

- [54] CATHODIC PROTECTION
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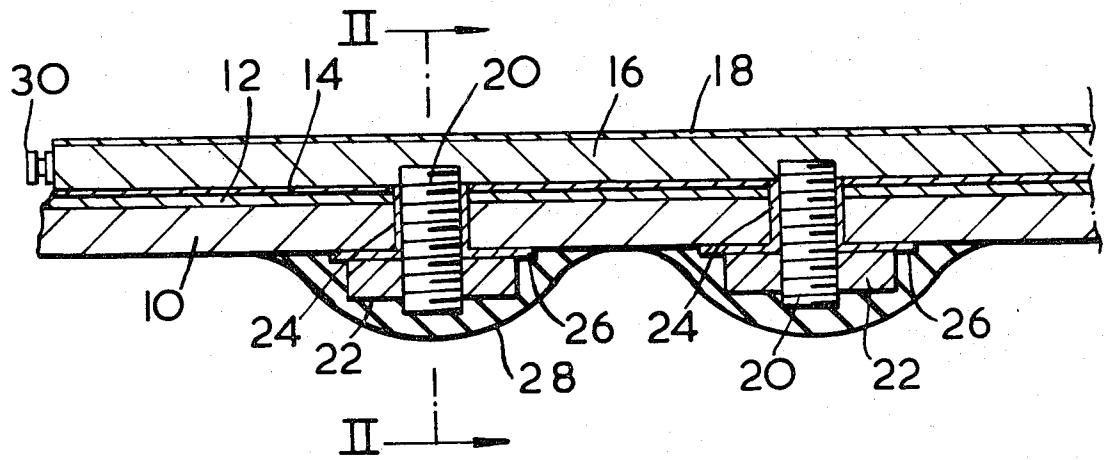
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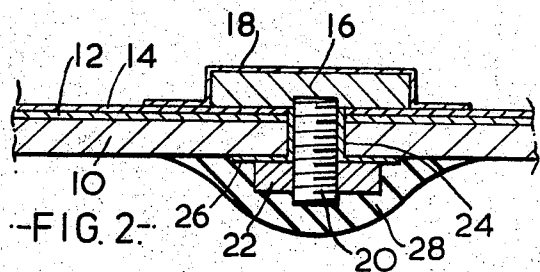
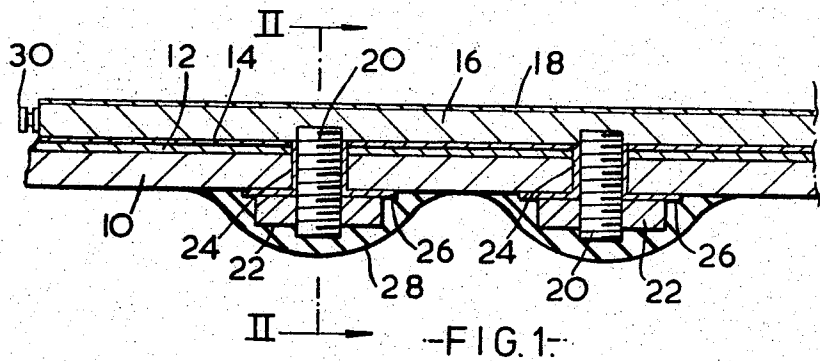
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[57] **ABSTRACT**
A cathodic protection system for a metal substrate has an anode which is normally electrically insulated from the substrate but which is disposed very close to the substrate. Cathodic protection only becomes effective when the electrical insulation breaks down and the metal substrate would otherwise be subject to corrosion. The system comprises an electrically insulating coating on the metal substrate and an electrically conducting coating applied over the insulating coating, a D.C. voltage being applied between the metal substrate and the conductive coating. The conductive coating or the insulating coating or both may be paint, the conductive layer being rendered conductive by the incorporation of an electrically conductive material such as elemental carbon.

10 Claims, 2 Drawing Figures





CATHODIC PROTECTION

The present invention relates to a cathodic protection system for the protection of metals such as the steel framework of buildings, ships or pipelines.

The phenomenon of cathodic protection has been known and applied industrially for many years. In a simple form, an iron/copper couple is immersed in a sodium chloride solution and an auxiliary anode is provided in electrical contact with the couple. The auxiliary anode is capable of readily providing a supply of electrons. The dissolution of the iron is reduced and the rate of hydroxyl ion production at the copper raised, so that the potentials of both the anode and the cathode are lowered.

By impressing an external cathodic current on the couple, the anodic current is reduced and the cathodic current increased. The corrosion current of the couple can be reduced to zero if the cathode is polarized down to the unpolarized potential of the anode.

A supply of electrons to protect a corroding metal can be provided from a D.C. source, the negative terminal of which is joined to the metal to be protected and the positive terminal to an anode, for example, scrap iron or graphite, located adjacent the metal to be protected and in a conducting medium.

One disadvantage with known cathodic protection systems is that the anodes must be immersed or buried in a conducting electrolytic medium and there must be a continuous conducting medium between the anodes and the metal to be protected. The known systems cannot, therefore, be applied to metal exposed to an air environment, such as structural steelwork for buildings.

A further disadvantage is that the anodes are of small size in relation to the metal to be protected, and in many cases are somewhat remote. Much of the driving potential is, therefore, absorbed in overcoming the resistance of the medium which, in the case of land based structures, can vary widely. Current distribution at the metal surface is, therefore, variable. Generally the greatest current density appears at the parts of the metal nearest to the anodes. Moreover there is always danger from interference by and with other metal structures and considerable study has to be made to overcome such interference. So important is this matter, particularly with pipelines in industrial areas, that it is sometimes deemed necessary to provide strip anodes of aluminium or other metal in an adjacent trench alongside pipelines.

According to the present invention there is provided a cathodic protection system which comprises a metal to be protected, an electrically non-conductive coating applied over the metal, an electrically-conductive coating applied over the non-conductive coating such that the metal and the electrically-conductive coating are electrically insulated one from the other, a source of D.C. voltage being applied between the metal and the electrically-conductive coating such that the electrically-conductive coating is anodic with respect to the metal.

Hence, a permanent impressed current electrode is applied close to all parts of the steel surface. Where any part of the steel is subjected to corrosive influences as by damage to the protective coating or by its saturation with aggressive aqueous solutions that part of the anode closest to the point of potential corrosion becomes effective. Thus the resistance of the circuit is in-

dependent of the resistance of the surrounding medium except at the immediate point of damage since virtually the whole of the impressed current is carried by the conductive paint layer. It is, therefore, not necessary to apply excessive potential to overcome the resistance of the surrounding medium.

The anode and cathodic steel are so close that sufficient electrolyte to maintain the protective current can be supplied by a film of condensed moisture, or by rain or condensed water droplets. On the other hand the system operates with equal effect when the conducting medium at the point of damage is damp soil or aqueous solution such as seawater in bulk. Thus the system is effective for underwater protection, underground protection and overground protection. Because of the continuous close proximity between anode and cathode there is no requirement for long "throw" (the distance over which current from the anodes is effective) to give protection, and the system is effective on the insides of water carrying pipes.

The invention will now be described further by way of example.

The metal such as steel to be protected is first prepared and coated according to a known method typically by blast cleaning through the impact of high velocity grit, abrasive slag or shot to remove mill scale, rust etc., or by chemically pickling using an inhibited acid solution or other chemical process. Alternatively the metal may be cleaned by manual means to the required standard. After cleaning the metal may be further chemically treated as by a phosphate or chromate dip. Following the prescribed treatment the metal is coated with an electrically insulating type material. Apart from this, there is no limitation beyond the normal known requirements of metal protection. Suitable coating materials are bituminous compositions, many types of paints, particularly, though not necessarily, those based on epoxy resins or chlorinated rubber, natural and synthetic rubber, polyvinyl chloride, and other synthetic resins, and certain wrapping materials. The above-mentioned protective coating, which may be a single or multiple application is then overcoated with an electrically-conductive paint. The coating must be applied in such a way that it is not in direct contact with the steel to be protected, and should cover either the whole surface to be protected or such part as is deemed necessary to give the required protection. The conductive paint thickness is such as to produce the required conductivity of the surface. In general, low resistivity is desirable for protecting large areas or long lengths, but very low resistivity is not always necessary nor economically suitable. For many purposes a resistivity of not more than 200 ohms per square (i.e. per square measuring one foot by one foot) is adequate but resistivity of below 20 ohms per foot square gives more control of the process. The conductive paints need to be durable in the conditions of use and particular types must be used with this in view so that sometimes it is necessary to sacrifice a measure of conductivity to maintain durability.

Certain metal pigmented paints are suitable for use with the present invention, though the selection of a particular type will depend upon the conditions to which the system is to be exposed. Non-metallic conductive paints are preferred to avoid loss of anode and of conductivity.

Among the paints which can be used for the conductive coating are chlorinated rubber paint, epoxy ester paint and chemically cured pitch epoxy paint, each of which being compounded with the incorporation of elemental carbon. A typical chlorinated rubber paint is formed by grinding together 40 percent by weight of a medium having the three components 30 percent by weight of a medium viscosity grade chlorinated rubber or chlorinated synthetic rubber such as alloprene R20, 10 percent by weight of a chlorinated hydrocarbon plasticiser such as cereclor S52 and 60 percent by weight of an aromatic hydrocarbon solvent having a boiling range of 165° to 185°C, such as shellsol A; 3 to 4 percent by weight of a dispersible gas carbon black pigment such as carbon black XC 72; 0.2 to 0.25 percent by weight of an N-alkyltrimethylene diamine such as duomeen TDO; and 26 to 30 percent by weight of the aromatic solvent. 15 to 20 percent by weight graphite is then added and fully dispersed by further grinding. The composition is then thinned to the required consistency with more of the aromatic solvent.

The electrical resistivity of a coating of chlorinated rubber paint depends on the carbon content in the dried film. At 33 percent by volume of pigment in the dried film, the resistivity is 10 to 12 ohms per foot square at 50 microns film thickness.

A typical epoxy ester paint is formed by mixing 0.02 grms rosaniline base (an amine dyestuff base) with 18.3 grms of a 60 percent by weight solution of a linseed oil fatty acid ester of epoxy resin and warming the mixture to 100°C, 6 to 8 grms of carbon black XC 72, 25 to 35 grms of white spirit and 30 to 35 grms xylol are then added and the whole is ground in a pebble mill for at least 24 hours, 12 to 16 grms of a coarse pigment grade lamellar graphite such as graphite foliac X1204 is then added and the mixture is further ground until the graphite is fully dispersed. An epoxy ester paint having a pigment content of 45 percent by volume in a dried film has an electrical resistivity of 7 ohms per foot square at 50 microns film thickness.

Chemically cured pitch epoxy paint is formed in two packs, pack A typically being formed by grinding together 3 to 4 percent by weight of carbon black XC72, 15 to 20 percent by weight of a coarse pigment grade lamellar graphite such as graphite 152S, 18 to 25 percent by weight of a 5 to 1 by weight mixture of xylol and N-butanol, and a medium which comprises 14.3 percent by weight of an epoxy resin, such as epikote resin 1001, having an epoxy equivalent 450 to 525, 14.3 percent by weight of an epoxy resin, such as epikote resin 828, having an epoxy equivalent of 175 to 210, 40 to 50 percent by weight of a coal tar pitch, such as orgol pitch which has viscosity of approximately 100 poise at 15.5°C, 20 to 25 percent by weight xylol, and 3 to 6 percent by weight of N-butanol. Pack B comprises 93.5 percent by weight of a 50 percent by weight solution of beckalide resin (a polyamide resin of amine number 140 to 150) in a solvent such as 5 to 1 by weight xylol and N-butanol or 4 to 1 by weight xylol and propanol, and 6.5 percent by weight of a curing agent such as curing agent K54 which is 2:4:6 tris-(dimethylaminomethyl)phenol. Pack B is added to pack A in a ratio to give optimum reaction with the epoxy resin. The electrical resistivity of such a paint is 300 ohms per foot square at 50 microns dry film thickness and 80 ohms per foot square at 125 microns dry film

thickness, at 42.5 percent by volume pigment content in the dried film.

In each case, a sufficient pigment content must be used to give a sufficiently low electrical resistivity. The lower limit of resistivity for a given film thickness is determined by a fall off in durability of the film at pigment contents in excess of 50 percent by volume in the dried film. The useful range of dry film resistivity is in the order of 1 to 1,000 ohms per foot square.

Electrical connections for a direct current supply usually of 1-2 volts, are made with the steel as for normal cathodic protection systems, and with the conductive paint coating. Connection with the conductive paint coating may be made either by (a) connecting the supply cables to bus-bars which are held in close electrical contact with the paint coating while it is still tacky and bolted to the structure with insulated bolts, washers and sleeves or (b) by welding or soldering connecting cables to metal foil embedded in the coating while it is wet, or (c) by embedding connecting cables in a suitable conductive mastic adhering to the paint coating. It is desirable in order to make use of the maximum conductive area of the paint coating, to use a linear contact such as a bus-bar rather than a point contact with the conductive paint. The electrical connections are such that the layer of conductive paint is anodic with respect to the metal. Monitoring and control are the same as for normal cathodic protection systems.

If required, the electrically-conductive paint coating may be further overcoated with decorative paint as required for special effects, though such over-coating is not necessary for protection. In such cases the anodic electrically-conductive paint coat acts as the middle layer of a "sandwich."

While the protective coatings are intact or in such a condition that they are not electrically-conductive when wet, the cathodic protection system does not operate and no current is consumed. When there is breakdown of the coating, or metal is exposed, or the coating develops pores, the electrically conductive coating operates as a node when wet, and so prevents corrosion. The anode coating itself is non-corrodible and so is not wasted. A single droplet of water falling on a crack in the protective coating system or on edges where the coating may have broken down, will provide the electrolyte for the current, and protect the wet area which would normally corrode. Thus it is not necessary to have a bulk of electrolyte for the system to be effective, and it would accordingly afford cathodic protection against corrosion on aerial exposure as well as in immersed or buried conditions. Even when overcoated with decorative paint the exposed edge of the conductive paint is sufficient to act as an effective anode at cracks in the film.

It has been found that when immersed in salt water under conditions of electrolysis at a potential difference of approximately 1.4 volts or greater chlorine is produced over the surface of the anodic paint coating in quantity dependent upon the current flowing. The quantity of chlorine produced can be controlled electrically and can be seen visually by bleaching action on dyestuffs placed on the surface. This offers a means of sterilising the painted surface and keeping it free from many living organisms without releasing quantities of dangerous or unpleasant materials into the environment.

The invention is further described, by way of example, with reference to the following specific compositions, and Examples, and with reference to the accompanying drawings, in which:

FIG. 1 is a section through a steel sheet provided with a cathodic protection system in accordance with one embodiment of the present invention, and

FIG. 2 is a section on the line II—II in FIG. 1.

Composition 1 Chlorinated Rubber Paint

Medium	39.7%
Carbon Black XC72	3.6%
Duomeen TDO	0.2%
Shellsol A	27.9%
Grind all the above in a pebble mill for 24 hours. Add Graphite and grind in the pebble mill until fully dispersed and thin with Shellsol A	17.9%
The medium consists of:	10.7%
Alloprene R20	30%
Cereclor S52	10%
Shellsol A	60%

All percentages are by weight.

This paint has a resistance of 10 to 12 ohms per foot square when applied at 50 microns dry film thickness and 4 to 5 ohms per foot square when applied at 125 microns dry film thickness. It is suitable for use in continuous immersion or atmosphere exposure.

Composition 2 Epoxy Ester Paint

Rosaline base mixed with a 60% solution of	0.02 grms
Epoxy Ester in white spirit and warmed to 100°C	18.3 grms
Carbon Black XC72	6.9 grms
White Spirit	29.0 grms
Xylol	32.0 grms
are added and the mixture is ground together in a pebble mill for at least 24 hours	
Graphite Foliac X2104 is then added and the mixture further ground until the Graphite is dispersed.	13.8 grms

This paint has a resistance of approximately 7 ohms per foot square when applied at a dry film thickness of 50 microns. It is suitable for use on metal frequently wet but not for continuous immersion.

Composition 3 Chemically Cured Pitch Epoxy Paint

This paint consists of two packs. Pack A, this base paint, is made as follows:	
Medium	31.8 grms
Carbon Black XC72	3.4 grms
Graphite 152S	17.2 grms
Xylol	17.2 grms
n-Butanol	3.4 grms
are milled together in a pebble mill for 24 hours or until the pigments are dispersed. Then a further quantity of	
Xylol	17.2 grms
n-Butanol	3.4 grms
is added.	
The medium consists of:	
Epikote Resin 1001	14.3%
Epikote Resin 828	14.3%
Orgol Pitch	42.9%
n-Butanol	4.8%

-Continued

Composition 3 Chemically Cured Pitch Epoxy Paint

Xylol	23.7%
To 93.6 grms of the above base paint, Pack A, is added 6.4 grms of Reactor, and after thorough mixing the paint is used immediately. The Reactor consists of	
Beckalide Resin 50% solution	93.5%
Curing Agent K54	6.5%

This paint has a resistance of 300 ohms per foot square when applied at 50 microns dry film thickness and 80 ohms per foot square when applied at 125 microns dry film thickness.

EXAMPLE 1

A steel structure was blast-cleaned to B.S. 4232 second quality or Swedish Standard SIS.05.59.00.1967 Sa2½ and the cleaned surface primed with an alkali resisting blast primer such as a chemically cured epoxy resin based blast primer. Two or three coats of a non-metal-pigmented chemically cured epoxy enamel were applied to the primed surface at such thickness that the metal was fully covered and electrically insulated. One good coat of electrically conductive chlorinated rubber paint was then applied at 50 microns dry film thickness. A second coat of the conductive paint was then over a band onto which a bus-bar was fitted. Fabric or metal foil was embedded into the paint and laid in contact with the bus-bar, the bus-bar and fabric or foil then being overpainted with the conductive paint. The bus-bar and the steel structure were then connected across a D.C. electrical supply with the conductive paint coating anodic with respect to the steel structure.

EXAMPLE 2

A steel structure was blast-cleaned to B.S. 4232 second quality or Swedish Standard SIS.05.59.00.1967 Sa 2½ and the cleaned surface primed with an alkali resisting blast primer such as a chemically cured epoxy resin based blast primer. Two or three coats of non-metal-pigmented chlorinated rubber paint were applied so that the metal was fully covered and electrically insulated. One good coat of electrically conductive chlorinated rubber paint was then applied at 50 microns dry film thickness. A second coat of the conductive paint was applied over a band onto which a bus-bar was fitted. Fabric or metal foil was embedded into the paint and laid in contact with the bus-bar, the bus-bar and fabric or foil then being overpainted with the conductive paint. The bus-bar and the steel structure were then connected across a D.C. electrical supply with the conductive paint coating anodic with respect to the steel structure.

EXAMPLE 3

A steel structure was blast-cleaned to B.S. 4232 second quality or Swedish Standard SIS.05.59.00.1967 Sa 2½ and the cleaned surface primed with an alkali resisting blast primer such as a chemically cured epoxy resin based blast primer. Oleo resin varnish based primers and undercoats, not metal-pigmented, were applied so that the metal surface was fully covered and electrically insulated. One or two good coats of electrically conductive epoxy ester paint were then applied to give

a minimum dry film thickness of conductive paint of 50 microns. A second coat of the conductive paint was applied over a band onto which a bus-bar was fitted. Fabric or metal foil was embedded into the paint and laid in contact with the bus-bar, the bus-bar and fabric or foil then being overpainted with the conductive paint. The bus-bar and the steel structure were then connected across a D.C. electrical supply with the conductive paint coating anodic with respect to the steel structure.

EXAMPLE 4

For Steel to be Only Partly Immersed in Water

A steel structure was blast-cleaned to B.S. 4232 second quality or Swedish Standard SIS.05.59.00.1967 Sa 2½ and the cleaned surface primed with an alkali resisting blast primer such as a chemically cured epoxy resin based blast primer. Two or three coats of a non-metal-pigmented chemically cured epoxy enamel was applied to the primed surface at such thickness that the steel surface was fully covered and electrically insulated. One good coat of electrically conductive chlorinated rubber paint was then applied at 50 microns dry film thickness. A second coat of the conductive paint was applied over a band onto which a bus-bar was fitted. Fabric or metal foil was embedded into the paint and laid in contact with the bus-bar the bus-bar and fabric or foil then being overpainted with the conductive paint. A decorative paint was applied over that part of the surface not to be immersed in water, completely covering the conductive paint and the bus-bar, but leaving terminals on the bus-bar clean for electrical connections. The bus-bar and the steel structure were then connected across a D.C. electrical supply with the conductive paint coating anodic with respect to the steel structure.

The drawings show a steel sheet 10 which has been provided with a cathodic protection system in accordance with the invention. The surface of the sheet 10 intended to be exposed to a corrosive environment, has a first coating 12 of electrically insulating paint and a second, overlying coating 14 of electrically conducting paint. An electrically conducting bus-bar 16 is fixed to the sheet 10 so as to be in intimate electrically conducting contact with the conducting layer 14. A further coating 18 of electrically conducting paint is applied over the bus-bar 16 and the adjacent region of the coating 14, a layer of sheet material such as fabric or foil being embedded in the coating 18.

The bus-bar 16 is secured to the steel sheet 10 by bolts 20 and nuts 22 which are electrically insulated from the sheet 10 by insulating sleeves 24 and insulating washers 26 respectively. The nut and bolt assemblies are protected at their exposed ends by an electrically insulating covering 28 of a material such as mastic or an epoxy resin.

A D.C. electrical supply (not shown) is applied across the bus-bar 16 and steel sheet 10 with the bus-bar anodic with respect to the steel sheet. Electrical

connection is made to the bus-bar 16 by way of a connector 30 and to the steel sheet by, for example, welding or mechanical means.

The system thus provides an anode which is normally insulated from but is disposed very close to the entire surface of a cathodic substrate. Cathodic protection of the substrate only becomes effective when the insulation between the anode and the substrate breaks down owing, for example, to physical damage or pore formation. By virtue of the invention, an anode for providing cathodic protection is immediately available at any point on the protected substrate surface when required. As the insulating layer between the anode and the substrate is very thin, even moisture condensation from the atmosphere can be sufficient to provide the necessary electrolyte link between the anode and substrate.

I claim:

1. A cathodic protection system comprising a metal to be protected, an electrically non-conductive coating applied in fluid form over the metal, an electrically conductive coating applied in fluid form over the non-conductive coating, said conductive coating being rendered electrically conductive by the incorporation of elemental carbon therein, such that the metal and electrically conductive coating are electrically insulated one from the other, a source of D.C. voltage being connected between the metal and the electrically conductive coating such that the electrically conductive coating is anodic with respect to the metal.

2. A cathodic protection system according to claim 1, wherein said conductive coating is a paint composition.

3. A cathodic protection system according to claim 2 in which the electrically conductive coating has a resistivity of up to 1,000 ohms/ft. sq.

4. A cathodic protection system according to claim 2 wherein the carbon content is up to 50 percent by volume of dried coating.

5. A cathodic protection system according to claim 2 wherein the conductive paint composition is a carbon-containing chlorinated rubber paint.

6. A cathodic protection system according to claim 2 wherein the conductive paint composition is a carbon-containing epoxy ester paint.

7. A cathodic protection system according to claim 2 in which the conductive paint composition is a carbon-containing chemically cured pitch epoxy paint.

8. A cathodic protection system according to claim 1 wherein there is another coating over the electrically conductive coating.

9. A cathodic protection system according to claim 1 in which the D.C. voltage source is of sufficient size to provide sufficient voltage to liberate chlorine from sea water.

10. A cathodic protection system according to claim 9 wherein the D.C. voltage source is of a size sufficient to provide at least 1.4 volts.

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