US 20030196912A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2003/0196912 A1**

Morgan (43) **Pub. Date: Oct. 23, 2003**

(54) **BODY**

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(21) Appl. No.: **10/124,056**

(22) Filed: **Apr. 17, 2002**

Publication Classification

(51) **Int. Cl.**[7] **C23F 13/00**
(52) **U.S. Cl.** **205/724**

(57) **ABSTRACT**

A sacrificial electrode system for cathodically protecting an iron and/or steel object against corrosion comprising of a sacrificial anodic material containing, but not limited to, zinc, magnesium, aluminum or a mixture of these materials, with a magnet, preferably of the ceramic type, coupled with a cap plate, embedded into the sacrificial anode material so that advantage can be taken of the magnetic flux for transfer of electrons from the anode material to the object being protected, the unit is affixed to the object being protected by use of an electrically conductive adhesive. The electrical connection is established via the combination of ceramic magnet and electrically conductive adhesive. The magnet is magnetized in the direction of its thickness and the conversion of Fe_2O_3 into Fe_3O_4 us furthered by the use of the electrically conductive adhesive and the magnet with cap plate.

FIG. 1

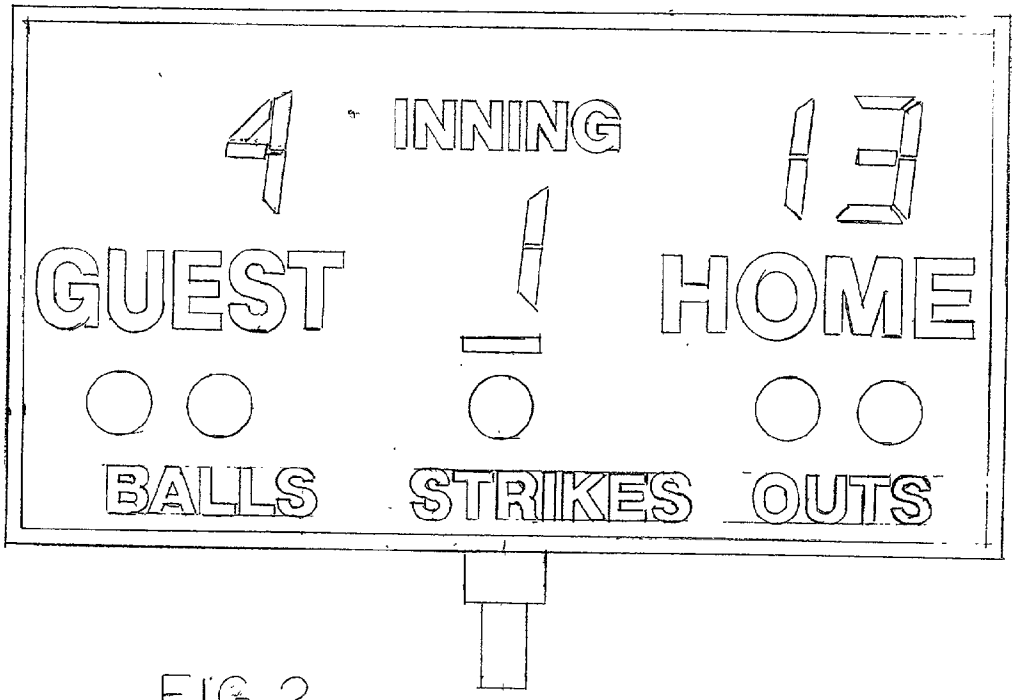


FIG. 2

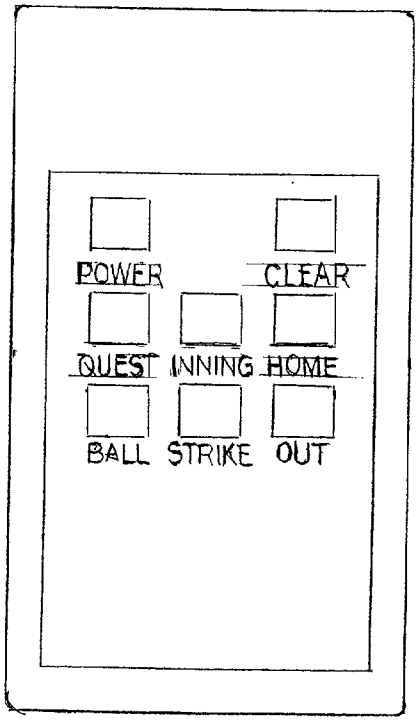


FIG. 3

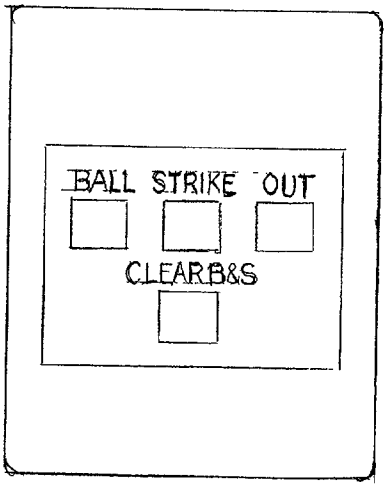


FIG.4

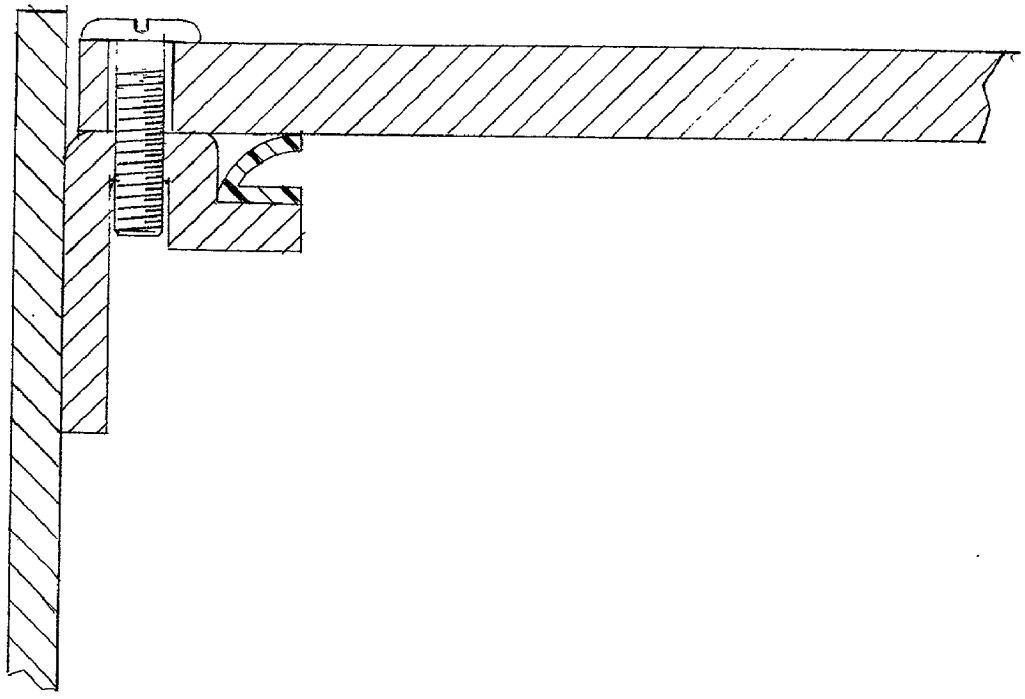


FIG.5

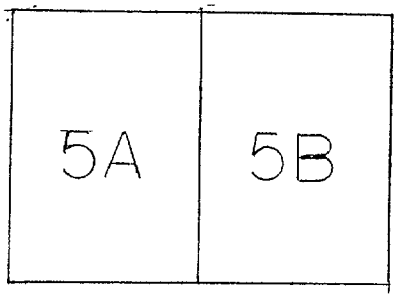


FIG.5A

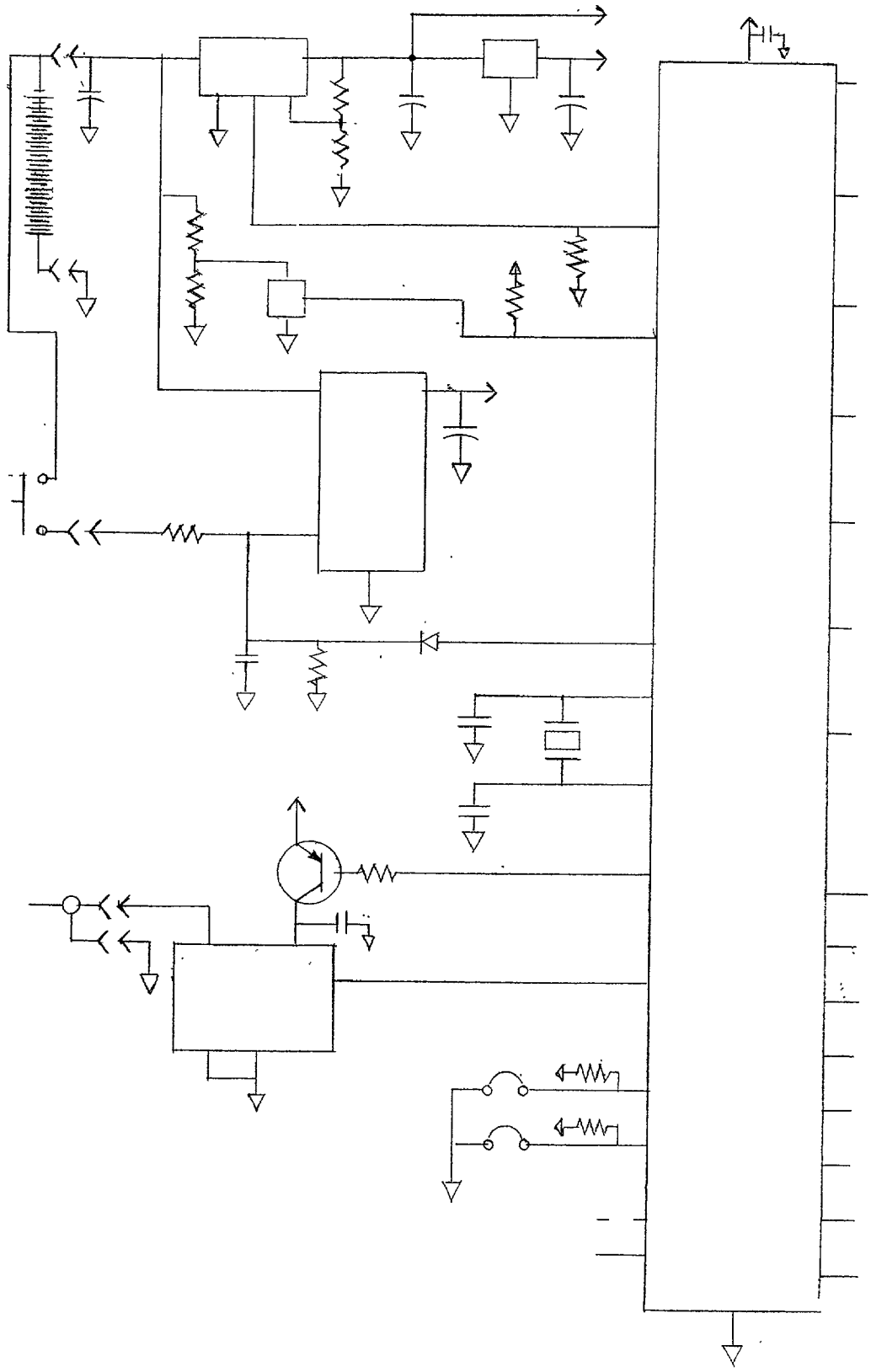
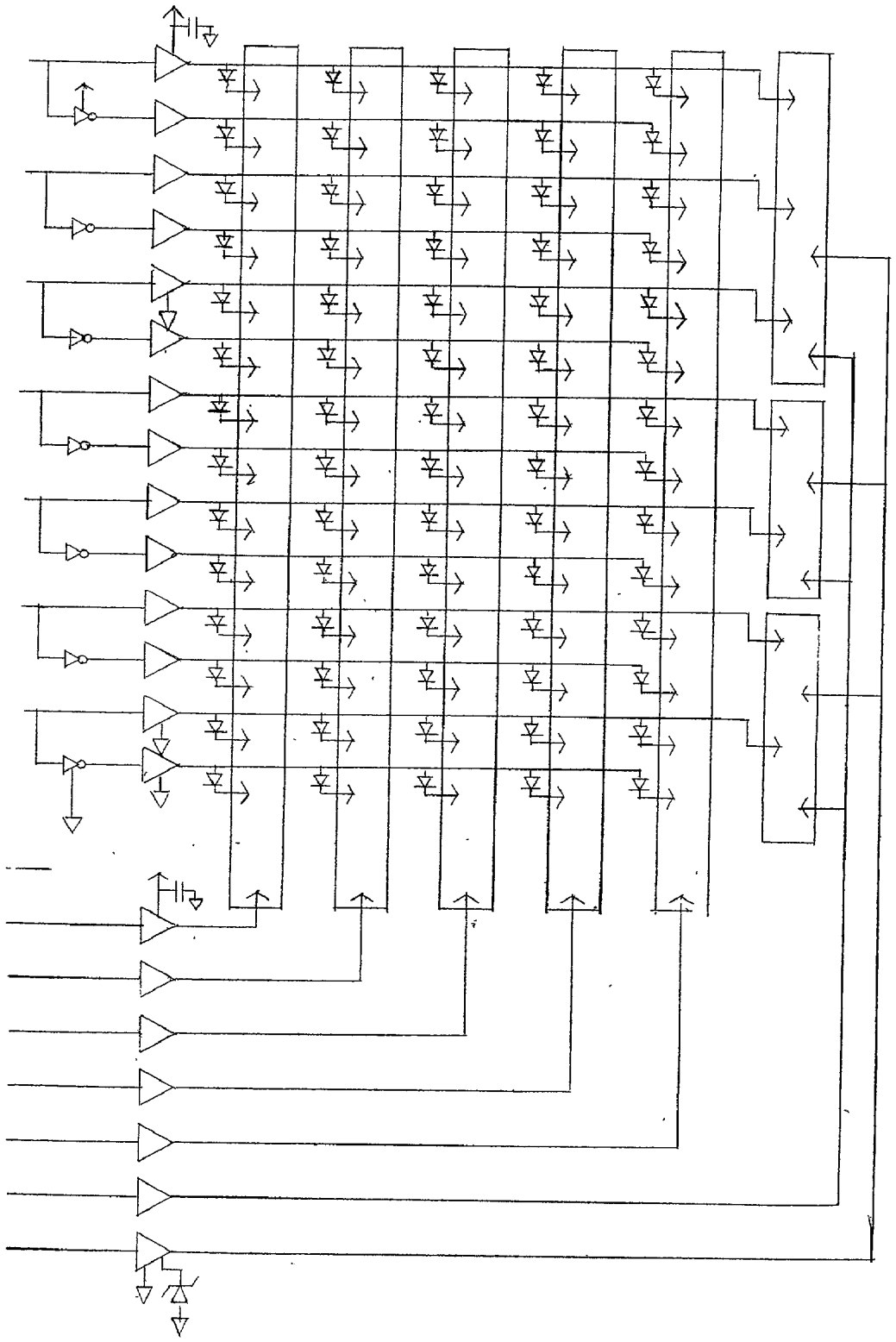


FIG. 5B



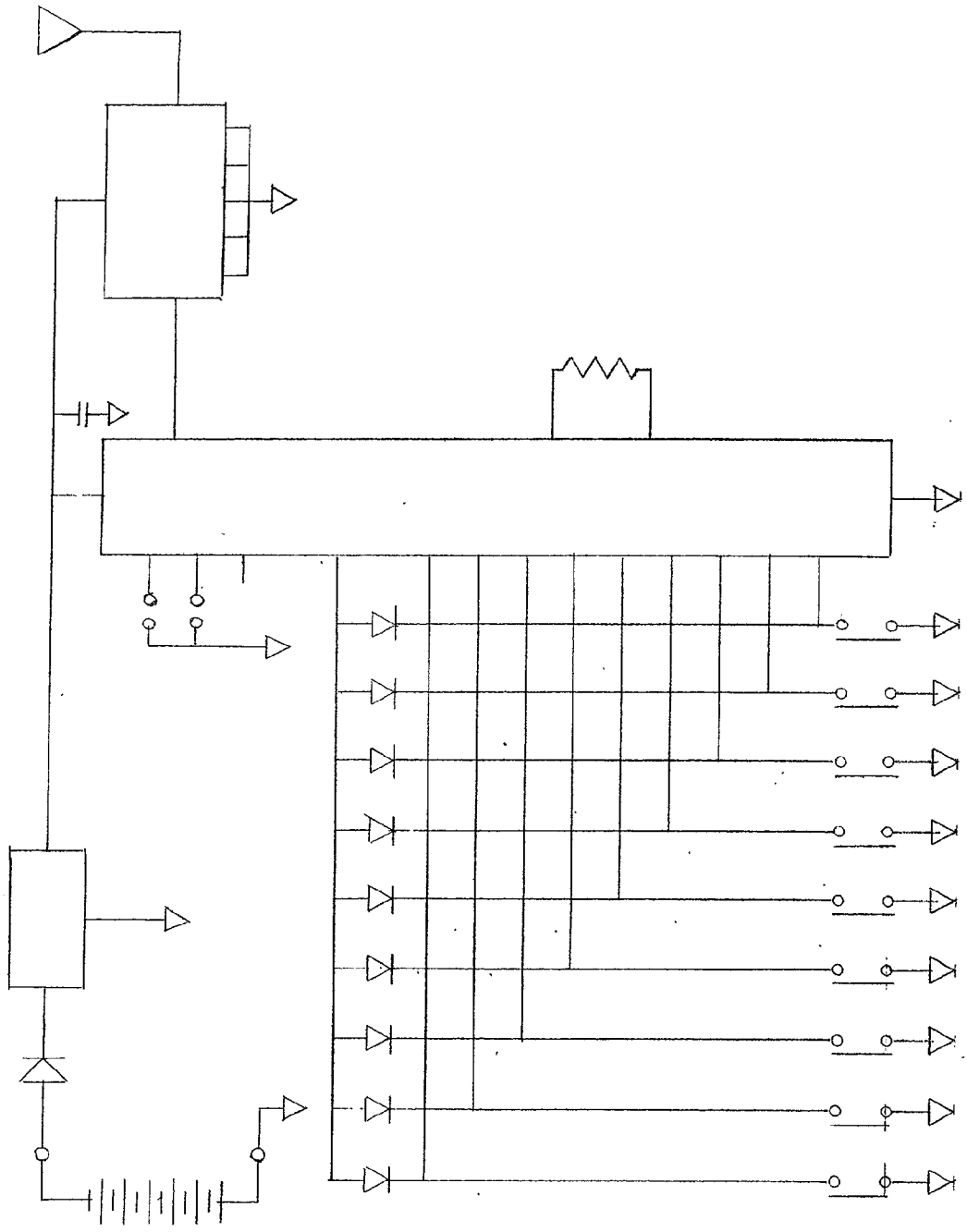
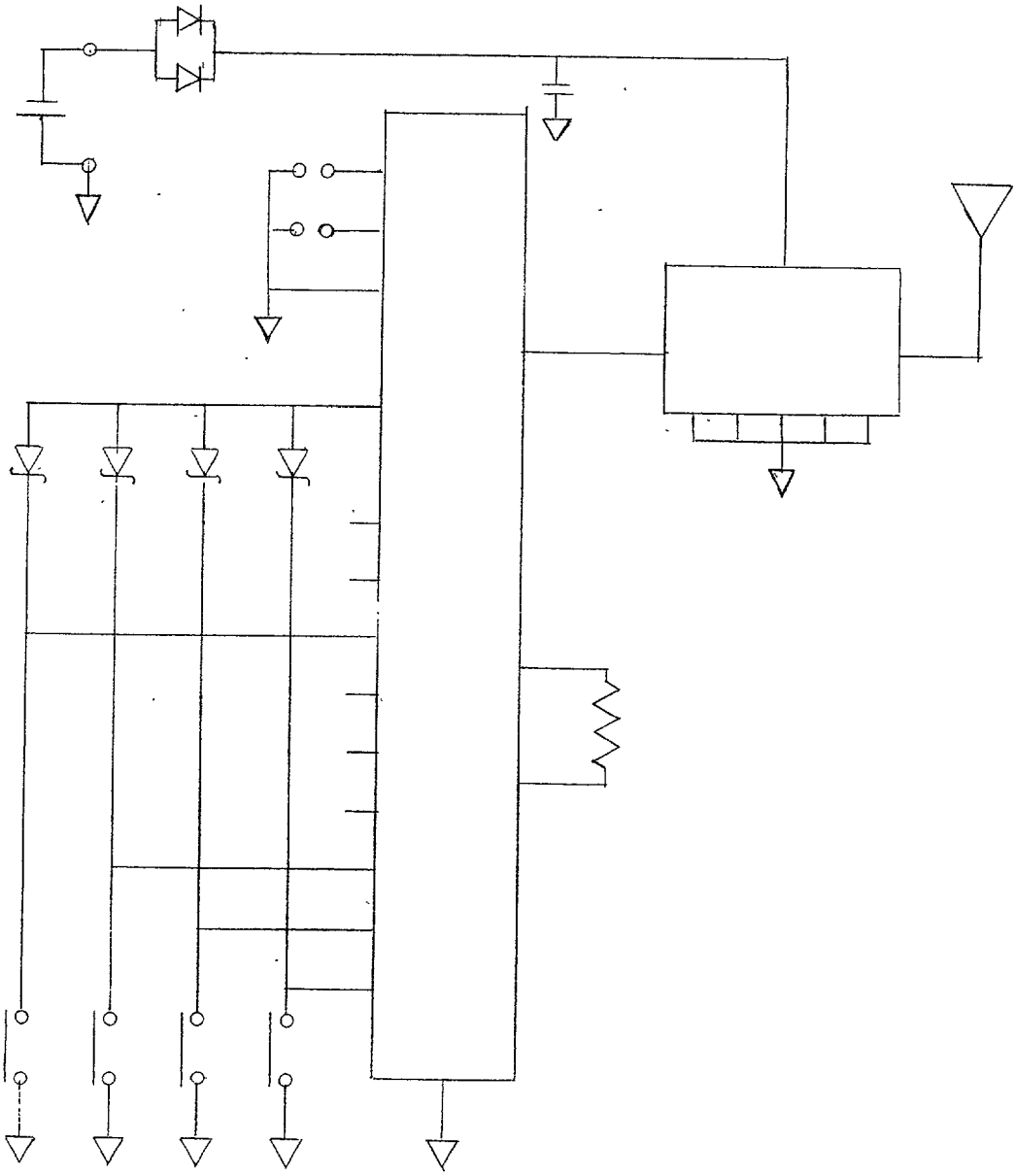


FIG.6

FIG. 7



BODY

[0001] The present invention relates to an electrode system for protecting a metal object against corrosion.

[0002] The invention relates particularly to electrodes of zinc, aluminum, magnesium, platinum, platinum-coated titanium, which are magnetically and electrically secured to ferro-magnetic metals, such as steel, steel compounds, nickel, cobalt for protecting these metals cathodically against corrosion.

[0003] The cathodic protection of ferro-magnetic metals by means of electrodes is inter alia known from Netherlands Pats. 36,564, 72,206, 74,279 and 81,577, German Pat. **644,418**, U.S. Pat. Nos. 2,766,200, 2,863,819, 3,011,959 and 3,513,082, French Pat. 1,271,669 and British Pat. 870,086.

[0004] It is known to fasten all sorts of articles to a Ferro-magnetic base by means of magnets. Dutch Pat. 100,332 discloses the mounting of an electrode by means of a metal magnet, for example to a steel object protected against corrosion. The electrode used according to this patent is a sacrificing anode, which is secured to the object to be protected by the means of a metal magnet, is electrically connected to the object to be protected inter alia by the means of the metal magnet.

[0005] By securing the sacrificing anode to the object by means of a metal magnet, the replacement and/or renewal of the anode and of the metal magnet is a simple operation, while is it not necessary to equip the object to be projected with special fastening means.

[0006] It has been found, however, that it is not so simple to secure a sacrificing anode to a metal magnet, and that the fitting of the sacrificing anode to the object to be protected by means of this metal magnet is not satisfactory in all cases.

[0007] such an arrangement has many disadvantages, and the problems, inherent to the cathodic protection are mostly not solved or partly so.

[0008] The disadvantages of the known method of securing an anode by the means of a metal or ceramic magnet, are inter alia the followings

[0009] (1) Hitherto where only metal magnets have been used for this purpose, and these especially in the horseshoe form. These metal magnets are generally made of a metal alloy consisting of steel, nickel, cobalt, aluminum, etc if the electric potential of such a metal magnet is measured in sea-water relative to ship's steel, there appears to be an important difference in potential in favor of the magnet or in favor of the shop's steel to be protected, by which strongly corrosive effects are generated.

[0010] This corrosion-promoting potential of these metal magnets may sometimes be 220 millivolts and more relative to the object to be protected so that, if through unforeseen conditions the anode does not function or insufficiently so, this metal magnet may locally effect strongly corrosive phenomena, which is very detrimental to the metal magnet or to the object to be protected, e.g., ships hulls, tankwalls etc.

[0011] (2) The metal magnets of high alloy steel referred to above are used with sacrificing anodes because these metal magnets effect the direct electric contact with the object to be protected. To this effect, it is naturally desirable that there is maintained an electric transition resistance as low as possible, for which reason the pole shoes and the object to be protected should be kept free of oxides etc. It would be expected that such an electric contact could be very well maintained so long as the sacrificing anode is secured to the magnet and the pole shoes of the metal magnet are in contact with the object to be protected.

[0012] Contrary to this expectation, practice has shown that corrosion phenomena occur between these pole shoes and the object to be protected, so that the electric conduction becomes inadequate and the attraction of the metal magnet relative to the object is considerably reduced. This phenomenon is to be ascribed to the circumstance that, however smooth the pole shoes of the metal magnet and the surface on which the metal magnet is mounted may be, there will still always be a water film between them, and a greater amount in the ever-present scratches and roughness. Although the sacrificing anode will supply its protective energy, this anode cannot sufficiently exert its influence in the interspace between the the pole shoes and the surface to be protected, because the pole shoes of the metal magnet and the ship's steel locally inhibits the cathodic protection, so that corrosion occurs. This corrosion may after some time be such that pit-corrosion occurs in one of the two contaction surfaces, the pits being in the long run filled with rust, so that the electric conduction becomes insufficient and the magnetic attraction is reduced. As a consequence, the object is "under-protected" and further corrosion occurs, which may grow to such an extent that the anode and the metal magnet comes off the object and the cathodic protection stops entirely.

[0013] (3) In the high-alloy metal magnet, selective selfcorrosion may occur which renders it unfit for use, so that one of the attractions of this manner of securing, namely an economic and continuous fixation, is lost.

[0014] (4) The existing metal magnets are very difficult to process, and, for example, are not easily made in a compact and streamline from. Horseshoe magnets create cumbersome vortices at some velocity of the ship, and owing to their form, they are as it were forced off the ships hull.

[0015] Streamline magnets are very desirable, it is true, for use upon the ships hull, because they offer little resistance in the navigation, but they are difficult to make because high-alloy metal magnets are not easily processed and made compact.

[0016] (5) The existing metal magnets are difficult to make or to assemble into units having a high magnetic power; so that only electrodes of comparatively small size and low weight can be used, which excludes their use in ships of some size.

[0017] (6) The existing high-alloy metal magnets have the property that in mounting, when they are dropped or struck against other objects, they strike sparks, so that their use in fire-hazardous spaces (e.g. oil tankers) must be contiered impossible.

[0018] (7) the storage of the known metal magnets must be regarded as very difficult, because, if the

magnetic poles are not closed, the magnets soon lose their magnetism. Shutting off the magnet poles when the electrode is already mounted to the magnet, presents difficulties in practice for the storage.

[0019] (8) The very high-alloy steel magnets are very difficult to process and as a consequence, a good form of mounting for sacrificing anodes of some size is very difficult to find.

[0020] (9) Experiments have shown that the existing metal magnets rapidly loose their magnetic power when they are subjected to vibrations as occur for example in a ship.

[0021] (10) The method of securing electrodes by means of metal magnets can only be used for mounting sacrificing anodes, because in this case the current is directly passed from the sacrificing anode to the surface to be protected. In the cathodic protection by the impressed voltage technique, the fixation by mean of a metal magnet could only be used if it would be possible for the anode to be mounted to the metal magnet in electrically insulated condition, which requirements, however, can hardly, if at all, be met.

[0022] It is an object of the present invention to remove the disadvantages of the prior method of securing electrodes by means of metal magnets, and to provide a magnetic fixation and electrically conductive of electrodes which can be successfiilly accomplished in almost all cases.

[0023] To this end, according to the invention, use is made of an electrode system comprising at least one magnet of a material which is corrosion-resistant and a layer of electrically conductive adhesive.

[0024] According to the invention, the electrode system comprises at least one magnet of a material which is electrically conductive.

[0025] According to the invention, the electrode system may comprise at least one magnet unit of ceramic material.

[0026] Magnet units of this ceramic material are here understood as being magnets consisting of mixtures of oxides, such as e.g. iron-barium oxides, iron-lead oxides, which are well mixed and subsequently sintered to mechanically very strong bodies and then after magnetization form magnets of exceptional strength and life. These ceramic magnets are not electrically conductive, possess on potential relative to the metal they are to protect, have a resistance of about 100,000 ohms per cm. and more and are further entirely resistant to corrosive electrolytes.

[0027] Although such ceramic magnets have been made in large quantities for all sorts of purposes since 1946, it is according to the invention, for the first time proposed to use the exceptionally good properties of these magnets and electrically conductive adhesive mounting electrodes on surfaces to be protected. The favorable properties of these ceramic magnets for the purpose according to the invention may be summarized as

[0028] (1) They do not possess a potential relative to the surfaces to be protected so that there can never occur an activated corrosion around or under the magnet.

[0029] (2) The ceramic magnets allow of being constructed in combination with electrically conductive members permanently maintaming the ideal contact with the object to be protected, and which do not have any adverse difference in potential relative to the object to be protected.

[0030] (3) The magnetic attraction of these ceramic magnets is ensured for scores of years both in open and in closed condition, so that a stable attachment to the object to be protected is obtained coupled with electrically conductive adhesive.

[0031] (4) The magnetic attraction is not reduced by the vibrations of, for example a ship, because these very ceramic magnets are particularly strongly resistant to vibrations and to other forms of mechanical loads.

[0032] (5) Since no corrosion can occur between the anode and the object to be protected, no magnetic losses can arise as a result of this, and undesirably reduce the attraction of the ceramic magnets to the object, so that the anode will not come off with all adverse effects

[0033] (6) The anode allow of being made in all possible shapes, and of being assembled from a plurality of small units to one large whole having a very strong magnetic attraction, should this be desired. The anode material is easily processed, so that the necessary streamline form can be made. In the case of for example, navigating vessels cathodically protected in this manner by means of an electrode system according to the invention, unnecessary resistance in the water is prevented, and the anode too, will not encounter extra loads in view of which the capacity of the magnet and electrically conductive adhesive should be made unduly high.

[0034] (7) When they are dropped struck or subjected to other impact contacts with rusty iron, the ceramic magnets, electrically conductive adhesive or anode have not tendency to strike sparks, so that fire hazard in, for example tankers is prevented.

[0035] (8) By virtue of the structural possibilities with ceramic magnets and the possibility of assembling strong magnet systems from smaller units of these magnets and to shape the same as desired with easily processed metal capable of forming a good anchorage along with the electrically conductive adhesive for the electrode, a strong electrode-magnet system is obtained, which provides an excellent cathodic protection, is easily mounted and can be economically replaced.

[0036] (9) The magnetic power of the ceramic magnets can be reinforced considerably by a combination with other ferro-magnetic materials which, as regards their potential are not detrimental to the surfaces to be protected either.

[0037] (10) The combination of ceramic magnets and electrically conductive adhesive per se or in conjunction with ferro-magnetic materials of the same lower potential than the object to be protected, a good magnetic adherence and proper electric con-

tract is after a short time even obtained on a rusty base. This is caused by the fact that rust, which consists of a loose moisture of Fe2O3 and FeOH, by the contact with the system according to the invention and under the influence of the magnetic force thereof, is in an electrolyte-like, for example, seawater, after a short time converted into strongly ferro-magetic Fe3O4, which adheres well to the metal base and is moreover a good electric conductor. No other form of attachment but a magnetic coupled with electrically conductive adhesive could effect this reaction.

[0038] According to the invention on magnet unit may have the form of a fiat disc.

[0039] According to the invention the disc-shaped magnet unit may be provided with a central hole.

[0040] Further, according to the invention the central hole, in the disc shaped magnet unit maybe threaded.

[0041] According to the invention one magnet unit may be sandwiched between foerromagnetic members which direct, bundle and/or reinforce the magnetic power of the magnet units.

[0042] Furthermore, according to the invention, the areas of the ferro-magnetic members having the magnet units between them may be in excess of the areas by which the magnet units are in contact with the ferro-magnetic members.

[0043] Furthermore, according to the invention, the magnet unit and the ferromagnetic members may be kept together by means of electrically conductive adhesive.

[0044] Furthermore, according to the invention, a plurality of magnet units may be combined to a magnet system, each pair of adjacent magnet units having a ferro-magnetic member between them.

What is claimed is:

1. A method of cathodically protecting a ferrous metal object against corrosion, comprising the steps of providing a magnet means having a ceramic magnet portion embedded into. Electrically conductive material having an equal or more negative potential than the object to be protected to the magnet means in a manner such that said electrically conductive adhesive constitutes the part of said magnet means which contacts the object to be protected. Mounting on and electrically connecting to sacrificial anode which constitutes said protective electrode and placing said magnet means with the protected object against which the object is to be protected by placing a surface of the anode in contact with the object is to be protected and the magnet means to the object to be protected and the magnet means does not accelerate the corrosion of the object to be protected after the protecting electrode is consumed.

2. A method of attaching a sacrificial anode by means of an electrically conductive adhesive while enhancing the cathodic protection process through the use of a magnet embedded into the sacrificial anode utilizing the beneficial properties of the magnet in a new and unique way.

3. A method of protecting objects that have been formally overlooked in the use of passive cathodic protection.

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