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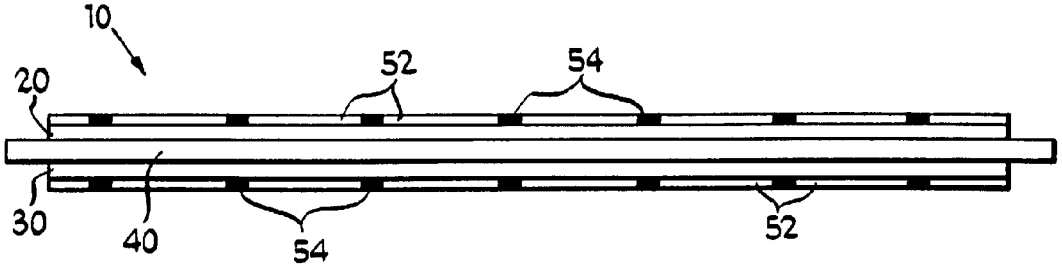
(54) Title: RIB SPACING WITH REGISTRATION POINT



(57) Abstract: An electrode plate (10) for use in an electrochemical cell, such as a zinc/bromine battery is provided. The electrode comprises a bipolar plate having a non-conducting spacing member (52) affixed to at least one side of the electrode plate. A visual registration indicator (60) is fabricated onto a spacing member for positioning the plates in a battery.

WO 02/25754 A1

TITLE OF THE INVENTION

RIB SPACING WITH REGISTRATION POINT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to electrochemical cells, and, more particularly, to a bipolar electrode plate comprising non-conductive non-intersecting spacing means wherein at least one of the spacing means further comprises a registration point.

2. Background Art

In various types of electrochemical cells (such as zinc/bromine batteries and super capacitors), bipolar electrode plates are stacked together with the anodic face of one electrode plate opposite the cathodic face of the adjacent electrode plate. In addition, a separator is positioned between the opposing bipolar plates to prevent contact therebetween. Furthermore, a gap is positioned between the electrode plates and the separator so as to enable an electrolyte fluid, such as a zinc-bromide electrolyte, to flow therethrough.

While a gap is necessary to allow the electrolyte to flow between the electrode plates and the separator, the separator may tend to deform into the gap without adequate support structures. Therefore, to prevent the separator from deforming, support structures have been designed which fit in the gap between the electrode plate and separator. One such design is in the form of a screen mesh. While the screen helps prevent deformation of the separator, there are many drawbacks associated with such a design.

One such drawback involves the obstruction of electrolyte flow. The screen causes the electrolyte to flow in a turbulent manner. In turn, this causes the metal to unevenly plate the electrode. This uneven metal plating affects, among other things, the power generated by the electrochemical cell.

Another drawback associated with the use of a screen support structure is that the overall thickness of the electrochemical cell is increased due to the interlaced supports making up the screen. As the individual support strands weave about one another, the overall thickness is doubled at the points where one strand passes over another.

In addition, when such prior art electrode plates are stacked on top of each other -- as is necessary when, for example, fabricating a zinc/bromine battery or super capacitor -- deformation of each of the cells, and, in turn, obstruction of the electrolyte flow paths occur due to the support structures on one or more sides of the bipolar electrode plate not being in substantial overlying alignment with the support structures on an adjacently positioned bipolar electrode plate.

Another disadvantage is, that gas is entrapped in the screen and is not released anywhere. By this, gas can accumulate, thereby decreasing the active electrode area.

SUMMARY OF THE INVENTION

The present invention is direct to an electrode for use in an electrochemical cell comprising, a bipolar electrode plate having a first side and a second side, and at least two non-conducting non-intersecting spacing members affixed to at least one of the first or second sides of the bipolar electrode plate. The first side may be an anode and the second side may be a cathode.

In a preferred embodiment, the non-conducting non-intersecting spacing members are parallel to one another and have a linear configuration. However, it also contemplated that the non-conducting spacing members have other geometries, such as a sinusoidal configurations. It is also contemplated that the non-conducting non-intersecting spacing members be positioned on both the first and second sides of the bipolar electrode.

In one preferred embodiment, spacing members on the first side of the bipolar electrode plate are not of the same height as the spacing members on the second side of the bipolar electrode plate. Alternatively, spacing members positioned on both the first and second sides of the bipolar electrode plate have the same, or substantially the same dimensions.

In the preferred embodiment of the invention, at least one spacing member includes a visual registration indicator. For example, the visual registration indicator may comprise one or more protrusions or other unique/differentiating markings or configurations formed on or in association with one or more of the spacing members.

In still another preferred embodiment, the spacing members comprise means for enhancing alignment. In such an embodiment, the alignment enhancing means

comprises the non-conducting spacing members having varying transverse cross-sectional dimensions.

In the preferred embodiment of the invention, the bipolar plate comprises a carbon plastic sheet, an active material sheet applied thereon, and a non-conductive border surrounding the perimeter of the carbon plastic and active material sheets. The bipolar plate may further comprise means for enhancing metal plating. In such a preferred embodiment, the means for enhancing metal plating may comprise recesses formed on one or both sides of the carbon plastic sheet. The recesses may be in the from of dimples, grooves, nodules, or as a textured surface.

The present invention is also directed to a method for aligning the spacing members on adjacently positioned bipolar electrode plates. In such an embodiment, the method comprises the steps of: a) producing bipolar electrode plates having at least two non-conducting non-intersecting spacing members on both sides and, wherein at least one spacing member on at least one side includes a visual registration indicator; and b) placing the bipolar electrode plates in an alignment fixture so that the visual registration indicator on each plate are positioned at a designated location on the alignment fixture.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described herein with reference to the drawings wherein:

Fig. 1 is a side view of one embodiment of the present invention;

Fig. 2 is a top plan view of the same embodiment shown in Fig. 1;

Fig. 3 is a top plan view of an alternative embodiment of the present invention;

Fig. 4 is a partial cross-sectional view of an electrochemical cell incorporating the spacing members of the present invention; and

Fig. 5 is a partial cross-sectional view of an electrochemical cell wherein the spacing members are misaligned, thereby causing the separator to deform and obstruct the respective channels.

DETAILED DESCRIPTION OF THE INVENTION

While this invention is susceptible to embodiment in many different forms, there is shown in the drawings and will be described below in detail several specific embodiments, with the understanding that the embodiments are to be considered to be an exemplification of the principles of the invention, and the embodiments are not intended to limit the invention to the embodiments illustrated.

Turning now to the drawings, and, more particularly, to Figs. 1 and 2, a bipolar electrode plate is shown generally at 10. Bipolar electrode plate 10 is comprised of an anode plate 20, a cathode plate 30, non-conductive border 40, spacing means ("ribs") 52, and registration indicator 60 associated with the spacing means.

Anode plate 20 is comprised of a carbon plastic that is resistant to corrosion when exposed to, for example, a metal-halogen electrolyte and the respective ions liberated during the energy storage process. One example of a suitable carbon plastic composition is provided by the Exxon Research and Engineering Co. and is disclosed in an article entitled "Conductive plastic speeds development of advanced storage battery" by Tien, H.C., Plastics Engineering, pp.21-24, August 1981. What has been described therein is a carbon-plastic formulation used for an electrode consisting of 100 parts by weight of polyolefin copolymer, 25 parts of special conductive carbon, 5 parts each of carbon and glass fiber, and 1 part of fumed silica powder. The conductive carbon used in the formulation is Ketjenblack, a Japanese product available through Noury Chemical Co. in New York. In a preferred embodiment, the anode is rectangular and has a thickness of 1.4 millimeters.

Additionally, anode plate 20 may further comprise recesses 22 uniformly distributed across the surface to enhance metal plating or deposition. In one embodiment, the recesses are dimples which are uniformly distributed across the front face of the anode plate to enhance metal deposition or plating. In another embodiment, the recesses 22 may comprise grooves. In a preferred embodiment, the grooves are parallel to the flow of electrolyte. In a preferred embodiment, dimples 22 do not fully pass through anode 20, and instead have a depth of, for example, 0.12 millimeters, and may be uniformly distributed over the anodic surface of the electrode at a frequency of approximately 8 dimples per square centimeter. Of course, other depths and areas of distribution are likewise contemplated.

Cathode plate 30 is comprised of carbon paper and has similar properties to anode plate 30 with respect to corrosion resistance. In a preferred embodiment, cathode plate 30 is comprised of carbon fibers, powder or a mixture therebetween as well as a plastic filler material to hold it together. In a preferred embodiment, cathode plate has identical dimensions, with respect to length and width, as anode plate 20. Anode plate 20 and cathode plate 30 are fusion bonded to one another in a preferred method of construction.

Non-conductive border 40 is provided alongside the entire perimeter of the anode and cathode plates. In a preferred embodiment, border 40 is comprised of plastic.

Across the exposed faces of anode plate 20 and cathode plate 30 are spacing means 52. In a preferred embodiment, spacing means 52 comprise non-conductive non-intersecting ribs. Ribs 52 are comprised of a non-conductive, corrosion resistant

material such as plastic.

When the individual electrode plates are stacked, they are not in direct contact with one another. In fact, the electrode plates are separated by separator 70 which is sandwiched in between the adjacent electrode plates as shown in FIG. 4. Spacing means ("ribs") 52 in alignment with one another, and on either side of separator 70, clamp down on and hold the separator in place. Therefore, separator 70, however, is not in direct contact with either adjacent electrode plate. Ribs 52 elevate separator 70 slightly above the surface of the respective electrode plates to provide a gap or channel 80 wherein electrolyte may flow. The amount of electrolyte flowing through channel 80 is directly dependent on the area of the channel. The area of channel 80 may be increased or decreased by increasing or decreasing the height of ribs 52, respectively.

In one embodiment, as shown in Fig. 2, ribs 52 have a substantially linear configuration. It is contemplated, however, that ribs 52 may also be sinusoidally configured as shown in FIG. 3. In fact, ribs 52 may be configured in any manner so long as they are not intersecting one another.

Ribs 52 affixed to the anodic face of an electrode may be configured substantially the same as those ribs affixed to the cathodic face of the same electrode. It is contemplated, however, that the ribs on the cathodic face differ in configuration from those on the anodic face. In particular, the ribs on one face, such as the anodic face, may be greater in height than those present on the cathodic face, or vice versa. The reason for the height differential is related to the plating of metal, such as zinc for example, upon the anodic face. In a preferred embodiment, the rib height on the anodic face is about 0.85 millimeters while on the cathodic face the rib height is about

0.55 millimeters.

Specifically, a greater rib height on the anodic face versus the cathodic face is preferred for high-energy applications. An equal rib height is preferred for standard applications, and a low rib height on both the anodic and cathodic faces is preferred for low energy/high power applications.

As metal plates onto the anodic face, the gap between adjacent plates begins to decrease. This decrease in gap size affects the flow of the electrolyte. Therefore, the height of the ribs is adjusted in order to maintain an equal quantity of fluid flow on either side of the electrode plate at all times.

Because ribs 52 have a narrow width, when the electrochemical cell is constructed and the electrode plate stack is compressed, there is the potential for some slippage or misalignment of the ribs. If ribs 52 on adjacent electrode plates are misaligned with one another, then separator 70 may be pressed downwardly into a channel below in the absence of a counteracting force from opposing spacing means. This, in turn, obstructs the flow of electrolyte passing through the channel.

To ensure alignment of spacing means 52 during cell construction and stack compression, and in turn, avoid obstruction of electrolyte flow by separator 70 dipping into a channel below, means 54 (Fig. 2) for enhancing alignment have been provided along the spacing means. Means 54 have a greater width than spacing means 52 so that there is a greater chance for overlap, and minimizes or eliminates the chance of slippage.

In a preferred embodiment, means 54 comprises nodes along the ribs. Nodes 54 have a width wider than ribs 52. The increased width of the nodes prevents the ribs

on adjacent electrode plates from falling out of contact with one another, resulting in electrolyte flow obstruction, by pushing the separator into the channel just below it as shown in Fig. 5.

When constructing the electrochemical cell, which is comprised of, among other things, a plurality of electrode plates and separators therebetween, it is necessary to ensure alignment of the spacing means affixed to adjacent electrode plates. To do this, a visual registration indicator 60 has been provided on at least one spacing rib on an electrode plate. The registration indicator is preferably constructed from the same material as the spacing rib. In a preferred embodiment, visual registration indicator 60 is comprised of one node positioned next to one another on a spacing rib as shown in Fig. 2. In another embodiment, visual registration indicator 60 may be comprise a protrusion. In yet another embodiment, visual registration indicator 60 may comprise a brightly colored area along a given spacing rib. It is contemplated that visual registration indicator 60 may be in any geometric form or pattern which is readily visible to an operator assembling the electrode plates together in a stack formation. Visual registration indicator 60 allows an operator who is assembling the electrochemical cell to place the electrode plates atop one another in a uniform manner. For example, the operator can ensure that electrode plates are stacked in a jig or die so that the visual registration indicator is always positioned in the upper right hand corner.

The foregoing description and drawings merely explain and illustrate the invention, and the invention is not limited thereto, as those skilled in the art who have the disclosure before them will be able to make modifications and variations to the system without departing from the scope of the invention.

CLAIMS

1. An electrode for use in an electrochemical cell comprising:

- a bipolar electrode plate having a first side and a second side; and

- at least one non-conducting spacing member affixed to at least one of the first or second sides of the bipolar electrode plate.

2. The electrode of claim 1 comprising at least two non-conducting non-intersecting spacing members affixed to at least one of the first or second sides of the bipolar electrode plate.

3. The electrode of claim 2, wherein the non-conducting non-intersecting spacing members are substantially parallel to one another.

4. The electrode of claim 1, wherein the non-conducting spacing member has a linear configuration.

5. The electrode of claim 4, wherein the non-conducting spacing member has a sinusoidal configuration.

6. The electrode of claim 1, wherein at least two non-conducting non-intersecting spacing members are located on both the first and second sides of the bipolar electrode.

7. The electrode of claim 6, wherein the at least two non-conducting non-intersecting spacing members on the first side are not equal in height to the at least two non-conducting non-intersecting spacing members on the second side.

8. The electrode of claim 6, wherein the non-conducting non-intersecting spacing members on the first and second sides have substantially the same dimensions.

9. The electrode of claim 2, wherein at least one spacing member includes a visual registration indicator.

10. The electrode of claim 9, wherein the visual registration indicator comprises a protrusion on the spacing member.

11. The electrode of claim 1, wherein the non-conducting spacing member further comprises means for enhancing alignment.

12. The electrode of claim 11, wherein the means for enhancing alignment comprises a non-conducting spacing member having a varying transverse cross-section.

13. The electrode of claim 1, wherein the first side is an anode and the second side is a cathode.

14. The electrode of claim 1, wherein the bipolar plate comprises a carbon plastic sheet, an active material sheet applied thereon, and a non-conductive border surrounding the perimeter of the carbon plastic and active material sheets.

15. The electrode of claim 14 further comprising means for enhancing metal plating.

16. The electrode of claim 15, wherein the means for enhancing plating comprises recesses in at least one side of carbon plastic sheet.

17. The electrode of claim 16, wherein the carbon plastic sheet comprises recesses on both of its sides.

18. The electrode of claim 15, wherein the configuration of the recesses is selected from a group consisting of dimples, grooves, nodules, or textured surface.

19. An electrochemical cell comprising:

- at least two adjacent bipolar electrode plates,

-the first bipolar electrode plate comprised of an anodic face and a cathodic face, and at least two non-conductive non-intersecting spacing members on each face, and

- the second bipolar electrode plate comprised of an anodic face and a cathodic face, and at least two non-conductive non-intersecting spacing members on each face, and wherein the at least two spacing members on opposing faces of the adjacent bipolar electrode plates are in substantial alignment with one another.

20. The electrochemical cell of claim 19, wherein the non-conducting non-intersecting spacing members are substantially parallel to one another.

21. The electrochemical cell of claim 20, wherein the spacing members are linearly configured .

22. The electrochemical cell of claim 20, wherein the spacing members are sinusoidally configured.

23. The electrochemical cell of claim 20, wherein at least one of the spacing members on each bipolar electrode plate is further comprised of a visual registration indicator.

24. The electrochemical cell of claim 23, wherein the visual registration indicator comprises a protrusion on the spacing member.

25. The electrochemical cell of claim 19, wherein the non-conducting non-intersecting spacing members further comprise means for enhancing alignment.

26. The electrochemical cell of claim 25, wherein the means for enhancing alignment comprises a non-conducting spacing member having a varying transverse cross-section.

27. The electrochemical cell of claim 19, wherein the bipolar plates further comprise means for enhancing metal plating.

28. The electrochemical cell of claim 27, wherein the means for enhancing plating comprises recesses on the anodic face.

29. A method for aligning spacing members on adjacent bipolar electrode plates comprising the steps of:

- producing bipolar electrode plates having at least two non-conducting non-intersecting spacing members on both sides, wherein at least one spacing member on at least one side includes a visual registration point; and

- placing the bipolar electrode plates in an alignment fixture so that the visual registration points on each plate are positioned at a designated location of the alignment fixture.

Fig 1

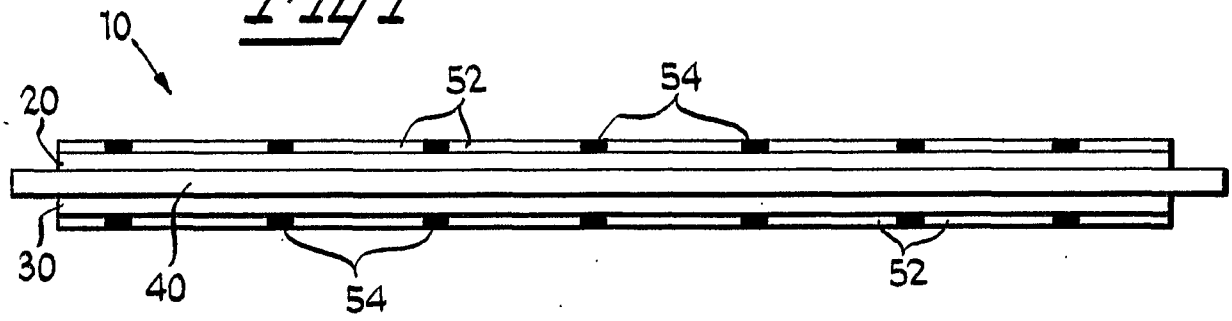


Fig 4

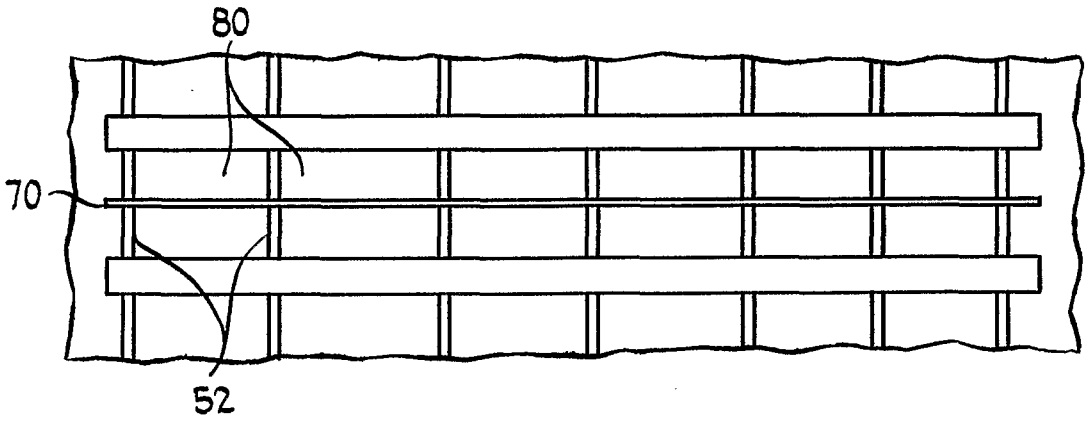


Fig 5

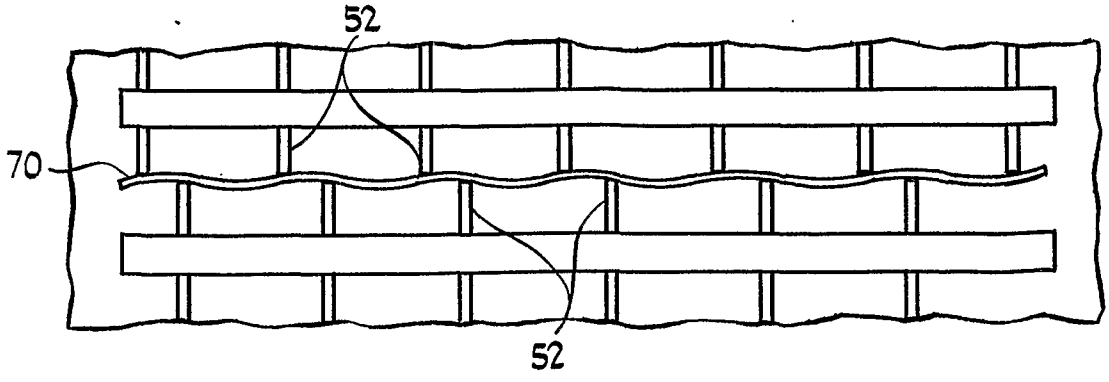


Fig 2

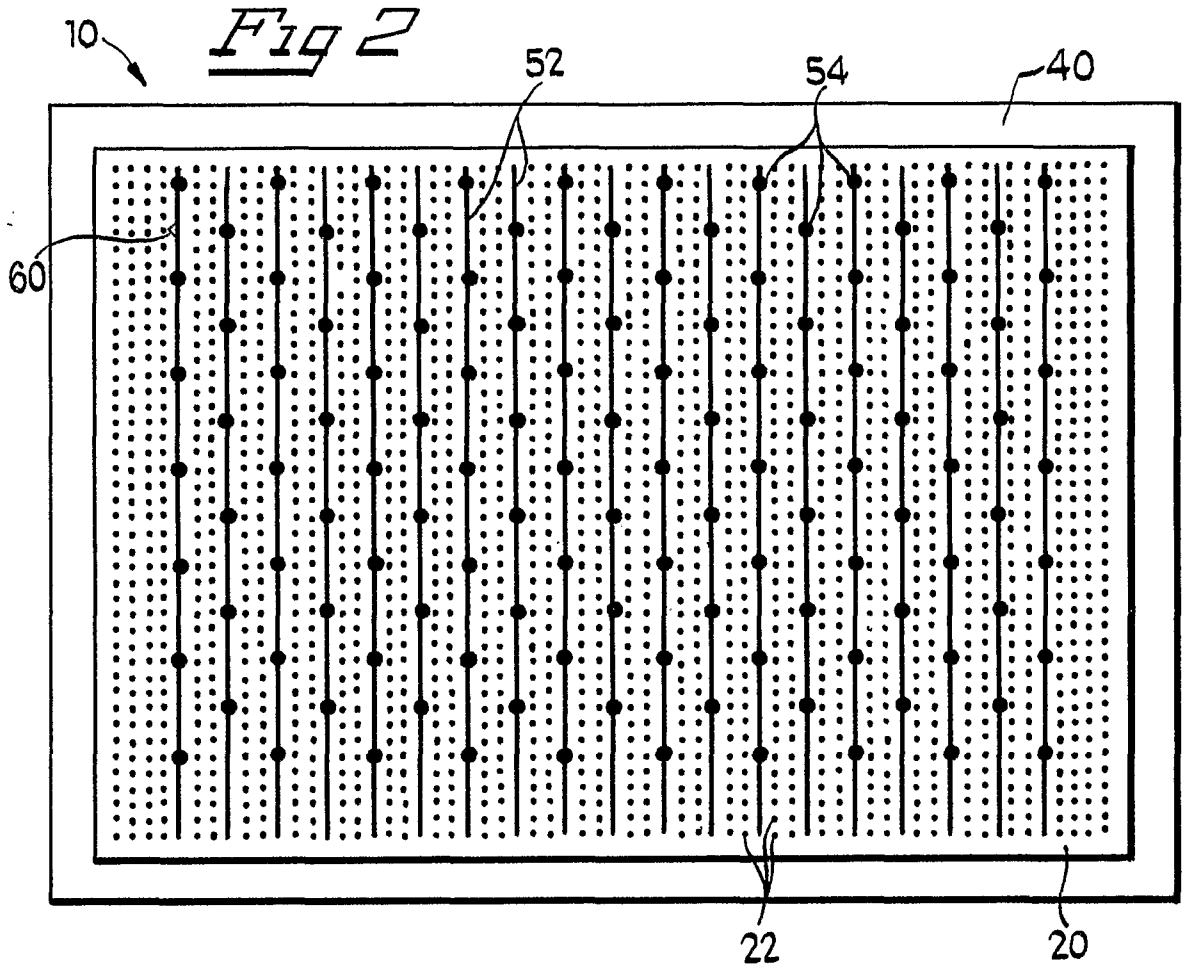
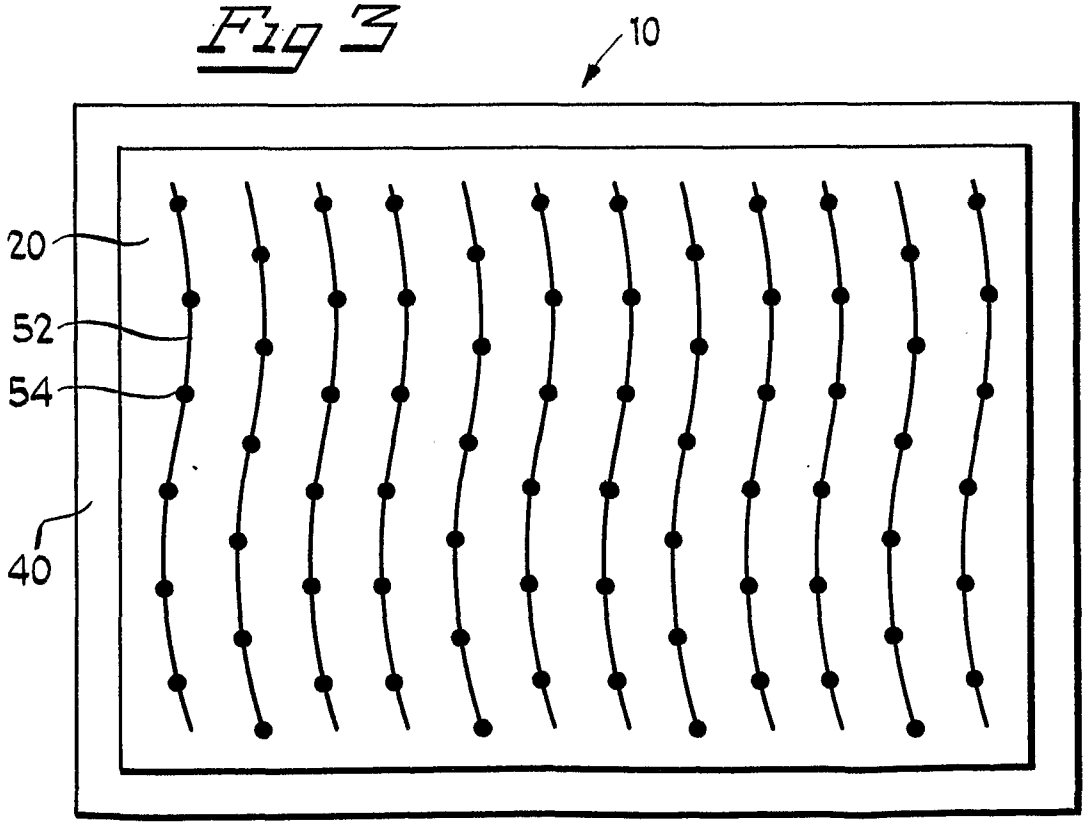


Fig 3



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/29448

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : H01M 2/14, 10/14, 10/18
US CL : 429/ 51, 130, 143

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 429/ 51, 130, 143

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WEST 2.0 (US, JP, EP AND DERWENT DATABASES)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,068,160 A (CLOUGH et al.) 26 November 1991, col.14, lines 54-69; col. 15, lines 20-44, figues 1-8 and claims.)	1-29
X	US 5,346,768 A (HODGETTS) 13 September 1994, figures 1-4, col. 4-5, and the claims.	1-29
X --- Y	EP 225,315 B (TOMAZIC) 10 June 1987, see the abstract attached, and figures 1-3.	1-5, 7, 9-14, 19-21, 23-26, 29 --- 6, 8, 15-18, 22, 27-28
Y	US 4,735,630 A (PLANCHAT) 05 April 1998, colums 2-3, claims 1-9 and the figures.	1-29
A	US 5,773,161 A (FAROOQUE et al.) 30 June 1998.	1

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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