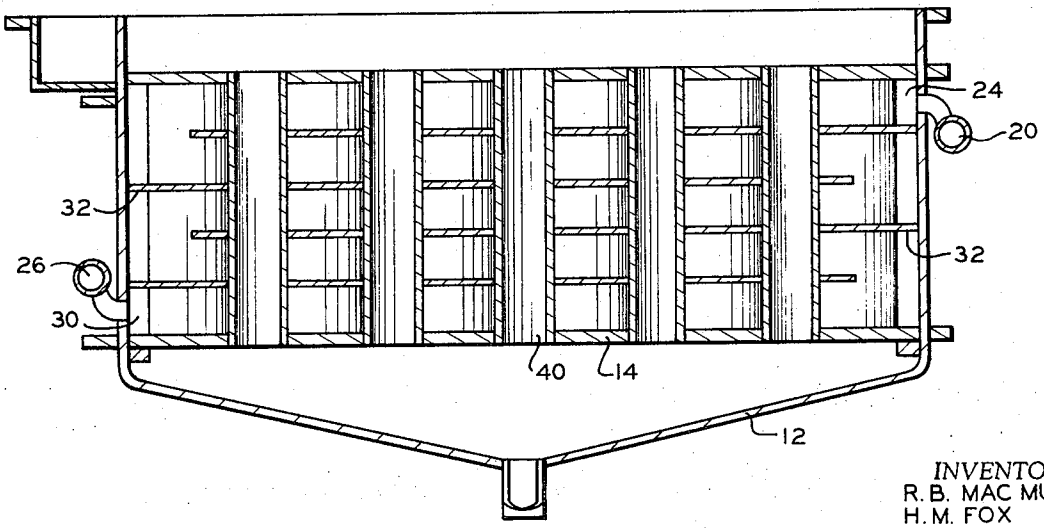


FIG. 3

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3,692,660

ELECTROLYTIC CELL

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Int. Cl. B01k 3/00
U.S. Cl. 204—246 12 Claims

ABSTRACT OF THE DISCLOSURE

An electrolytic cell having a heat exchanging shell disposed therein and dividing the cell container into an upper and lower electrolyte chamber. Electrode tube means extend through said shell and are in communication with said electrolyte chamber. Electrode means are disposed in said electrode tube means in a manner to preserve said communication. Downcomer tube means, interspersed among said electrode tube means, also extend through the shell into communication with said electrolyte chamber. Baffle arrangements in said shell, and arrangements of said electrode tube means and said downcomer tubes, improve the efficiency of the cell.

This invention relates to improved electrolytic cells.

Electrolytic cells comprising a heat exchanging shell disposed in the cell container are known in the art. For example, U.S. Pat. 3,404,083, issued Oct. 1, 1968, in the name of M. S. Kircher, relates to an electrolytic cell of this type. In the cells described in said patent, cylindrical cathodic tubes extend vertically through the heat exchanging shell and are in communication with an upper and a lower electrolyte chamber which contains a liquid electrolyte. An anode is suspended in each of said cathodic tubes in a manner to leave an annulus between the wall of the cathodic tube and the outer wall of the anode. Interspersed among said cathodic tubes are other open tubes, generally like said cathodic tubes, but which do not contain an anode and are referred to as downcomer tubes. A coolant inlet is connected to one side of said shell for the introduction of a coolant medium. A coolant outlet means is connected to an opposite side of said shell to provide an outlet for said coolant medium. In operation, heat is liberated at the anode and creates a thermal siphon and electrolyte circulates upwardly from the lower to the upper electrolyte chamber and cools the anode. Heat is dissipated through the walls of the cathodic tubes into the coolant flowing through the heat exchanging shell.

In electrolytic cells of this type, difficulties are encountered from nonuniform cooling of the walls of the various cathodic tubes, with some tubes being cooled more than others. This can result in nonuniform operating temperatures of the anodes in the various cathodic tubes. In some processes this is a serious operating problem. Overcooling the wall of a cathodic tube can cause the formation of a film of overcooled electrolyte on said wall. Since the conductivity of the electrolyte decreases with decreasing temperature, the resistivity of the cell will be increased and a higher voltage will be required to maintain the desired constant current flow. This will result in increased power costs. Furthermore, since electrolytic cells are normally operated at low voltages, any increase in voltage drop is a serious matter because it rapidly decreases the cell efficiency. In some cases, such as where the electrolyte has a freezing point close to the cell operating temperature, crystallization of the electrolyte on the wall of the cathodic tube can occur. In aggravated cases this can lead to blockage of the annular space between the wall of the anode and the wall of the cathodic tube. Increasing the temperature of the entering coolant medium does not provide an adequate solution because this results in a marked decrease in cooling efficiency due to the decrease in the temperature differential between the coolant and the electrolyte being cooled.

In some electrochemical conversion processes, such as electrochemical fluorination, it is important and highly desirable that all the electrodes, e.g., anodes, at which the reaction is occurring be at essentially the same temperature. This is difficult to accomplish, particularly in large cells containing a multiplicity of anodes. It is also desirable that differences in temperature of the electrolyte in the upper and lower electrolyte chambers be as small as possible. This is also difficult to accomplish, particularly in large cells.

The present invention provides a solution for the above described problems. The present invention provides an improved heat exchanger shell for cells of the type described, wherein multipath flow of coolant is obtained. Preferably, said multipath flow is also countercurrent with respect to flow of electrolyte in the downcomer tubes. It has also been found that by providing arrangements of the downcomer tubes and the electrode-containing tubes, wherein each downcomer tube is positioned generally at the center of a cluster of electrode-containing tubes, the cooling efficiency and general efficiency of the cell can be further improved.

Thus, according to the invention, there is provided an electrolytic cell comprising: a container; a heat exchanging shell mounted in said container and dividing said container into an upper electrolyte chamber and a lower electrolyte chamber; a coolant inlet means connected to a wall of said heat exchanging shell; a coolant outlet means connected to a wall of said heat exchanging shell at a point spaced apart from said inlet means in a generally vertical direction; at least one baffle means extending generally horizontally across said heat exchange shell from a wall thereof and between said inlet means and said outlet means so as to provide multiple pass flow of coolant through said shell between said inlet means and said outlet means; at least one electrode tube means extending in a generally vertical direction through said shell and said baffle means, and in communication with said upper and lower electrolyte chambers; and at least one downcomer tube means extending in a generally vertical direction through said shell and said baffle means, and in communication with said upper and lower electrolyte chambers.

A number of advantages are obtained or realized when employing the improved cell of the invention. By providing baffles in the heat exchanging shell so as to induce multiple pass flow of coolant through said shell, essentially the same amount of cooling with respect to all the electrodes in the cell can be obtained. In other words, essentially the same amount of cooling is obtained on the electrodes which are most removed from the coolant inlet as is obtained on the electrodes which are adjacent said coolant inlet. This makes possible much more uniform operations of the multiple electrodes in the cell. Furthermore, overcooling of the walls of the electrode tubes near the coolant inlet is also avoided. This eliminates danger of forming an overcooled film of electrolyte on the walls of the electrode tubes which causes increased power requirements, and also makes it possible to maintain a greater temperature differential between the temperature of a coolant and the temperature of the electrolyte to be cooled. This provides for maximum efficiency in the cooling of the electrolyte. The preferred countercurrent flow of coolant with respect to the flow of electrolyte in the cell also improves cell efficiency in that

smaller downcomer tubes can be employed. Thus, more electrode tubes can be employed per cell. This increases overall cell efficiency because the cell throughput is increased. Still another advantage of the invention is that the flexibility of the cell is increased. The number of different electrolytes which can be used in any given cell arrangement is greater because the danger or risk of forming an overcooled film of electrolyte, or of freezing of any particular electrolyte on the walls of the electrode tubes, can be eliminated.

The invention is applicable to and can be employed in cells for carrying out a wide variety of electrochemical conversion processes using a wide variety of electrolytes. The invention is particularly applicable to cells wherein the electrolyte being used has a freezing point relatively close to the desired cell operating temperatures. The essentially anhydrous liquid hydrogen fluoride electrolytes containing a conductivity additive, such as potassium fluoride, are examples of such electrolytes. Thes electrolytes are used in processes for the electrochemical fluorination of fluorinatable compounds. Said conductivity additives can be present in the electrolyte in any suitable molar ratio of additive to hydrogen fluoride ranging from about 1:4.5 to 1:1 and having freezing points within the range of about 50 to about 200° C. A presently preferred group of said electrolytes includes those having a conductivity additive to hydrogen fluoride ratio within the range of about 1:4 to about 1:2 and having freezing points within the range of about 60 to about 75° C. Since the preferred cell operating temperature in fluorination processes employing those electrolytes is usually within the range of about 60 to about 105° C., commonly about 80 to about 100° C., it is important that the wall of the cathodic tube not be overcooled so as to avoid the formation of an overcooled film, or crystallization or freezing of said electrolytes, on the walls of said cathodic tube.

FIG. 1 is an elevation view, taken partly in cross section along the line **1—1** of FIG. 2, of a cell structure in accordance with their invention.

FIG. 2 is a diagrammatic plan view of the cell illustrated in FIG. 1.

FIG. 3 is a cross-sectional view taken along the line **3—3** of FIG. 2.

FIG. 4 is a diagrammatic plan view of another cell structure in accordance with the invention.

FIGS. 5, 6, 7, and 8 are diagrammatic illustrations of various embodiments of a heat exchanging shell which can be employed in the cell of FIG. 1.

FIG. 9 is a diagrammatic plan view of a downcomer tube means in the heat exchanging shell of the cell of FIG. 1, showing the inclusion of fins on the walls of said downcomer tube.

FIG. 10 is a cross section of one type of anode which can be employed in the cells of the invention.

Referring now to the drawings, wherein like reference numerals have been employed to denote like elements, the invention will be more fully explained. In FIGS. 1, 2 and 3, there is illustrated an electrolytic cell, designated generally by the reference number **10**, which comprises a container **12** having a heat exchanging shell **14** mounted therein. Said container and heat exchanging shell can be fabricated integrally, but preferably are fabricated separately and the heat exchanging shell then mounted in said container **12**, as shown. Any convenient means can be employed for mounting and/or supporting the heat exchanging shell in the cell container. For example, lugs **15** can be employed. Said heat exchanging shell **14** divides said container **12** into an upper electrolyte chamber **16** and a lower electrolyte chamber **18**. A coolant inlet means comprises a header conduit **20**, and a plurality of inlet conduits **22** (only one is shown) connected to a wall of said container and in communication with a passageway **24** formed in said heat exchanging shell. A coolant outlet means comprises a header conduit **26**, and a plurality of outlet conduits **28** (only one is shown) connected to a wall of said container and in communication with another passageway **30** formed therein. Preferably, said coolant inlet means and said coolant outlet means are connected to opposite walls of said heat exchanging shell, and also spaced apart vertically, as illustrated in the drawing. However, it is within the scope of the invention for said coolant outlet means and said coolant inlet means to be connected to the same wall of the heat exchanging shell, as illustrated in FIGS. 5 and 6. In such instances, it is usually preferred that said coolant inlet means and said coolant outlet means be connected to said same wall, one above the other, i.e. spaced apart vertically. The relative vertical positions of said coolant inlet means and said coolant outlet means can be reversed from that shown, depending upon the service of the cell. Said container **12** and heat exchanging shell **14** can be constructed of any suitable metal, such as steel, stainless steel, or the like. It is preferred that the heat exchanging shell **14** be constructed of a metal or other material having a high heat conductivity.

At least one baffle means **32** extends generally horizontally across said heat exchange shell from a wall thereof, to a point adjacent an opposite wall thereof, and between said coolant inlet means and said coolant outlet means so as to form said passageways **24** and **30** and provide multiple pass flow of coolant within said shell between said coolant inlet means and said coolant outlet means Depending upon the size of the cell and the heat exchanging shell mounted therein, it is usually preferred to employ a plurality of said baffle means **32** so as to provide more flow passageways through said heat exchange shell. When said heat exchange shell **14** and said container **12** are fabricated integrally, the wall(s) of container **12** become wall(s) of said heat exchanging shell, and said baffle means **32** are connected thereto.

As here illustrated, a plurality of cathodic tube means **34** extend in a generally vertical direction through said heat exchanging shell **14** and are in communication with said upper electrolyte chamber **16** and said lower electrolyte chamber **18**. An anode means **36** is disposed in each of said cathodic tubes **34** in a manner to provide an annular space **38** surrounding said anode means so as to preserve said communication between the upper and lower electrolyte chambers.

A plurality of downcomer tube means **40** extend in a generally vertical direction through said heat exchanging shell **14** and also are in communication with said upper electrolyte chamber **16** and said lower electrolyte chamber **18**. Said downcomer tubes **40** are open tubes and do not contain any electrode structure. If desired, the inner wall of said downcomer tubes **40** can be provided with internally extending fins **42**, as illustrated in FIG. 9. Preferably, said cathodic tube means **34** and said downcomer tube means **40** are arranged in alternate rows, with respect to each other, which rows extend across said shell and thus across said container. Still more preferably, the centers of said downcomer tubes **40** in a row thereof are positioned between the centers of said cathodic tubes **34** in an adjacent row thereof. See FIG. 2. In the presently most preferred arrangement, each one of said downcomer tubes **40** is disposed generally at the center of a cluster of a plurality of said cathodic tubes **34**. See FIG. 2 wherein a said cluster of cathodic tubes **34** comprises 4 tubes arranged in a generally rectangular pattern with a downcomer tube **40** at the general center of the rectangle. While in FIGS. 1, 2 and 3, the cells of the invention have been illustrated as containing a plurality of said cathodic tubes **34** and a plurality of said downcomer tubes **40**, it is within the scope of the invention to provide the cell with only one cathodic tube **34** and only one downcomer tube **40**. The cells of the invention have been illustrated as having a plurality of cathodic tubes **34** and a plurality of downcomer tubes **40** because this is the usually preferred arrangement in commercial installation, and is the arrangement in which the invention finds its greatest and most valuable application.

In FIGS. 5–8 there are illustrated various arrangements of the coolant inlet means and the coolant outlet means in relation to the baffles **32** which are provided to induce multiple pass flow through heat exchanging shell **14**. In FIG. 5 said coolant inlet means and coolant outlet means are both connected to the same wall of the heat exchanging shell and are positioned one above the other. A single baffle means **32** is connected to said same wall of the heat exchanging shell and extends therefrom between said inlet means and said outlet means to a point adjacent but spaced apart from the opposite wall of said heat exchanging shell. It will be understood that said baffle means is also connected to the two side walls of the heat exchanging shell which are not shown so as to cause multipass flow of coolant medium as indicated by the arrow in the drawing. In FIG. 6 the coolant inlet means is positioned adjacent to and spaced apart from the top of heat exchanging shell **14**, and the coolant outlet means is positioned adjacent to and spaced apart from the bottom of said heat exchanging shell. It will be understood that, depending upon the desired flow of the coolant medium, it is within the scope of the invention for said coolant inlet means and said coolant outlet means to be reversed in position, i.e., the coolant inlet means can be positioned adjacent the bottom of the shell and the coolant outlet means positioned adjacent to the top of the shell. In FIG. 6 a plurality of said baffle means **32** is provided. A first one of said baffle means is connected to the wall of the shell above the one of said inlet means or said outlet means which is positioned adjacent to the bottom of the shell, and the last one of said baffle means is connected to the wall of the shell below the other of said inlet means or said outlet means which is positioned adjacent the top of the shell. FIGS. 7 and 8 illustrate other arrangements of said baffle means **32**; in FIGS. 7 and 8 it will be noted that the coolant inlet means and the coolant outlet means are connected to opposite walls of said heat exchanging shell **14**. The arrangements illustrated in FIGS. 1, 7, and 8 represent presently preferred arrangements with the coolant inlet and coolant outlet connected to said opposite walls. Preferably, said inlet and outlet are positioned vertically in a manner to provide countercurrent flow of coolant medium with respect to the flow of electrolyte through annular space **38**. For example, with flow of electrolyte upward through said annular space **38**, the coolant inlet **20** would be connected as shown in FIG. 1. This provides maximum efficiency in heat removal and, together with the multipass cross flow of coolant and the above-described cluster arrangement of downcomer tubes and electrode tubes, provides maximum efficiency in maintaining all the electrodes in the electrode tubes at essentially the same operating temperature.

Said anode means **36** can comprise any suitable type of anode structure, depending upon the requirements of the electrolytic conversion process to be carried out in the cell **10**. An enlarged cross-sectional view of said anode **36** is shown in FIG. 10. As illustrated in FIGS. 1 and 10, said anode structure is a composite carbon anode structure comprising a first or outer section of porous carbon **44** which is generally cylindrical in shape and is hollow. A second or core section of less porous carbon, or essentially impervious carbon, **46** has the general shape of a generally cylindrical rod and is disposed within said first section of carbon **44** and secured herein by any suitable means, such as a friction fit. A current collector **48**, here shown to be a hollow metal conduit, such as copper, extends into said second section of carbon **46**. Said current collector can be disposed in a hole drilled to fit and accommodate the metal conduit, or said current collector can be threaded into said second section of carbon. Said first section of carbon **44** extends at the lower end thereof beyond the lower end of said second section of carbon **46**. The bottom surface of said second section of carbon **46**, together with the inner surfaces of said extended portion of said first section of carbon **44**, define a cavity **50** in the lower portion of the anode. A vaporous feedstock can be introduced from feedstock header **52** by means of the header arrangement shown and passed through said current collector **48** to cavity **50** for introduction into porous carbon section **44** of the anode **36**. Each of the current collectors **48** is connected by means of a suitable lead **54** to the anode bus **56**. The heat exchanging shell means **14** can be rendered cathodic by means of any suitable connection thereto which is also connected to the cathode bus of the electric current source. If desired, the entire cell container **12** can be rendered cathodic by suitable connections thereto. In such instances the heat exchanging shell **14** would be connected to container **12** by suitable means.

It will be noted that each of the anodes **36** is individually suspended by means of suspension means **60** in a cathodic tube **34** and is individually connected to feedstock header **52**, and the anode bus **56**. Said suspension means **60** can comprise any suitable suspension means. As here illustrated, said suspension means comprises a flange member which covers an opening **62** in the top of container **12**. Said opening is large enough to permit the ready removal of the anode **36** from the container. Said suspension means or closure members **60** can be made of any suitable metal, properly insulated from the container shell, or can be made of any suitable insulating material such as Teflon or other suitable plastic material.

Referring now to FIG. 4, there is illustrated a cell structure generally similar to that illustrated in FIGS. 1, 2, and 3 except that the container **12'** is generally circular in shape. The heat exchanging means **14'** conforms in shape to the shape of said container **12'**. As in FIGS. 1, 2, and 3, a plurality of downcomer tubes **40** and a plurality of cathodic tube means **34** are arranged as described above in connection with said FIGS. 1, 2, and 3. While not shown in FIG. 4, it will be understood that the cell of FIG. 4 can be provided with suitable baffle means **32** and inlet conduit means and outlet conduit means arranged as described above in connection with FIGS. 1, 2, 3, and 5–8, so as to provide multipass flow of coolant through the cell.

In the operation of the cell structure illustrated in the drawings, for example, in the fluorination of a fluorinatable feedstock such as ethylene dichloride, an essentially anhydrous $KF \cdot 2HF$ electrolyte is introduced into the cell. The level of said electrolyte **64** is preferably maintained slightly above the tops of the anode structures **36**. The ethylene dichloride feedstock in vapor form is passed via conduct **52** through hollow current collector **48** and introduced into cavity **50**. Said feedstock then enters the porous carbon section **44** of anode **36**, travels upwardly therethrough, and within the pores of said anode is at least partially fluorinated. Products of the reaction and unreacted feedstock exit from the top of the porous section of the anode and are withdrawn from the cell via conduit **66** and passed to any suitable separation means for the recovery of the products. If desired, the unconverted feedstock can be recycled to the call by means of a recycle line not shown. During the cell operation, the heat liberated at anodes **36** creates a thermal siphon in the cathodic tube **34**, causing electrolyte to circulate from lower electrolyte chamber **18** up through annular space **38** and into upper electrolyte chamber **16**, as shown by the arrows in the drawing. Hydrogen liberated from the walls of cathodic tubes **34** aid this circulation by a gas lift effect. Said circulating electrolyte in passing through annular space **38** cools anodes **36**. The circulating electrolyte then flows downwardly through downcomer conduits **40** wherein the heat collected by the electrolyte is dissipated through the walls of the downcomer tubes and removed from the system by means of coolant introduced through coolant inlet means **20** and removed via coolant outlet means **26**. If desired, said gas lift effect can be augmented by means of a suitable inert gas introduced into said annular space **38** by means of header arrangement **68** con-

nected to conduit **70** which in turn is connected to a suitable source of inert gas.

Said inert gas can be any gas which is inert, or essentially inert, with respect to the electrolyte used in the cell, the feedstock, and the products produced in the cell. Examples of suitable inert gases include the commonly known inert gases such as helium, argon, krypton, xenon, nitrogen, etc. Nitrogen, because of its ready availability, is one preferred gas. Frequently, a gas produced in the electrochemical conversion process can be employed as the inert gas. When such gases produced in the process are available, they represent a preferred gas for use in the practice of the invention. For example, in the electrochemical fluorination of fluorinatable organic compounds using an electrolyte comprising hydrogen fluoride, some perhalogenated compounds are frequently produced in the process. Said perhalogenated compounds are inert in the process and can be used in the practice of the invention to enhance circulation of the electrolyte through said annular space **38**. Hydrogen is produced at the cathode in such fluorination processes and can be used to enhance said circulation.

The electrolytic cells of the invention are applicable to a wide variety of electrochemical conversion processes. The cells of the invention are applicable to any electrochemical conversion process wherein it is desired to remove heat of reaction from the system. Said electrolytic cells can be employed in systems where heat is liberated at the anode or in systems where heat is liberated at the cathode. Where the principle reaction is occurring at the cathode and heat is liberated at the cathode, the above designated cathodic tubes are designated as anodic tubes and contain a cathode. Thus, generically speaking, cathodic tube means **34** can be referred to as an electrode tube means, and anode means **36** can be referred to as an electrode means. Some examples of processes wherein the cells of the invention can be employed are electrochemical halogenation such as the fluorination process described above, electrochemical cyanation, and cathodic conversions such as the reduction of alcohol to hydrocarbons or the reduction of acids to alcohols.

Further details of an electrochemical fluorination process in which the cells of the invention can be employed can be found in U.S. Pat. 3,511,760, issued May 12, 1970, to H. M. Fox and F. N. Ruehlen. See also U.S. Pats. 3,461,049 and 3,461,050, issued Aug. 12, 1969, to W. V. Childs.

The electrolytic cells of the invention can be of any suitable dimensions, depending upon the process to be carried out therein, and the desired throughput for said process. By way of example, and not by way of limitation, in one embodiment of the invention the heat exchanger shell **14** was designed to have an overall length of approximately 90 inches and overall width of approximately 75 inches, with cathodic tubes **34** having an outside diameter of approximately 9½ inches, and downcomer tubes **40** havng an outside diameter of approximately 6½ inches. The overall height of said heat exchanger shell **14** was approximately 30 inches. Anode **36** had an overall length, including fittings on the top, of approximately 36 inches. Said anode had an overall outside diameter in the carbon portion of approximately 7½ inches. The remainder of the elements of the cell were generally proportional in size.

While certain embodiments of the invention have been described for illustrative purposes, the invention is not limited thereto. Various other modifications or embodiments of the invention will be apparent to those skilled in the art in view of this disclosure. Such modifications or embodiments are within the spirit and scope of the disclosure.

We claim:

1. An electrolytic cell comprising, in combination:

a container;

a heat exchanging shell mounted in said container and dividing said container into an upper electrolyte chamber and a lower electrolyte chamber;

a coolant inlet means in communication with a passageway formed in said heat exchanging shell as described hereinafter;

a coolant outlet means in communication with another passageway formed in said heat exchanging shell as described hereinafter;

at least one baffle means extending across said heat exchange shell from a wall thereof and between said inlet means and said outlet means so as to form a plurality of said passageways for multiple pass flow of coolant through said shell between said inlet means and said outlet means;

a plurality of electrode tube means extending in a generally vertical direction through said shell and said baffle means, and in communication with said upper and lower electrolyte chambers;

a plurality of downcomer tube means extending in a generally vertical direction through said shell and said baffle means, and in communication with said upper and lower electrolyte chambers; and

a plurality of electrodes disposed in said electrode tube means with space surrounding said electrodes so as to preserve said communication; and

wherein said electrode tube means and said downcomer tube means are arranged in alternate rows, with respect to each other, extending across said container and said shell.

2. An electrolytic cell in accordance with claim **1** wherein the centers of said downcomer tubes in a row thereof are positioned between the centers of said electrode tubes in an adjacent row thereof.

3. An electrolytic cell in accordance with claim **1** wherein each one of said downcomer tubes is disposed generally at the center of a cluster of a plurality of said electrode tubes.

4. An electrolytic cell in accordance with claim **3** wherein said cluster of electrode tubes comprises four tubes arranged in a generally rectangular pattern.

5. An electrolytic cell in accordance with claim **1** wherein:

said coolant inlet means and said coolant outlet means are both connected to the same wall of said shell and are positioned one above the other; and

a single baffle means is connected to said same wall of said cell and extends therefrom between said inlet means and said outlet means.

6. An electrolytic cell in accordance with claim **1** wherein:

one of said coolant inlet means or said coolant outlet means is positioned adjacent to and spaced apart from the bottom of said shell, and the other of said inlet means or said outlet means is positioned adjacent to and spaced apart from the top of said shell;

a plurality of said baffle means is provided;

a first one of said means is connected to said wall of said shell above said one of said inlet means or said outlet means which is positioned adjacent the bottom of said shell; and

the last one of said baffle means is connected to said wall of said shell below said other of said inlet means or said outlet means which is positioned adjacent the top of said shell.

7. An electrolytic cell in accordance with claim **6** wherein said coolant inlet means and said coolant outlet means are both connected to the same wall of said shell and are positioned one above the other.

8. An electrolytic cell in accordance with claim **6** wherein said coolant inlet means and coolant outlet means are connected to opposite walls of said shell.

9. An electrolytic cell in accordance with claim **8** wherein:

said container is generally rectangular in shape;

said heat exchanging shell conforms in shape to the shape of said container;

said electrodes are individually suspended in said electrode tube means with an annular space surrounding said electrodes so as to preserve said communication; and

means are provided for connecting each of said electrodes to a source of electric current.

10. An electrolytic cell in accordance with claim **9** wherein fins are provided on the internal surfaces of said downcomer tube means.

11. An electrolytic cell in accordance with claim **9** wherein said electrode tube means is a cathodic tube and said electrode is an anode.

12. An electrolytic cell in accordance with claim **11** wherein said container is generally circular in shape instead of rectangular.

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204—262, 272, 274

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,692,660 Dated: September 19, 1972

R. B. MacMullin et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, lines 5 and 6, delete "(all c/o Phillips Petroleum Company, Bartlesville, Okla. 74003)" and insert therefor --- assignors to Phillips Petroleum Company, Bartlesville, Oklahoma 74004 ---; column 8, line 47, delete "cell" and insert therefor --- shell ---.

Signed and sealed this 3rd day of April 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents