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(54) Method of making a unitary electric current transmission element for monopolar or bipolar filter press-type electrochemical cell units.

(57) A method for making and assembling either a monopolar or bipolar filter press-type electrochemical cell unit employing an electric current transmission element. The transmission element is an integrally formed, unitary, cast structural element positioned between the peripheral boundaries for adjacent electrolyte compartments of two cells located on opposite sides of the transmission element. The transmission element comprises a planar support portion (114) having anode and or cathode bosses (118) extending outwardly from opposite sides of the support portion. The bosses not only serve as a mechanical support for respective flat plate anode and or cathode components but also they serve as stand-off means and electrical current collectors and dispersers from the electrode component of one cell to the electrode component of the next cell. Simplicity of design coupled with incorporation of many functional elements into a single and unitary part eliminates warpage problems, inherent high voltage problems and membrane "hot spot" problems. The transmission element may optionally be provided with protective metal side liners (186) and electrical leads (190) to the cell units which allows the transmission element to be employed in a monopolar or bipolar cell series.

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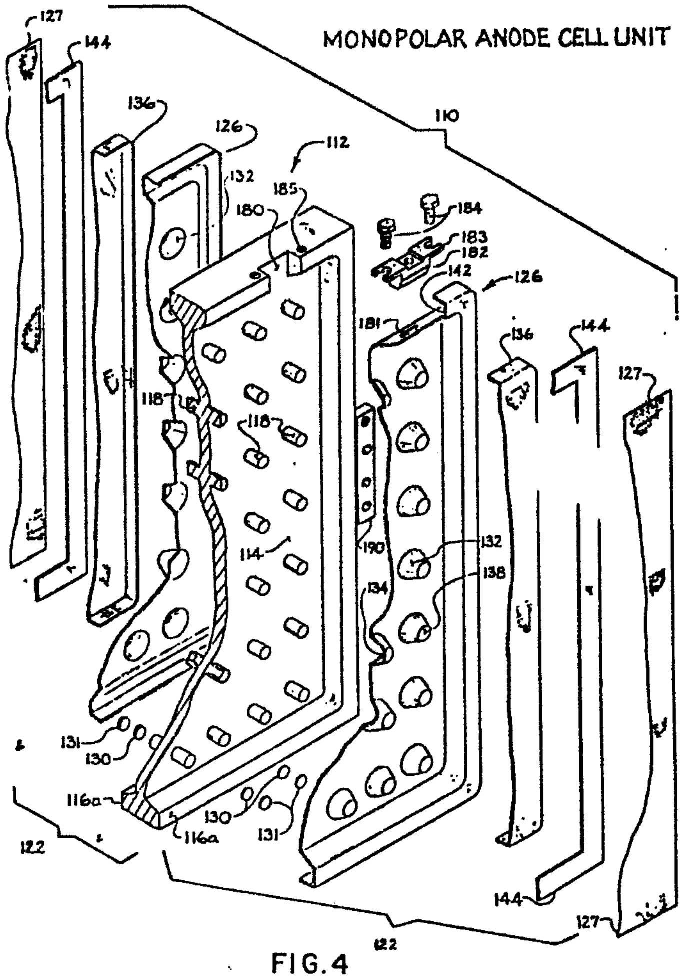

MONOPOLAR ANODE CELL UNIT
127
144
136
126
132
112
110
185
180
184
183
182
142
126
181
136
144
127
118
118
118
114
190
132
138
134
131
130
116a
116a
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122
122
144
127

FIG.4

METHOD OF MAKING A UNITARY ELECTRIC CURRENT TRANSMISSION ELEMENT FOR MONOPOLAR OR BIPOLAR FILTER PRESS-TYPE ELECTROCHEMICAL CELL UNITS

The invention relates to a method of making a cell unit for one of the repeating units of a "bipolar" electrode type series of electrolysis cells arranged in a configuration which is commonly referred to as a filter press-type cell series. Surprisingly, this invention also relates to a method of employing virtually the same cell unit for one of the repeating units of a "monopolar" electrolysis cell. Monopolar cells arranged in a filter press-type configuration are well known to those skilled in the art. What is not well known is the ability of using a fluid impermeable structural element, i.e., an electric current transmission element in either a bipolar or a monopolar cell configuration. This is surprising because of the different electric current transmission properties inherently required for an electrode used in a monopolar or a bipolar cell arangement.

The structure of bipolar cells relates to cells which employ substantially hydraulically impermeable, planar ion exchange membranes which are disposed between flat surfaced, substantially parallel, foraminous, electrodes, i.e., metal anodes and cathodes when said electrodes are mounted at a distance from the fluid impermeable structure which physically separates adjacent electrolysis cells. Such cells are particularly useful in the electrolysis of aqueous solutions of alkali metal chlorides; especially in the electrolysis of aqueous solutions of sodium chloride. The cell structure may also be used in electrolyzing other solutions to make products such as potassium hydroxide, iodine, bromine, bromic acid, persulfuric acid, chloric acid, adiponitrile and other organic compounds made by electrolysis.

Employment of an electric current transmission element of the present invention decreases the cost of manufacture of the cell units, decreases the labor required to assemble them, simplifies their manufacture, greatly reduces the warpage of the components of a cell unit, and provides a much sturdier cell structure than do bipolar, filter press-type cells of the prior art.

Reducing the warpage of components of a cell unit allows the cell to be operated more efficiently; i.e., produce more units of electrolysis products per unit of electricity. Reducing the warpage reduces the deviation from design of the gap width between the electrodes of each electrolysis cell. Ideally this gap width is uniformly the same between the anode and cathode in order to have a uniform current density spread between the faces of the electrodes. Among other things, structural warpage causes deviation of this gap resulting in some parts of the anode and cathode being closer together than others. At these locations, the electrical resistance is less, the electrical current flow is higher, and thus the electrical heating is greater. This electrical heating is sufficient in many instances to cause damage to the membrane at these locations. These locations of unacceptably high electrical current concentration and high heat are referred to herein as "hot spots".

To avoid these hot spots, the prior art has had to design its cell structures with a greater than desired gap width between the anode and cathode of each electrolysis cell. This, of course, increases the cell operating voltage and decreases the cell operating efficiency. Complexity of design and fabrication is another drawback of those cells.

Except for the structures used for the terminal cells of a bipolar cell series, the structures for the intermediate cells in the series are identical cell structural units which are squeezed together. Examples of such cells operated in a cell series are disclosed in U.S. Patent Nos. 4,111,779; 4,017,375; 4,364,815; 4,111,779; 4,115,236; 4,017,375; 3,960,698; 3,859,197; 3,752,757; 4,194,670; 3,788,966; 3,884,781; 4,137,144; and 3,960,699.

Monopolar cells differ first from bipolar cells in that each anode and each cathode of the cells in the series are electrically connected, respectively, in parallel and not in an electrical series as are the bipolar cells. That is, in a typical monopolar cell series, the anode of each cell is electrically connected through its cell's peripheral structure to the same positive electrical energy supply source as each of the other anodes of the cells in the series so that each anode is at substantially the same absolute voltage potential. Likewise, the cathode of each monopolar cell is connected through its cell's peripheral structure to the same negative electrical energy supply source as each of the other cell cathodes in the series so that each cathode in the monopolar cell series is at substantially the same absolute voltage potential. Thus, although the cells in a monopolar configuration are physically arranged in a face-to-face series configuration, they nevertheless have their like electrodes connected in an electrically parallel configuration. A monopolar cell assembly may be called a stack or a series. Two or more monopolar cell assemblies may be connected in series electrically. Conversely, the electrodes in a bipolar cell series are connected in a series electrical arrangement instead of a parallel electrical arrangement. In a bipolar cell series the positive electrical current carrying conductor is connected only to the anode of one of the two terminal cells of the bipolar series and the negative electrical current carrying conductor is applied to the cathode of the other terminal cell which is located at the opposite end of the bipolar cell series. A large D. C. voltage potential is applied from a source to the conductors such that an electrical current will flow from cell to cell in the bipolar cell series. Two or more bipolar cell series may be electrically connected in parallel.

This different electrical connecting arrangement forces a monopolar cell series to be different in other ways from a bipolar cell series. For example, a monopolar anode unit located in the interior portion of a monopolar cell series serves as the anodes for its two adjacent cells. Likewise, the interior cell monopolar cathode unit acts as the cathodes for two cells which are adjacent to it.

Further descriptions of monopolar electrodes used in a filter press-type series of electrolytic cells are given in U.S. Patent No. 4,056,458 and U.S. Patent No. 4,315,810. Both of these patents teach the use of one type of structure to support a monopolar cell unit and they teach the use of other structures (a plurality of conductor rods or bars) to distribute electricity from an electrical source located outside the cells to monopolar electrode elements disposed within the cell. Other complexities of the monopolar cell series which call for many parts and many connections are observed from a study of these two patents.

The present invention allows the construction of monopolar cell series which are much more simple, much sturdier, but yet economical to manufacture and operate.

The present invention relates to making and assembling electrolytic cell units used as repeating units in filter press-type cell series. Such cell units incorporate an electric current transmission element (hereinafter referred to as an ECTE) comprising a generally planar support portion, a plurality of bosses extending from opposite surfaces of the support portion, and a frame-like flange portion extending around the peripheral edges of said support portion. The ECTE is useful for both monopolar and bipolar cell units. It is useful in brine electrolysis and in other electrochemical processes. Employing an integrally formed electric current transmission element in a monopolar or bipolar cell unit as a fundamental building block is a primary object of the invention.

The invention particularly resides in a method for making an electric current transmission element which is useful as a major component of one of a plurality of repeating cell units disposed between two terminal cells of a filter press-type series of electrochemical cells, said method comprising the step of:

forming the electric current transmission element from an electrically conductive metal in a mold, with said mold having its interior shaped so that the transmission element has a planar support portion, a frame-like flange portion extending around a peripheral portion of the planar support portion which forms the peripheral boundaries of electrode compartments located on opposite sides of the planar support portion, and a plurality of bosses projecting outwardly from opposite sides of the planar support portion, said electric current transmission element comprising an integrally formed, one-piece structural element, characterized in that said electric current transmission element is suitable for use in a monopolar or bipolar cell unit and includes attachment means for at least one electrical current carrying conductor provided on the planar support portion or the flange portion of said electric current transmission element, wherein said attachment means are utilized exclusively for the terminal cells of a bipolar cell series or are utilized for all of the cells of a monopolar cell series.

The preferred method of integrally forming a unitary ECTE is by sand casting molten metal, preferably a ferrous metal. Other methods of integrally forming a unitary ECTE include die casting, powdered metal pressing and sintering, hot isostatic pressing, hot forging and cold forging.

Furthermore, it is within the scope of the invention to integrally form a unitary, or one-piece, ECTE by utilizing inserts, chills and cores. In fact, the particular location of chills of particular metals has resulted in the surprising result of not only making a more uniform casting but simultaneously producing an ECTE with better electrical conductive properties. In so doing, these chills then turn into inserts, of course.

For certainty of definition, the meaning of chills, inserts and cores in metal structure forming will now be given as these terms are generally used in the art. Chills are items placed in a mold and act as aids in casting the part. Their primary purpose is to control the cooling rate of the molten metal at specific locations in the mold. By controlling the cooling of the molten metal, metal shrinkage can more accurately be controlled thereby improving part quality through reduced imperfections and defects. Chills may or may not become an integral part of the casting and may, in some cases, act as inserts as well.

Inserts are those items placed in a mold to aid in the function of the mold; aid in the forming of the part; or which will become a functional part of the finished article. They retain their identity, to varying degrees, after the formation is complete. They are usually metallic, although any other suitable material may be used. Inserts may, in some cases, act as chills as well.

Cores are items placed in a mold and serve to eliminate metal in unwanted areas of a casting. Cores are used in the mold where it would be impractical or impossible to form the mold in such a way as to eliminate the unwanted metal. A typical example would be a core used to create the internal cavity of a cast metal body. Cores may, in some cases, act as chills as well.

The particularly useful chills which turn into inserts to increase the electrical conductivity of an ECTE are located transversely to the planar support portion and run into the bosses. Preferred inserts or chills are made of a solid metal that has the bulk of the metal of the ECTE formed around them. Preferably the metal formed around them is formed by casting it in a molten state in a sand mold.

Cores can also be used in forming openings passing all the way through the planar support portion of the ECTE in a monopolar cell unit to improve circulation. Such cores would be of no significant advantage in a bipolar cell unit so long as the ECTE has at least one liner or pan on one of its sides to prevent the mixing of anolyte or catholyte from the adjacent bipolar compartments.

The method of assembling the cell unit can further comprise the fitting of a suitable liner to one or both sides of the ECTE to protect the metal of the

ECTE from corrosive attack by the electrolyte with which it is expected to be used.

The method of assembling the cell unit preferably further comprises electrically and mechanically attaching planarly disposed electrode components indirectly to each side of the ECTE by welding these electrode components to the liner which itself is welded directly or indirectly through an intermediate metal wafer or coupon to the ECTE. These electrode components can be the electrodes themselves or they can be electrically conductive members for further conducting electricity to the actual electrodes themselves. Usually the electrodes have a catalytically active material deposited upon them.

After the cell units are fabricated individually, they are then formed into a filter press-type cell series by compressing them together with a hydraulic press, bolts, tie rods, or the like.

The present invention is suitable for use with the newly developed solid polymer electrolyte electrodes. Solid polymer electrolyte electrodes are an ion-exchange membrane having an electrically conductive material embedded in or bonded to the ion-exchange membrane. Such electrodes are well known in the art and are disclosed in, for example, U.S. Patent Nos. 4,457,815 and 4,457,823.

In addition, the present invention is suitable for use as a zero gap cell. A zero gap cell is one in which at least one electrode is in physical contact with the ion-exchange membrane. Optionally, both of the electrodes may be in physical contact with the ion exchange membrane. Such cells are disclosed in U.S. Patents Nos. 4,444,639; 4,457.822; and 4,448,662.

Electrode components which may be employed are preferably foraminous structures which are substantially flat and may be made of a sheet of expanded metal perforated plate, punched plate, or woven metal wire. Optionally, the electrode components may be current collectors which contact an electrode. Electrodes may optionally have a catalytically active coating on their surface. The electrode components may be welded to the bosses or to the liner, if a liner is used. Preferably, the electrode components are welded because the electrical contact is better.

Other electrode components which may be used in conjunction with the present invention include current collectors, spacers, mattresses and other elements known to those skilled in the art. Special elements or assemblies for zero gap configurations or solid polymer electrolyte membranes may be used. Also, the electrolytic units of the present invention may be adapted for a gas chamber for use in conjunction with a gas-consuming electrode, sometimes called a depolarized electrode. The gas chamber is required in addition to the liquid electrolyte compartments. A variety of electrode components which may be used in the present invention are well known to those skilled in the art and are also disclosed in, for example, U.S. Patent Nos. 4,444,623; 4,350,452; and 4,444,641.

A better understanding of this invention will be better obtained by discussing its bipolar and monopolar aspects separately as follows.

In making and assembling an improved cell unit used in forming a bipolar cell, the cell unit is separated from an adjacent cell unit by a separator such as a substantially hydraulically impermeable ion-exchange membrane or a hydraulically permeable porous asbestos diaphragm except in a chlorate cell wherein no separator is used when an alkali metal chloride (brine), such as sodium chloride, is electrolyzed to produce the respective alkali metal chlorate, e.g., sodium chlorate. Although this invention also applies to cell units which employ no separator between the anode and cathode, nevertheless it is discussed primarily with respect to cell units which employ permselective ion exchange membranes in order to show where the membranes would go. The membranes are sealably disposed between each of the cell units so as to form a plurality of cells. Each of said cell units preferably but not necessarily has at least one planarly disposed membrane defining and separating the anolyte compartment from the catholyte compartment of each cell unit. The cell unit has an ECTE which physically separates the anolyte compartment of a cell unit located on one side of the ECTE from the catholyte compartment of an adjacent cell unit located on the opposite side of the ECTE. The ECTE has a planarly disposed foraminous, "flat plate" anode component situated in its adjacent anolyte compartment and a planarly disposed, foraminous, "flat plate" cathode component situated in its adjacent catholyte compartment. Both electrode component faces are substantially parallel to the membrane planarly disposed between them and to the ECTE. The ECTE has the anode component of the adjacent anolyte compartment electrically connected through it to the cathode component of the adjacent catholyte compartment.

The anolyte and catholyte compartments adjacent to the ECTE have a structure around their periphery to complete their physical definition. This cell unit also has an electrical current conductor associated with it for providing electrical current passage through the ECTE from its adjacent catholyte compartment to its adjacent anolyte compartment. This cell unit includes components stand-off means for maintaining the anode and cathode of the two cells adjacent to the ECTE at predetermined distances from the ECTE.

The invention employs a castable metal as part of the ECTE which transfers electricity through the ECTE from the catholyte compartment to the adjacent anolyte compartment. Preferably this metal is ductile iron.

The ECTE is formed in such a fashion so as to provide the structural integrity required to physically support the adjacent electrolyte compartments while loaded with electrolyte as well as to support the associated cell appurtenances.

The anode component stand-off means and that part of the electrical current conductor located in the ECTE on the anolyte side of the ECTE are combined into a multiplicity of anode bosses projecting a predetermined distance outwardly from the support portion of the ECTE into the anolyte compartment adjacent to the support portion. These anode bosses are capable of being mechanically and electrically connected either directly or indirectly to said anode component through at least one compatible metal intermediate positioned in an abutting fashion between the anode component and the anode bosses. Preferably the anode bosses all have flat end surfaces which preferably lie in the same geometrical plane.

The cathode component stand-off means and that part of the electrical current conductor located on the catholyte side of the planar support portion are combined into a multiplicity of cathode bosses projecting a predetermined distance outwardly from the support portion into the catholyte compartment adjacent to the support portion. These cathode bosses are capable of being mechanically and electrically connected either directly or indirectly to the cathode component through at least one weldably compatible metal intermediate positioned in an abutting fashion between the cathode component and the cathode bosses. Preferably the cathode bosses all have flat end surfaces which preferably lie in the same geometric plane.

The invention preferably further comprises anode bosses being spaced apart in a fashion such that anolyte can freely circulate through the totality of the otherwise unoccupied adjacent anolyte compartment, and, likewise, said cathode bosses being spaced apart in a fashion such that catholyte can freely circulate throughout the totality of the otherwise unoccupied adjacent catholyte compartment.

Preferably the material of the unitary ECTE is selected from ferrous metals such as iron, steel, stainless steel, or from nickel, aluminum, copper, chromium, magnesium, tantalum, cadmium, molybdenum, zirconium, lead, zinc, vanadium, tungsten, iridium, rhodium, cobalt, alloys of each, and alloys thereof. More preferably the metal of the ECTE is selected from ferrous metals whose primary constituent is iron.

The invention preferably includes an anolyte side liner made of a metal sheet fitted over those surfaces of the anolyte compartment side of the ECTE which would otherwise be exposed to the corrosive environment of the anolyte.

Preferably the metal of the anolyte side liner is resistant to corrosion of the anolyte and is formed with caps so as to fit over and around the anode bosses with the liner being connected to the flat ends of the anode bosses of the ECTE.

Preferably the invention also comprises having the liner sufficiently depressed around the spaced anode bosses toward the planar support portion in the spaces between the bosses so as to allow free circulation of the anolyte between the lined ECTE and the membrane of the adjacent anolyte chamber. Note that the liner replaces the ECTE surface adjacent to the anolyte chamber as one boundary contacting the anolyte.

The metal liner is preferably connected to the anode bosses by welding, soldering, brazing or film forming, through a metal intermediate which is disposed between the bosses and the liner with the metal of the metal intermediate being weldably compatible with both the metal of the anolyte side liner and the metal of which the ECTE is made, that is weldably compatible with both metals to the point of being capable of forming a solid solution with them at welds of them upon their welding.

The anolyte side liner is made of a metal selected from titanium, tantalum, niobium, hafnium, zirconium, alloys of each and alloys thereof.

Another way of connecting an anolyte side liner to the ECTE when these metals are weldably incompatible is that where no metal intermediate is used, but wherein the anolyte side liner is bonded directly to the anode bosses by explosion bonding or diffusion bonding.

In most instances it is desired that the anolyte side liner extends over the lateral face of the anolyte compartment peripheral frame-like flange portion of the ECTE so as to form a sealing face thereat for the membrane when the cell segments are squeezed together to form a cell series.

In most instances it is desired that the anolyte side liner be connected to the ECTE at the ends of the anode bosses. However, this invention includes connecting the liner to the sides of these bosses and even connecting the liner to the planar support portion between the bosses. Preferably, however, the anolyte side liner is welded to the ends of the anode bosses through an intermediate metal coupon or wafer.

A catholyte side liner is required less frequently than an anolyte side liner. However, there are occasions, such as in high concentration caustic catholyte compartments, wherein a catholyte side liner is needed. Thus, this invention also comprises a catholyte side liner made of a metal sheet fitted over those surfaces of the ECTE which would otherwise be exposed to the catholyte of the adjacent cell. Preferably the catholyte side liner is made of nickel.

Plastic liners may be used in some cases where provision is made for electrically connecting the cathode component to the cathode bosses through the plastic. Also combinations of plastic and metal liners may be used. The same is true for anolyte side liners.

The catholyte side liner is depressed sufficiently around the spaced cathode bosses toward the planar support portion in the spaces between the bosses so as to allow free circulation of the catholyte between the lined ECTE and the membrane of the adjacent catholyte chamber. Note that the liner replaces the ECTE surface adjacent to the catholyte chamber as one boundary contacting the catholyte.

Unlike the anolyte side liner, it is usually not necessary that the catholyte side liner be connected to the cathode bosses through a metal intermediate. Hence, it is preferred that the catholyte side liner be directly connected to the cathode bosses by welding without a metal intermediate being disposed between the bosses and the liner. A metal intermediate can be used, however. If so, then the metal intermediate must be weldably compatible with both the metal of the catholyte side liner and the metal of which the ECTE is made.

The metal for the catholyte side liner is selected from ferrous metals, nickel, chromium, magnesium, tantalum, cadmium, zirconium, lead, zinc, vanadium, tungsten, iridium, molybdenum, cobalt, alloys of each or alloys thereof.

In many instances it is desired that the metal of the ECTE, the catholyte side liner, and of the cathode component of the adjacent cell be all selected from ferrous metals.

In some instances it is preferred to have the metal intermediates situated between the cathode bosses and the adjacent catholyte side liner. The metal intermediates are similar to those discussed in attaching the anolyte side liner. However, in most cases, the metal of the catholyte side liner can be welded directly to the planar support portion without the need of a metal intermediate.

The catholyte side liner is formed so as to fit over and around the ends of the cathode bosses and is welded directly on one side of the liner to the bosses in a manner so as to provide an electrical connection between the ECTE and the cathode component. The cathode component itself is directly welded to the opposite side of the cathode side liner.

As with the anolyte side liner, it is preferred that the catholyte side liner also extend over the lateral face of the catholyte compartment peripheral flange portion so as to form a sealing face thereat for the membrane when the cell segments are squeezed together to form a cell series.

In most instances it is desired that the catholyte side liner be connected to the ECTE at the ends of the cathode bosses. However, this invention includes connecting the liner to the support portion between the bosses.

The present invention is also a method of making and assembling cell units for monopolar cells assembled in a filter press configuration.

The ECTE for the monopolar cell unit is the same as that described above for the bipolar cell unit with the exception that each monopolar ECTE also has means for electrically connecting it to an external power source. These means may be added as a separate element to the ECTE or may be integrally formed with it. Otherwise, the monopolar ECTE may have the same physical appearance as does the bipolar ECTE and is made of the same metals. It is also made the same way; e.g., by a single casting to make an integral unit of the support portion, the peripheral flange, and the electrode component bosses on opposite sides of the support portion.

Of course, contrary to the bipolar cell unit, in the monopolar cell unit, the bosses on opposite sides of the support portion are of the same kind; i.e., the bosses on opposite sides are all anode bosses or they are all cathode bosses. They are not such that they will be anode bosses on one side and cathode bosses on the other side as is the case with bipolar cell units. The terminal cells for a monopolar cell series are end cell units with only one side requiring an electrode component.

The single electrical polarity of the monopolar cell unit also forces the electrolyte compartments located on both sides of the ECTE to be the same kind; that is, these adjacent compartments will either be both anolyte compartments or they will both be catholyte compartments.

The ECTE is formed so as to provide the structural integrity to support the cell weight. It also provides the electrical current pathway to the two electrode components electrically connected on opposite sides of it if it is electrically connected as an anode, or vice versa if it is electrically connected as a cathode.

The liners discussed for bipolar electrode cell units are much the same as are those for monopolar electrode cell units. They may be alike in appearance and they serve the same function of protecting the ECTE from electrochemical attack.

Of course, unlike the bipolar anolyte and catholyte side liners discussed above wherein each ECTE had an anolyte side liner on one of its sides and a catholyte side liner on its other side, the monopolar ECTE has either anolyte side liners or catholyte side liners on both of its sides depending on whether the monopolar ECTE is to be used as an anode or as a cathode. Note, if the catholyte concentration is below about 22 percent at a temperature below about 85°C it may not be necessary to have a catholyte side liner. These monopolar anolyte and catholyte side liners are made from the same materials and by the same methods as are those described above for the bipolar cell unit. The monopolar anolyte and catholyte side liners are also attached to the monopolar ECTE in the manner described above for their counterpart bipolar anolyte and catholyte side liners.

The monopolar electrode components are like those described for the bipolar electrode cell unit described above and are attached in the same way. Like the bipolar electrode components, the monopolar electrode components do not necessarily have to be the electrodes themselves, electrodes being defined as the place where the electrochemical reactions are initiated. The electrode components can be members which themselves conduct electricity to the anodes and from the cathodes.

Nozzles are preferably a casting of titanium or nickel and of a shape to fit in channels or notches in the peripheral frame-like flange portion.

Bipolar cells utilize both catholyte and anolyte nozzles while monopolar cells utilize one or the other.

The invention can be better understood by reference to the drawing illustrating the preferred embodiments made by the method of the invention, and wherein like reference numerals refer to like parts in the different drawing figures.

Figure 1 is an exploded, partially broken-away perspective view of a bipolar electric current transmission element shown with accompanying parts forming one bipolar electrode type filter press-type cell unit;

Figure 2 is a cross-sectional side view of three bipolar filter press-type cell units employing the electric current transmission elements. The cell units are shown as they would appear in a filter press cell series;

Figure 3 is an exploded, sectional side view of a cell unit;

Figure 4 is an exploded, partially broken-away perspective view of a monopolar unitary electric current transmission element and accompanying components forming one monopolar anode type filter-press cell unit of a cell series;

Figure 5 is a cross-sectional side view of three monopolar cell units shown in the same manner as they would appear if they were taken as the three bipolar cell units of Figure 2 were taken, that is the cell units are shown in a filter press arrangement showing a monopolar anode cell unit fitted between two like monopolar cathode cell units;

Figure 6 is an exploded, sectional side view of the cell unit used in forming a monopolar anode cell unit made according to the method of this invention, said sectional view being taken along line 8-8 of Figure 8 and showing only those parts which actually contact the imaginary sectional cutting plane taken along line 8-8 in Figure 8 in order not to obscure these elements by showing the other parts which are behind the imaginary sectional view cutting plane and which are normally shown in a sectional view;

Figure 7 is a partially broken-away elevation of a monopolar cathode cell unit which employs elements made according to the method of this invention;

Figure 8 is a partially broken-away elevation of a monopolar anode cell unit which employs elements made according to the method of this invention; and

Figure 9 is an exploded, sectional side view of the cell structure used in forming a monopolar cathode cell unit made according to the method of this invention, said sectional view being taken along line 11-11 of Figure 7 and said view showing only those parts which actually contact the imaginary sectional cutting plane taken along line 11-11 in Figure 7 in order not to obscure these elements by showing the other parts which are behind the imaginary sectional view cutting plane and which are normally shown in a sectional view.

Referring to Figures 1, 2 and 3, a "flat plate" bipolar electrode type, filter press-type electrolysis cell unit 10 is shown employing the preferred embodiment of an electric current transmission element (ECTE) 12 made according to the method of this invention.

In the preferred embodiment, ECTE 12 is made of cast ductile iron. It has a solid planar support portion 14, a peripheral frame-like flange portion 16 extending laterally from opposite sides of the peripheral edges of the support portion 14, protruding and spaced-apart anode bosses 18, and protruding and spaced-apart cathode bosses 20.

By having these parts all cast into a single unitary element, many problems are simultaneously eliminated or greatly reduced. For example, most of the warpage problems, fluid leakage problems, electric current maldistribution problems, and complications of cell construction on a mass production basis are greatly alleviated. This simplicity of cell design allows ECTEs to be constructed which are much more reliable and which are constructed much more economically.

An anolyte compartment 22 of an adjacent cell can be seen on the right side of ECTE 12. On the left side of ECTE 12, a catholyte compartment 24 of an adjacent cell unit can be seen. Thus ECTE 12 separates one cell from another. One very important feature in cells of this type is to conduct electricity from one cell to another as cheaply as possible.

On the anolyte compartment side of ECTE 12, there is a liquid impervious anolyte side liner 26 preferably made from a single sheet of titanium, although it can be made from two or more sheets. This liner 26 is hot formed by a press in a fashion so as to fit over and substantially against the surfaces of the ECTE 12 on its anolyte compartment side. This is done to protect the ductile iron of ECTE 12 from the corrosive environment of the anolyte compartment 22. Liner 26 also forms the left boundary of anolyte compartment 22 with an ion-exchange membrane 27 forming the right boundary (as shown in Figure 3). ECTE 12 is cast so that its peripheral structure forms the frame-like flange portion 16 which serves not only as the support for the peripheral boundary of the anolyte compartment 22 but also as the support for the peripheral boundary of the catholyte compartment 24. Preferably the titanium liner 26 is formed with no stresses in it in order to provide a liner which atomic hydrogen can not attack as rapidly to form brittle, electrically non-conductive titanium hydrides. Atomic hydrogen is known to attack stressed titanium more rapidly. Avoiding these stresses in the liner is accomplished by hot forming the liner in a press at an elevated temperature of from 482°C to 704°C (900°F to 1300°F). Both the liner metal and press are heated to this elevated temperature before pressing the liner into the desired shape. The liner may be held in the heated press for about fifteen minutes to prevent formation of stresses in it as it cools. Other methods that can be used to form a liner may include vacuum, hydraulic, explosion, cold forming and other methods known in the art.

The titanium anolyte side liner 26 is connected to the ductile iron ECTE 12 by resistance or capacitor discharge welding. Such welding is accomplished indirectly by welding the liner 26 to the flat ends 28 of the cylindrically shaped, solid anode bosses 18 through vanadium wafers 30 and titanium wafers 31 which themselves are welded to the vanadium wafers 30. Vanadium is a metal which is weldable itself and which is weldably compatible with titanium and iron. By weldably compatible is meant that a joint of sufficient mechanical strength and electrical conductivity is formed. This is often accomplished by welding two or more metals together such that they form a ductile solid solution. Titanium and iron are not weldably compatible with each other, but both are weldably compatible with vanadium. Hence, the vanadium wafers 30 are used as an intermediate metal between the iron anode bosses 18 and the titanium liner 26 to accomplish the welding of them together to form an electrical connection between liner 26 and ECTE 12 as well as to form a mechanical support means for ECTE 12 to support anolyte side liner 26. For better welding of a thin titanium liner 26 to iron anode bosses 18 the second wafer 31 made of titanium is welded to the outside of vanadium wafers 30 before welding liner 26 to the anode bosses 18 of ECTE 12.

The preferred fit of the anolyte side liner 26 against the ECTE 12 can be seen from the drawing (Fig. 2). The liner 26 has indented hollow caps 32 pressed into it. These caps 32 are frustroconically shaped, but are hollow instead of being solid as are the anode bosses 18. Caps 32 are sized and spaced so that they fit over and around anode bosses 18. Caps 32 are sized in depth of depression so that their interior ends 34 abut the titanium wafers 31 after the titanium wafers 31 and the vanadium wafers 30 have been welded to the flat ends 28 of the anode bosses 18. The particular shape of these bosses and caps is not significant. They could be square shaped or any other convenient shape. However, preferably their ends 28 are all flat and preferably they all lie in the same imaginary geometrical plane. In fact the anode bosses 18 and caps 32 can be shaped and located so as to guide anolyte and gas circulation in the anolyte compartment 22.

The anolyte side liner 26 is resistance or capacitor discharge welded at the interior ends 34 of its indented caps 32 to the flat ends 28 of anode bosses 18 through the interposed, weldably compatible, vanadium wafers 30 and the titanium wafers 31.

Anode component 36 is a substantially flat sheet of expanded metal, punched plate, metal strips or woven wire made of titanium. In this preferred embodiment anode component 36 has a catalyst coating containing an oxide of ruthenium. It is welded directly to the outside of the flat ends 38 of indented caps 32 of side liner 26. These welds form an electrical connection and a mechanical support means for anode component 36. Other catalyst coatings can be used.

Again it should be emphasized that the anode component 36 need not be the anode itself, but it can include a current distributing planar surface which conducts electricity to the anode either directly or indirectly through a mattress or other electrode elements.

In Figure 2 membrane 27 is seen to be disposed in a flat plane between the anode component 36 of one cell unit 10 and the cathode component 46 of the next adjacent cell unit 10 so as to sharply define the anolyte and catholyte compartments of the cell located between the planar support portion 14 of each of two adjacent ECTEs 12.

Representative of the types of permselective, ion-exchange membranes envisioned for use with the structure made according to this invention are those disclosed in U.S. Patent Nos.: 3,909,378; 4,329,435; 4,065,366; 4,116,888; 4,126,588; 4,209,635; 4,212,713; 4,251,333; 4,270,996; 4,123,336; 4,151,053; 4,176,215; 4,178,218; 4,340,680; 4,357,218; 4,025,405; 4,192,725; 4,330,654; 4,337,137; 4,337,211; 4,358,412; and 4,358,545.

Of course, it is within the purview of this invention to provide a plurality of cells using more than one membrane, e.g., a three-compartment cell with two membranes spaced from one another so as to form a compartment between them as well as the compartment formed on the opposite side of each membrane between each membrane and its respective adjacent cell unit 10.

The location of anode 36 within anolyte compartment 22 with respect to the titanium lined support portion 14 is determined by the relationships between the lateral extension of flange portion 16 from support portion 14, the extension of anode bosses 18 from the support portion 14, the thickness of the vanadium wafers 30, the thickness of anolyte side liner 26, and the like. It can be readily seen that anode component 36 can be moved by changing the extension of anode bosses 18 from the support portion 14. It may be preferred, however, that the flange portion 16 on the anolyte side of support portion 14 extend the same distance as do the anode bosses 18 from the support portion 14. This adds to the simplification of construction of ECTE 12 because a machine metal planar can plane both the end surfaces 28 of anode bosses 18 as well as the lateral face 16a of the flange portion 16 at the same time in a manner so that these surfaces all lie in the same geometrical plane. The same preference is true for like surfaces 16c on the catholyte side of ECTE 12. A departure from this preference can be used to generate considerable distance between an electrode component and the membrane, for example, to accommodate a mattress or to produce an electrolytic gap.

For fluid sealing purposes between membrane 27, and flange surface 16a, it is preferred for anolyte side liner 26 to be formed in the shape of a pan with an off-set lip 42 extending around its periphery. Lip 42 fits flush against the lateral face 16a of flange portion 16. The peripheral portion of membrane 27 fits flush against a first peripheral gasket 44 which itself fits against side liner lip 42. A second peripheral gasket 45 fits flush against the other side of the peripheral portion of membrane 27. In a cell series, as shown in Figure 2, the gasket 45 fits flush against an off-set lip 72 on the catholyte side liner or against the lateral face 16c of the flange portion 16 on the catholyte side of the next adjacent ECTE 12 and flush against membrane 27 when there is no side liner 48. Various gasket selections can be made to optionally accommodate a mattress or produce an electrolyte gap.

Although membrane 27 is shown having two gaskets 44, 45 on each of its sides around its peripheral portion, this cell design permits the use of only one gasket on either side of the membrane.

Sometimes the side liner 48 is desired to be present, but often it is not necessary for it to be present. For example, in the electrolysis of sodium chloride brine to produce caustic in the catholyte compartment at concentrations below about 22 percent at catholyte temperatures below about 85°C, a ferrous metal ECTE 12 would usually not need a nickel liner 48 to protect it from the catholyte. But for such brine electrolysis at catholyte temperatures above about 85°C and caustic concentrations above about 22 percent, a nickel liner 48 is usually required to protect the metal of ECTE 12 from corrosion by the catholyte.

Referring to Figures 2 and 3, the catholyte side (the left side) of ECTE 12 is seen to appear as the mirror image of its anolyte side in this most preferred embodiment. The flange portion 16 forms the peripheral boundary of the catholyte compartment 24, while the catholyte side liner 48 and membrane 27 form its remaining boundaries. Spaced cathode bosses 20 may be solid, cylindrical or frustro-conically shaped protrusions extending outwardly from support portion 14 into catholyte compartment 24. The preferred frustums of cones will closely approach a right cylinder. The shape of these cathode bosses 20 is not critical. They are preferably flat on their ends 40, and these ends 40 preferably all lie in the same geometrical plane. This also applies to the indented caps 70 of the catholyte side liner 48 discussed below. These cathode bosses 20 and side liner caps 70 can be shaped and located so as to guide the catholyte and gas circulation.

When a side liner is desired on the catholyte compartment side of ECTE 12, it can easily be provided in the same manner as is the anolyte compartment side liner 26. The catholyte side liner 48 is made of a metal which is highly resistant to corrosive attack from the catholyte in the catholyte compartment 24. The metal must also be sufficiently ductile and workable so as to be pressed from a single sheet of metal into the non-planar form shown. This includes being capable of having the frustro-conically shaped caps 70 pressed into the sheet. Of course, these caps 70 must be spaced so that they fit over and around the spaced cathode bosses 20 as well as the other parts of the side of ECTE 12 which would otherwise be exposed to the catholyte in compartment 24. It is preferred that this side liner 48 have an indented lip 72 extending around its periphery in a fashion so as to abut the lateral face 16c of flange portion 16 on the side of ECTE 12 which is adjacent to the catholyte compartment 24. Side liner 48 is preferably connected to ECTE 12 by resistance or capacitor discharge welding of the internal ends 74 directly, in an abutting fashion, to the flat ends 40 of cathode bosses 20. That is, this is preferable if the metal of the liner 48 and ECTE 12 are weldably compatible with each other. If these metals are not weldably compatible, then metal intermediates or combinations of metal intermediates should be used which are weldably compatible with the metal of liner 48 and ECTE 12. Such intermediates (not shown) are disposed between the flat ends 40 and the internal ends 74. However, no such intermediates are necessary when the liner 48 is made of nickel and ECTE 12 is made of a ductile iron as is preferred to do.

It will be noticed that both the anode component 36 and the cathode component 46 have their peripheral edges rolled inwardly toward ECTE 12 and away from the membrane 27. This is done to prevent the sometimes jagged edges of these electrode components from contacting the membrane 27 and tearing it.

The cathode component is a foraminous, substantially planar sheet of nickel and is attached to nickel side liner 48 by welding the cathode 46 to the outer surface 76 of the caps 70 formed in the side liner 48. In this preferred embodiment, the nickel cathode component 46 has a catalytic coating on it and thus serves as the cathode itself. It may be pressed against the membrane 27 as is the adjacent titanium anode component 36 pressed against the membrane so as to allow virtually no gap to exist between the membrane 27 and its adjacent electrodes.

A preferred catalytic coating for the nickel cathode component 46 is a heterogeneous mixture of nickel oxide and ruthenium oxide. A preferred method for depositing this coating is disclosed in U.S. Patent Application Serial No. 499,626 filed on May 31, 1983.

Of course, the nickel cathode component 46 could be provided without a catalytic coating, or the cathode component could merely be an electrical transfer agent of electricity coming from the cathode formed by other elements (not shown) embedded in or pressed against the membrane.

Both the anolyte and catholyte compartments 22 and 24 have inlet and outlet means for introducing raw materials and removing product gases and liquids. These inlet and outlet means pass through the flange portion 16 of ECTE 12. The preferred inlet and outlet means is best illustrated by the anolyte compartment outlet means whose several parts (80-85 in Figure 1 and 180-185 in Figure 4) are shown. An open-sided channel 80 is formed in the flange portion 16 on its anolytic side; an opening 81 is cut in titanium side liner 26. Opening 81 in side liner 26 coincides with the boundaries of channel 80. Nozzle 82 is then sealingly welded to the opening 81 in the flange of the side liner 26 in a manner such that the bottom of nozzle 82 at least reaches the anolyte compartment 22, and the top of nozzle 82 extends at least to the top of flange channel 80 so that no anolyte products can contact the iron of flange channel 80. Bolt ear fittings 83 extend from the side of nozzle 82 so that nozzle 82 can be secured to flange portion 16 by bolts 84 screwed into drilled and threaded holes 85 formed in flange portion 16.

An anolyte compartment inlet (not shown) like the anolyte compartment outlet just described is formed on the bottom anolyte side of flange portion 16. Catholyte compartment inlet and outlet means (not shown) are formed, in like manner as are the anolyte compartment outlet with the exception that the inlet and outlet means are formed in the flange portion on the catholyte side of ECTE 12 and with the further exception that the catholyte nozzles are made of nickel instead of titanium.

The bipolar cell operates as follows. The feed brine is continuously fed into anolyte compartment 22 via anolyte compartment inlet while fresh water or dilute caustic solutions may be fed into catholyte compartment 24 via catholyte compartment inlet. Electric power (D.C.) is applied across the cell series in such a fashion so that the anode 36 of each cell is positive with respect to the cathode 46 of that cell; i.e., the positive electrical lead of the power source is electrically connected to the anode of the terminal cell unit at one end of the cell series, and the negative electrical lead of the power source is electrically connected to the cathode of the terminal cell unit at the other end of the cell series. Excluding depolarized cathodes or anodes, the electrolysis proceeds as follows. Chlorine gas is continuously produced at the anode 36; sodium cations are transported through membrane 27 to the catholyte compartment. In the catholyte compartment 24 hydrogen gas and an aqueous solution of sodium hydroxide are continuously formed. The chlorine gas and depleted brine continuously flow from the anolyte chamber 22 via anolyte chamber outlet while the hydrogen gas and sodium hydroxide continuously exit the catholyte compartment 24 via catholyte chamber outlet. Depolarized electrodes can be used to suppress the production of hydrogen or chlorine or both if desired.

The side liners 26 and 48 can be formed from several sheets which are sealably welded together to form an impervious single sheet. This includes the ability to be pressed so that they have frustro-conically shaped caps 32 and 70. It should also be understood that the invention is not limited to the caps 32, 70 being frustro-conically shaped nor limited to the anode and cathode bosses 18 and 20 being cylindrically or frustro-conically shaped. The ends 28 and 40 of the bosses 18 and 20 should present sufficient surface area to which electrical connections can be made to their respective electrodes to provide an electrical path with sufficiently low electrical resistance. The bosses 18 and 20 should be spaced so they provide a fairly uniform and fairly low electrical potential gradient across the face of the electrode to which they are attached. They should be spaced so that they allow free electrolyte circulation from any unoccupied point within their respective electrolyte compartment to any other unoccupied point within that compartment. Thus the bosses will be fairly uniformly spaced apart from one another in their respective compartments. It should be noted here that although anode and cathode bosses 18 and 20 are shown in a back to back relationship on the support portion 14, they need not be. They can be offset from each other.

The materials from which anode and cathode bosses 18 and 20 are made are, preferably the same as that of ECTE 12 since part of this invention is to make them an integral part of that cell element.

The metals from which anolyte and catholyte side liners 26 and 48 are made are usually different because of the different electrolyte corrosion and electrolytic corrosion conditions to which they are exposed. This is true not only in chlor-alkali cell electrolytes, but also in other electrolytes. However, some materials may be serviceable in both electrolytes. Thus the metals chosen must be chosen to fit the conditions to which they are going to be exposed. Typically titanium is the preferred metal for the anolyte compartment liner 26.

The preferred embodiment of the monopolar cell unit made by the method of this invention is illustrated in Figure 4. Except for the arrangement and positioning of these cell elements, essentially the primary difference between them and the bipolar cell units are their electrical connection means. An additional difference is that a bipolar cell unit has its longest dimension oriented in the horizontal direction while a monopolar cell unit has its longest dimension in the vertical direction. This longest dimension distinction is only preferred and is not critical for cells made by the present invention.

Thus it can be seen that the method of this invention produces cell unit structural parts for assembling a monopolar cell unit which can be used as a bipolar cell unit by merely rearranging the side liners and the electrode components and by making provision for any necessary electrical connection. The support portion provides not only the thickness to support the weight of either a monopolar or a bipolar cell unit, but it also is sufficiently thick (at least about one centimeter) to provide a very low resistance electrical path for the monopolar cell units. This combination of features results in a novel, simple, interchangeable

ECTE which are economical to manufacture, economical to assemble with other cell parts to make either a monopolar or bipolar cell unit, which are economical to operate, and which have a very long, useful life.

In the monopolar cell unit illustrated in Figure 4, the same reference numbers are used for like parts of the bipolar cell unit 10 of Figures 1-3.

In the monopolar anode cell unit illustrated in Figure 4, the unitary ECTE 12 is provided with anode side liners 26 on opposite sides thereof thus forming anolyte chambers on the opposite sides of the support portion 14. The cell unit is further provided with anode components 36 and membranes 27 to essentially complete the structural components of the anode cell unit. If the cell unit is a cathode cell unit, the electrical connecting means are such that ECTE 12 is rendered cathodic with the electrodes on opposite sides of ECTE 12 being the cathodes to form catholyte chambers on opposite sides of the support portion 14.

Of course, the monopolar anode and cathode ECTEs each have an electrical connection means such as anode or cathode bus terminal 190. These connecting means are attached to the flange portion 16. Otherwise, the primary significant structural differences between the monopolar and bipolar cell units are that in a bipolar cell unit, one side has parts adapted for use in an anolyte environment whereas the opposite side has parts adapted for use in a catholyte environment, but in a monopolar cell unit, both sides are adapted for the same electrolyte. But if the parts are made such that they are interchangeable between monopolar

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and bipolar cell units, then all one has to do before assembling these parts is to determine what type of cell units he desires his particular cell series to be before he assembles parts taken from the group of parts made according to the method of this invention and according to the method of assembling this invention.

Thus when a monopolar anode cell unit for this invention is desired, a titanium side liner 26 is attached to each side of ECTE 12, followed by the attachment of the anode 36 to each of the side liners. For the cathode cell units for this cell series, a nickel side liner 48 is connected to each side of ECTE 12 followed by the attachment of a cathode component 46 to each of the side liners 48.

Thus a generic method of making and assembling a cell unit for either a filter press cell series of both the monopolar and bipolar filter press-type of electrochemical cell series has been described.

The necessary step in completing the assembly of any filter press cell series is the manner of impressment of electrical power to the cell series. A bipolar cell series is formed by the connection of a positive electrical power source lead or conductor to one end of a cell series and a negative electrical power source lead or conductor to the other end of that cell series with the potential difference between these two leads being applied across the intervening cell units of the series. A monopolar filter press-type electrochemical cell series is completely defined when alternating cell units of the series are connected to a positive and a negative electrical power source. That is, every other cell unit of a monopolar cell series will be connected to a positive electrical power source with the other cell units connected to a negative electrical power source.

Anode or cathode bus terminal 190 used to connect the power source to the monopolar anode cell unit or monopolar cathode cell unit, respectively, are preferred to be integrally cast with their respective ECTEs 12, but they need not be.

EXAMPLE 1

Four (4) electric current transmission elements were cast for a nominal 61 cm x 61 cm monopolar electrolyzer.

All electric current transmission elements were cast of ASTM A536, GRD65-45-12 ductile iron and were identical in regard to as-cast dimensions. Finished castings were inspected and found to be structurally sound and free of any surface defects. Primary dimensions included: nominal 61 cm x 61 cm outside dimensions, a 2 cm thick support portion, sixteen 2.5 cm diameter bosses located on each side of the support portion and directly opposing each other, a 2.5 cm wide sealing means area 6.4 cm thick around the periphery of the cell casting. Machined areas included the sealing means faces (both sides parallel) and the top of each boss (each side machined in a single plane and parallel to the opposite side). There were sixteen bosses on each side.

The cathode cell incorporated 0.9 mm thick protective nickel side liners on each side of the cell unit. Inlet and outlet nozzles, also constructed of nickel were pre-welded to the liners prior to spot welding the liners to the cell unit. Final assembly included spot welding catalytically coated nickel electrodes to the liners at each boss location.

The distance between the planes of the ends of the bosses was 58.2 mm for the monopolar cathode cell, which corresponds to the ECTE thickness. The overall cell thickness, from the outside of one nickel electrode component to the outside of the other nickel electrode component was 69.2 mm. Thus, the ECTE thickness was 92 percent of the total thickness.

The cathode terminal cell was similar to the cathode cell with the exception that a protective nickel liner was not required on one side, as well as the lack of an accompanying nickel electrode.

The anode cell incorporated 0.9 mm thick protective titanium liners on each side of the ECTE. Inlet and outlet nozzles, also constructed of titanium, were prewelded to the liners prior to spot welding the liners to the ECTE. Final assembly included spot welding titanium electrodes to the liners at each boss location through intermediate vanadium and titanium wafers. The anodes were coated with a catalytic layer of mixed oxides of ruthenium and titanium.

The anode terminal cell was similar to the anode cell with the exception that a protective titanium liner was not required on one side, as well as the lack of an accompanying titanium electrode.

1. A method for making an electric current transmission element which is useful as a major component of one of a plurality of repeating cell units disposed between two terminal cells of a filter press-type series of electrochemical cells, said method comprising the step of:

forming the electric current transmission element from an electrically conductive metal in a mold, with said mold having its interior shaped so that the transmission element has a planar support portion, a flame-like flange portion extending around a peripheral edge portion of the support portion which forms the peripheral boundaries of electrode compartments located on opposite sides of the support portion, and a plurality of bosses projecting outwardly from opposite sides of the support portion, said transmission element comprising an intergrally formed, one-piece structural element, characterized in that said transmission element is suitable for use in a monopolar or a bipolar cell unit and includes attachment means for at least one electrical current carrying conductor provided on the support portion or the flange portion of said transmission element, wherein said attachment means are utilized exclusively for the terminal cell units of a bipolar cell series or are utilized for each of the cell units of a monopolar cell series.

2. The method of Claim 1 including the steps of:

forming a side liner for at least one side of the opposed sides of the electric current transmission element from at least one sheet of metal which is impervious to and chemically non-reactive with the electrolyte to which it is to be exposed, said side liner being formed so as to cover the side and to conform substantially to the shape of said electric current transmission element including having caps pressed into the side liner in a manner such that the liner can be electrically and mechanically attached to the bosses on that side of the electric current transmission element by welding, and

welding at least a plurality of said caps of side liner to said bosses.

3. The method of Claim 1 or 2 including the step of welding the side liner to the bosses of said electric current transmission element through a metal intermediate placed between the bosses and the side liner, wherein the metal intermediate is a metal which is weldably compatible with both metals of the electric current transmission element and the side liner.

4. The method of Claim 1, 2 or 3 wherein the electric current transmission element is made of a ferrous metal, and the side liner is made of a metal selected from titanium and nickel.

5. A method of making and assembling a cell unit capable of being disposed between two terminal cells of a filter press-type electrolysis cell series, said method comprising:

(A) forming an integral solid casting of an electric current transmission element for said cell unit from an electrically conductive metal by pouring the molten metal into a mold, said mold having its interior shaped so that the electric current transmission element has: (1) a planar support portion, (2) a frame-like flange portion around the periphery of the casting to form the outside boundaries of electrode compartments which are located on opposite sides of the planar support portion, and (3) solid bosses projecting outwardly from opposite sides of the planar support portion;

(B) removing said electric current transmission element from said mold;

(C) welding a substantially planarly disposed electrode component to the ends of the bosses, characterized in that said cell unit includes attachment means for at least one electrical current carrying conductor provided on the planar support portion or the flange portion of said electric current transmission element and is suitable for use in a monopolar cell series.

6. The method of Claim 5 wherein a side liner is attached to at least one side of said electric current transmission element between the transmission element and the electrode component thereby leaving the electrode component attached to the side liner instead of the transmission element.

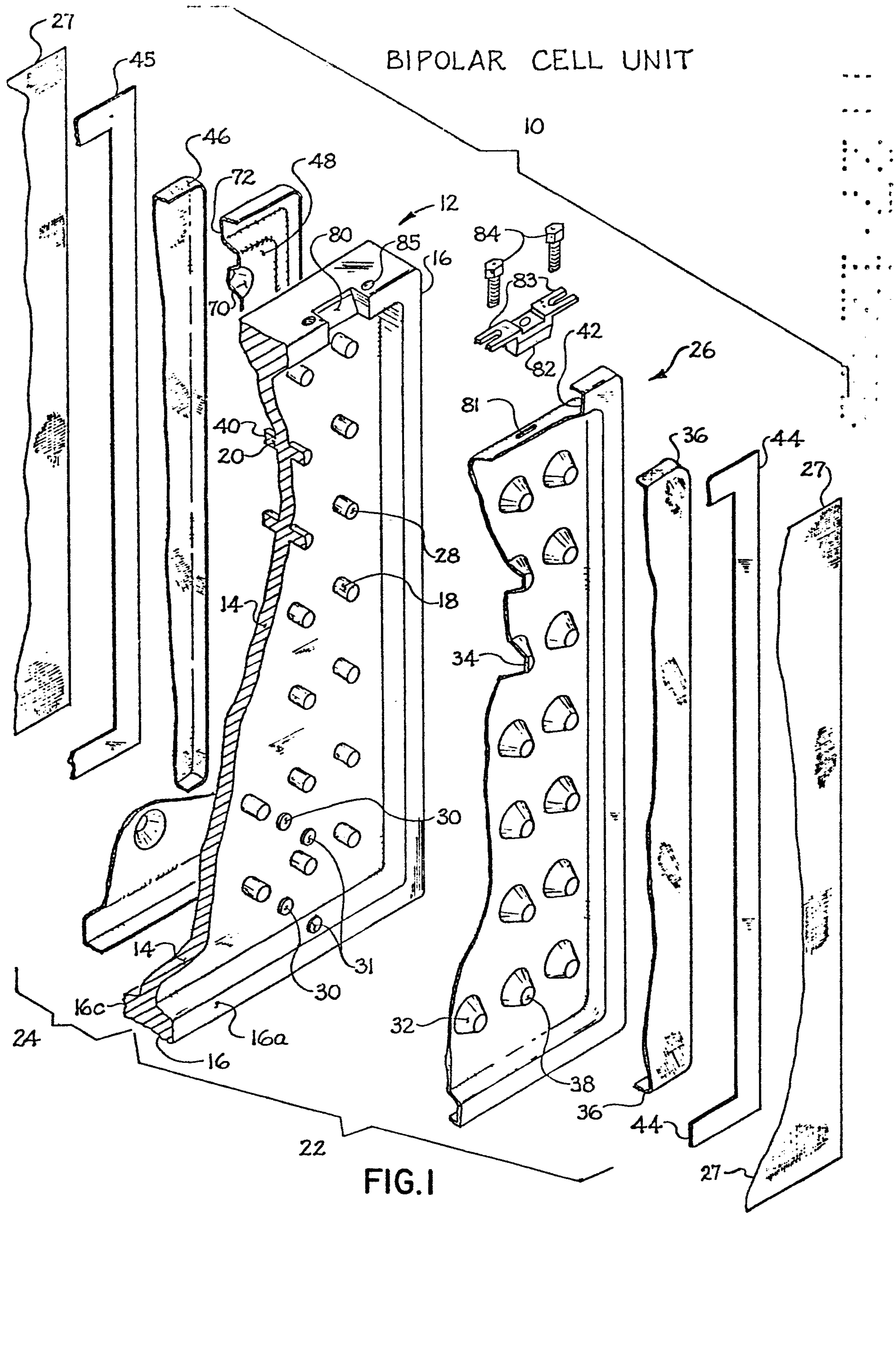
7. A method of making and assembling a cell unit capable of being disposed between two terminal cells of a filter press electrolysis cell series, said method comprising:

(A) forming an integral solid casting of an electric current transmission element for said cell unit by pouring a molten, electrically conductive, metal into a mold, cooling the metal until it becomes sufficiently rigid to retain the shape imparted to it by the mold upon its removal from the mold, said mold having its interior shaped so that the transmission element has: (1) a planar support portion, (2) a frame-like flange portion around the peripheral edges of the support portion to form the outside boundaries of the electrode compartments which are located on opposite sides of the support portion, and (3) solid bosses projecting outwardly from opposite sides of the support portion;

(B) removing said transmission element from the mold;

(C) attaching a side liner to each side of said transmission element, said side liner having previously been formed from at least one sheet of metal which is impervious to and chemically non-reactive with the electrolyte to which it is to be exposed and being formed to cover the sides of said transmission element and shaped to conform substantially to the shape of the side of the transmission element, said side liner having depressions in the sheet such that the depressions fit over the bosses, said attachment of said side liners to sides of the transmission element being accomplished by welding at least half of the depressions to the bosses located on each side of said transmission element;

(D) welding substantially planarly disposed electrode components to the ends of the depressions of the two side liners, and characterized in that said cell unit includes attachment means for a least one electrical current carrying conductor provided on the planar support portion or the flange portion of said electric current transmission element and is suitable for use in a monopolar cell series.


BIPOLAR CELL UNIT
10
12
27
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72
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80
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16
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83
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42
26
70
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40
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28
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14
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36
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16c
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16a
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38
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FIG.1

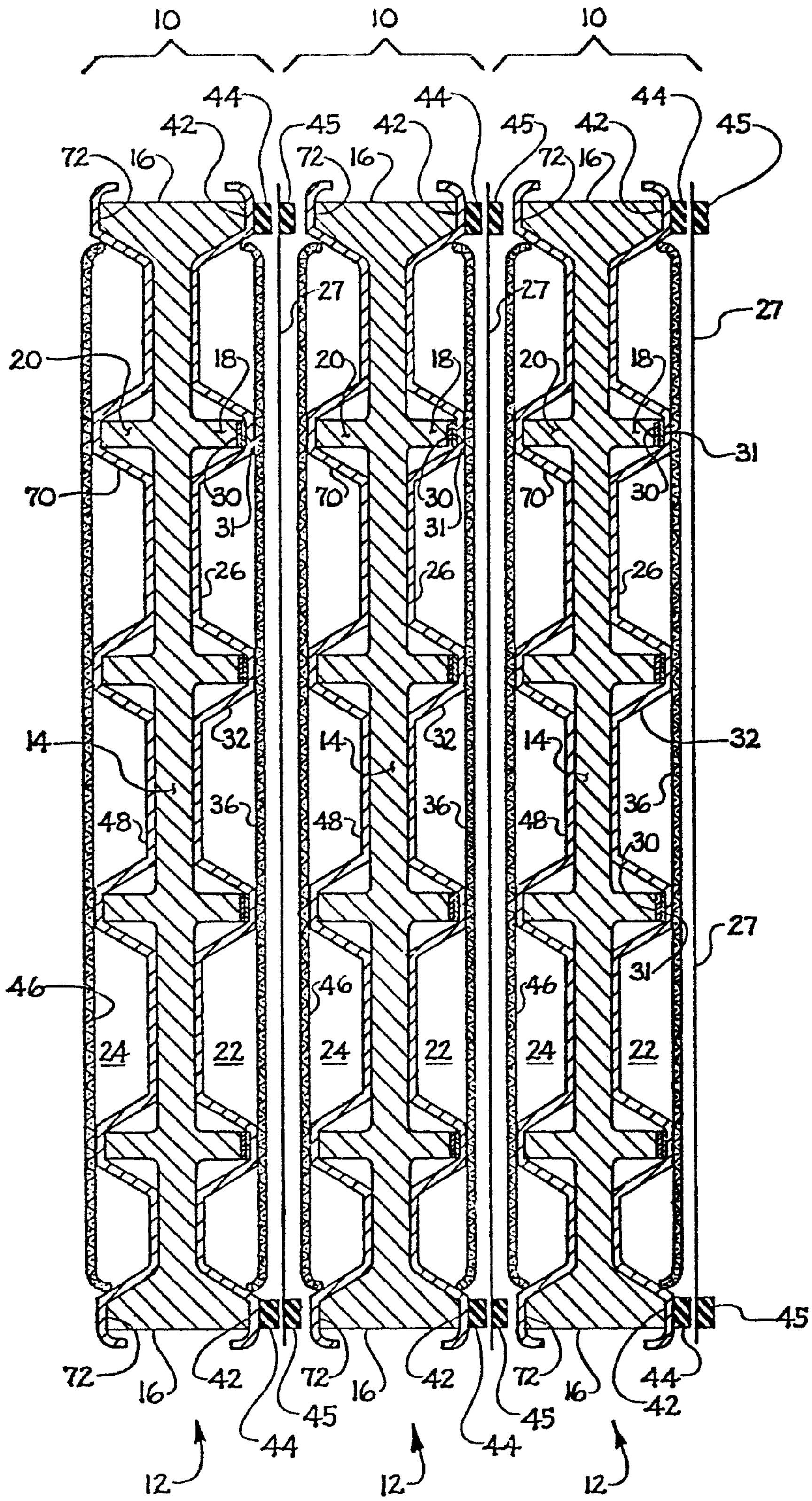

FIG.2

BIPOLAR ASS'LY

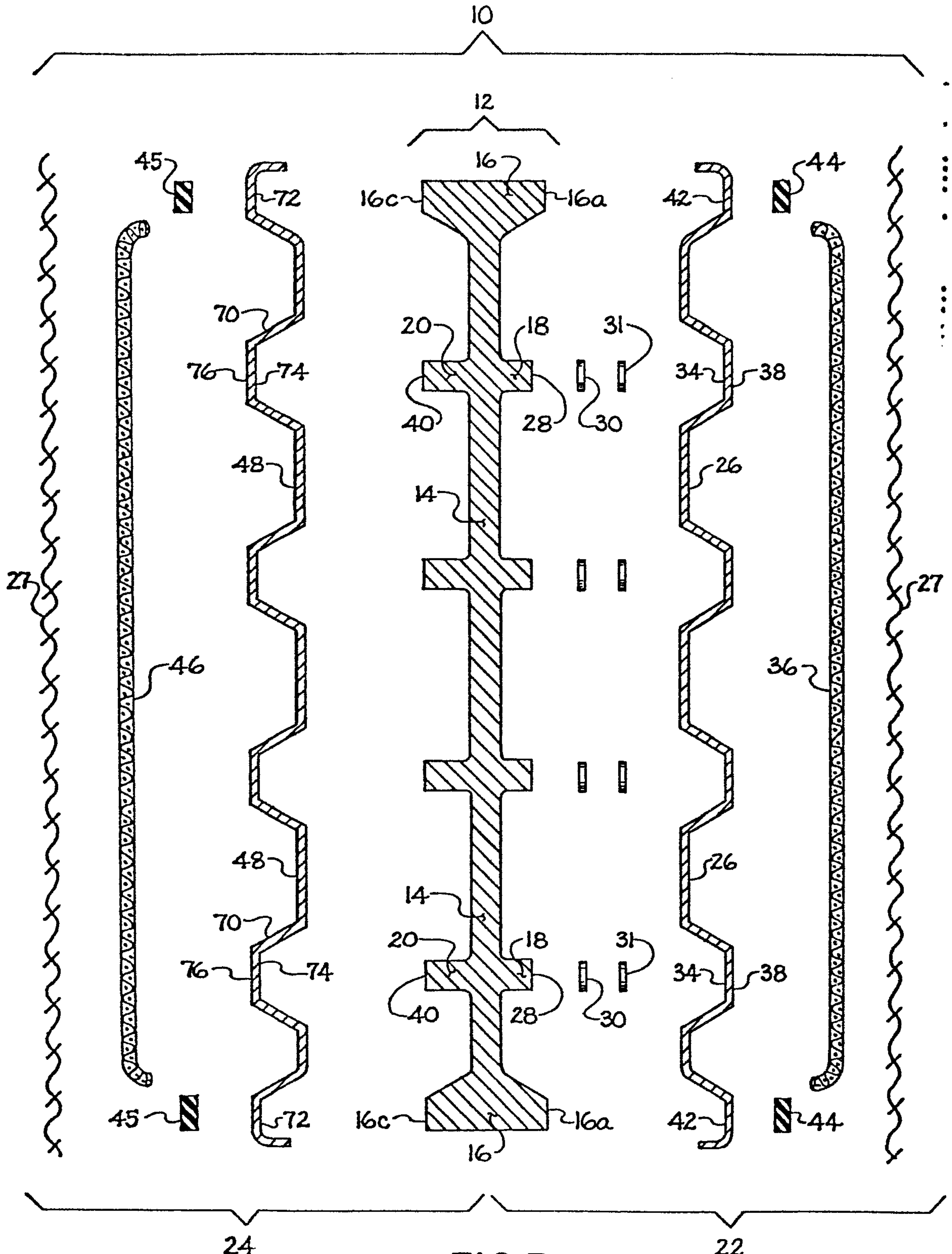

FIG.3

BIPOLAR CELL UNIT

MONOPOLAR ANODE CELL UNIT

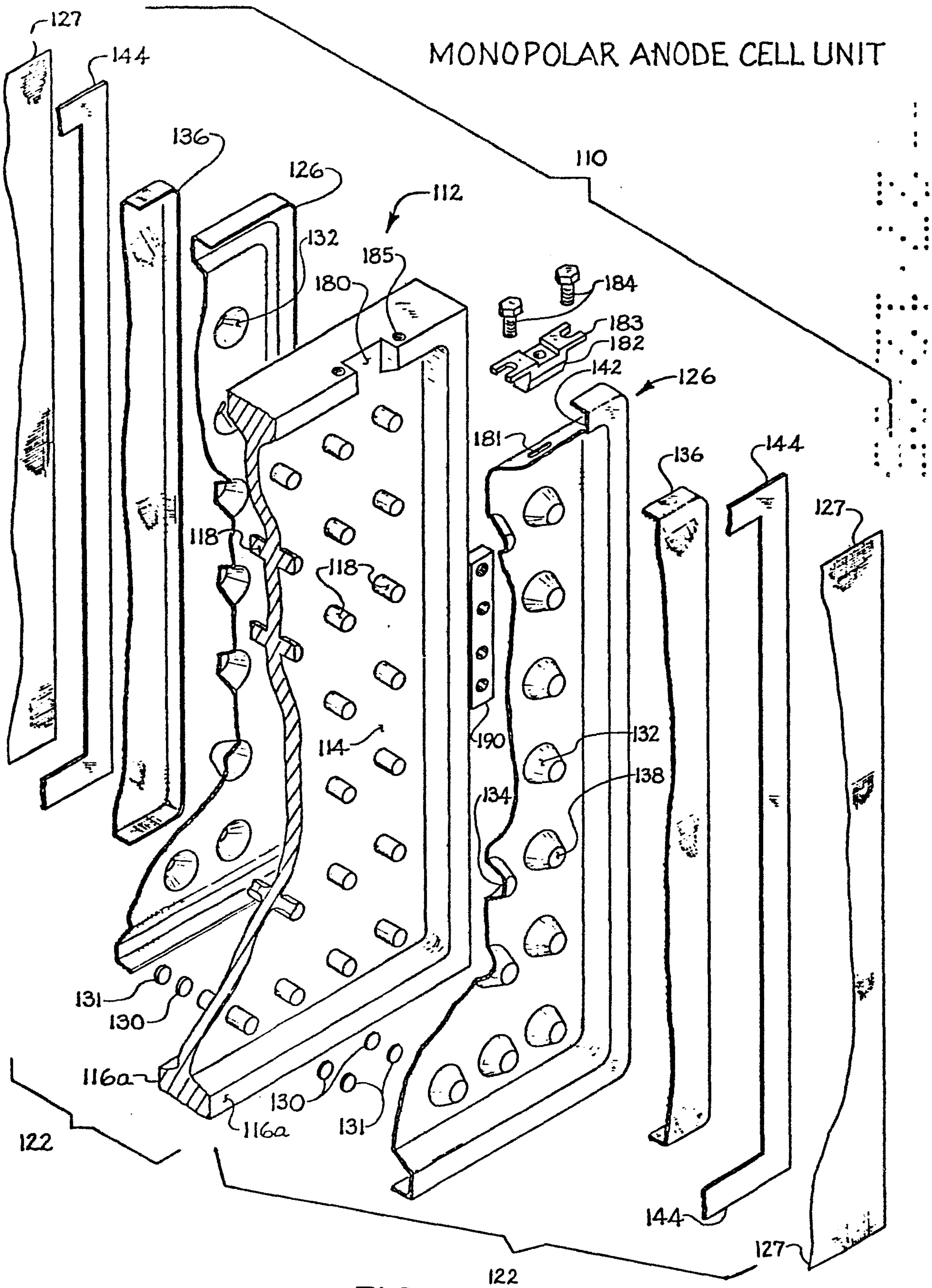

FIG.4

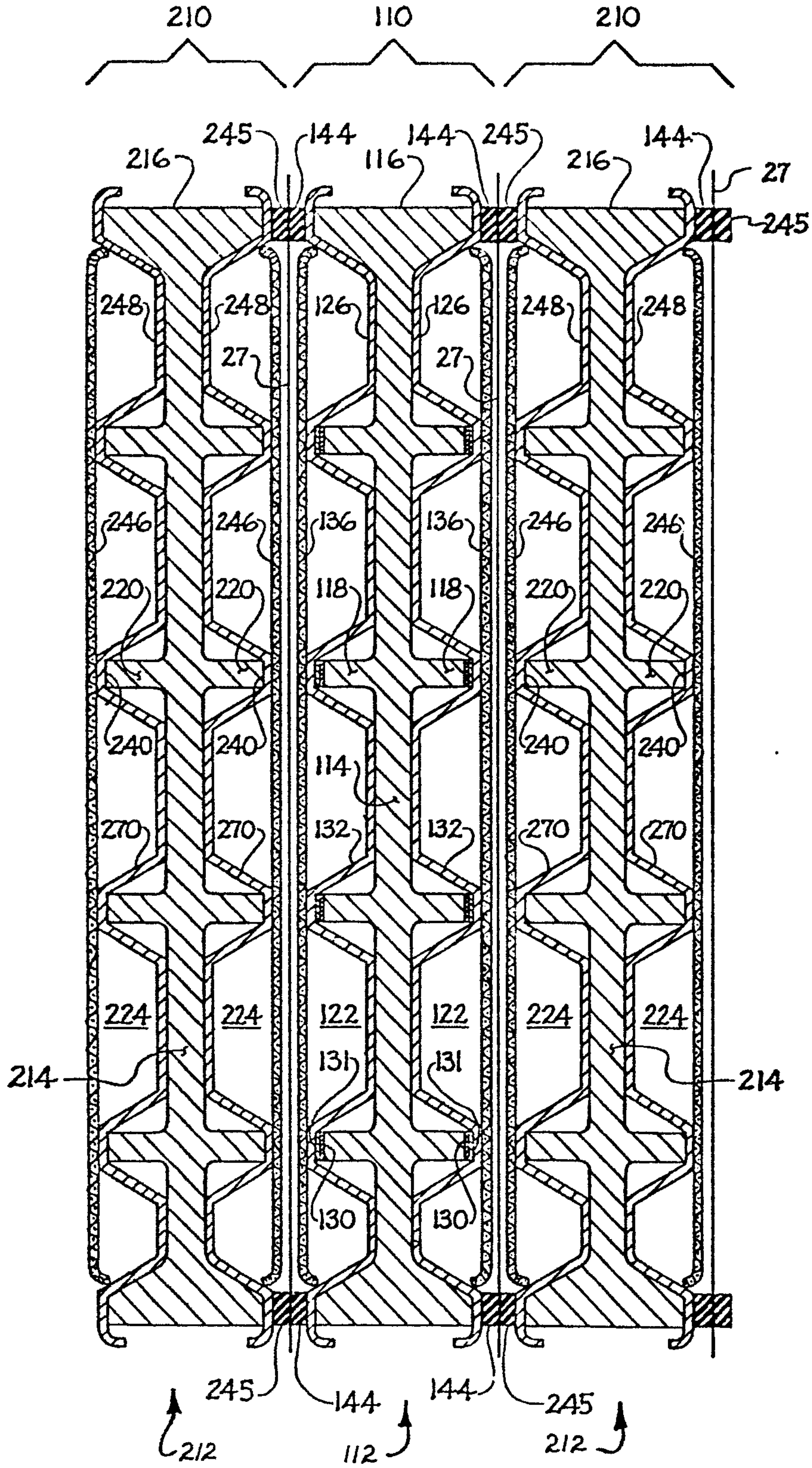

FIG. 5

MONO. CELL ASS'LY

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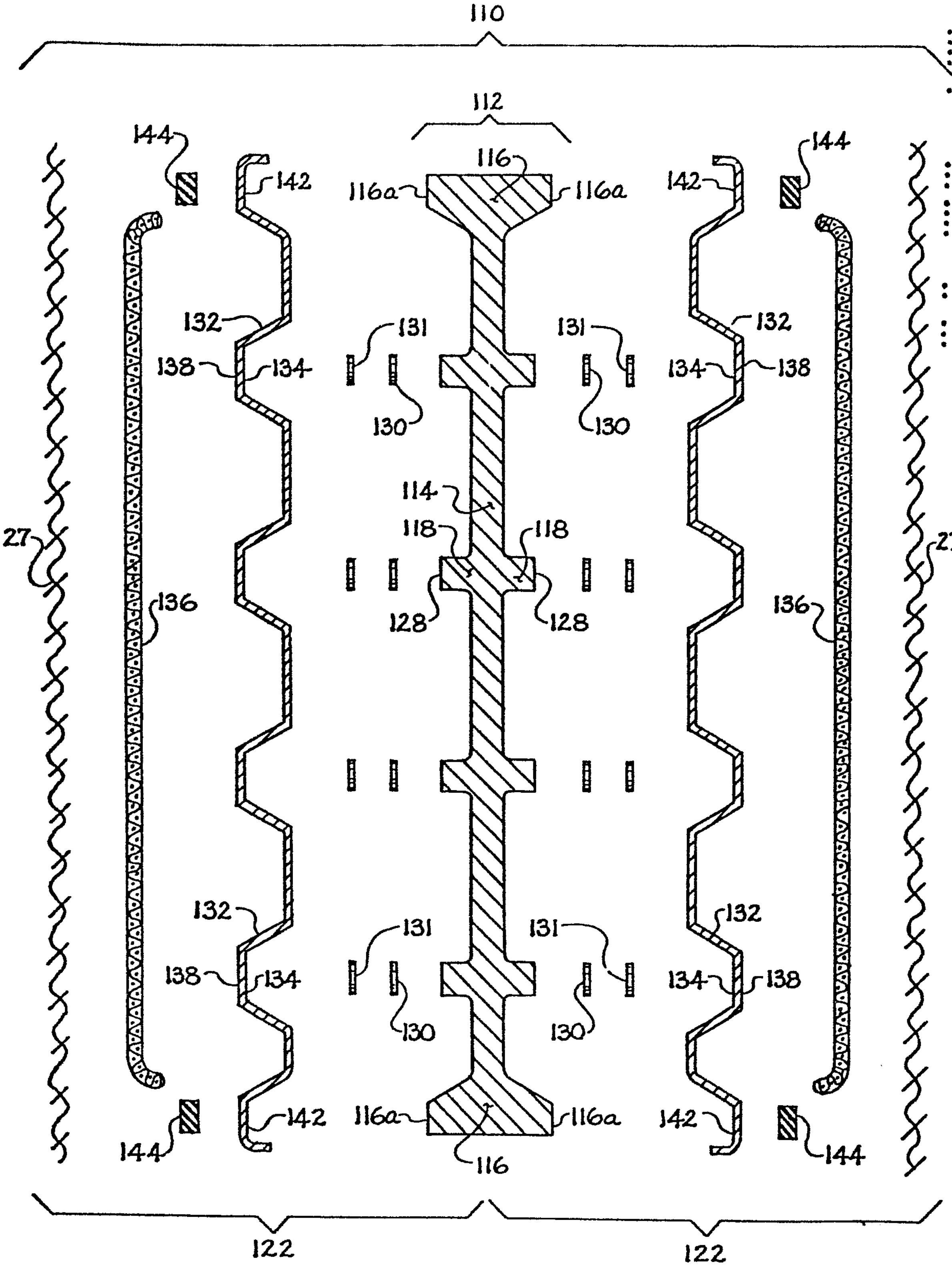

FIG.6

MONO. ANODE CELL UNIT

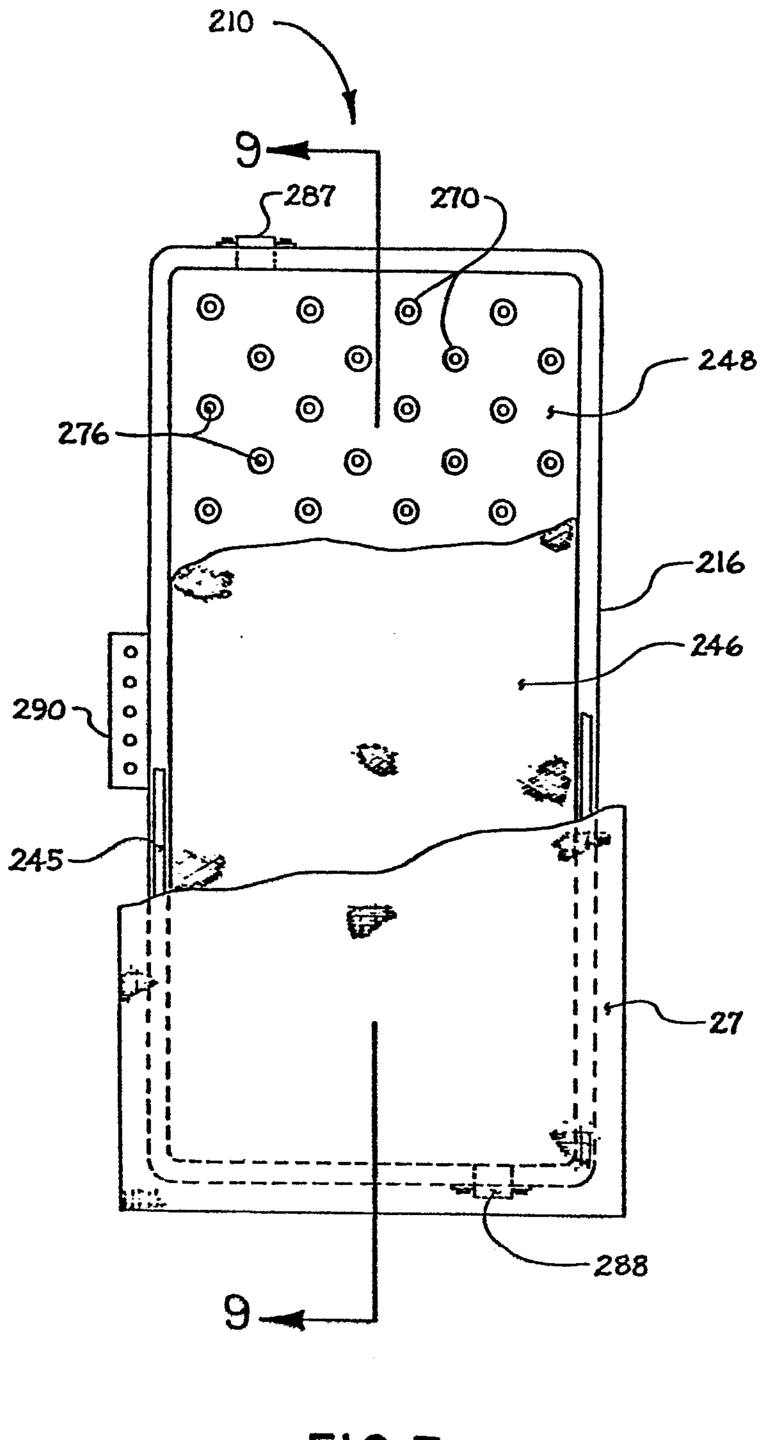

FIG.7

MONO. CATHODE CELL UNIT

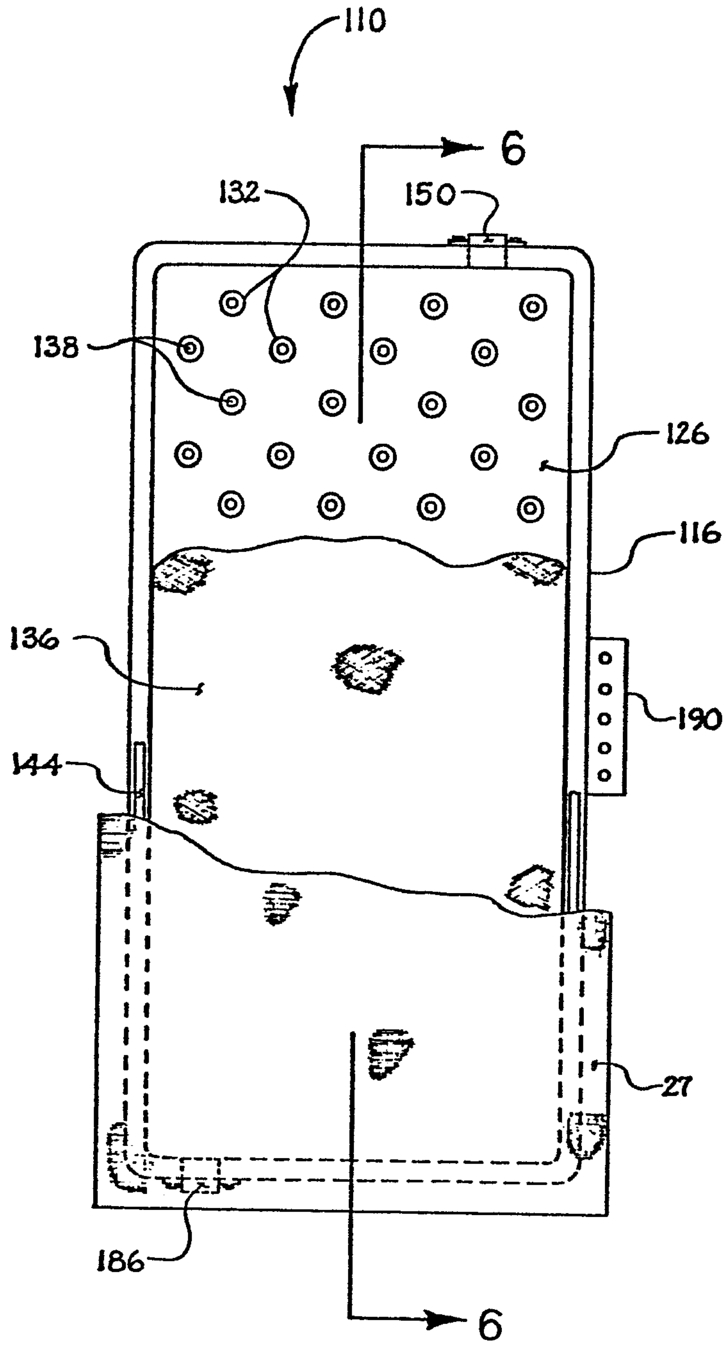

FIG.8

MONO. ANODE CELL UNIT

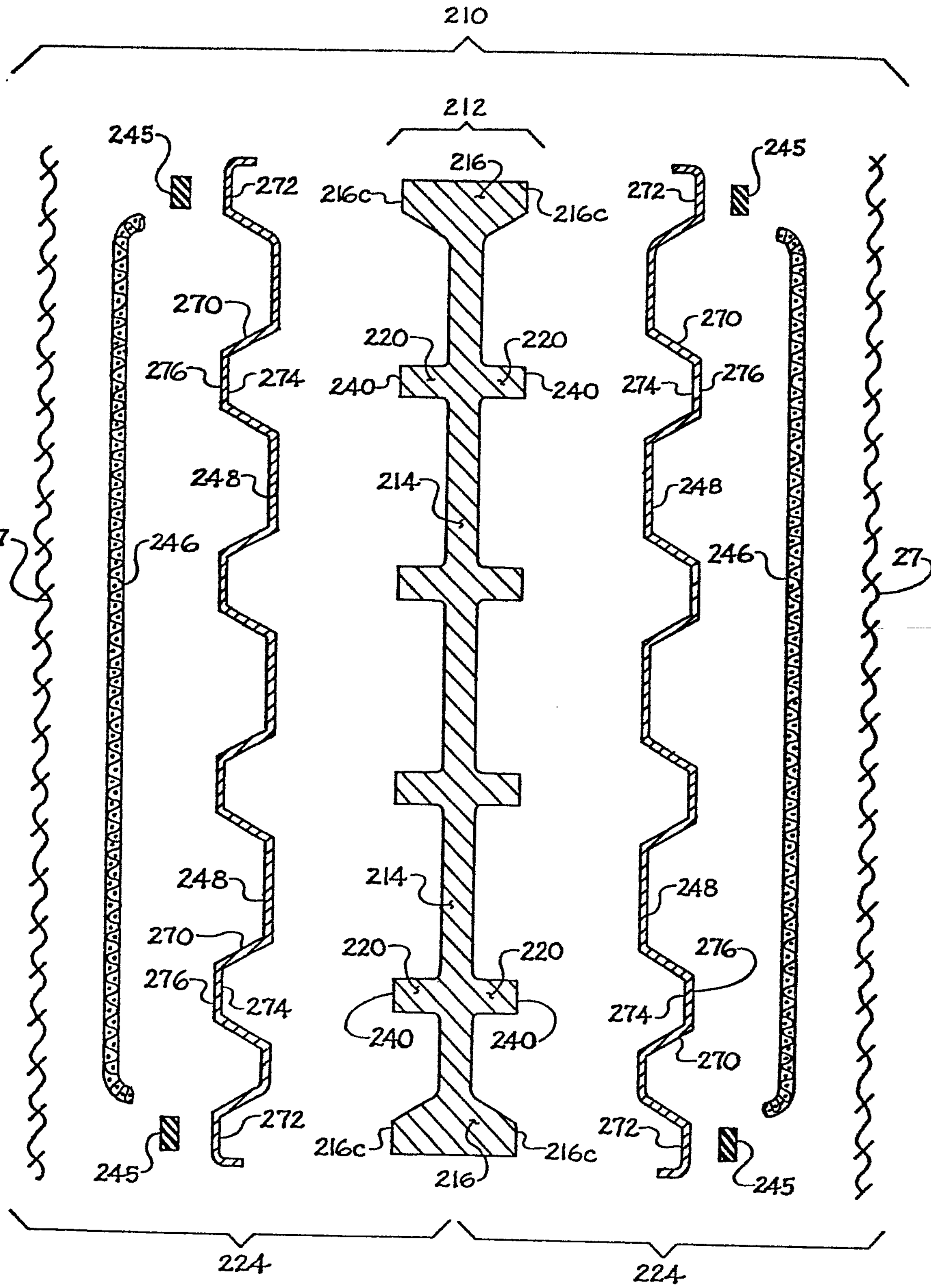

FIG. 9

MONO. CATHODE CELL UNIT

European Patent Office

EUROPEAN SEARCH REPORT

0185270

Application number

EP 85 11 5536

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.4)
Y	WO-A-8 403 523 (THE DOW CHEMICAL CO.) * Whole document *	1-7	C 25 B 9/04 C 25 B 9/00
Y	EP-A-0 080 288 (IMPERIAL CHEMICAL INDUSTRIES) * Page 6, lines 18-31; page 10, lines 1-8; page 19, lines 12-34; figures 1,2,4 *	1,5,7	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)
C 25 B 9

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	07-03-1986	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
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P : intermediate document
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