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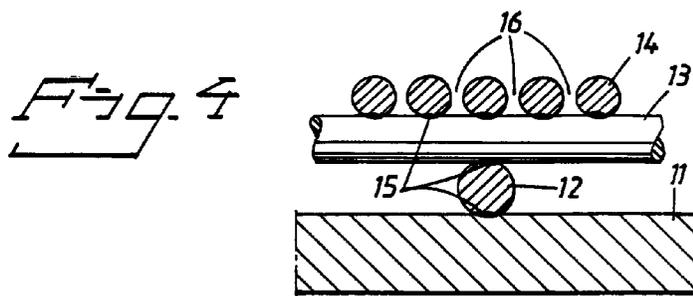
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(54) Electrode and method of producing an electrode

(57) The invention relates to a method of producing an electrode comprising an electrode structure (3;14) attached to an underlying base structure (1;11), wherein the method comprises the steps of: (a) applying on the base structure (1;11) the electrode structure (3;14) and between said base structure and said electrode structure applying contact filaments (2;12); and

(b) joining said base structure, electrode structure and contact filaments together at joints (15) by electrical welding. The invention also includes an electrode produced by the method, an electrolytic cell comprising an electrode according to the invention, and the use of such an electrode in electrolysis.



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Description

The present invention relates to an electrode comprising an electrode structure fitted to an underlying base-structure with the aid of contact filaments electrically welded in between the structures, a method of producing such an electrode, an electrolytic cell comprising an electrode according to the invention, and the use of such an electrode in electrolysis.

Today, titanium is the most common material used in cells and electrodes in advanced electrochemical applications, due to its excellent material properties. However, titanium is a poor conductor and is passivated when operated as an anode. The passivation is overcome in industrial cells by a suitable activation of the titanium. Membranes are used in many electrochemical processes. Membranes are very thin and fragile. Membranes are also sensitive for variations in current densities. Moreover, it is important to have a clean, smooth and even electrode surface in order not to damage the membrane.

The active coating of the electrode is often a kind of ceramic material, which actually not is aimed for welding, leading to e.g. melting and deformation around and in the weld joint. Therefore, the coating will often be damaged when coated electrode surfaces are welded. Areas where the coating have been damaged on the surface of the electrode implies the current to take other ways around the damaged area. Due to the higher current densities and amperage in the cell's of today, there will be large differences in the current distribution over the electrode surface because of these damaged areas. Thin and yieldable membranes will be damaged by large differences in the current distribution over the electrode surface.

The membrane quality have so far limited the possible current density in the cells. But as the membranes under development and of tomorrow will be able to stand up to twice as much current per area unit as the membranes of today, the demands on the quality of the cell, of the electrode structure and variations in current distribution, will increase accordingly.

In many electrolytic processes, use is made of electrodes which comprises an electrode surface in the shape of a net, an expanded mesh, wire-gauze, grid, threads, rods or the like, welded to an underlying structure. These are usually welded by the use of spot welding (a resistance welding method). In welding operations carried out by resistance welding and other contact welding operations (electrical), the current source can be different types of alternating current (A.C.) and direct current (D.C.). The quality of the welding is dependent on several conditions, such as the current intensity and type of current source. Also the welding time and the mechanical pressure of the electrode are important parameters.

The quality of the welding joint is dependent on the electrical contact between the surfaces to be con-

nected. It is always a matter of a more or less poor electrical contact in the welding operation, due to the fact that electrodes usually are covered with a catalytically active material with poor conductivity. A poor electric contact may cause an electric arc resulting in damages on the surfaces. A weak contact may require longer welding time which leads to tension and deformation due to the increased heat. One way to improve the contact is to increase the mechanical pressure on the electrode, i.e. the force on the electrode put on the material to be welded. However, an increased pressure of the electrode causes damages on the surfaces on the material surrounding the welding joint. When the conditions at welding are incorrect as described above, it leads to a raw and uneven surface (e.g. on account of welding sparks) which would damage a membrane, and it may also result in damages on the coating of the electrode surface.

US-A-5,373,134 discloses an electrode which front side is fitted with channel-forming threads. The threads are welded to the underlying structure by means of a plurality of contactlessly welded fixing points along each thread. However, the welding of the threads to the base structure with e.g. laser welding is a rather complicated, time-consuming and difficult operation.

DE-B-2538000 discloses a bipolar electrode construction comprising a base plate and a grid-like electrode. The rods serving as an electrode, are connected to underlying stabilising rods in order to form a grid with acceptable mechanical strength and to keep the grid together. The assembly is done before the grid is welded to the base structure. The electrode is not intended for use in membrane cells.

EP-B1-0044035 discloses an electrode comprising a net-type metal sheet which is welded on a foraminous planner electrode support.

EP-A1-0080288 relates to an electrode comprising a sheet material provided with projections, where said projections are attached to a foraminate sheet, e.g. by welding.

Furthermore, it is well known to the person skilled in the art that large and coarse connection details can be used for the joint of threads to an underlying surface. Such large and coarse connection details used in the joint at welding does not serve for a well defined and good contact.

The solution according to the invention provides a method for producing an electrode, where all of the drawbacks mentioned above are reduced to a minima.

With the present invention, an optimal electrical contact is established in the welding sequence, resulting in a homogeneous current distribution and a reliable joint of high quality. The welding operation is simplified and is easily automated and requires a low power input.

According to the present invention, various sources for current distribution at welding can be chosen. The welding time will also be reduced.

The invention, according to the claims, relates to a

method of producing an electrode comprising an electrode structure attached to an underlying base structure, wherein the method comprises the steps of;

- (a) applying on the base structure the electrode structure and between said base structure and said electrode structure applying contact filaments; and
 (b) joining said base structure, electrode structure and contact filaments together at joints by electrical welding.

The contact filaments serve for that smooth and durable welding joints with high mechanical strength are formed.

The contact filaments can in principle be applied in any order. Either the contact filaments are applied first to the base structure, or first to the electrode structure. Preferably the contact filaments are applied first to the base structure.

Another designation for "filament" would be contacting-threads, as they serves for a well-defined contact between the surfaces welded together. With the use of the word "filament" is meant a thin thread or wire, which according to the present invention can have a thickness in the range of between about 0.05 mm up to about 5 mm. Suitably the contact filaments have a thickness of from about 0.1 mm up to about 2 mm, more suitably from about 0.1 up to about 0.8 mm, preferably from about 0.2 mm up to about 0.8 mm and most preferably from about 0.3 mm up to about 0.6 mm. In case the contact filaments are not circular, the thickness of the broadest part of the filament is measured parallel to the extent of the electrode. The contact filaments can have any extension.

The geometric cross-section of the contact filament is not critical, they may be for example circular, square, oval, rectangular or triangular, even if they preferably are substantially circular for economical reasons.

Optimal mechanical stability is achieved if the contact filaments are narrow and thin, but the distance between the contact filaments is not critical as long as sufficient stability is obtained. However, the number of contact filaments which can be applied are also related to the current density. If the current density is high, the number of contact filaments can be increased. If the current density is low, the number of contact filaments may be decreased.

If the electrode is aimed for use with a membrane which easily can be damaged, the surface of the electrode should suitably be smooth and substantially free from sharp portions which, for example, might be caused by welding sparks.

The method according to the invention can be used for restoration of passivated electrodes, where a new electrode structure can be welded on an old, passivated electrode, but also for producing new electrodes. In the case of producing new electrodes with the method according to the invention, the cross-sectional area of

the contact filaments can be even larger than the thickness of the electrode structure. In the case of restoring old electrodes with a new electrode structure, the cross-sectional area is preferably equal to or smaller than the thickness of the electrode structure.

The method according to the present invention may be suitable for electrodes in any electrochemical process, especially in restoration of old, passivated and worn out electrodes. By the present invention a new active electrode surface can be welded at the site of the electrochemical plant. This is particularly advantageous when the plant is situated far away from the factory of the electrode manufacturer.

By electrical welding is meant welding operations where an electrical contact between the welding electrode and the pieces to be welded takes place. Hence, contactless welding methods such as laser welding and electron beam welding, are excluded. Preferably use is made of resistance welding.

By the use of contact filaments, a well defined and reliable contact surface is established, due to a small and sharp transmitting area. In order to get a smooth weld-joint, the contacting surfaces have to be even and preferably also needle-sharp. These conditions serves for an excellent contact in the welding operation. If the contact is poor or the surface is not well-defined, e.g. a rough surface, the current will take another way around the area.

The electrode structure can be made of longitudinal or transverse threads, have the shape of a net, wire-gauze, mesh, grid or the similar. The electrode structure may also be a perforated plate or an expanded metal sheet (forming a mesh).

The underlying structure, also called the base structure, preferably comprises through openings to facilitate the circulation of electrolyte.

The electrode structure can have the shape of threads which are applied directly on the contact filaments or, as in a preferred embodiment, the threads may be connected to supporting threads resulting in an electrode construction in the shape of a net, wire-gauze, mesh, grid or the similar, which are welded to the contact filaments. The threads can be transverse or parallel with the extension of the contact filaments. Suitably the electrode is provided with substantially parallel threads of electrically conducting material which are attached to and in electric contact with the underlying structure and the contact filaments. In a preferred embodiment, these electrode threads form channels as described in US-A-5,290,410 and US-A-5,373,134, which are hereby incorporated by references. Thus, the threads becomes channel-forming threads resulting in a large number of unbroken channels for circulation of the electrolyte and efficient removal of any gas formed.

The underlying base structure, on which the electrode structure and the contact filaments are welded, may have any shape and structure. Preferably the underlying base structure is a former electrode surface.

As examples of prior art structures and electrodes that may be modified, mention can be made of common metal sheets, perforated plate electrodes, electrodes of expanded metal, electrodes having longitudinal or transverse rods, threads or wires, or electrodes including bent or straight lamellae punched from a common metal sheet, which lamellae can extend vertically or horizontally, for example louver-type electrodes. These types of electrode are well known to those skilled in the art and are described in e.g. the above-mentioned EP 415,896 and in GB 1,324,427. One preferred embodiment of the electrode according to the invention is a louver-type electrode. In one embodiment the underlying base structure has through openings.

The entire electrode, i.e. both the electrode structure, the contact filaments and the underlying structure, is suitably made of the same material, for example Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zr, Nb, Ag, Pt, Ta, Pb, Al or alloys thereof. If the electrode is to function as an anode, Ti or Ti alloys are preferred, whereas Fe, Ni or alloys thereof are preferred if the electrode is to function as a cathode. It is also preferred that the electrode structure, the contact filaments and the underlying base structure are activated by some suitable, catalytically active material, depending on the intended use as an anode or a cathode. Also electrodes in which only the electrode structures are activated may be used. Useful catalytic materials are metals, metal oxides or mixtures thereof from Group 8B in the Periodic Table, i.e. Fe, Co, Ni, Ru, Rh, Pd, Os, Ir, or Pt, among which Ir and Ru are especially preferred.

The invention relates to a method of producing an electrode, where contact filaments are attached both to an electrode structure and to an underlying structure by a plurality of welded fixing points along each filament. The conditions during the welding operation according to the present invention are varied within the ordinary, well known to the person skilled in the art, if not otherwise stated.

In operating the preferred electrical welding methods mentioned above, the result is a small, well defined joint at the actual point of contact, whereas the remainder of the filament is essentially unaffected, making the method particularly suitable for very thin contact filaments, preferably a thickness from about 0.1 to about 2 mm and more preferred from about 0.1 up to about 0.8 mm. The electric contact is good, at the same time as the contact filaments can be mechanically pulled off, without damaging the underlying structure. Subsequently, the electrode can again be provided with contact filaments without necessitating any further processing, which facilitates regeneration of passivated electrodes. The welding method can be used for welding of all metals that are normally used in the production of electrodes, and has proved highly advantageous, inter alia, if the contact filaments and/or the underlying structure are made of titanium or some titanium alloy. Owing to the high capacity in e.g. resistance welding,

the time of production can be made short.

The method can be applied both when producing electrodes and when modifying existing electrodes. In the production of electrodes, any activation with catalytic coating is, for practical reasons, preferably carried out before application of the electrode structure. An existing, activated electrode can, however, be provided with an electrode structure without the active coating being damaged during the welding. It is also possible to provide a non-activated electrode or an electrode whose activity has faded after being used for a long time, with an activated electrode structure. Regarding preferred dimensions and materials, reference is made to the description of the electrode according to the invention.

The contact filaments are preferably resilient and are suitably coiled up on a plastic film. The contact filaments can in this manner easily be transported as a reel. The plastic film may on one side be provided with glue or paste. The plastic film may also be in the form of an adhesive (sticky) tape. Hence, the contact filaments can be coiled up on the plastic film with the predetermined distances between each filament and get caught on the tape or the glue. In welding the contact filaments to a surface, the reel can easily be uncoiled at the same time as the contact filaments are welded to the surface.

The present invention also incorporates an electrode obtainable by the method according to the invention, containing an electrode structure and an underlying base structure, wherein contact filaments are attached between said electrode structure and said underlying base structure at joints by electrical welding. The electrode can be particularly advantageous in electrolytic production of chlorate, or chlorine and alkali in membrane cells, but may also be very useful in electrochemical recovery of metals or recovery of gases from diluted solutions.

Furthermore, the invention relates to an electrolytic cell comprising at least one electrode fitted with contact filaments according to the invention. Preferably it also comprises an ion-selective membrane arranged between an anode and a cathode so as to engage the electrode structure according to the invention. Besides, the cell can be designed according to conventional techniques, well known to those skilled in the art.

Finally, the invention relates to a method in electrolysis, at least one of the electrodes being an electrode attached with contact filaments according to the invention. The method can be especially suitable in electrolysis in a membrane cell, particularly in electrolysis of an alkali metal chloride solution (for example sodium or potassium chloride solution for the production of chlorine and alkali), due to the extremely small impact on the material and the coating, resulting in a smooth and even surface facing the membrane.

The invention will now be described in more detail with reference to the accompanying drawings. However, the invention is not restricted to the embodiments illus-

trated, but many other variants are feasible within the scope of the claims.

Fig. 1 is a schematic top side view of an electrode where contact filaments are attached to an underlying base structure and also illustrated are various cross-sections of contact filaments and electrode structures. Fig. 2 is a side cross-sectional view of a hollow base structure provided with contact filaments and electrode structure. Fig. 3 is a schematic top side view illustrating the construction of a thread-electrode, while fig. 4 shows a side cross-sectional view of the thread-electrode in fig. 3. Fig. 5-6 shows side sectional views of a finished electrode provided with threads serving as electrode structure.

In fig. 1, contact filaments 2 may be attached to an underlying structure 1. Different kinds of electrode structures are also shown. The electrode structure can have the shape of a mesh 3a, a grid 3b (or channel-forming-threads) or a punched metal sheet 3c (e.g. a louver electrode). The contact filaments can have different geometric cross-section. The cross-section can be a square 2a, circular 2b, triangular 2c or rectangular 2d.

Fig. 2A illustrates a metal sheet 1 with punched sectional flaps 4 forming an open, hollow structure on the surface of the sheet. On the upper edges of the flaps 4, the contact filaments 2 are welded. An electrode structure 3 is welded on the contact filaments 2. Fig. 2B shows flaps 5, which have been formed from punching a metal sheet, forming a so called louver electrode. Contact filaments 2 are welded on flaps 5 and an electrode structure 3 is attached on the contact filaments 2. In fig. 2C the contact filaments 2 are arranged along the top of the flaps 5, parallel with the openings in the structure. The electrode structure 3 has the shape of waves, in that they follows the recesses in the louver structure. In fig. 2D the contact filaments are again arranged transverse to the slits in the structure. Both the contact filaments and the electrode structure are wave-shaped.

Figs 3 and 4 illustrate a plurality of parallel threads 14, forming channels 16, attached to stabilising transverse threads 13, where the stabilising threads 13 are applied and extend perpendicular to underlying contact filaments 12 applied to an underlying base structure 11. In Fig. 4, the position of the welding points 15, which are normally not seen from above, has been marked.

Figs 5-6 illustrate electrodes comprising channels 16 defined by threads 14, i.e. channel-forming threads, which via welded contact points, are attached to stabilising, transverse threads 13. In fig. 5 the stabilising threads 13 extend parallel to the contact filaments 12, whereby the channel-forming threads 14 are also supported by the contact filaments 12. By this design, substantially completely unbroken channels 16 are formed along the front side of the electrode. In the embodiment in fig. 6, the stabilising threads 13 are attached to transverse contact filaments 12.

Claims

1. A method of producing an electrode comprising an electrode structure (3;14) attached to an underlying base structure (1;11), **characterised** in that the method comprises the steps of:
 - (a) applying on the base structure (1;11) the electrode structure (3;14) and between said base structure and said electrode structure applying contact filaments (2;12); and
 - (b) joining said base structure, electrode structure and contact filaments together at joints (15) by electrical welding.
2. Method as claimed in claim 1, **characterised** in that the contact filaments have a thickness from about 0.1 mm to about 2 mm.
3. Method as claimed in claim 2, **characterised** in that the contact filaments have a thickness from about 0.1 mm to about 0.8 mm.
4. Method as claimed in claim 1, **characterised** in that the underlying base structure (1;11) is a foraminous structure in the shape of a perforated plate, expanded metal, rods, threads or wires, or lamellae punched from a common metal sheet.
5. Method as claimed in claim 1, **characterised** in that the electrode structure is made of expanded metal (3a).
6. Method as claimed in claim 1, **characterised** in that the electrode structure is made of longitudinal or transverse threads (3b;16),
7. Method as claimed in claim 1, **characterised** in that the contact filaments have a circular geometric cross-section.
8. An electrode obtainable by the method, containing an electrode structure (3;14) and an underlying base structure (1;11), **characterised** in that contact filaments (2;12) are attached between said electrode structure and said underlying base structure at joints (15) by electrical welding.
9. An electrode as claimed in claim 8, **characterised** in that the contact filaments have a thickness from about 0.1 mm to about 2 mm.
10. An electrode as claimed in claim 9, **characterised** in that the contact filaments have a thickness from about 0.1 mm to about 0.8 mm.
11. Electrolytic cell, **characterised** in that it comprises at least one electrode with contact filaments (2;12)

according to any one of claims 8-10.

12. Electrolytic cell as claimed in claim 11, **characterised** in that it comprises an anode, a cathode and an ion-selective membrane arranged between said anode and said cathode. 5
13. Method in electrolysis, **characterised** in that use is made of an electrode with contact filaments (2;12) according to any one of claims 8-10. 10
14. Method as claimed in claim 13, **characterised** in that a membrane cell is used.
15. Method as claimed in claim 14, **characterised** in that it includes electrolysis of alkali metal chloride solution to chlorine and alkali, the anode being an electrode with contact filaments (2;12) according to claims 8-10. 15

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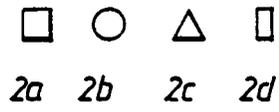
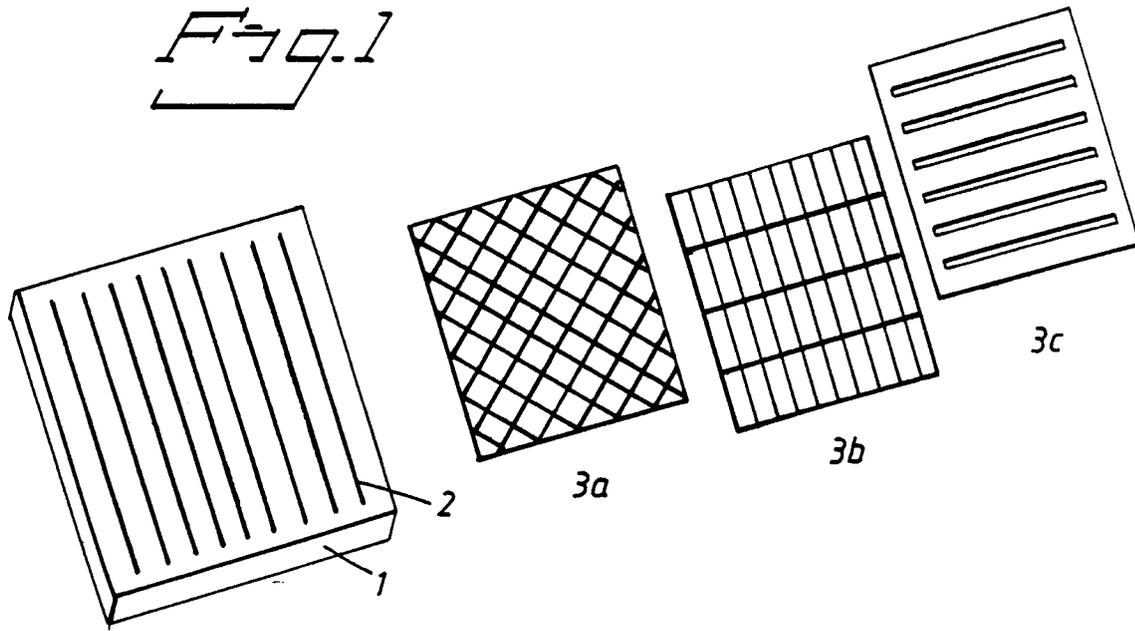


Fig. 2A

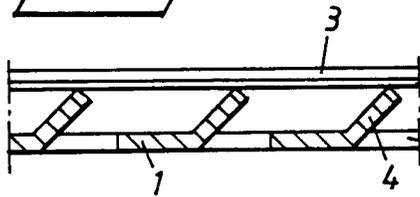


Fig. 2B

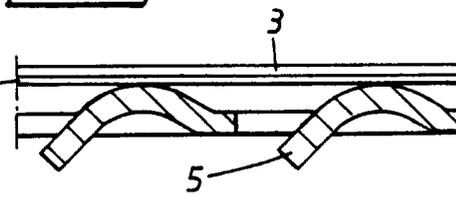


Fig. 2C

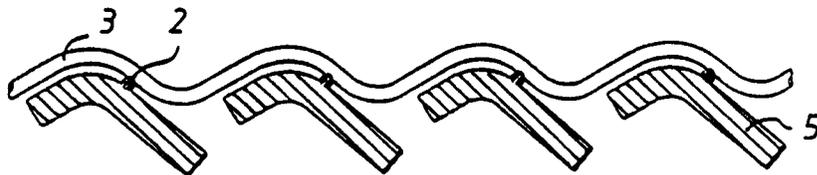


Fig. 2D

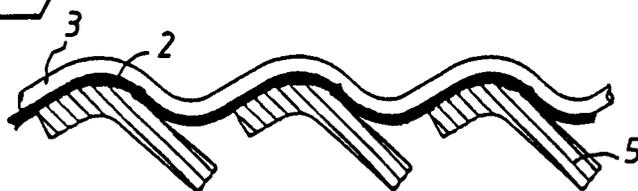


Fig. 3

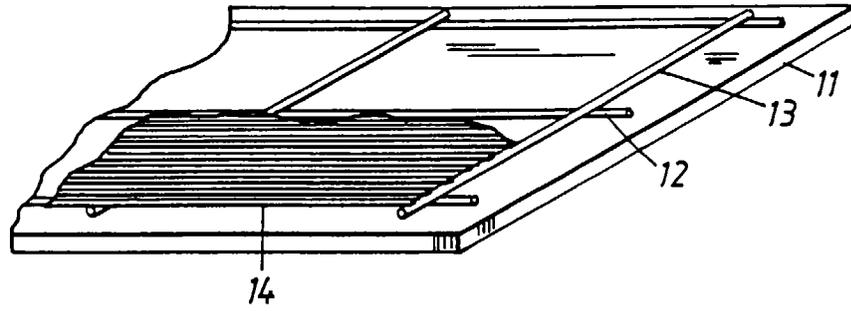


Fig. 4

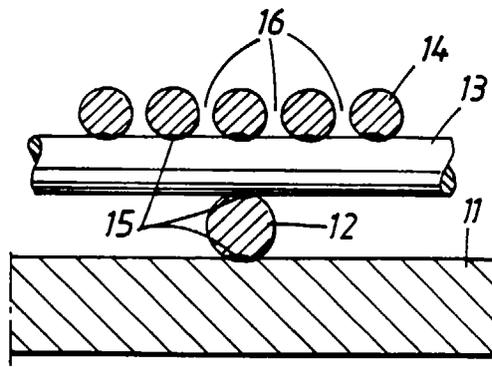


Fig. 5

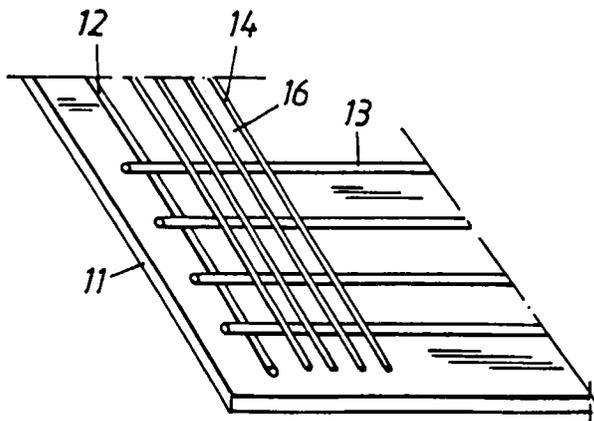
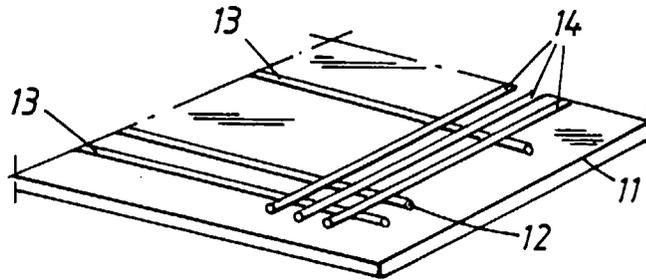


Fig. 6



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 97 20 3293

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.6)
X	PATENT ABSTRACTS OF JAPAN vol. 016, no. 249 (C-0948), 8 June 1992 & JP 04 056792 A (PERMELEC ELECTRODE LTD), 24 February 1992, * abstract *	1	C25B11/00 C25B11/03
A	GB 2 018 826 A (ANSELM THOMAS KUHN)		
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			C25B
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
THE HAGUE		5 February 1998	Groseiller, P
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