(12) STANDARD PATENT (11) Application No. **AU 2011303882 B2**
(19) AUSTRALIAN PATENT OFFICE

(54) Title
Anode for cathodic protection and method for manufacturing the same

(51) International Patent Classification(s)
C23F 13/10 (2006.01) ***B21D 31/04*** (2006.01)

(21) Application No: **2011303882** (22) Date of Filing: **2011.09.15**

(87) WIPO No: **WO12/035107**

(30) Priority Data

(31) Number	(32) Date	(33) Country
MI 2010 A 001689	**2010.09.17**	**IT**

(43) Publication Date: **2012.03.22**
(44) Accepted Journal Date: **2015.01.22**

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(56) Related Art
CA 2078616 A1

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
22 March 2012 (22.03.2012)

PCT

(10) International Publication Number
WO 2012/035107 A1

(51) International Patent Classification:
C23F 13/10 (2006.01) *B21D 31/04* (2006.01)

(21) International Application Number:
PCT/EP2011/066021

(22) International Filing Date:
15 September 2011 (15.09.2011)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
MI 2010 A 001689
17 September 2010 (17.09.2010) IT

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU,

[Continued on next page]

(54) Title: ANODE FOR CATHODIC PROTECTION AND METHOD FOR MANUFACTURING THE SAME

(57) Abstract: It is described a metal anode for cathodic protection in form of mesh ribbon having meshes whose holes are of rhomboidal shape, characterised by having such holes of rhomboidal shape arranged with the major diagonal oriented along the direction of the ribbon length and by the fact that the side edges along the ribbon length are free from cutting protrusions. It is also described a method for obtaining such anode.

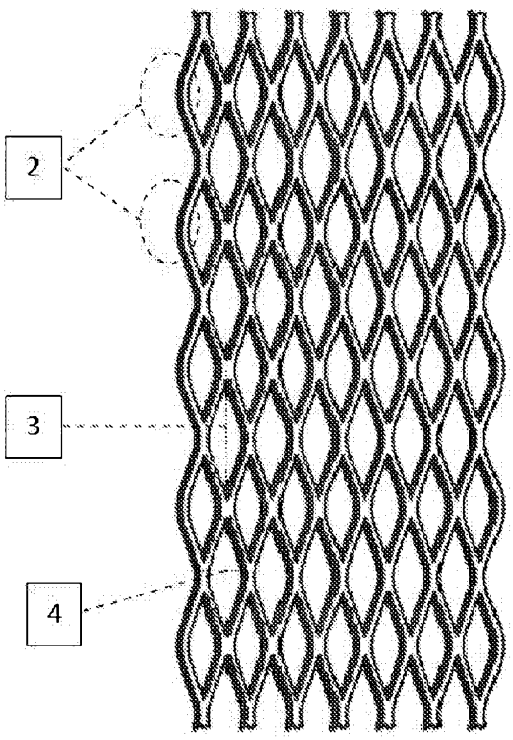

Fig. 1B

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RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

ANODE FOR CATHODIC PROTECTION AND METHOD FOR MANUFACTURING THE SAME

FIELD OF THE INVENTION

The invention relates to the field of cathodic protection of reinforced concrete structures, and in particular to a design of anode particularly efficient in terms of electrical resistance per unit length and of flexibility, and particularly safe to install and handle.
The invention also relates to the method of production of such anode.

BACKGROUND OF THE INVENTION

Corrosion phenomena affecting reinforced concrete structures are well known in the art. The steel reinforcement inserted in the cementitious structures to improve the mechanical properties thereof normally works in a passivation regime induced by the alkaline concrete environment; however, after some time, the ion migration across the porous surface of the concrete causes a localised attack to the protective passivation film. Particularly worrying is the attack by chlorides, which are virtually present in all kinds of environments where the reinforced concrete structures are employed, and to an even higher extent where an exposure to brackish water (bridges, pillars, buildings located in marine zones), antifreeze salts (bridges and road structures in cold climate zones) or even seawater, such as for instance in the case of piers and docks, takes place. The critical value of chloride exposure has been esteemed around 0.6 kg per cubic metre of concrete, beyond which the passivation state of the reinforcing steel is not guaranteed. Another form of concrete decay is represented by the carbonatation phenomenon, that is the formation of calcium carbonate by reaction of the lime of the cementitious mixture with atmospheric carbon dioxide. Calcium carbonate lowers the concrete alkali content (from pH 13.5 to pH 9) bringing iron in an unprotected state. The presence of chlorides and the simultaneous carbonatation represents the worst of conditions for the preservation of the reinforcing bar of the structures. The corrosion products of steel are more voluminous than steel itself, and the mechanical stress resulting from their formation may lead to concrete delamination and fracturing phenomena, which translate into huge damages from the point of view of economics besides the one of safety. For this reason, it is known in the art that the most effective method for indefinitely prolonging the lifetime of reinforced concrete structures exposed to the atmospheric agents, even in the case of relevant salt concentrations, consists of cathodically polarising the steel reinforcement. In this way, the latter becomes the site of an oxygen cathodic reduction, suppressing the anodic corrosion and dissolution reactions. Such system, known as cathodic protection of reinforced concrete, is practised by coupling anodic structures of various kinds to the concrete, respect to which the reinforcement to be protected

acts as a cathodic counterelectrode; the electrical currents involved supported by an external rectifier transit across the electrolyte consisting of the porous concrete partially soaked with a salty solution.

The anodes commonly used for the cathodic protection of reinforced concrete consist of a titanium substrate coated with transition metal oxides or other types of catalysts for anodic oxygen evolution. As the substrate it is possible to make use of other valve metals, either pure or alloyed; pure titanium is however the largely preferred choice for the sake of cost.

European Patent EP458951 discloses a grid-type electrodic structure for cathodic protection consisting of a plurality of metal ribbons having an electrocatalytic coating, said metal ribbons having voids of different geometries.

This type of ribbons can be manufactured by punching of solid metal ribbons or more commonly by the traditional methods of metal expansion wherein a metal sheet is expanded by pressuring and punching through a series of knives arranged orthogonal to the advancement direction of the ribbon itself. This first step allows obtaining an expanded metal sheet. Such sheet is then subjected to a second step of cutting suitable for obtaining ribbons of the required dimensions. Said expanded metal ribbons present meshes having voids of rhomboidal shape with the major diagonal oriented orthogonal to the ribbon length.

This method of manufacturing has the inconvenience of producing metal ribbons with meshes having cutting side protrusions automatically formed during the operation of cutting, making these anodes difficult to handle and the installation phase accordingly dangerous.

Metal ribbons with smooth lateral edges are disclosed in Canadian Patent Application CA 2078616 A1; by the method described this document, the ribbons obtained present a continuous longitudinally-extending solid section of a certain width, which is invariably formed in the manufacturing process and which can only be used for spot-welding. In present-day cathodic protection systems, however, it is preferred not to weld ribbon anodes at all, but rather to overlay them directly to the reinforcement with plastic spacers arranged in-between. In such case, the longitudinally-extending solid section is just a loss of material, especially because this solid section invariably gets coated with precious metals during the application of the catalytic layer. Such catalytic layer however cannot work properly on a non-foraminous structure and affects the calculation of the actual current density impressed to the anodic structure, thereby complicating the design of the overall cathodic protection system.

SUMMARY OF THE INVENTION

Various aspects of the invention are set out in the accompanying claims.

Under one aspect, the invention relates to an anode in form of mesh ribbon for systems of cathodic protection, for instance of cathodic protection of reinforced concrete structures, overcoming the inconveniences of the prior art, whose edges are substantially free of discontinuities in form of cutting protrusions and have a sinusoidal shape.

In the context of the present description reference is made, for the sake of simplicity, to cathodic protection of reinforced concrete structures; it is understood that the invention may be practised in the field of cathodic protection in general, for instance comprising the cathodic protection of metal tank bottoms.

Under another aspect, the invention relates to a method for manufacturing said anode.

Under a further aspect, the invention relates to a cathodic protection system comprising at least one anode in form of mesh ribbon whose edges are substantially free of cutting protrusions.

Some of the most significant results obtained by the inventors are presented in the following description, which is merely provided by way of example without wishing to limit the invention.

The anode according to the invention consists of a ribbon of expanded metal characterised by meshes with rhomboidal shaped voids with the major diagonal oriented along the direction of the ribbon length. In one embodiment, the lateral edges of the ribbon have a sinusoidal profile and are free of cutting protrusions.

The inventors have surprisingly noticed that an anode for cathodic protection as hereinbefore described displays a remarkably reduced ohmic resistance per unit length, for instance up to 4-fold reduced, with respect to the anodes of the prior art.

The lower electrical resistance makes possible to reduce the number of electrical connections, for instance in a grid system, with sensible savings of material and installation time.

In one embodiment, the metal mesh ribbon is made of titanium.

In another embodiment, the metal mesh ribbon is coated with a catalytic coating containing noble metals or oxides thereof.

In one embodiment, the dimensions of the ribbon can have a width ranging from 3 mm to 100 mm with a thickness of 0.25 mm to 2.5 mm and a length of 1 m to 150 m.

BRIEF DESCRIPTION OF THE DRAWINGS

For the sake of a better understanding of the invention, reference will be made to the following drawings, having the purpose of depicting some preferred embodiments thereof without limiting its extent.

- Fig. 1A shows a top-view of a traditional expanded metal anode.
- Fig. 1B shows a top-view of an expanded metal anode according to the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

In detail, Fig. 1A shows a top view of the traditional anode in which are distinguishable cutting protrusions **1** due to the manufacturing method including a cutting step, the rhomboidal geometry with major diagonal **3** of rhomboidal voids arranged in the direction of the ribbon width and the minor diagonal **4** of the same arranged in the direction of the ribbon length.

Fig. 1B shows a top-view of the anode according to the invention in which are distinguishable non-cutting blunt lateral edges **2**, the rhomboidal geometry with major diagonal **3** of rhomboidal voids arranged in the direction of the ribbon length and the minor diagonal **4** of the same arranged in the direction of the ribbon width.

EXAMPLE

Some of the most significant results obtained by the inventors are reported in Table 1, wherein ohmic resistance data of representative anodes of the invention are compared to traditional anodes. Anodes labelled A and B are anodes of rhomboidal geometry with the major diagonal of rhomboids oriented orthogonal to the ribbon length likewise depicted in Fig. 1A, traditionally obtained by longitudinal expansion with respect to the displacement direction of a solid metal ribbon. Anodes labelled C and D are anodes of rhomboidal geometry according to one embodiment of the invention, likewise depicted in Fig. 1B.

Anodes C and D were prepared by orthogonal expansion with respect to the displacement direction of a solid metal ribbon allowed to run in an apparatus along a parallel row of knives which expand the solid ribbon in an orthogonal direction by pressuring and punching. The ribbon manufacturing is completed by means of a last series of knives, having blades of predefined length higher than the blades of previous knives, which upon applying a pressure are suitable for modelling the lateral edge of the ribbon as depicted in Fig. 1B. Besides the advantages already explained in terms of conductivity due to the anode geometry, this method has the advantage of providing an expanded metal ribbon free of longitudinally-extending solid sections which, being not subsequently cut, does not present any cutting edge and is therefore much safer and easy to handle during the installation. This method moreover allows to advantageously obtain a metal ribbon of the desired length directly upon completion of the expansion. Such method of production furthermore allows obtaining ribbons of higher length than the traditional method thereby facilitating big size installation which would require connections of multiple ribbons, with a lower solidity of the overall anodic system.

From the data reported in the table it can be noticed that for a given width, the anodes of the invention display an ohmic resistance about 60% lower.

Table 1

Anodes in accordance with Fig. 1A	**R- Ohmic Resistance**
A - 20mm wide	0.22 Ohm/m
B - 10mm wide	0.43 Ohm/m
Anodes in accordance with Fig. 1B	**R- Ohmic Resistance**
C - 20mm wide	0.088 Ohm/m
D - 10mm wide	0.177 Ohm/m

The previous description is not intended to limit the invention, which may be used according to different embodiments without departing from the scopes thereof, and whose extent is univocally defined by the appended claims.

Throughout the description and claims of the present application, the term "comprise" and variations thereof such as "comprising" and "comprises" are not intended to exclude the presence of other elements or additives.

The discussion of documents, acts, materials, devices, articles and the like is included in this specification solely for the purpose of providing a context for the present invention. It is not suggested or represented that any or all of these matters formed part of the prior art base or were common general knowledge in the field relevant to the present invention before the priority date of each claim of this application.

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CLAIMS

1. Anode for cathodic protection in form of expanded metal ribbon with rhomboidal meshes free of longitudinally-extending solid sections, wherein said rhomboidal meshes are geometrically arranged with the major diagonal parallel to the direction of the ribbon length.
2. Anode according to claim 1, wherein the lateral edge profiles along the length of said ribbon are free of discontinuities.
3. Anode according to claim 1 or 2, wherein said metal is titanium.
4. Anode according to any one of claims 1 to 3, wherein said metal is coated with a catalytic layer.
5. Anode according to claim 4, wherein said catalytic layer comprises noble metals or oxides thereof.
6. Method of manufacturing the anode according to any one of claims 1 to 3 comprising the following steps:
   - running of a metal ribbon through an expanding device equipped with at least one row of knives of a first predetermined length arranged parallel to the direction of the ribbon displacement,
   - expansion of the metal ribbon by means of pressing and punching action of said at least one row of knives,
   - formation of lateral edge profiles of the expanded metal ribbon by means of pressing and punching action of a last row of knives having blades of a second predetermined length higher than said first length.
7. A cathodic protection system comprising at least one anode according to any one of claims 1 to 5 embedded in a cementitious structure equipped with metal reinforcement bars.
8. Method for cathodic protection of a reinforced concrete structure consist of applying an anodic potential to said anodes of said cathodic protection system of claim 7.
9. An anode substantially as hereinbefore described with reference to any one of the embodiments illustrated in the accompanying drawings.

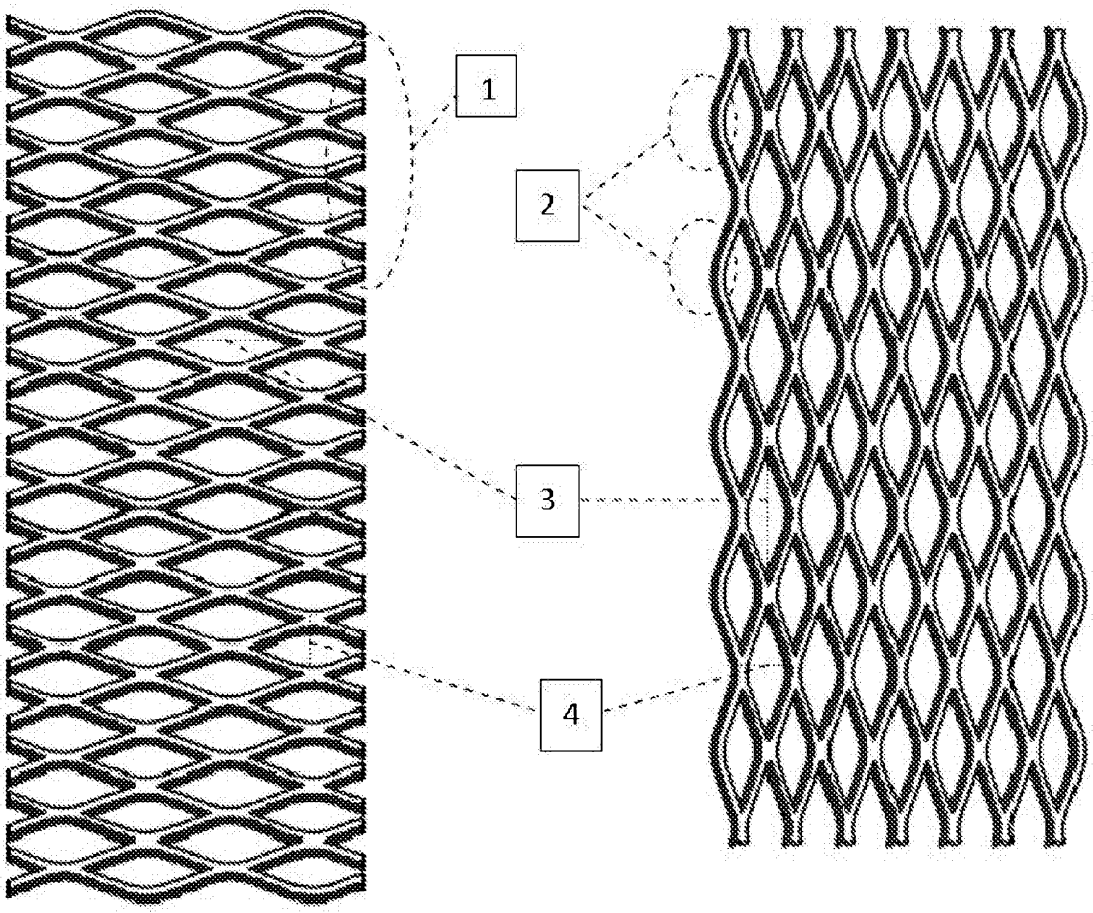

Fig. 1A

Fig. 1B