(19) Octrooicentrum Nederland

(11) 2011269

(12) C OCTROOI

(21) Aanvraagnummer: **2011269**

(22) Aanvraag ingediend: **05.08.2013**

(51) Int.Cl.:
C25D 3/56 (2006.01) *C25D 7/00* (2006.01)
F16B 33/00 (2006.01) *C23F 13/06* (2006.01)
C23C 2/06 (2006.01)

(43) Aanvraag gepubliceerd:
-

(47) Octrooi verleend:
09.02.2015

(45) Octrooischrift uitgegeven:
18.02.2015

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(54) **Structure for use in a corrosive environment.**

(57) The invention pertains to a structure for use in a humid environment, comprising:
- a primary structural element, which primary structural element is made of metal and is provided with a coating, which coating has a composition comprising zinc in a content of at least 40 wt% based on the weight of the coating,
- a secondary structural element, which secondary structural element is made of metal and is provided with a coating, which coating is an alloy comprising aluminum and manganese, in which alloy the content of aluminum and manganese together is at least 90 wt % based on the weight of the coating, which alloy comprises more aluminum by weight than manganese, and wherein the primary structural element and the secondary structural element are in electrical contact with each other.

NL C 2011269

P31611NL00/NBL

Structure for use in a corrosive environment

The invention pertains to a metal structure that is suitable for use in a corrosive environment, for example a structure that is to be arranged outdoors.

When a metal structure is used in a corrosive environment, there is a risk that the structural integrity of the structure is compromised by corrosion of one or more of the structural elements that form part of the structure. For example humidity can cause corrosion of the metal surfaces of the structural elements that are in contact with the humid environment directly. In addition to this corrosion due to the contact with a humid environment itself, arranging the metal structure in a humid environment may provoke galvanic corrosion of at least one of the structural elements, in particular when materials with a dissimilar composition are used for structural elements that are in electrical contact with each other. The dissimilar composition can give rise to a galvanic potential difference between the structural components having the dissimilar material composition. The moisture from the humid environment can act as an electrolyte that closes the electric circuit between the structural elements that are in electrical contact with each other. The closed electric circuit allows electrons to move from one structural element to the other, therewith causing galvanic corrosion.

It is known to provide metal structural elements with a coating in order to provide resistance against corrosion of their surfaces that are in direct contact with the corrosive, for example humid, environment. Such coatings can be organic coatings, e.g. paint, or metal coatings. For example, structural elements made of steel can be provided with a zinc coating by means of galvanizing.

The metallic coating materials that are used for coating structural elements are usually less noble than the material of the substrate, so in case a galvanic cell forms within the structural element itself, e.g. due to a damaged coating, the coating corrodes rather than substrate, so that the structural integrity of the structure at least initially is compromised to a lesser extent. This is called “cathodic protection”.

The downside of the use of a less noble coating material however is that it can be affected by galvanic corrosion when an other structural element that is in electrical contact with the coating, is of a more noble material. In particular when a zinc coating is used to protect steel, this regularly occurs, as zinc is less noble than steel.

The “Corrosion Guides” as issued by the National Physical Laboratory of Middlesex, United Kingdom, in the series “Corrosion Control” comprise a volume called “Bimetallic Guide”, which discusses galvanic corrosion and related design issues. On page 4 of this

“Bimetallic Guide”, a table is present which shows that zinc can be attacked by galvanic corrosion if it is combined with aluminum or aluminum alloys.

The object of the invention is to provide a structure that has resistance to galvanic corrosion and that at least offers an alternative choice of a combination of materials, in particular coating materials, as compared to what is known from the prior art.

This object is achieved by the structure of claim 1.

The inventors have found that a primary structural element that is made of metal and is provided with a coating that has a composition comprising zinc (Zn) in a content of at least 40 wt% based on the weight of the coating, can in a corrosive environment be combined with a secondary structural element that is also made of metal but has a coating that is an alloy comprising aluminum (Al) and manganese (Mn), in which alloy the content of aluminum and manganese together is at least 90 wt % based on the weight of the coating, which alloy comprises more aluminum than manganese by weight. If those two structural elements are in electrical contact with each other, and the structure of which the structural elements form a part is arranged in a corrosive environment, a good resistance against galvanic corrosion is observed, even in case the corrosive environment is a saline humid environment.

Furthermore, it has been observed that the corrosion resistance for combination of coating materials according to the invention is largely independent of the relative size of the surface areas of the primary and secondary structural elements.

The structural elements being in electrical contact with each other means that the two structural elements are not electrically insulated from each other. For example, electrical contact is present when there is direct physical contact between the metal or metallic coating of the primary structural element and the metal or metallic coating of the secondary structural element. In an other example, electrical contact is present when the metal or metallic coating the primary structural element is connected to the metal or metallic coating of the secondary structural element via one or more conductive elements, for example via a metallic bolt or metal rings. In general, electrical contact is present when a path is provided that allows electrons to move from the primary structural element (including its coating) to the secondary structural element (including its coating) or vice versa. This path does not have to be a closed loop within the structure, it is for example possible that the path can be closed by the presence of an electrolyte, e.g. saline water.

In particular, good resistance to galvanic corrosion has been observed when the aluminum content in the coating of the secondary structural element is at least about 75 wt% based on the weight of the coating.

Preferably, the aluminum content in the coating of the secondary structural element is at least about 75 wt% based on the weight of the coating, and at least about 80 wt% of the remainder of the coating is manganese.

Preferably, the manganese content in the coating of the secondary structural element is between about 1 wt% and about 25 wt%, more preferably between about 5 wt% and about 18 wt%, based on the weight of the coating.

Examples of compositions of the aluminum manganese coating are: about 81-83 wt%, e.g. 82 wt%, aluminum, based on the weight of the coating and about 19-17 wt%, e.g. 18 wt%, manganese, based on the weight of the coating; about 84-86 wt%, e.g 85 wt%, aluminum, based on the weight of the coating and about 16-14 wt%, e.g.15 wt%, manganese, based on the weight of the coating; or about 94-96 wt%, e.g. 95 wt%, aluminum, based on the weight of the coating and about 6-4 wt%, e.g. 5 wt%, manganese, based on the weight of the coating.

Optionally, the aluminum manganese coating of the secondary structural element consists of aluminum, manganese and inevitable impurities.

The aluminum manganese alloy coating of the secondary structural element according to the invention also has good properties with respect to enhancing the corrosion resistance against corrosion due to direct contact with the corrosive environment. The addition of manganese to the aluminum has an effect on the morphology of the coating layer. It results in a dense structure with small crystallites. The grain size is generally smaller than in a pure aluminum coating that is deposited using electrochemical deposition from an ionic liquid.

The dense morphology of the aluminum manganese coating of the secondary structural element provides a good protection for the material of the substrate, as it makes a strong barrier between the substrate and the environment.

The aluminum manganese alloy that is used for the coating of the secondary structural element is less noble than steel, in particular less noble than the types of mild steel that are generally used in construction. So, in case a secondary element is made of steel, and the aluminum manganese coating on it becomes damaged, the coating provides cathodic protection for the steel substrate.

Preferably, the thickness of the coating of the secondary structural element is between about 1.5 µm and about 100 µm, preferably between about 5 µm and about 30 µm.

Suitable coatings for the primary structural element for example include zinc-coatings (e.g. of the type that is generally indicated in the art, for example in the draft European standard dEN10346:2013, by "Z"), zinc-iron alloy coatings (e.g. of the type that is generally indicated in the art, for example in the draft European standard dEN10346:2013, by "ZF"), zinc-aluminum alloy coatings (e.g. of the type that is generally indicated in the art, for example in the draft European standard dEN10346:2013, by "ZA"), zinc-magnesium alloy coatings (e.g. of the type that is generally indicated in the art, for example in the draft European standard dEN10346:2013, by "ZM") and aluminum-zinc alloy coatings (e.g. of the type that is generally indicated in the art, for example in the draft European standard dEN10346:2013, by "AZ").

Examples of suitable coatings for the primary structural element include coatings that can be obtained by galvanization (e.g. batch galvanization, hot-dip galvanization or electrogalvanization), coatings of Aluzinc®, coatings of Magnelis® and zinc coatings having at least about 90 wt% of pure zinc.

A possible coating material for the primary structural element is a hot-dip zinc coating (Z), which can be applied on a first metal substrate by immersing the first metal substrate in a molten bath containing a zinc content of at least about 99 wt% of the molten bath. Such a coating generally comprises about 99 wt% to about 99.9 wt% of zinc (based on the weight of the coating), the balance generally being aluminum and inevitable impurities. By providing the first metal substrate with such a coating, a primary structural element according to the invention can be obtained.

A possible coating material for the primary structural element is a hot-dip zinc-iron alloy coating (ZF), which can be applied on a first metal substrate by applying a zinc coating by immersing the first metal substrate in a molten bath containing a zinc content of at least about 99 wt% and a subsequent annealing which produces an iron-zinc coating with an iron content of normally about 8 wt% to about 12 wt% (based on the weight of the coating), the balance being mainly zinc. By providing the first metal substrate with such a coating, a primary structural element according to the invention can be obtained.

A possible coating material for the primary structural element is a hot-dip zinc-aluminum alloy coating (ZA), which can be applied on a first metal substrate by immersing the first metal substrate in a molten bath which is composed of zinc and approximately 5 wt% aluminum and small amounts of mischmetal. Such a coating generally comprises about 5 wt% of aluminum (based on the weight of the coating), the balance generally being zinc and the mischmetal. By providing the first metal substrate with such a coating, a primary structural element according to the invention can be obtained.

A possible coating material for the primary structural element is a hot-dip zinc-magnesium coating (ZM), which can be applied on a first metal substrate by passing the first metal substrate through a molten zinc bath with aluminum and magnesium contents in sum of about 1.5 wt% to about 8 wt%, the remainder being mainly zinc. Such a coating generally comprises aluminum and magnesium contents in sum of about 1.5 wt% to 8 about wt% (based on the weight of the coating), the remainder being mainly zinc. By providing the first metal substrate with such a coating, a primary structural element according to the invention can be obtained.

A possible coating material for the primary structural element is a hot-dip aluminum-zinc alloy coating (AZ), which can be applied on a first metal substrate by immersing the first metal substrate in a molten bath which is composed of about 55 wt% aluminum, about 1.6wt% silicon and the balance zinc. Such a coating generally comprises about 55 wt% aluminum, about 1.6 wt% silicon (based on the weight of the coating) and the balance zinc. By providing the first metal substrate with such a coating, a primary structural element according to the invention can be obtained.

A possible coating material for the primary structural element comprises about 2-8 wt% aluminum, about 0-5 wt% magnesium, about 0-0.3 wt% alloying elements, the balance being zinc and inevitable impurities. Such a coating for example comprises about 93.5 wt% zinc, about 3.5 wt% aluminum and about 3 wt% magnesium.

Another possible coating material for the primary structural element comprises about 43 wt% zinc, about 55 wt% aluminum and about 1.5-2 wt% silicon.

In general, a structure of the type to which the invention pertains comprises at least two types of structural elements. The first type of structural elements for example comprises a metal beam, profile, rod, strip, and/or sheet. Such structural elements form the framework of the structure and bear the mechanical loads that are exerted on the structure. The second type of structural elements comprises fasteners, supports and the like (e.g. bolts, nuts, screws, clips, clamps). They hold the structural elements of the first type together by connecting them to each other. The structural elements of the second type can alternatively or in addition be used for connecting other objects to the structural elements of the first type. Such objects could for example be solar panels, switch boxes or other electrical equipment, cables and/or sensors, or e.g. an exhaust system of a vehicle.

The primary structural element according to the invention can be a structural element of the first type or a structural element of the second type. The secondary structural element according to the invention can be a structural element of the first type or a structural element of the second type.

Optionally, the primary structural element according to the invention is a structural element of the first type and the secondary structural element according to the invention is a structural element of the second type.

Optionally, the structure according to the invention comprises a primary structural element according to the invention which is a structural element of the first type, which is connected to a structural element of the first type of a different material (e.g. stainless steel or aluminum). In this possible embodiment, both structural elements of the first type are connected to each other by means of a structural element of the second type, which is a secondary element according to the invention. Such a structure could for example comprise a beam that is provided with a coating that has a composition comprising zinc in a content of at least 40 wt% based on the weight of the coating, which is connected to a beam of for example stainless steel or aluminum by means of a bolt (or a bolt and a nut), which bolt is provided with a coating that is an alloy comprising aluminum and manganese, in which alloy the content of aluminum and manganese together is at least 90 wt % based on the weight of the coating, which alloy comprises more aluminum than manganese by weight.

Optionally, the primary structural element according to the invention is a structural element of the first type and the secondary structural element according to the invention is also a structural element of the first type.

Optionally, the primary structural element according to the invention is a structural element of the second type and the secondary structural element according to the invention is a structural element of the first type.

Optionally, the primary structural element according to the invention is a structural element of the first type and the structure further comprises one or more secondary structural elements according to the invention that are a structural element of the first type as well as comprises one or more secondary structural elements according to the invention that are a structural element of the second type.

Optionally, the structure according to the invention comprises a primary structural element according to the invention which is a structural element of the first type and a secondary structural element according to the invention which is a structural element of the second type, and an object, e.g. a functional device, that is connected to the primary structural element by means of the secondary structural element. Such a structure could for example comprise a beam that is provided with a coating that has a composition comprising zinc in a content of at least 40 wt% based on the weight of the coating, and a further object (e.g a functional device like a solar panel, a support for a solar panel, a switch box or other type electrical equipment, a cable and/or sensor, or e.g. an exhaust system of a vehicle) which is of a different material (e.g. stainless steel or aluminum), which further object is connected to the beam with the zinc coating by means of a bolt (or a bolt and a nut) that is provided with a coating that is an alloy comprising aluminum and manganese, in which alloy the content of aluminum and manganese together is at least 90 wt % based on the weight of the coating, and which alloy comprises more aluminum than manganese by weight.

It has been observed that the corrosion resistance for combination of coating materials according to the invention is largely independent of the relative size of the surface areas of the primary and secondary structural elements. So, the primary structural element can have a larger surface area than the secondary structural element, or the primary structural element can have a smaller surface area than the secondary structural element, or the primary structural element and the secondary structural element can have substantially the same surface area. This is a further advantage of the invention, as many known corrosion resistant coating material combinations require that one coating material of the combination has to the used for the structural element with larger surface area and the other coating material of the combination has to the used for the structural element with the smaller surface area.

A structure according to the invention can for example be used as a mounting system for solar panels or be a part of such a mounting system. It can however also be used in other structures, like bridges, power pylons, cranes, support structures, or in automotive applications such as underbodies or chassis or other parts of cars or trucks, or parts of other vehicles, e.g. motorcycles.

The structure according to the invention can be arranged or used in a corrosive environment, for example a humid environment, optionally a saline humid environment, for example outdoors, for example on land or in a marine environment or on land in an area close to the sea. For example, the structure can be a support structure for solar panels or can be used as a mounting system for solar panels or can be a part of such a mounting system, allowing to arrange solar panels in corrosive environment, for example in areas close to the sea or even in a marine environment, e.g. on board of a ship or drilling rig. For example, the structure can be a vehicle or a part of a vehicle.

The coatings of the primary and secondary structural elements can be applied using methods that are generally known in the art. Optionally, the aluminum manganese alloy coating is applied to the secondary structural element by means of electrodeposition from an ionic liquid. By using this method for applying the aluminum manganese coating, a dense coating layer with small crystallites and little or no cracks or voids can be obtained.

It is desirable that the aluminum manganese coating of the secondary structural element adheres well to the substrate. It has been found that in case electrodeposition from an ionic liquid is used to apply the aluminum manganese coating, it is advantageous to give the substrate onto which the aluminum manganese coating will be applied a pretreatment by means of etching, optionally by means of electrochemical etching, optionally by means of electrochemical etching in an ionic liquid.

The etching roughens the surface of the substrate, which results in a better adhesion of the coating onto the substrate. The etching also removes for example oxides or contamination from the surface of the substrate. This also improves the adherence of the coating.

It is possible to carry out the electrochemical etching in the same type of ionic liquid as the ionic liquid in which the electrochemical deposition of the aluminum manganese coating takes place. It is even possible to carry out the electrochemical etching in the same bath of ionic liquid as the bath of ionic liquid in which the electrochemical deposition of the aluminum manganese coating takes place.

In a possible embodiment, a voltage in the range of about 0.5 V to about 1.5 V versus an aluminum electrode is used during the electrochemical etching, for example during an etch time of about 1 second to about 90 seconds.

In a possible embodiment, prior to carrying out the pretreatment of the substrate by etching, the substrate is cleaned and/or degreased. This can for example be done by means of an acid, such as sulfuric acid.

In a possible embodiment, the ionic liquid is stirred or otherwise agitated during the electrochemical deposition of the aluminum manganese coating onto the substrate to form the secondary structural element. This prevents that the surface is damaged due to a lack of reactive substances near the surface to form the coating.

In a possible embodiment, the ionic liquid is a combination of 1-ethyl-3-methylimidazoliumchloride (EMIMCl) and aluminum chloride ($AlCl_3$), preferably in a mol ratio of about 1:1.5, and further comprises $MnCl_2$, preferably between about 0.01 wt% and about 5 wt% $MnCl_2$, optionally between about 0.02 and about 1 wt% $MnCl_2$, based on the weight of the ionic liquid.

In a possible embodiment, the current density during the deposition of the aluminum manganese coating is between about 2 A/dm^2 and about 7 A/dm^2, preferably about 4 A/dm^2.

In a possible embodiment, the process of the deposition of the aluminum manganese coating is carried out at a process temperature between about 45°C and about 100°C, optionally between 75°C and 95°C, optionally at about 90°C.

In a possible embodiment, the secondary structural element is cleaned after the deposition of the aluminum manganese coating, for example by water and/or acetone.

In a possible embodiment, the deposition time of the deposition of the aluminum manganese coating is between about 1 minute and about 60 minutes, optionally between about 3 minutes and about 50 minutes, optionally between about 7 minutes and about 15 minutes, optionally between about 8 minutes and about 12 minutes, optionally about 10 minutes.

The invention will be described in more detail below under reference to the drawing, in which in a non-limiting manner exemplary embodiments of the invention will be shown.

The drawing shows in:

Fig. 1 : a first example of a structure according to the invention,

Fig. 2 : a second example of a structure according to the invention,

Fig. 3 : an example of structures according to the invention being used in a mounting system for a solar panel,

Fig. 4 : a first image of the aluminum manganese coating of the secondary structural element obtained by electrochemical deposition from an ionic liquid,

Fig. 5 : a second image of the aluminum manganese coating of the secondary structural element obtained by electrochemical deposition from an ionic liquid,

Fig. 6: results of accelerated galvanic corrosion tests that have been carried out on different combinations of materials in a saline humid environment, shown as photos of bolts in a profile,

Fig. 7: results of the accelerated galvanic corrosion tests of fig. 6, photos of the profile only,

Fig. 8: results of further accelerated corrosion tests that have been carried out on bolts of different materials.

Fig. 1 shows a first example of a structure according to the invention.

The structure of fig. 1 has a primary structural element 1, which in this example is a beam. It also has a secondary structural element 2, which also is a beam. The primary structural element 1 and the second structural element 2 are in electrical contact with each other. When the structure is arranged in a corrosive, e.g. a humid, environment, the moisture will act as an electrolyte, closing the electric circuit between the primary structural element 1 and the secondary structural element 2. If the moisture is saline, it will be an effective electrolyte, increasing the risk of galvanic corrosion.

The primary structural element 1 and the secondary structural element 2 can be fixed to each other, e.g. by welds or by bolts, but this is not necessary as long as they are in electrical contact with each other, e.g. via electrically conductive structural elements.

Both beams are made of metal, e.g. steel, and are provided with a coating.

The coating of the primary structural element 1 is a metal coating, of which a main component is zinc (Zn). The coating of the primary structural element comprises at least 40 wt% zinc, based on the weight of the coating. The primary structural element 1 can for example have a zinc-coating (e.g. Z-type in accordance with draft European Standard dEN10346:2013), a zinc-iron alloy coating (e.g. ZF-type in accordance with draft European Standard dEN10346:2013), a zinc-aluminum coating (e.g. ZA-type in accordance with draft

European Standard dEN10346:2013) a zinc-magnesium alloy coating (e.g. ZM-type in accordance with draft European Standard dEN10346:2013), or an aluminum-zinc alloy coating (e.g. AZ-type in accordance with draft European Standard dEN10346:2013).

The coating of the secondary structural element 2 is an aluminum manganese coating, which means that the material of the coating is an alloy comprising aluminum and manganese. The coating comprises more aluminum than manganese by weight and the content of aluminum and manganese together is at least 90 wt % based on the weight of the coating.

Preferably, the aluminum content in the coating of the secondary structural element 2 is at least about 75 wt% based on the weight of the coating. Optionally, at least about 80wt% of the remainder of the coating is manganese. For example, the aluminum manganese coating of the secondary structural element comprises about 81-83 wt%, e.g. 82 wt%, aluminum, based on the weight of the coating and about 19-17 wt%, e.g. 18 wt%, manganese, based on the weight of the coating; about 84-86 wt%, e.g 85 wt%, aluminum, based on the weight of the coating and about 16-14 wt%, e.g.15 wt%, manganese, based on the weight of the coating; or about 94-96 wt%, e.g. 95 wt%, aluminum, based on the weight of the coating and about 6-4 wt%, e.g. 5 wt%, manganese, based on the weight of the coating.

Fig. 2 shows a second example of a structure according to the invention.

The structure of fig. 2 comprises two strips 4. These strips are primary structural elements, and are made of metal and provided with a coating that has a zinc content of at least 40 wt% based on the weight of the coating. For example, the strips 4 are galvanized or otherwise provided with for example a zinc-coating (e.g. Z-type in accordance with draft European Standard dEN10346:2013), a zinc-iron alloy coating (e.g. ZF-type in accordance with draft European Standard dEN10346:2013), a zinc-aluminum coating (e.g. ZA-type in accordance with draft European Standard dEN10346:2013) a zinc-magnesium alloy coating (e.g. ZM-type in accordance with draft European Standard dEN10346:2013), or an aluminum-zinc alloy coating (e.g. AZ-type in accordance with draft European Standard dEN10346:2013).

The strips 4 are connected to each other by a bolt 5. The bolt is provided with a coating that is an alloy comprising aluminum and manganese, wherein the coating comprises more aluminum than manganese by weight and the content of aluminum and manganese together is at least 90 wt % based on the weight of the coating. In the structure of fig. 2, bolt 5 is a secondary structural element.

Preferably, the aluminum content in the coating of the bolt 5 is at least about 75 wt% based on the weight of the coating. Optionally, at least about 80wt% of the remainder of the coating is manganese. For example, the aluminum manganese coating of the bolt comprises about 81-83 wt%, e.g. 82 wt%, aluminum, based on the weight of the coating and about 19-17 wt%, e.g. 18 wt%, manganese, based on the weight of the coating; about 84-86 wt%, e.g. 85 wt%, aluminum, based on the weight of the coating and about 16-14 wt%, e.g.15 wt%, manganese, based on the weight of the coating; or about 94-96 wt%, e.g. 95 wt%, aluminum, based on the weight of the coating and about 6-4 wt%, e.g. 5 wt%, manganese, based on the weight of the coating.

Fig. 3 shows an example of structures according to the invention being used in a mounting system for a solar panel, in side view.

In the embodiment of fig. 3, a solar panel 10 is mounted onto a support structure 8. The support structure comprises a first leg 20, a second leg 22 and a slanting beam 21 that extends between the first leg 20 and the second leg 22. The slanting beam 21 is in this embodiment welded to the first leg 20 and the second leg 22 to form a portal. Although not visible in fig. 3, the support structure comprises a second portal similar the one that is made up by the first leg 20, the slanting beam 21 and the second leg 22. This second portal is arranged next to the portal that is made up by the first leg 20, the slanting beam 21 and the second leg 22.

The support structure 8 further comprises a bottom strip 23 and a top strip 24. The bottom strip 23 and the top strip 24 extend from the portal that is made up by the first leg 20, the slanting beam 21 and the second leg 22 to the second portal. The bottom strip 23 and the top strip 24 are arranged adjacent to the solar panel 10, and therewith prevent that the solar panel 10 slides up or down on the slanting beam 21.

The bottom strip 23 and the top strip 24 are connected to the portal that is made up by the first leg 20, the slanting beam 21 and the second leg 22 and the second portal by bolts 30.

The support structure 8 further comprises at least one side plate 25. The side plate 25 is connected to the slanting beam 21 by a bolt 32 and to the solar panel 10 by a bolt 31. The side plate 25 prevents the solar panel from moving sideways over the slanting beam 21.

A cable 11 connects the solar panel 10 to a switchbox 12. The switchbox 12 is connected to the first leg 20 by a bottom support profile 27 and a top support profile 26. The top support profile 26 and the bottom support profile 27 are connected to the switchbox by bolts 33 and to the first leg 20 by bolts 34.

The cable 11 is strapped to the first leg by a metallic cable strap 35.

In the support structure 8 of fig. 3, the first leg 20, the second leg 22, the slanting beam 21, the second portal, the bottom strip 23, the top strip 24, the side plate 25, the top support profile 26 and the bottom support profile 27 are structural elements of the first type. At least one of them, but preferably all of them are primary structural elements in accordance with the invention. The first leg 20, the second leg 22, the slanting beam 21, the second portal, the bottom strip 23, the top strip 24, the side plate 25, the top support profile 26 and/or the bottom support profile 27 qualify as primary structural element in accordance with the invention if they are made of metal and provided with a coating that has a composition with a zinc contents of at least 40 wt%. So, for example, they are galvanized or otherwise provided with for example a zinc-coating (e.g. Z-type in accordance with draft European Standard dEN10346:2013), a zinc-iron alloy coating (e.g. ZF-type in accordance with draft European Standard dEN10346:2013), a zinc-aluminum coating (e.g. ZA-type in accordance with draft European Standard dEN10346:2013) a zinc-magnesium alloy coating (e.g. ZM-type in accordance with draft European Standard dEN10346:2013), or an aluminum-zinc alloy coating (e.g. AZ-type in accordance with draft European Standard dEN10346:2013).

In the support structure 8 of fig. 3, the bolts 30, 31, 32, 33, 34 and the metal strap 35 are structural elements of the second type. At least one of them, but preferably all of them are secondary structural elements in accordance with the invention. The bolts 30, 31, 32, 33, 34 and/or the metal strap 35 qualify as secondary structural element in accordance with the invention if they are provided with a coating which is an alloy comprising aluminum and manganese as the main components, which coating comprises more aluminum than manganese by weight and the content of aluminum and manganese together is at least 90 wt %.

Preferably, the aluminum content in the coating of the bolts 30, 31, 32, 33, 34 and the metal strap 35 is at least 75 wt%. For example, the aluminum manganese coating of the bolts 30, 31, 32, 33, 34 and the metal strap 35 comprises about 82 wt% aluminum and about 18 wt% manganese, or about 85 wt% aluminum and about 15 wt% manganese or about 95 wt% aluminum and about 5 wt% manganese.

Optionally, not all of the first leg 20, the second leg 22, the slanting beam 21, the second portal, the bottom strip 23, the top strip 24, the side plate 25, the top support profile 26 and the bottom support profile 27 are provided with a coating which contains at least 40 wt% zinc. Optionally, not all bolts 30, 31, 32, 33, 34 and/or the metal strap 35 are provided with a coating which is an alloy comprising aluminum and manganese as the main components, which coating comprises more aluminum than manganese by weight and the content of aluminum and manganese together is at least 90 wt %. However, the support structure 8 comprises at least one primary structural element that is made of metal and that is provided with a coating which has a composition that comprises at least 40 wt% zinc, and at least one secondary structural element that is in electrical contact with this particular primary structural element, which secondary structural element is made of metal and is provided with a coating which is an alloy comprising aluminum and manganese as the main components, the coating of said secondary structural element comprising more aluminum than manganese and the content of aluminum and manganese together being at least 90 wt%.

Fig. 4 and fig. 5 show images of the aluminum manganese coating of the secondary structural element obtained by electrochemical deposition from an ionic liquid, as is part of the method of claim 14. The images of fig. 4 and fig. 5 have been obtained by an electron microscope. The fine grained and dense structure of the aluminum manganese coating is clearly visible.

A structure according to the invention can for example be manufactured by a method in accordance with claim 14, optionally according to a combination of claim 14 with the dependent claims 15-22.

According to this method, a first metal substrate is provided with a coating that comprises at least 40 wt% zinc based on the weight of the coating. This can be done by methods known in the art, such as galvanizing, e.g. batch galvanizing, hot-dip galvanizing or electrogalvanizing. Thereby, a primary structural element according to the invention is obtained.

Further, a second metal substrate is provided onto which a coating will be applied that is an alloy comprising aluminum and manganese, which alloy comprises more aluminum than manganese by weight and in which alloy the content of aluminum and manganese together is at least 90 wt % based on the weight of the coating.

Preferably, the second metal substrate is cleaned and/or degreased before the other method steps are carried out. The cleaning and/or degreasing can be carried out for example by using an acid, e.g. sulfuric acid.

After the optional cleaning and/or degreasing, the second metal substrate is etched, optionally electrochemically etched, such that the surface of the substrate is roughened and/or contamination and/or oxides are removed from the surface of the second substrate as well .

The second metal substrate is arranged in a bath of ionic liquid. This can be done either before or after the electrochemical etching. If the second substrate is arranged in the bath of ionic liquid before the etching, the etching can be carried out in this bath of ionic liquid in the form of electrochemical etching.

After the etching, the second substrate can be removed from the bath of ionic liquid and transferred to a second bath of ionic liquid, in which the deposition of the aluminum manganese coating is applied. Alternatively, the deposition of the aluminum manganese coating on the second metal substrate can take place in the same bath as in which the electrochemical etching took place.

Alternatively, it is possible that the etching does not take place in an ionic liquid but for example in a aqueous solution. The etching does not have to be an electrochemical etching, it can for example alternatively be chemical etching. In case the etching does not take place in the ionic liquid from which the aluminum manganese coating is deposited, the second metal substrate is arranged in the bath of ionic liquid after the etching.

In case electrochemical etching is applied, the etching can for example be carried out at a voltage in the range of about 0.5V to about 1.5V versus an aluminum electrode, during about 1 to about 90 seconds.

After the etching, the aluminum manganese coating is applied to the second substrate. A source of aluminum and manganese is provided and the coating is deposited by means of electrodeposition from an ionic liquid, which for example is a combination of 1-ethyl-3-methylimidazoliumchloride (EMIMCl) and aluminum chloride ($AlCl_3$), and further comprises $MnCl_2$. The mol ratio between 1-ethyl-3methylimidazoliumchloride (EMIMCl) and aluminum chloride ($AlCl_3$) is preferably between about 1:1 and about 1:2.5, more preferably about 1: 1.5. Preferably, the content of $MnCl_2$ is between about 0.01 wt% and about 5 wt%, optionally between 0.02 and 1 wt%, based on the weight of the ionic liquid.

Optionally, the deposition takes place in waterfree conditions, for example under an argon atmosphere. Such conditions are in particular suitable when a combination of 1-ethyl-3-methylimidazoliumchloride (EMIMCl) and aluminum chloride ($AlCl_3$), further comprising $MnCl_2$ is used to deposit the aluminum manganese coating from.

Preferably, during the deposition of the aluminum manganese coating, the ionic liquid is agitated, for example by stirring it. This ensures that sufficient reactive components to form the aluminum manganese coating are available in the vicinity of the surface of the second metal substrate.

It was found that a suitable current density for the deposition process of the aluminum manganese coating is between about 2 A/dm^2 and about 7 A/dm^2, preferably about 4 A/dm^2.

Optionally, the thickness of the deposited aluminum manganese coating is between about 1.5 µm and about 100 µm, preferably between about 5 µm and about 30 µm.

After the deposition of the aluminum manganese coating, the second substrate has become a secondary structural element in accordance with the invention.

After the deposition of the aluminum manganese coating, the second substrate is taken out of the bath of ionic liquid and optionally cleaned, for example by acetone and/or water.

Optionally, the electrochemical etching of the second metal substrate and/or the electrodeposition of the aluminum manganese coating onto the second metal substrate take place at a process temperature between about 45°C and about 100°C, optionally between about 75°C and about 95°C, optionally at about 90°C.

Connecting the primary structural element and the secondary structural element to each other such that the primary structural element and the secondary structural element are in electrical contact with each other finishes the manufacturing of the structure according to the invention.

Optionally, the coating of the primary structural element is applied in one of the following ways:

- by immersing the first metal substrate in a molten bath containing a zinc content of at least about 99 wt%,
- by applying a zinc coating by immersing the first metal substrate in a molten bath containing a zinc content of at least about 99 wt% and a subsequent annealing which produces an iron-zinc coating with an iron content of normally about 8 wt% to about 12 wt% based on the weight of the coating,
- by immersing the first metal substrate in a molten bath which is composed of zinc and approximately 5 wt% aluminium and small amounts of mischmetal.
- by passing the first metal substrate through a molten zinc bath with aluminium and magnesium contents in sum of about 1.5 wt% to about 8 wt%.
- by immersing the first metal substrate in a molten bath which is composed of about 55 wt% aluminium, about 1.6 wt% silicon and the balance zinc.

Fig. 6 and fig. 7 show results of accelerated cyclic galvanic corrosion tests that have been carried out on different combinations of materials in a humid and saline environment.

The accelerated corrosion tests have been carried out as follows: a bolt of stainless steel, a bolt with an aluminum manganese coating in accordance with the invention and several types of galvanized bolts were arranged in a profile provided with a ZM-type coating about 93.5 wt% Zn, about 3.5 wt% Al and about 3 wt% Mg.

The profile with the bolts was subjected to the following test cycle:

- 24 hours salt spray test in accordance with ASTM_B 117), with 5% NaCl at 35°C,
- four days at a condensate water climate, each day having 8 hours at 40°C and 95% relative humidity and 16 hours at 20°C and 75% relative humidity,
- two days at room climate, at 20°C and 65% relative humidity.

This test cycle was repeated six times, so a total of six weeks testing took place.

The stainless steel bolt and galvanized bolts that were used were regular commercially available bolts. Chemical analysis showed the stainless steel bolt was made of a 304-type stainless steel, having about 18 wt% Cr, about 8 wt% Ni, about 2 wt% Cu, about 1.7 wt% Mn, about 0.25 wt% Si and about 0.25 wt% Mo as alloying elements. It is identified by the supplier as DIN 916 inox.

The galvanized bolts are in fig. 6 identified by the text on the respective heads of the bolts. The bolt indicated by “NORM 8.8” is galvanized according to EN ISO 4042 and EN 12329 as supplied by Eriks + Baudoin and Fabory. The coating on this bolt was about 19 µm thick and contained Zn, Al, Si and Ti.

The bolt indicated by “HBS 8.8U” is galvanized according to ISO 10684 as supplied by Eriks + Baudoin and Fabory. The coating on this bolt was about 56 µm thick and contained Zn and Pb.

The bolt indicated by “CW 8.8” is galvanized. The coating on this bolt was about 7 µm thick and contained mainly Zn.

The bolt indicated by “JD 8.8” is electrogalvanized according to EN ISO 4042 and EN 12329.The coating on this bolt was about 7 µm thick and contained mainly Zn.

Fig. 6 shows the combination of the profile and the bolt. Column A of fig. 6 shows the situation at the start of the test. Column B of fig. 6 shows the situation after one week and column C of fig. 6 shows the situation after six weeks, so at the end of the test.

Fig. 7 shows the profile only. Picture A of fig. 7 shows the profile near the hole in which the stainless steel bolt was present during the test. Picture B of fig. 7 shows the profile near the hole in which the batch galvanized NORM bolt was present during the test. Picture C of fig. 7 shows the profile near the hole in which the galvanized HBS 8.8u bolt was present during the test. Picture D of fig. 7 shows the profile near the hole in which the electrogalvanized JD 8.8 bolt was present during the test. Picture E of fig. 7 shows the profile near the hole in which the bolt with the aluminum manganese coating according to the invention was during present the test.

After the full test of six weeks, the combination of the ZM-coated profile and the stainless steel bolt showed white corrosion of the ZM-coating. The stainless steel bolt was unaffected.

After the full test of six weeks, the combination of the ZM-coated profile and the galvanized CW 8.8 bolt showed some white corrosion of the ZM-coating, and the entire bolt was corroded and showed a lot of red rust.

After the full test of six weeks, the combination of the ZM-coated profile and the galvanized HBS 8.8u bolt showed some white corrosion of the ZM-coating, and the bolt showed quite some red rust and white oxides.

After the full test of six weeks, the combination of the ZM-coated profile and the batch galvanized NORM bolt showed hardly any white corrosion of the ZM-coating, but the bolt was covered with white oxides.

After the full test of six weeks, for the combination of the ZM-coated profile and the electrically galvanized JD 8.8, the bolt showed a lot of red rust.

After the full test of six weeks, the combination of the ZM-coated profile and the bolt with the aluminum manganese coating according to the invention showed no white corrosion or other degradation of the ZM-coating. The bolt had some red rust, but upon closer inspection it showed that this was only at places where the coating did not adhere to the bolt. Where the coating was present, no degradation of the coating was observed.

Fig. 8 shows the result of accelerated corrosion tests in which the bolts as such were subjected to a humid and saline environment. This test is mainly directed at determining the resistance against corrosion due to the direct contact with the humid and saline environments. No galvanic corrosion was induced in this test.

The test cycle and the types of bolts that were tested were the same as for the galvanic corrosion test of which fig. 6 and 7 show the results.

Column A of fig. 8 shows the situation at the start of the test. Column B of fig. 8 shows the situation after one week and column C of fig. 8 shows the situation after six weeks, so at the end of the test. With respect to the with the aluminum manganese coating according to the invention, it must be noted that only the top of the bolt, which is the part enclosed by the box “a” in column C of fig. 8, was provided with the aluminum manganese coating according to the invention.

The stainless steel bolt came out of this test rather clean. It was not affected by corrosion.

Also the bolt that was coated with the aluminum manganese coating according to the invention came out of the test with hardly any corrosion, at least on the part of the bolt that was coated with the aluminum manganese coating according to the invention.

The galvanized bolt indicated as “HBS 8.8U” came out of the test with a lot of white oxides on its surface.

The galvanized bolts indicated as “CW 8.8” and “JD 8.8”came out of the test covered with red rust.

The galvanized bolt indicated as “NORM 8.8” came out of the test with white oxides on its surface, although less than the bolt “HBS 8.8U” showed.

CONCLUSIES

1. Structuur voor gebruik in een corrosieve omgeving, omvattende:
- een primair constructief element, welk primair constructief element gemaakt is van metaal en voorzien is van een coating, welke coating een samenstelling heeft die zink omvat in een gehalte van ten minste 40 gewichts% gebaseerd op het gewicht van de coating,
- een secundair constructief element, welk secundair constructief element gemaakt is van metaal en is voorzien van een coating, welke coating een legering is van aluminium en mangaan, in welke legering het gehalte van aluminium en mangaan samen ten minste 90 gewichts% is gebaseerd op het gewicht van de coating, welke legering meer aluminium dan mangaan bij gewicht omvat, en
waarbij het primaire constructieve element en het secundaire constructieve element in elektrische contact met elkaar zijn.

2. Structuur volgens conclusie 1,
waarbij de structuur meerdere primaire constructieve elementen omvat, en waarbij ten minste twee primaire constructieve elementen met elkaar verbonden zijn door een secundair constructief element.

3. Structuur volgens een van de voorgaande conclusies,
waarbij het primaire constructieve element een van een balk, een profiel, een strip, een staaf, een plaat is.

4. Structuur volgens een van de voorgaande conclusies,
waarbij het secundaire constructieve element een steun of een bevestigingsmiddel sis, mogelijk een van een bout, en moer, een combinatie van een bout en een moer, een schroef, en klem, een clip.

5. Structuur volgens een van de voorgaande conclusies,
waarbij de structuur verder een functionele inrichting bevat, welke functionele inrichting door een secundair constructief element verbonden is met een primair constructief element.

6. Structuur volgens claim 5,
waarbij de functionele inrichting een is van een zonnepaneel, een schakelkast, een kabel, een sensor, een uitlaatsysteem.

7. Structuur volgens een van de voorgaande conclusies,

waarbij het aluminiumgehalte in de coating van het secundaire constructieve element ten minste ongeveer 75 gewichts% is, gebaseerd op het gewicht van de coating.

8. Structuur volgens een van de voorgaande conclusies, waarbij aluminiumgehalte in de coating van het secundaire constructieve element ten minste ongeveer 75 gewichts% is, gebaseerd op het gewicht van de coating, en ten minste 80% van de rest van de coating mangaan is.

9. Structuur volgens een van de conclusies 7 of 8, waarbij de coating van het secundaire constructieve element ongeveer 81 - 83 gewichts% aluminium en ongeveer 19 -17 gewichts% mangaan omvat, gebaseerd op het gewicht van de coating, of
waarbij de coating van het secundaire constructieve element ongeveer 84 - 86 gewichts% aluminium en ongeveer 16 -14 gewichts% mangaan omvat, gebaseerd op het gewicht van de coating, of
waarbij de coating van het secundaire constructieve element ongeveer 94 - 96 gewichts% aluminium en ongeveer 6 - 4 gewichts% mangaan omvat, gebaseerd op het gewicht van de coating/

10. Structuur volgens een van de voorgaande conclusies, waarbij de dikte van de coating van het secundaire constructieve element tussen ongeveer 1.5 µm en ongeveer 100 µm is, bij voorkeur tussen ongeveer 5 µm en ongeveer 30 µm.

11. Structuur volgens een van de voorgaande conclusies, waarbij het metaal van de primaire en/of de secundaire constructieve element staal is, bijvoorbeeld constructiestaal.

12. Structuur volgens een van de voorgaande conclusies, waarbij de coating van het primaire constructieve element een zinkcoating is die ten minste ongeveer 90 gewichts% puur zink bevat, een coating van een zink-ijzer legering, een coating van een zink-aluminium legering, een coating van een zink-magnesium legering of een coating van een aluminium-zink legering.

13. Structuur volgens conclusie 12, waarbij de coating een hot-dip coating is.

14. Werkwijze voor het vervaardigen van een structuur volgens een van de voorgaande conclusies, welke werkwijze omvat:

- het verschaffen van een eerste metalen substraat,
- het van een coating voorzien van het eerste metalen substraat, welke coating een samenstelling heeft die zink omvat in een gehalte van ten minste 40 gewichts% gebaseerd op het gewicht van de coating, en daardoor het verkrijgen van het primaire constructieve element,
- het verschaffen van een tweede metalen substraat,
- het aanbrengen van het tweede metalen substraat in een bad van ionische vloeistof,
- het etsen van het tweede substraat,
- het verschaffen van een bron van aluminium en mangaan,
- het elektrochemisch afzetten van een coating vanuit de ionische vloeistof op het tweede metalen substraat, welke coating een legering is van aluminium en mangaan, in welke legering het gehalte van aluminium en mangaan samen ten minste 90 gewichts% is gebaseerd op het gewicht van de coating, welke legering meer aluminium dan mangaan bij gewicht omvat, en daardoor het verkrijgen van het secundaire constructieve element, en optioneel, tijdens dit elektrochemisch afzetten het agiteren van de ionische vloeistof,
- het verbinden van het primaire constructieve element en het secundaire constructieve element met elkaar, zodanig dat het primaire constructieve element en het secundaire constructieve element in elektrisch contact zijn met elkaar.

15. Werkwijze volgens conclusie 14,
waarbij het etsen van het tweede metalen substraat het oppervlak van het tweede metalen substraat opruwt en/of oxides en/or vervuilingen van het oppervlak van het tweede substraat verwijdert.

16. Werkwijze volgens een van de claims 14-15,
waarbij de ionische vloeistof een combinatie is van 1-ethyl-3-methylimidazoliumchloride (EMIMCl) en aluminumchloride ($AlCl_3$), bij voorkeur in een molverhouding van ongeveer 1:1.5, en verder omvattende $MnCl_2$, bij voorkeur tussen ongeveer 0.01 gewichts% en ongeveer 5 gewichts% $MnCl_2$, mogelijk tussen ongeveer 0.02 gewichts% en ongeveer 1 gewichts% $MnCl_2$, gebaseerd op het gewicht van de ionische vloeistof.

17. Werkwijze volgens een van de conclusies 14-16,
waarbij het etsen van het tweede metalen substraat en het elektrochemisch afzetten van de coating van een legering van aluminium en mangaan worden uitgevoerd in hetzelfde bad van ionische vloeistof.

18. Werkwijze volgens een van de conclusies 14-17,
waarbij het etsen van het tweede metalen substraat elektrochemisch etsen is.

19. Werkwijze volgens conclusie 18,
waarbij het elektrochemisch etsen van het tweede metalen substraat wordt uitgevoerd bij een voltage van tussen ongeveer 0.5V en 1.5V versus een aluminium elektrode, bij voorkeur gedurende ongeveer 1 seconde tot ongeveer 90 seconden.

20. Werkwijze volgens een van de conclusie 14-19,
waarbij het elektrochemisch afzetten van de coating die een legering is die aluminium en mangaan omvat een procesparameter heeft die de stroomdichtheid is, welke stroomdichtheid ligt tussen ongeveer $2A/dm^2$ en ongeveer $7A/dm^2$, bij voorkeur ongeveer 4 A/dm^2.

21. Werkwijze volgens een van de conclusies 14-20,
waarbij voorafgaand aan het etsen van het tweede metalen substraat, het tweede metalen substraat wordt schoongemaakt en/of ontvet.

22. Werkwijze volgens een van de conclusies 14-21,
waarbij de coating van het primaire constructieve element wordt aangebracht op ten minste een van de volgende manieren:
- door het dompelen van het eerste metalen substraat in een gesmolten bad dat een zinkgehalte van ten minste ongeveer 99 gewichts% heeft,
- door het aanbrengen van een zinkcoating door het dompelen van het eerste metalen substraat in een gesmolten bad dat een zinkgehalte van ten minste ongeveer 99 gewichts% heeft en vervolgens gloeien dat een ijzergehalte van normaal ongeveer 8 gewichts% tot ongeveer 12 gewichts% oplevert, gebaseerd op het gewicht van de coating,
- door het dompelen van het eerste metalen substraat in een gesmolten dat dat samengesteld is uit zink en ongeveer 5 gewichts% aluminium en kleine hoeveelheden mischmetal,
- door het passeren van het eeste metalen substraat door een gesmolten zink-bad met een aluminium- en magnesiumgehalte van opgeteld ongeveer 1.5 gewichts% tot ongeveer 8 gewichts%,
- door het dompelen van het eerste metalen substraat in een gesmolten bad dat is samengesteld uit ongeveer 55 gewichts% aluminium, ongeveer 1.6 gewichts% silicium en de balans zink.

23. Bevestigingssysteem voor een zonnepaneel, welk bevestigingssysteem ten minste een structuur volgens een van de conclusies 1-13 omvat.

24. Voertuig, omvattende ten minste een structuur volgens een van de claims 1-13.

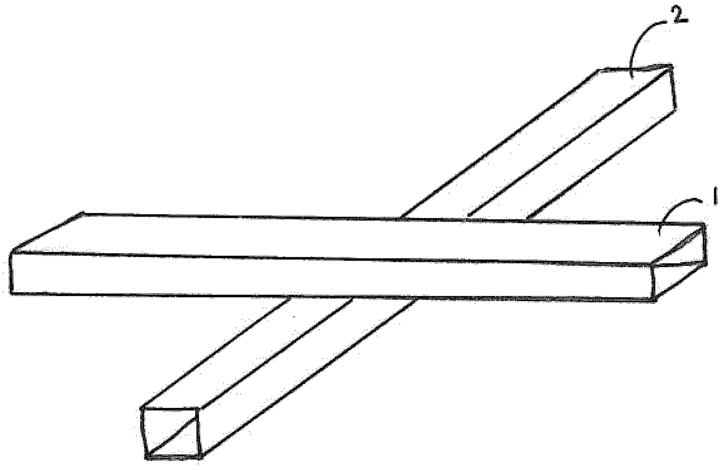

Fig. 1

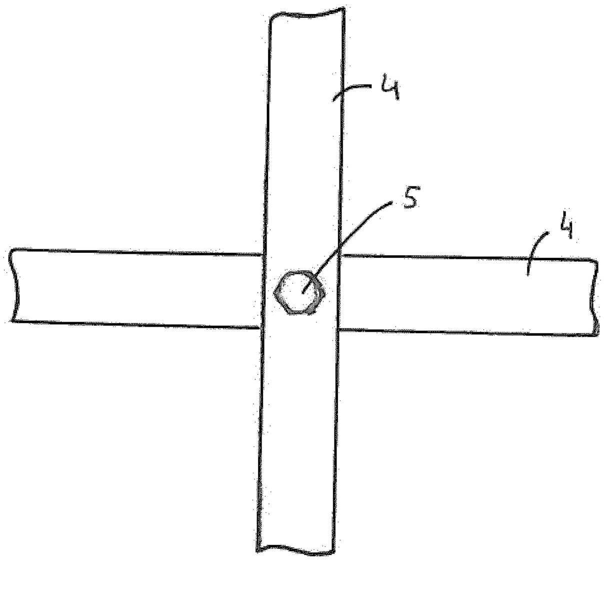

Fig. 2

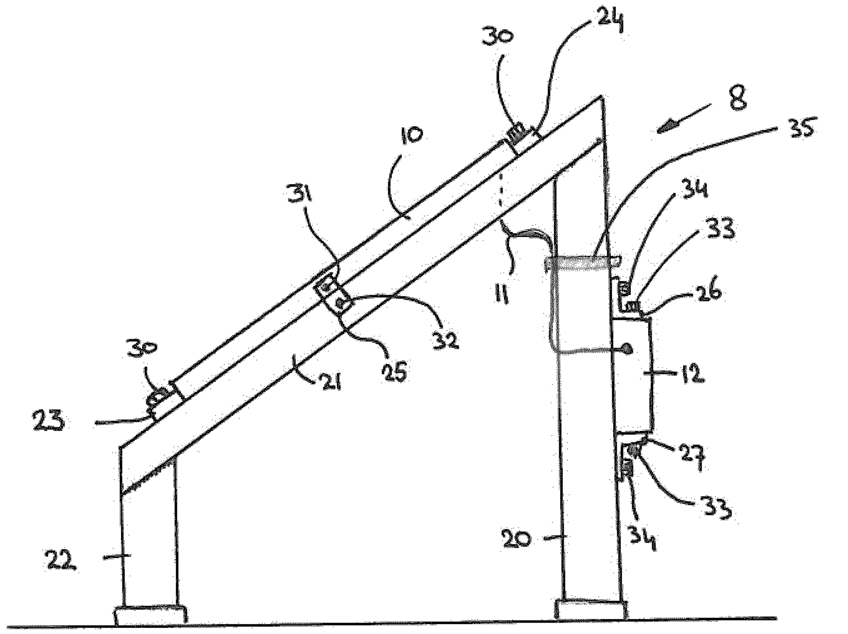

Fig. 3

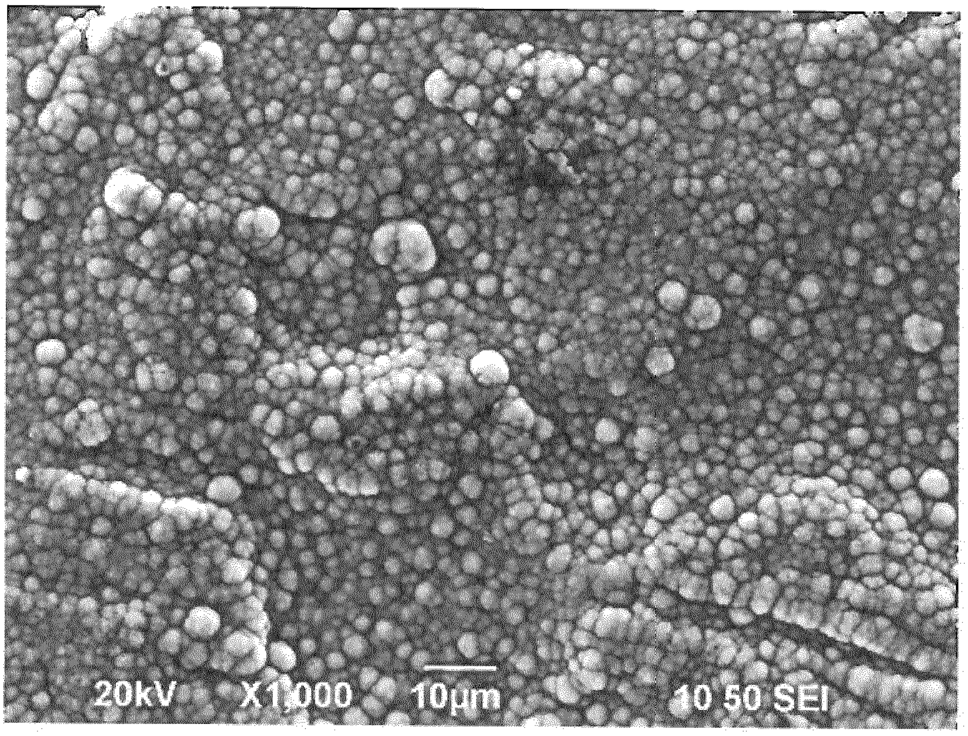

Fig. 4

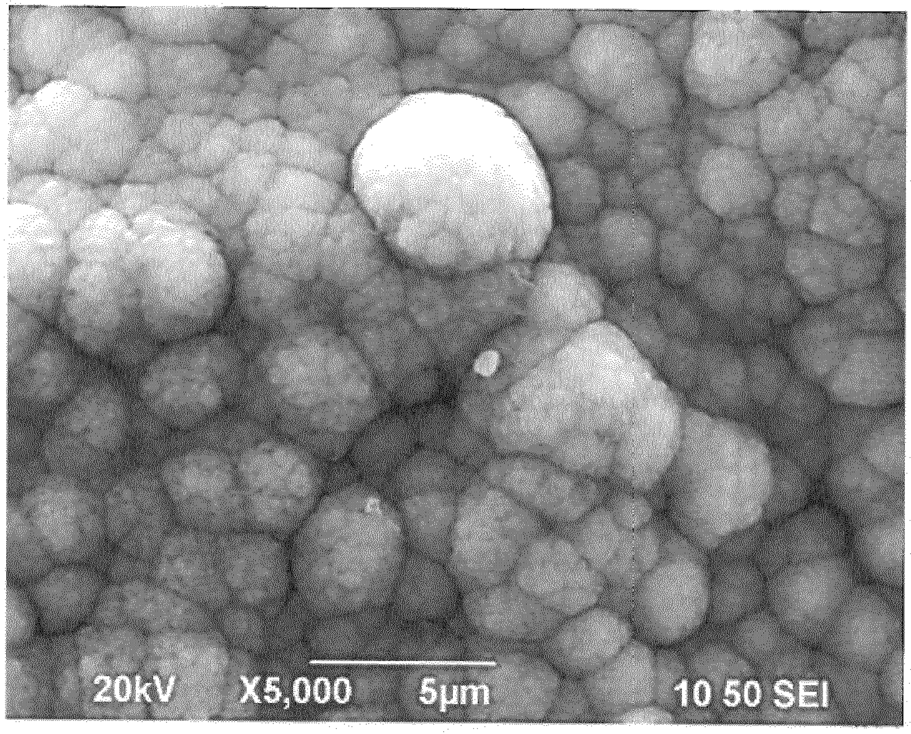

Fig. 5

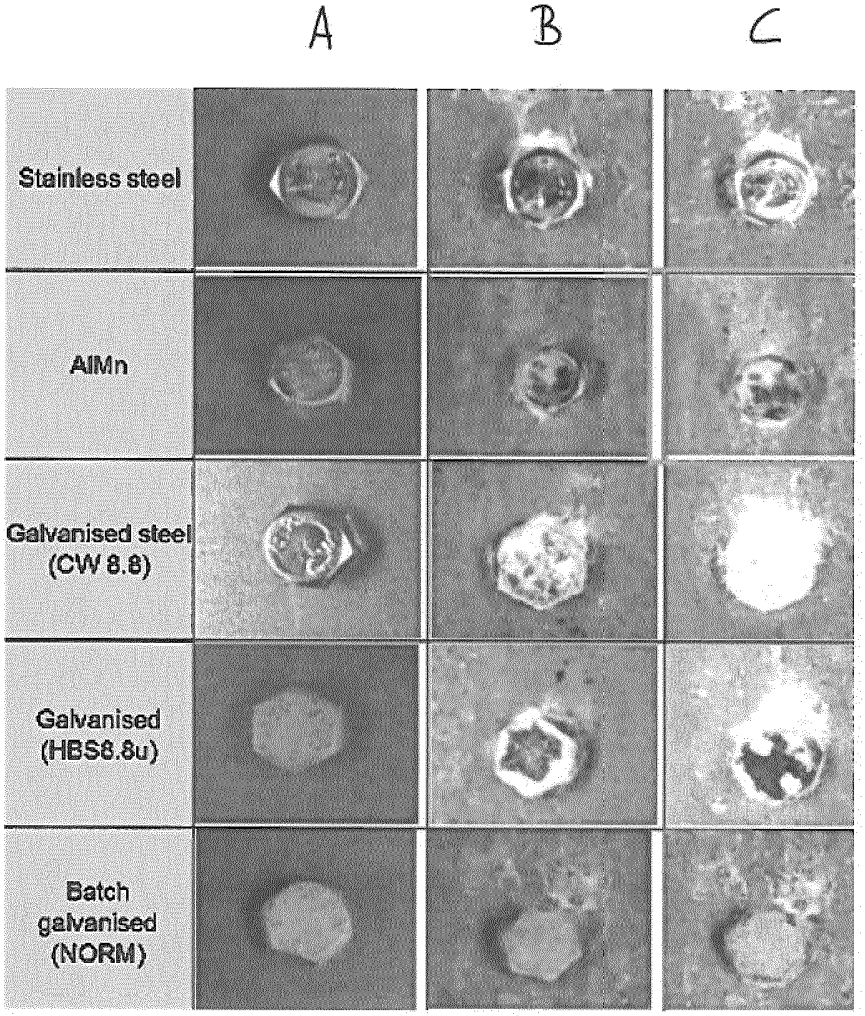
A
B
C
Stainless steel
AlMn
Galvanised steel
(CW 8.8)
Galvanised
(HBS8.8u)
Batch
galvanised
(NORM)

Fig. 6

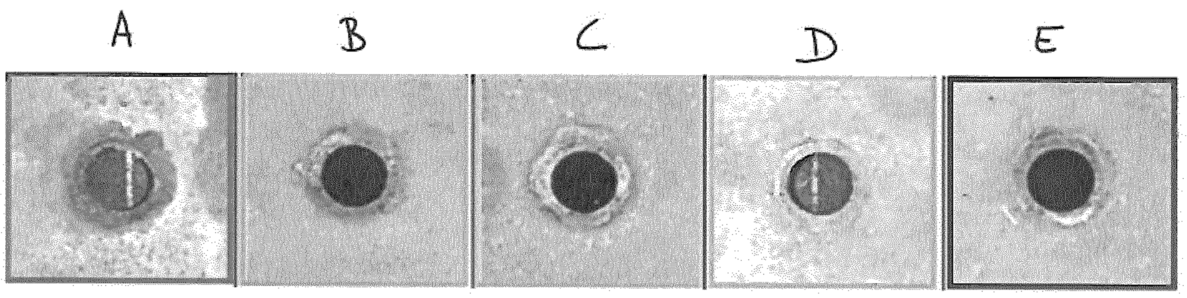
A
B
C
D
E

Fig. 7

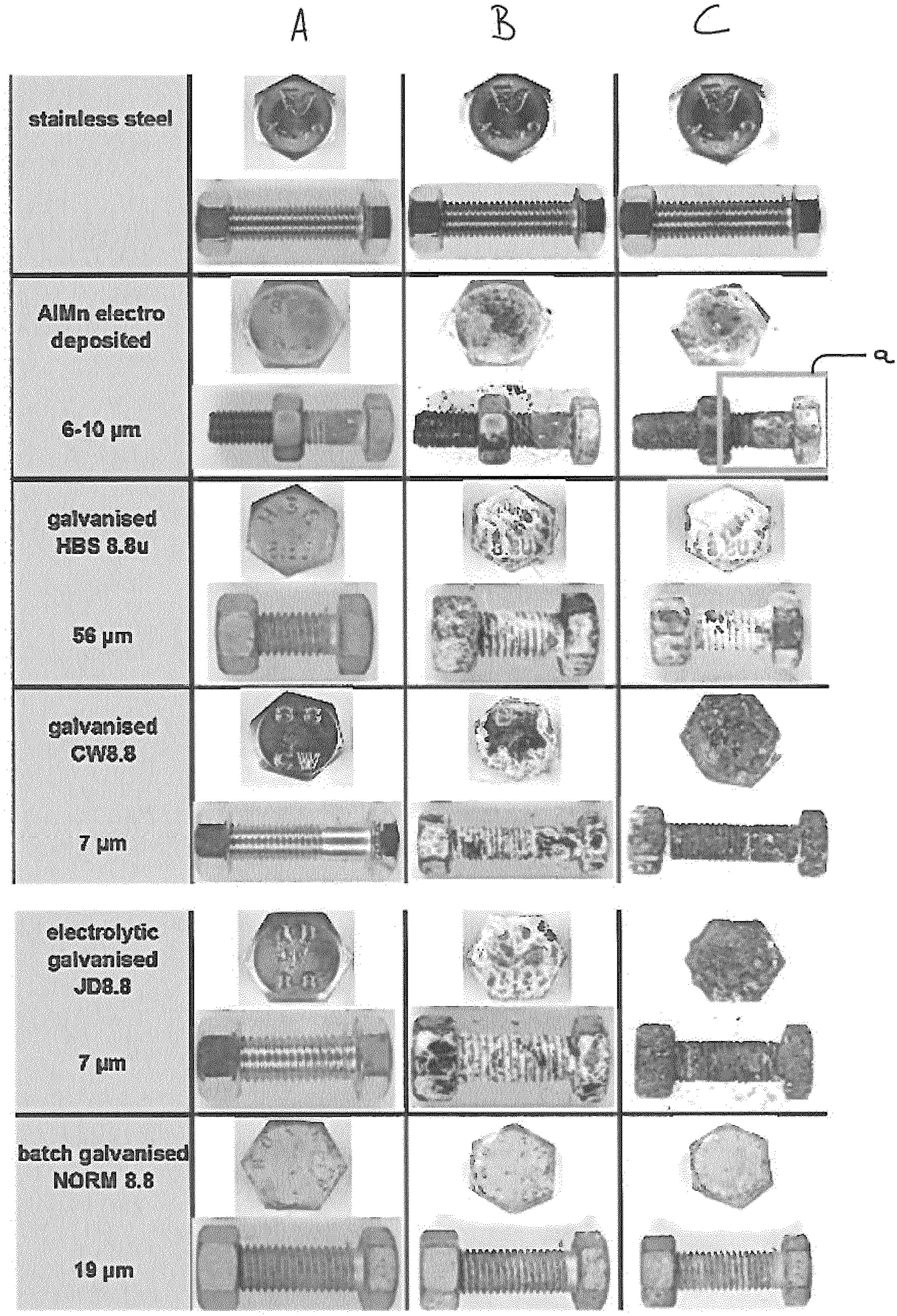
A
B
C
stainless steel
AlMn electro deposited
6-10 µm
a
galvanised HBS 8.8u
56 µm
galvanised CW8.8
7 µm
electrolytic galvanised JD8.8
7 µm
batch galvanised NORM 8.8
19 µm

Fig. 8

SAMENWERKINGSVERDRAG (PCT)

RAPPORT BETREFFENDE NIEUWHEIDSONDERZOEK VAN INTERNATIONAAL TYPE

IDENTIFICATIE VAN DE NATIONALE AANVRAGE	**KENMERK VAN DE AANVRAGER OF VAN DE GEMACHTIGDE** **P31611NL00/NBL**
Nederlands aanvraag nr. **2011269**	Indieningsdatum **05-08-2013**
	Ingeroepen voorrangsdatum
Aanvrager (Naam) **Onderzoekscentrum voor aanwending van staal N.V.**	
Datum van het verzoek voor een onderzoek van internationaal type **26-10-2013**	Door de Instantie voor Internationaal Onderzoek aan het verzoek voor een onderzoek van internationaal type toegekend nr. **SN60930**

I. CLASSIFICATIE VAN HET ONDERWERP (bij toepassing van verschillende classificaties, alle classificatiesymbolen opgeven)	
Volgens de internationale classificatie (IPC) **C25D3/56;C25D7/00;F16B33/00;C23F13/06;C23C2/06**	
II. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK	
Onderzochte minimumdocumentatie	
Classificatiesysteem	Classificatiesymbolen
IPC	**C25D;F16B;C23F;C23C**
Onderzochte andere documentatie dan de minimum documentatie, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen	
III. ☐ **GEEN ONDERZOEK MOGELIJK VOOR BEPAALDE CONCLUSIES**	(opmerkingen op aanvullingsblad)
IV. ☐ **GEBREK AAN EENHEID VAN UITVINDING**	(opmerkingen op aanvullingsblad)

Form PCT/ISA 201 A (11/2000)

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2011269

A. CLASSIFICATIE VAN HET ONDERWERP
INV. C25D3/56 C25D7/00 F16B33/00 C23F13/06 C23C2/06
ADD.

Volgens de Internationale Classificatie van octrooien (IPC) of zowel volgens de nationale classificatie als volgens de IPC.

B. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK

Onderzochte mimimum documentatie (classificatie gevolgd door classificatiesymbolen)
C25D F16B C23F C23C

Onderzochte andere documentatie dan de mimimum documentatie, voor dergelijke documenten, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

Tijdens het onderzoek geraadpleegde elektronische gegevensbestanden (naam van de gegevensbestanden en, waar uitvoerbaar, gebruikte trefwoorden)

EPO-Internal, WPI Data, COMPENDEX

C. VAN BELANG GEACHTE DOCUMENTEN

Categorie °	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
X	DE 10 2007 058716 A1 (DAIMLER AG [DE]) 10 juni 2009 (2009-06-10) * alineas [0010] - [0021]; conclusies * -----	1-24
A	JP 2000 129467 A (SUMITOMO METAL IND) 9 mei 2000 (2000-05-09) * samenvatting * -----	1-24
A	US 2012/155988 A1 (SCHUMACHER WILLIAM A [US] ET AL) 21 juni 2012 (2012-06-21) * alineas [0007] - [0023]; figuur 1 * -----	1-24
A	WO 01/00903 A2 (VOLVO PERSONVAGNAR AB [SE]; DANFOSS AS [DK]; ISACSSON MALTE [SE]; HYTT) 4 januari 2001 (2001-01-04) * conclusies * -----	1-24

☐ Verdere documenten worden vermeld in het vervolg van vak C.

☒ Leden van dezelfde octrooifamilie zijn vermeld in een bijlage

° Speciale categorieën van aangehaalde documenten

"A" niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft
"D" in de octrooiaanvrage vermeld
"E" eerdere octrooi(aanvrage), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven
"L" om andere redenen vermelde literatuur
"O" niet-schriftelijke stand van de techniek
"P" tussen de voorrangsdatum en de indieningsdatum gepubliceerde literatuur
"T" na de indieningsdatum of de voorrangsdatum gepubliceerde literatuur die niet bezwarend is voor de octrooiaanvrage, maar wordt vermeld ter verheldering van de theorie of het principe dat ten grondslag ligt aan de uitvinding
"X" de conclusie wordt als niet nieuw of niet inventief beschouwd ten opzichte van deze literatuur
"Y" de conclusie wordt als niet inventief beschouwd ten opzichte van de combinatie van deze literatuur met andere geciteerde literatuur van dezelfde categorie, waarbij de combinatie voor de vakman voor de hand liggend wordt geacht
"&" lid van dezelfde octrooifamilie of overeenkomstige octrooipublicatie

Datum waarop het onderzoek naar de stand van de techniek van internationaal type werd voltooid	Verzenddatum van het rapport van het onderzoek naar de stand van de techniek van internationaal type
2 mei 2014	

Naam en adres van de instantie	De bevoegde ambtenaar
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Mauger, Jeremy

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ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Informatie over leden van dezelfde octrooifamilie

Nummer van het verzoek om een onderzoek naar de stand van de techniek

NL 2011269

In het rapport genoemd octrooigeschrift	Datum van publicatie	Overeenkomend(e) geschrift(en)	Datum van publicatie
DE 102007058716 A1	10-06-2009	DE 102007058716 A1	10-06-2009
		EP 2215287 A1	11-08-2010
		JP 5323083 B2	23-10-2013
		JP 2011509204 A	24-03-2011
		WO 2009071136 A1	11-06-2009
JP 2000129467 A	09-05-2000	GEEN	
US 2012155988 A1	21-06-2012	BR PI1105577 A2	09-04-2013
		CN 102537010 A	04-07-2012
		DE 102011120775 A1	21-06-2012
		US 2012155988 A1	21-06-2012
WO 0100903 A2	04-01-2001	AU 6040700 A	31-01-2001
		DE 60011914 D1	05-08-2004
		DE 60011914 T2	21-07-2005
		EP 1210469 A2	05-06-2002
		SE 9902504 A	31-12-2000
		US 2002086178 A1	04-07-2002
		WO 0100903 A2	04-01-2001

WRITTEN OPINION

File No.	Filing date *(day/month/year)*	Priority date *(day/month/year)*	Application No.
SN60930	05.08.2013		NL2011269
International Patent Classification (IPC) INV. C25D3/56 C25D7/00 F16B33/00 C23F13/06 C23C2/06			
Applicant Onderzoekscentrum voor aanwending van staal N.V.			

This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☒ Box No. VII Certain defects in the application
- ☒ Box No. VIII Certain observations on the application

	Examiner
	Mauger, Jeremy

Form NL237A (Dekblad) (July 2006)

WRITTEN OPINION

Box No. I Basis of this opinion

1. This opinion has been established on the basis of the latest set of claims filed before the start of the search.
2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the application and necessary to the claimed invention, this opinion has been established on the basis of:

   a. type of material:

   ☐ a sequence listing

   ☐ table(s) related to the sequence listing

   b. format of material:

   ☐ on paper

   ☐ in electronic form

   c. time of filing/furnishing:

   ☐ contained in the application as filed.

   ☐ filed together with the application in electronic form.

   ☐ furnished subsequently for the purposes of search.

3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
4. Additional comments:

Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty	Yes:	Claims	1-24
	No:	Claims	
Inventive step	Yes:	Claims	
	No:	Claims	1-24
Industrial applicability	Yes:	Claims	1-24
	No:	Claims	

2. Citations and explanations

   see separate sheet

WRITTEN OPINION

Box No. VII Certain defects in the application

see separate sheet

Box No. VIII Certain observations on the application

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1 Reference is made to the following documents:

D1 DE 10 2007 058716 A1 (DAIMLER AG [DE]) 10 juni 2009 (2009-06-10)

D2 JP 2000 129467 A (SUMITOMO METAL IND) 9 mei 2000 (2000-05-09)

2 The closest prior art for the structure of claim 1 and the method of claim 14 is represented by document D1. Document D1 (see paragraphs [0010[-[0021] and claims) discloses structures allowing metal parts to be joined together whilst minimising the risk of galvanic corrosion. In document D1 a zinc coated steel bolt is connected to a stainless steel part and an intermediate part (typically made from an aluminium alloy) is interposed between the bolt and the stainless steel.

3 The structure of claim 1 is novel because the documents fail to disclose a structural element coated with an aluminium-manganese alloy layer in contact with a further zinc coated structural element. The method of claim 14 is similarly novel because it involves the deposition of an aluminium-manganese layer on a structural element and then electrically coupling this element to a further zinc coated structural element.

4 The general problem addressed by the application is the provision of structures resistant to galvanic corrosion and methods for making them. In particular the application relates to steel structures containing fasteners. The same general problem is addressed in document D1 and since aluminium-manganese alloys appear to perform similarly to the aluminium alloys disclosed in document D1, the objective problem in light of document D1 is considered to the provision of alternative structures and methods.

4.1 The solution to this problem proposed in the application (an aluminium-manganese coating on one of the parts and a zinc coating on the other part) is however considered to represent an obvious alternative to the structures proposed in document D1. A standard method to minimise the danger of galvanic corrosion is to interpose a metal of an intermediate galvanic potential between two parts with a large difference between their galvanic potentials. This interposed metal may be a coating on either part or a separate part. This principle in used both in the application and in document D1. The skilled person when looking for alternative materials fulfilling these requirements would in particular consider aluminium alloys not specifically mentioned in document D1 and thus in an obvious manner employ aluminium-manganese alloys. Electroplated aluminium-manganese are furthermore known to provide good corrosion properties (see D2, abstract). Thus the subject-matter of independent claims 1 and 14 is considered not to be inventive.

4.2 The subject-matter of the dependent claims is also not considered to involve an inventive step, as these claims merely define standard alternatives to known structures and methods.

Re Item VII

Certain defects in the application

1 The relevant background art disclosed in document D1 is not mentioned in the description, nor is this document identified therein.

Re Item VIII

Certain observations on the application

1 Claims 7-10, 12, 16, 19, 20 and 22 all define numerical ranges qualified by the word "ongeveer" (about). This qualification makes it impossible for the skilled person to determine the scope of the ranges claimed. The claims are therefore unclear.